BURO HAPPOLD

NOMA 2&3 Angel Square

Ground Engineering Desk Study Report

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1 Executive Summary

Buro Happold Limited were appointed by MEPC Ltd to undertake a Phase I Desk Study to provide an initial assessment of the likely ground conditions specific to the proposed development at for 2 & 3 Angel Square Plots (formerly plots M & N), Manchester. The site area is currently occupied by public car parking areas, managed by RCP Parking Ltd, with the main access from Angel Street. The immediate surrounding area comprises urban development including residential, warehouses, offices and manufacturing facilities.

The Proposed Development comprises the erection of two high quality commercial office buildings of 13 and 14 storeys, alongside public realm, car parking, extensive cycle parking facilities, and associated highways and access arrangements. The Proposed Development will be phased and at this stage the phasing and delivery strategy is not fixed.

Reviews of historical maps indicate that the proposed development site has undergone a rich industrial history including the remains of cotton mills and associated reservoirs (Arkwright's Mill - Shudehill Mill), an iron foundry, a saw mill and timber yard, a brewery, a public baths and wash house, public houses, shops and housing of various types.. The past and present uses of the site and its surroundings indicates the potential for a variety of contaminants to be present.

Two scheme specific intrusive ground investigations have been undertaken (SSL 2015/2021 GI's) which comprised a number of exploratory holes to determine the depth and properties of any Made Ground, superficial deposits and the bedrock; soil, rock and groundwater sampling and testing, monitoring of ground gas and groundwater and assessment of contamination risk specific to the development and current guidelines. The ground conditions comprise a variable depth of Made Ground, overlying superficial deposits (Glacial Till – sand, gravel and clay), underlain by the Chester Formation (Sherwood Sandstone Group). The Sherwood Sandstone Group is classified as a 'Principal Aquifer' (formerly a 'Major Aquifer').

The SSL 2021 GI groundwater data indicates static water level (SWL) between ~30.08 m AOD and 24.97 m AOD (15.69 to 21.92 m bgl) within the sandstone bedrock (Chester Formation). Localised perched groundwater is also recorded within the Made Ground/superficial deposits (~0.50 to 3.95 m BGL). It is worthy of note that there were no groundwater strikes within the trial pits or window samples during the SSL 2021 GI. In relation to ground gas, it is considered that Characteristic Situation 1 (CS1) is a suitable classification for the entire site. In accordance with Table 4 (page 22, BS 8485:2015+A1:2019) if the Site is classified as CS1, 0 points are required and thus ground gas protection is therefore not required.

SSL 2021 GI: 10 No. soil samples underwent soil chemical analysis and were assessed against the C4SL and S4UL screening criteria. 2 No. of the 10 No. samples tested recorded determinands that exceeded the relevant 'commercial' threshold for lead (2,330 mg/kg). TP104 at 0.50 m BGL – Lead: 5910 mg/kg (located under 2 AS plot) and TP111 at 1.80 mg/kg – Lead: 4300 mg/kg (located in between 3 AS and NMS). Given the depths of the samples, is likely that this material will be removed from site during the lower ground level excavation. If left insitu, the area will be covered in hardstanding or appropriate soft landscaping builds, thus breaking any source-pathway-receptor linkage.

14 No. tests on samples within Made Ground deposits were screened for ACM. 1 No. sample recorded the presence of asbestos fibres, namely Chrysotile in TP108 at 0.60 m BGL (located under 3 AS plot).

Waste Acceptance Criteria (WAC) testing was also carried out on 10 No. samples. 7 No. soil samples tested were classified as 'Non-Hazardous' and 3 No. soil samples were classified as 'Hazardous'. TP102 at 0.70 m bgl – Lead (1060 mg/kg) and

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Zinc (1580 mg/kg - located under 2 AS plot). TP104 at 0.50 m bgl – Lead (5910 mg/kg - located under 2 AS plot) and TP111 at 1.80 m bgl – Lead (4300 mg/kg - located in between 3 AS and NMS)).

Minor historical ground contamination is present within the Made Ground materials. Based on the qualitative risk assessment and the results from the SSL 2015/2021 GI, the risk of ground contamination affecting the Proposed Development is considered to be predominantly low to low/moderate.

The Zetica Unexploded Bomb Risk Map shows the Site to be in an area of 'Moderate' risk. It is known that Arkwrights Mill on/adjacent to the western site boundary was bombed in 1940 during the 'Manchester Blitz' and post-war historical maps show a number of 'Ruins' on site and immediately to the east. In addition, these maps do not record many buildings which were recorded on site pre-war (World War II). A detailed UXO risk assessment has been carried out which classifies the site as 'medium' and recommends UXO mitigation measures during any groundworks, boreholes or piled foundations.

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2 Introduction

Buro Happold Engineering has been appointed by NOMA (GP) Ltd to undertake site investigation works for the proposed development of two new build office developments on 2&3 Angel Square (Plots M and N) within the NOMA Masterplan. Please note, for the purposes of this Desk Study report, 2&3 Angel Square have been evaluated as one proposed development site herein referred to as 'the Site'.

The Site is located to the north of Manchester City Centre and approximately 220 m east of Manchester Victoria Railway Station, centred on National Grid reference ^{3}84400 E, ^{3}99053 N. It is also in the immediate vicinity of the existing Co-operative Insurance Society (CIS) Tower which lies just beyond the corner of the western boundary. The site area is currently occupied by public car parking areas, managed by RCP Parking Ltd, with the main access from Angel Street. The immediate surrounding area comprises urban development including residential, warehouses, offices and manufacturing facilities. A site location plan is included as Figure 2—1 and an aerial photograph is included as Figure 2—2.

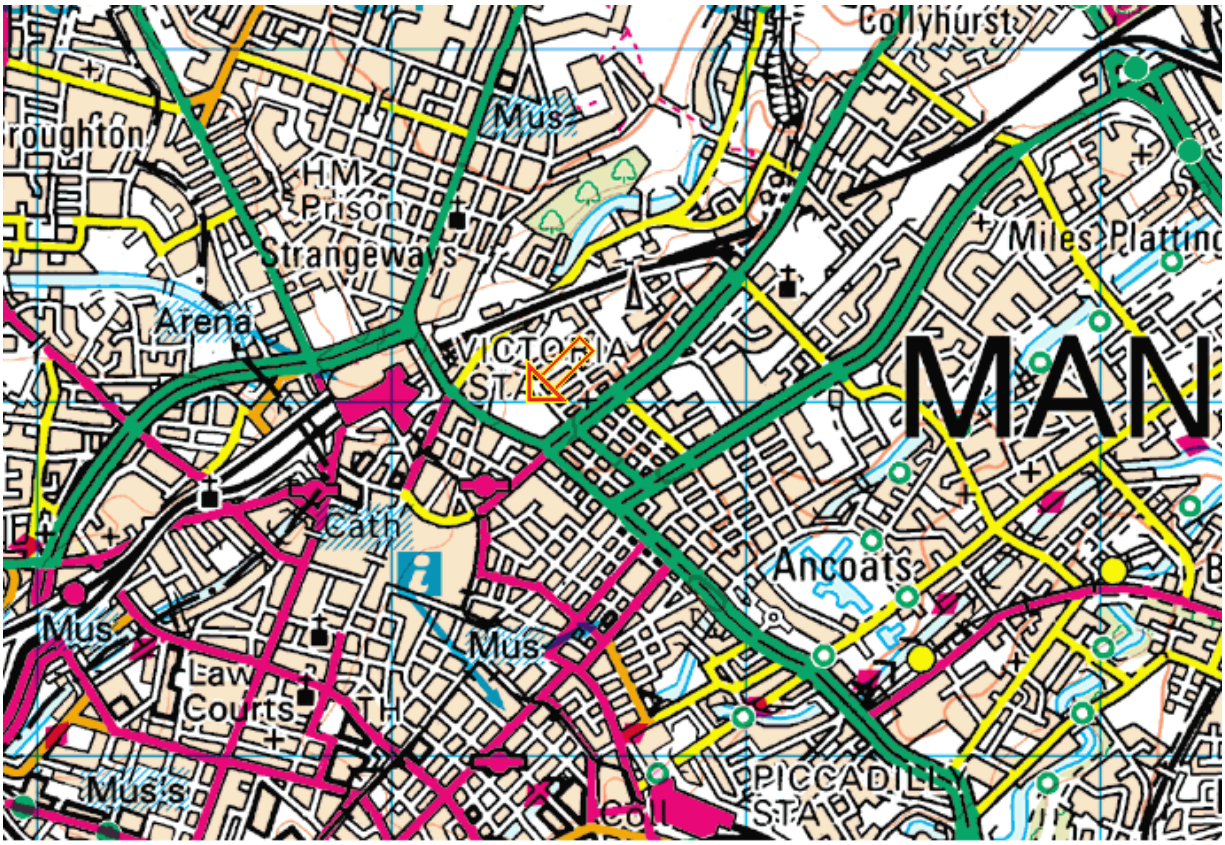

Figure 2—1 Site Location

The Proposed Development comprises the erection of two high quality commercial office buildings of 13 and 14 storeys, alongside public realm, car parking, extensive cycle parking facilities, and associated highways and access arrangements. The Proposed Development will be phased. At this stage the phasing and delivery strategy is not fixed. It is possible that either 2 Angel Square or 3 Angel Square could be delivered first as a standalone building, or the delivery could be concurrent. In advance of works starting on 2 & 3 Angel Square, the Noma Marketing Suite is

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proposed to be erected on site as a temporary building in the southwestern corner of the Site and will consist of a single storey building with associated car parking and public realm.

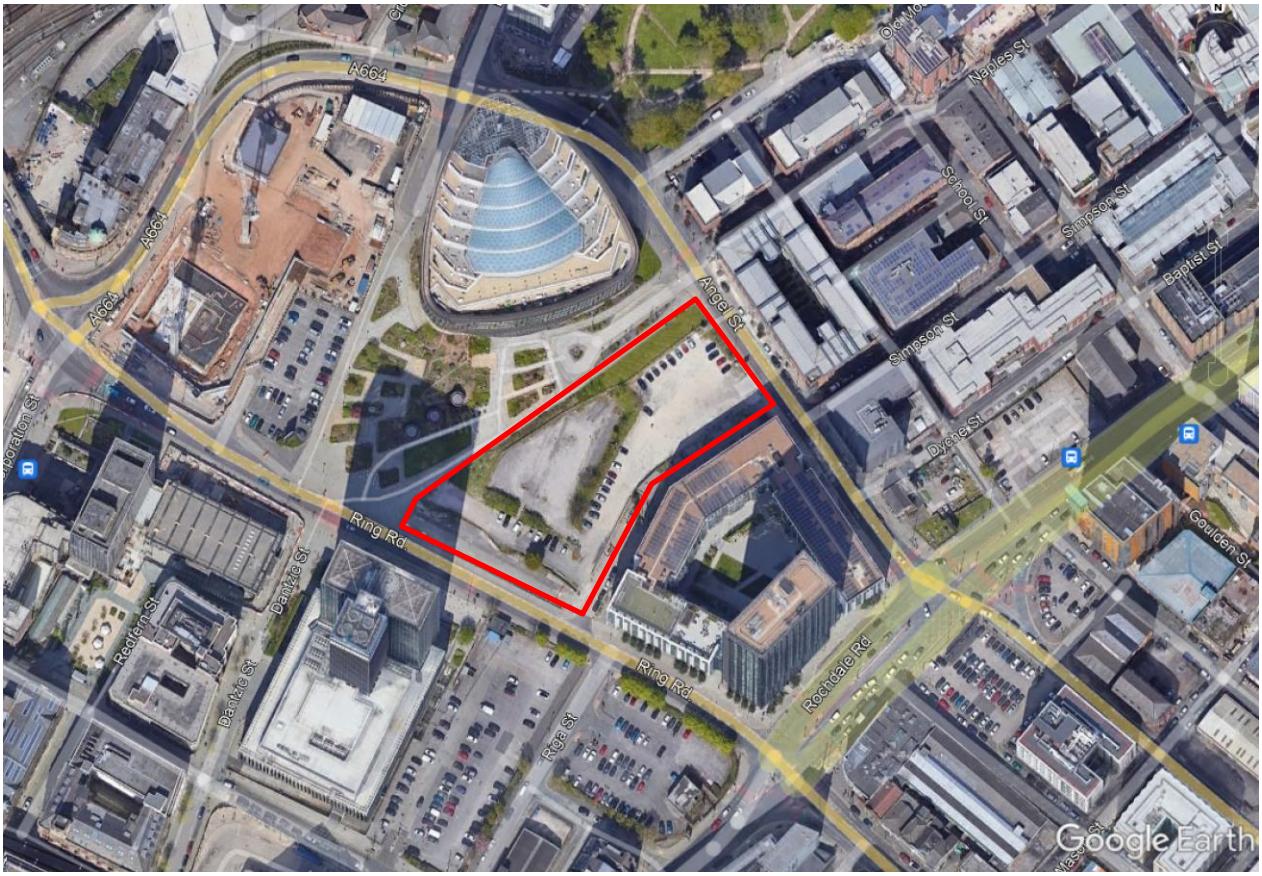

Figure 2—2 Aerial Photo (2&3 AS redline boundary shown)

The redevelopment options for the area surrounding the site are also being considered as part of a masterplanning exercise for NOMA, but this is outside the scope of this study. The old masterplan area with the Site positioned for overall context is presented in Figure 2—3. An architect's impression of the proposed development and associated layout is included as Appendix A.

A desk study has been undertaken to allow an appropriate ground investigation to be designed and to optimize, as far as possible, the positioning of the exploratory holes. The purpose of this report is to collate and summarize the information for the Site and immediate surrounding area, including:

- The general physical constraints of the Site such as topography, landscape and existing structures;
- An assessment of the generalized past and present usage of the Site;
- An assessment of the anticipated ground conditions in respect of geology, hydrology, hydrogeology, mining activity and geohazards, if any;
- An assessment of the environmental setting of the Site, including the possibility of encountering ground gas as well as potentially contaminating substances; and
- A summary of current development proposals.

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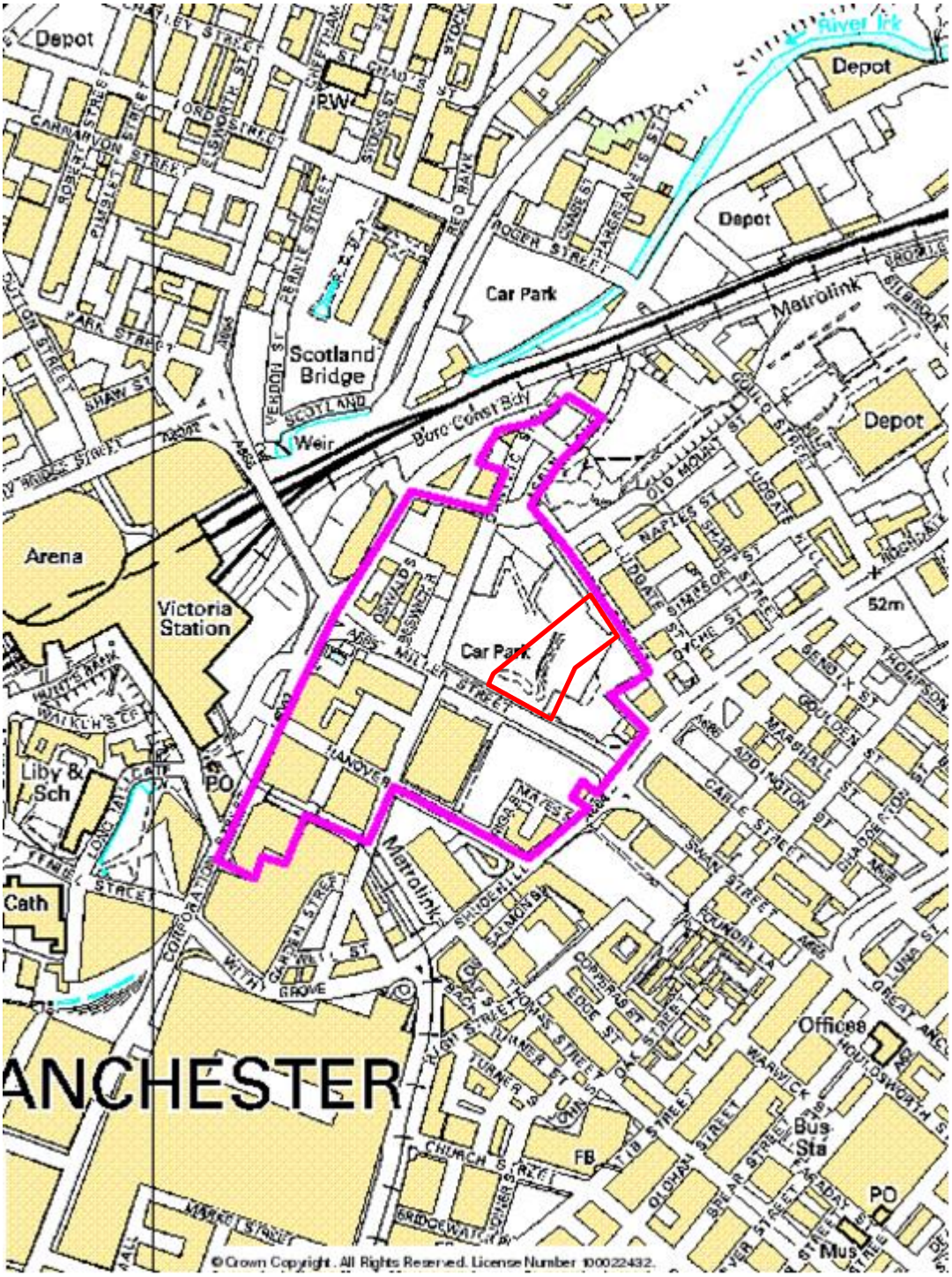

Figure 2—3 Old Masterplan Boundary (2&3 AS redline boundary shown)

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The principal source of information relied upon is a Groundsure® Report[1], which provides a database of information within a 1 km radius of the site as supplied by different statutory authorities and other relevant bodies.

A summary of all the information sources used in this report is included as Appendix B. Other references typically include:

- British Geological Survey. 2010. Manchester. England and Wales Sheet 85. Bedrock. 1:50,000. (Keyworth, Nottingham: British Geological Survey).
- British Geological Survey. 2011. Manchester. England and Wales Sheet 85. Bedrock and Superficial. 1:50,000. (Keyworth, Nottingham: British Geological Survey)
- Structural Soils Limited (Factual) Report entitled '*Report on Ground Investigation at Co-operative Head Office, Manchester*' (Ref: 761072 Rev 1 Final), dated September 2009, prepared on behalf of the Co-operative Group Limited.
- Structural Soils Limited Report entitled '*Factual Report on Ground Investigation - NOMA Plot L, Manchester*' (Ref: 762850 Rev 2 Final), dated January 2014, prepared on behalf of the Co-operative Group Limited.
- Structural Soils Limited Report entitled '*Factual Report on Ground Investigation – 2&3 Angel Square, Manchester* (Ref: 763315 Rev 2 Final), dated July 2015, prepared on behalf of the Co-operative Group Limited.
- Sanctus Limited report entitled 'Contract Completion Report, Angel Square, Manchester' (Report No. S1918), dated June 2015, on behalf of NOMA.
- Salford Archaeology report entitled 'NOMA Plots 2&3, Angel Street, Manchester – Archaeological Evaluation Report' dated June 2021, on behalf of NOMA GP Limited;
- 1st Line Defence report entitled *'2&3 Angel Square, Manchester – Detailed Unexploded Ordnance (UXO) Risk Assessment*' (ref: DA13039-00) dated April 2021, on behalf of MEPC.
- Structural Soils Limited Report entitled *'2&3 Angel Square and NOMA Marketing Suite, Manchester – Report on Ground Investigation'* (ref: 765325), dated October 2021, on behalf of MEPC.
- Buro Happold report entitled '*2&3 Angel Square & Marketing Suite – Ground Engineering Summary Report*' (Ref: 043434-BH-XX-XX-RP-GE-0001 Rev 03) dated December 2021, on behalf of MEPC.

Please note that further documentation has been reviewed and a more detailed commentary of ground related aspects for the site and the immediate surrounding area are included in the following Buro Happold documents:

- BuroHappold Engineering Report entitled 'The Co-Operative Group HQ Building, Manchester Ground Engineering Desk Study Report' (Ref: 023842 Rev 00), dated July 2009, prepared on behalf of the Co-operative Group Limited.
- BuroHappold Engineering Report entitled 'The co-operative Head Office, Manchester Ground Engineering Interpretative Report' (Ref: 023842 Rev 00), dated October 2009, prepared on behalf of the Co-operative Group Limited.

[1] Groundsure Report Order Number GS-6225239 (August 2019) NOMA 2&3 Angel Square.

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- BuroHappold Engineering Report entitled 'NOMA Plot L, Manchester Ground Engineering Desk Study Report' (Ref: 032292 Rev 00), dated November 2013, prepared on behalf of the Co-operative Group Limited.
- BuroHappold Engineering Report entitled '2&3 Angel Square, Manchester Ground Engineering Desk Study Report' (Ref: 033536 Rev 00), dated August 2015, prepared on behalf of the Co-operative Group Limited.
- BuroHappold Engineering Report entitled 'NOMA 2&3 Angel Square - Ground Engineering Desk Study Report' (Ref: 043434 Rev 00), dated September 2019, prepared on behalf of NOMA (GP) Limited.

- The British Geological Survey (BGS);
- The Coal Authority;
- Published technical reports;
- Historical literature;
- Documents found during internet searches; and
- Any information provided by the Client i.e. previous desk studies or ground investigation / utilities information.

Based on the currently available data an assessment of the existing ground conditions has been undertaken in order to assess potential foundation solutions and to identify key issues likely to affect the groundworks associated with the current development proposal.

It should be noted that this assessment is based on some information in respect of works undertaken in the general vicinity of the Site as opposed to the specific site area. Such information has been taken to be representative of the ground conditions underlying the footprint of the Site supported by the site specific data.

In addition, it should be noted that groundwater conditions summarized are those observed as part of previous ground investigations and take no account of fluctuations due to seasonal, local drainage, the River Irwell or any other localised effects.

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3 The Site

3.1 Site Location

The Site is located north of Manchester City Centre, approximately 220 m east of Manchester Victoria Railway Station and to the east of the CIS Tower. The Ordnance Survey (OS) National Grid Reference (NGR) for the centre of the site is ^{3}84400 E, ^{3}99053 N. The site location is shown in Figure 2—1.

3.2 Site Description

The Site is trapezoidal in shape and measures approximately 110 m to 145 m in length and 50 m to 85 m in width, with the widest section in the southwest of the Site. The Site measures approximately 0.83 hectares of previously developed land. The Site is bound by 1 Angel Square (the Co-operative Group headquarters), Miller Street, Angel Gardens and Angel Street. The Site currently comprises two development plots, identified as Plots 2 & 3 (formerly known as Plots M&N on the NOMA Masterplan), which are in temporary use as surface car parking. The public car park is operated by RCP Parking Ltd, which occupies the area between Angel Street and Miller Street over a number of terraces with retaining structures or trees and vegetation on the slopes separating the various levels. Access to the Site is currently from the west via an entrance on Angel Street. The Site is located to the northern edge of Manchester City centre, and the range of retail, office, leisure, residential and transport infrastructure associated with the city.

The existing site layout is presented in Figure 2—2 and the site boundaries can be described as follows:

- To the northeast - Angel Street with commercial & residential buildings beyond.
- To the southeast - Existing car parking (53˚ NOMA - Plot L) with Rochdale Road beyond.
- To the southwest - Miller Street with car parking beyond.
- To the northwest - No.1 Angel Square with existing car parking beyond.

There is a substantial change in level across the Site, falling away from Angel Street down to Miller Street. Overall, the proposed development site generally slopes in a westerly direction towards the western corner of the Site midway along Miller Street. The Site can be split into two areas separated by an existing rough S Shaped embankment, namely:

- The eastern area predominantly comprises the former archaeological excavation for Arkwrights Mill. The majority of the platform is between 46 – 47 m AOD, however, the maximum elevation (to the nearest metre) is ~48 m AOD in the far eastern corner of the platform, with a minimum elevation of ~45 m AOD in the northern corner.
- The western area currently comprises existing car parking, however, during the construction of 1 Angel Square this area of site was utilised as a site compound with two temporary buildings. The area slopes to the southwest from a maximum elevation of ~44.5 m AOD in the northern corner, with a minimum elevation of ~41 m AOD in the western corner.

There is thus currently a ~7 m difference in height across the Site separated by slopes with localised or potentially buried retaining structures.

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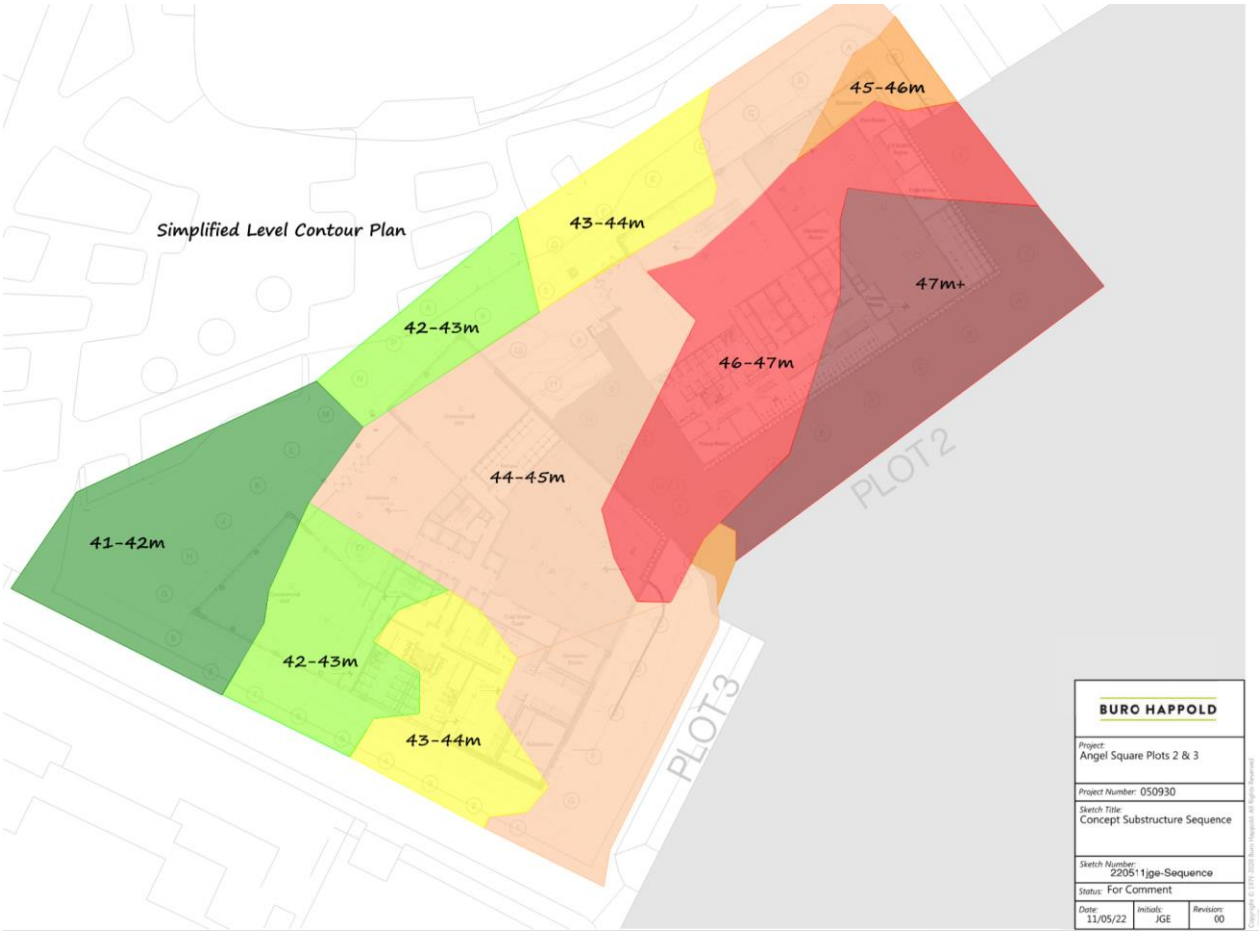

Figure 3—1 Site levels (simplified)

3.3 Site Utilities

Service plans have been obtained from the relevant utility companies in order to obtain information on the expected position and extent of buried and overground cables, pipes, wires etc, which may present constraints on future site development works. In addition, site specific surveys have been carried out by Charter Oaks Limited on behalf of William Downie Associates (WDA - ref: NOMA Marketing Suite (with topo) dated April 2021) and WDA (ref: 157-WDA-SS-EX-DR-UC-MU100(211222) dated May 2021). These plans have been consolidated and are included as Appendix C. It should be noted that the service plans issued by the various utility companies generally only record the public mains locations and do not include individual private supply routes. As such, the information available for most development sites is usually restricted to the periphery (unless public roads or rights of way cross the site) and, therefore, the absence of service routes beneath the footprint of the proposed development site on such drawings is not confirmation that the site is clear of services. Any additional private service routes connecting the mains to existing buildings need to be identified and located.

It should also be noted that during the SSL 2021 GI a ~3.2 m below ground chamber was encountered in TP110a. This is not recorded on any previous surveys, therefore it is recommended that further investigation is undertaken to understand if the existing chamber / infrastructure is still in use and requires diverting, or if it is part of an abandoned system to be grubbed up/ grouted up.

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Guidance issued by the individual service providers should be followed at all times when excavating in the vicinity of buried services. Where appropriate, the service providers should be consulted to mark their equipment in the vicinity of any proposed excavation works.

Figure 3-2-Abandoned chamber found during GI

Figure 3-3-Abandoned chamber found during GI

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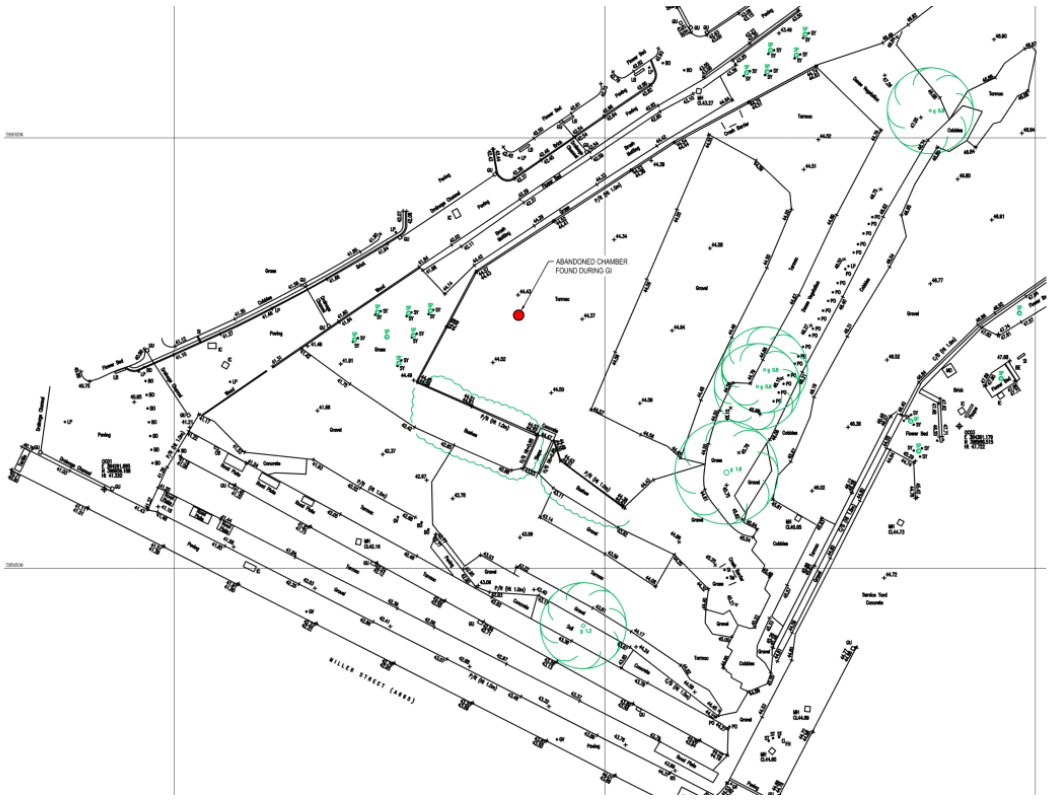

Figure 3-4-Abandoned chamber found during GI

3.4 Site History

Historical Ordnance Survey (OS) maps covering the Site have been studied to detail the historical development of the Site and the immediate surrounding area (~ 100 m radius of the site). Extracts of historical maps as provided in the Groundsure Report are included in Appendix D. Key features are identified in the following paragraphs in chronological order.

OS maps covering the Site have been studied to detail the historical development of the Site and the surrounding area. In addition, a number of reports have been completed by Oxford Archaeology North / Salford Archaeology as well as a historical archaeological desk study and a report of an investigation by Channel Four's Time Team, which include several earlier maps (1650 to 1848) as discussed below. Extracts of historical maps are included in Appendix D with key features identified in the following paragraphs. It should be noted that historical maps and data included within the archaeology reports are not reproduced herein. Reference should be made to these reports, and these should be read in conjunction with this report.

The earliest map available is a plan of Manchester**Error! Bookmark not defined.** dating to c 1650 and shows the proposed development site as open fields.

The 1741 map records the Site as open fields. In the immediate vicinity, '*Mill Lane*' is recorded along the southern boundary of the Site.

The 1793 map records '*Simpson's Factory*' along the southeast border of the Site and its associated reservoirs in the centre of the Site. In the immediate and surrounding area, '*Mill Lane*' is now recorded as '*Millers Street*' and '*Angel*

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Street' is recorded along the northern boundary of the Site. A number of unnamed industrial buildings are recorded surrounding the Site, in particular to the west of the site where associated infrastructure (including roads recorded as '*Factory Court, Factory Lane, Joiner Street*') are recorded. '*Alms Houses*' are recorded immediately to the south of the Site on the opposite side of '*Millers Street*'.

The 1794 map records '*Simpsons Factory*' is now recorded as '*Mr Simpsons Cotton Works*' and the reservoir is shown to be slightly reduced in size. There are no significant changes to the immediate surrounding area.

The 1822 plan of Arkwright's Mill (thought to be formerly '*Mr Simpsons Cotton Works'*) shows a mill in the western corner of the site bordering Miller Street with '*Cottages*' to the north of the main mill building.

The 1831 map (Banck's and Co's) records a number of residential properties along the northeastern boundary and there is an unnamed industrial building along the southern section of the northwestern boundary of the Site. '*Mr Simpsons Cotton Works*' is now recorded as '*Norris & Hodgess Cotton Mill*' and the reservoir to the west of the mill is indicated to be larger in size. In the immediate surrounding area, the road adjacent to the unnamed industrial building is recorded as '*Ropery*' and the '*Alms Houses*' are no longer recorded.

The earliest OS map available is dated 1848 (extract of 60 inch map), which shows '*Norris & Hodgess Cotton Mill*' is now recorded as a '*Warehouse*' and is part of a complex labelled '*Manchester Mills (Cotton)*'. The far western mill is now recorded as a '*Warehouse*' and the western extent of the '*Manchester Baths & Wash Houses*' is recorded in the south corner of the Site. In the immediate vicinity, '*Ropery*' is now recorded as '*Rope Walk*' with predominantly residential housing and a '*Timber Yard*' beyond. A '*Brewery*' is recorded immediately west of the far western '*Warehouse*'. To the east of the Site, '*Manchester Foundry*' and 2 No. associated '*Boilers*', a '*Saw Mill*' and associated '*Reservoir*', '*The Brewery Arms Public House*', a '*Timber Yard*' and '*Keynon Street*' are recorded. Two '*Timber Yards*' and a '*Saw Mill*' are recorded to the south of the Site over '*Miller Street*'. '*Victoria Station*' is also recorded approximately 220 m to the east of the Site.

The 1848 1:10,560 map identifies a number of industrial sites in the wider surrounding area, including a railway line and a '*Gas Works*' approximately 250 m and 300 m to the northeast respectively.

The 1892/1893 1:2,500 edition map records the reservoir associated with '*Manchester Mills (Cotton)*' has decreased in size with only the northern extent remaining. A number of unnamed industrial buildings are recorded to the south of the remaining reservoir. The far western '*Warehouse*' has expanded to the west and north and '*Rope Walk*' is no longer recorded. '*Manchester Baths & Wash Houses*' are also no longer recorded. A network of small roads (one of which is recorded as '*Factory Yard*') are recorded to the east of Arkwrights Mill leading to the new industrial buildings. In the immediate surrounding area, '*Manchester Foundry*' and 2 No. associated '*Boilers*', '*Saw Mill*' and associated '*Reservoir*', '*Brewery*' and the eastern, western and southern '*Timber Yards*' are no longer recorded.

The 1894/1896 1:10,560 edition map no longer records the '*Reservoir*' on site. There are no significant changes to the immediate surrounding area.

The 1908 1:2,500 edition map records the far western '*Warehouse*' has expanded to the east and further north. In the immediate surrounding area, the former reservoir appears to have been infilled and two small unnamed buildings are now located there. An *'Iron Works*' is now recorded immediately to the east of Arkwrights Mill and a '*Printing Works*' is recorded on New Mount Street approximately 40 m to the northeast.

The 1909 1:10,560 and the 1923/1938 1:10,560 edition maps record no significant changes to the Site or the immediate surrounding area.

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The 1922/1933 1:2,500 edition map records no major changes to the Site. In the immediate surrounding area, the '*Iron Works*' is now recorded as '*Disused*'.

The 1949 1:1,250 edition map only shows the northern extent of the Site and records a '*Warehouse*' on the site of the northern extent of the former reservoir and the residential houses along '*Angel Street*' are no longer recorded. There are no significant changes to the immediate surrounding area that is shown.

The 1951/1952 1:2,500 edition map no longer records Arkwrights Mill, the far western '*Warehouse*' and a number of unnamed buildings on Site. In the immediate surrounding area, three '*Ruins*' and a '*Warehouse*' are recorded to the southwest of '*Keynon Street*'. A smaller 'Ruin' is recorded at the junction of '*Naples Street*' & '*Angel Street*'. A '*Garage*' is also recorded 30 m to the north.

The 1948-1953 1:2,500 edition map records 3 No. small '*Ruins*' to the south of the '*Warehouse*'.

The 1952/1955 1:1,250 edition map does not cover the majority of the site. There are no significant changes to the site or immediate surrounding area that is shown.

The 1956 1:10,560 edition map records the eastern part of a new unnamed T-shaped building in the western corner of the Site (considered to be Baxendale's Iron Works based on archive photographic evidence). There are no major changes to the immediate surrounding area.

The 1953/1958 & 1954-1959 1:2,500 edition maps does not record any significant changes to the Site. In the immediate surrounding area, the small '*Ruins*' to the south of '*Kenyon Street*' are no longer recorded.

The 1958/1963 1:1,250 edition map records a '*Car Park*' to the west of '*Factory Road*'. In the immediate surrounding area, the '*Printing Works*' is now recorded as a '*Works*' and the nearby '*Ruin*' is no longer recorded.

No major changes are recorded on subsequent maps until the 1978-1980 1:1,250 edition map which no longer records the Baxendales Building and records the entire site as a '*Car Park*' – its current condition. In the immediate surrounding area, the map no longer records the '*Warehouse*' and '*Kenyon Street*' is now recorded as '*Kenwright Street*'.

The 1984-1988 1:1,250 edition map records that Miller Street has been widened along the southern boundary of the Site.

The 1985/1988 and 1988/1991 1:10,000 edition maps do not record any significant changes to the Site or the immediate surrounding area.

The 1992/1995 1:1,250 edition map only shows the northern extent of the Site but does not record any significant changes to the Site or the immediate surrounding area.

No further major changes are recorded to the Site or the surrounding area until the 2002 1:10,000 edition map which records no significant changes to the Site itself, but an *'Arena'* is now recorded adjacent to '*Victoria Station*' approximately 300 m to the northwest (the Manchester Evening News Arena, opened 1995 [2]) and two Metrolink tram lines are recorded running northeast and southeast from '*Victoria Station*'.

The 2010 1:10,000 edition map records no significant changes to the Site or surrounding area.

[2] www.men-arena.com.

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For ease of reference, the key points of site history likely to affect the proposed development are summarised as site constraints in Figure 3—5.

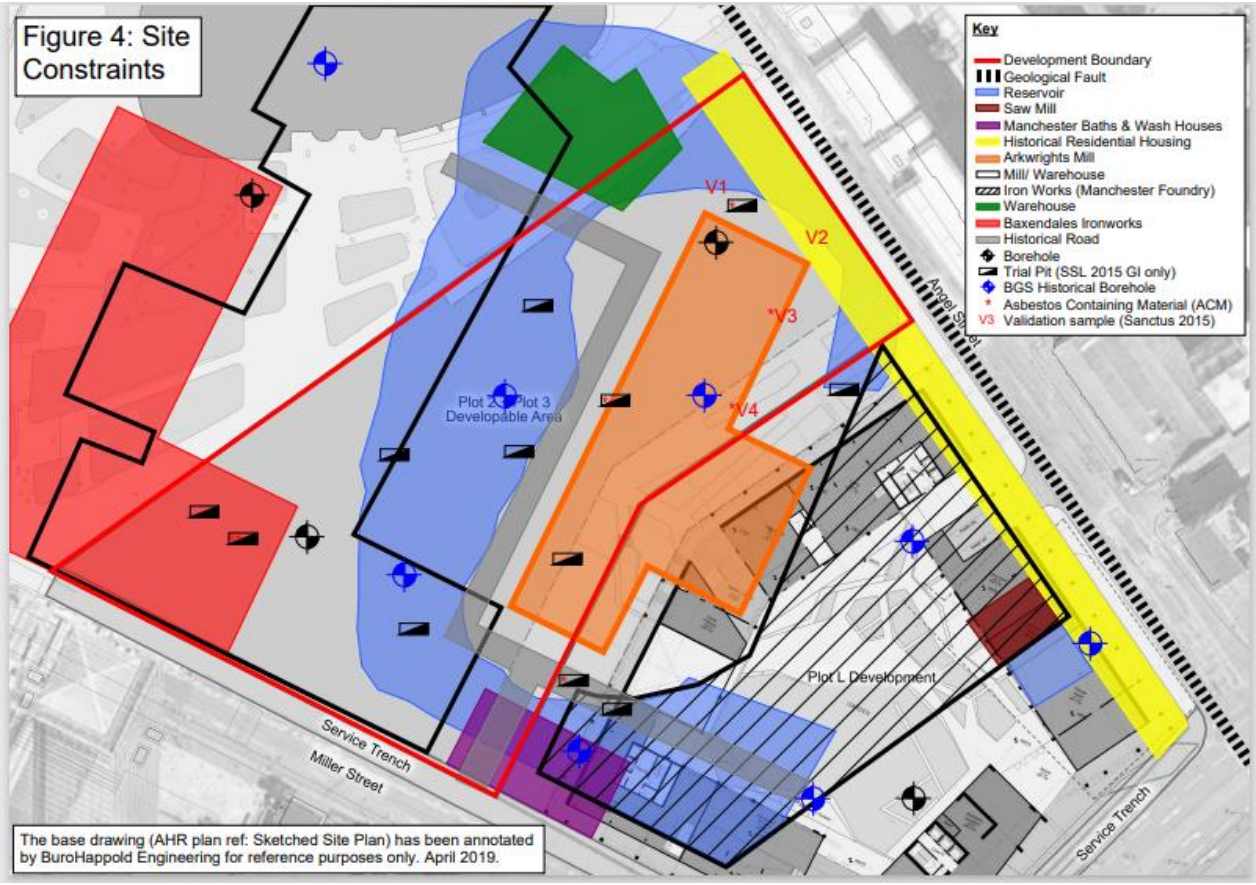

Figure 3—5 Site Constraints

3.5 Archaeology

Manchester is an area of archaeological interest with developments taking place within the city from the Roman period, but the major interest is in industrial archaeology. A number of recent archaeological reports for the Site and surrounding area have been completed by Gifford Limited, Oxford Archaeology North & Salford Archaeology as well as another report produced by Wessex Archaeology in April 2006 following an investigation by Channel Four's Time Team (filmed by Videotext Communications Ltd). Reference should be made to these reports, and they should be read in conjunction with this report. An overview of the items detailed in the reports are outlined in the following paragraphs, however, it should be noted that the detailed interface between proposed construction and existing archaeology are beyond the scope of this report.

The potential archaeological remains that exist on or adjacent to the Site may include the remains of cotton mills and associated reservoirs, an iron foundry, a saw mill and timber yard, a brewery, a public baths and wash house, public houses, shops and housing of various types. Although some evidence of features along Miller Street are likely to have been destroyed either during the Manchester Blitz or during road widening works in the early 1990s, the Time Team investigation and Oxford Archaeology Norths recent works shows that evidence of Arkwright's Mill both on site and to the west of the proposed development site is well preserved and close to the surface (Figure 3—6 refers). The mill was

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'*Manchester's first steam-powered cotton mill*' and was of great archaeological importance to the city. Existing foundations may also be present within the Site.

During 2014, Arkwright's Mill was subject to an intrusive archaeological excavation by Oxford Archaeology North which comprised an evaluated excavation of the majority of the main footprint of the building as well as the Engine House. Full and detailed photographic records were taken as well as surveying to Ordnance Datum with the remains left insitu. The study concluded that the site is '*of considerable archaeological and historical significance on a regional level*', however the '*overall group value is reduced by extensive loss of the component buildings and infrastructure*' over the years that followed its use. In addition, Salford Archaeology completed further trenching across the site during 2021. Reference to the findings of this study should be made in conjunction with these reports.

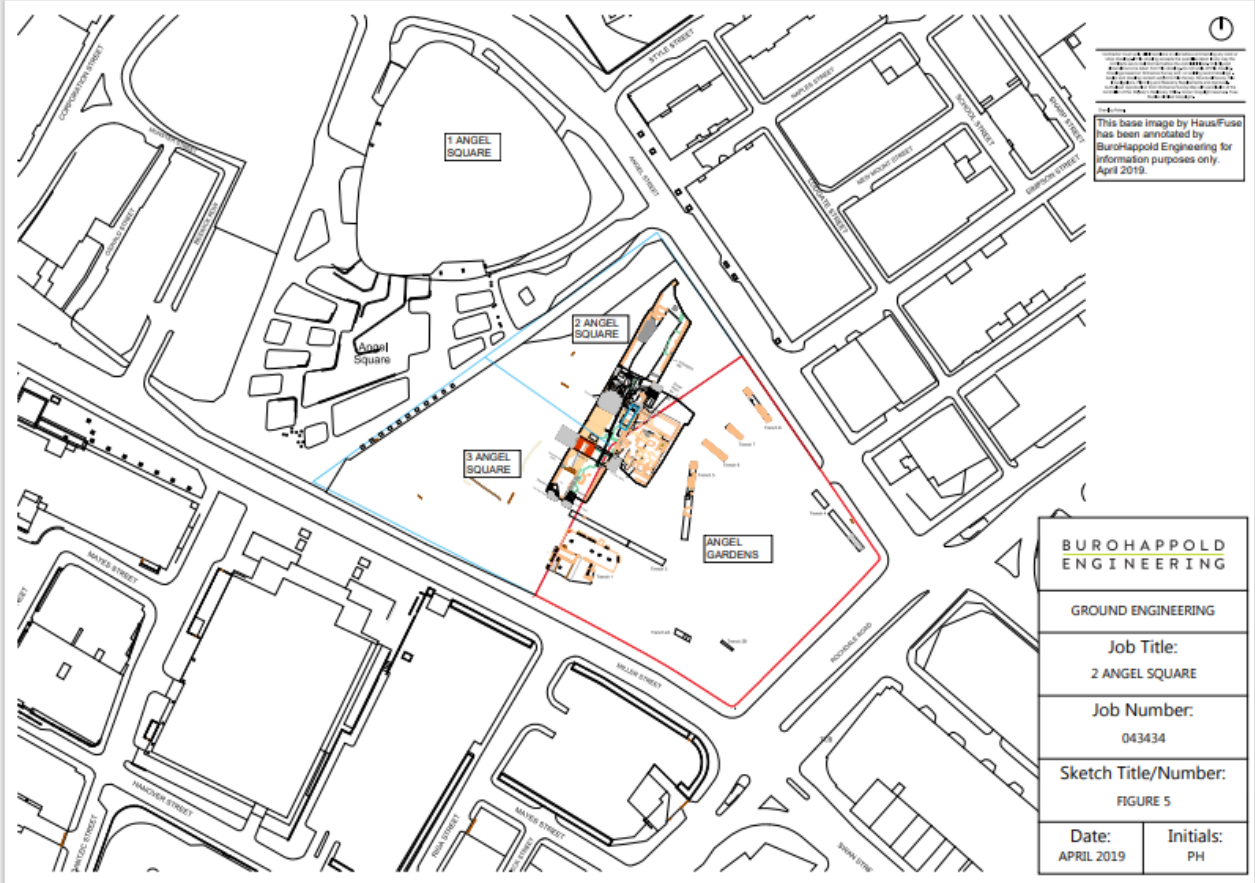

Figure 3—6 Archaeological Trenches (2014)

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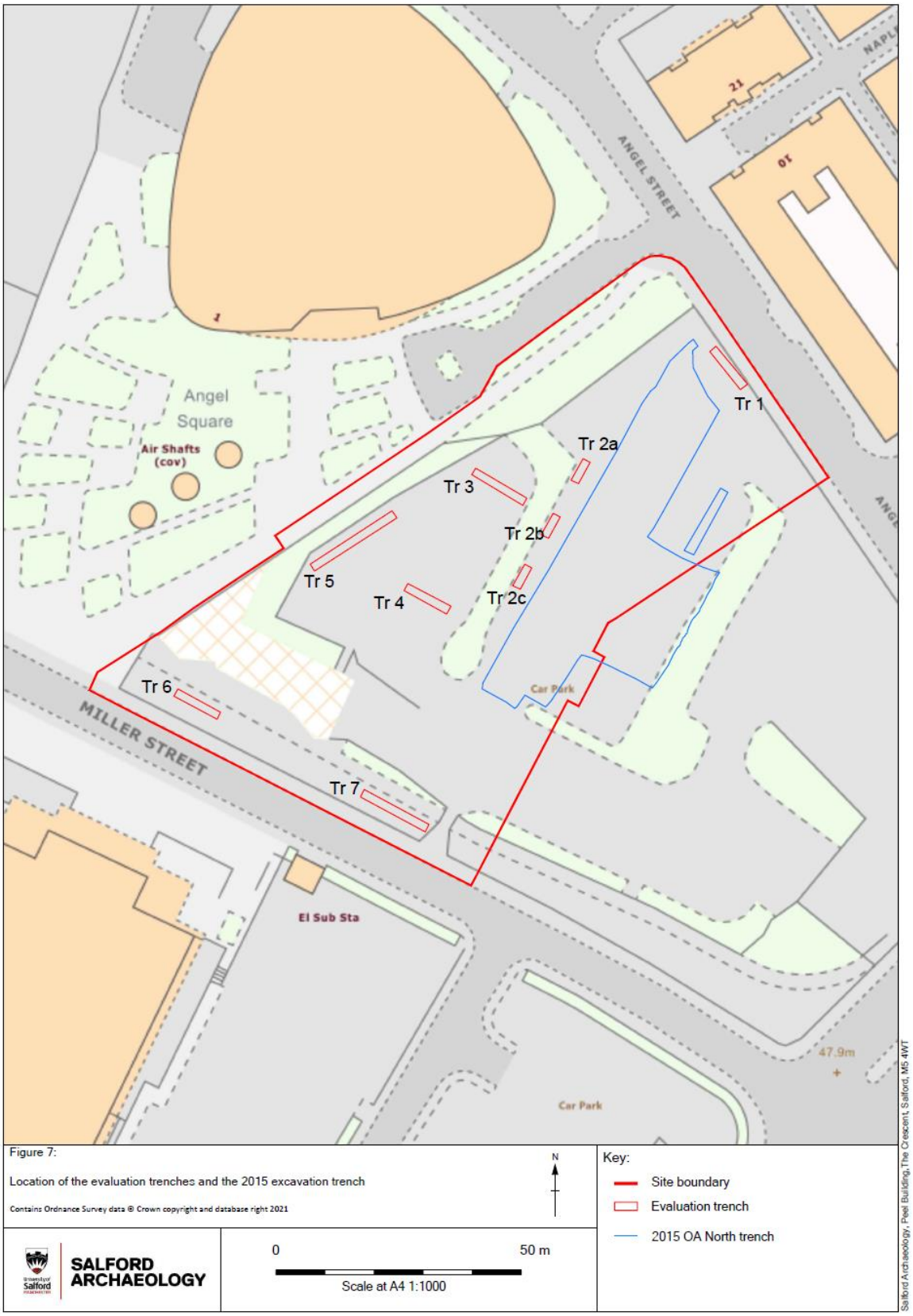

Figure 3—7 Extract from Salford Archaeology Report – Arkwright's Mill and 2021 trenches

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4 Ground Conditions

4.1 General

The anticipated ground conditions underlying the Site have been assessed on the basis of both published and unpublished data available for the Site and the immediate surrounding area. The available data has been summarised in the following sections and has been combined to establish as accurate a ground model as possible.

4.2 Published Geology

The British Geological Survey (BGS) Maps[3] [4], and Regional Geology Guides [5] have been obtained and reviewed as part of this study, with relevant information presented below. The geological information from the Groundsure report is included in Appendix E and also presented below.

The geological map indicates the Site is directly underlain by Boulder Clay overlying Triassic Chester Formation (CF - Sherwood (Bunter) Sandstone Group). No Made Ground is recorded within the site boundary on the map.

The Groundsure report states that the Site is underlain by Glacial Till (Diamicton) overlying the Chester Formation. In addition, 'Made Ground (undivided)' is also recorded on site. Given the urban setting and development history of the site, including numerous buildings of different ages and reprofiling of the Site to create terraced levels for car parking, a reasonable thickness of Made Ground is anticipated. Made Ground material due to its nature is likely to be very variable in both composition and characteristics.

4.2.1 Drift Geology

The 1" to 1 mile and 1:50,000 geological maps were studied to determine the probable nature and extent of any drift deposits under the site and in the surrounding area. The maps indicate that the site is underlain by Quaternary Boulder Clay. The total thickness of the drift deposits is not recorded on the geological map.

4.2.2 Solid Geology

The Groundsure report states that the Site is underlain by the Chester Formation (CF). The 1" to 1 mile and 1:50,000 British Geological Survey (BGS) maps indicate the solid geology on site to be Triassic Sherwood Sandstone (formerly Bunter Sandstone). The Sherwood Sandstone Group typically comprises well cemented medium and coarse grained sandstones and pebbly sandstones/conglomerates with occasional red brown mudstones. The Sherwood Sandstone is indicated to be underlain by the Manchester Marls (mudstone) over the Collyhurst Sandstone lying unconformably over Carboniferous Warwickshire Group which is underlain by the Carboniferous Upper Coal Measures (Westphalian C) typically comprising a mixture of mudstones, siltstones and sandstones with coal seams. The geological map cross-section indicates that productive coal measure strata are at least 250 m beneath the Site.

The Site is located between two faults both trending northwest-southeast, namely, the Ardwick Fault which is indicated to run 400 m southwest of the Site, downthrown to the northeast by approximately 100 m, and an unnamed fault approximately 100 m northeast of the Site, downthrown to the northeast by an unknown magnitude. The angle and

[3] BGS (1970). Manchester. England and Wales Sheet 85. Solid and Drift Geology. 1" to 1 mile. British Geological Survey.
[4] BGS (1975). Manchester. England and Wales Sheet 85. Solid Geology, 1: 50,000, British Geological Survey.
[5] BGS (2002) British Regional Geology: The Pennines and Adjacent Areas, (4th Ed), British Geological Survey Nottingham.

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direction of dip of the bedrock strata between these faults is not recorded but the regional dip is indicated to be to the south and southwest.

4.3 Unpublished Geology

As part of this study the BGS Geoscience Database has been consulted to ascertain whether any exploratory hole records exist for the site or the immediate surrounding area. Borehole records from this source have been obtained and examined below.

Two site specific GI's have been undertaken by Structural Soils Limited (SSL), both under the supervision of Buro Happold. Historical GI's for the adjacent sites have also been taken into consideration to inform the ground model - SSL 2009 GI at 1 Angel Square to the northwest and SSL 2013 GI at Angel Gardens to the southeast. Please note, BHL01 and BHL03 from the SSL 2013 GI for Angel Gardens were located on the 2&3 Angel Square site.

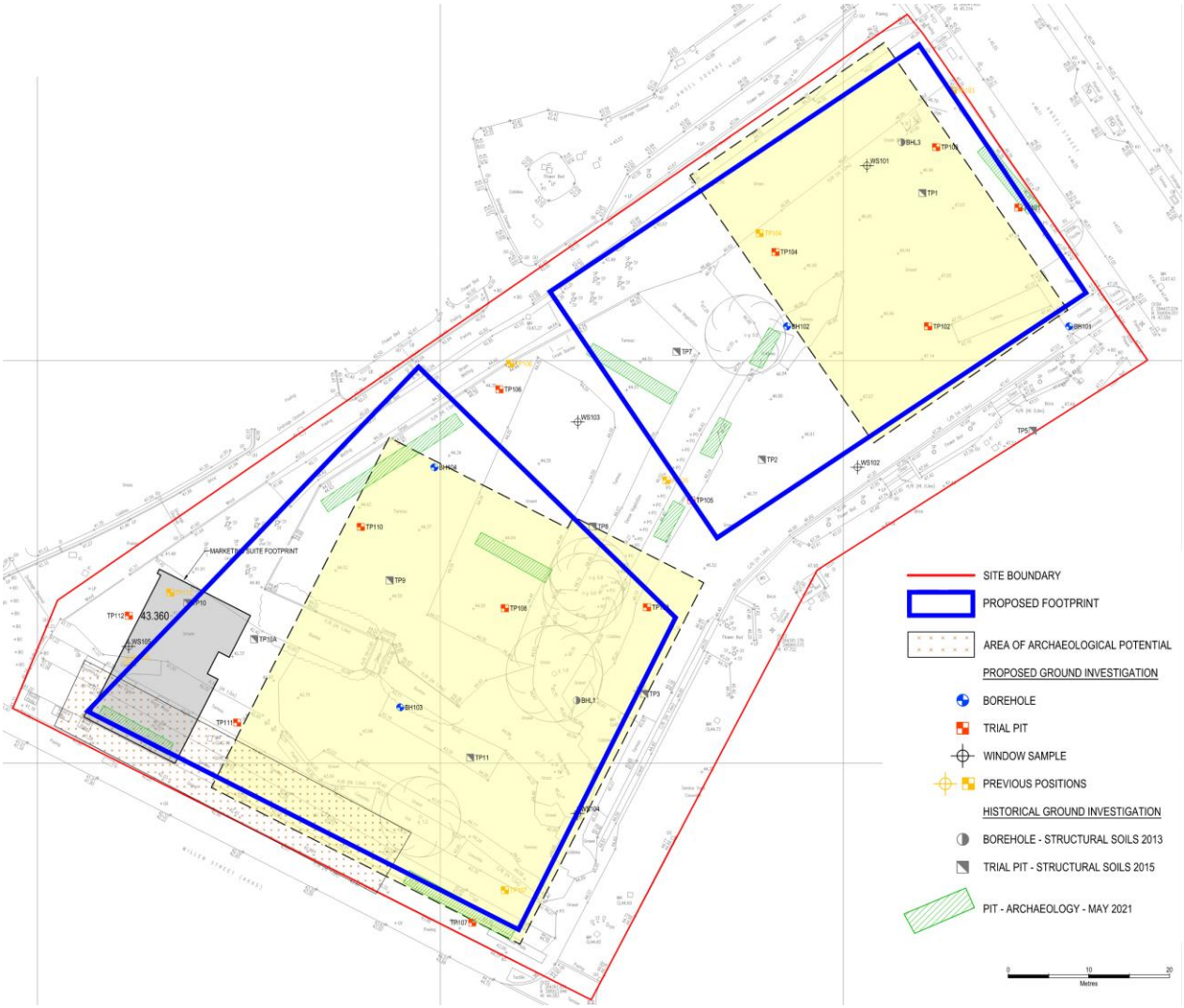

Figure 4—1 Historical and Recent GI Locations

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The SSL 2015 GI was undertaken during January 2015 and comprised 13 No. machine excavated trial pits (TP1 - TP4, TP4A, TP5 – TP10, TP10A and TP11) across the Site and its surrounds, along with associated chemical testing including asbestos identification and quantification. Groundwater and ground gas monitoring was also carried out in historical borehole BHL01 on the Angel Gardens site. All other historical borehole installations could not be found.

The second site specific ground investigation was undertaken by SSL between the 19th of July and the 3rd of August 2021, (herein referred to as the SSL 2021 GI). It comprised 4 No. boreholes (BH101-104), 5 No. window samples (WS101-105) and 12 No. trial pits (TP101-112 and 110a) across the Site. The boreholes were drilled to depths ranging between 25.00 and 31.00 m BGL using cable percussive drilling with rotary drilling follow to obtain rock core. Sampling, geotechnical and geo-environmental testing (including asbestos identification and quantification) and groundwater and ground gas monitoring was also undertaken as part of the SSL 2021 GI.

Please note, during the archaeological excavation of Arkwrights Mill (blue outline on Figure 3—7), the presence of asbestos within the Made Ground was recorded. A strategy for dealing with asbestos contamination within the footprint of Arkwrights Mill was completed during May 2015 comprising the removal of all Asbestos Containing Material (ACM) off site.

4.3.1 Material Type and Distribution

The ground conditions have been assessed on the basis of the available information. The general sequence of strata encountered based on available BGS borehole logs in the surrounding area and that of the ground conditions encountered during the SSL 2015/2021 GI's are summarized in Table 4—1.

The ground conditions comprise varying depths of Made Ground which is underlain by superficial deposits (dense to very dense sand, gravel and firm to very stiff clay), underlain by completely weathered sandstone bedrock, in turn underlain by very weak to weak sandstone bedrock (Chester Formation). It is considered that the seepages encountered are localised and variable perched groundwater may be encountered within the Made Ground and superficial deposits.

The relevant BGS records and the deeper SSL exploratory hole records are included as Appendix E herein.

4.4 Hydrology

The hydrology relevant to the Site has been reviewed based on information provided on current and historical OS maps. The nearest surface water feature to the Site is the River Irk located approximately 250 m north of the Site, flowing to the southwest to its confluence with the River Irwell on the south side of Manchester Victoria Railway Station. The River Irk is understood to be culverted beneath the railway station.

The Site is not indicated to be within Flood Zone 2 or 3 as presented in the Groundsure Report[1], based on the relevant Environment Agency information and reproduced in Appendix F.

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Table 4—1 Conceptual Ground Model based on SSL 2015 / 2021 GI data.

Depth to Top of Strata (m BGL)	Typical Thickness (m)	Generalised Description
0.00	0.15 – 5.00	Black brown slightly clayey slightly sandy angular to subangular GRAVEL of brick and ash with high cobble and medium boulder content. Gravel comprises various materials including sandstone, mudstone, limestone, glass, tarmac, coal, slag, concrete, slate, clinker, brick, rare granite and ceramic fragments. AND Black sandy fine to coarse GRAVEL in clayey matrix with pottery and snail shells (1.80 - 2.20 m BGL in TP5 only – former reservoir) [MADE GROUND]
0.35 – 4.65	>0.20 - 14.80	Firm to very stiff brown/red brown slightly sandy silty gravelly CLAY. Gravel is fine to coarse angular to rounded of sandstone & mudstone. AND Dense to very dense orange brown, slightly clayey, slightly gravelly fine to coarse SAND. Gravel is fine to coarse, subangular to rounded of quartzite, limestone, sandstone and ironstone. Occasional layers of brown, sandy, gravel. [GLACIAL TILL / GLACIOFLUVIAL]
11.10 – 21.90	>10.00 - >17.00 (thickness not proven)	Very dense reddish brown slightly gravelly fine to coarse SAND. Gravel is subrounded to rounded fine to course of quartzite. AND Very weak to weak, red/brown, medium to coarse grained sandstone with occasional layers of marl. [CHESTER FORMATION]

Note: During the SSL 2015 GI groundwater was recorded in TP1, TP5 and TP7 as 'slight seepage' at 1.10, 1.80 and 0.50 m BGL (44.56, 45.57 and 44.24 m AOD respectively).

During the SSL 2021 GI groundwater was recorded in: BH101 at 11.70 m bgl, BH103 at 5.70 m bgl, and BH104 at 5.20 m bgl. No groundwater strikes were recorded within the window samples or trial pits during the SSL 2021 GI.

4.5 Hydrogeology

4.5.1 Groundwater Vulnerability

The Environment Agency Groundwater Vulnerability Map Sheet 17 (Derbyshire and North Staffordshire) indicates that the Site is underlain by a '*Major Aquifer*' with '*Soils of High Leaching Potential (U)*' (Appendix G refers). It should be noted that the site is labelled 'U' for urban, and a note is normally included on the maps explaining that such a classification means that '*Soil information for restored mineral workings and urban areas is based on fewer observations than elsewhere. A worst case vulnerability classification (H) is assumed until proved otherwise*'.

The Groundsure Report[1] records that the Site is underlain by a 'Principal Aquifer' (formerly termed a 'Major Aquifer') with soils of 'High Leaching Potential' defined as '*Geology of high intergranular and/or fracture permeability, usually providing a high level of water storage and may support water supply/river base flow on a strategic scale*'. This is considered to refer to the Chester Formation (Sherwood Sandstone) beneath the Site.

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The Groundsure Report[1] records no water abstractions within the site boundary or within 500 m of the Site. There are 6 No. abstractions locations within 1 km of the Site including: Interbrew UK Ltd (520 & 524/5 m NW), British Telecommunications plc (639 m SW & 955 m NW), Joseph Holt Ltd (721 m NW), Lancashire Dairies Ltd (907 m NW).

4.5.2 Groundwater

Examination of the general topography and hydrology of the locality, based on the current and historic OS maps indicates that the prevailing direction of groundwater flow is likely to be to the northwest, towards and in the direction of flow of the nearest watercourses as summarised in Section 4.4.

It is considered likely that groundwater underlying the Site will be in hydraulic continuity with the River Irk due to the close proximity of this watercourse to the Site. Localised groundwater may be encountered in the Made Ground deposits perched on underlying low permeability Glacial Boulder Clay. Deeper groundwater conditions within the weathered and intact sandstone bedrock are likely to be controlled by the hydraulic conductivity of the sandstone (degree of cementation, degree of fissuring, faults etc).

4.5.2.1 SSL 2009/2013 Groundwater Data

Ground investigations for the adjacent plots have been considered in this assessment for completeness. A total of 12 No. groundwater monitoring visits were undertaken as part of the SSL 2009 GI for 1 Angel Square and the SSL 2013 GI for Angel Gardens. A further 3 No. visits were carried out to monitor any historical installations left in-situ, namely BHL01 (SSL 2013 GI).

The majority of the post fieldwork groundwater monitoring results for the Chester Formation show a typical range of between 25.49 m AOD and 26.20 m AOD (~20.00 to 23.30 m bgl).

4.5.3 SSL 2021 Groundwater Data

As part of the SSL 2021 GI groundwater and gas monitoring wells were installed in the 4 No. boreholes and 5 No. window samples. All (6 No.) post-fieldwork monitoring visits have been undertaken, between the 13th of August 2021 and the 22nd of October 2021. The SSL 2021 GI groundwater data indicates static water level (SWL) between ~30.08 m AOD and 24.97 m AOD (15.69 to 21.92 m bgl) within the sandstone bedrock (Chester Formation). Localised perched groundwater is also recorded within the Made Ground/superficial deposits (~0.50 to 3.95 m BGL). It is worthy of note that there were no groundwater strikes within the trial pits or window samples during the SSL 2021 GI.

The hydraulic regime within the bedrock is considered to be controlled by the nature of the cementation and fracturing of the rock mass. It is also important to note that the Chester Formation is classified as a Principal Aquifer by the Environment Agency, therefore consideration for the prevention of the migration of contamination (if any) and protection of the Principal Aquifer may be required.

Groundwater ingress is not considered to cause significant problems for envisaged excavation works. It is envisaged that any perched water seepages will be relatively minor and could be controlled by sump pumping methods. It should be noted, however, that where locally more significant water ingress is encountered then more substantial water control measures may be required.

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4.5.4 Mining Activity

The Groundsure Report[1] states that the site is *'the site lies in or in proximity to the coal mining reporting area as defined by the Coal Authority'*. A Coal Authority (CA) Reports for each plot[6] (Appendix H refers) has been obtained for the proposed development as the Site overlies coal bearing strata and, as such, further assessment in respect of previous coal mining activity was considered necessary.

The CA Report states that:

- The Site is within the likely zone of influence from workings in 1 No. seam of coal at 820 m depth which was last worked in 1965. Furthermore, reserves of coal do exist in the locality which could be worked in the future subject to feasibility, licences and planning consents.
- There are no recorded mine entries within the Site or within 20 m of the site boundary.
- In respect of opencast mining, the Site is not within the boundary of any past or present workings. In addition, there is no licence to extract or proposed licence to extract coal by opencast methods within the immediate vicinity of the Site.
- No subsidence, in respect of the Coal Mining Subsidence Act 1991, has been recorded in respect of the immediate site area.

Given the published and unpublished geology of the Site, the site history and the CA Report information it is considered that the risk arising from former coal mining operations can be considered to be low.

4.6 Ground Instability and Geo-Hazard

A summary of the anticipated risk in respect of typical causes of instability or geo-hazards specific to this Site which are not covered in other sections of this report is presented in Table 4—2.

Table 4—2 Summary of Natural Ground Subsidence Hazards at the Site

Subsidence Hazard Type	Applicable to this Site?		Comments
	No	*Yes*	
Collapsible Ground	✓	-	Groundsure states *'Very Low'*.
Compressible Ground	✓	-	Groundsure states *'Very Low'*.
Ground Dissolution	✓	-	Groundsure states *'Negligible'*.
Landslide	✓	-	Groundsure states *'Very Low'*.
Shrinking/Swelling Clay	✓	-	Groundsure states *'Very Low'*.
Running Sand	✓	-	Groundsure states *'Very Low'*.

On the basis of the desk study work undertaken and the nature of the strata likely to be encountered on site, collapsible or compressible ground, ground dissolution, landslides, shrinking/swelling clay and running sand are not considered to be issues for the proposed development.

[6] Coal Authority CON29M Reports (51002015179001 & 51002015179002). (April 2019)

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4.7 Trees

The presence of existing trees and shrubs on the Site has been noted (particularly on embankments along the eastern boundary) and may need to be considered in the development proposals for the Site. An Ecological Survey and Assessment[7] was undertaken by ERAP (Consultant Ecologists) in August 2019. The presence of the existing trees may impact on the depth of the proposed foundations and service runs in the vicinity of any trees to be retained.

[7] ERAP (Consultant Ecologists) Ltd Report entitled "Ecological Survey and Assessment, 2 & 3 Angel Square, Manchester, M4 4AF" dated August 2019.

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5 Environmental Setting

5.1 General

The environmental setting of the Site has been reviewed on the basis of both published and unpublished data obtained for the Site and the immediate surrounding area. The available data is summarised in the following sections and has been combined to establish any ground or groundwater contamination as well as ground gas generation that may potentially be present.

5.2 Potential Contaminative Land Uses

A review of the historical development of the Site and surrounding area, as outlined in Section 3.4 of this report, has shown that the Site and the immediate surrounding area have been subject to a reasonable degree of historical development. Land uses considered to be potentially contaminative with respect to human health, controlled waters, ecosystems and/or the built environment can be summarised as follows.

Within the Site Boundary

- Simpsons Factory (later known as Mr Simpsons Cotton Works, Norris & Hodges's Cotton Mill, Manchester Mills & Warehouses) and associated reservoirs.
- Residual asbestos within Made Ground (beneath Arkwrights Mill footprint – now remediated).
- Mill and associated cottages, Warehouse and Baxendale's Iron Works (name shown in historical photographs of the Site) in the far west of the Site.
- Residential properties along the northwestern boundary.
- Western extent of Manchester Baths & Wash Houses in the southern corner of the Site.
- Car park and any oil/petrol spills from car parking.

Outside the Site Boundary

- Manchester Foundry (Iron Works) and associated boilers to the east of the Site.
- Timber Yards (to the west, east and south of the Site), Saw Mills (to the east & south of the site) & associated reservoirs.
- The Brewery Arms Public House to the east of the Site.
- Ruins to the southwest of Kenyon Street (later recorded as Kenwright Street).
- Car parking to the east of the Site and any oil/petrol spills from car parking.
- Printing Works to the northeast of the Site.
- Garage to the north of the Site.
- Various industrial/commercial land uses in the vicinity of the Site including the railway infrastructure and associated goods warehouses etc.

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Given the types of land use specific to the Site and the close proximity of some off site facilities, it is considered possible that some contamination of the soils and groundwater may have occurred. The degree of contamination arising from previous land uses is typically a function of previous site practices, operational procedures and the degree/condition of any hardstanding that may have been in place when any specific land use was in operation. As such, the determination of the actual degree of contamination present has been assessed as part of the site specific investigation works.

5.3 Potential Contaminants of Concern

Due to the rich industrial site history of the proposed development site and information from the SSL 2021 GI, variable thicknesses of Made Ground were recorded. Further information regarding other potential sources of contamination is presented in Section 7.2.

Made Ground typically comprises reworked site material due to former development or material that has been imported onto the site from an external source. As such, any Made Ground present may represent a potential source of contamination. Urban fill commonly contains heavy metals, arsenic, and polycyclic aromatic hydrocarbons (PAHs) in background concentrations and can include locally elevated 'hotspots' which may pose a risk to human health and/or controlled waters.

Potentially contaminative on-site historical land uses identified in Section 5.2 which are considered to have affected the Site include the infilled reservoirs, asbestos in Made Ground, Manchester Baths & Wash Houses, residential properties and the industrial land uses namely the Simpsons Factory (later known as Mr Simpsons Cotton Works, Norris & Hodgess Cotton Mill, Manchester Mills), Mill and associated cottages, Garage, Printworks, Warehouse and Baxendale's Iron Works, existing car park and any oil/petrol spills from car parking.

With the exception of asbestos, minor historical ground contamination is present within the Made Ground materials (Section **Error! Reference source not found.** refers), however, at least half of the material is likely to be removed as part of the proposed excavation works with the remainder covered with an appropriate material (hardstanding or soft landscaping build up ~0.50m). Removal of material from site is a key consideration - further chemical testing may be required during groundworks for classification purposes.

Based on the chemical testing undertaken for the adjacent plots, the Site and the proposed end development, it is considered that the chemical concentrations in soils are not likely to pose a significant risk to end users of the Proposed Development.

It is worthy of note that gross asbestos removal has occurred in the former footprint of (Arkwrights Mill) and the former Manchester Foundry (on the adjacent site) via hand picking during archaeological works.

Potential offsite historical sources which are considered to be up hydraulic gradient (i.e., located to the southeast of the proposed development site) include a variety of former mill, factory and works sites.

5.3.1 SSL GI 2015 Geoenvironmental Assessment

All Made Ground sampled recorded concentrations of all determinants below "commercial" thresholds with the exception of Lead at a concentration of 3750 mg/kg in TP4A at 2.00 m BGL. Please note, TP4A is not located within the confines of the proposed 2&3 Angel Square development boundary and as such is not discussed further.

All natural soils sampled recorded concentrations of all determinants below commercial thresholds.

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5 No. samples recorded the presence of Asbestos Containing Material (ACM). TP1 / TP2 have been removed as part of the Arkwrights Mills remediation. TP4A is located offsite. The waste materials recorded in TP10A (1.00 / 2.00 m bgl) are located beneath the southwestern corner of 3AS (also under the NOMA Marketing Suite). The material is to be removed & segregated if encountered during excavations. Material can also be left insitu and capped appropriately (no change from existing situation).

The leachate results record a number of minor exceedances (less than an order of magnitude) of lead, barium, antimony, sulphate and fluoride. Given the extremely limited number of exceedances, the magnitude of the exceedances, the low soil concentrations recorded on the respective samples and the fact that the assessment criteria used are considered to be overly onerous for the purpose of the analysis, it is considered that leaching of such determinants to controlled water receptors is unlikely and as such no further analysis on the associated leachate concentrations is considered necessary.

5.3.2 SSL 2021 GI

10 No. soil samples underwent soil chemical analysis and were assessed against the C4SL and S4UL screening criteria. 2 No. of the 10 No. samples tested recorded determinands that exceeded the relevant 'commercial' threshold for lead (2,330 mg/kg). Given the depths of the samples, is likely that this material will be removed from site during the lower ground level excavation. If left insitu, the area will be covered in hardstanding or appropriate soft landscaping builds, thus breaking any source-pathway-receptor linkage.

- TP104 at 0.50 m BGL – Lead: 5910 mg/kg (located under 2 AS plot)
- TP111 at 1.80 mg/kg – Lead: 4300 mg/kg (located in between 3 AS and NMS)

14 No. tests on samples within Made Ground deposits were screened for ACM. 1 No. sample recorded the presence of asbestos fibres, namely Chrysotile in TP108 at 0.60 m BGL (located under 3 AS plot).

Waste Acceptance Criteria (WAC) testing was also carried out on 10 No. samples. 7 No. soil samples tested were classified as 'Non-Hazardous' and 3 No. soil samples were classified as 'Hazardous'.

The 3 No. 'Hazardous' soil samples were classified for the following properties:

- TP102 at 0.70 m bgl – Lead (1060 mg/kg) and Zinc (1580 mg/kg - located under 2 AS plot);
- TP104 at 0.50 m bgl – Lead (5910 mg/kg - located under 2 AS plot); and
- TP111 at 1.80 m bgl – Lead (4300 mg/kg - located in between 3 AS and NMS)).

5.4 Landfill Entries

The Groundsure Report[1] identifies 2 No. waste treatment, transfer or disposal sites within a 250 m radius of the Site, as follows:

- 204 m NE of site. Breakers Yard. NGR: 384516, 399239. Date 1984.
- 209 m NE of site. Breakers Yard. NGR: 384493, 399247. Date 1990.

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No landfill sites are recorded by the local authority or the BGS within a 500 m radius of the site. The nearest recorded landfill site is 698 m N of the Site:

- Queens Road Tip, Collyhurst. Deposited waste included Inert, Commercial, Industrial and Special Waste and Liquid Sludge. Input dates: 31 December 1955 to 31 December 1970. License status: Not supplied.

The above facilities are considered to be down or along hydraulic gradient of the Site and are typically in the Irk Valley or on the opposite side of the river, thus the risk of contamination to the proposed development site arising from these facilities is considered to be low.

5.5 Ground Gas

Ground gas typically consists of methane and carbon dioxide generated by the decomposition of organic materials. Although other gases are often associated with gas generation, methane and carbon dioxide are those which are typically measured during ground investigations, along with measurements for oxygen concentrations (to assess oxygen depletion) and flow rate. Ground gas is generally generated by and associated with the following ground conditions:

- Made Ground – typically non-engineered and poorly sorted material containing an organic component including soil, vegetation and timber;
- Alluvium/Peat – natural drift deposits often associated with river floodplains and generally having a high organic content sometimes with peat inclusions or peat layers;
- Coal Measures – 'mine' gas is often generated in such strata and can permeate through old workings and rock masses disturbed by mining activities; and
- Landfill – 'landfill' gas is often generated by the decomposition of organic materials placed in landfills. 'Inert' waste is similar to the Made Ground described above with the degree of gas generation dependent upon the amount of organic material present. Domestic waste, however, has a very high organic content and generates large quantities of gas over a sustained period (decades).

An appraisal of the likelihood of the above features affecting the proposed development is summarised below:

- There is Made Ground recorded within the unpublished geology as summarized in Section 4.3 which is of substantial thickness (0.30 to 4.00m). However, the Made Ground encountered is mainly comprised of rubble and ash, which are unlikely to represent a significant source of ground gas. It is worthy of note that timber is recorded locally within BGS logs. Based on the available data, it is reasonable to assume that the likelihood of ground gas being encountered within the Made Ground materials can be considered to be low.
- The published and unpublished geology as summarized in Sections 4.2 and 4.3 respectively do not indicate that peat or alluvial material is likely to be present across the Site and in the immediate surrounding area. As such, the likelihood of ground gas being encountered arising from alluvial materials can be considered to be low.
- The published and unpublished geology (Sections 4.2 and 4.3) indicate that productive coal bearing strata exist beneath the Site but are at significant depth. As such the likelihood of ground gas being encountered arising from coal mining activities can be considered to be low.

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- The Groundsure Report[1] does not identify any landfill sites within 250 m of the Site – the nearest is 700 m to the north, on the far side of the River Irk. The report also identifies small Waste Transfer/Management sites within 500 m of the Site, however, given the distance of these facilities from the Site and their settings, the likelihood of ground gas being encountered arising from landfill sites can be considered to be low.

Given the environmental setting of the Site, ground gas is not considered to be a major issue at this stage. Notwithstanding this, ground gas monitoring has been undertaken as part of the site specific ground investigation to clarify the ground gas regime beneath the Site and allow appropriate protection measures to be assessed and incorporated into any substructure designs as necessary.

5.5.1 SSL 2021 GI – Ground Gas

As part of the SSL 2021 GI, 11 No. ground gas monitoring wells were installed for monitoring. All post-fieldwork monitoring visits have been undertaken between on the 13th of August 2021 and the 22nd of October 2021. It should be noted that in a number of occasions it was not possible to access the monitoring wells due to cars being parked over the exploratory position, however, this is not considered to have a significant influence over the final classification of characteristic situation.

The ground gas concentrations and flow rates obtained from the installations to date have been assessed against the classification scheme presented in CIRIA C665 (Assessing risks posed by hazardous ground gas to buildings (2007)). A short summary is provided below;

- Gas flow rates recorded to date suggest very low flow ranging between -1.5 and 1.0 l/hr.
- Oxygen (O_2) levels generally range between 19.0 and 21.0 % in all boreholes. A relatively low oxygen concentration of 9.8 % was recorded in WS102 (response zone 0.00-1.00 m bgl in Made Ground) on the 6th October 2021 and 13.0% in WS105 (response zone 0.00-4.00) on the 13th August 2021. Bulk gas analysis in WS102 recorded elevated nitrogen.
- Carbon Dioxide (CO_2) levels generally range between 0.1 and 1.0% across the site. An elevated concentration of 5.0 % was recorded in WS102 (in Made Ground) on the first monitoring visit only (13th August 2021).
- Methane (CH_4) levels generally ranged between 0.0 and 0.1% across all monitoring wells. Slightly elevated Methane (CH_4) concentrations were noted in BH102 (Sandstone) ranging between 1.3% and 1.4% on the 22nd of October 2021 and 6th of October 2021. It is noted that no identifiable sources of methane were recorded in the exploratory logs during the SSL 2021 GI. It is also considered that any pathway between the Sandstone (bedrock) and the proposed building is broken by the superficial glacial till / glaciofluvial deposits.

The post-fieldwork ground gas monitoring results identified a maximum Characteristic Situation 2 (CS2) in BH102 and a typical Characteristic Situation CS1 for the rest of the site. It should be noted that the monitoring well recording CS2 was a deep flooded well located in the sandstone and that any pathway between the sandstone and the proposed building is considered to be broken by the overlying superficial glacial till and glaciofluvial deposits.

In addition, the maximum Characteristic Situation recorded in the Made Ground material (the most likely source of any ground gas) is CS1. It is therefore considered that Characteristic Situation 1 (CS1) is a suitable classification for the entire site. In accordance with Table 4 (page 22, BS 8485:2015+A1:2019) if the Site is classified as CS1, 0 points are required and thus ground gas protection is therefore not required.

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5.6 Radon Affected Areas

The Groundsure Report[1] records that '*the site is in an area where less than 1% of homes are above the action level*' and the corresponding BRE[8] guidance document indicates that no radon protection measures are required for development undertaken in this area.

5.7 Japanese Knotweed

We understand that Japanese Knotweed was cleared as part of the site wide operations extending from No. 1 Angel Square during 2010-2011. Japanese Knotweed is an invasive, non-native plant species. The Wildlife and Countryside Act (1981) made it illegal to spread Japanese Knotweed and guidance on the management of Japanese Knotweed on development sites is given in the Environment Agency's (EA) code of practice, 2001.

Currently available information indicates that the material is not hazardous but is highly invasive, destroying other flora and habitats for fauna. It spreads by root growth so can invade from neighbouring sites as well. There are a variety of methods available for treating infested areas including spraying with herbicides or digging, spraying and removal to landfill.

5.8 Unexploded Ordnance

The Zetica Unexploded Bomb Risk Map (Appendix I refers) shows the Site to be in an area of *'Moderate'* risk. It is known that Arkwrights Mill on/adjacent to the western site boundary was bombed in 1940 during the *'Manchester Blitz'* and post-war historical maps show a number of *'Ruins'* on site and immediately to the east. In addition, these maps do not record many buildings which were recorded on site pre-war (World War II).

The Site has not been significantly redeveloped since World War II thus the risk from unexploded ordnance is considered to be reasonably high. A detailed unexploded ordnance desktop study[9] has been prepared for the site by First Line Defence Limited and should be read in conjunction with this report. It recommended that UXO supervision is required for ground investigation and construction works.

5.9 Pollution Incidents

The Groundsure Report[1] records that there have been no pollution incidents on the Site itself, however, there have been 5 No. pollution incidents within 500 m of the Site as recorded below:

- Category Three – Minor Incident Water (Oils & Fuel - mixed waste oils) 282 m to the NW;
- Category Three – Significant Incident Land (Waste - Household) 411 m to the N;
- Category Three – Significant Incident Land (Waste - Commercial) 411 m to the N;
- Category Three – Significant Incident Land (Waste - Asbestos) 411 m to the N; and
- Category Three – Significant Incident Land (Waste - Tyres) 411 m to the N.

[8] BRE 1999. Radon. Guidance on protective measures for new dwellings. British Research Establishment. 1999.
[9] First Line Defence Limited report *'2&3 Angel Square, Manchester – Detailed Unexploded Ordnance (UXO) Risk Assessment'* (ref: DA13039-00) dated April 2021.

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There are no recorded Substantiated Pollution Incidents within 500 m of the Site.

Given the minor categorisations of many of the impacts recorded, their distance from the Site and the fact that none are located directly up hydraulic gradient of the site (Section 4.4 refers), the potential impact of contamination from these sources on the proposed development site is considered to be low.

5.10 Radioactive Substances

1 No. Registered Radioactive Substances has been identified to be present within a 500 m radius of the Site:

- 31 m E of the Site, Brooke Edgeley Specialist Technical Services Ltd. Disposal of radioactive waste (was Rsa60 Section 6). Date: 7 August 2000. Status: Authorisation revoked or cancelled/Cancelled.

Brooke Edgeley Specialist Technical Services Ltd advised the following: The licence was for storage of old lightening conductor air terminals between 2000 and 2002 in a specialized metal cabin. The metal cabin was decommissioned by a radioactive specialist as part of the closure of the Angel Street premises in 2003. Subsequently the Site has been re-developed and new build flats now occupy the site. As such the risk to the proposed development site from this source can be considered to be low.

5.11 Nitrate Vulnerability

The Site is located in a Nitrate Vulnerability Zone (NVZ). Given the urban location of the proposed development site, nitrate vulnerability is not considered to pose a significant constraint on the proposed development.

5.12 Area of Conservation

The Groundsure Report[1] records that the Site is not located within a specific area of conservation, a National Park or a RAMSAR site. Nor is the Site recorded to be in a Site of Special Scientific Interest (SSSI). As such, it is not considered that this will pose a constraint on the Proposed Development.

5.13 Current Industrial Data

The Groundsure Report[1] indicates that there are 5 No. potentially contaminative industrial sites within 100 m of the Site, namely:

• Infrastructure & Facilities	Electricity Substation	Electrical Features	12 m to the SW.
• Transport, Storage & Delivery	Warehouse	Container & Storage	34 m to the E.
• Infrastructure & Facilities	Electricity Substation	Electrical Features	70 m to the SE.
• Industrial Products	Business Comms Consultant	Radar/Telecomms	71 m to the NE.
• Repair & Servicing	Computermend	Electrical Eq. Repair/Service	12 m to the SW.

Given the commercial rather than industrial nature of the active facilities and their distance from the proposed development site, the risk of contamination arising from these sources can be considered to be low.

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5.14 Fuel Station Entries

The Groundsure Report records 4 No. Fuel Stations within 500 m of the Site, namely:

• Unbranded (12 Rochdale Road)	Obsolete	296 m to the E	Up hydraulic gradient.
• Obsolete (95-109 Rochdale Road)	Obsolete	408 m to the E	Up/along hydraulic gradient.
• Texaco (58-76 Cheetham Hill Road)	Open	426 m to the NW	Down hydraulic gradient.
• Obsolete (37-41 Cheetham Hill Road)	Obsolete	455 m to the NW	Down hydraulic gradient.

There are 2 No. fuel stations considered to be up or up/along hydraulic gradient and 2 No. fuel stations down hydraulic gradient from the Site. Given the fact that the 2 No. which are located up or up/along are obsolete, the risk of contamination of the Site arising from the fuel stations can be considered to be low.

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6 Proposed Development

Figure 6—1 Architects visuals of the two buildings

The current development proposals consist of the following main elements (Appendix A refers), namely:

2 Angel Square

- A new build split level office complex with 13 storeys, basement car parking and landscaping of the periphery and public realm area.

3 Angel Square

- A new build split level office complex with 14 storeys, basement car parking and landscaping of the periphery and public realm area.

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Key Design Considerations

The key elements of the proposed development in respect of the ground investigation works undertaken can be summarized as follows:

- Column loadings associated with up to 14 storeys of commercial development including plant loadings.
- Retaining structures between split levels associated with current topographical considerations.
- Locally confined/restricted site boundary possibly requiring both temporary and permanent support.
- Material assessment for bulk earthworks.
- UXO risk mitigation procedures for any intrusive site or construction works.
- Excavation and removal of any buried obstructions.
- Hard and soft landscaping to the periphery and central part of the site.
- Ground gas and groundwater regime.
- Contamination assessment in respect of both human health and waste disposal, in particular in relation to residual asbestos fibres within the Made Ground.

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7 Preliminary Conceptual Site Model

7.1 Ground Model

The anticipated ground conditions underlying the Site based on the information available can be summarized as follows:

- Made Ground: recorded as black brown slightly clayey slightly sandy angular to subangular GRAVEL of brick and ash with high cobble and medium boulder content. Gravel comprises various materials including sandstone, mudstone, limestone, glass, tarmac, coal, slag, concrete, slate, clinker, brick, rare granite and ceramic fragments. Highly variable thickness and distribution (0.15 m and 5.00 m BGL). Please note, a black sandy fine to coarse GRAVEL in clayey matrix with pottery and snail shells was recorded at 1.80 - 2.20 m BGL in TP5 SSL 2015 GI only – thought to be representative of a former reservoir.
- Glacial Till: recorded as firm to very stiff brown/red brown slightly sandy gravelly CLAY. Gravel is fine to coarse angular to rounded of sandstone & mudstone AND orange brown, slightly clayey, slightly gravelly fine to coarse SAND. Gravel is fine to coarse, subangular to rounded of quartzite, limestone, sandstone and ironstone. Occasional layers of brown, sandy, gravel. Thicknesses varied between >0.20 -14.80 m.
- CF – Chester Formation: Soft becoming medium hard, red/brown, medium to coarse grained SANDSTONE with occasional layers of marl. Rockhead between 11.10 and 21.90 m BGL (SSL 2021 GI).

The River Irk is situated approximately 250 m to the northwest of the Site and flows in a southwesterly direction towards Manchester Victoria Railway Station to its confluence with the River Irwell. It is considered likely that the groundwater underlying the Site may be in hydraulic continuity with the River Irk. Perched water may also be present within any Made Ground encountered particularly where there are buried obstructions. The hydraulic connectivity within the Made Ground materials is expected to be highly variable and any perched water is likely to be present in localised pockets of granular fill.

7.2 Potential Sources of Contaminants

Potential contamination sources from review of regulatory data and historical maps have been identified and are summarised in Table 7-1. The 'Contaminants of Concern' in this risk assessment are based primarily on information from the review of historical information.

Table 7-1 Potential Sources of Contamination

Potential Source	Location	Likely Age	Potential Contaminants of Concern
Made Ground	Onsite	From 1800s to present	Metals, sulphates, PAHs, solvents, fuel and oil waste and asbestos.
Fuel and oil spills from car parking retained within soils	On and off site	From 1970s to present	Petroleum hydrocarbon, fuel, oils.
Ground gas sourced from Made Ground and nearby infilled reservoir	On and off site	From 1800s to present	Methane, carbon dioxide.
Various commercial / industrial site uses	On and off site	From 1800 to present	Leachable contaminants: metals, PAHs, petroleum, hydrocarbons.

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7.3 Receptors and Pathways

Site specific pathway-receptor linkages have been identified in Table 7-2 with respect to the sources outlined in Table 7-3 and with respect to the anticipated future uses.

Table 7-2 Receptor and Pathways

Receptor		Pathway
Human Health	Future site users / visitors.	Direct / dermal contact. Inhalation of contaminated dusts, gas & vapour.
	Offsite land users.	Inhalation / ingestion of contaminated dust.
	Investigation and construction workers.	Direct / dermal contact. Ingestion / inhalation of contaminated soils. Inhalation of gas / vapour.
Controlled Waters	Principal Aquifer within the Chester Formation.	Leaching of contaminants through permeable strata.
Below Ground Infrastructure	Buried concrete foundations. Services pipework (if any).	Direct contact.

7.4 Risk Assessment

The qualitative risk assessment of the potential pollutant linkages described above is presented in Table 7-3. Based on the assessment, the risk of ground contamination affecting the Proposed Development is considered to be predominantly low to low/moderate.

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Table 7-3 Qualitative Risk Assessment

Pollutant Linkage				**Risk Assessment**			**Description of source [bold text]** Comment on hazard realisation [normal text]
Source	Contaminants of Concern	Pathway	Receptor	Consequence	Probability	Risk	
Historic warehouses Made Ground material used to backfill basements Car parking Urban Made Ground material	Metals, cyanide, chlorides, phenols, PAHs, solvents, fuel and oil wastes and asbestos	**The site has a variety of historic uses**					
		Direct /dermal contact, ingestion, inhalation	Construction / Maintenance workers	Medium	Unlikely	Low	Potential for direct contact with contaminated materials during excavations / earthworks. Can be mitigated by good working practice, health and safety and use of PPE if necessary.
		Direct / dermal contact, ingestion, inhalation	Future site occupants and visitors	Medium	Low	Low	Pathway likely be removed in the end use as the site is envisaged to be covered either by the building(s) or hard / soft landscaping with clean build-ups. To be finalised as the development proposals evolve.
		Ingestion / inhalation	Occupants and visitors of neighbouring properties	Medium	Unlikely	Low	Residential / commercial neighbours surrounding and adjacent to the site. Good working practices i.e. dust suppression will need to be in place.
		Migration via permeable strata	Groundwater (Principal A Aquifer – Chester Fm.)	Medium	Unlikely	Low	Downward leaching of contaminants into the Principal A Aquifer (Chester Fm) due to infiltration is considered unlikely – current information suggests that there is a thickness of low permeability clay (Glacial Till) above the Chester Fm. Further prevention will be provided in the end use by drainage networks and potentially cover by hardstanding (depending on exact development proposals – to be reviewed). Procedures must be taken to avoid the creation of pathways during construction.
		Direct contact	Below ground services / infrastructure	Mild	Low Likelihood	Low	Any new services likely to be in clean corridors / trenches. Underground substructure will be designed to withstand appropriate concentrations of any chemicals that may be encountered (e.g. sulphate).
Potentially contaminative historic land uses to east / northeast (mills, warehouses, existing car parking etc.)	Leachable contaminants – metals, fuels, PAHs, petroleum hydrocarbons	**Mills/Warehouses recorded from1848 until 1933. Existing car parking potential source contamination from petrol and oils spills.**					
		Direct / dermal contact, ingestion, inhalation	Construction / Maintenance workers	Medium	Unlikely	Low	Potential for exposure to contaminated waters during foundation / service run excavation and ground works. Capable of mitigation by good working practice and use of PPE.
		Direct / dermal contact, ingestion, inhalation	Future site occupants and visitors	Medium	Unlikely	Low	Pathway likely be removed in the end use as the site is envisaged to be covered either by the building(s) or hard / soft landscaping with clean build-ups. To be finalised as the development proposals evolve.
Asbestos fibres and fragments within Made Ground	Asbestos	**Residual Asbestos Containing Material (ACM possibly present in Made Ground beneath the site.**					
		Inhalation	Construction / Maintenance workers	Severe	Unlikely	Low / Moderate	Residual ACM fibres may be present in the Made Ground. Mitigation during groundworks required e.g. damping down material during excavations as well as following good working practice / use of appropriate PPE as required.
			Future site occupants and visitors	Severe	Unlikely	Low	Pathway between any asbestos in Made Ground and receptors is likely to be removed in the end use as the site is envisaged to be covered by either a building, hard landscaping with clean build-up, or soft landscaping with clean topsoil. This will need to be reviewed as the development proposals evolve.
Made Ground	Gas and vapour	**A variable thickness of Made Ground is anticipated to be present onsite, and there is the potential for this to be contaminated and provide a source of hazardous gas and vapour beneath the site.**					
		Inhalation Explosion (methane)	Construction / maintenance workers	Severe	Unlikely	Low	Ground gas classification is CS1. Potential for uncontrolled exposure to hazardous ground gas / vapour (if present) in confined unventilated excavations (if required).

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Appendix A Proposed Development Details

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Appendix B Information Source Summary

Information Sources	Information Obtained?		Comments
	YES	NO	
Environment Agency (e.g. for information on landfill sites, water abstraction, pollution incidents)	✓		Groundsure® Report data.
The Local Authority (e.g. for information on environmental health & planning)	✓		Via internet searches.
Archaeological records	✓		Oxford Archaeology Reports, Gifford Report, Wessex Archaeology Report.
Local history sources (e.g. libraries, museums, societies)	✓		Via internet searches.
Coal Authority (coal mining records)	✓		Coal Authority Report Data
British Geological Survey (maps and information about the geology of the area)	✓		BGS maps and memoirs.
Historical borehole information	✓		BGS data.
Aquifers (major and minor, and groundwater vulnerability)	✓		Groundsure® Report data.
Hydrogeology (groundwater levels)	✓		Groundsure® Report data and BGS data.
Ordnance Survey (current & previous editions of plans)	✓		Groundsure® Report data.
Newspaper reports		✓	---
Waste, Hazardous Substances	✓		Groundsure® Report data.
Service/Utility Companies	✓		WDA 56_UMP_(A)_01 Rev 2 (dated 14/05/19)
Existing site investigations	✓	-	Onsite and adjacent site (SSL 2009, 2013 & 2015 data).

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Appendix C Utilities Information

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Appendix D Historical Maps

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Appendix E Historical & Recent Borehole Logs

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Appendix F Indicative Fluvial Floodplain Map

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Appendix G Groundwater Vulnerability Map

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Appendix H Coal Authority Report

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Appendix I Zetica Unexploded Bomb Map/Detailed UXO Report

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