Rocco Ventures Limited

70-86 Royal College Street, London, NW1 0TH

Ground Investigation Report (GIR) and Geotechnical / Geo-environmental Assessment

371944-01 (01)

RSK

MARCH 2020

RSK GENERAL NOTES

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Rev 00	16 January 2020	First issue
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APPENDICES

1 INTRODUCTION

1.1 Commissioning

RSK Environment Limited (RSK) was commissioned by Heyne Tillett Steel on behalf of Rocco Ventures Limited to carry out a Geoenvironmental and Geotechnical Site Investigation of the land at 70 to 86 Royal College Street, London, NW1 0TH. The project was carried out to an agreed brief as set out in RSK's proposal (Ref. 371944-T01 (00), dated 28th June 2019).

This report is subject to the RSK service constraints given in **Appendix A** and limitations that may be described through this document.

1.2 Proposed development

The site in question is being considered for the demolition and redevelopment with the construction of a new health care centre with single storey basement. The planned layout of the site is shown in **Appendix B**.

1.3 Objectives

The investigation has been commissioned in order to obtain and collate information pertaining to the ground conditions beneath the site, from which potential risks to human health, controlled waters and the environment can be assessed, in order to support planning.

In addition, the investigation has been commissioned in order to present a review of the geotechnical data obtained from the ground investigation and make recommendations with regards to the soil parameters for geotechnical design in relation to the proposed development.

The objectives of the investigation are therefore as follows:

- To accurately record the ground conditions encountered within the exploratory holes;
- To identify and assess the potential risks to human health, controlled waters, buildings / structures and the environment;
- To inform off-site waste disposal options;
- To recommend appropriate soil parameters for geotechnical design purposes;
- Confirm the engineering characteristics of the ground sufficiently to enable the detailed design of the proposed new buildings; and
- To establish the need for any additional investigations.

1.4 Scope of works

The scope of this assessment has been developed in accordance with relevant British Standards and authoritative technical guidance as referenced through the report. The assessment of the contamination status of the site is in line with the technical approach presented in CLR 11 Model Procedures for the Management of Land Contamination (Environment Agency, 2004) and in general accordance with BS 10175: 2011 + A2 2017 (BSI, 2017). It is also compliant with relevant planning policy and guidance.

The scope of the intrusive investigation has been designed in line with the recommendations of BS5930: 2015 Code of practice for ground investigations (BSi, 2016), which maintains compliance with BS EN 1997-1 and 1997-2 and their related standards. It has also been developed in general accordance with BS 10175: 2011 + A2 2017. Ground gas assessment has been undertaken in general accordance with BS8756: 2013 and BS 8485:2015+A1:2019.

A brief summary of relevant legislation and policy relating to contaminated land is given in **Appendix C**.

The scope of works for the assessment has included the following:

Desk Study:

- review of the history of development on the site and surroundings, including a study of historical ordnance Survey mapping and other sources of historical information via an environmental database report.
- assessment of local geology, hydrogeology and surface water setting, including the identification of potential geological hazards including mining etc.
- assessment of the potential risks from past, present and future coal mining activities obtained from a Coal Authority Mining Report.
- review of relevant information held by appropriate statutory authorities, e.g. local authority Environmental Health Departments and Environment Agency/ NRW/ SEPA*, obtained from the environmental database report and/ or consultations.
- completion of a site reconnaissance survey to assess the visual condition of the site.
- development of an initial conceptual site model (CSM) identifying potential contaminant linkages for potential contaminants, completion of a preliminary risk assessment (PRA) and identification of key uncertainties and assumptions in the CSM.
- preliminary consideration of geotechnical constraints and hazards.
- identification of the need for further action, e.g. intrusive investigations, if any.

Intrusive Investigation

- design and implementation of an intrusive investigation, in situ testing, soil sampling, laboratory geoenvironmental and geotechnical testing, groundwater and ground gas monitoring of installed boreholes.
- interpretation of data to develop a refined conceptual site model (CSM).

- generic quantitative risk assessment (GQRA) to evaluate potentially complete contaminant linkages identified in the refined CSM.
- identification of the need for further action, e.g. supplementary intrusive investigations/ monitoring, remediation works or other mitigation, if any.
- interpretation of ground conditions and geotechnical data to provide preliminary recommendations with respect to foundations design.
- preliminary assessment of the potential waste classification (hazardous / non-hazardous) implications of soil arisings.
- preparation of this factual and interpretative report with recommendations for further works (i.e. undertake a remedial options appraisal to identify appropriate mitigation measures/produce a remedial implementation and verification plan) and/or remediation as necessary.

1.5 Existing reports

No existing reports relevant to the site assessment have been provided to RSK.

1.6 Limitations

The comments given in this report and the opinions expressed are based on the ground conditions encountered during the site work and on the results of tests made in the field and in the laboratory. However, there may be conditions pertaining to the site that have not been disclosed by the investigation and therefore could not be taken into account. In particular, it should be noted that there may be areas of made ground not detected due to the limited nature of the investigation or the thickness and quality of made ground across the site may be variable. In addition, groundwater levels and ground gas concentrations and flows may vary from those reported due to seasonal, or other, effects and the limitations stated in the data should be recognised.

Asbestos is often present in soils in discrete areas. Whilst asbestos-containing materials may not have been encountered during the intrusive investigation or supporting laboratory analysis, it is often encountered in discrete areas and could therefore be encountered during more extensive ground works.

Preliminary geotechnical recommendations are presented and these should be verified in a Geotechnical Design Report once proposed construction and structural design proposals are confirmed.

2 SITE DETAILS

2.1 Site location

Site location details are presented in **Table 1** and a site location plan is provided on **Figure 1**.

Table 1 Site location details

Site name	70 – 86 Royal College Street
Full site address and postcode	70 – 68 Royal College Street, London, NW1 0TH
National Grid reference (centre of site)	TQ 29395 83866

2.2 Site description

The site boundary and current site layout are shown on **Figure 2**. The site covers an area of c. 0.14 hectares. It is currently occupied by a former ATS Tyre Centre.

The site is rectangular in shape and the former tyre centre is comprised of three sub-structures; 2 No two-storey warehouse/garage buildings and a single storey outbuilding.

2.3 Surrounding land uses

The site is located in Camden Town, amongst a mixture of residential and commercial properties. Immediate surrounding land uses are described in **Table 2**.

Table 2 Surrounding land uses

North	The Golden Lion public house bounds the site to the north.
East	An area of open hardstanding used for car parking bounds the site to the east.
South	An access road into the car park bounds the site to the south, beyond which a Parcel Force courier depot is present.
West	Royal College Street bounds the site to the west, beyond which three storey terraced townhouses are present.

2.4 Development plans

The proposed layout of the site, at the time of preparing this report, is shown in **Appendix B**.

The proposed development involves the construction of a new health care centre building with six superstructure storeys and a single storey of basement beneath the entire site footprint. No soft landscaped areas are currently proposed at ground level.

3 PRELIMINARY RISK ASSESSMENT (PRA)

3.1 Site history

3.1.1 Historical development record

The development history of the site and surrounding area based upon assessment of historical plans and records is detailed in **Table 3**. The historical maps reviewed are shown within the environmental database report in **Appendix D**.

Table 3 Summary of historical development

Date	Land use/features on site	Land use/features in vicinity of site (of relevance to the assessment)
1873 - 1896	- Site is occupied by what appears to be terraced residential properties.	- Area heavily developed with predominantly residential properties. - Playing cards & stationary manufactory approximately 100m to the southeast. - Chapel and school adjacent to site's eastern boundary. - Adjoining street called 'Great College Street'. - Grand Union Canal present some 120m east of site. - Densely developed railway yard with 'Goods Depot' and 'Coal Depots' present some 125m east.
1896 – 1951	- No change within site boundary.	- Properties surrounding the site to the east replaced with large mineral water manufactory. - Chapel and fire station approximately 50m to the north east of the site. - Chapel converted to Cinema by 1916. - 'Refuse Destructor' approximately 75m north. - Smithy noted some 110m to the north
1951 – 1961	- All properties within site boundary demolished – site vacant	- Properties beyond road to north and 'Refuse Destructor' form one structure called 'St Pancras Generating Station'. - Transformer noted some 85m north west. - Mineral Water Manufactory relabelled 'Idris Factories'. - Adjoining street renamed 'Royal College Street'. - Playing cards & stationary manufactory factory layout changes and has been relabelled Britannia Works.
1961 – 1969	- Garage constructed in the centre of the site (No.72 – 86)	- Residential properties on the southern site boundary are no longer present. - 'St Pancras Generating Station' layout has changed marginally and been relabelled 'Works'.

Date	Land use/features on site	Land use/features in vicinity of site (of relevance to the assessment)
		- Transformer has been replaced with small units of unknown usage.
1969 - 1982	- Extension of garage to the south east	- Area previously known as 'Idris Factories' redeveloped as one large structure known as 'G P O Garages & Workshops'. - 'Electricity Works' across road to the north (Previously called 'St Pancras Generating Station').
1982 - 1984	- Further extension to the garage building in the south east direction	- No significant changes other than a few minor developments.
1984 - 1995	- Site redeveloped with large L-shaped building (60 – 86) with small outbuilding in south eastern part of site (Buildings which currently occupy the site)	- 'Electricity works' renamed as 'St Pancras Commercial Centre' with a number of sub-structures within footprint. - No significant changes other than a few minor developments.
2002	- No change within site boundary.	- Factory site to the east has been redeveloped and an access road constructed to the existing car park outside the southern site boundary.

3.1.2 Unexploded ordnance

A preliminary Risk Assessment was carried out by a specialist contractor to assess the risk to the site and what, if any, mitigation measures would be required for any intrusive work. The report (1st Line Defence Report ref EP9407-00, dated 31st July 2019) stated that the site was situated in an area that was subject to very high-density bombing, according to official Home Office statistics. London bomb census mapping indicates an incident involving a high explosive bomb in close proximity to the site, which left a number of houses labelled as either sustaining 'total destruction', 'damaged beyond repair' and 'seriously damaged; doubtful if repairable'.

In light of the above, it was recommended that appropriate UXO risk mitigation measures were adopted for any intrusive investigations on site.

3.2 Information from environmental database report

Relevant environmental permits and incidents detailed within the environmental database report (see **Appendix D**) are summarised below in **Table 4**.

Table 4 Summary of environmental permits, landfills and incidents

Data type	On-site	<250m from site	>250m from site of relevance	Details
Agency and hydrological				
Environmental permits – incorporating Integrated Pollution Prevention and Control, Integrated Pollution Controls, Local Authority Integrated Pollution Prevention and Control	0	0	0	
Enforcement and prohibition notices	0	0	0	
Pollution incidents to controlled waters, Prosecutions relating to controlled waters, Substantiated pollution incident register, Water Industry Act referrals	0	1	2	<250 m: incident 96 m south of site involving firefighting run-off in January 2002. >25 0m: incidents 290 m NW and 370 m NE of site involving waste materials and demolition materials and wastes in 2001 and 2003.
Discharge consents	0	0	0	
Registered radioactive substances	0	6	11	<250 m: Keeping and disposal of radioactive materials and waste – Royal Veterinary College 196m and 232 m south/southeast.
Landfill and waste				
Active landfills	0	0	0	
Historic / closed landfills	0	0	0	
Other waste management licences	0	0	3	Scrap metal depot 335 m – 337 m southwest dating up to 1984

Data type	On-site	<250m from site	>250m from site of relevance	Details
Potentially in-filled land (pit, quarry, pond, marsh, river, stream, dock etc)	1	10	10	The site is noted to be potentially above an area as being highlighted as worked ground. <250 m: 10 records of former canals 86 m – 124 m north / northeast. >250 m: 10 records between 322 m – 495 m from site including canals, tunnel, pond, burial ground and unspecified heaps.
Hazardous substances/ industrial land uses				
Control of Major Accident Hazards (COMAH) sites	0	0	0	
Explosives sites, Notification of Installations Handling Hazardous Substances (NIHHS), Planning hazardous substance consents/ enforcements	0	0	0	
Contaminated land Part 2A register entries and notices	0	0	0	
Fuel station entries	1	0	1	On site: historic land use believed to include storage of fuels >250 m: 1 record for fuel station 423 m to the north.
Note: Entries have only been included within the table where they are located within a 250m radius of the site or, where they fall outside of this radius but are considered to comprise a significant entry.				

In summary, items that have been identified to represent an on-going potential source of contamination that could affect the site comprise:

- Worked ground on site.
- Historic land use of site as a former fuel station – A total of seven decommissioned 13,000 litre underground tanks are believed to exist on site.

These entries have been carried forward for consideration within the initial conceptual site model contained in Section 6.

3.3 Information from regulatory authorities

3.3.1 Planning records

Planning records held by the Local Authority Planning Department pertaining to the site and relevant to the current assessment are summarised in **Table 5**.

Table 5 Planning information

Year	Details and application reference no.
1998	Ref No. PE9800492 The formation of a new entrance and alterations to a link building by the replacement of a door and windows with a roller shutter both in the west elevation.
1983	Ref No. J12/10/D/36899 The redevelopment of the site by the erection of a single storey with mezzanine building and associated parking provision for use as a tyre service depot for the storage, supply and fitting of tyres, batteries, exhausts and other vehicle fitments.
1979	Ref No. J12/10/D/29538 Retention, for a further limited period, of the petrol filling station managerial training centre.
1976	Ref No. J12/10/D/22953 (R) Redevelopment to provide a part seven, part three storey building comprising petrol filling station, light industrial premises, 14 flats and a shop.

3.3.2 Petroleum licensing information

A petroleum environmental search undertaken by the London Fire Brigade, has indicated the presence of seven 13,638 litre capacity underground tanks are believed to exist on site. According to archives, the site was licensed for the storage of petrol from 1st June 1973 to 31st May 1985. It is understood that all of these tanks were decommissioned, and water filled in March 1984. No further information was available as to whether the tanks were made permanently safe or removed off site. A number of archive drawings were made available to help with determining the approximate location of these tanks.

A copy of this information is included in **Appendix E**.

3.3.3 Site services

Buried utility services and their backfill can provide preferential pathways for gas, vapour or groundwater to migrate along to another part of the site or to a receptor. They can also represent significant constraints to development.

Buried services present on-site or located adjacent to site boundaries that could represent a pathway for migration of groundwater and gases/ vapours comprise:

- Telecoms (Zayo Group UK Ltd.) – running adjacent to site boundary, along Royal College Street.
- Gas (Cadent Gas) – running adjacent to site boundary, along Royal College Street.

- Electricity (UK Power Network) – running adjacent to site boundary, along Royal College Street.

3.4 Site geology

3.4.1 Anticipated geological sequence

Published records (British Geological Survey) for the area indicate the geology of the site to be characterised by the succession recorded in **Table 6**.

Table 6 Site geology

Strata	Description	Estimated thickness
London Clay Formation	Bioturbated or poorly laminated blue-grey or grey-brown, slightly calcareous, silty to very silty clay, clayey silt, with some layers of sandy clay.	~ 25 m

With reference to the historical data there have clearly been several phases of construction and demolition on the site and therefore the presence of made ground should be expected. In addition to the several phases of development, reference to the 1:10,000 scale geological map also indicates that the site lies over an area of potentially worked ground.

3.4.2 Radon

An initial review of the environmental database report indicates that the site is not located within an 'Affected Area'. An 'Affected Area' is one with 1% or more homes above the radon Action Level of 200 Bq m^{-3}, and therefore the risk of significant ingress of radon into structures on-site is considered low and protection measures are not necessary in the construction of non-domestic buildings.

Although the radon data used in production of the ukradon indicative atlas comes from measurements in homes, the maps indicate the likely extent of the local radon hazard in all buildings.

Notwithstanding the above it is noted that the proposed development will comprise the excavation of a single level basement to some 7.00 m bgl prior to the construction of the basement box. Although the detailed design of the basement has not been formalised at this stage it is understood that the basic waterproofing measures will comprise a primary water resistive reinforced concrete box with a secondary cavity wall system with associated sump pumps. Despite the risk from radon gas being low a programme of radon gas monitoring should be implemented following the construction of the basement box and ground floor level slab to ensure any requirements for the design and construction of the cavity wall system can incorporate radon protection measures, if required. The advice of a specialist designer should be taken if any specific radon protection measures are deemed to be necessary.

3.5 Mining and quarrying

Evidence has been sought to identify any mining, quarrying, landfilling and land reclamation operations, past and present, which have taken place within 500m of the site.

The Groundsure report (July, 2019) indicates there are no records of historical mining within a 500m radius of the site.

An area of worked ground is noted on the 1:10,000 scale geological map as noted above.

3.6 Hydrogeology

A summary of the hydrogeological setting of the site, with respect to the anticipated geological sequence set out in Section 3.5 is presented below in **Table 7**.

Table 7 Summary of hydrogeological setting

Condition	Description
Aquifer characteristics	The site is underlain by an unproductive stratum relating to the London Clay formation.
Depth to groundwater and flow	It is likely that shallow perched water may be present in any made ground deposits present on-site.
Rising groundwater levels	As defined within CIRIA Special Publication 69 (Simpson et al., 1989) the site does not lie within the critical areas in the London basin in which shallow foundations and basements are potentially at risk from the rising groundwater levels in the deep aquifer.
Licensed groundwater abstractions	The environmental database report indicates that there are 20. current licensed groundwater abstractions within a 2 km radius of the site.
Source protection zones	Information available in the Groundsure report * indicates that the site does not lie within a currently designated groundwater Source Protection Zone (SPZ).

3.7 Hydrology

A summary of the hydrology within the site area is summarised in **Table 8**.

Table 8 Summary of hydrology in site area

Condition	Description
Surface watercourse s/features	There are no ponds, streams or drainage ditches on or adjacent to the site. The nearest identified surface watercourse to the site is the Grand Union canal located approximately 120 m to the east of the site.
Surface water abstractions	The environmental database report indicates that there are 5 current licensed surface water abstractions within a 2 km radius of the site. The closest of these, which is located 408 m southeast was utilised historically for Make-up or Top up water.

Condition	Description
Historic water courses	The now culverted River Fleet is noted to the east of the site somewhere between the site and St Pancras Way, although the exact location cannot be easily identified.

3.8 Sensitive land uses

The environmental database report (Groundsure, July 2019) does not identify any environmentally sensitive areas within a 500 m radius of the site.

4 SITE RECONNAISSANCE FINDINGS

A site reconnaissance survey was completed on 29th July 2019 by RSK. The characteristics of the site observed during the walkover and from current ordnance Survey maps are summarised in **Table 9**.

A site plan is provided in **Figure 2** with photographic records included in Appendix F detailing the main features identified below.

Whilst the walkover summary includes consideration of current operations and housekeeping on the site as potential sources of contamination, it does not constitute a comprehensive environmental audit of the site, as covered under ISO 14001.

Table 9 Site reconnaissance findings

Feature	Description
Physical characteristics	
Access constraints	The majority of the site was accessible at the time of the survey, with the exception of the tyre storage block located in the south eastern part of the site which was inaccessible.
Site topography	The site is essentially level, there were no slopes observed on site, however the eastern part appears to be some 1.50 m higher than Parcel Force car park directly adjacent to the eastern boundary.
Surface cover	The entire site is covered with a surface cover of concrete, asphalt and buildings.
Site drainage	Drainage runs and covers are noted across the site. Historical information for the site suggests the network of pipes could be quite extensive.
Trees and hedges	There is a self-seeded Sycamore growing out of the retaining wall to the rear of the site, this will be removed as part of the demolition . Two semi mature trees present outside the site on the pavement along the western boundary.
Invasive species	A pocket of Japanese Knotweed was located on the eastern site boundary between the main garage building and the tyre storage building.
Existing buildings on-site	The current buildings on site include the former ATS tyre centre and the tyre storage outbuilding.
Retaining walls and adjacent buildings on or close to site boundary	A public house bounds the site to the north. Residential houses are present to the west. The surrounding area around the site mainly comprises commercial units with large areas of open hard landscaping to the east.

Feature	Description
Basements on-site	It is understood there are no basements on site, however, it is believed the Golden Lion public house bounding the site to the north does have a single storey basement. No basements were observed, however, a small lift pit does appear to be present within the northern eastern part of the site, although this was not accessible during the walkover.
Made ground, earthworks and quarrying	Nominal thickness of made ground expected on site due to previous phases of development.
Potentially unstable slopes on or close to site	There were no slopes observed on site, however the eastern part of the site appears to be some 1.50 m higher than the Parcel Force Depot car park located directly to the east.
Buried and overhead services present	Yes, numerous recent and historic ground scars observed across site.
Environmental characteristics	
Underground/ above ground storage tanks and pipework	None observed during reconnaissance, however, it is understood a number of historic underground tanks are likely to exist on site.
Potentially hazardous materials storage and use	A number of chemicals and gases were noted on site. A single canister / tank of an unknown gas source was noted in the northern building. Paints and other chemicals of unknown composition were noted on shelves in the northern building. No evidence of staining was observed on the floor.
Asbestos-containing materials	Offices and garages appear to be of a relatively modern construction. No obvious signs of asbestos were noted on site.
Waste storage	None observed Some general refuse sacks were noted in adjacent to the tyre storage building on the south eastern site boundary.
Fly-tipping	None observed
Electricity sub-stations / transformers	None observed.
Evidence of possible land contamination on-site	None observed.
Potential off-site sources of ground contamination	None observed

No potentially significant land contamination or geotechnical issues were identified during the site reconnaissance survey.

5 PRELIMINARY GEOTECHNICAL CONSTRAINTS

5.1 Design class

BS EN 1997-1 defines three different Geotechnical Categories that structures may fall into, which are summarised as follows:

- Category 1: Small and relatively simple structures for which it is possible to ensure that the fundamental requirements will be satisfied on the basis of experience and qualitative geotechnical investigations; with negligible risk.
- Category 2: Conventional types of structure and foundation with no exceptional risk or difficult ground or loading conditions.
- Category 3: Structures or part of structures, which fall outside limits of Geotechnical Categories 1 and 2. Examples include very large or unusual structures; structures involving abnormal risks, or unusual or exceptionally difficult ground or loading conditions; structures in highly seismic areas; structures in areas of probable site instability or persistent ground movements that require separate investigation or special measures.

Based on the information provided above on the proposed development and in view of the anticipated ground conditions, a Geotechnical Category 2 has been assumed for the purposes of designing the geotechnical investigation. This should be reviewed at all stages of the investigation and revised where necessary.

5.2 Preliminary geotechnical hazards assessment

A summary of commonly occurring geotechnical hazards associated with the anticipated geology outlined in Section 3 above is given in **Table 10** together with an assessment of whether the site may be affected by each of the stated hazards.

Table 10 Summary of preliminary geotechnical risks that may affect site

Hazard category	Hazard status based on desk study findings and proposed development		Engineering considerations if hazard affects site
	Could be present and/or affect site	Unlikely to be present and/or affect site	
Sudden lateral changes in ground conditions	☒	☐	Likely to affect ground engineering and foundation design and construction.
Shrinkable clay soils	☒	☐	Design to NHBC Standards Chapter 4 or similar.

Hazard category	Hazard status based on desk study findings and proposed development		Engineering considerations if hazard affects site
	Could be present and/or affect site	Unlikely to be present and/or affect site	
Highly compressible and low bearing capacity soils, (including peat and soft clay)	☐	☒	Likely to affect ground engineering and foundation design and construction
Silt-rich soils susceptible to rapid loss of strength in wet conditions	☒	☐	Likely to affect ground engineering and foundation design and construction.
Running sand at and below water table	☐	☒	Likely to affect ground engineering and foundation design and construction.
Karstic dissolution features (including 'swallow holes' in Chalk terrain)	☐	☒	May affect ground engineering and foundation design and construction – refer to Section 4.1.2.
Evaporite dissolution features and/or subsidence	☐	☒	May affect ground engineering and foundation design and construction.
Ground subject to or at risk from landslides	☐	☒	Likely to require special stabilisation measures.
Ground subject to peri-glacial valley cambering with gulls possibly present	☐	☒	Likely to affect ground engineering and foundation design and construction.
Ground subject to or at risk from coastal or river erosion	☐	☒	Likely to require special protection/stabilisation measures.
High groundwater table (including waterlogged ground)	☒	☐	May affect temporary and permanent works.
Rising groundwater table due to diminishing abstraction in urban area	☐	☒	May affect deep foundations, basements and tunnels.
Underground mining	☐	☒	Likely to require special stabilisation measures.
Effects of extreme temperature (e.g. cold stores or brick kilns/furnaces)	☐	☒	Likely to affect ground engineering and foundation design and construction.
Existing sub-structures (e.g. tunnels, foundations, basements, and adjacent sub-structures)	☒	☐	Likely to affect ground engineering and foundation design and construction.

Hazard category	Hazard status based on desk study findings and proposed development		Engineering considerations if hazard affects site
	Could be present and/or affect site	Unlikely to be present and/or affect site	
Filled and made ground (including embankments, infilled ponds and quarries)	☒	☐	Likely to affect ground engineering and foundation design and construction.
Adverse ground chemistry (including expansive slags and weathering of sulphides to sulphates)	☒	☐	May affect ground engineering and foundation design and construction.
Site topography	☐	☒	May affect ground engineering and foundation design and construction.
Note: Seismicity is not included in the above table as this is not normally a design consideration in the UK.			

6 INITIAL CONCEPTUAL SITE MODEL

In line with CLR11 (Environment Agency, 2004) and BS 10175: 2011 + A2 2017 (BSI, 2017), RSK has used information in the preceding sections to identify sources of contaminants, receptors that may be impacted and plausible linking pathways. Where all three are present this is termed a potentially complete contaminant linkage and a qualitative risk estimation is made.

6.1 Potential soil, soil vapour and groundwater linkages

6.1.1 Potential sources of contamination

Potential sources of soil and groundwater contamination identified from current activities and the history of the site and surrounding area are presented in **Table 11**. Ground gas sources are addressed in the next section.

Table 11 Potential sources of soil and groundwater contamination

Potential sources	Contaminants of concern	Current or historical?
On-site		
Made ground (i.e. fill material) - Former phases of development - Former use as a petrol pumping station - Worked ground	Unknown fill material but potentially including brick, ash and clinker and containing toxic and phytotoxic metals, inorganics, polycyclic aromatic hydrocarbons (PAHs), asbestos	Historical
Possible asbestos containing materials (ACM) within existing buildings	Asbestos	Current
Car parking on site	Petroleum hydrocarbon spills generally likely to be minor in nature (TPH and PAH)	Current / historical
Storage of oils/chemicals on-site	Lube oil, diesel, kerosene, chlorinated solvents	Historical
Underground storage tank and associated pipework - Historic records indicate seven 13,000 litre capacity tanks on site.	Petroleum hydrocarbons (petrol/diesel)	Historical
Off-site		
Former electricity works to the north	Hydrocarbons and polychlorinated biphenyls (PCB's)	Historical

Potential sources	Contaminants of concern	Current or historical?
Current and former surrounding industrial activities. - Delivery depot - Builders merchant - Former manufactories	Potential for organic solvents, chlorinated and non-chlorinated solvents, fuel oils, mineral oils, lubricating oils, metals, acid/alkalis, dyes, PCB's etc.	Current/ Historical

6.1.2 Sensitive receptors and linking exposure/ migration pathways

Sensitive receptors identified at or in the vicinity of the site that could be affected by the potential sources identified above comprise:

- future site users – future workers and users of the proposed healthcare building [inhalation exposure with impacted soil, soil vapour and dust/fibres].
- current adjacent site users – residential, commercial and public open space users [migration of contamination via dust/fibre deposition, vapour or groundwater migration combined with inhalation].
- future buildings and services [direct contact with contaminated soils or groundwater and chemical attack].

Potential linking pathways are show in brackets for each item above.

Please note that construction workers and future maintenance workers have not been identified in the conceptual model as receptors because risks are considered to be managed through health and safety procedures according to the CDM Regulations.

Ecological receptors are only considered within the conceptual model in the context of statutory protected sites.

6.2 Potential ground gas linkages

6.2.1 Ground gas generation potential

Potential ground gas sources identified for the site and surrounding are shown in **Table 12**.

Table 12 Potential ground gas sources

Potential sources	Indicative ground gas generation potential (CIEH, 2008)	Additional information
On-site		
Made ground with low degradable organic content (e.g. up to 5% organic material and no easily degradable waste).	Very low	Made ground from previous phases of development

Potential sources	Indicative ground gas generation potential (CIEH, 2008)	Additional information
Off-site		
No significant off-site potential ground gas generation sources identified		

Given the anticipated ground conditions set out above, significant potential sources of ground gas generation have been identified associated with the made ground soils on site.

6.2.2 Preferential pathways for ground gas migration

Credible preferential pathways potentially connecting the source and receptor through vertical and lateral migration are:

- made ground soils which is likely to be permeable.
- building foundations
- construction joints and cracks within building structure.
- utility routes and service penetrations into buildings

6.2.3 Sensitive receptors and linking pathways

Sensitive receptors identified at or in the vicinity of the site that could be affected by the potential ground gas sources identified above comprise:

- future site users – commercial workers [migration and ingress of ground gases into buildings, build-up in confined spaces and explosion/asphyxiation].
- future buildings and services [migration and ingress of ground gases into buildings, build-up in confined spaces and explosion].

The assessment has identified receptors to include building structures and proposed end-users.

Construction workers have not been identified as receptors for the purposes of this assessment. Risks may still be present to construction workers especially where works include the entry into excavations within the ground. Construction workers should undertake appropriate risk assessments and risks should be managed through health and safety procedures and the use of PPE.

6.3 Preliminary risk assessment

The preliminary risk assessment findings and potentially complete contaminant linkages are shown in **Table 13** overleaf. The risk classification based on the combination of hazard consequence and probability using a risk matrix from CIRIA C552 (Rudland et al., 2001), a summary of which is included in **Appendix G**.

Table 13 Risk estimation for potentially complete contaminant linkages

Potential source	Potential receptor	Possible pathway	Likelihood	Severity	Potential risk and Justification
On-site: Made ground across the site from historical phases of development. (heavy metals, PAH, sulphate, asbestos, PCB's etc)	Human health (future site users)	Inhalation of dust/fibres/vapours Direct contact	Low likelihood	Medium	**Low Risk** The excavation to form the proposed basement is likely to wholly remove the made ground from the site. Any made ground left on site will remain encapsulated under a full cover of buildings and hardstanding thereby breaking any potential pathways between potential contaminants and future end users.
	Water supply pipes Building structures	Chemical attack on structures/water pipes	Likely	Mild	**Moderate / Low Risk** Composition of made ground unknown and presents a potential risk.
	Groundwater	Vertical and lateral migration	Unlikely	Medium	**Low Risk** The site is anticipated to be wholly underlain by low permeability soils of the London Clay Formation and groundwater is not expected to be present beneath the site.
On-site: Car parking (TPH and PAH)	Human Health (future site users)	Direct contact Inhalation of vapours Chemical attack on buried structures	Unlikely	Medium	**Low Risk** Considering the presence of existing hardcover across the site, any releases are likely to be relatively contained and only impact the soils in the vicinity of the car park, coupled with the fact that the proposed basement excavation is likely to wholly remove the made ground from site, therefore the risk is considered to be low.

Potential source	Potential receptor	Possible pathway	Likelihood	Severity	Potential risk and Justification
On site: Historical underground fuel tanks (TPH)	Human Health (future site users)	Inhalation of vapours from soil / groundwater	Likely/low	Medium	**Moderate / Low Risk** The excavation to form the proposed basement is likely to wholly remove any made ground and the underground fuel tanks – however, depending on the depth of excavation and the degree to which these tanks may have leaked, there is the potential for residual volatile contamination to be present beneath the finished basement slab. Where the basement is to be used as a car park, then it would be expected to be ventilated, which would mitigate potential vapour risks. Should the basement be used for any other use, where vapours could accumulate in confined spaces, then this pollutant link would be active.
On-site: Ground gases from made ground soils across and surrounding the site (methane and carbon dioxide)	Human health (future site users) Water supply pipes and building structures	Inhalation of contaminated vapours/gases Migration and accumulation of explosive ground gases	Unlikely	Severe	**Moderate / Low Risk** Although the impact of asphyxiation/explosion of hazardous ground gases may be severe in the short term, it is considered that there is a very low likelihood that significant quantities of putrescible made ground will be present in the vicinity of the site, as such, the risk level associated with this potential pollutant linkage is considered moderate / low.
Off-site: Made ground, electricity works, manufactories, depots	Human health (future site users) Water supply pipes Building structures	Inhalation of contaminated vapours/gases Surface run-off Lateral migration	Unlikely	Medium	**Low Risk** It is anticipated that the site has been covered with hardstanding throughout its development history such that any contaminants entering the site via surface run-off are unlikely to have entered the underlying soil. The proposed development will also likely remove the existing made ground soils and maintain the hardcover across the site, therefore breaking any pollutant linkage with future site users. New buried services and structures will be appropriately designed to withstand chemical attack.

Risk matrix		Consequences			
		Severe	Medium	Mild	Minor
Probability	Highly likely	Very high	High	Moderate	Moderate/low
	Likely	High	Moderate	Moderate/low	Low
	Low likelihood	Moderate	Moderate/low	Low	Very low
	Unlikely	Moderate/low	Low	Very low	Very low

Potentially complete contaminant linkages with a potential risk of moderate to low or higher identified in in **Table 13** comprise:

- Chemical attack by direct contact of building structures and permeation of plastic water supply pipes by Contaminates of Potential Concern (COPC) within impacted made ground soils;
- Inhalation of organic vapours at the site by future site users from potential contaminates associated with leaking underground fuel tanks;
- Generation of ground gases from the made ground beneath the site, ingress into the buildings, accumulation of explosive ground gases and subsequent inhalation risk.

Whilst the above potential pollutant linkages have been identified in the PRA, it is considered that these are unlikely to exist following the proposed development, due to the likely removal of the majority, if not all, of the made ground soils from the site following the excavation and construction of the proposed basement and building.

Assessment of chemical attack by direct contact of building foundation / concrete structures with contaminates (including elevated sulphate concentrations) within aggressive ground conditions is discussed within 11.6.

6.4 Data gaps and uncertainties

Key data gaps and uncertainties identified in the CSM at desk study stage include:

- access not available to the tyre storage building in the south eastern corner of the site;
- the full location and condition of all historic underground tanks is unknown;
- parts of site were developed before first published OS map and prior history is not known; and
- there are no previous investigations available for the site, therefore no information on actual concentrations of contaminants in soil and groundwater or ground gas at this stage.

7 SITE INVESTIGATION STRATEGY & METHODOLOGY

7.1 Introduction

RSK carried out intrusive investigation works and subsequent monitoring of boreholes between 13th August 2019 and 16th August 2019.

7.2 Objectives

The specific objectives of the investigation were as follows:

- to establish the ground conditions underlying the site including the extent and thickness of any made ground.
- to investigate specific potential sources of contamination identified in initial CSM.
- to determine groundwater depth and flow direction.
- to determine the ground gas regime underlying the site.
- to assess geotechnical properties of soils.
- to obtain the details of the existing foundations of the buildings on site.

7.3 Selection of investigation methods

The techniques adopted for the investigation were chosen with consideration of the objectives and site constraints, which are described below.

Cable percussion drilling was chosen based on the targeted drill depth, requirement for in-situ geotechnical data, the opportunity to collect both disturbed and undisturbed samples and install monitoring wells. This was supplemented by window sampler boreholes to obtain several investigation locations and achieve greater visibility of the Made Ground.

In addition to the aforementioned boreholes, a series of number of shallow hand excavated foundation inspection pits were completed across the site in order to obtain the existing foundation details of the buildings on site.

Prior to conducting intrusive works, utility service plans were obtained, and buried service clearance undertaken in line with RSK's health and safety procedures.

7.4 Investigation strategy

The ground investigation was carried out using intrusive ground investigation techniques in general accordance with the recommendations of BS5930:2015 Code of practice for ground investigations, which maintains compliance with BS EN 1997-1 and 1997-2 and their related standards. Whilst every attempt was made to record full details of the strata encountered in the boreholes, techniques of hole formation and sampling will inevitably lead to disturbance, mixing or loss of material in some soils and rocks.

Details of the investigation locations, installations and rationale are presented in **Table 14**.

Table 14 Exploratory hole and monitoring well location rationale

Investigation Type	Designation	Monitoring well installation	Rationale Examples below
Boreholes by cable percussive methods	BH1 and BH2	Gas/ groundwater*	To prove the geological succession beneath the site and obtain geotechnical data, determine the contamination status of the ground and to install additional dual purpose groundwater and gas monitoring wells.
Boreholes by dynamic / windowless sampling methods	WS1	Gas	To determine the contamination status of the ground beneath the site and to install additional gas monitoring wells.
	WS2 to WS3	Gas	Target historic tanks and determine the contamination status of the ground beneath the site and to install additional gas monitoring wells.
Trial-pits excavated by hand	TP1	n/a	This trial pit was designed to obtain the construction details of the basement to the neighbouring pub on the northern boundary of the site.
	TP2 and TP3	n/a	These trial pits were designed to obtain the existing foundation details of the former ATS centre building and tyre storage outbuilding and determine the contamination status of the ground beneath the site. TP2 was located to also investigate the historically positioned internal tank.

7.4.1 Implementation of investigation works

The exploratory holes were logged by an engineer in general accordance with the recommendations of BS 5930:2015 (which incorporates the requirements of BS EN ISO 14688-1, 14688-2 and 14689-1).

The monitoring well construction and associated response zones are detailed on the exploratory hole records in **Appendix H**. The response zones were installed to target identified gas generation sources detailed in the initial preliminary CSM.

The soil sampling and analysis strategy was designed to characterise each encountered soil strata, permit an assessment of the potential contaminant linkages identified and investigate the geotechnical characteristics. In addition, samples were taken to allow for geo-environmental and geotechnical testing to be undertaken.

Soils collected for laboratory analysis were placed in a variety of containers appropriate to the anticipated testing suite required. They were dispatched to the laboratory in cool boxes under chain of custody documentation. Samples were stored in accordance with the RSK quality procedures to maintain sample integrity and preservation and to minimise the chance of cross contamination.

Selected samples were placed in polythene bags for headspace screening with a photo-ionisation detector (PID) fitted with a 10.6 eV bulb. The PID screening results are presented on the exploratory hole records.

7.5 Japanese Knotweed

An area of Japanese knotweed was identified on site during the reconnaissance survey and the intrusive investigation. This area was sectioned off for the during of the site works. A plan showing the location of the identified Knotweed is included in Figure 3. There are several methods by which Japanese Knotweed can be treated/eradicated, all of which are detailed in the EA's (2006b) 'The Knotweed Code of Practice'. A competent contractor should be employed to manage and perform the works in line with this guidance to eradicate the Knotweed from the site.

7.6 Monitoring programme

7.6.1 Ground gas monitoring

In line with the initial CSM, response zones were installed to target the sources or pathways as detailed in **Table 12**.

Three monitoring rounds have been undertaken to date to provide data to support refining of the CSM. The number of monitoring rounds undertaken is in general accordance with the decision matrix presented as Figure 6 of BS8576.

An infrared gas meter was used to measure gas flow, concentrations of carbon dioxide (CO_2), methane (CH_4) and oxygen (O_2) in percentage by volume, while hydrogen sulphide (H_2S) and carbon monoxide (CO) were recorded in parts per million.

Initial and steady state concentrations were recorded. In addition, during the first monitoring round, all wells were screened with a PID to establish if there are any interferences and cross-sensitivity of other hydrocarbons with the infrared gas meter.

The atmospheric pressure before and during monitoring, together with the weather conditions, were recorded.

All ground gas monitoring results together with the temporal conditions are contained within **Appendix I**. Equipment calibration certificates are available on request.

7.7 Laboratory testing

Laboratory testing was undertaken at a UKAS accredited laboratory with ISO17025 and MCERTS accredited test methods were specified where applicable for contamination testing and as shown in the laboratory test certificates appended.

7.7.1 Chemical analysis of soil samples

The soil sampling strategy was designed to characterise made ground and natural strata typically within the upper 1.00 m of the ground profile whilst also characterising deeper strata and the potential for contaminant migration from relevant sources of identified within the preliminary CSM.

The programme of chemical tests undertaken on soil samples obtained from the intrusive investigation is presented in **Table 15** with the laboratory testing results contained in **Appendix J**.

Table 15 Summary of chemical testing of soil samples

Stratum	Tests undertaken	No. of tests
Made ground	Asbestos screening and ID	5
	Soils suite (Heavy Metals, pH)	2
	Total Organic Carbon (TOC)	3
	Polychlorinated Biphenyls (PCB)	2
	Hazardous Waste Suite (pH, metals, TPH, PAH, moisture content, asbestos screen)	4
	Volatile Organic Compounds (VOC)	2
Reworked London Clay Formation	Total Organic Carbon (TOC)	1
London Clay Formation	Total Organic Carbon (TOC)	1
	Hazardous Waste Suite (pH, metals, TPH, PAH, moisture content, asbestos screen)	1

7.7.2 Geotechnical analysis of soils

Where appropriate disturbed, bulk and undisturbed soil samples were taken for geotechnical classification testing with the depth and nature of samples detailed within the exploratory hole records.

Where appropriate, testing was undertaken in accordance with BS 1377:1990 Method of Tests for Soils for Civil Engineering Purposes or, where superseded, by the relevant part of BS EN ISO 17892:2014 Geotechnical investigation and testing - Laboratory Testing of Soil. Tests carried out in order to classify the concrete class required on-site have been undertaken following the procedures within BRE SD1:2005.

The programme of geotechnical tests undertaken on samples obtained from the intrusive investigation is presented in **Table 16**. The results and UKAS accreditation of tests methods are shown in **Appendix K**.

Table 16 Summary of geotechnical testing undertaken

Strata	Tests undertaken	No. of tests
Made Ground	BRE SD1	2
London Clay Formation	Atterberg limits	6
	Single stage quick undrained triaxial test	15
	Consolidation	2
	Total, water soluble and acid soluble sulphate and pH	6

8 SITE INVESTIGATION FACTUAL FINDINGS

The results of the intrusive investigation and subsequent geoenvironmental and geotechnical laboratory analysis undertaken are detailed below.

8.1 Ground conditions encountered

The descriptions of the strata encountered, notes regarding visual or olfactory evidence of contamination, list of samples taken, field observations of soil and groundwater, in-situ testing and details of monitoring well installations are included on the exploratory hole records presented in **Appendix H**.

The exploratory holes revealed that the site is underlain by a variable thickness of made ground and reworked London Clay Formation over London Clay Formation. This appears to confirm the stratigraphical succession described within the preliminary CSM.

For the purpose of discussion, the ground conditions encountered during the fieldworks are summarised in **Table 17** with the strata discussed in subsequent subsections.

Table 17 General succession of strata encountered

Stratum	Exploratory holes encountered	Depth to top of stratum m bgl	Proven thickness (m)
Made ground	All positions	Ground level	1.00 – 3.40
Reworked London Clay Formation	BH2 and WS2	1.20 – 1.30	1.80 – 2.00
London Clay Formation	BH1, BH2, WS2 and WS3	1.00 – 3.40	Proven to 30.45m bgl

8.1.1 Made ground

The majority of the exploratory holes were advanced through a superficial covering of either concrete or asphalt.

The made ground encountered from surface to a maximum depth of 3.40 m bgl generally comprised of sandy gravelly clay and gravelly sand. The gravel content typically comprised of angular to rounded, fine to coarse brick, flint, concrete, roadstone and asphalt, ash, with occasional cobbles of broken brick and concrete.

8.1.2 Reworked London Clay Formation

Possible reworked London Clay Formation was encountered within BH2 and WS2 beneath the made ground to a maximum depth of 3.30 m bgl. This stratum generally comprised firm slightly sandy gravelly clay. The gravel content typically comprised of angular to rounded fine to coarse flint, chert and mixed lithologies.

8.1.3 London Clay Formation

This stratum was encountered beneath the made ground/reworked London Clay Formation and comprised a firm to very stiff consistency, high to extremely high strength silty grey brown clay proven to a depth of 30.45 m below ground level.

A summary of the in-situ and laboratory test results recorded in the stratum are presented in **Table 18**.

Table 18 Summary of in-situ and laboratory test results for granular unit

Soil parameters	Min. Value	Max. Value	Reference
Moisture content (%)	20	31	Appendix K
Liquid limit (%)	72	74	Appendix K
Plastic limit (%)	24	31	Appendix K
Plasticity index (%)	41	49	Appendix K
Plasticity term	Very high		Appendix K
Volume change potential	High		Appendix K
SPT 'N' values	21	80	Appendix H Figure 5
Undrained shear strength inferred from SPT 'N' values (kN/m^2)*	95	360	Appendix K Figure 7
Undrained shear strength measured by triaxial testing (kN/m^2)	81	471	Appendix K Figure 7
Consistency term from field description	Firm	Very stiff	Appendix K
Strength term (inferred from Triaxial testing)	High	Extremely high	Appendix K
Notes: *derived using a Stroud Factor of 4.5.			

8.1.4 Visual/olfactory evidence of soil contamination

A strong hydrocarbon odour was noted within the made ground soils encountered within borehole WS3 between 0.70 m bgl and 1.00 m bgl. In addition, samples from the same hole at 0.80 m, 1.20 m and 1.50 m revealed PID readings of 146.6 ppm, 52.9 ppm and 10.2 ppm, respectively. This appears to correlate with the location of the tanks on site noted on **Figure 4.**

8.2 Groundwater

8.2.1 Groundwater encountered during intrusive works

Groundwater was not encountered during the intrusive investigation works.

8.2.2 Groundwater encountered during monitoring

Resting groundwater levels recorded during the monitoring programme are summarised in **Table 19** based on the data provided in **Appendix I**.

Table 19 Summary of groundwater monitoring results

Monitoring well	Response zone stratum	Depth to groundwater (m BGL) – min.	Depth to groundwater (m BGL) – max.
BH1	MG/LCF	2.69	3.31
BH2	RLCF/LCF	3.26	3.48
WS2	MG	0.91*	Dry
WS3	MG	0.99*	Dry

Notes:
MG = Made Ground
RLCF = Reworked London Clay Formation
LCF = London Clay Formation
m BGL = metres below ground level
* = suspected condensation rather than legitimate groundwater level

The findings reflect a potentially perched groundwater table at the made ground/reworked London Clay and London Clay Formation interface.

It should be noted that groundwater levels might fluctuate for a number of reasons including seasonal variations. On-going monitoring would be required to establish both the full range of conditions and any trends in groundwater levels.

8.3 Chemical laboratory results

The soil testing results are presented in **Appendix J**.

No asbestos containing materials (ACM's) were identified during the intrusive investigation or subsequent laboratory testing of the samples tested. Whilst ACM's were not encountered in this investigation, asbestos is usually found in discreet places and may therefore still be encountered during more extensive groundworks.

8.4 Geotechnical laboratory results

The results of the geotechnical testing are discussed in Section 11 and presented in **Appendix K**.

8.5 Ground gas monitoring

The results of the ground gas monitoring and testing carried out are given in **Appendix I** and discussed in section 9.

8.6 Existing foundations

In order to inform the proposed demolition works, there was a requirement to understand the foundations to the existing buildings on site.

A total of three hand dug foundation inspection pits were excavated as part of the investigation (TP1 to TP3).

8.6.1 Trial Pit TP1

This pit was excavated on the external face of the southern elevation of the Golden Lion Public House. The pit was advanced to 1.20 m at which point excavations were terminated. The footings to the public house were not encountered over the zone of excavation as was predicted due to the presence of a basement. No waterproofing of note was observed on the basement wall face, only exposed masonry. A mass concrete obstruction was present running east to west across the southern portion of the pit. This is possibly associated with the foundations to the northern ATS building.

8.6.2 Trial Pit TP2

This pit was excavated on the external face of the western elevation of the central ATS building. The pit exposed what appeared to be a mass concrete footing extending to a depth of 1.42 m bgl and observed to be founded within made ground.

8.6.3 Trial Pit TP3

This pit was excavated on the northern face of the tyre storage building. The foundations were observed to comprise a mass concrete footing some 0.67 m bgl and founded within made ground.

Photographs of the inspection pits can be found in **Appendix P**. Trial pit foundation drawings are included in Appendix H.

9 GEO-ENVIRONMENTAL ASSESSMENT

9.1 Refinement of initial CSM

The exploratory holes confirm the stratigraphical succession described within the initial conceptual site model in that the site is underlain by a moderate thickness of made ground with the London Clay Formation beneath.

Whilst a persistent groundwater table was not encountered during the intrusive investigation, the post site work monitoring visits, undertaken between August and September 2019, has indicated the presence of potentially perched groundwater along the made ground / London Clay Formation interface.

With the exception of WS2, where staining together with a strong hydrocarbon odour was noted of the made ground soils, no visual or olfactory evidence of significant soil or groundwater contamination was encountered at any of the other exploratory positions.

The findings of the intrusive investigation generally confirm those discussed within the PRA. The pollutant linkages are therefore largely considered to remain unchanged.

Further quantitative assessment has been carried out to assess whether the made ground and shallow soils across the site contain any deleterious materials or contaminates that may pose a risk to future site users and potable water supply pipes.

Pollutant linkages with respect to chemical attack from direct contact of COPC with building structures (including concrete foundations) has been assessed separately within Section 11.6.

9.2 Linkages for assessment

In line with CLR11 (Environment Agency, 2004), there are two stages of quantitative risk assessment, generic (GQRA) and detailed (DQRA). The GQRA comprises the comparison of soil, groundwater, soil gas and ground gas results with generic assessment criteria (GAC) that are appropriate to the linkage being assessed. This comparison can be undertaken directly against the laboratory results or following statistical analysis depending upon the sampling procedure that was adopted.

Following the refinement of the initial CSM, the potentially complete contaminant linkages that require further assessment and the methodology of assessment are presented in **Table 20**.

Table 20 Linkages for GQRA

Potentially relevant contaminant linkage	Assessment method
Soil	
1. Oral, dermal and inhalation exposure with impacted soil, soil vapour and dust by site users	Human health GAC in **Appendix L** for a proposed commercial end use.

Potentially relevant contaminant linkage	Assessment method
2. Inhalation exposure of future site users to asbestos fibres	Qualitative assessment based on the asbestos minerals present, their form, concentration, location and the nature of the proposed development.
3. Contaminants permeating potable water supply pipes	Comparison of soil data to GAC in Appendix M for plastic water supply pipes using UKWIR (2010) guidance.
Ground Gas	
4. Concentrations of methane and carbon dioxide in ground gas entering and accumulating in enclosed spaces or small rooms in new buildings, which could affect future site users. For methane this could create a potentially explosive atmosphere, while death by asphyxiation could result from carbon dioxide.	Gas screening values (GSV) have been calculated using maximum methane and carbon dioxide concentrations with maximum flow rates recorded at the site. The GSV have been compared with the revised Wilson and Card classification presented in BS8485.

9.3 Methodology and assessment of soil results

The analysis of laboratory results relating to soil samples submitted for testing is included in the following sections.

9.3.1 Oral, dermal and inhalation exposure with impacted soil by future site users

Despite the proposed development plans being likely to involve the whole removal of the made ground soils from site before leaving the site entirely covered with hardstanding, for completeness, the soil results have been compared against the appropriate GAC for a commercial end use.

From the comparison of the results, both from non – targeted positions and those locations that targeted specifically any possible buried tanks, it is concluded that none of the determinants exceed the assessment threshold limits for a proposed commercial end use.

Concentrations of PCBs and VOCs were recorded at laboratory detection limits.

9.3.2 Inhalation exposure of future occupants/site users to asbestos fibres

The visual inspection at the laboratory identified no materials suspected of potentially containing asbestos and the scheduled laboratory screening for asbestos found no detectable asbestos fibres within the samples of made ground.

Whilst not detected during these works, it should be appreciated that asbestos is often present in discrete areas and may therefore be found during more extensive groundworks. Groundworkers should be made aware of the potential for it to be present in the made ground soils and should have asbestos awareness training. The potential presence of asbestos in the made ground should be addressed in the contractor’s risk assessments and method statements.

9.3.3 Impact of organic contaminants on potable water supply pipes

For initial assessment purposes, the results of the investigation have been compared with the GAC presented in Appendix M for this linkage, which are reproduced from *UKWIR Report 10/WM/03/21. Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites* (UKWIR, 2010).

The results have recorded elevated concentrations of total petroleum hydrocarbons above the screening criteria for plastic polyethylene (PE) water supply pipes. The risk may therefore be mitigated by laying contaminant resistant/barrier pipes in service trenches backfilled with clean (suitable for use) granular material. Alternatively, polyvinyl chloride (PVC) water supply pipes are expected to be suitable for use on the development.

It should be noted that at the time of this investigation the future routes of water supply pipes had not been established, hence the investigation and sampling strategy may not be fully compliant with UKWIR recommendations. Consequently, a targeted investigation and specific sampling/analytical strategy may be required at a later date once the route(s) of the supply pipe(s) are known. In addition, it is recommended that the relevant water supply company be contacted at an early stage to confirm its requirements for assessment, which may not necessarily be the same as those recommended by UKWIR.

9.4 Ground gas risk assessment

9.4.1 Appropriate guidance

The risks to development from ground gases have been assessed in accordance with BS8485:2015, which provides guidance on ground gas (methane and carbon dioxide) characterisation and hazard assessment, as well as a framework for the prescription of protection measures within new buildings.

The process involves characterising the gas hazard from combining the qualitative assessment of risk (using the conceptual site model) with ground investigation data so that a 'characteristic situation' (CS) can be derived for the site. Characteristic situations range from CS1 to CS6, the higher the CS the higher the hazard potential. Protection measures within new buildings can be prescribed using a point scoring system, taking in to consideration the CS and the proposed building type.

BS8485 indicates that the gas hazard can be characterised using the following methods:

- an empirical semi-quantitative approach using gas monitoring data to determine the 'characteristic situation' of the site (or zones of the site) and subsequent protective measures (Wilson and Card approach).
- an empirical semi-quantitative approach using TOC data to determine the 'characteristic situation' of the site (or zones of the site) and subsequent protective measures (CL:AIRE RB17 approach), or
- detailed quantitative assessment methodologies.

For the purpose of this assessment, the first approach listed above has been used to characterise the gas hazard and provide advice on the protective measures likely to be required within new buildings at the site.

9.4.2 Summary of the refined conceptual site model for ground gas

In the assessment of risks and selection of appropriate mitigation measures, BS8485 highlights the importance of the conceptual model. In summary, potential sources of ground gas within influencing distance of the site identified in Section 6.2 comprises only a limited thickness of made ground soils with a low organic content, which the ground investigation confirmed as being likely to have a 'very low' generation potential.

Pathways and receptors for ground gas were identified in Section 6.2.

This assessment has been undertaken to assess risks to building structures and proposed end users. The assessment has not taken into consideration the health and safety of construction workers. Risks may still be present to construction workers especially where works include the entry into excavations within the ground. Construction workers should undertake appropriate risk assessments and risks should be managed through health and safety procedures and safe systems of work.

The risk assessment has been undertaken based on the current understanding of the CSM.

9.4.3 Empirical semi-quantitative approach using borehole monitoring data (Wilson and Card approach)

The empirical semi quantitative approach using gas monitoring data is based on calculations of the gas screening value (GSV). BS8485 defines the GSV as the *'flow rate (l/hr) of a specific hazardous gas representative of a site or zone, derived from assessment of borehole concentration and flow rate measurements and taking account of all other influencing factors, in accordance with a conceptual site model'.*

Once derived for both methane and carbon dioxide the GSVs are compared to the thresholds presented in Table 2 of BS8485, so that a CS can be determined for the site, or a zone. It is important to note that the GSV thresholds are guideline values and not absolute. The GSV thresholds may be exceeded in certain circumstances, if the site conceptual model indicates it is safe to do so. Similarly, consideration of additional factors such as very high concentrations of methane, should lead to consideration of the need to adopt a higher risk classification than the GSV threshold indicates.

The results of the ground gas monitoring and testing undertaken at the site are given in **Appendix I**.

The maximum results recorded are presented in **Table 21**.

Table 21 Summary of ground gas monitoring results

Borehole	Response zone/ stratum	Probable source(s) of ground gas	Number of monitoring visits	Methane (%)	Carbon dioxide (%)	Oxygen (%)	Flow rate (l/hr)	Water level (m bgl)	Atmospheric pressure (mbar)
BH1	MG	MG	2	0.0	0.8	19.7	0.0	2.9	1024
BH2	MG	MG	2	0.0	0.4	20.3	-0.1	3.37	1024
WS2	MG	MG	2	0.0	0.1	17.2	0.0	Dry	1024
WS3	MG	MG	2	0.0	1.0	19.3	0.0	Dry	1024

Note: *MG – Made Ground*

Maximum concentrations and flows are presented in this table except for oxygen, where the minimum value is presented

BS8485 suggests that the GSV should be derived by multiplying the worse credible (worst case) recorded flow value in any standpipe in that strata or zone with the maximum gas concentration in any other standpipe in that strata or zone. Further guidance is given in BS8485 section 6.3.

The gas monitoring data obtained from the monitoring visits have been considered and have identified a maximum steady state methane concentration of <0.1% and a maximum steady state concentration of carbon dioxide of 1.0%. No positive gas flow rates were recorded.

- methane GSV (<0.0001 l/hr) = methane concentration (<0.1 % v/v)/100 x flow rate (<0.1 l/hr).
- Carbon Dioxide GSV (<0.0001 l/hr) = carbon dioxide concentration (0.4 % v/v)/100 x flow rate (<0.1 l/hr).

Based on the GSVs derived and the method for determining the CS presented within Table 2 of BS8485, the site has been characterised as 'Characteristic Situation 1' (CS1), for which no ground gas protection measures are considered necessary within proposed buildings.

9.5 Uncertainties and implications in refined CSM and GQRA

In accordance with good practice, data gaps and uncertainties in the refined CSM have been identified at this stage. These are summarised in Table 22 along with the likely implications.

Table 22 Data gaps and uncertainties

Data gap/ uncertainty	Details	Implications
Limited sampling positions within the footprint of the former ATS centre building	-	There is a gap in the coverage for soil data in this area.
Unable to investigate within the tyre storage outbuilding	Access was not permissible.	There is a gap in coverage for soil data in this area.
Asbestos not found in made ground samples tested	Although not encountered to date, asbestos containing material (ACM) could still be present in discrete locations	Vigilance should be maintained for any potential ACM or fibrous material during below ground works

10 PRELIMINARY WASTE ASSESSMENT

In accordance with the definition provided in the Waste Framework Directive (WFD), materials are only considered waste if 'they are discarded, intended to be discarded or required to be discarded, by the holder'. Naturally occurring soils are not considered waste if reused on the site of origin for the purposes of development. Soils such as made ground that are not of clean and natural origin (irrespective of whether they are contaminated or not) and other materials such as recycled aggregate, do not become waste until the criteria above are met. Further background information is provided in **Appendix G**.

Excavation arisings from the development may therefore be classified as waste if surplus to requirements or unsuitable for reuse. The following assessments assume the material tested is classified subsequently as waste.

RSK recommends that a Sampling Plan be prepared to support any waste classifications and hazardous waste assessments, prior to any material being excavated. Given the level of data obtained, scale of the development and heterogeneity of the site soils, the following assessment should be considered indicative and further assessment should be undertaken following the preparation of a waste sampling plan.

10.1 Hazardous waste assessment

Technical Guidance WM3 (EA, 2018) sets out in Appendix D requirements for waste sampling. It is a legal requirement to correctly assess and classify waste. The level of sampling should be proportionate to the volume of waste and its heterogeneity. The preliminary assessment provided below is based only upon the available sample results and may not be sufficient to adequately classify the waste.

10.1.1 Chemical contaminants

Envirolab, an RSK company, has developed a waste soils characterisation assessment tool (HASWASTE), which follows the guidance within Technical Guidance WM3. The analytical results have been assessed using this tool to assess the hazardous properties to support potential off-site disposal of materials in the future. Note that it is ultimately for landfills to confirm what wastes they are able to accept within the constraints of their permit.

The results are summarised in **Table 23** and presented in full in **Appendix O**.

Table 23 Results of waste soils characterisation assessment (HASWASTE)

Sample ref/ depth	Hazardous properties identified
TP1 @ 0.50m	Not hazardous
TP2 @ 0.50m	Not hazardous
TP3 @ 0.30m	Not hazardous
TP3 @ 0.60m	Not hazardous
BH1 @ 0.50m	**Hazardous** – pH corrosive HP8

Sample ref/ depth	Hazardous properties identified
BH2 @ 0.60m	Not hazardous
WS1 @ 0.40m	Not hazardous
WS2 @ 0.30m	**Hazardous** – pH corrosive HP8
WS2 @ 0.80m	Not hazardous
WS2 @ 1.40m	Not hazardous
WS3 @ 0.40m	Not hazardous
WS3 @ 0.80m	Not hazardous
WS3 @ 1.20m	Not hazardous
WS3 @ 2.30m	Not hazardous

The samples of made ground from BH1 at 0.50m and WS2 at 0.30m have been classed as potentially hazardous waste based on the observed elevated pH levels. These elevated levels have exceeded the threshold value of 11.5 with levels of 12.91 and 12.33, respectively. Given the negligible exceedances and coupled with the fact that the elevations are likely to be associated with the presence of concrete fragments within the samples (as noted on the exploratory logs), it is considered that these samples may be considered to be 'not hazardous' in nature subject to confirmation from the receiving landfill operator.

WAC testing would be required in order to further classify the materials into hazardous/stable non-reactive or non-hazardous/inert materials.

Prospective landfill operatives should be contacted at an early stage to discuss the waste classification of any material destined for off-site disposal and requirements for additional testing.

10.1.2 Asbestos within waste soils

Technical Guidance WM3 requires that within a mixed waste the separately identifiable wastes be assessed separately.

For instance, where waste soil contains identifiable pieces of asbestos (visible to the naked eye) the asbestos should, where feasible, be separated from the soil and classified separately. This should be disposed of within a hazardous, stable non-reactive hazardous waste landfill or a special cell in a non-hazardous waste landfill.

Samples of the shallow soils were collected from site and analysed for the presence of asbestos. No asbestos containing materials were identified in any of the samples tested.

10.2 WAC assessment

All inert, stable non-reactive hazardous and hazardous wastes have limit values (waste acceptance criteria) set out in legislation that must be met before that class of landfill can accept the waste. Currently, no WAC are in place for non-hazardous waste.

Soil and other materials that are found not to be hazardous may be classified as either non-hazardous or inert. In order to determine whether they can be classed as inert the soil must be tested and found to be below the inert waste acceptance criteria.

Sample WS3 @ 0.4m was submitted for waste acceptance criteria (WAC) testing for Full 1 Batch waste suite, the results of which are presented in **Appendix J**.

The results of the WAC testing indicate that the leaching limit values (lead) and total content of organic parameters for inert waste have been exceeded and therefore the waste is not suitable for disposal within an inert landfill but should be disposed of at a landfill or treatment facility which is permitted to take non-hazardous waste.

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11 GEOTECHNICAL ASSESSMENT

11.1 Proposed development

It is understood that the proposed development comprises the construction of a new health care building with six superstructure storeys and single storey basement. The existing load bearing masonry building will be demolished, and the shallow foundations grubbed out.

At this stage no specific information relating to building loads has been provided.

11.2 Key geotechnical hazards / development constraints

The key risks identified from the available ground investigation data are discussed below:

- London Clay Formation soils of very high volume change potential;
- adverse ground chemistry due to elevated sulphates in the London Clay Formation;
- possible perched water table along made ground / London Clay Formation interface;
- existing basement to public house bounding the site along the northern boundary; and
- moderate depth of made / reworked ground encountered in site.

11.3 Ground model and characteristic values

The preliminary ground model summarised in **Table 24** has been adopted for the purpose of the preliminary foundation design recommendations.

Table 24 Ground model derived from ground investigation

Stratum	Depth to top of stratum (m bgl)	Thickness (m)
Made Ground	0.00	3.50
Reworked London Clay Formation	1.00	2.40
London Clay Formation	3.40	Proven to 30.00 [1]
Notes: 1) base of stratum not proven m bgl – metres below ground level		

Groundwater has been recorded within the installations at depths ranging between 2.69m to 3.48m below existing ground level.

The geotechnical design parameters presented in **Table 25** are based on the results of the fieldwork, in-situ and laboratory testing, and reflect RSK's understanding of the proposed construction at the time this report was written. The designer should assess the applicability of the characteristic values provided below for the design situation under consideration and to ensure that it is a cautious estimate of the value affecting the occurrence of the relevant limit state(s).

Table 25 Summary of characteristic geotechnical design parameters

Design parameter	Stratum	
	Made Ground + Reworked London Clay Formation	London Clay Formation
Unit weight - $\gamma_{,k}$ (kN/m^3)	19.0[1]	20.0[1]
Undrained shear strength – $c_{u,}$ (kN/m^2)	-	70 + 7.92z
Peak Effective Angle of Friction - $\varphi'_{pk,k}$ (◦)	24[1]	24[1]
Critical State Angle of Friction - $\varphi'_{cv,k}$ (◦)	22[1]	22[2]
Effective cohesion - $c'_{,k}$ (kN/m^2)	0[1]	2[1]

Notes:
1) assumed empirical values in the absence of testing
2) Estimated using Figure 1 and 2 for fine soils and equations 3 & 4 for coarse soils from BS 8002:2015
3) Subject to loading

11.4 Foundations

11.4.1 Foundation options

As discussed above, based on the desk study information and works completed to date, the ground profile beneath the site currently comprises a moderate thickness of made and reworked ground overlying the London Clay Formation.

Although detailed loading information has not been provided at this stage based on our understanding of the proposed development, and envisaged high column loadings, it is considered that conventional shallow spread foundations are unlikely to be suitable for the proposed six storey building.

In light of the above, recommendations for the design of rafted and piled foundation solutions are provided in the following sections.

11.4.2 Piled foundations

Recommendations for the design and construction of pile foundations in relation to the ground conditions are set out in **Table 26**.

Table 26 Design and construction of piled foundations

Design/construction considerations	Design/construction recommendations
Pile type	The construction of bored/CFA piles is considered technically feasible at this site.
Possible constraints on choice of pile type	Given the close proximity of the site to a residential area it is considered possible that the vibration/noise associated with pile driving may not be acceptable.

Design/construction considerations	Design/construction recommendations	
Temporary casing	The presence of shallow perched groundwater has been recorded and therefore bored piles may require temporary casing. Alternatively, the use of Continuous Flight Auger (CFA) injected bored piles will usually overcome this issue.	
Man-made obstructions	The presence of buried sub-structures or other obstructions within the made ground may lead to some difficulty during piling. Given the proposed basement excavation is likely to remove all of the made ground soils from site, buried man-made structures are unlikely to be an issue with regards to piling. Notwithstanding the above, it is proposed to install a contiguous pile retaining wall around the perimeter of the site prior to basement excavation, therefore it is recommended that consideration be given to pre-pile probing at each of the pile positions. Where buried obstructions are encountered, it may be necessary to make allowance for removing the obstruction.	
Hard strata	An allowance should be made for chiselling thin 'rock' bands (claystone) within the London Clay Formation.	
Pile design parameters for London Clay Formation	Pile design parameter	Bored
	Undrained shear strength c_u (kN/m^2)	Cu = 70 + 7.92.z kN/m^2 where z = depth into clay
	Adhesion factor α	0.5
	End bearing factor N_q	9
General parameters	Model factor (γ_{Rd})	1.4
	Average limiting shaft friction (kN/m^2)	110
SLS Check	Factor of Safety of 1.2 on shaft resistance	
Special precautions relating to bored pile shafts and bases	Bored pile concrete should be cast as soon after completion of boring as possible and in any event the same day as boring. Prior to casting the base of the pile bore should be clean, otherwise a reduced safe working load will be required. Similarly, if the pile bore is left open the shaft walls may relax/soften, leading to a reduced safe working load.	

The design resistances have been calculated in accordance with BS EN 1997-1 and the UK National Annex, using partial resistance factors for bored piles, given in **Table 27**.

Table 27 Partial resistance factors (γ_R)

Resistance	Set	
	DA1 C1	DA1 C2[1)]
Base - γ_b	1.0	2.0
Shaft (compression) - γ_s	1.0	1.6
Total (compression) - γ_t	1.0	2.0

[1)] no serviceability verification

The design procedure for piles varies considerably, depending on the proposed type of pile. However, for illustrative purposes **Table 28** gives likely working pile loads for traditional bored/CFA, cast-in-situ concrete piles of various diameters and lengths, based on the design parameters given in **Table 26**.

Table 28 Typical pile design resistances for bored/CFA cast-in-situ piles

Typical Design resistance for DA1 – Combinations C1 & C2 & SLS (kN)									
Depth of pile toe below proposed basement level of 7.0 m BGL	Pile diameter								
	450mm			600mm			750mm		
	C1	C2	SLS	C1	C2	SLS	C1	C2	SLS
10.00	818	496	578	1147	689	771	1503	896	963
11.00	910	553	654	1269	765	872	1655	991	1090
12.00	1005	613	734	1396	845	978	1814	1091	1223
13.00	1105	675	816	1528	927	1088	1980	1194	1361
14.00	1208	739	902	1666	1014	1203	2152	1302	1504
15.00	1315	806	992	1809	1103	1323	2331	1414	1653
16.00	1426	876	1084	1957	1195	1446	2516	1529	1807
17.00	1537	945	1177	2105	1288	1569	2701	1645	1961
18.00	1648	1015	1269	2253	1380	1692	2886	1760	2116

When dimensioning a pile, the design load must be multiplied by the appropriate partial factor, γ_G.

It should be stressed that the above capacities do not take into consideration limiting concrete stress nor pile group effects, the latter of which is more pronounced for a large number of closely spaced piles. In addition, no consideration has been given in the design to the change in stress as a result of the bulk excavation and removal of overburden. This may need to be considered in the final design.

Settlement of new piles designed on the basis of the working loads outlined above would typically be anticipated to be in the range of 0.5% to 1.0% of the pile diameter. It should be noted, however, that this range is for individual piles and could significantly increase if the piles are installed in closely spaced groups. As such, it may be necessary to determine the overall settlement of the foundation system once the final pile layout is known.

Notwithstanding the above, it is recommended that the detailed advice of a specialist-piling contractor be sought as to the most suitable type of pile for the prevailing ground conditions and as to their lengths and diameters to support the required design loads.

11.4.3 Raft foundation

Based on the soil profile beneath the site and an envisaged reduced level of the basement in the order of 7.00 m bgl, it is assumed that a raft would be constructed within the high to extremely high strength clay of the London Clay Formation.

All foundation excavations should be inspected, any made ground and soft, organic or otherwise unsuitable materials removed and replaced with suitably compacted engineered fill or mass concrete.

For preliminary design purposes a net safe bearing pressure (safety factor F_s=3.0) a of 164kN/m^2 for the London Clay Formation is considered acceptable. In order to confirm the net allowable bearing pressure, preliminary settlement checks have been undertaken which indicate a bearing pressure of 190kN/m^2 imparts some 25 mm of settlement. As such, a net allowable bearing pressure of 164kN/m^2 can be considered suitable for the proposed development.

It should be stressed that in the absence of details concerning the final excavation level it is recommended a site-specific settlement analysis be considered when the development details have been finalised.

Given the presence of localised perched groundwater within the made ground, above the London Clay Formation, it may be impractical to undertake open excavations without the implementation of some form of groundwater management to control the perched groundwater identified.

11.4.4 Foundation works risk assessment

It is not anticipated that a foundation works risk assessment report will be required for the development because no significant ground contamination has been identified and in any case the site is underlain by a significant thickness of London Clay Formation that will break any potential pathway for downward migration of contamination.

11.4.5 Basement floor slabs

The sub-grade soil conditions beneath the footprint of the proposed basement slab will comprise of high to extremely high strength clay (London Clay Formation).

Consideration will need to be given to designing the basement slab to withstand both heave of the underlying cohesive soils resulting from unloading due to excavation and possible groundwater pressures.

With regard to heave of the underlying clay, it is noted that incorporating a suitable compressible layer beneath the slab could negate the associated uplift pressures. On this matter, given the anticipated programme of excavation and subsequent basement construction is unlikely to be instantaneous, it can be assumed that some 50% of the immediate elastic heave will have occurred prior to slab installation. In the long-term condition, heave pressures could be considered to have reduced to a total of some 25% of the former overburden.

An assessment of the potential magnitude of both long-term and short-term heave associated with the formation of the basement should be undertaken once the proposed loading scheme has been fully established.

The results of the monitoring programme have recorded possible perched groundwater above the level of the proposed basement level. Therefore, the design should consider the associated hydrostatic uplift pressures acting on the underside of the slab and any potential further rise in groundwater levels or an abnormal event, such as a burst water main etc.

11.5 Retaining wall design

The characteristic geotechnical design parameters provided in **Table 25** may be referenced for retaining wall design.

In order to prevent damage to adjacent structures and road infrastructure, the design of the retaining wall must address the risk of excessive deformation of the wall. Bracing, both in the temporary and permanent condition will therefore be required, to ensure that the horizontal and vertical soil movement remain within acceptable levels.

Groundwater has been recorded within the installations at depths below ground level ranging between 2.69 m to 3.48 m possibly indicating a perched water table above the London Clay Formation. As such, it will be necessary to make an allowance for hydrostatic pressures acting behind proposed retaining structures. Groundwater seepages may be encountered during excavation of the basement if a contiguous piled wall is adopted, but the anticipated fine-grained nature of the soils suggests that pumping from open sumps should be sufficient to keep the excavation reasonably dry.

11.6 Chemical attack on buried concrete

This assessment of the potential for chemical attack on buried concrete at the site is based on BRE Special Digest 1: Concrete in aggressive ground, which represents the most up-to-date guidance on this topic currently available in the UK.

The desk study and site reconnaissance indicate that, for the purposes of assessing the aggressive chemical environment of the site, the site should be considered as comprising brownfield ground likely to contain pyrite.

Based on testing results, **Table 29** gives the characteristic pH, water-soluble and total sulphate content values for soils from each of the geological units and groundwater encountered on-site.

Table 29 Characteristic pH, water soluble sulphate and total sulphate values

Stratum	pH	Water Soluble Sulphate (mg/l)	Total Potential Sulphate (%)
Made ground	8.01	124	0.15
London Clay Formation	7.68	2310	2.25

Based on the results above and following the steps outlined in the BRE guidance, the Design Sulphate Classes and Aggressive Chemical Environment for Concrete classifications are summarised in **Table 30**, on the basis of water soluble sulphate and total potential sulphate, respectively.

Table 30 Concrete design class

Stratum	Ground water	Water Soluble Sulphate		Total Potential Sulphate	
		DS Class	AC Class	DS Class	AC Class
Made Ground	Static	DS-1	AC-1s	DS-1	AC-1s
London Clay Formation	Static	DS-3	AC-2s	DS-4	AC-3s

Assuming that disturbed ground will be minimised by the use of piled foundations, the recommended ACEC Classification is therefore AC-2s with a Design Sulphate Class of DS-3.

However, it is envisaged that the proposals will include the reuse of the pyritic London Clay Formation, i.e. cutting and filling, or excavation and backfill, as such, the recommended ACEC Classification will increase to AC-3s with a Design Sulphate Class of DS-4.

12 CONCLUSIONS AND RECOMMENDATIONS

12.1 Geoenvironmental assessment

The results of the GQRA for the site have indicated that any pollutant linkages to end users identified as part of the preliminary risk assessment are unlikely to exist following the potential redevelopment of the site. This is due to the fact that the proposed development will essentially either wholly remove the made ground soils from the site as part of the planned basement excavation or alternatively maintain the current encapsulation of soils beneath hardstanding or buildings. Therefore, the associated risks to end users of the main site are considered to be low.

The conceptual model and results of initial ground gas monitoring conducted on site indicate Characteristic Situation 1, for which no gas protection measures are required on site.

It is possible that ground works could encounter different conditions from those revealed by the site investigation. It is therefore recommended that the ground works be monitored for previously undetected suspect materials and if found appropriate additional testing and advice is sought.

12.2 Reuse of materials and waste

Twelve of the fourteen samples tested are not likely to be classified as hazardous waste. However, two samples from BH1 and WS2 have potentially been classified as hazardous due to elevated pH levels.

To determine whether waste might be classified as inert or non-hazardous waste, WAC testing will need to be undertaken.

WAC testing on a sample from WS3 has indicated that the sample is likely to be classified as Stable Non-reactive Hazardous Waste to be disposed of in a Non-Hazardous Landfill. This is due to elevated levels of Total Organic Carbon (TOC) and Lead, exceeding the threshold for inert waste.

Prospective landfill operatives should be contacted at an early stage to discuss the waste classification of any material destined for off-site disposal and requirements for additional testing.

12.3 Geotechnical assessment

The findings of the ground investigation has proven the presence of a moderate thickness of made ground overlying the London Clay Formation, which was proven to the full depth of investigation of 30.00m below ground level.

Groundwater was generally not encountered during the intrusive investigation, but was recorded at depths ranging between 2.69 to 3.48 m bgl during the post site work monitoring visits, indicating a potential perched groundwater table along the made ground / London Clay Formation interface.

The ground conditions appear suitable for the construction of new piles to support the proposed column loads, alternatively a rafted solution may be adopted.

The design of basement floor slabs will need to consider both heave of the underlying clay soils resulting from unloading due to excavation and groundwater pressures.

Assuming that disturbed ground will be minimised by the use of piled foundations, the recommended ACEC Classification is therefore AC-2s with a Design Sulphate Class of DS-3.

However, it is envisaged that the proposals will include the reuse of the pyritic London Clay Formation, i.e. cutting and filling, or excavation and backfill, as such, the recommended ACEC Classification will increase to AC-3s with a Design Sulphate Class of DS-4.

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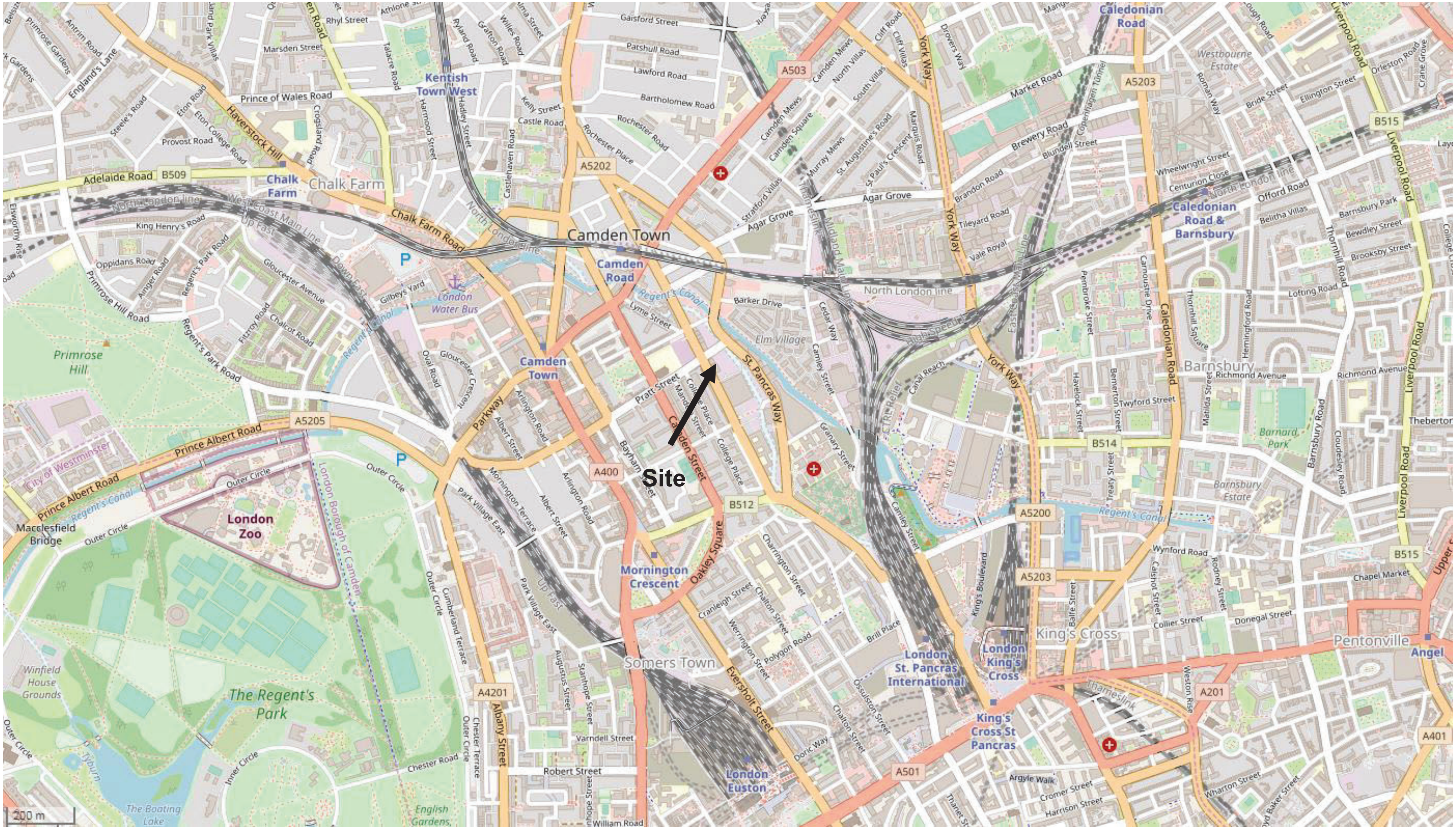
FIGURES



RSK	Site Location Plan	**Client:**	Rocco Ventures Ltd.	**Figure No:**	1
		Site:	60 – 86 Royal College Street, London	**Job No:**	371944
		Scale:	NTS	**Source:**	OpenStreetMap

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Project Title: 60 - 86 ROYAL COLLEGE STREET, LONDON

Drawing Title: EXPLORATORY HOLE LOCATION PLAN

Rev	Drawn	Date	Checked	Date	Approved	Date
01	SA	13.09.19	AT	13.09.19	AT	13.09.19

Scale	Original Size	Project Number	Drawing File	Drawing Number
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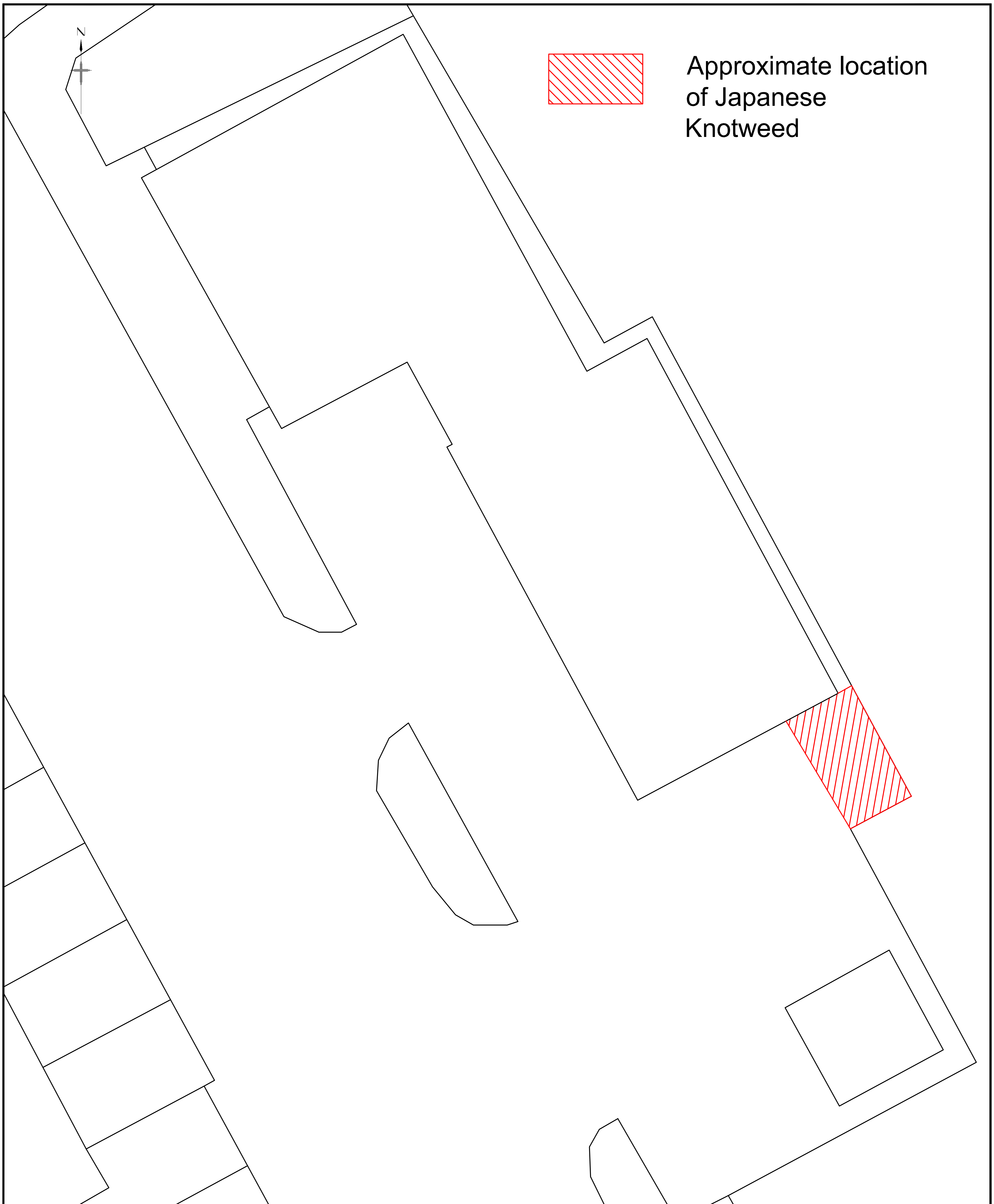

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Client: ROCCO VENTURES LTD.

Project Title: 60 - 86 ROYAL COLLEGE STREET, LONDON

Drawing Title: JAPANESE KNOTWEED LOCATION PLAN

Rev	Drawn	Date	Checked	Date	Approved	Date
01	SA	13.09.19	AT	13.09.19	AT	13.09.19

Scale	Original Size	Project Number	Drawing File	Drawing Number
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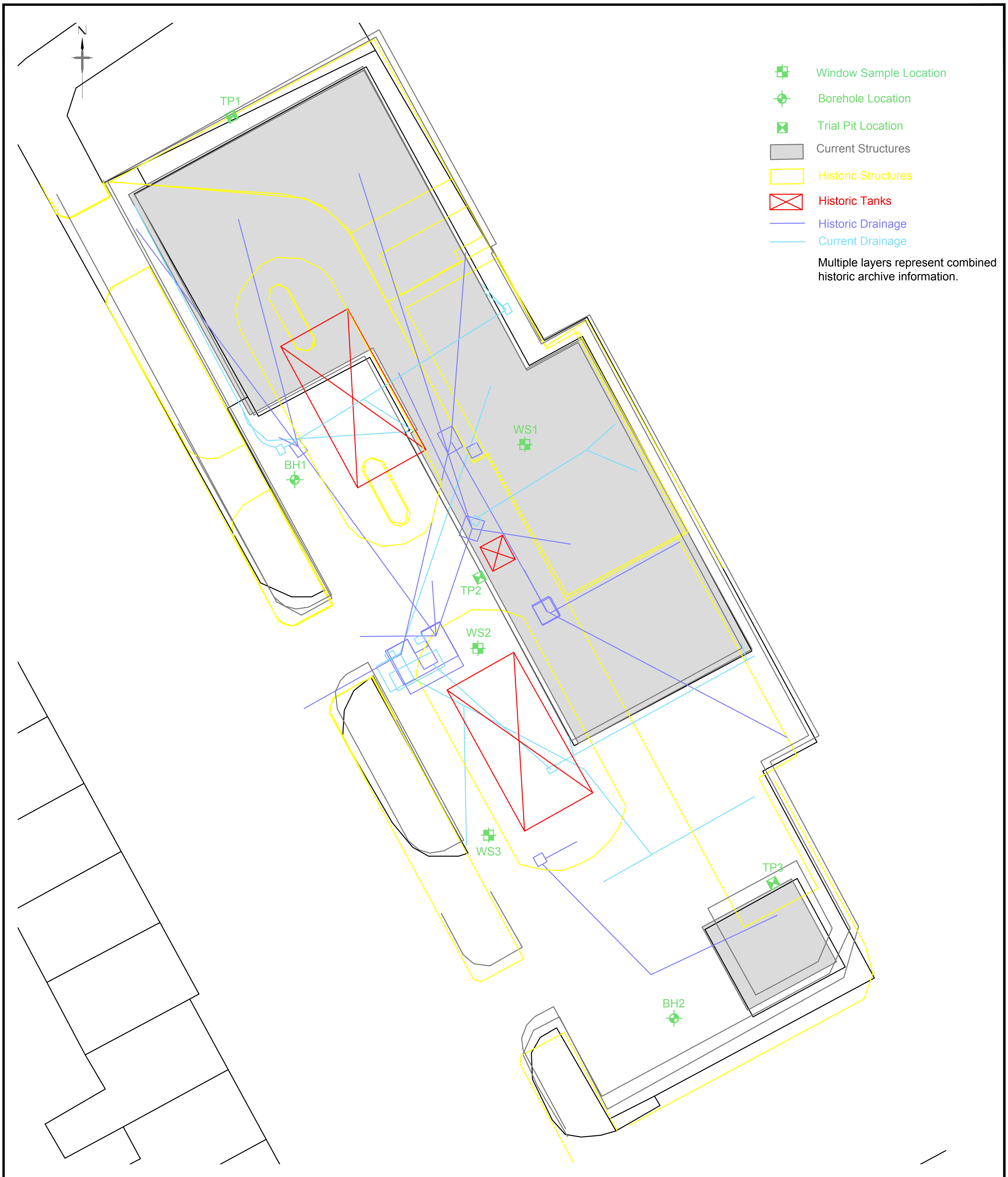

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Client: ROCCO VENTURES LTD.

Project Title: 60 - 86 ROYAL COLLEGE STREET, LONDON

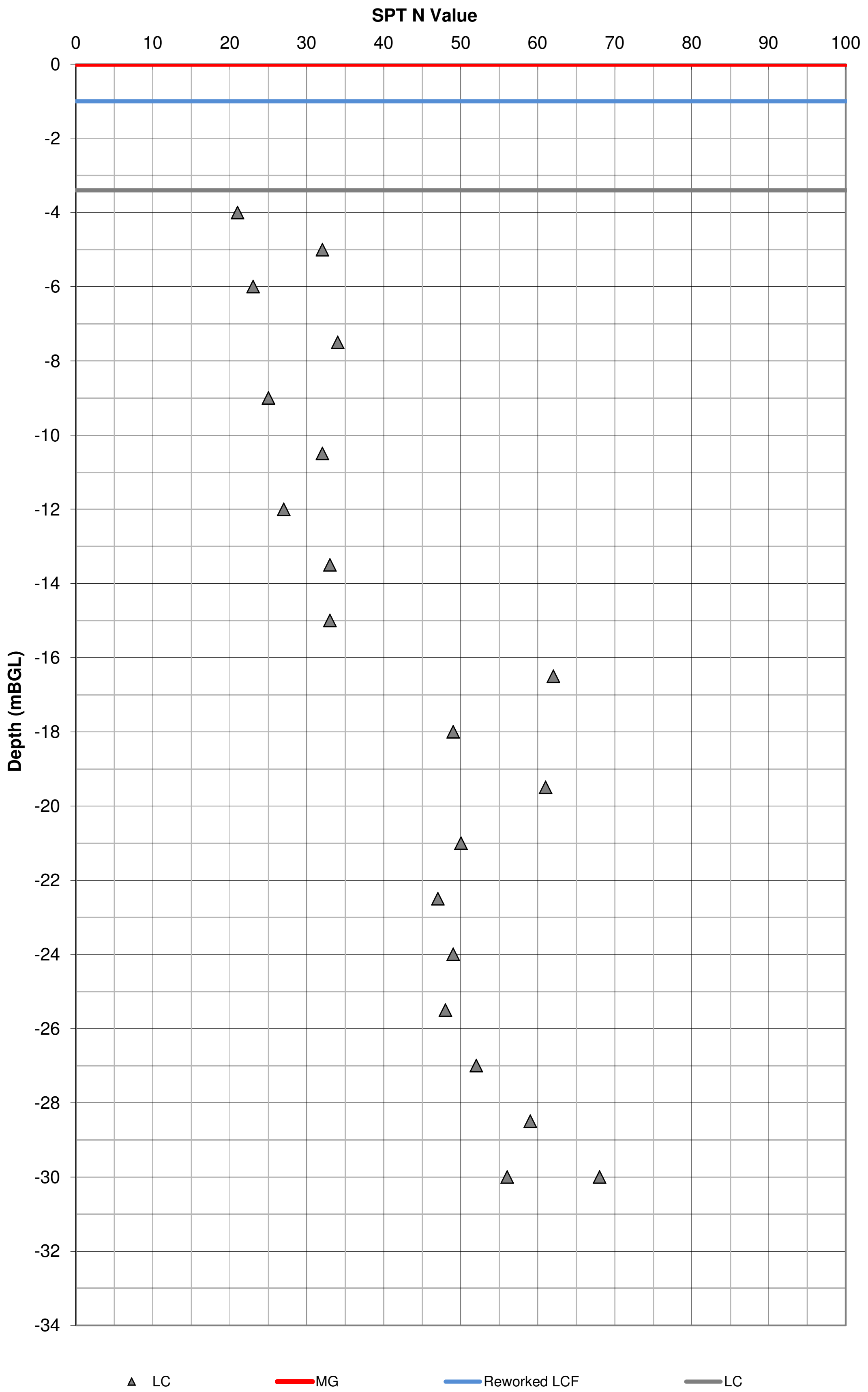
Drawing Title: POTENTIAL SOURCES OF CONTAMINATION PLAN

Rev	Drawn	Date	Checked	Date	Approved	Date
01	SA	13.09.19	AT	20.09.19	AT	20.09.19

Scale	Original Size	Project Number	Drawing File	Drawing Number
NTS	A3	371944 01 (00)	Fig 4 - PSCP.dwg	FIGURE 4

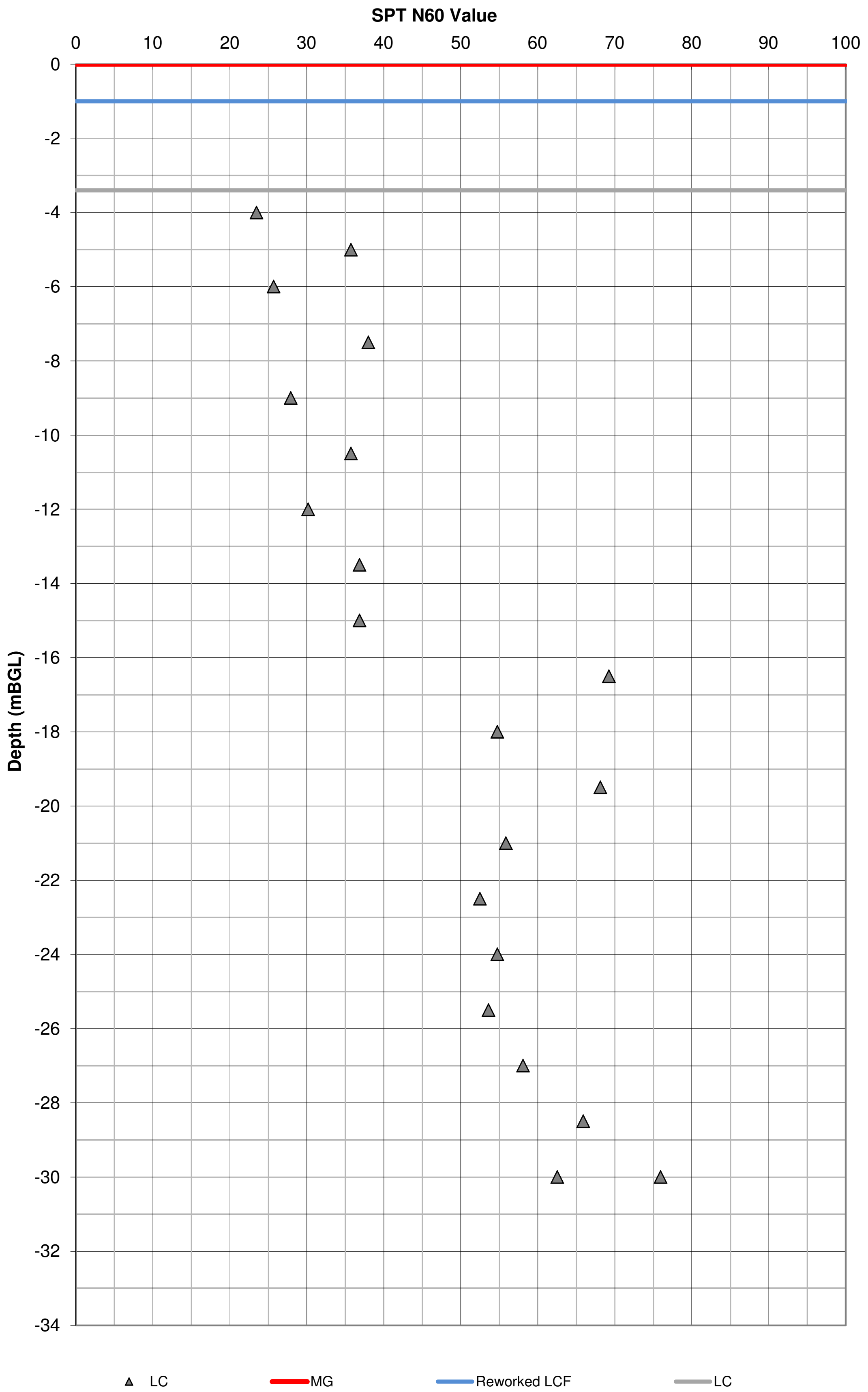
SPT N VALUE vs DEPTH

Site:	Client:	Job Number:	371944
60-86 Royal College Street	Rocco Ventures Ltd.	Figure	5

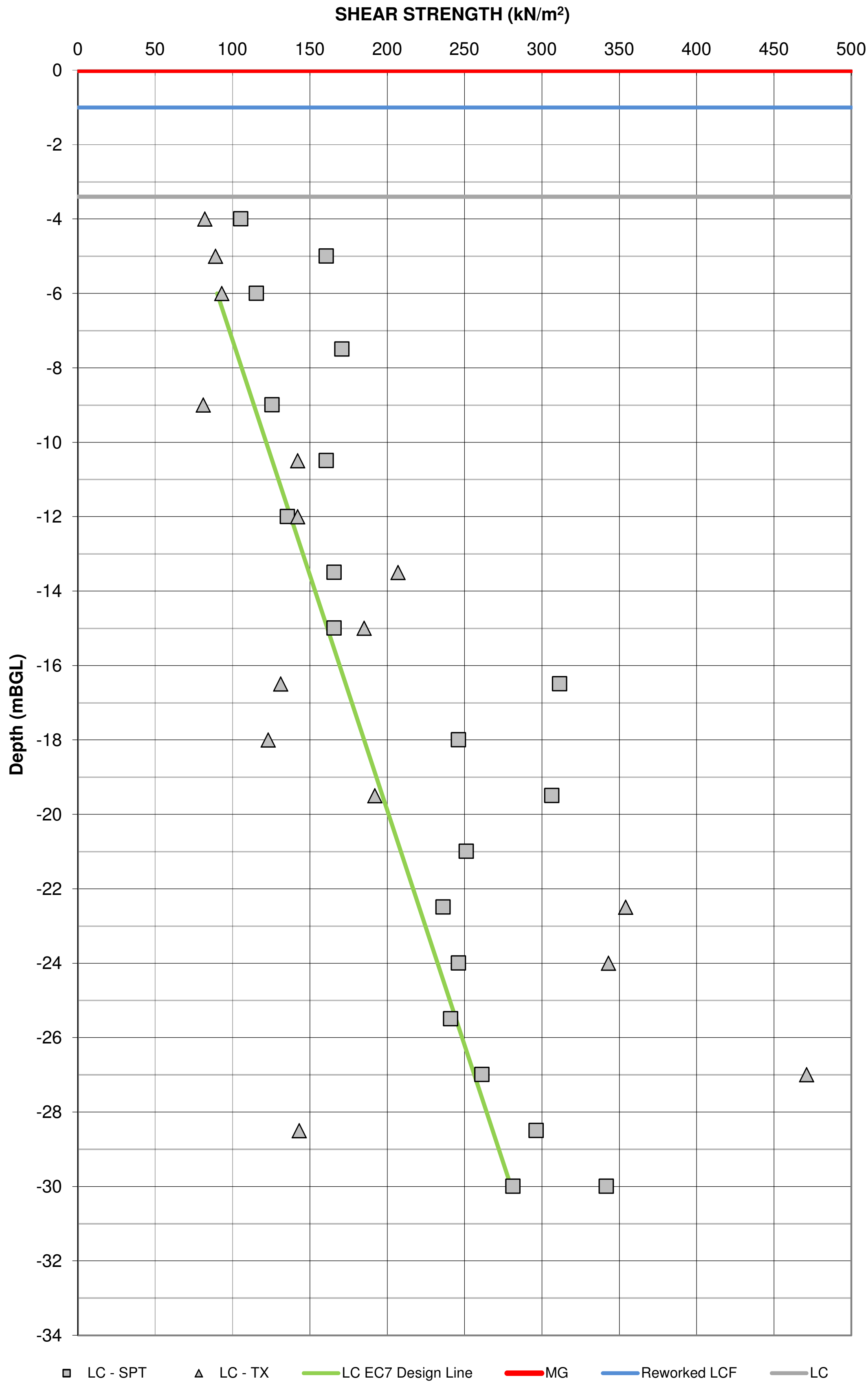


SPT N60 VALUE vs DEPTH

Site:	Client:	Job Number:	371944
60-86 Royal College Street	Rocco Ventures Ltd.	Figure	6



RSK	SHEAR STRENGTH vs DEPTH		
Site: 60-86 Royal College Street	**Client:** Rocco Ventures Ltd.	**Job Number:**	371944
		Figure	7



APPENDIX A
SERVICE CONSTRAINTS

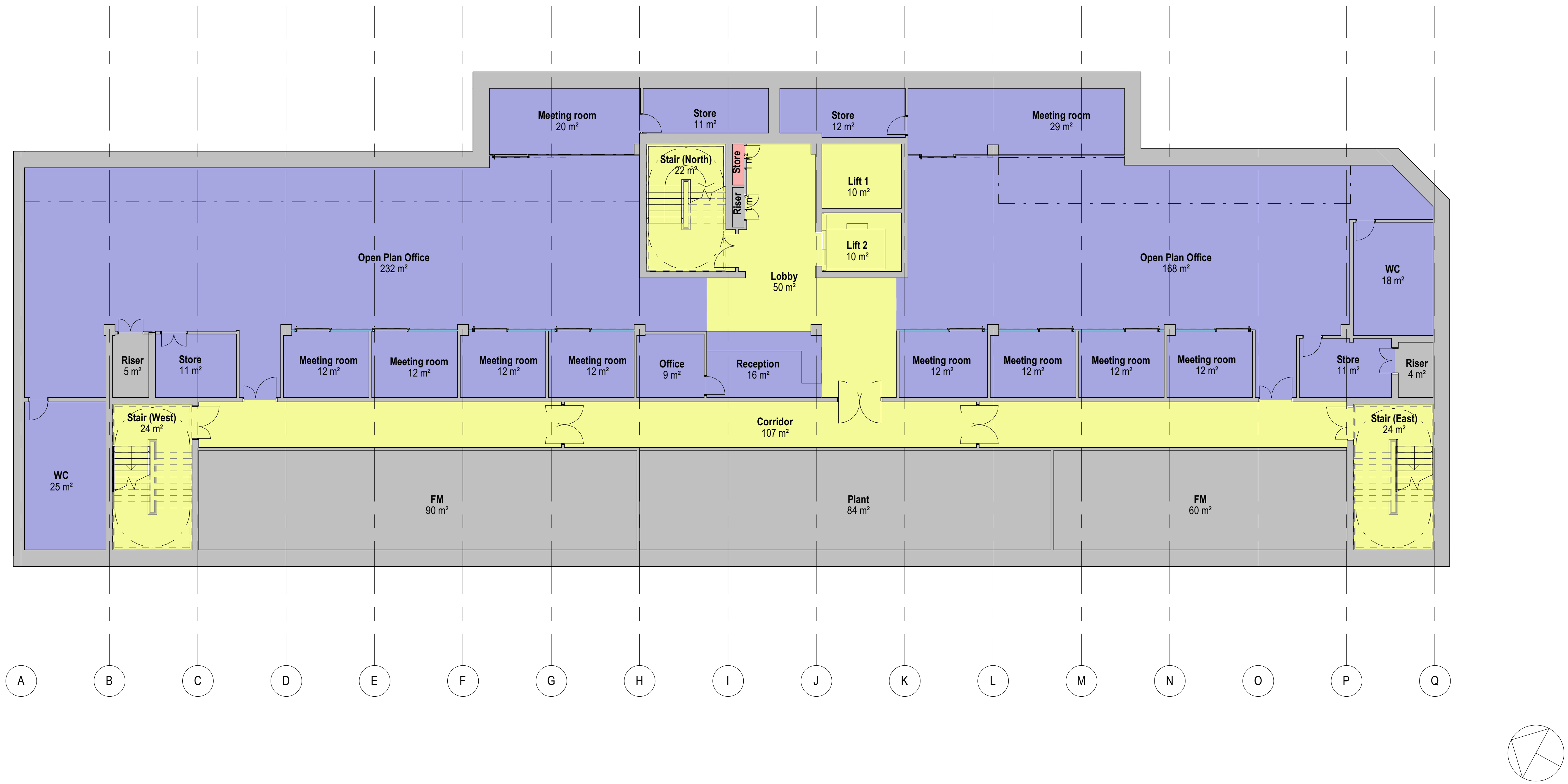
1. This report and the site investigation carried out in connection with the report (together the "Services") were compiled and carried out by RSK Environment Limited (RSK) for Heyne Tillett Steel on behalf of Rocco Ventures Limited (the "client") in accordance with the terms of a contract [RSK Group Standard Terms and Conditions] between RSK and the "client", dated 28th June 2019.. The Services were performed by RSK with the skill and care ordinarily exercised by a reasonable environmental consultant at the time the Services were performed. Further, and in particular, the Services were performed by RSK taking into account the limits of the scope of works required by the client, the time scale involved and the resources, including financial and manpower resources, agreed between RSK and the client.
2. Other than that, expressly contained in paragraph 1 above, RSK provides no other representation or warranty whether express or implied, in relation to the Services.
3. Unless otherwise agreed in writing the Services were performed by RSK exclusively for the purposes of the client. RSK is not aware of any interest of or reliance by any party other than the client in or on the Services. Unless expressly provided in writing, RSK does not authorise, consent or condone any party other than the client relying upon the Services. Should this report or any part of this report, or otherwise details of the Services or any part of the Services be made known to any such party, and such party relies thereon that party does so wholly at its own and sole risk and RSK disclaims any liability to such parties. Any such party would be well advised to seek independent advice from a competent environmental consultant and/or lawyer.
4. It is RSK's understanding that this report is to be used for the purpose described in the introduction to the report. That purpose was a significant factor in determining the scope and level of the Services. Should the purpose for which the report is used, or the proposed use of the site change, this report may no longer be valid and any further use of or reliance upon the report in those circumstances by the client without RSK 's review and advice shall be at the client's sole and own risk. Should RSK be requested to review the report after the date of this report, RSK shall be entitled to additional payment at the then existing rates or such other terms as agreed between RSK and the client.
5. The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable. The information and conclusions contained in this report should not be relied upon in the future without the written advice of RSK. In the absence of such written advice of RSK, reliance on the report in the future shall be at the client's own and sole risk. Should RSK be requested to review the report in the future, RSK shall be entitled to additional payment at the then existing rate or such other terms as may be agreed between RSK and the client.
6. The observations and conclusions described in this report are based solely upon the Services which were provided pursuant to the agreement between the client and RSK. RSK has not performed any observations, investigations, studies or testing not specifically set out or required by the contract between the client and RSK. RSK is not liable for the existence of any condition, the discovery of which would require performance of services not otherwise contained in the Services. For the avoidance of doubt, unless otherwise expressly referred to in the introduction to this report, RSK did not seek to evaluate the presence on or off the site of asbestos, invasive plants, electromagnetic fields, lead paint, heavy metals, radon gas or other radioactive or hazardous materials, unless specifically identified in the Services.
7. The Services are based upon RSK's observations of existing physical conditions at the Site gained from a visual inspection of the site together with RSK's interpretation of information, including documentation, obtained from third parties and from the client on the history and usage of the site, unless specifically identified in the Services or accreditation system (such as UKAS ISO 17020:2012 clause 7.1.6):
    a. the Services were based on information and/or analysis provided by independent testing and information services or laboratories upon which RSK was reasonably entitled to rely
    b. the Services were limited by the accuracy of the information, including documentation, reviewed by RSK and the observations possible at the time of the visual inspection
    c. the Services did not attempt to independently verify the accuracy or completeness of information, documentation or materials received from the client or third parties, including laboratories and information services, during the performance of the Services.

    RSK is not liable for any inaccurate information or conclusions, the discovery of which inaccuracies required the doing of any act including the gathering of any information which was not reasonably available to RSK and including the doing of any independent investigation of the information provided to RSK save as otherwise provided in the terms of the contract between the client and RSK.

8. The intrusive environmental site investigation aspects of the Services is a limited sampling of the site at pre-determined locations based on the known historic / operational configuration of the site. The conclusions given in this report are based on information gathered at the specific test locations and can only be extrapolated to an undefined limited area around those locations. The extent of the limited area depends on the properties of the materials adjacent and local conditions, together with the position of any current structures and underground utilities and facilities, and natural and other activities on-site. In addition, chemical analysis was carried out for a limited number of parameters [as stipulated in the contract between the client and RSK] [based on an understanding of the available operational and historical information,] and it should not be inferred that other chemical species are not present.

9. Any site drawing(s) provided in this report is (are) not meant to be an accurate base plan, but is (are) used to present the general relative locations of features on, and surrounding, the site. Features (intrusive and sample locations etc) annotated on-site plans are not drawn to scale but are centred over the approximate location. Such features should not be used for setting out and should be considered indicative only.

APPENDIX B
DEVELOPMENT DRAWINGS



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DRAWINGS SHALL BE READ IN CONJUNCTION WITH THE FOLLOWING BEFORE WORK COMMENCES:

- THE CDM DESIGN ISSUES REGISTER
- THE BDP RISK SERIES OF DRAWINGS
- THE PROJECT CDM RISK REGISTER

NOTES

- Comms. Space
- Office Zone
- Outpatient
- Plant / FM

REVISION	DESCRIPTION	DRAWN	CHECKED	DATE

REVISION	DESCRIPTION	DRAWN	CHECKED	DATE

CLIENT

Rocco Ventures Ltd

BDP.

3 St Paul's Place
129 Norfolk Street
Sheffield
S1 2JE
United Kingdom

T +44 [0]114 273 1641
www.bdp.com

PROJECT TITLE
Royal College Street, London

NUMBER
P3000358

ISO ... FICATION
C...me... In ...idence

WIP

Lower Ground Plan

SCALE
@ A3
1 : 200

DATE FIRST ISSUED
14/08/19

DRAWING No.
RCS-BDP-01-LG-DR-A-ZZ_70_60-0000-S0-P01

REVISION
XX

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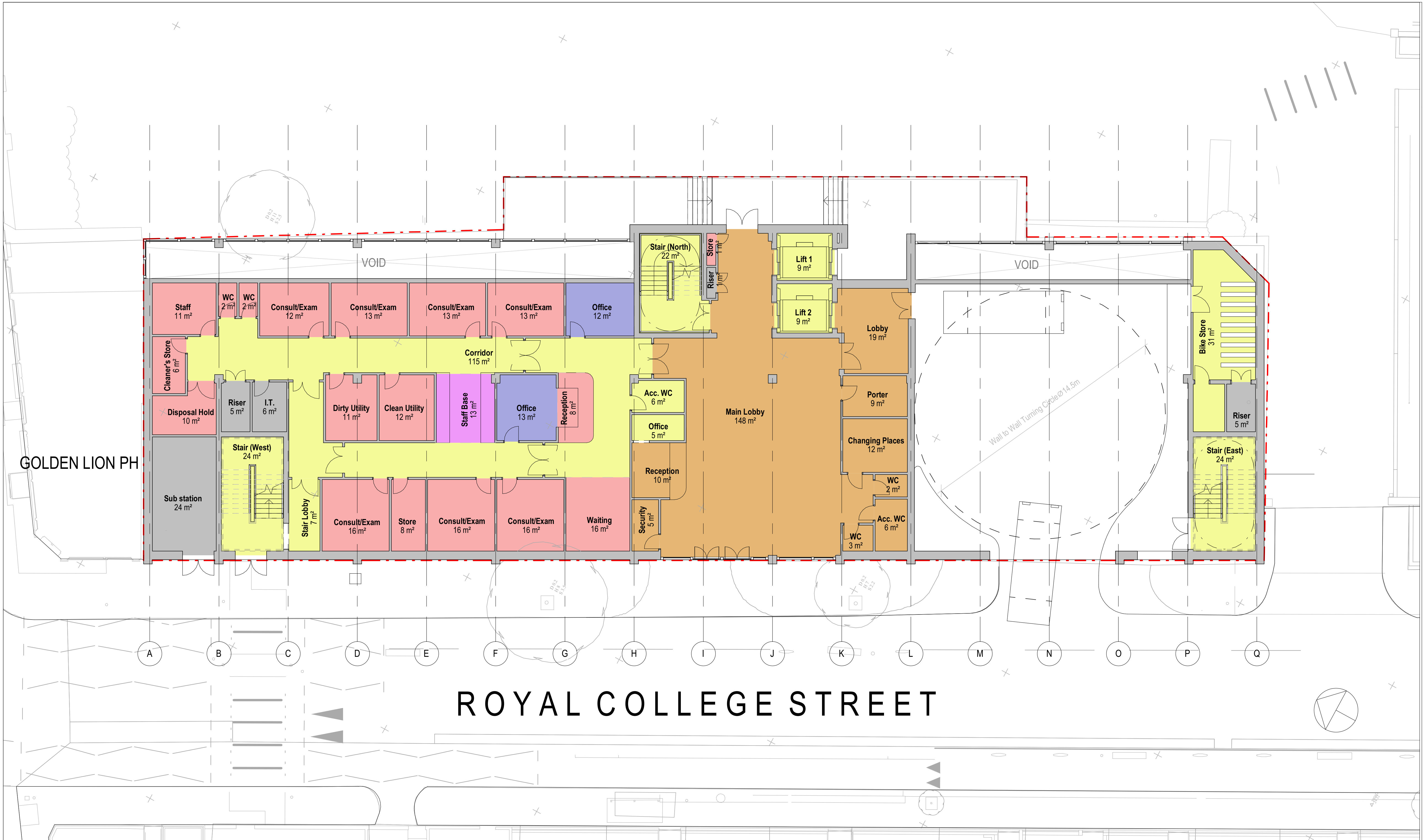

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NOTES

- Comms. Space
- Main Entrance Zone
- Office Zone
- Outpatient
- Plant / FM
- Staff Zone

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PROJECT TITLE
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WIP

P3000358 — Comme... In ...idence

Ground Floor Plan

SCALE @ A3
1 : 200

DATE FIRST ISSUED
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NOTES

- Comms. Space
- Inpatient
- Office Zone
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- Staff Zone

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First Floor Plan

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NOTES

- Comms. Space
- Inpatient
- Office Zone
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- Staff Zone

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WIP

P3000358

Second Floor

SCALE
@ A3
1 : 200

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NOTES

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- Inpatient
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www.bdp.com

PROJECT TITLE
Royal College Street, London

NUMBER: P3000358
ISO ... FICATION: ... me ... In ... idence

Third Floor

WIP

SCALE @ A3
1 : 200

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14/08/19

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RCS-BDP-01-03-DR-A-ZZ_70_60-0000-S0-P01

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NOTES

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- Inpatient
- Office Zone
- Plant / FM
- Staff Zone

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United Kingdom

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PROJECT TITLE
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NUMBER
P3000358

ISO ... FICATION
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Fourth Floor

SCALE
@ A3
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RCS-BDP-01-04-DR-A-ZZ_70_60-0000-S0-P01

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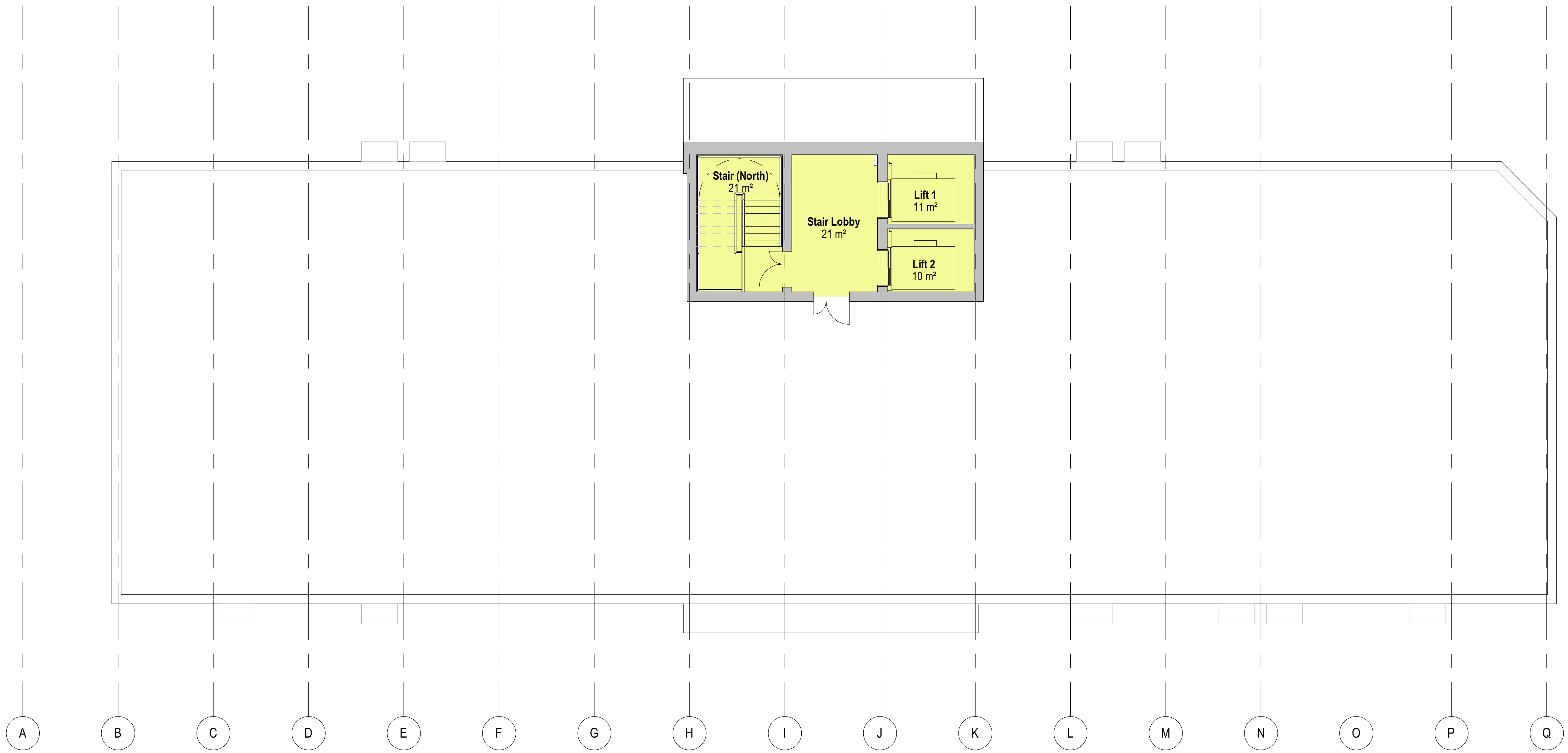

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- THE BDP RISK SERIES OF DRAWINGS
- THE PROJECT CDM RISK REGISTER

NOTES

Comms. Space

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REVISION	DESCRIPTION	DRAWN	CHECKED	DATE

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United Kingdom

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BDP.

WIP

PROJECT TITLE
Royal College Street, London

P3000358 Comme In idence

Roof

SCALE
@ A3
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14/08/19

DRAWING No.
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APPENDIX C
SUMMARY OF LEGISLATION AND POLICY RELATING TO CONTAMINATED LAND

Part IIA of the Environmental Protection Act 1990

Part IIA of the Environmental Protection Act 1990 (Part IIA) and its associated Contaminated Land Regulations 2000 (SI 2000/227), which came into force in England on 1 April 2000, formed the basis for the current regulatory framework and the statutory regime for the identification and remediation of contaminated land. Part IIA of the EPA 1990 defines contaminated land as 'any land which appears to the Local Authority in whose area it is situated to be in such a condition by reason of substances in, on or under the land, that significant harm is being caused, or that there is significant possibility of significant harm being caused, or that pollution of controlled waters is being or is likely to be caused'. Controlled waters are considered to include all groundwater, inland waters and estuaries.

In August 2006, the Contaminated Land (England) Regulations 2006 (SI 2006/1380) were implemented, which extended the statutory regime to include Part IIA of the EPA as originally introduced on 1 April 2000, together with changes intended chiefly to address land that is contaminated by virtue of radioactivity. These have been replaced subsequently by the Contaminated Land (England) (Amendment) Regulations 2012, which now exclude land that is contaminated by virtue of radioactivity.

The intention of Part IIA is to deal with contaminated land issues that are considered to cause significant harm on land that is not undergoing development (see Environmental Protection Act 1990: Part 2A Contaminated Land Statutory Guidance, April 2012). This document replaces Annex III of Defra Circular 01/2006, published in September 2006 (the remainder of this document is now obsolete).

Planning Policy

Contaminated land is often dealt with through planning because of land redevelopment. This approach was documented in Planning Policy Statement: Planning and Pollution Control PPS23, which states that it remains the responsibility of the landowner and developer to identify land affected by contamination and carry out sufficient remediation to render the land suitable for use. PPS23 was withdrawn early in 2012 and has been replaced by much reduced guidance within the National Planning Policy Framework (NPPF), reference ISBN: 978-1-5286-1033-9, February 2019.

The new framework has only limited guidance on contaminated land, as follows:

Chapter 11. Making effective use of land

117 Planning policies and decisions should promote an effective use of land in meeting the need for homes and other uses, while safeguarding and improving the environment and ensuring safe and healthy living conditions. Strategic policies should set out a clear strategy for accommodating objectively assessed needs, in a way that makes as much use as possible of previously-developed or 'brownfield' land.

118. Planning policies and decisions should:

c) give substantial weight to the value of using suitable brownfield land within settlements for homes and other identified needs, and support appropriate opportunities to remediate despoiled, degraded, derelict, contaminated or unstable land.

Chapter 15. Conserving and enhancing the natural environment

170. Planning policies and decisions should contribute to and enhance the natural and local environment by:

e) preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability. Development should, wherever possible, help to improve local environmental conditions such as air and water quality, taking into account relevant information such as river basin management plans; and

f) remediating and mitigating despoiled, degraded, derelict, contaminated and unstable land, where appropriate.

Ground conditions and pollution

178. Planning policies and decisions should ensure that:

a) a site is suitable for its proposed use taking account of ground conditions and any risks arising from land instability and contamination. This includes risks arising from natural hazards or former activities such as mining, and any proposals for mitigation including land remediation (as well as potential impacts on the natural environment arising from that remediation);

b) after remediation, as a minimum, land should not be capable of being determined as contaminated land under Part 2A of the Environmental Protection Act 1990; and

c) adequate site investigation information, prepared by a competent person, is available to inform these assessments.

179. Where a site is affected by contamination or land stability issues, responsibility for securing a safe development rests with the developer and/or landowner.

Water Resources Act (WRA)

The Water Resources Act 1991 (Amendment) (England and Wales) Regulations 2009 updated the Water Resources Act 1991, which introduced the offence of causing or knowingly permitting pollution of controlled waters. The Act provides the Environment Agency with powers to implement remediation necessary to protect controlled waters and recover all reasonable costs of doing so.

Water Framework Directive (WFD)

The Water Framework Directive 2000/60/EC is designed to:

- enhance the status and prevent further deterioration of aquatic ecosystems and associated wetlands that depend on the aquatic ecosystems
- promote the sustainable use of water
- reduce pollution of water, especially by ‘priority’ and ‘priority hazardous’ substances

- ensure progressive reduction of groundwater pollution.

The WFD requires a management plan for each river basin be developed every six years.

Groundwater Directive (GWD)

The 1980 Groundwater Directive 80/68/EEC and the 2006 Groundwater Daughter Directive 2006/118/EC of the WFD are the main European legislation in place to protect groundwater. The 1980 Directive is due to be repealed in December 2013. The European legislation has been transposed into national legislation by regulations and directions to the Environment Agency.

Priority Substances Directive (PSD)

The Priority Substances Directive 2008/105/EC is a 'Daughter' Directive of the WFD, which sets out a priority list of substances posing a threat to or via the aquatic environment. The PSD establishes environmental quality standards for priority substances, which have been set at concentrations that are safe for the aquatic environment and for human health. In addition, there is a further aim of reducing (or eliminating) pollution of surface water (rivers, lakes, estuaries and coastal waters) by pollutants on the list. The WFD requires that countries establish a list of dangerous substances that are being discharged and EQS for them. In England and Wales, this list is provided in the River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. In order to achieve the objectives of the WFD, classification schemes are used to describe where the water environment is of good quality and where it may require improvement.

Environmental Permitting Regulations (EPR)

The Environmental Permitting (England and Wales) Regulations 2016 (as amended) provide a single regulatory framework that streamlines and integrates waste management licensing, pollution prevention and control, water discharge consenting, groundwater authorisations, and radioactive substances regulation. Schedule 22, paragraph 6 of EPR 2016 states: 'the regulator must, in exercising its relevant functions, take all necessary measures - (a) to prevent the input of any hazardous substance to groundwater; and (b) to limit the input of non-hazardous pollutants to groundwater so as to ensure that such inputs do not cause pollution of groundwater.'

Notes:

1. *The above information is provided for background but does not constitute site-specific advice*
2. *The above summary applies to England only. Variations exist within other countries of the United Kingdom*

APPENDIX D
ENVIRONMENTAL DATABASE REPORT

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Site Details:

Client Ref: EMS_557620_749524
Report Ref: EMS-557620_749524
Grid Ref: 529396, 183863

Map Name: 1056 Scale Town Plan

Map date: **1873**

Scale: 1:1,056

Printed at: 1:1,056

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Surveyed 1870
Revised N/A
Edition 1873
Copyright N/A
Levelled N/A

Surveyed 1870
Revised N/A
Edition 1873
Copyright N/A
Levelled N/A

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Map legend available at:
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Site Details:

Client Ref: EMS_557620_749524
Report Ref: EMS-557620_749524
Grid Ref: 529396, 183863

Map Name: 1056 Scale Town Plan

Map date: **1873**

Scale: 1:1,056

Printed at: 1:1,056

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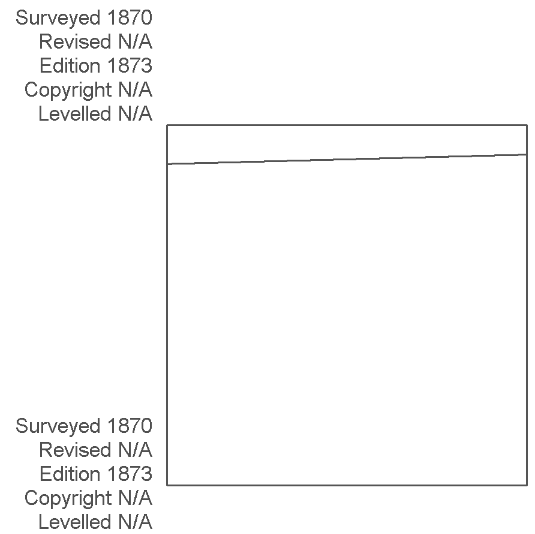

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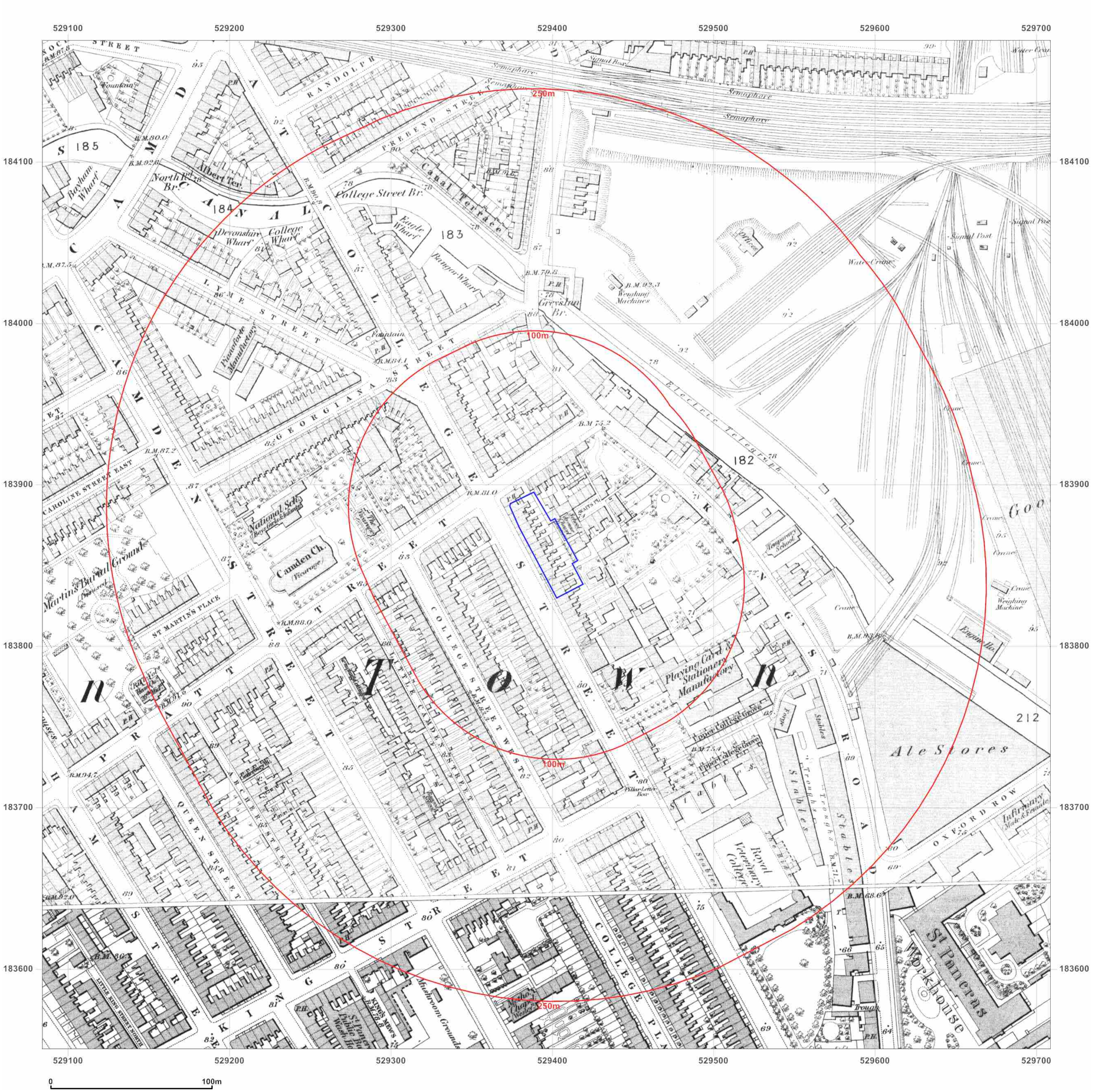

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Site Details:

Client Ref: EMS_557620_749524
Report Ref: EMS-557620_749524
Grid Ref: 529396, 183863

Map Name: County Series

Map date: **1876-1879**

Scale: 1:2,500

Printed at: 1:2,500

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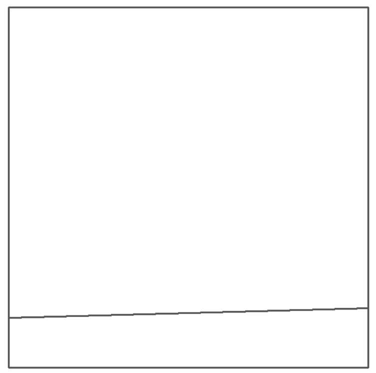
Surveyed 1870
Revised N/A
Edition 1879
Copyright N/A
Levelled N/A



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Edition 1876
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Site Details:

Client Ref: EMS_557620_749524
Report Ref: EMS-557620_749524
Grid Ref: 529396, 183863

Map Name: 1056 Scale Town Plan

Map date: **1896**

Scale: 1:1,056

Printed at: 1:1,056

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Revised N/A
Edition 1896
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Levelled N/A

Surveyed 1894
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Edition 1896
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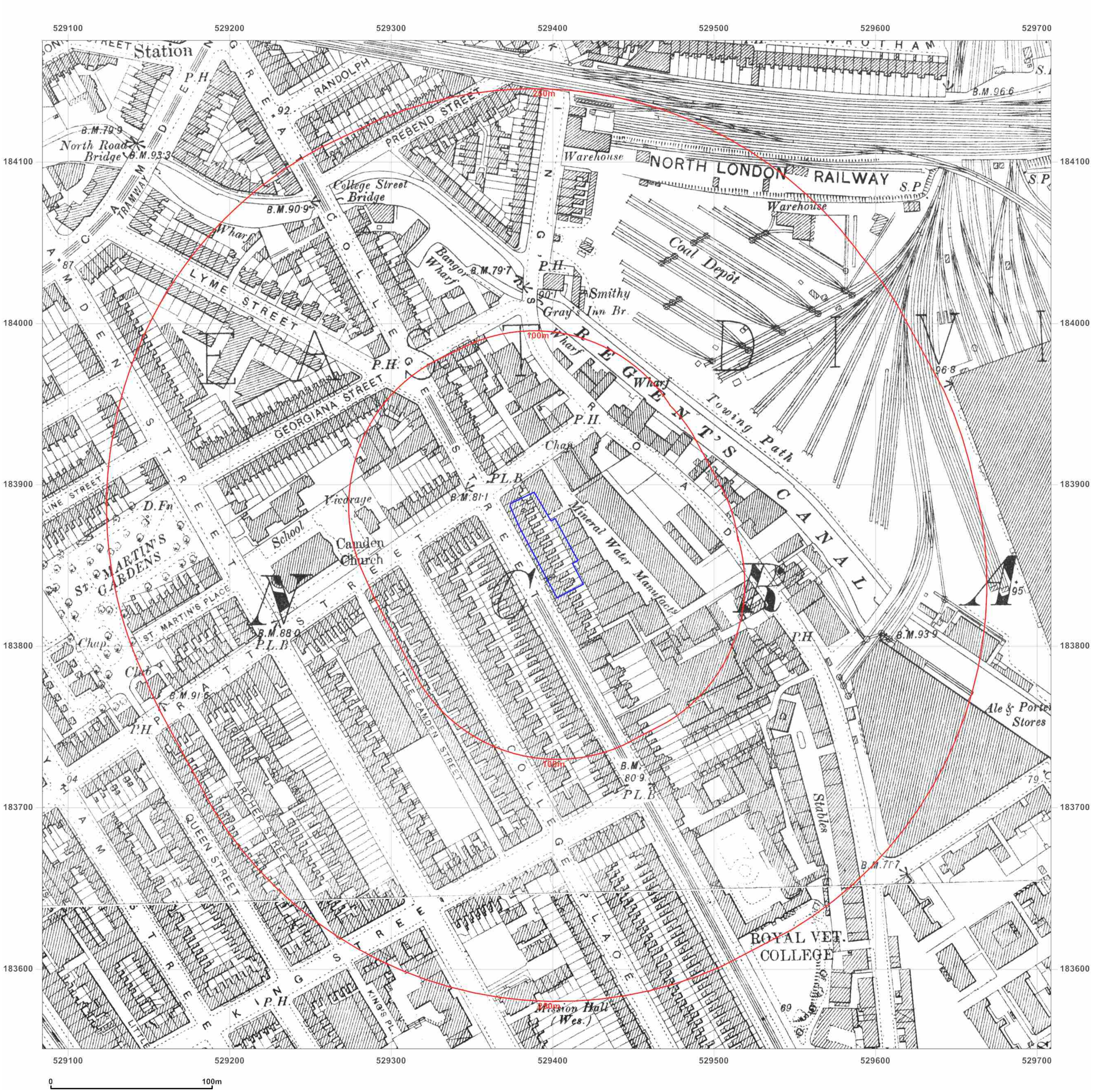

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Site Details:

Client Ref: EMS_557620_749524
Report Ref: EMS-557620_749524
Grid Ref: 529396, 183863

Map Name: County Series

Map date: **1896**

Scale: 1:2,500

Printed at: 1:2,500

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Revised 1896
Edition N/A
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Levelled N/A

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Revised 1896
Edition N/A
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Levelled N/A

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Report Ref: EMS-557620_749524
Grid Ref: 529396, 183863

Map Name: County Series

Map date: 1916

Scale: 1:2,500

Printed at: 1:2,500

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Surveyed 1916
Revised 1916
Edition N/A
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Surveyed 1916
Revised 1916
Edition N/A
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Report Ref: EMS-557620_749524
Grid Ref: 529396, 183863

Map Name: National Grid

Map date: **1951-1952**

Scale: 1:1,250

Printed at: 1:2,000

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Surveyed 1951 Revised 1951 Edition N/A Copyright N/A Levelled 1934	Surveyed 1951 Revised 1951 Edition N/A Copyright N/A Levelled 1934

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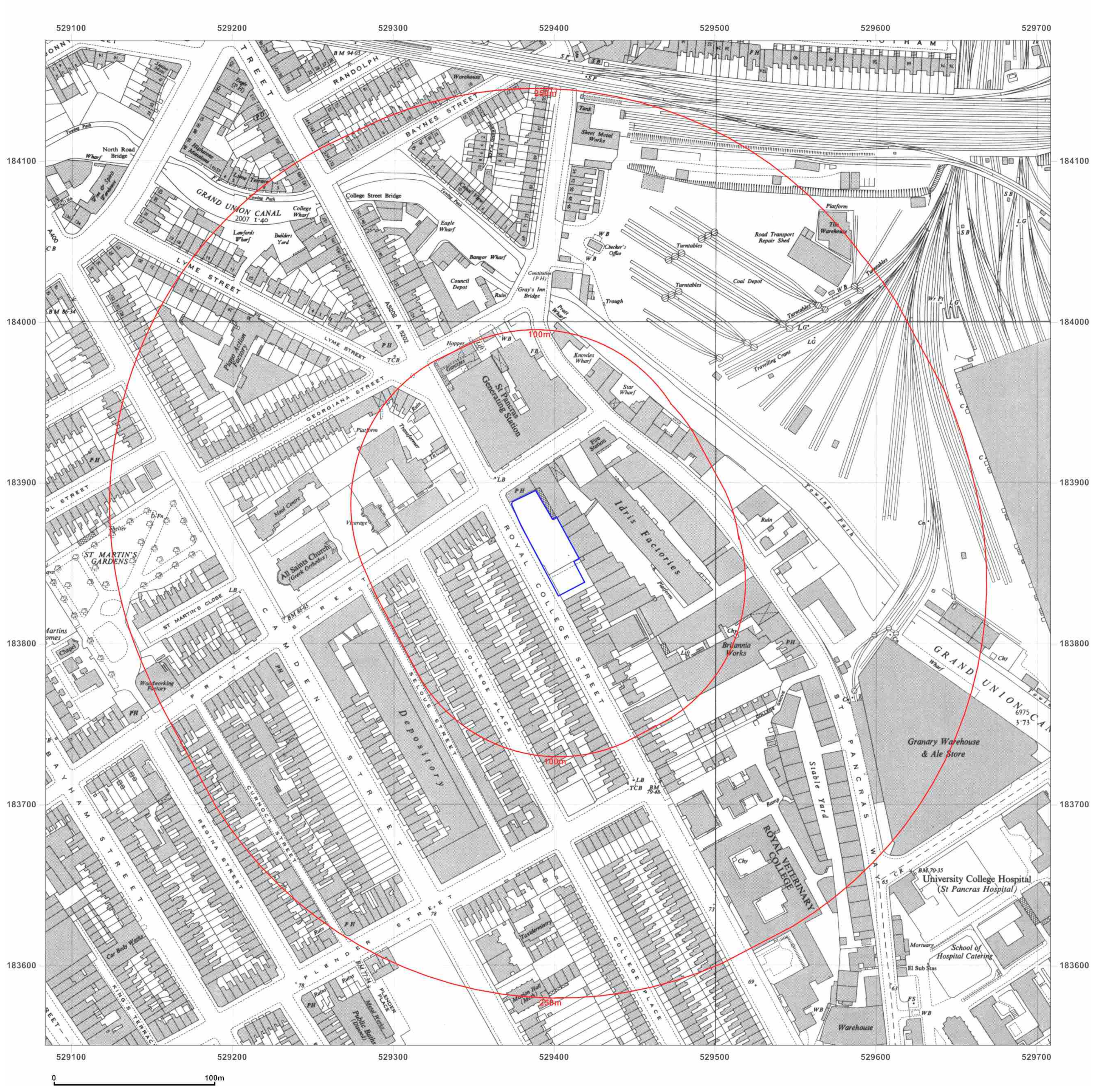
Production date: 25 July 2019

Map legend available at:
www.groundsure.com/sites/default/files/groundsure_legend.pdf



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Site Details:

Client Ref: EMS_557620_749524
Report Ref: EMS-557620_749524
Grid Ref: 529396, 183863

Map Name: National Grid

Map date: **1952**

Scale: 1:2,500

Printed at: 1:2,500

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Surveyed 1952
Revised 1952
Edition 1954
Copyright N/A
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Surveyed 1952
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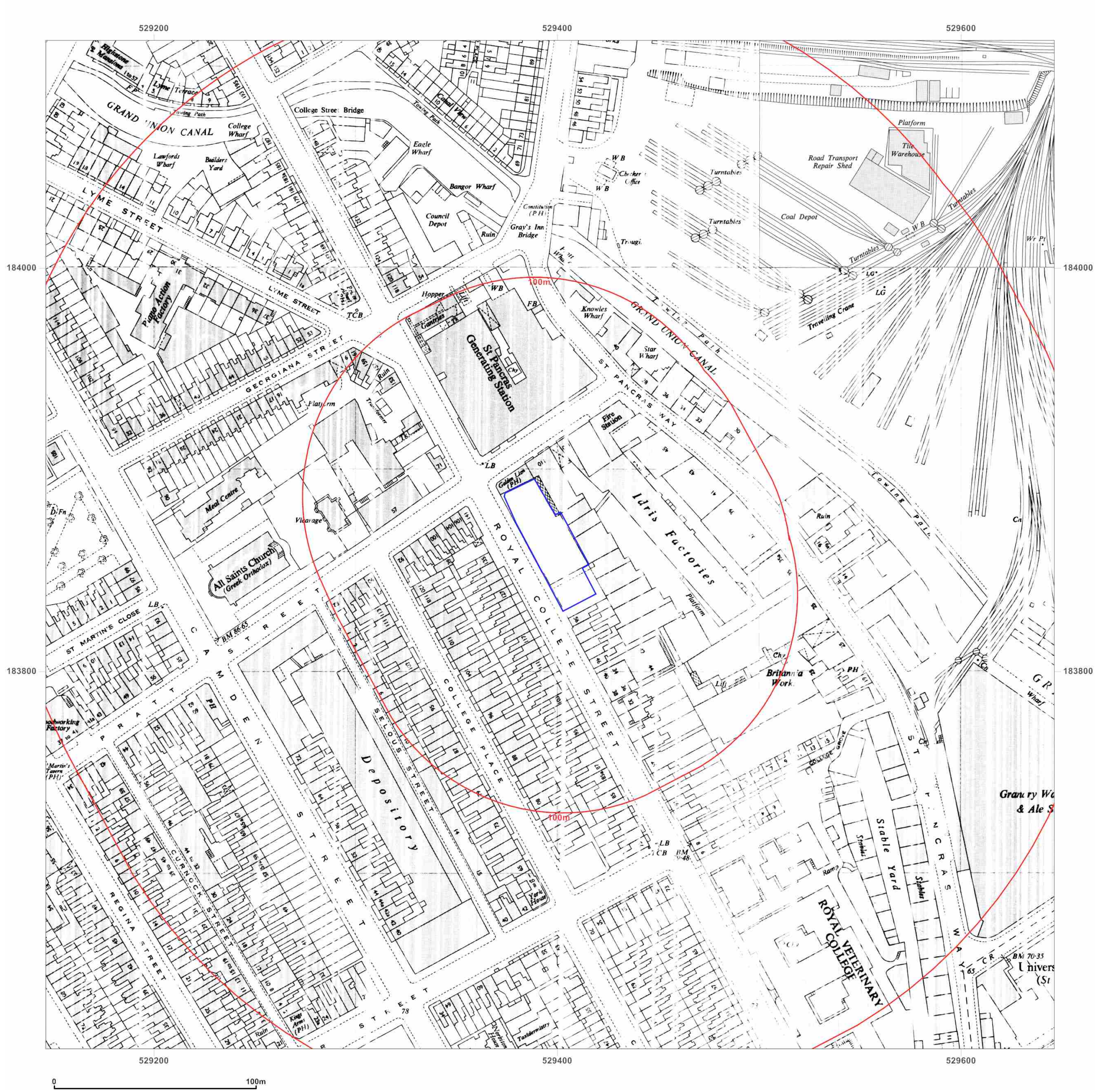

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Site Details:

Client Ref: EMS_557620_749524
Report Ref: EMS-557620_749524
Grid Ref: 529396, 183863

Map Name: National Grid

Map date: **1952-1953**

Scale: 1:1,250

Printed at: 1:2,000

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