GREAT ORMOND STREET HOSPITAL
P22 IMRI PROJECT, LONDON

VOLUME 1

PHASE I GEOENVIRONMENTAL DESK STUDY
PRELIMINARY RISK ASSESSMENT

Report No E8013-18-1

March 2018

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1 INTRODUCTION

In January 2018 SOCOTEC UK Ltd was commissioned by Kier Construction Ltd (Kier) to carry out a geoenvironmental Desk Study at Southwood Courtyard, wtithin Great Ormond Street Hospital London, as part of the P22 iMRI project. This was required to obtain preliminary geotechnical and geoenvironmental information for a proposed new 3 storey building to provide healthcare space for Great Ormond Street Hospital.

This desk study has been prepared in broadly accordance with British Standards BS5930:2015 and BS10175:2011+A2:2017 and all normative references, including Environment Agency guidance report CLR 11, *Model Procedures for the Management of Land Contamination.* A site walkover was undertaken on the 25th January

The desk study presents and discusses the available data obtained for the site and surrounding area regarding its physical, historical and environmental setting. It identifies the potential issues at the site, develops an initial conceptual site model (CSM) for geoenvironmental considerations and provides an assessment of geotechnical aspects and other pertinent ground hazards that could affect the development, including underground services.

The principal objective of this investigation and the context of the CSM developed within this report are to provide an assessment of potential significant risks in order to:

- Conduct a preliminary risk assessment of potential contamination;
- Assess the potential requirements for mitigation or investigation of land contamination to ensure that the proposed development will be 'suitable for use';
- Identify any significant contamination constraints for the project; and
- Give an account of the anticipated ground conditions at the site based upon published geological and hydrogeological information; and,
- Provide an account of any past or historic mining activities, or geological hazards on or near the site which may pose a geotechnical risk to the proposed development.

2 SOURCES OF INFORMATION

The following sources of information have been used in preparation of this report:

- Extracts of available historical Ordnance Survey (OS) maps covering the period from 1871 to 2014 which are presented in Appendix C.
- An Enviro Insight report produced by Groundsure, for an area up to 1 km from the centre of the site which is reproduced in Appendix C. The Enviro Insight report is compiled from a series of environmental information databases maintained by regulatory bodies and various 3rd parties, listed in the back of Appendix D.
- A Geo Insight report produced by Groundsure, for an area up to 1 km from the centre of the site which is reproduced in Appendix D. The Geo Insight report is compiled from a series of geological and mining information databases maintained by regulatory bodies and various 3rd parties, listed in the back of Appendix E. Design and access statement information for the site (supplied by Kier).
- WSP Phase 2B non-intrusive survey of buried services (draft) (supplied by Kier).
- Service information provided by Linesearch.
- Archaeological assessment for the site provided by CgMs.
- Heritage Assessment provided by CgMs.
- Ground Conditions Report provided by Thomasons.
- Unexploded Ordnance Desk Study and Risk Assessment provided by Zetica.
- Contaminated Land enquiry response provided by Camden Council.
- Building Control enquiry response provided by Camden Council.
- Planning Department enquiry response provided by Camden Council.
- Planning Application 2017/3377/P for the proposed development.
- The British Geological Survey (BGS) website.
- A walkover survey conducted on 25 January 2018. The walkover photographs are appended in Appendix B

3 SITE LOCATION AND DESCRIPTION

3.1 Site Location

The P22 iMRI project is within an area of land known as the Southwood Courtyard, within the confines of Great Ormond Street Hospital for Children; and has an approximate centre at National Grid reference TQ 305 820, and a postal address as follows:

Southwood Courtyard,
off Powis Place,
Great Ormond Street Children's Hospital,
Camden,
London
WC1N 3JH

Great Ormond Street Hospital is located in the Bloomsbury area within London Borough of Camden and is located just over 1km south east of Euston Train Station at. A Site Location Plan is included within Appendix A.

3.2 Site Description

A site walkover was undertaken on 25th January 2018 as part of the desk study, and photographs showing the site condition on this date are shown in Appendix B. The site description is summarised below, with further pertinent information observed during the reconnaissance visit presented in Section 3.3. An existing site plan is also included in Appendix A for reference.

The site is roughly rectangular in shape, with approximate dimensions of 30m by 25m, and is generally flat lying with an elevation of approximately 23m AOD. The site's surface is composed of hard standing concrete and macadam, with four drainage gulleys present. Three 2.80m deep light wells are present running alongside the site's perimeter on three sides for the existing Southwood Building, indicating the presence of basement floors.

The courtyard is accessed through Powis Place, off Great Ormond Street and is bound by the Southwood Building of Great Ormond Street Hospital on three sides, the Variety Club Building on to the east and the hospital chapel to the south.
The Southwood Courtyard lies within the great Ormond Street Hospital estate, which itself is within a predominantly commercial and residential area of Camden, including further healthcare facilities, and with some areas of public open space.

3.3 Site Reconnaissance

In addition to the above, the following observations were made during the site reconnaissance.

- The adjacent hospital buildings are of mixed construction ages, ranging from 1875 to 2002; and elevations range from single storey buildings (the chapel) to 15 storey hospital buildings.
- A significant phase of construction / demolition occurred in the 1980s.
- Anecdotal information indicated that the courtyard was used as a car parking area.
- More recently the area housed temporary cabins for construction contractors and storage areas, including gas storage. These have now been removed.
- No chemical/fuel storage tanks were observed on site or in the immediate area;
- Evidence of hydrocarbon staining was observed on the site surface, with a visible sheen present during rainfall events.
- A light tube disposal bin is present on site.
- A surface water drainage system is evident on site, indicated by gulleys and manholes / covers.
- No trees or ecologically important features were identified on site;
- 2.80m deep light wells are located alongside the site on three sides, with (anecdotally) redundant utility services present within them.

4 PROPOSED DEVELOPMENT

It is understood that the proposed development will comprise a new three storey building to provide healthcare space for Great Ormond Street Hospital. The facilities will include physiotherapy and rehabilitation facilities, an iMRI suite and operating theatre. Works include a stair link at second floor level to the Southwood Building, a two storey link to the Variety Club Building, entrance ramps and stairs, a green roof, cycle parking, artificial lighting, plant equipment and associated works. The development is proposed to link to existing services in the area, including drainage.

Proposed development plans are included in Appendix A.

5 PHYSICAL AND HISTORICAL SETTING

5.1 Historical Land Usage

The development of the site and surrounding area has been reviewed by reference to the historical maps, anecdotal information and other information sources and is summarised below and detailed in Table 1.

In summary the site's development history changes as Great Ormond Street Hospital expands, redevelops and modernises, initially located to the south of the site and previously known as The Hospital For Sick Children. The site walkover and historical mapping indicates several construction / demolition and redevelopment phases have occurred on site and in the immediate area.

In 1875 the site was used as landscaped gardens, potentially associated with the hospital, located between properties fronting onto Great Guildford Street to the north and Great Ormond Street to the south until circa. 1895 when hospital structures were constructed on site. Further hospital expansions around the late 1930s to the 1950s led to the demolition of these structures on site and the establishment of the majority of the site's bounds, potentially resulting in the courtyard area seen to the this current day.

No further development occurred onsite until 1994 when Great Ormond Street Hospital was redeveloped and the 1870s chapel was relocated to the south western corner of the courtyard and the new Variety Club Building is built. In 2010 temporary cabins and storage units are positioned within the courtyard, and removed in 2017.

TABLE 1 SUMMARY OF SITE HISTORY

DATE	ON SITE DEVELOPMENT	NEARBY DEVELOPMENT
1871 to 1882	The site is shown as being located within landscaped gardens located between properties fronting onto Great Guildford Street to the north and Great Ormond Street to the south. The gardens appear to be linked to the Hospital for Sick Children, which opened in 1852, and is shown southeast of the site on the corner of Great Ormond Street and Powis Place.	Several healthcare facilities are present in close proximity to the site, including the Homeopathic Hospital, the Foundling Hospital and the National Hospital for the Paralyzed and Epileptic all within 100m of the site. Elsewhere, the surrounding area predominantly comprises undifferentiated residential and light commercial premises. Other nearby land uses include educational facilities, gardens, public open spaces and a Timber yard located adjacent to the site's north-eastern boundary. A drinking fountain is also present approximate 120m north east of the site.

DATE	ON SITE DEVELOPMENT	NEARBY DEVELOPMENT
1895 to 1920	Within the western half of the site, the garden area is longer present, now replaced by buildings due to new construction and expansion of the Hospital for Sick Children. The eastern half of the site is recorded to be relatively unchanged, until 1916, when a fountain is shown.	Residential premises located to the west and northwest of the site have been demolished and replaced with hospital buildings.
1938 to 1958	Further hospital developments has led to demolition of the existing buildings on site and removal of the remaining garden areas, primarily due the construction of the Southwood building , which replaces part of the 1875 hospital buildings and encloses the northern, eastern and western sides of the site. The site is now seen to be in a similar layout as to the present day.	The Timber Yard premises seem to have been moved further east due to hospital developments expanding it's former area. Following the 1958 mapping, the Timber Yard is generically termed as a depot. Print works constructed 100m east of site. Residential properties 30m north of the site are demolished and redeveloped into Nurses Home. In the 1951 mapping, several small scale redevelopment changes are evident in the surrounding area, likely due to bomb damage during World War II. 1958 further expansion of Great Ormond Street hospital on east boundary as the Southwood building is extended.
1966 to 1991	No significant changes to the confines of the site.	Further expansions of the surrounding healthcare facilities are recorded. An extension is constructed onto the Southwood building on the eastern side of the courtyard Print works is now generically labelled as Works until 1974 where it is seen to have been demolished. An unspecified tank is shown approximately 15 southwest of the site between the 1982 and 1994 mapping.
1991 to 1994	Great Ormond Street Hospital main building on the southern boundary of the site is demolished and rebuilt to create the Variety Club Building. The Chapel of St. Christopher (Hospital Chapel), which was located within the confines of the old building frontage, is relocated to the south east corner of the courtyard.	No Significant changes.
1994 to 2017	Courtyard used as a car park facility and used for storage units and temporary cabins.	Redevelopment of the wider campus including the construction of the Morgan Stanley Clinical Building, which opened in 2012; the Premier Inn Clinical Building, (2017); and the Zayed Centre for Rare Disease in Children, which commenced construction in 2016 is due for completion in 2018.

5.2 Published Geology and Previous Investigations

The published geological map for the area, BGS Sheet 256 (2006), the BGS Geology of Britain Viewer (2018) and Geo Insight report shows the superficial geology to be comprised of fluvial sand and gravel deposits of the Lynch Hill Gravel Member, with superficial deposits being recorded as absent approximately 150m northeast of the site.

The Lynch Hill Gravel Member deposits are sedimentary superficial deposits formed during the Wolstonian Stage of the Quaternary period; they generally consist of sand and gravel, locally with lenses of silt, clay or peat. BGS records indicate that this stratum may directly overlie bedrock; which comprises the London Clay Formation. London Clay mainly comprises bioturbated or poorly laminated, blue-grey or grey-brown, slightly calcareous, silty clay.

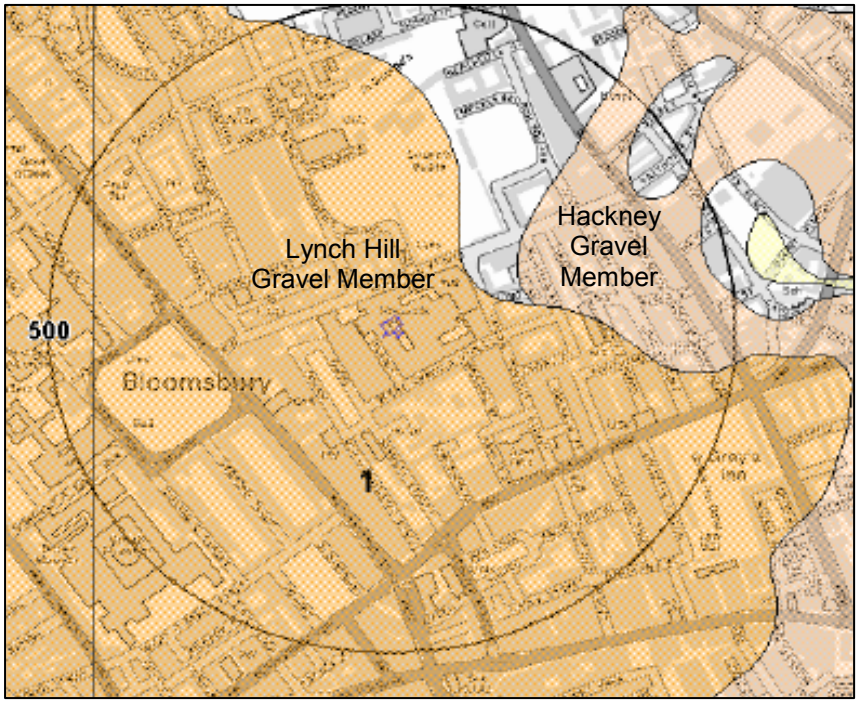

FIGURE 1: Geological Map Extract (taken from the Geo Insight Report)

Local borehole records held by the BGS (approximately 20m north of the site), indicate that the superficial deposits have been removed (or were absent), and show Made Ground directly overlying firm to stiff CLAY. This is further evidenced on site, by the Ground Conditions Report (Thomasons, 2017). The report summarised the findings of a 2013 intrusive trial pit investigation for the installation of a tower crane within the Southwood Courtyard area, and made the following key observations, verbatim:

- *The ground encountered was loose fines made ground, with brick rubble plus suspected asbestos sheeting. This was to a depth of approximately 2- 2.7m below ground level, where the brick masonry floor of a previous basement could be observed.*
- *Additional vertical masonry walls were also observed, which indicated that a previous basement of a building, existed under part of the yard.*
- *The full extent of the basement walls could not be observed as the made ground was so loose, it posed a stability problem to the adjacent temporary building and temporary underground train (now since removed).*

Photographs showing some of the Made Ground materials encountered during the 2013 investigation are shown below.

Photo 1: Southwood Courtyard Excavation

Source: Thomasons, 2017

Photo 2: Southwood Courtyard Excavation

Source: Thomasons, 2017

5.3 Natural Geological Hazards

Information on various natural geological hazards is contained within the Geo Insight report where the risks for the site were classified between negligible risk to a moderate risk geological hazard. This information is summarised in Table 2, below.

TABLE 2 SUMMARY OF GEOLOGICAL RISKS

HAZARD	RISK CATEGORY
Shrink Swell Clay	Moderate.
Landslides	Very low.
Ground Dissolution of Soluble Rocks	Negligible.
Compressible Deposits	Negligible.
Collapsible Deposits	Very Low.
Running Sand	Very Low.

For all negligible and very low risk hazards, the BGS state that no special precautions or targeted ground investigation works are required and it is considered unlikely that increases in construction costs will occur.

The moderate risk of shrink / swell on site relates to the underlying London Clay, which is considered to potentially be of high plasticity. The BGS recommend not to plant or remove trees or shrubs near to buildings without expert advice about their effect and management. They go on to advise that there is a probable increase in construction cost to reduce potential shrink-swell problems, and for new builds, consideration should be given to advice published by the National House Building Council (NHBC) and the Building Research Establishment (BRE).

It should be noted that the above risk categories relate to natural geological hazards, and do not take into account the Made Ground that is anticipated to be on site (see Section 5.2). Made Ground deposits are inherently variable, have poor geotechnical properties and can be prone to compressibility and collapse.

5.4 Ground Workings

The Geo Insight report and historical mapping records indicate that no historical surface or shallow underground workings occurred on site; however evidence provided by the Ground Conditions Report (Thomasons, 2017) indicates that a basement was previous on site. The footprint of the former basement is unknown, but localised ground workings are expected, along with Made Ground deposits to at least a depth of 2.70m bgl.

5.5 Mining, Tunnels and Natural Cavities

The site does not lie within a Coal Mining area; however, the Geo insight report indicated Johnson Poole and Bloomer held mining plans and maps within 1km of the property. Upon contacting Johnson Poole and Bloomer directly, they stated that:

> *There is no indication of any mining in the area of the site.*

No other mining activities, or natural cavities have been indicated within the area of the site.

In addition, there are no underground railways or tunnels recorded within, or within close proximity to the site; with the nearest recorded underground line running approximately 200m to the west and at a depth of approximately 36 m bgl (Piccadilly Line).

5.6 Hydrogeology and Groundwater Abstraction

The hydrogeological characteristics of the site are summarised below.

The Lynch Hill Gravel Member is considered to be a Secondary (A) Aquifer. However, as discussed in Section 5.2, natural superficial deposits are anticipated to be thin or absent beneath the site, with limited permeable layers capable of holding groundwater.

The underling London Clay Formation is classed as an Unproductive Aquifer and is considered to have a negligible significance for water supply or river base flow, as such there are no groundwater abstraction licenses held within 500m of the site, and the site does not fall within a groundwater Source Protection Zone.

As the underlying London Clay Formation will act as an impermeable barrier to downward groundwater migration, a perched groundwater body may be present within the Made Ground or Lynch Hill Gravel Member deposits.

5.7 Hydrology and Surface Water Abstraction

There are no surface water abstraction licences within 1000m of the site, and no surface water courses or features are located within 250m of site.

A northwest / southeast trending culvert is located approximately 120m southwest of the site.

5.8 Flood Risk

The site is not located within any floodplain zones and is considered to have a very low risk of flooding from rivers. However the site is considered to be at risk from superficial deposit flooding from shallow unconsolidated sedimentary aquifers which overlie unproductive aquifers and there is a risk of flooding at flooding at surface. The BGS provide the following recommendations in relation to the potential superficial flooding:

> *Where potential for groundwater flooding to occur at surface is indicated, this means that given the geological conditions in the area groundwater flooding hazard should be considered in all land-use planning decisions. It is recommended that other relevant information e.g. records of previous incidence of groundwater flooding, rainfall, property type, and land drainage information be investigated in order to establish relative, but not absolute, risk of groundwater flooding.*

It is recommended that groundwater levels are observed as part of any future intrusive ground investigation works. The risk of groundwater flooding needs to be considered fully by the Client, and a Flood Risk Assessment may be required to establish the relative risk of groundwater flooding. Specialist risk assessments may also be required if design proposals were to include underground structures such as basement levels.

5.9 Ground Gas

5.9.1 Radon

The site is not located in a radon affected area, and no protection measures are required.

5.9.2 Landfill

No current or historical landfills are shown within 500 m of the site. Two historical landfills are located within 1000m from site with the nearest located 844m south of the site.

5.9.3 Made Ground

Made Ground materials are expected on site to depths of at least 2.70m bgl. Made Ground generally has the potential to produce ground gas through the degradation of contaminants and organic materials; therefore posing a potential risk to the proposed development.

Ground gas may migrate from off-site source. Whilst the underlying shallow deposits are considered permeable in nature and could facilitate gas migration, there are no recorded historic ground workings, landfills or Made Ground deposits in close proximity to the site, and therefore there is not considered to be any significant off site source.

5.10 Heritage and Archaeology

A Grade II listed building is located immediately to the south of the site (the hospital Chapel of St. Christopher) and the site is located within an Archaeological Priority Area, as designated by the London Borough of Camden.

No assessment or recommendations are made within this report, and full reference should be made to the Archaeological Desk Based Assessment (CgMs, 2017) and Built Heritage Statement (RPS CgMs, 2017), for all archaeological and built heritage considerations.

5.11 Ecology

The site is bound by buildings and is covered by hard standing. No trees, or protected species or habitats are present. It is therefore considered that an ecology survey is not required.

5.12 Unexploded Ordnance (UXO)

The Zetica Regional Unexploded Bomb Risk Map indicated there is high risk of UXO underlying the site. Following this, Zetica were contacted to undertake a Preliminary Pre-Desk Study Assessment, which indicated that several High Explosive (HE) bombs fell in close proximity to the Site. Based upon the recommendations within the preliminary assessment, a detailed desk study was commissioned to fully assess the risk to the site and to determine the Unexploded Ordnance (UXO) hazard level.

No assessment or recommendations are made within this report, and full reference should be made to the UXO Desk Study & Risk Assessment (Zetica, 2018) , which concludes that (verbatim):

> *No records have been found indicating that the Site was bombed and no other significant sources of UXO hazard have been identified on the Site.*
>
> *Given this, it is considered that the Site has a low UXO hazard level"*
>
> *To ensure that the UXO risk is reduced to As Low As Reasonably Practicable (ALARP) the following mitigation is advised: Where a low risk of UXO encounter is anticipated, industry good practice is simply to raise the awareness of those involved in excavations so that in the unlikely event that a suspect item is discovered, appropriate action is taken. This can be achieved through UXO awareness briefings to site staff. Clearance certification for borehole or pile locations is considered prudent only if a zero tolerance to risk is adopted.*

5.13 Utilities

The site and surrounding area are likely to contain underground services and it is recommended a full utility survey is undertaken prior to construction works commencing to determine any construction constraints.

6 ENVIRONMENTAL SETTING

6.1 Designated Environmentally Sensitive Sites

The site does not lie within 1km from the following designated environmentally sensitive sites:

- Sites of Special Scientific Interest (SSSI) and Ramsar.
- Local and National Nature Reserves (LNR, NNR,).
- Special Protection Areas (SPA) and Special Areas of Conservation (SAC).
- World Heritage Sites and Ancient Woodlands.
- Areas of Outstanding Natural Beauty (AONB) and Environmentally Sensitive Areas (ESA).
- Forest and National Parks.
- Records of Nitrate sensitive areas or Green Belt; and.
- No Part 2A Contaminated Land sites (within 500m)

6.2 Environmental Permits, Incidents and Registers Map

From the information provided in the Enviro Insight report, there are no activities, sites, or permits relating to the following within 500m of the site:

- Historic IPC or current Integrated Pollution Prevention and Control (IPPC) activities;
- Water Industry Referrals (potentially harmful discharges to the sewer);
- Red List Discharge Consents (potentially harmful discharges to controlled waters);
- Discharge consents;
- Dangerous or hazardous sites (including COMAH and NIHHS site);
- Listed dangerous substance inventory sites;

The hospital site, in its wider context, held one historic environmental permit for incineration & furnace processes (now obsolete), and variations on permits to hold, use and dispose of radioactive materials, dating back to 1993 and in use to the current day. The furnace / chimney could not be identified on the historical mapping, though the Enviro Insight report indicates that it was located approximately 60m east of the site.

seven environmental permits have been issued (three of which are historic relating to dry cleaning and three are current relating to dry cleaning) with the nearest at 204m south west from site.

The Enviro Insight report records one pollution incident on the National Incidents Recording System (NIRS) within 250m of the site; which is located approximately 185m south west; the pollutant is identified as organic solvents and is recorded to of had no impact to water, land or air.

6.3 Landfill and Other Waste Sites

According to the information provided in the Enviro Insight report there are no current landfills within 1 km of the site. There are two historic landfills licence records with 1km from the site with the nearest at 844m south of the site.

The Enviro Insight report indicates that there are no licensed waste management facilities or registered waste transfer sites within 1 km of the site.

6.5 Potentially Contaminative Current Land Uses

The Enviro Insight report covers other potential contamination sources than those mentioned above, including:

- Current Industrial Data;
- Petrol and Fuel Stations – none historic or current recorded within 250m of the site;
- Underground High Pressure Oil and Gas Pipelines – none recorded within 250m.

There are no records of current contaminative land uses on site.

According to the Enviro Insight report, the proposed development site is within 250m of twenty nine potentially contaminative industrial sites. These are summarised in the table overleaf and show that three records are held within 100m of the site, all of which relate to hospital activities (including one recorded for Great Ormond Street Hospital). Other activities of note include a water pumping station, approximately 140m south, and a vehicle repair, testing and servicing located 190m south of the site.

TABLE 3: CURRENT LAND USE

DISTANCE & DIRECTION	COMPANY OR TYPE	ACTIVITY	CATEGORY
69m South west	The National Hospital for Neurology & Neurosurgery	Hospitals	Health Practitioners and Establishments
69m East	Great Ormond Street Hospital	Hospitals	Health Practitioners and Establishments
70m South	Royal London Hospital for Integrated Medicine	Hospitals	Health Practitioners and Establishments
139m South	Pump	Water Pumping Stations	Industrial Features
140m East	Len Fowler Trophies Ltd	Medals, Trophies, Ceremonial and Religious Goods	Consumer Products
142m East	Persephone Books	Published Goods	Industrial Products
145m Southwest	Queens Square Imaging Centre	Hospitals	Health Practitioners and Establishments
151m South	Atlantic Books Ltd	Published Goods	Industrial Products
151m South	Murdoch Books	Published Goods	Industrial Products
171m East	Corporate Mobile Recycling	Recycling, Reclamation and Disposal	Recycling Services
188m East	Rhinegold Publishing	Published Goods	Industrial Products
188m East	Opera Now Magazine	Published Goods	Industrial Products
190m South	Wrong Fuel Solution	Vehicle Repair, Testing and Servicing	Repair and Servicing
190m South	Fine Time Watches Ltd	Jewellery, Gems, Clocks and Watches	Consumer Products
190m South	At Your Disposal	Recycling, Reclamation and Disposal	Recycling Services
190m South	Scotfax	Office and Shop Equipment	Industrial Products
190m South	Natrelle Ltd	Cosmetics, Toiletries and Perfumes	Consumer Products
201m Southwest	Hertz Car Hire	Vehicle Hire and Rental	Hire Services
208m South	Cougar Solar	Electronic Equipment	Industrial Products
208m South	The London Gasworks	Industrial Engineers	Engineering Services
208m South	Daibola	Published Goods	Industrial Products
208m South	R S F Holdings Ltd	Distribution and Haulage	Transport, Storage and Delivery
208m South	UK Water Softeners	Colours, Chemicals and Water Softeners and Supplies	Industrial Products
208m South	Podium Designs	Medals, Trophies, Ceremonial and Religious Goods	Consumer Products
212m East	Maggie Owen London	Jewellery, Gems, Clocks and Watches	Consumer Products
213m West	Russell Square	Underground Network Stations	Public Transport, Stations and Infrastructure
233m South	Electricity Sub Station	Electrical Features	Infrastructure and Facilities
240m Northeast	Av2 Hire Ltd	Electronic Equipment	Industrial Products
248m East	Shortlist	Published Goods	Industrial Products

7 INITIAL CONCEPTUAL SITE MODEL

7.1 General

In line with existing legislation and the current regime for the management of contaminated land, assessments are undertaken using a risk based approach. It is necessary to define a Conceptual Site Model (CSM) for the site which identifies the potential sources of contamination, the receptors and the pathways that can connect them. In order for there to be a risk from contamination, one or more relevant pollutant linkages must exist, connecting a contamination source, a receptor (an entity which might be affected by the contamination) and a pathway (or mechanism) by which the receptor can be exposed to the contaminant.

A discussion of potential sources, pathways and receptors and a tabulated summary of the CSM indicating potential pollutant linkages follow. The criteria used for assessing the relevance of identified potential pollutant linkages are based on the proposed development and environmental sensitivity of the site and surrounding area.

7.2 Potential Sources of Contamination

Potential sources of contamination are usually associated with current and former industrial activities, where the processing, storage, use, transportation and disposal of raw materials, products and wastes often leads to the contamination of underlying ground and groundwater. In addition, natural processes can also give rise to contamination such as hazardous gases.

Based on the information presented above, potential sources of contamination from current and historical site uses and from potentially significant off site sources have been assessed, and are summarised in the table below, with the contaminants identified based on desk study data, knowledge of the source/activity and within published guidance, such as Department of the Environment Industry Profiles (DoE, 1996)

TABLE 4 POTENTIAL SOURCES OF CONTAMINATION

SITE USE / ACTIVITY AND AREA	SOURCES	CONTAMINANTS
Historical On-site and Adjacent Use: Hospital activities; Unspecified tank (14m east) ***On-site Current Use*** Storage units and temporary cabins ***Historic On-site Use:*** Car parking area;	Storage, leakage, spillage and poor disposal practices of fuels, oils and miscellaneous cleaning / degreasing chemicals.	Petroleum Hydrocarbons (petrol and diesel, mineral oils), Volatile organic compounds (VOCs & SVOCs).
Historical Onsite Use Demolition material from previous construction and development phases; Other Made Ground materials deposited when backfilling the basement ***Historical Adjacent Use:*** Furnace / incinerator (location unknown)	Demolition Material Made Ground of unknown origin; Furnace ashes / wastes	Heavy metals, PAH, TPH, and asbestos
Historical Offsite Uses: Timber Yard (approx. 50m east)	Timber coatings	Creosotes (PAH), and organic solvents (VOCs & SVOCs) and metals.
Historical Offsite Uses Print works (approx., 100m east)	Printing supplies and equipment	Metals and organic solvents (VOCs & SVOCs).

7.3 Potential Migration Pathways

- The following potential pathways have been identified as potential migration pathways for the proposed hospital building with full hardstanding coverage (no areas of soft landscaping): Inhalation soil vapour and/or water vapour.
- Lateral and vertical migration of gases and/or vapours through permeable strata from off-site sources;
- Leaching of contaminants from soils into soil pore water and shallow groundwater.
- Downward migration of soil pore water and shallow groundwater.
- Lateral groundwater flow towards the site and towards the culvert.

- Preferential pathways including existing and proposed new services trenches and foundations.
- Surface water runoff into drains.

In addition to the above, the construction workers and adjacent site users may be posed acute risks during the enabling works construction phase form the following pathways:

- Direct soil, soil dust and/or water ingestion.
- Dermal contact with contaminated soil, soil dust and/or water.
- Inhalation of soil dust.
- Inhalation of soil and/or water vapour.

7.4 Potential Receptors

Potential receptors have been identified and categorised as follows:

7.4.1 Human Health

- Construction workers.
- Current site users – sensitive commercial end use.
- Future site users – sensitive commercial users.
- Neighbouring residents, staff and patients.
- Maintenance workers.

7.4.2 Controlled Waters

- Secondary (A) aquifer within the superficial deposits (if present) or perched groundwater body within the Made Ground.
- Culvert flowing along the western boundary 120m from the site.

7.4.3 Property, Buildings, Structures and Services

- Property in the form of new buildings and structures.
- Below ground concrete structures and foundations of the new development and existing structures.
- Below ground services, particularly drinking water supply pipes.

7.5 Summary

The relevant pollutant linkages based on the potential sources, pathways and receptors outlined above are tabulated below:

TABLE 5 INITIAL CONCEPTUAL SITE MODEL

SOURCE	PATHWAY	RECEPTOR
Current Storage units and temporary cabins; **On site and adjacent current and historical hospital activities;** **On site Historical Use as Car Par** (TPH, PAH, SVOCs and VOCs)	Ingestion, direct contact, inhalation of dust	➢ Construction site workers ➢ Future site users ➢ Neighbouring site occupants
	Leaching and downward migration	➢ Secondary A Aquifer within superficial deposits ➢ Service channels
	Lateral Groundwater Migration	➢ Drainage Culvert (off site) ➢ Secondary A Aquifer within superficial deposits ➢ Service channels
	Direct contact	➢ New water supply pipes;
On Site Made Ground Deposits (contaminants as above, with the addition of metals and asbestos)	As above	As above
	Inhalation of asbestos fibres / dust	➢ Construction site workers ➢ Future users ➢ Neighbouring site occupants
	Direct contact	➢ New water supply pipes; ➢ Concrete
Historic Offsite Timber Yard and Printing Works (PAH, SVOCs and VOCs)	Lateral Groundwater Migration and subsequent inhalation of vapours	➢ Construction site workers ➢ Neighbouring site occupants ➢ Future site users

There are currently a series of uncertainties and assumptions in the CSM presented above as this is based on desk study information only:

- Ground conditions have been conceptualised based on BGS geological maps and other primarily desk based information.
- The presence and extent of any suspected contamination is unknown given the limited site investigation data.
- The presence and depth of any groundwater bodies at the site is currently unknown.
- The ground gas regime within the site has not been characterised.

8 PRELIMINARY RISK ASSESSMENT

8.1 Assessment of Environmental Risks Methodology

The identification of potential pollutant linkages is a key aspect of the evaluation of potentially contaminated land. An approach based on CIRIA report C552 has been adopted. For each of the pollutant linkages, an estimate is made of:

- The potential severity of the risk; and
- The likelihood of the risk occurring.

Table 7 below presents the classification of the severity of the risk:

TABLE 6 SEVERITY OF RISK

RISK FACTOR	TYPICAL EXAMPLES
Severe	Acute risks to human health; Major pollution of controlled waters
Medium	Chronic (long-term) risk to human health; Pollution of controlled waters
Minor	Damage to non-sensitive species or ecosystems, buildings or services

The probability of the risk occurring is classified according to the criteria provided in Table 8 below:

TABLE 7 PROBABILITY OF RISK OCCURING

PROBABILITY RATING	DESCRIPTION
High Likelihood	Pollutant linkage may be present, and risk is almost certain to occur in the long term, or there is evidence of harm to the receptor.
Likely	Pollutant linkage may be present, and it is probable that the risk will occur over the long term.
Low Likelihood	Pollutant linkage may be present and there is a possibility of the risk occurring, although there is no certainty that it will do so.
Unlikely	Pollutant linkage may be present but the circumstances under which harm would occur are improbable.

An overall qualitative evaluation of the level of risk is gained from a comparison of the severity and probability as presented in Table 9 below:

TABLE 8 RISK RATING EVALUATION

		SEVERITY		
		SEVERE	MEDIUM	MINOR
PROBABILITY	HIGH LIKELIHOOD	Very high risk	High Risk	Moderate / low risk
	LIKELY	High risk	Moderate risk	Low risk
	LOW LIKELIHOOD	Moderate risk	Moderate/ low risk	Very low risk
	UNLIKELY	Moderate / low risk	Low risk	Very low risk

8.2 Preliminary Risk Assessment

Table 10 overleaf details the potential risks associated with the various potential pollutant linkages identified through the assessment of the data collated in this report. The risk category should be reviewed if further information is made available or the environmental setting of the site changes, for example through a proposed change in the development layout or end use.

TABLE 9 PRELIMINARY RISK ASSESSMENT

SOURCE	PATHWAY	RECEPTOR	SEVERITY	PROBABILITY	RISK RATING	COMMENTS
TPH, PAH, VOCs and SVOCs associated with storage, leaks and spills from: - Recent car park activities, - Recent storage cabins - Historic hospital activities; - Historic nearby unspecified tank (14m E)	Ingestion, direct contact, inhalation of dust	Construction site workers	Severe	Unlikely	Moderate / Low	Creation of dust and contact with soils is likely during construction, but it is considered unlikely that contamination will be elevated enough to pose an acute risk to construction workers. Post construction these pathways are likely to be severed altogether due to the hardstanding cover.
		Future site users	Medium	Unlikely	Low	
	Inhalation of vapours (arising from polluted groundwater and soils)	Construction Workers	Severe	Low	Moderate	It is not considered likely that gross volatile contamination will be present; however if it is present, it may pose an acute risk to construction workers and chronic risk to future site users.
	Inhalation of vapours (arising from polluted groundwater and soils)	Future site users	Medium	Low	Moderate / Low	
	Leaching and downward migration	Secondary A Aquifer	Medium	Low	Moderate / Low	Potential for infiltration and leaching is low due to absence of soft landscaping and the preferential pathway for rainfall is likely to be towards the existing service channels and drains. The Secondary A Aquifer is anticipated to be thin or absent at the site; however lateral migration within the aquifer or perched water is possible, ultimately discharging into the River Thames ~ 1.3km south.
	Leaching and lateral migration	Offsite Culvert; Controlled surface watercourse	Minor	Low	Very Low	
Metals, TPH, PAH and VOCs within Made Ground associated with: - Historic construction / demolition phases - Infilling of basement areas; - potential for incineration wastes	Ingestion, direct contact, inhalation of dust	Construction site workers	Severe	Low	Moderate	Creation of dust and contact with soils is likely during construction, but it is not considered likely that contamination will be elevated enough to pose an acute risk to construction workers. Post construction these pathways are likely to be severed altogether due to the hardstanding cover.
		Future Residents	Medium	Unlikely	Low Risk	
	Leaching and downward migration	Secondary A Aquifer	Medium	Low	Moderate / Low	Potential for infiltration and leaching is low, as above. Pathways to controlled water bodies not certain, as above.
	Leaching and lateral migration	Offsite Culvert; Controlled surface watercourse	Minor	Unlikely	Very Low	
Made Ground (general)	Direct Contact	New Water Supply Pipes	Medium	Likely	Moderate Risk	Elevated levels of organic contaminants within the Made Ground materials may permeate plastic drinking water pipes and pose a risk to human health.
		Concrete Foundations	Minor	High	Moderate / Low	The Made Ground and London Clay is likely to have elevated levels of sulphate within it, which could potentially create an aggressive environment of sub-surface concrete.

SOURCE	PATHWAY	RECEPTOR	SEVERITY	PROBABILITY	RISK RATING	COMMENTS
Asbestos within the Made Ground demolition material	Inhalation	Construction Site Workers	Severe	Likely	High	Given the multiple phases of demolition at the site, there is the potential for asbestos to be present within the Made Ground materials, which could pose a high risk to construction workers
		Future Residents	Severe	Low	Moderate	Post construction the inhalation pathway will largely be severed altogether due to the hardstanding cover, except for excavation works such as the laying of utility pipes.
Historic Timber Yard (20m NE); Printing Works (100m E) (oils, chlorinated solvents, metals and VOCs)	Lateral Groundwater Migration and subsequent inhalation of vapours	Construction Site Workers	Severe	Low	Moderate	Whilst these sources have the potential as a source of volatile contaminants, the pathway to the site is considered unlikely due the anticipated hydrogeology of the surrounding area.
		Future Residents	Medium	Low	Moderate / Low	

9 GEOTECHNICAL ASPECTS

9.1 Anticipated Ground Model and Potential Hazards

The anticipated ground conditions are expected to comprise Made Ground of at least 2.70m in depth. Underlying the Made Ground, thin superficial deposits may be present, comprising River Terrace Deposits of sand and gravel. The underlying solid geology comprises the London Clay Formation, the depth to bedrock is currently unknown, but is anticipated to be less than 10m bgl, with local borehole records indicating depth to rockhead between 5 to 8m bgl.

The Made Ground is considered to be an unsuitable engineering material and is indicated to be variable, with over-sized materials such as concrete and brick work which could pose an obstruction to excavations and piles, and lead to a high risk of settlement and voids to be present.

A perched groundwater body within the Made Ground is possible, along with a shallow groundwater aquifer within the granular superficial deposits (if present). As such, there is a potential for groundwater flooding which needs to be considered further.

9.2 Possible Foundation Options

The loose shallow made ground deposits are not considered to be a suitable bearing stratum for the proposed development, as they are considered likely to offer an insufficient bearing capacity and present constraints associated with differential settlements, voids and compressibility. It is anticipated that a piled foundation solution will be required, targeting competent material within the London Clay Formation. A thorough investigation would be required to determine allowable bearing capacities and compared against proposed loadings. Historic obstructions within the made ground and previous located basement footprint may require excavating prior to piling.

9.3 Excavations

It is anticipated that shallow excavations at the site will be within the capabilities of mechanical excavators and traditional excavation techniques; however the previous investigations have indicated that the loose granular Made Ground deposits are likely to be unstable and contain large masonry features and artefacts, including buried wall structures, large concrete slabs and old floor bases. Consideration should also be given to the potential of shallow groundwater to pose a further constrain to any excavation works.

10 CONCLUSIONS AND RECOMMENDATIONS

10.1 Conclusions

10.1.1 Preliminary Risk Assessment

The site has had significant development throughout its history, being primarily used as a hard standing courtyard for general purposes such as car parking and storage and temporary cabins in more recent years,. The potential for on-site contamination is considered to be relatively low, with the most likely on site contaminants expected potentially being asbestos, within Made Ground deposits associated with previous development phases on site.

Few historical industrial activities have occurred within the site's environs and the potential for significant contamination is anticipated to be low. Offsite historical sources primarily include a timber yard, a print works and adjacent health care facilities, which are primarily potential sources of volatile compounds; however, the scale of these sources is considered relatively limited and the pathways considered in the context of the site are unlikely due the geology present and recent and historic redevelopment.

The risk to future site users is lessened by the absence of soft landscaping in the proposed development. There is considered to be a very low risk to users of the three storey structure as the building will be well ventilated and the footprint will solely comprise hard standing; effectively removing the majority of any pathways present.

The controlled water receptors are considered to be low sensitive in the context of the proposed development. A culverted watercourse is located 120m away from the site, the bedrock is classed as an Unproductive Aquifer and groundwater present within the superifical deposits is likely to have limited mobility due to the limited extent of natural granular material beneath the site.

Preliminary Risk Assessment and Conceptual Site Model indicates there is generally a moderate and moderate / low risk from contamination to the identified receptors at the site, and a potentially high risk to construction workers due to the potential for asbestos within the Made Ground materials.

10.1.2 Geotechnical Risk Assessment

Geotechnical hazards may be present at the site, in the form of:

- Made Ground of an unknown depth and nature;
- Differential settlements, and collapse of voids due to varying loose made ground deposits across the site proving unsuitable for shallow foundations;
- Obstructions and large hard materials present within the Made Ground;
- Volume change due to the shrink / swell of the plastic London Clay Formation;
- The potential for shallow groundwater posing a constraint on open excavations;
- The potential for flooding from onsite hard standing and existing drainage;
- The risk of contamination impeding foundation and new water systems
- The unknown depth to bedrock; and,
- Restrictions and easements for excavation designs due to the stability of existing stratum on site.
- The close proximity of adjacent buildings and basement floors.

It should also be noted that the construction works are to take place within a small confined courtyard area, within a sensitive (hospital) environment and buildings abutting the site on all sides, including the presence of basement floors. As such careful consideration needs to be given to choosing appropriate construction techniques, which are logistically suitable and help to minimise vibration, noise, dust and general nuisance during the construction phase.

10.2 Recommendations

It should be appreciated that the desk study can only give only give indications of the likely geotechnical and geoenvironmental conditions and consequently an intrusive investigation is recommended to confirm the findings within this report and to provide detailed information and design parameters to allow for further chemical and geotechnical assessments.

The objectives of such an investigation would be to assess the presence of contamination within the Made Ground materials and Secondary Aquifer / perched groundwater body underlying the site, in order to inform Generic Quantitative Risk Assessments or human health, ground gas and controlled waters. In addition, the ground conditions should be confirmed and groundwater levels established to inform geotechnical design for foundations, floor slabs, hard standing areas and flood assessment

Taking into account the proposed end use of the development, it is recommended that the ground investigation to be undertaken should comprise the following:

- Cable percussive drilled boreholes, along with in-situ SPT testing and geotechnical sampling to confirm the ground conditions underlying the site, and in particular to achieve competent London Clay Formation and obtain information for pile design.
- Conduct a series of dynamic windowless sample boreholes drilled for contamination sampling purposes and to confirm the spatial variability of the made ground deposits within the building footprint.
- Dynamic Cone Penetration for density and obstruction investigation within the loose made ground deposits, and to determine the presence and location of historic basement floors.
- Survey of all exploratory hole positions to National Grid and Ordnance Datum;
- Collection of samples for subsequent geoenvironmental laboratory testing. Based on the CSM the chemical analysis suite may include heavy metals, pH, asbestos, inorganics, total petroleum hydrocarbons, polycyclic aromatic hydrocarbons and (semi) volatile organic compounds;.
- Collection of samples for subsequent geotechnical laboratory testing to provide parameters to confirm the ground conditions and to aid geotechnical design;
- Collection of samples and testing to assess the potential of Concrete in Aggressive Ground, in line with the current BRE guidance.
- Installation of gas monitoring and groundwater wells and subsequent monitoring and within the underlying made ground and underlying London Clay formation to confirm whether additional gas design procedures or remediation is required prior to construction
- An interpretative report to provide recommendations for geotechnical design (foundation options and pavement design) and to assess the risks to human health and controlled waters.

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APPENDIX A
FIGURES AND DRAWINGS

Location Plan *[Ansell and Bailey]*	16021 – (00)011-C
Existing Ground Floor Plan *[Ansell and Bailey]*	16021 – (01)033
Proposed Ground Floor Plan *[Ansell and Bailey]*	16021 – (01)029
Proposed Section 1 *[Ansell and Bailey]*	16021 – (03)006

PURPOSE OF ISSUE: (A)FOR COMMENT / CO-ORDINATION (B)FOR INFORMATION (C)FOR APPROVAL (D)FOR TENDER (E)FOR CONSTRUCTION (F)FINAL DESIGN DRAWING

Rev	Rev Date	Revision Description	Drawn/ Checked	Purpose of Issue
A	12-05-2017	For Planning	.	.
B	25-05-2017	For Planning		
C	06-06-2017	For Planning		

Ownership Boundary

Planning Application Boundary

0 12.5 25 37.5 50 62.5metres

For 1:1250 scale

North

FOR APPROVAL

Location Plan	16021 JOB NUMBER	(00)011 DRAWING NUMBER	C REV
Great Ormond Street Hospital for Children - NHS Foundation Trust	May 2017 DATE	1:1250@A3 SCALE	

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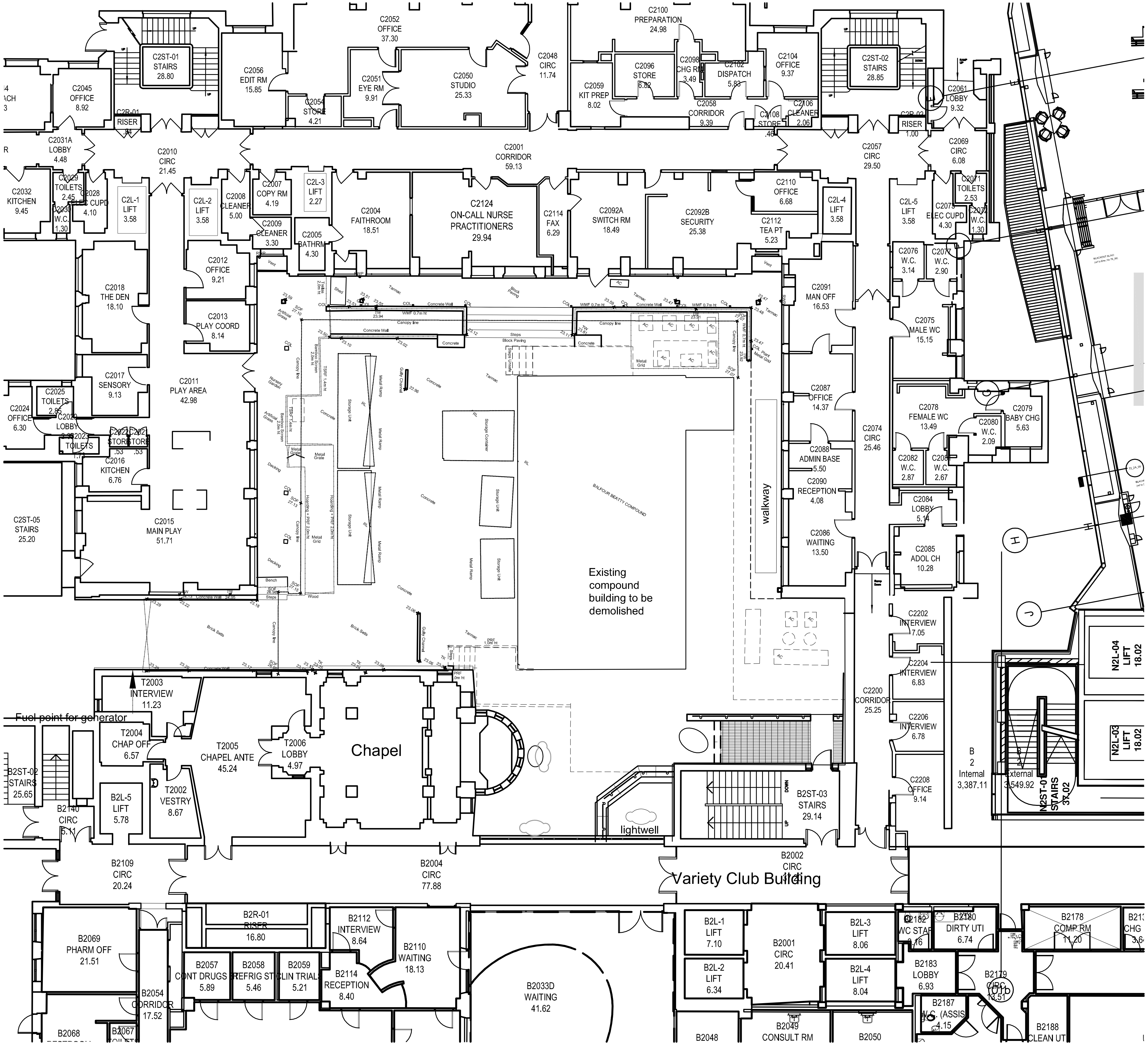
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37.30
C2100
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24.98
C2ST-01
STAIRS
28.80
C2056
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C2051
EYE RM
9.91
C2050
STUDIO
25.33
C2048
CIRC
11.74
C2096
STORE
6.82
C2102
DISPATCH
5.83
C2104
OFFICE
9.37
C2ST-02
STAIRS
28.85
C2045
OFFICE
8.92
C2059
KIT PREP
8.02
C2058
CORRIDOR
9.39
C2061
LOBBY
9.32
C2001
CORRIDOR
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C2010
CIRC
21.45
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C2004
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C2114
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C2L-4
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C2L-5
LIFT
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C2018
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C2091
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C2076
W.C.
3.14
C2077
W.C.
2.90
C2075
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C2080
W.C.
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C2074
CIRC
25.46
C2016
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C2088
ADMIN BASE
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C2082
W.C.
2.87
C2090
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STAIRS
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C2086
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C2085
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Existing
compound
building to be
demolished
BALFOUR BEATTY COMPOUND
C2202
INTERVIEW
7.05
N2L-04
LIFT
18.02
C2204
INTERVIEW
6.83
T2003
INTERVIEW
11.23
C2200
CORRIDOR
25.25
Fuel point for generator
T2004
CHAP OFF
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T2005
CHAPEL ANTE
45.24
T2006
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4.97
Chapel
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16.80
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B2110
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CONSULT RM
B2050

PURPOSE OF ISSUE: (A)FOR COMMENT / CO-ORDINATION (B)FOR INFORMATION (C)FOR APPROVAL (D)FOR TENDER (E)FOR CONSTRUCTION (F)FINAL DESIGN DRAWING

Rev	Rev Date	Revision Description	Drawn/ Checked	Purpose of Issue
.	.	.	.	.

0 2 4 6 8 10metres

For 1:200 scale

North

FOR APPROVAL

Level 02 Existing Plan	16021 JOB NUMBER	(01)033 DRAWING NUMBER	. REV
Great Ormond Street Hospital for Children - NHS Foundation Trust	May 2017 DATE	1:200@A3 SCALE	

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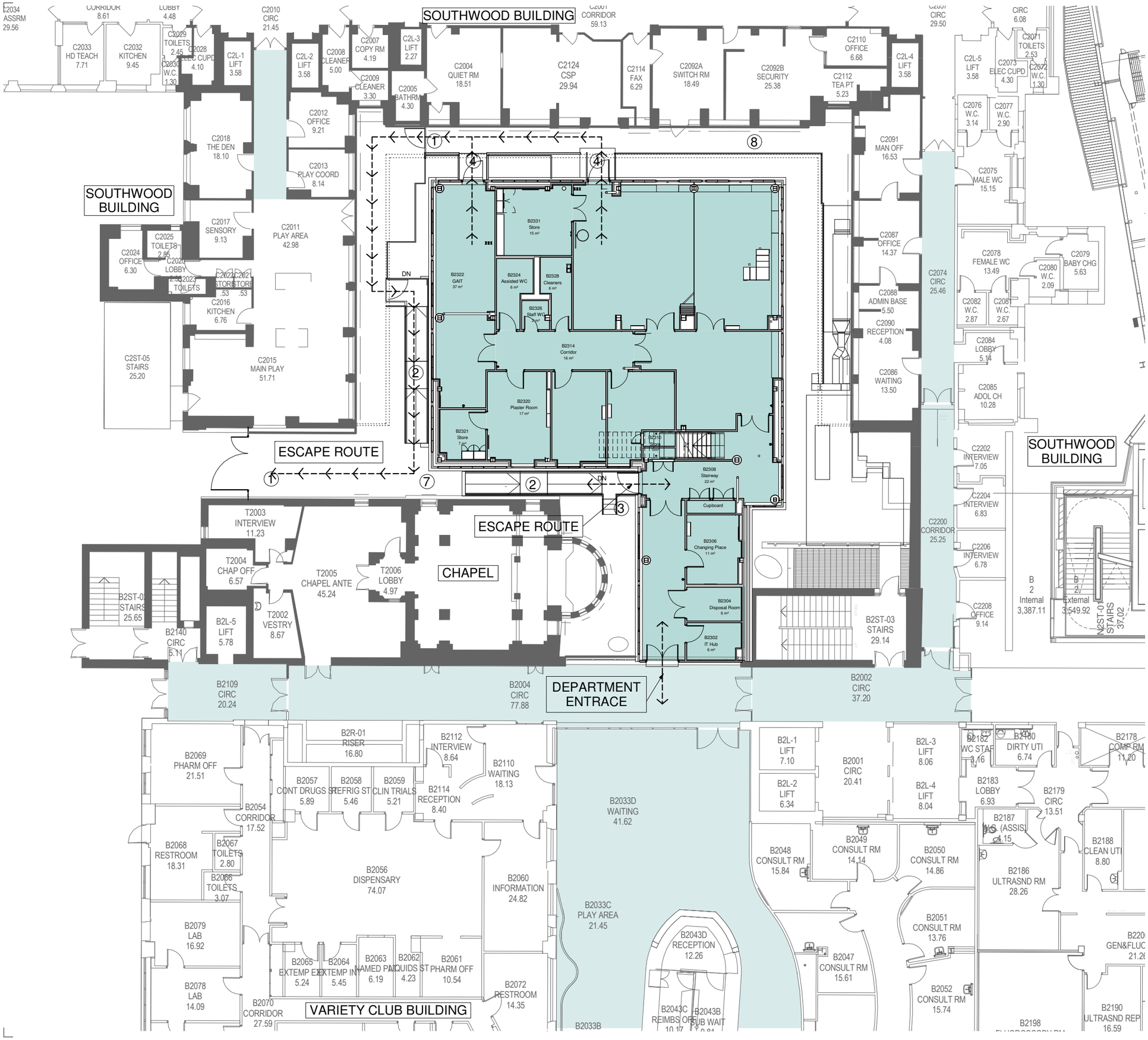

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PURPOSE OF ISSUE - A = FOR COMMENT/ CO-ORDINATION B = FOR INFORMATION C = FOR APPROVAL D = FOR TENDER E = FOR CONSTRUCTION F = FINAL DESIGN DRAWING

Rev	Rev Date	Revision Description	Drawn/ Checked	Purpose of Issue
A	22/03/2017	General Update	VS/MH	C
B	31/03/2017	General Update	VS/MH	C
C	06/04/2017	Colour Added	VS/MH	A
D	13/04/2017	General Update	VS/MH	A
E	28/04/2017	Pricing Issue	VS/MH	P
F	12/05/2017	For Planning	VS/MH	C
G	25/05/2017	For Planning	VS/MH	P
H	06/06/2017	For Planning	VS/MH	P

KEY

1. New Galvanised steel gates
2. New Galvanised steel ramps and balustrades
3. New Galvanised steel maintenance stair
4. New Galvanised steel bridge link
5. New Galvanised steel platform and stairs with BigFoot support
6. New Galvanised steel roof access ladder
7. Existing Tarmac surface
8. Existing Stone walkway
9. Existing concrete balcony
10. New 450 x 450 paving slabs with gravel border
11. New green roof with gravel border
12. New Galvanised steel guarding

0 1 2 3 4 5metres
For 1:100 scale

FOR APPROVAL

North

Proposed Level 02 (Ground Floor) Plan showing surrounding clinical uses	16021 JOB NUMBER	(01)029 DRAWING NUMBER	H REV
Great Ormond Street Hospital for Children - NHS Foundation Trust	03/03/2017 DATE	1 : 100 SCALE @ A1	

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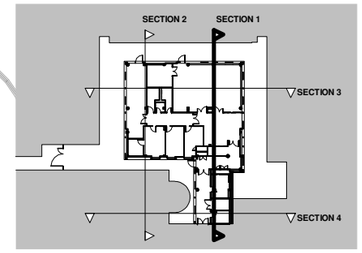
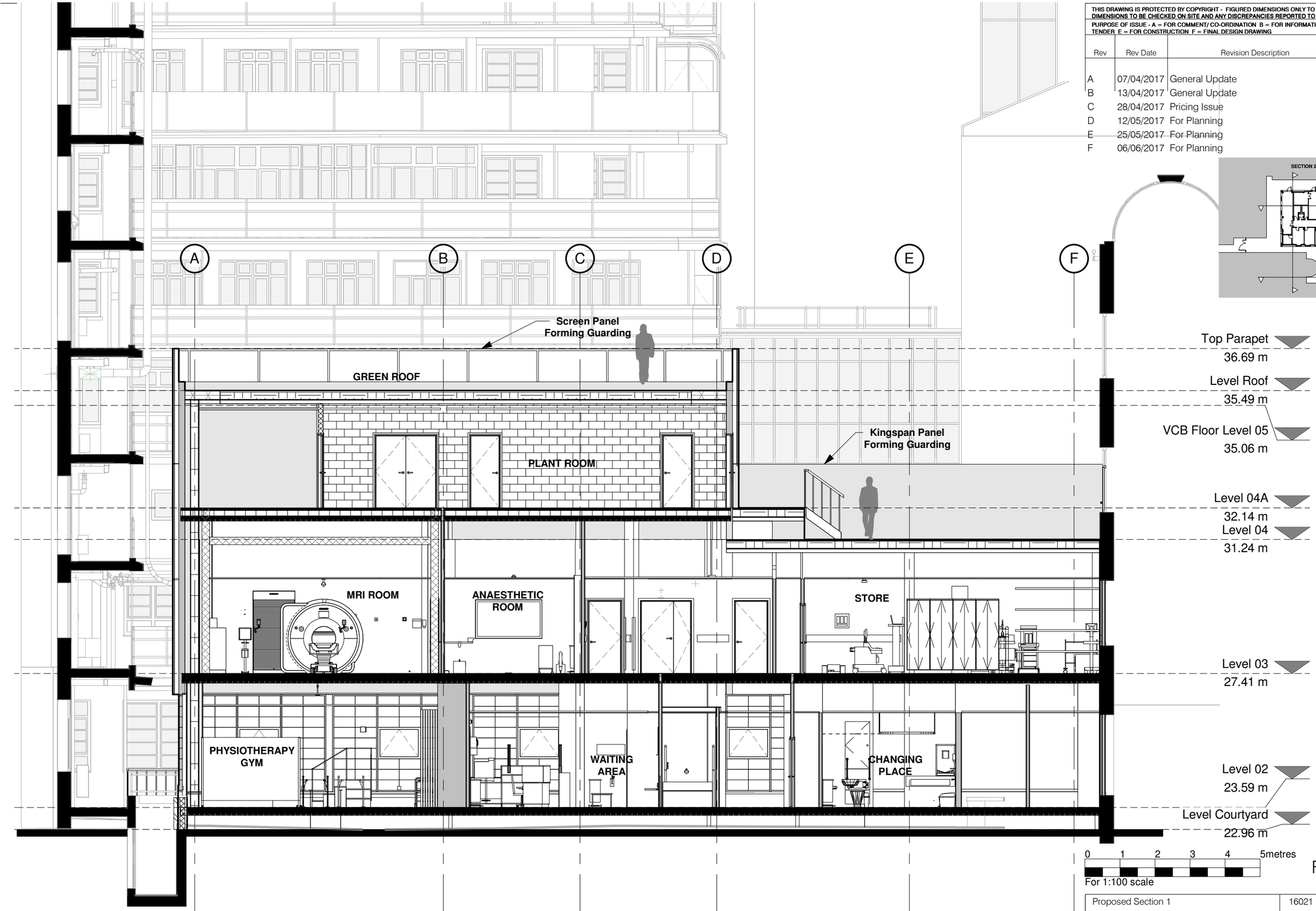
Rev	Rev Date	Revision Description	Drawn/ Checked	Purpose of Issue
A	07/04/2017	General Update	VS/MH	A
B	13/04/2017	General Update	VS/MH	A
C	28/04/2017	Pricing Issue	VS/MH	P
D	12/05/2017	For Planning	VS/MH	C
E	25/05/2017	For Planning	VS/MH	P
F	06/06/2017	For Planning	VS/MH	P





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For 1:100 scale

FOR APPROVAL

For Section Lines See Drawing 16021(01)029 - Proposed Level 02 (Ground Floor) Plan showing surrounding clinical uses

Proposed Section 1	16021 JOB NUMBER	(03)006 DRAWING NUMBER	F REV
Great Ormond Street Hospital for Children - NHS Foundation Trust	27/03/2017 DATE	As indicated SCALE @ A3	

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APPENDIX B
SITE WALKOVER PHOTOGRAPHS

Site Walkover Photographs

Plate 1:

View of site entrance from Powis Place into southeast corner of Courtyard

Notes:	Project	GREAT ORMOND STREET HOSPITAL – P22 iMRI PROJECT	Plate
	Project No.	E8013-18	1
	Carried out for	Kier Construction Limited	

Site Walkover Photographs

Plate 2:

View of Courtyard from southeast corner facing northwest

Notes:	Project	GREAT ORMOND STREET HOSPITAL – P22 iMRI PROJECT	Plate
	Project No.	E8013-18	2
	Carried out for	Kier Construction Limited	

Site Walkover Photographs

Plate 3:

View of courtyard from western boundary facing east

Notes:	Project	GREAT ORMOND STREET HOSPITAL – P22 iMRI PROJECT	Plate
	Project No.	E8013-18	3
	Carried out for	Kier Construction Limited	

Site Walkover Photographs

Plate 4

View of courtyard from western boundary facing south east

Notes:	Project	GREAT ORMOND STREET HOSPITAL – P22 iMRI PROJECT	Plate
	Project No.	E8013-18	4
	Carried out for	Kier Construction Limited	

Site Walkover Photographs

Plate 5

View of courtyard from north east corner facing southwest

Notes:	Project	GREAT ORMOND STREET HOSPITAL – P22 iMRI PROJECT	Plate
	Project No.	E8013-18	5
	Carried out for	Kier Construction Limited	

Site Walkover Photographs

Plate 6

Western boundary light well along Southwood Building

Notes:	Project	GREAT ORMOND STREET HOSPITAL – P22 iMRI PROJECT	Plate
	Project No.	E8013-18	6
	Carried out for	Kier Construction Limited	

Site Walkover Photographs

Plate 7

Northern boundary light well along Southwood courtyard

Notes:	Project	GREAT ORMOND STREET HOSPITAL – P22 iMRI PROJECT	Plate
	Project No.	E8013-18	7
	Carried out for	Kier Construction Limited	

APPENDIX C
GROUNDSURE MAP INSIGHT

Groundsure Map Insight Reports (large and small scale) GS-4706469

[Included separately due to file size]

APPENDIX D
GROUNDSURE ENVIRO INSIGHT

Groundsure Enviro Insight Report GS-4706467

[Included separately due to file size]

APPENDIX E
GROUNDSURE GEO INSIGHT

Groundsure Geo Insight GS-4706468

[Included separately due to file size]