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GEOENVIRONMENTAL APPRAISAL

of land at

RADCLIFFE HUB, RADCLIFFE

Prepared for

BURY COUNCIL

Report No. 5238-G-R001

Date: August 2022

EXECUTIVE SUMMARY

ID Geoenvironmental Limited (IDG) have been commissioned by Bury Council (The Client) to undertake a Geoenvironmental Appraisal of land at Radcliffe Hub, Radcliffe. A third party, Vinci Construction UK Limited (Vinci), have been appointed by Bury Council as the Design & Build Contractor for the proposed development.

The proposed project comprises the construction of a three-storey leisure and community centre that will include a lower ground floor level (i.e. basement). The centre is to include a swimming pool, climbing wall, fitness suite, library and community rooms. Vinci have indicated the new building will be constructed with piled foundations.

IDG's investigation included a review of an Ove Arup & Partners' desk study report, a coal mining assessment and a ground investigation comprising four window sample boreholes and three rotary boreholes accompanied by chemical and geotechnical testing.

A summary of salient geoenvironmental issues is provided in the following table.

Issue	Remarks
Ground Conditions	Made Ground between 0.6m – 1.8m thick is present across the site with several below ground obstructions associated with former buildings encountered during the investigation. Glaciofluvial Sheet Deposits typically comprising low shear strength brown sandy gravelly clay underlain by medium dense grey gravelly sand were encountered directly beneath the Made Ground and were proven to depths ranging between 3.0m to 5.2m bgl. Geotechnical testing indicates that cohesive Glaciofluvial Sheet Deposits at the site should be regarded as being of medium volume change potential. Pennine Middle Coal Measures (PMCM) bedrock comprising grey to dark grey thinly laminated Mudstone with extremely variable rock mass characteristics was encountered at depths ranging from 3.0m bgl to 5.2m bgl and were proven to a maximum depth of 18.0m in BH07. A thin band of coal was encountered in BH06 at a depth of 13.2-13.3m.
Mining	Seven coal seams have been worked beneath the site from a depth of 103-486m with the Coal Authority commenting that there is no risk of probable unrecorded shallow mineworkings beneath the site. The possibility of unrecorded shallow mine workings beneath the site has been discounted.
Hazardous Gas	No significant risk from landfill or mines gas has been identified.
Radon	The site is in an intermediate probability radon area (1 to 3% of homes are estimated to be at or above the Action Level) and current Building Control Regulations do not require radon protection measures to be installed in new buildings. However, a radon assessment will be required after construction of the building which is likely to require the monitoring of radon in the building, therefore consideration should be given to the installation of basic radon protection measures during construction of the development to mitigate any potential issue upon completion of the building.
Contamination & Remediation	No significant pollutant linkages have been identified at the site and a Remediation Strategy should not be required by the Local Planning Authority. However, a dye works was present in the south of the site. Whilst no evidence of contamination associated with the dye works was encountered during the investigation, IDG recommend that a watching brief be provided by a Geoenvironmental Consultant during any excavations that occur within the footprint of the dye works during re-development on the site.
Foundations	Vinci have indicated the building will be constructed with piled foundations. Cohesive superficial deposits of medium volume change potential are present at the site and it is recommended that the potential for negative skin friction is considered in the design of the piles. PMCM bedrock lies at depths of between 3.0m and 5.2m bgl beneath the site and has extremely variable rock mass characteristics. The PMCM bedrock was observed to be highly weathered with several thin bands within the strata noted to have weathered to a clay. Average UCS values indicate the PMCM bedrock in close proximity to a geological fault inferred to be present in the east the site should be classed as having very weak intact rock strength, with the bedrock located further away being classed as weak rock. Sub-surface concrete classification of DS-2, AC-2 considered appropriate for the Made Ground, Glaciofluvial Sheet Deposits and PMCM Mudstone. However, should piled foundations need to be extended to depths in excess of 13m in the vicinity of BH06, or evidence of coal seams be encountered during the piling at the development then consideration should be given to increasing the sub-surface concrete classification to DS-5, AC-5m. Calorific value testing of the PMCM strata recorded values above 7.0MJ/kg in several samples which indicate they may present a risk of spontaneous combustion. IDG recommend the piling contractor are provided with a copy of this report in order to determine if any precautionary measures are required to mitigate the risk of spontaneous combustion of the PMCM strata during piling.

This brief summary should not be assumed to represent a complete account of all the potential geo-environmental issues that may exist at the site. As such it is strongly recommended that the report be read in its entirety.

Issue	Remarks
Groundwater	A shallow groundwater body present within the Glaciofluvial Sheet Deposits rests at depths of between 1.33m bgl (BH06) and 4.15m bgl (WS02) and its piezometric surface falls from the north of the site to the southwest of the site. A deeper groundwater body in the PMCM in BH07 is under sub-artesian pressure and resting at a level approximately 1.0m above the top of the PMCM at elevations of between 60.93 – 60.97m AOD. This is approximately 0.3-0.4m below the proposed floor level of the basement at the development (61.3m AOD). IDG recommend the well installed in BH07 be decommissioned (i.e. removed and grouted up) as part of the preparatory works for the site.
Excavations	Excavations in the Granular Glaciofluvial Sheet Deposits are likely to be unstable and running sand should be anticipated. Allowance should be made for difficult digging for any excavations that extend into the PMCM bedrock. Groundwater within the PMCM bedrock at BH07 has been recorded at depths of between 3.16m – 3.20m bgl. Provision for groundwater control should be made for any deep excavations required during development.

The following further works are recommended:

- Decommissioning of BH07 during the preparatory works due to sub-artesian groundwater in the PMCM strata.
- Watching brief to be provided by a Geoenvironmental Consultant during any excavations that occur within the footprint of the former dye works buildings during the preparatory works at the site.

This brief summary should not be assumed to represent a complete account of all the potential geo-environmental issues that may exist at the site. As such it is strongly recommended that the report be read in its entirety.

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APPENDICES

Appendix A - Drawings

Drawing No.	Title
5238-G-D001	Site Location Plan
5238-G-D002	Existing Site Features & Site Photographs
5238-G-D003	Historical Features Plan
5238-G-D004	Exploratory Hole Location Plan
RADHUB-PAL-VV-XX-DR-A-1105 Rev P03	Proposed Site Layout Plan
RADHUB-POZ-V4-B1-DR-A-1201 Rev P07	Lower Ground Floor Plan
RADHUB-POZ-V4-ZZ-DR-A-1400 Rev P04	Proposed Sections – Sheet 1 of 2
RADHUB-POZ-V4-ZZ-DR-A-1401	Proposed Sections – Sheet 2 of 2

Appendix B - Historical OS Plans

Appendix C - Search Responses & Desk Study Data

From	Date	Content
Landmark	22/11/21	Environmental Search Response
Coal Authority	22/11/21	Coal Mining Report
BGS	13/7/22	Radon Report

Appendix D - Exploratory Records

Appendix E - Contamination Analysis & Chemical Test Results

Appendix F - Geotechnical Test Results

Appendix G – Groundwater Monitoring Records

Appendix H - General Notes

01	Environmental Setting
02	Ground Investigation Fieldwork
03	Geotechnical Testing
04	Contamination Laboratory Analysis & Interpretation (including WAC)
05	Hazardous Gas

Revision History

From	Date	Comments
5238-G-R001	August 2022	Original Report

FOREWORD

(Geoenvironmental Appraisal Report)

This report has been prepared for the sole internal use and reliance of the Client named on page 1. This report shall not be relied upon or transferred to any other parties without the express written authorisation of ID Geoenvironmental Limited (IDG); such authorisation not to be unreasonably withheld. If any unauthorised third party comes into possession of this report, they rely on it at their peril and the authors owe them no duty of care and skill.

The report presents observations and factual data obtained during our site investigation, and provides an assessment of geoenvironmental issues with respect to information provided by the Client regarding the proposed development. Further advice should be sought from IDG prior to significant revision of the development proposals.

The report should be read in its entirety, including all associated drawings and appendices. IDG cannot be held responsible for any misinterpretations arising from the use of extracts that are taken out of context.

The findings and opinions conveyed in this report (including review of any third party reports) are based on information obtained from a variety of sources as detailed within this report, and which IDG believes are reliable. All reasonable care and skill has been applied in examining the information obtained. Nevertheless, IDG cannot and does not guarantee the authenticity or reliability of the information it has relied upon.

The report represents the findings and opinions of experienced geo-environmental consultants. IDG does not provide legal advice and the advice of lawyers may also be required.

Intrusive investigation can only investigate shallow ground beneath a small proportion of the total site area. It is possible therefore that the intrusive investigation undertaken by IDG, whilst fully appropriate, may not have encountered all significant subsurface conditions. Consequently, no liability can be accepted for conditions not revealed by the exploratory holes. Any opinion expressed as to the possible configuration of strata between or below exploratory holes is for guidance only and no responsibility is accepted as to its accuracy.

It should be borne in mind that the timescale over which the investigation was undertaken may not allow the establishment of equilibrium groundwater levels. Particularly relevant in this context is that groundwater levels are susceptible to seasonal and other variations and may be higher during wetter periods than those encountered during this commission.

Where the report refers to the potential presence of invasive weeds such as Japanese Knotweed, or the presence of asbestos containing materials, it should be noted that the observations are for information only and should be verified by a suitably qualified expert.

This report assumes that ground levels will not change significantly from those existing at present. If this is not to be the case, then some modification may be required.

ID Geoenvironmental Limited cannot be responsible for the consequences of changing practices, revisions to waste management legislation etc that may affect the viability of proposed remediation options.

IDG reserve the right to amend their conclusions and recommendations in the light of further information that may become available.

GEOENVIRONMENTAL APPRAISAL

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RADCLIFFE HUB, RADCLIFFE

1 INTRODUCTION

1.1 The Commission and Brief

1.1.1 ID Geoenvironmental Limited (IDG) have been commissioned by Bury Council (The Client) to undertake a Geoenvironmental Appraisal of land at Radcliffe Hub, Radcliffe, hereafter referred to as 'the site'. A third party, Vinci Construction UK Limited (Vinci) have been appointed by Bury Council as the Design & Build Contractor for the proposed development.

1.1.2 The principal objective of this phase of investigation is to identify salient geoenvironmental issues affecting the site.

1.1.3 Bury Council provided IDG with a copy of a Constraints Desk Study report (Ref. RAD-ARP-RP-CG-0001, Issue 2, dated April 2021) by Ove Arup & Partners Ltd (Arup). The scope of works for IDG's investigation was determined by the findings of the Arup report and comprised:

- Review of Arup's Constraints Desk Study Report
- Mining Risk Assessment
- Update of the preliminary conceptual site model and design of an intrusive investigation.
- An intrusive investigation comprising four window sampling boreholes and three rotary boreholes.
- Installation of monitoring wells and monitoring of groundwater levels over a six-month period.
- Undertaking a quantitative contamination risk assessment using generic assessment criteria.
- Identification of site development constraints and provision of recommendations for site remediation works.

1.2 The Proposed Development

1.2.1 It is understood that consideration is being given to redevelopment of the site with a three-storey leisure and community centre that will include a lower ground floor level (i.e. basement). The centre is to include a swimming pool, climbing wall, fitness suite, library and community rooms.

1.2.2 Drawing No. RADHUB-PAL-VV-XX-DR-A-1105 Rev P03 presented in Appendix A shows the extent of the proposed building with cross sections (Drawing No. RADHUB-POZ-V4-ZZ-DR-A-1400 Rev P04 & RADHUB-POZ-V4-ZZ-DR-A-1401) also presented in Appendix A that show the proposed floor elevations of the building and indicate the floor level of the basement will be at an elevation of 61.3m AOD.

1.2.3 Vinci have indicated that the new leisure and community centre will be constructed with piled foundations.

1.2.4 IDG have classified the proposed development as Geotechnical Category 2.

1.3 Report Format and Limitations

1.3.1 All standard definitions, procedures and guidance are contained within Appendix H, which includes background, generic information on:

- Assessment of the environmental setting of the site
- Ground investigation fieldwork
- Geotechnical Testing
- Contamination Testing
- Hazardous Gas

- 1.3.2 General notes and limitations relevant to all IDG investigations are described in the Foreword and should be read in conjunction with this report. The text of the report draws specific attention to any modification to these procedures and to any other special techniques employed.

2 SITE DESCRIPTION

2.1 General

- 2.1.1 The site location is shown on Drawing No. 5238-G-D001 presented in Appendix A. Site details are summarised in the following table.

Summary of Site Location Details

Location	Radcliffe town centre
NGR	378540, 406950
Approximate Area	0.73Ha

2.2 Site Features

- 2.2.1 An IDG Engineer completed a walkover survey of the site on 23rd November 2021. Existing site features together with a photographic record of the site at the time of the walkover survey are shown on Drawing No. 5238-G-D002 presented in Appendix A.
- 2.2.2 The site falls gently in elevation from north to south and comprises Radcliffe Market Hall, several commercial units and an open space in the north featuring a bandstand. An electrical transformer and substation is present along the southwest site boundary.
- 2.2.3 The site is bounded by Dale Street to the northwest, Church Street to the northeast, a car park for a Lidl superstore to the southwest and the River Irwell to the southeast.
- 2.2.4 IDG did not observe any signs of invasive vegetation such as Japanese Knotweed or Himalayan Balsam during the site walkover. However, it should be noted that IDG are not qualified ecologists and recommend that specialist ecological advice be sought prior to development.

3 PREVIOUS INVESTIGATION FINDINGS

3.1 General

- 3.1.1 The Client provided IDG with a copy of a Constraints Desk Study report for Radcliffe Town Centre (Report Ref. RAD-ARP-RP-CG-0001 Issue 2, dated April 2021) undertaken by Ove Arup & Partner Limited (Arup).
- 3.1.2 Arup's Desk Study report investigated two parcels of land located to the north and south of Dale Street referenced as the northern block and the southern block.
- 3.1.3 Comparison of the extent of the two blocks investigated in Arup's Desk Study indicates the area identified as the Southern Block in Arup's report has the same extent as the site to be investigated by IDG.
- 3.1.4 Pertinent desk study information relating to the site presented in Arup's report (i.e. the southern block) is presented below.

3.2 Site Features

- The market building and adjacent disused offices occupy the full river side elevation and are 2 to 3-storey brick structures. The basement underlies all sections of these buildings and the southern edge of this forms the river wall.
- The remainder of the site comprises a 3-storey brick clad commercial block with single storey to the rear, an external public realm area with seating. A covered bandstand area is situated in the north of the site.
- An electrical substation was noted on the southwestern corner of the commercial block.

- The River Irwell is situated immediately southeast of the site and flows from the northeast to the southwest.
- Ground level varies between 66.2m AOD in the north to 61.5m AOD in the south, and 64.8m AOD in the west to 64.2m AOD in the east.
- The basement of the market building was briefly accessed during the site visit where a number of structural defects were identified.

3.3 Environmental Setting

- The site is underlain by Glaciofluvial Sheet deposits comprising sand and gravel.
- Given the history of the site, Made Ground is expected across the entire site.
- Bedrock beneath the majority of the site is the Pennine Middle Coal Measures (PMCM) strata comprising mudstone, siltstone and sandstone. There is a NW-SE trending fault in the east of the site, which results in the Nob End Sandstone formation underlying the eastern part of the site.
- The PMCM is classified as a Secondary A Aquifer.
- There are no active licensed groundwater abstractions located within 1km of the site.
- The site is not within a groundwater Source Protection Zone.
- The Environment Agency flood risk mapping indicates the site is not located within an area at risk of river or coastal flooding, except for a small area just north of the market building on the corner of Blackburn Street.
- There are no landfills with an active licence within 500m of the site.
- The Environment Agency records show two historical landfills within 500m of the site:
 - an inert waste landfill located 183m west of the site, operated by Bury Council and licenced between March and May 1991.
 - landfill located 265m north of the site which was first recorded to operate from December 1974. The date the landfill ceased operating and the type of waste accepted are unknown.
- The presence of unrecorded areas of landfilling is unlikely within the site.

3.4 Mining

- There are nine records of ground workings within 500m of the site. The closest of these is Stand Lane Colliery, 139m southeast of the site, which was operational from 1874 to 1926.
- The closest surface mineral working was Scar Top, 227m northeast of the site which quarried sandstone.
- The site is not located within a Development High Risk Area.
- Groundsure Coal Mining report states “The property lies within the potential zone of influence of recorded workings in 7 seams of coal. The most recent underground working in the area was in 1900. These workings lie between 35m and 325m. Any ground movement due to this coal mining activity should have stopped”.
- Further evaluation of the seam depth will be required to mitigate the risk of the presence of shallow worked seams below the site.

3.5 Previous Site Investigations of Adjacent Site (Lidl Superstore)

3.5.1 Two phases of ground investigation were undertaken on land immediately southwest of the site, prior to the development of a new Lidl superstore.

Ian Farmer Associates (2015)

- Two window sample holes were drilled in January 2015 to depths of 1.36m bgl and 4.22m bgl.

LK Consult (2015)

- Additional geo-environmental assessment was undertaken later in 2015, this included:
 - Drilling of 9 window sample boreholes from 0.3 to 5.16m bgl
 - Drilling of 2 cable percussive boreholes from 4.2 to 6.36m bgl
 - Excavation of 5 hand excavated trial holes from 0.7 to 1.0m bgl
 - Standard penetration tests approximately every 1m in natural strata.
 - Installation of monitoring wells in 6 boreholes for gas monitoring and groundwater sampling.
- Ground conditions encountered were generally consistent and comprise Made Ground underlain by natural sand, sand and gravel and clay deposits. PMCM Mudstone bedrock was encountered in 5 locations between 3.5m bgl and 5.7m bgl.
- Made Ground was generally formed of a surface layer of hard surfacing (concrete, tarmac, block paving, and flagstones) over construction sub-base (yellow sand and gravel comprising limestone). This formed a layer up to 0.8m thick overlying slightly silty slightly clayey gravelly sand with frequent to occasional brick, ash, clinker, glass, concrete and coal fragments – areas of high clay content were noted within Made Ground.
- A weak hydrocarbon odour was identified in WS1 between 1.0m and 2.5m bgl and an in-situ measurement of volatile hydrocarbons detected a concentration of 0.9ppm in a soil sample collected from this location.
- Soft clays and loose sand, inferred to represent an alluvial deposit, was encountered beneath Made Ground in certain locations and ranged in thickness between 0.3 and 2m thick.
- A layer of medium to dense sand and gravel, inferred to represent a glaciofluvial sand and gravel deposit was encountered below the alluvial deposit (or Made Ground where alluvium was absent).
- Groundwater levels were recorded between 2.87m to 4.03m bgl.
- One sample of Made Ground identified elevated lead concentrations above generic human health risk assessment criteria for a commercial land use.
- Groundwater sampling did not identify elevated concentrations of contaminants.
- One exceedance of hexavalent chromium was identified in one leachate test.
- Maximum concentrations of 8.4%v/v carbon dioxide and 0.1%v/v methane were recorded and maximum flow was detected as 0.3l/h. LK Consult Ltd recommended installing gas protection in the new building.
- Groundwater was recorded in the Lidl investigation at a similar level to the River Irwell and it is therefore likely that groundwater is in continuity with the River Irwell.

3.6 Arup's Conceptual Site Model

3.6.1 Potential contamination sources identified in Arup's report are summarised below:

- Made Ground at the site may comprise demolition materials from past use of the site and may therefore contain asbestos, heavy metals, PAHs and potentially volatile and semi-volatile hydrocarbons.
- The soils below the electrical substation in the south of the site may have been impacted by leaks of transformer oil (a type of refined mineral oil) and coolant fluids which may contain polychlorinated biphenyls (PCB).
- Dye works may be a source of a range of possible contaminants including metals, inorganics, acids, solvents, pesticides, fungicides. However, given the age of the dye works which once occupied parts of the site the likelihood of many of these contaminants, in particular the volatile hydrocarbons, is considered to be low.
- The ground gas generating potential at the site is expected to be low and the ground gas regime at the site is likely to be very similar to the adjacent Lidl site.

3.7 IDG Comments

- 3.7.1 After review of Arup's Desk Study report IDG generally consider it to be a thorough and comprehensive assessment of the site's environmental setting and potential contamination sources. However, IDG consider the land use history, whilst acceptable for the site, is lacking detail regarding the surrounding area, as such IDG consider a further assessment of the site and surrounding area's historical land use should be undertaken. In addition, Arup's report does not make any comment regarding the aquifer status of the superficial deposits or the risk of radon gas at the site.
- 3.7.2 Section 3.5 of the Arup report states the need for further assessment of potential mining risks beneath the site, as such IDG consider a detailed assessment needs to be undertaken as part of IDG's Geoenvironmental Appraisal of the site.
- 3.7.3 IDG consider Arup's report to generally be acceptable, with further consideration of the following factors to be undertaken by IDG to ensure all elements of a Desk Study have been completed prior to undertaking intrusive investigation:
- Historical land use
 - Aquifer status of the superficial deposits
 - Radon gas risk
 - Mining risk at the site

4 SITE HISTORY

4.1 Historical OS Maps

- 4.1.1 In order to investigate the development history and previous land uses at the site and immediate surrounding land, site centred extracts from Ordnance Survey (OS) plans dating back to 1848 were examined. These plans are presented in Appendix B.
- 4.1.2 The following table provides a summary of the salient points relating to the history of the site. Significant former uses/operations are highlighted in bold text for ease of reference.

Summary of Information from Historical Plans

Date(s)	Site	Surrounding Land
1848 (plan presented in Arup report)	Several small buildings present in the south of the site including a dye works . Road present in north and east of the site.	Numerous buildings present to north and east of the site. Open land to the southwest of the site. River Irwell forms the south-eastern boundary of the site.
1893	Two streets present on site, Foundry Street & Factory Street Numerous buildings present on site with the largest being a Market Hall	Irwell Mill (Cotton) with two small reservoirs located immediately south southwest of the site Irwell Preserve Works located on the opposite bank of the Irwell Cawdaw Works (dying) present 50m south of the site on the opposite bank of the River Irwell. Several streets and numerous small to large buildings present of the northwest and northeast of the site. Chemical works located 230m southeast of the site Iron works located 50m west of the site Seymour Works (Dying) with reservoir located 100m northeast of the site Several cotton mills located within 250m of the site Gas Works located 170m west of the site
1909	Several buildings and Factory Street in east of the site are no longer present, replaced by an open marketplace.	Circular feature, considered to be a gas holder constructed 125m west of the site Seymour Works (cotton mill) recorded as being disused
1929	Row of buildings constructed in the east of the site	No significant changes in the surrounding area

Date(s)	Site	Surrounding Land
1937	Buildings in south of the site no longer present	Irwell Mill immediately southwest of the site has been demolished and replaced with a cinema. No other significant changes noted.
1956	Majority of buildings are no longer present. Majority of the site is now a bus station . Market Hall constructed along the eastern boundary of the site	Buildings immediately west of the site no longer present.
1970	Bus shelter and buildings in north of the site no longer present and replaced by several new buildings. Small rectangular Building in southwest of the site present (this is currently an electricity substation)	Many buildings to the north of the site have been demolished and have not been replaced Cinema just beyond the southwest boundary, no longer present and replaced with a bus station Gas works to the west of the site no longer present
1994-1995	No significant changes on site	Numerous roads and buildings to the south and southwest of the site no longer present and replaced with a new highway called Pilkington Way and several car parks

- 4.1.3 The approximate extents of buildings shown to be present on site on the 1848 and 1893 OS plans are shown on Drawing No. 5238-G-D003 presented in Appendix A.

5 SUPERFICIAL DEPOSITS

5.1 Aquifer Status

- 5.1.1 Review of the Envirocheck report presented in Appendix C indicates the superficial deposits at the site are classed as a Secondary A Aquifer.

6 RADON GAS

6.1 Radon Report

- 6.1.1 IDG purchased a site specific radon report for the site from the BGS which is included in Appendix C. Review of the report indicates the site is in an intermediate probability radon area (1 to 3% of homes are estimated to be at or above the Action Level) with the report also stating that no radon protective measures are required for new buildings at the site.
- 6.1.2 However, on consideration of the type of building to be constructed, employers must ensure the health and safety of employees and others who have access to their work environment and BRE document BR211:2015 notes that an assessment of health and safety risks under national regulations should include radon where the workplace is in a radon-affected area, or in any location where there is a basement that is regularly occupied, with both of these scenarios applying to the site. This assessment would likely require the monitoring of radon in the building post construction, therefore consideration should be given to the installation of basic radon protection measures during construction of the development to mitigate any potential radon gas issue upon completion of the building.

7 MINING RISK ASSESSMENT

7.1 Geology

1:50,000 Scale Plan

- 7.1.1 BGS Sheet 85 depicts the site to be underlain by Glaciofluvial Sheet Deposits with the bedrock beneath the site comprising PMCM strata.

1:10,560 Scale Plan

- 7.1.2 Sheet SD70NE, a partially completed plan from the BGS, shows a fault crossing in the northeast of

the site, trending northwest-southeast. The downthrow is to the east. The amount of throw is not stated.

- 7.1.3 The approximate location of the fault is shown on Drawing No. 5238-G-D004 presented in Appendix A.

7.2 Coal Mining Information

Coal Authority Interactive Map

- 7.2.1 Inspection of available information for the site presented on The Coal Authority's online website identifies the following:

- The site is not located in a development high risk area.
- There are no coal outcrops beneath the site.
- The site is not located in an area of past shallow coal mine workings.
- The site is not in an area where there is probable shallow coal mine workings.

Arup Information

- 7.2.2 Arup's report identifies the disused Stand Lane Colliery located 140m southeast of the site.

Coal Authority Consultants Report

- 7.2.3 A Coal Authority Consultants Report for the site purchased by IDG indicates the following:

- Seven coal seams worked beneath the site from 103-468m with the last seam worked in 1900.
- No mine entries onsite or within 100m of the site.
- Probable unrecorded shallow mineworkings beneath the site stated as none.
- No coal outcrops located beneath the site.
- Geological fault indicated to cross the site in a northwest/southeast trend in the north of the site.
- No recorded mine gas within 500m of the site.
- The Coal Authority has not received a damage notice or claim for the subject property, or any property within 50 metres of the enquiry boundary, since 31st October 1994.

7.3 BGS Borehole Records

- 7.3.1 Records have been obtained from the BGS for the exploratory holes shown in the table below.

BGS Borehole Records

BGS BH Ref.	Date	Location	Final Depth (m)	Summary of Strata Encountered
SD70NE75/D	May - 1972	71m N	7.62	0.0 – 2.13m – Made Ground 2.13 – 3.67m – Clayey SAND 3.67 – 7.62m – SHALE & SANDSTONE
SD70NE75/C	May - 1972	75m N	7.62	0.0 – 1.07m – MADE GROUND 1.07 – 3.3m – SAND 3.35 – 7.62m – SANDSTONE
SD70NE30	Unknown	252m E	83.82	0.0 – 1.22m – MADE GROUND 1.22 – 3.96m – SAND & GRAVEL 3.96 – 65.84m – MARL 65.84 – 83.82m – SANDSTONE

7.4 Coal Mining Assessment

- 7.4.1 The Coal Authority's Consultants report purchased by IDG identifies seven coal seams have been worked beneath the site from a depth of 103-486m. The depths stated in the Coal Authority report are different from those stated in Arup's report which notes seven seams have been worked at a depth of 35-325m beneath the site. The difference in the depth of worked seams is attributed to the geology beneath the 'Northern Block' of Arup's investigation.

- 7.4.2 The risk of probable unrecorded shallow mineworkings beneath the site is stated in the Coal Authority report to be none. Support for this comment is provided from the geology recorded in BGS boreholes and the investigation undertaken for the adjacent Lidl superstore which recorded granular deposits to depths of between 3.3m-5.7m bgl and a groundwater body at depths of between 2.87m and 4.03m bgl which is considered to demonstrate continuity to the water level in the River Irwell.
- 7.4.3 Given the Coal Authority's comments, the ground conditions recorded in vicinity of the site and the likelihood of a groundwater body in continuity with the adjacent River Irwell, IDG consider the possibility of unrecorded shallow mine workings beneath the site can be discounted.

8 PRELIMINARY CONCEPTUAL SITE MODEL

General

- 8.1.1 Based on the data presented in the preceding sections of this report, a Preliminary Conceptual Site Model has been determined as outlined below.

Potential Contamination Sources

- 8.1.2 Historical maps indicate the site has had several phases of development generally associated with commercial retail use and show a dye works was present in the south of the site in the mid 19th Century. It is therefore considered likely that Made Ground deposits are present across the site which may present a risk of metals, Speciated PAH and asbestos contamination. Localised contamination (metals, inorganics, acids, solvents) associated with the dye works may also be present, however IDG agree with Arup's assessment that given the age of the dye works the likelihood of many of these contaminants being present, in particular the volatile hydrocarbons, is considered to be low.
- 8.1.3 In addition, an electricity substation constructed in the 1960s is present in the south of the site which represents a potential source of localised PCB contamination.
- 8.1.4 No significant risk from landfill or mines gas has been identified.
- 8.1.5 The site is in an intermediate probability radon area (1 to 3% of homes are estimated to be at or above the Action Level) and current Building Control Regulations do not require radon protection measures to be installed in new buildings.
- 8.1.6 However, a radon assessment will be required after construction of the building which is likely to require the monitoring of radon in the building, therefore consideration should be given to the installation of basic radon protection measures during construction of the development to mitigate any potential issue upon completion of the building.

Human Receptors

- 8.1.7 Following the proposed redevelopment, human receptors will include workers and customers within the new properties, visitors using public open space areas, and workers/residents in neighbouring properties.
- 8.1.8 In addition, future utility maintenance workers could be affected by contaminants that remain in the ground following site redevelopment.
- 8.1.9 Transient risks to construction workers from handling contaminated soils are normally addressed by the adoption of appropriate health and safety measures during the construction works, and therefore these receptors are not considered further.
- 8.1.10 Similarly, risks to workers/residents in neighbouring properties due to airborne dust or vapours during redevelopment works should be addressed by the adoption of suitable measures.

Controlled Water Receptors

- 8.1.11 The superficial deposits beneath the site are classified as a Secondary A Aquifer. The underlying bedrock is also classified as a Secondary A Aquifer. The site is not located within a Source Protection Zone and there are no surface or groundwater abstractions within 1km of the site.
- 8.1.12 The nearest surface watercourse is the River Irwell, which flows in a south-westerly direction, immediately beyond the site's south-eastern boundary.
- 8.1.13 Based on the above, the site's environmental setting has been assessed as moderate sensitivity.

Preliminary Conceptual Site Model

- 8.1.14 A Preliminary Conceptual Site Model has been prepared after consideration of all the data presented in the preceding sections of this report. Potential pollutant linkages are summarised in the following table.

Summary of Potential Pollutant Linkages

Potential Contamination Source	Receptors	Plausible Pathways	Evidence / Site Features
Metals & PAHs in Made Ground	Human Health (future site users – commercial users)	Ingestion, direct contact, inhalation of dust	Former buildings on site have been demolished
	Shallow groundwater in Superficial Deposits which are in continuity with the River Irwell	Leaching and migration of dissolved heavy metals contamination	
Asbestos in Made Ground	Human Health (future site users – commercial users)	Inhalation of dust containing asbestos fibres	Former buildings on site have been demolished
Hydrocarbon impacted soils (PCBs, solvents)	Human Health (future site users – commercial users)	Ingestion, direct contact and inhalation of vapours	PCBs from electricity substation on site Dye works on site
	Shallow groundwater in Superficial Deposits which are in continuity with the River Irwell	Migration of free product and leaching and migrations of dissolved phase hydrocarbons	
Hazardous Gas (Radon)	Human Health	Migration of radon through granular strata and ingress into confined spaces leading to adverse health effects	The site is in an intermediate probability radon area, current Building Control Regulations do not require radon protection measures to be installed in new buildings. Consideration should be given to the installation of basic radon protection measures during construction of the development to mitigate any potential issue upon completion of the building

9 GROUND INVESTIGATION DESIGN

9.1 Ground Investigation Design & Strategy

9.1.1 The preliminary conceptual site model was used as a basis for design of an appropriate ground investigation, the scope of which is summarised below.

Ground Investigation Strategy

Exploratory Holes	Purpose
Window Sampling Boreholes	To determine the general nature of soils underlying the site, including the: • nature, distribution and thickness of Made Ground • nature, degree and extent of contamination • proportion of undesirable elements e.g. biodegradable matter, foundations etc To install monitoring wells across the site in order to determine groundwater levels and assess flow direction and retrieve representative groundwater samples, to determine water quality.
Rotary Coring Boreholes	To determine the general nature of soils underlying the site, including the: • nature, distribution and thickness of Made Ground • nature, degree and extent of contamination • proportion of undesirable elements e.g. biodegradable matter, foundations etc • recovery of rock cores for geotechnical testing To install monitoring wells across the site in order to determine groundwater levels and assess flow direction and retrieve representative groundwater samples, to determine water quality.

9.1.2 An assessment of potential contaminants associated with the former uses has been undertaken which identified the following potential contaminants within soil and/or groundwater at the site:

- Metals
- PAHs
- Asbestos fibres
- PCBs
- Solvents

10 FIELDWORK

10.1 Exploratory Hole Location Constraints

10.1.1 The investigable area of the site was severely limited due to the site's setting, i.e. town centre with trading businesses and numerous buried services present. Therefore, window sampling and rotary drilling were the only practical methods of investigation.

10.1.2 It should be noted that the methods of intrusive investigation adopted allow only a limited inspection of the ground (especially soils with a significant proportion of coarse material). Furthermore, assessment of the strength of cohesive soils can be limited due to disturbance caused by drilling.

10.2 Scope of Works

10.2.1 Fieldwork was supervised by IDG during three visits (January, May and July 2022) and comprised the exploratory holes listed in the following table.

Scope of Ground Investigation Works

Technique	Exploratory holes	Final depth(s)	Remarks
Window Sampling boreholes	WS01 – WS04	3.6 – 6.7m	SPTs typically at 1m centres. Monitoring wells installed
Rotary Probeholes	BH05 – BH07	13.5 – 18.0m	SPTs typically at 1m centres. Monitoring wells installed

10.2.2 Notes describing ground investigation techniques, in-situ testing and sampling are included in Appendix H.

10.2.3 Exploratory hole locations are shown on Drawing No. 5238-G-D004 presented in Appendix A.

11 GROUND CONDITIONS

11.1 Exploratory Hole Records

11.1.1 A complete record of strata encountered beneath the proposed development site is given on the exploratory hole logs in Appendix D.

11.1.2 The exploratory hole logs include:

- Details of the samples taken
- Descriptions of the strata
- Details of groundwater conditions encountered
- Results of in-situ testing
- Details of monitoring wells installed

11.1.3 Ground conditions encountered are described below.

11.2 Ground Conditions

11.2.1 The ground conditions encountered across the site typically comprised hardstanding underlain by Made Ground proven to depths of 0.6 – 1.8m.

11.2.2 Several below ground obstructions were encountered at shallow depth during the investigation as summarised in the following table.

Below Ground Obstructions Summary

Hole ID	Depth of Obstruction	Type of Obstruction
WS01	0.50m	Sandstone slab
WS01A	0.95m	Concrete
WS03	0.85	Ceramic drain
WS04	0.1 – 0.2m	Concrete slab

Superficial Deposits

11.2.3 Glaciofluvial Sheet Deposits were encountered beneath the Made Ground at WS01B, WS02, WS03A, WS04, BH05, BH06 & BH07 and typically comprised brown sandy gravelly clay underlain by grey gravelly sand.

11.2.4 A summary of the depth that the Glaciofluvial Sheet Deposits were encountered is presented in the following table.

Superficial Deposits Summary

Hole ID	Top of Glaciofluvial Sheet (m bgl)	Base of Glaciofluvial Sheet (m bgl)	Thickness (m)	Top of Glaciofluvial Sheet (m AOD)	Base of Glaciofluvial Sheet (m AOD)
WS01B	0.9	4.2	3.2	63.07	59.77
WS02	1.5	5.2	3.7	62.95	59.25
WS03A	1.4	4.9	3.4	62.96	59.46
WS04	1.6	3.5	1.9	62.03	60.13
BH05	0.6	3.0	2.4	63.50	61.10
BH06	0.6	3.2	2.6	65.02	62.42
BH07	1.8	4.3	2.5	62.33	59.83

11.2.5 Review of the table indicates Superficial Deposits range in thickness from 1.9m proven in WS04 to 3.7m proven in WS02. The table also indicates the base of the Superficial Deposits reduces in elevation from the north (BH06 – 62.42m AOD) towards the southwest (WS02 – 59.25m AOD).

Bedrock

11.2.6 PMCM bedrock comprising grey to dark grey thinly laminated Mudstone was encountered in several boreholes at depths ranging from 3.0m bgl in BH05 to 5.2m bgl in WS02 and proven to a maximum depth of 18.0m (BH07).

- 11.2.7 A thin band of coal was encountered in BH06 at a depth of 13.2-13.3m.
- 11.2.8 The Mudstone recovered from BH05-BH06 was observed to be highly weathered with several thin bands within the strata noted to have weathered to a clay. Core recovery in BH07 was noticeably improved in comparison to BH05 and BH06 with the Mudstone showing less evidence of weathering and fewer drilling induced fractures and natural fractures.
- 11.2.9 A summary of the rock core logging information is presented below.

Core Logging Summary

Hole ID	Range of TCR (%)	Range of SCR (%)	Range of RQD (%)	RQD Rock Description	Fracture Index (If)
BH05	42 – 100	7 – 90	0 – 54	Very poor to fair	2.9 – 10.0
BH06	30 – 83	18 – 68	0 – 46	Very poor to poor	Not Possible
BH07*	40 – 100	26 – 90	23 – 58	Very poor to fair	2.0 – 4.7

*Core recovery from 4.5m to 6.0m omitted from summary table due to zero recovery as a result of inclusion of cobbles from overlying superficial deposits destroying the core.

- 11.2.10 Review of the table indicates the description of the RQDs calculated for the boreholes range from very poor to fair and can typically be described as poor.

11.3 Visual & Olfactory Evidence of Hydrocarbon Contamination

- 11.3.1 No evidence of hydrocarbon contamination was noted in any of the exploratory holes.

11.4 Groundwater

- 11.4.1 Two groundwater bodies were encountered during the investigation, one within the Glaciofluvial Sheet Deposits and the second within the PMCM strata. Further details are provided below.

Glaciofluvial Sheet Deposits

- 11.4.2 Groundwater monitoring wells with response zones within the Glaciofluvial Sheet Deposits were installed in six boreholes during the investigation. Details of the well installations together with the recorded standing water level based on monitoring results to date are presented in Appendix G and summarised in the following table.

Glaciofluvial Sheet Deposits - Groundwater Levels

Hole ID	Groundwater Body	Installation Response Zone Depth (m bgl)	Recorded Standing Water Levels (m bgl)	Recorded Standing Water Levels (m AOD)
WS01B	Glaciofluvial Sheet deposits	2.0 – 4.0	3.74 – 3.83	60.14 – 60.23
WS02	Glaciofluvial Sheet deposits	1.6 – 4.6	4.06 – 4.15	60.30 – 60.39
WS03A	Glaciofluvial Sheet deposits	2.0 – 5.0	2.09 – 3.87	60.49 – 62.27
WS04	Glaciofluvial Sheet deposits	1.0 – 3.0	Dry	-
BH05	Glaciofluvial Sheet deposits	2.0 – 3.0	2.36 – 2.94	61.16 – 61.73
BH06	Glaciofluvial Sheet deposits	2.0 – 3.0	1.33 – 2.52	63.10 – 64.29

- 11.4.3 Review of the table indicates shallow groundwater body present within the Glaciofluvial Sheet Deposits rests at depths of between 1.33m bgl (BH06) and 4.15m bgl (WS02) across the site.
- 11.4.4 Conversion of the standing water level to ordnance datum indicates the piezometric surface of the shallow groundwater body present within the Glaciofluvial Sheet Deposits falls from the north of the site (BH06) to the southwest of the site (WS02).

Pennine Middle Coal Measures

- 11.4.5 A groundwater monitoring well with a response zone within the PMCM strata was installed in BH07. Details of the well installation together with the recorded standing water level based on monitoring results to date are presented in Appendix G and summarised in the following table.

Pennine Middle Coal Measures - Groundwater Levels

Hole ID	Groundwater Body	Installation Response Zone Depth (m bgl)	Recorded Standing Water Levels (m bgl)	Recorded Standing Water Levels (m AOD)
BH07	PMCM	7.6 – 17.1	3.16 – 3.20	60.93 – 60.97

11.4.6 Review of the table indicates the groundwater present within the PMCM strata at BH07 rests at depths of between 3.16m – 3.20m bgl.

11.4.7 The groundwater level in BH07 is approximately 1.0m higher than the top of the PMCM strata and indicates the groundwater within the PMCM strata is under sub-artesian pressure.

11.5 Groundwater Sampling

Groundwater Sampling within Glaciofluvial Sheet Deposits

11.5.1 An IDG engineer visited the site on 5th July 2022 to carry out development of all of the wells installed into the Glaciofluvial Sheet Deposits in accordance with current best practice.

11.5.2 Monitoring wells installed in WS01B, WS02, BH05 and BH06 had standing water levels within 0.2m - 0.4m of the bottom of the well and as a result, less than 2-3 litres of groundwater was purged from each of the wells before they were dry, with groundwater recovery noted to be slow in all wells. WS03A had in excess of 2m of standing water within the well and was fully developed.

11.5.3 An IDG engineer made a further visit on 9th July 2022 to obtain representative water samples from the wells.

11.5.4 Less than 1-2 litres of groundwater was purged from WS01B, WS02, BH05 and BH06 before the wells were dry and this was accompanied with slow groundwater recovery and therefore no samples were taken from these wells. WS03A was fully purged with good groundwater recovery and sampled.

11.5.5 No free product or visual or olfactory evidence of contamination was identified by the Engineer during purging or sampling of the wells.

11.5.6 The water sample obtained from WS03A was placed in a cool box and despatched to a UKAS accredited chemical testing laboratory.

Groundwater Sampling within PMCM Strata

11.5.7 An IDG engineer visited the site on 12th July 2022 to carry out development of the well installed into the PMCM at BH07 in accordance with current best practice. BH07 had in excess of 13m of standing water within the well and was fully developed.

11.5.8 An IDG engineer made a further visit on 14th July 2022 to obtain representative water samples from the well. BH07 was fully purged and sampled with good groundwater recovery observed.

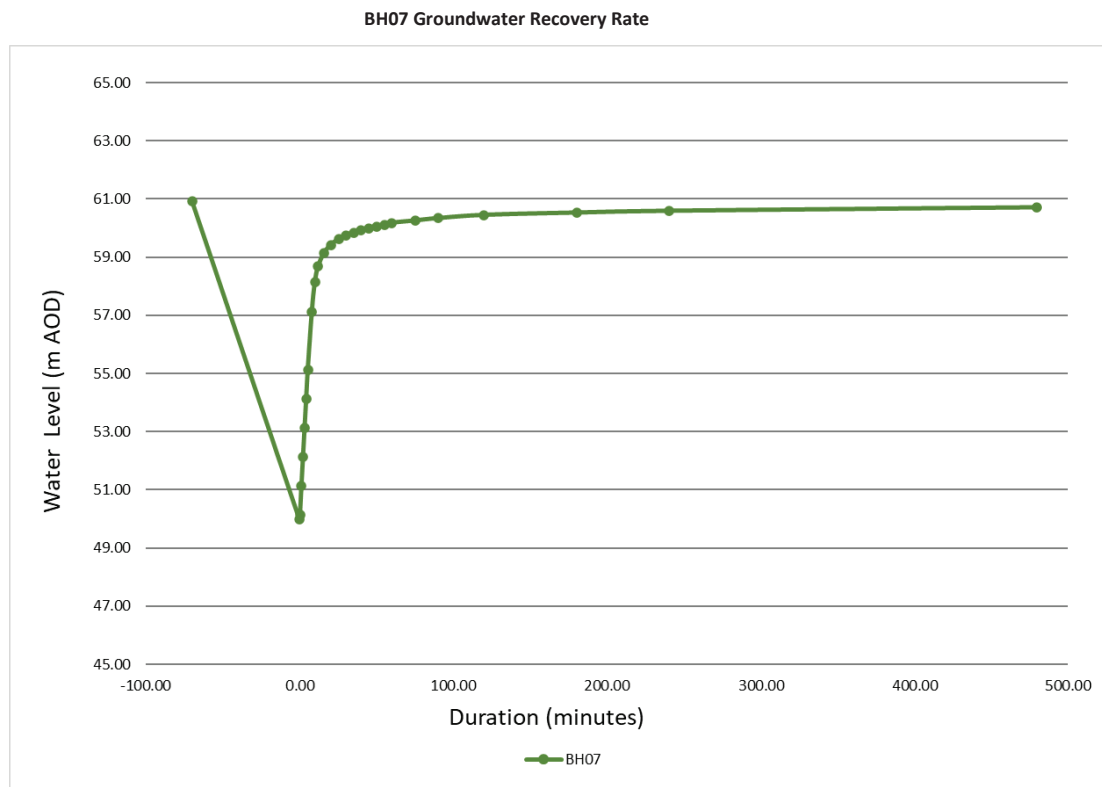
11.5.9 No free product or visual or olfactory evidence of contamination of the groundwater was identified by the Engineer during purging or sampling of the well.

11.5.10 The groundwater sample obtained from BH07 was placed in a cool box and despatched to a UKAS accredited chemical testing laboratory.

11.6 Groundwater Recovery – PMCM Strata

11.6.1 An IDG engineer recorded the rate of recovery of the groundwater level within BH07 after it had been purged on 14th July 2022.

11.6.2 The groundwater recovery observed in BH07 are presented in Appendix G and shown in the figure below.



- 11.6.3 Review of the figure above indicates the water level in BH07 dropped almost 11 metres during the purging of the borehole with a rapid recovery (8.14m) recorded in the first 10 minutes after pumping ceased and a relatively slow recovery thereafter.
- 11.6.4 At the end of the test (8 hours) the groundwater level in BH07 was 0.22m lower than its resting level prior to purging.
- 11.6.5 The rapid groundwater recovery observed in BH07 is considered to be a result of secondary permeability (i.e. infiltration through fissures) in the PMCM strata which is supported by the highly fractured state of the recovered rock cores.

12 HAZARDOUS GAS

- 12.1.1 A preliminary assessment of the risks associated with hazardous ground gas has been undertaken as described in Section 8.
- 12.1.2 IDG did not encounter any new evidence of potential hazardous ground gas sources during the intrusive investigation and therefore IDG consider the preliminary assessment presented in Section 8 to be valid and the risk of hazardous ground gases such as carbon dioxide and methane at the site can be discounted.
- 12.1.3 The site is in an intermediate probability radon area (1 to 3% of homes are estimated to be at or above the Action Level) and current Building Control Regulations do not require radon protection measures to be installed in new buildings.
- 12.1.4 However, a radon assessment will be required after construction of the building which is likely to require the monitoring of radon in the building, therefore consideration should be given to the installation of basic radon protection measures during construction of the development to mitigate any potential issue upon completion of the building.

13 CHEMICAL ANALYSIS

13.1 General

- 13.1.1 An assessment of potential contaminants associated with the former uses of the site has been undertaken as outlined in Section 9.1.2.

13.2 Testing Scheduled

- 13.2.1 Based on the above assessment, an IDG Engineer submitted a test schedule (summarised in the following table) to a UKAS accredited laboratory.

Chemical Testing Scheduled

Matrix	Type of Sample	No. of Samples	Determinands
Soil	Made Ground	7	pH and total metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc), Speciated PAH & asbestos screen
		1	Speciated TPH
		1	PCBs
	Glaciofluvial Deposits	1	pH and total metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc), speciated PAH & Speciated TPH
	PMCM	1	pH and total metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc), speciated PAH & Speciated TPH
		8	Calorific Value
Groundwater	Glaciofluvial Deposits	1	pH and total metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc) & Speciated PAH
	PMCM	1	pH and total metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc)

13.3 Human Health Generic Risk Assessment

- 13.3.1 The soil contamination test results are shown in Tables 1 to 3 presented in Appendix E, together with the laboratory test results. The results have been classified by comparison with the relevant LQM/ClEH S4UL (2015) UK guidance threshold values for a *commercial end use*. A 1% SOM content has been utilised for screening purposes.

- 13.3.2 Notes outlining current guidance with respect to the interpretation of analytical data are included in Appendix H.

Inorganic Contamination - Metals

- 13.3.3 No elevated concentrations of inorganic contaminants were detected in any of the samples tested.

Inorganic Contamination - Asbestos

- 13.3.4 Asbestos fibres were not identified in any of the samples screened.

Organic Contamination - Speciated PAHs

- 13.3.5 No elevated concentrations of Speciated PAHs were detected in any of the samples tested.

Organic Contamination - Speciated TPH

- 13.3.6 No elevated concentrations of aromatic or aliphatic TPH bandings or BTEX compounds were detected.

Organic Contamination - PCBs

- 13.3.7 A sample of Made Ground recovered from WS01B, the exploratory hole location located nearest to a potential source of PCB (substation in the west of the site), was subjected to PCB analysis.

- 13.3.8 No PCB concentrations above the laboratory's test methods' level of detection were recorded.

13.4 Controlled Waters Generic Risk Assessment

Groundwater Samples

- 13.4.1 Groundwater analysis test results are summarised in Tables 4 & 5 which are presented in Appendix E together with the laboratory test results. The significance of the results has been assessed by comparison with relevant guidance thresholds as shown in the tables.

Inorganic Contamination

- 13.4.2 No elevated concentrations of inorganic contaminants were detected in the water samples obtained from the groundwater bodies within the Glaciofluvial Sheet Deposits or the PMCM strata.

Organic Contamination - Speciated PAHs

- 13.4.3 Concentrations were not detected above the test method's limit of detection for each speciated PAH compound (<0.1ug/l) in a groundwater sample obtained from the Glaciofluvial Sheet Deposits.
- 13.4.4 It is noted that this value (<0.1ug/l) exceeds the assessment criteria for Fluoranthene (0.075ug/l) and Naphthalene (0.075ug/l). However, the total PAH recorded in the sample is also <0.1ug/l and therefore IDG consider it unlikely that the concentrations of Fluoranthene or Naphthalene are in excess of the assessment criteria and therefore the concentrations of PAH compounds in groundwater within the Glaciofluvial Sheet Deposits are not considered significant.

13.5 Other Testing - Calorific Value

- 13.5.1 Seven samples of PMCM were subjected to calorific value analysis. The results of the calorific value analysis are presented in the table below.

Calorific Value Testing Summary

Exp Hole	Strata	Depth (m)	Result (MJ/kg)
BH06	Dark Grey Mudstone	8.8	8.6
BH06	Dark Grey Mudstone	11.5	11.0
BH06	Coal	13.3	9.2
BH07	Grey Mudstone	6.5	2.1
BH07	Grey Mudstone	9.5	2.9
BH07	Grey Mudstone	12.5	2.0
BH07	Grey Mudstone	15.5	1.8

- 13.5.2 The results of the calorific value testing recorded values ranging between 1.8MJ/kg to 11.0MJ/kg.
- 13.5.3 There is no statutory guidance for the assessment of potential combustibility of in-situ material; however, the second edition of the ICRL Guidance Note 61/84 (Notes on the Fire Hazards of Contaminated Land) states that materials with calorific values exceeding 10MJ/kg are likely to ignite and suggests there is an unacceptable risk of smouldering for materials with a calorific value exceeding 7MJ/kg. Therefore, for the purpose of this assessment, a calorific value of 7MJ/kg has been adopted as the screening criteria.
- 13.5.4 Application of this screening criteria indicates the three samples tested from BH06 recorded calorific values above 7MJ/kg. Whilst these materials are at a depth in excess of 8m below ground level they may be disturbed during piling activities for the proposed development. IDG recommend the piling contractor are provided with a copy of this report in order to determine if any mitigation measures are required to reduce the risk of spontaneous combustion of the PMCM strata during piling.

14 CONTAMINATION AND REMEDIATION

14.1 Introduction

14.1.1 The Preliminary Conceptual Site Model was presented in Section 8 of this report. In order to produce a Revised Conceptual Site Model, consideration has been given to the following:

- the nature and distribution of Made Ground
- the nature and distribution of contamination sources
- sources of hazardous gas

14.1.2 The above issues have been discussed in preceding sections of this report and are summarised in the sections below.

14.2 Contaminant Sources

14.2.1 The results of the chemical testing have been presented in the preceding section of this report; an assessment of the significance of the results is summarised below.

Soil Contamination

14.2.2 No evidence of organic or inorganic contamination has been identified in the Made Ground or natural soils tested during the investigation.

Groundwater

14.2.3 Samples of the groundwater bodies present within the Glaciofluvial Sheet Deposits and the PMCM strata were tested and no evidence of contamination was identified.

Hazardous Gas

14.2.4 No hazardous ground gas sources have been identified. The risk of hazardous ground gases such as carbon dioxide and methane at the site has therefore been discounted.

14.2.5 The site is in an intermediate probability radon area (1 to 3% of homes are estimated to be at or above the Action Level) and current Building Control Regulations do not require radon protection measures to be installed in new buildings.

14.2.6 However, a radon assessment will be required after construction of the building which is likely to require the monitoring of radon in the building, therefore consideration should be given to the installation of basic radon protection measures during construction of the development to mitigate any potential issue upon completion of the building.

14.3 Pollutant Linkages

14.3.1 As outlined above, no contamination sources have been identified in the soils or groundwater beneath this site. No sources of hazardous ground gases such as carbon dioxide and methane have been identified although the site is located in an intermediate probability radon area.

14.3.2 Potential receptors identified in connection with the development were outlined in Section 8 and are shown in the following table together with the contamination sources and plausible pathways.

Revised Conceptual Site Model and Potential Remediation Options

Sources	Receptors	Plausible Pathways	Potential Remediation Options
Hazardous Gas (radon)	Human Health	Migration of Radon gas through granular strata and ingress into confined spaces leading to adverse health effects	The site is in an intermediate probability radon area, current Building Control Regulations do not require radon protection measures to be installed. Consideration should be given to the installation of basic radon protection measures during construction of the development to mitigate any potential issue upon completion of the building

- 14.3.3 Based on the Revised Conceptual Model presented above, the only potential pollutant linkage identified at the site relates to radon gas, however, current building control regulations do not require radon protection measures to be installed in new buildings to mitigate the risk. As such, no specific remediation works are considered necessary for radon gas at the site.

14.4 Remediation Strategy

- 14.4.1 Based on the Revised Conceptual Site Model, no significant pollutant linkages have been identified at the site and a Remediation Strategy should not be required by the Local Planning Authority.

14.5 Considerations for Development

Land Contamination

- 14.5.1 Whilst no contamination has been identified by the investigation, the following comments are provided for consideration by Vinci during the construction of the proposed development.

Made Ground

- 14.5.2 Where Made Ground is to remain beneath soft landscaped areas, it is recommended that a 300mm thick surface cover of uncontaminated soil should be placed as a growing medium over the Made Ground.
- 14.5.3 The growing medium may be formed entirely of topsoil, or alternatively may comprise subsoil overlain by topsoil; in this case the topsoil thickness should be a minimum of 150mm.

Petroleum Hydrocarbon Contamination

- 14.5.4 No areas of significant hydrocarbon contamination were encountered during the site works.
- 14.5.5 However, a dye works was present in the south of the site. Whilst no evidence of hydrocarbon contamination was encountered during the investigation, IDG consider this still represents a low risk of hydrocarbon contamination. It is therefore recommended that a watching brief be provided by a Geoenvironmental Consultant during any excavations that occur within the footprint of the dye works during re-development on the site.
- 14.5.6 In addition, if odorous or discoloured soils or liquids are encountered during development work, these may represent localised areas of hydrocarbon contamination and further advice should be sought from IDG.

Radon Gas

- 14.5.7 The site is in an intermediate probability radon area (1 to 3% of homes are estimated to be at or above the Action Level) and current Building Control Regulations do not require radon protection measures to be installed.
- 14.5.8 However, a radon assessment will be required after construction of the building which is likely to require the monitoring of radon in the building, therefore consideration should be given to the installation of basic radon protection measures during construction to mitigate any potential issue upon completion of the building.

Groundwater

- 14.5.9 No evidence of contamination has been recorded in either the groundwater body present within the Glaciofluvial Sheet Deposits or the groundwater body present within the PMCM strata.

14.6 Other Development Issues

- 14.6.1 Historical OS plans indicate several generations of buildings have been present on site, it should be assumed that foundations and other buried infrastructure associated with these buildings remain and will need to be removed to facilitate development of the site.
- 14.6.2 Groundwater levels recorded in the PMCM in BH07 indicate it is under sub-artesian pressure and resting at a level approximately 1.0m above the top of the PMCM strata with groundwater monitoring recording the water level at depths ranging between 3.16 – 3.20m bgl. Furthermore, conversion of the water levels to ordnance datum indicates the water level in BH07 rests at elevations of between 60.93 – 60.97m AOD. This is a level approximately 0.3-0.4m below the proposed floor level of the basement of the development.
- 14.6.3 IDG therefore recommend the well installed in BH07 be decommissioned (i.e. removed and grouted up) as part of the preparatory works for the site to remove a pathway for groundwater within the PMCM to enter any deep excavations made during redevelopment of the site (i.e. excavation for the construction of the basement areas) and also to mitigate any long term groundwater issues to the proposed development from the borehole.
- 14.6.4 Calorific value testing of the PMCM strata recorded values above 7.0MJ/kg in several samples of PMCM strata which indicate they may present a risk of spontaneous combustion. Whilst the affected samples were taken from depths in excess of 8m below ground level they may be disturbed during piling activities for the proposed development. IDG recommend the piling contractor are provided with a copy of this report in order to determine if any precautionary measures are required to mitigate the risk of spontaneous combustion of the PMCM strata during piling.

15 RE-USE, DISPOSAL AND IMPORT OF MATERIALS

15.1 Background

- 15.1.1 Materials are considered to be waste if they are discarded, if there is an intention to discard, or if there is a requirement to discard. Waste can only be disposed of at a site holding an environmental permit.
- 15.1.2 Soils (Made Ground or natural deposits) are considered to be waste at the point of excavation. If these “waste” soils are placed back into the ground or transferred to other sites, it could be deemed that waste has been disposed of without a permit. The person disposing of the waste and anyone who knowingly facilitates the disposal may be liable for payment of Landfill Tax. All parties involved could also be liable to penalties for non-compliance and face criminal prosecution.

15.2 Re-use of Materials

- 15.2.1 Given the extent of the proposed new development, it is considered unlikely that a large volume of material generated during construction will be able to be retained on site. It is therefore considered that a U1 Waste Exemption, obtained from the EA, would be appropriate to enable the reuse of a limited amount of Made Ground and natural materials on site (<1000 tonnes).
- 15.2.2 Should more than 1000 tonnes of Made Ground and natural materials be anticipated to be retained on site during redevelopment it is considered a Materials Management Plan (MMP) should be produced for the site in accordance with the CL:AIRE *Definition of Waste, Construction Industry Code of Practice*.

15.3 Waste Classification

- 15.3.1 Based on the current development proposals it is envisaged that the majority, to all of the of arisings generated from the development will be disposed of off-site.
- 15.3.2 Therefore, indicative waste classification information is provided in the following table.

Waste Classification Summary

Material Type	Waste Classification	Remarks
Made Ground	Non-Hazardous	
Glaciofluvial Sheet deposits	Inert	
PMCM - Mudstone	Inert	

- 15.3.3 Waste Acceptance Criteria (WAC) testing was also undertaken on three samples of material to aid its offsite disposal. The results of the WAC testing are presented in Appendix E.

15.4 Import of Materials

- 15.4.1 Development of the site may require importation of materials such as quarried stone aggregate or crushed brick and concrete (6F5 or similar) to site. Should any of the latter be imported during development of the site these materials are likely to be designated 'waste' upon export from their donor sites and will be subject to waste management legislation. In addition, changes to landfill tax rules in April 2018 could also mean that illegal deposits of 'waste' could attract landfill tax and fines.
- 15.4.2 To ensure that waste materials are not illegally deposited, any imported waste for use in the proposed development should comply with importation criteria agreed with the EHO of the Local Authority. As a minimum, any 6F5 material derived from crushed brick or concrete must be imported in accordance with one of the following:
- A Waste Exemption as defined by the EA, typically U1 Use of Waste in Construction.
 - Waste & Resources Action Programme (Ref: LIT 8709); End of waste criteria for the production of aggregates from inert waste.

16 GEOTECHNICAL TESTING

16.1 In-Situ Testing

- 16.1.1 Standard Penetration Tests (SPTs) were carried out during the drilling of the window sample and rotary boreholes in accordance with guidance contained in BS EN ISO 22476-3 and ASTM D1586. The results of the in-situ testing are shown on the exploratory hole records presented in Appendix D and are summarised in the following table.

Summary of SPT Results

Strata	No. of Tests	Range of 'N' Values	Average SPT 'N' value	Estimated Strength
Made Ground	2	2-16	9	N/A
Cohesive Glaciofluvial Sheet deposits	4	4-7	5	Low shear strength
Granular Glaciofluvial Sheet deposits	12	4-45	14	Medium Dense
PMCM - Mudstone	8	12-50	46	N/A

- 16.1.2 The SPT results indicate the Cohesive Glaciofluvial Sheet deposits has low shear strength and the Granular Glaciofluvial Sheet deposits should be considered to be medium dense.

16.2 Laboratory Testing

- 16.2.1 Samples of natural soil and rock were delivered to a suitably accredited laboratory with a schedule of geotechnical testing drawn up by IDG.
- 16.2.2 The geotechnical laboratory test results are presented in Appendix G and summarised below.

16.3 Soil Classification Testing

- 16.3.1 The Atterberg limit test is used to determine arbitrarily defined boundaries between the liquid and plastic states, and between the plastic and brittle states of fine grained soils, expressed as water percentage. Testing for moisture content, liquid limit, plastic limit and plasticity index was carried out in accordance with guidance contained in BS1377-2:1990.

- 16.3.2 The results are summarised in the following table, together with an assessment of Volume Change Potential (Shrinkability).

Plasticity Index Results

Soil Type	Plasticity Index	Volume Change Potential
Glaciofluvial Sheet deposits	29	Medium

- 16.3.3 For the purposes of foundation design, it is recommended that all cohesive soils be regarded as being of medium volume change potential.

16.4 Particle Size Distribution (PSDs)

- 16.4.1 PSDs tests were carried out on samples of the Glaciofluvial Sheet deposits in order to evaluate the range of grain sizes. The results of the PSD tests are summarised in the following table.

Particle Size Distribution Results

Sample Location		WS02	WS02
Sample Depth		1.5-2.0m	2.5-3.5m
Material Type		Glaciofluvial Sheet deposits	Glaciofluvial Sheet deposits
Material Description		Silty sandy CLAY with rare gravel	Silty SAND with occasional gravel
Soil Fraction	Particle Size (mm)		
Cobbles	<200	0%	0%
Gravel	2.0 - 200	1%	16%
Sand	0.063 - 2.0	11%	58%
Silt	0.002 - 0.063	53%	20%
Clay	<0.002	35%	6%

- 16.4.2 Classification of the materials in accordance with Table 6/2 of the 600 Series Earthworks specification for highway works is provided in the table below.

600 Highways Series Material Classification

Sample Location and Depth	WS02 – 1.5m-2.0m	WS02 – 2.5m-3.5m
Material Description	Glaciofluvial Sheet deposits	Glaciofluvial Sheet deposits
Material Type	Silty sandy CLAY with rare gravel	Silty SAND with occasional gravel
Materials Classification	Class 2A	Class 1B

16.5 Point Load Strength Index Testing

- 16.5.1 Testing to determine the uniaxial compressive strength (UCS) of the rock cores was not possible on the majority of cores due to the poor recovery. Therefore, point load testing undertaken in accordance ASTM STANDARD D 5731 was performed on several samples with samples tested axially through the vertical axis of the core and a correction factor applied to determine a UCS value. The results are presented in the following table.

Point Load Strength Index Test Results

Borehole Ref.	Depth (m)	Material Description	IS ₅₀ (Diametral) (MPa)	Calculated UCS Value* (MPa)	Intact Rock Strength Assessment
BH05	4.0	Grey Mudstone	0.23	2.90	Very weak rock
	5.0	Grey Mudstone	0.58	7.31	Weak rock
	7.2	Grey Mudstone	0.59	7.43	Weak rock
	9.8	Grey Mudstone	0.32	4.03	Very weak rock
	10.2	Dark grey Mudstone	0.20	2.52	Very weak rock
	13.2	Dark grey Mudstone	0.17	2.14	Very weak rock
BH06	5.5	Grey & dark grey Mudstone	0.16	2.02	Very weak rock
	7.7	Grey & dark grey Mudstone	0.33	4.16	Very weak rock
	11.0	Dark grey Mudstone	0.11	1.39	Very weak rock
	13.2	Black Coal	0.43	5.42	Weak rock
BH07	7.2	Grey Mudstone	0.32	4.03	Very weak rock
	8.8	Grey Mudstone	1.01	12.73	Moderately weak rock
	9.75	Grey Mudstone	0.36	4.54	Very weak rock
	10.0	Grey Mudstone	1.01	12.73	Moderately weak rock
	11.0	Grey Mudstone	0.72	9.07	Weak rock
	13.0	Grey Mudstone	0.36	4.54	Very weak rock
	15.1	Dark grey Mudstone	0.53	6.68	Weak rock
	16.2	Dark grey Mudstone	0.09	1.13	Very weak rock
	16.6	Dark grey Mudstone	0.40	5.04	Weak rock
	17.0	Dark grey Mudstone	0.54	6.80	Weak rock

*UCS value derived from application of a conversion factor of 12.6 for mudstone strata taken from Rusnak & Mark, 2000.

- 16.5.2 The results of the point load testing indicate the intact rock strength of the PMCM strata encountered during the investigation ranges from very weak rock (1.12 MPa) to moderately weak rock (12.73MPa).
- 16.5.3 Consideration of the UCS results in relation to the geological fault that is indicated to cross the site in the east shows that the boreholes located closest to the fault (BH05 and BH06) recorded average UCS values of 4.39MPa (BH05) and 3.24MPa (BH06). In contrast BH07, located a greater distance away from the geological fault recorded an average UCS value of 6.73MPa.
- 16.5.4 The average UCS values indicate the intact rock in close proximity to the geological fault should be classed as being very weak rock with the bedrock located further away being classed as weak rock with the difference in intact rock strength being attributed to increased weathering due to the disturbance of the bedrock that occurred adjacent to the fault.

16.6 Unconfined Compressive Strength

- 16.6.1 Unconfined compressive strength (UCS) tests were performed on two samples of rock core obtained from BH07 in accordance with ASTM D7012 – 14 Method C.

UCS Test Results

Hole ID	Depth (m bgl)	Material	Compressive Strength (MPa)	Intact Rock Strength Assessment
BH07	9.75 – 9.90	Mudstone	8.9	Weak Rock
BH07	16.6 – 16.75	Mudstone	5.2	Weak Rock

- 16.6.2 The results of the UCS tests ranged between 5.2 – 8.9MPa with an average UCS value of 7.05MPa giving an intact rock strength assessment of weak rock. This shows a good correlation with the converted UCS values calculated from the point load testing undertaken on samples obtained from BH07.

16.7 Deformation Modulus

- 16.7.1 Deformation modulus (E_m) values have been calculated for the PMCM strata based on the average UCS values determined from the point load and UCS testing and are shown in the table below.

Deformation Modulus (E_m) Summary

Hole ID	Material	Mass Factor* (j)	Modulus Ratio* (M_r)	Average UCS (MPa)	Deformation Modulus (MPa)
BH05	Mudstone	0.2	75	4.39	65.9
BH06	Mudstone	0.2	75	3.24	48.6
BH07	Mudstone	0.2	75	6.78	101.0

* Mass factor (j) and modulus ratio (M_r) values have been taken from Hobbs, N.B, 1974.

- 16.7.2 The above results indicate the deformation modulus values of the PMCM strata based on the averaged UCS values for each borehole range between 48.6 and 101MPa.

16.8 Sub-surface Concrete Classification

- 16.8.1 An assessment to determine the appropriate specification for buried concrete has been carried out in accordance with guidance contained in BRE Special Digest 1:2005 *Concrete in Aggressive Ground*.
- 16.8.2 The site has been classified as brownfield that contains pyrite. The groundwater regime has been classified as mobile.

Soil & Rock Samples

- 16.8.3 Samples of Made Ground, Glaciofluvial Sheet deposits and PMCM were submitted for testing for pH, water-soluble sulphate, acid-soluble sulphate and total sulphur. The results for each material type analysed are shown in the following table together with calculated values for total potential sulphate and oxidisable sulphide.

Summary of Sub-surface Concrete Classification Testing – Soils & Rock

Material Type	pH Values	Soluble Sulphate (mg/l)	Acid Soluble Sulphate (mg/kg)	Total Sulphur (mg/kg)	Total Potential Sulphate (%)	Oxidisable Sulphide (%)
Made Ground	8.1 – 9.8	30 - 40	-	-	-	-
Glaciofluvial Sheet Deposits	7.7 – 8.7	10 - 20	-	-	-	-
PMCM - Mudstone	7.5 – 9.1	10 - 80	<200 - 210	167 - 1150	0.05 – 0.34	0.06 – 0.32
PMCM - Coal	7.6 – 8.1	10 - 170	420	40900	12.27	12.22

- 16.8.4 Samples of Mudstone and Coal recorded an oxidisable sulphide content greater than 0.3%. It is therefore considered likely that pyrite is present in the PMCM strata at the site.

Groundwater Samples

- 16.8.5 Groundwater samples from the Glaciofluvial Sheet Deposits and PMCM strata were subjected to pH and sulphate analysis. The results for each groundwater body are shown in the following table.

Summary of Sub-surface Concrete Classification Testing – Groundwater

Groundwater Body	pH	Sulphate (mg/l)
Glaciofluvial Sheet Deposits	6.8	16
PMCM	7.4	67

Sub-Surface Concrete Assessment

- 16.8.6 Therefore, in accordance with Table C2 of BRE Special Digest 1:2005, sub-surface concrete classification for the various materials present at the site are summarised in the following table.

Summary of Sub-Surface Concrete Classification

Material Type	Design Sulphate Class	ACEC Class
Made Ground	DS-1	AC-1
Glaciofluvial Sheet deposits	DS-1	AC-1
PMCM - Mudstone	DS-2	AC-2
PMCM - Coal	DS-5	AC-5m

- 16.8.7 Review of the table above indicates a sub-surface concrete classification of DS-2, AC-2 to be appropriate for the Made Ground, Glaciofluvial Sheet Deposits and PMCM Mudstone.
- 16.8.8 However, should piled foundations need to be extended to depths in excess of 13m in the vicinity of BH06, or evidence of coal seams encountered during the piling at the development then consideration should be given to increasing the sub-surface concrete classification to DS-5, AC-5m.

17 GEOTECHNICAL ASSESSMENT

17.1 Introduction

- 17.1.1 Geotechnical issues affecting the site are described below.

17.2 Proposed Development

- 17.2.1 Consideration is being given to redevelopment of the site with a three-storey leisure and community centre that will include a lower ground floor level (i.e. basement). The leisure and community centre is to include a swimming pool, climbing wall, fitness suite, library and community rooms, with the floor level of the basement indicated to be at an elevation of 61.3m AOD.

17.3 Geology

- 17.3.1 Geological plans indicate the site is underlain by Glaciofluvial Sheet deposits and the bedrock beneath the site to be the PMCM comprising mudstone, siltstone and sandstone. The geological plans also infer a NW-SE trending fault in the east of the site, which results in the Nob End Sandstone formation underlying the eastern part of the site. The downthrow of the fault is to the east, the amount of throw is not stated.

17.4 Coal Mining Risk

- 17.4.1 Seven coal seams have been worked beneath the site from a depth of 103-486m with the Coal Authority commenting that there is no risk of probable unrecorded shallow mineworkings beneath the site.
- 17.4.2 The possibility of unrecorded shallow mine workings beneath the site has been discounted.

17.5 Summary of Ground Conditions

- 17.5.1 Made Ground between 0.6m – 1.8m thick is present across the site with several below ground obstructions associated with former buildings encountered during the investigation.
- 17.5.2 Glaciofluvial Sheet Deposits were encountered directly beneath the Made Ground and were proven to depths ranging between 3.0m to 5.2m. The Glaciofluvial Sheet Deposits typically comprised low shear strength brown sandy gravelly clay underlain by medium dense grey gravelly sand. Geotechnical testing indicates that cohesive Glaciofluvial Sheet Deposits at the site should be regarded as being of medium volume change potential. Assessment of the elevation of the base of the Glaciofluvial Sheet Deposits to ordnance datum indicates the base of the deposits reduces in elevation from the north (BH06 – 62.4m AOD) towards the southwest (WS02 – 59.3m AOD) of the site.

- 17.5.3 PMCM bedrock comprising grey to dark grey thinly laminated Mudstone was encountered at depths ranging from 3.0m bgl in BH05 to 5.2m BGL in WS02 and proven to a maximum depth of 18.0m in BH07. A thin band of coal was encountered in BH06 at a depth of 13.2-13.3m.
- 17.5.4 Review of the borehole logs indicates the PMCM has extremely variable rock mass characteristics. The PMCM mudstone recovered from BH05-BH06 was observed to be highly weathered with several thin bands within the strata noted to have weathered to a clay. In addition, *where possible to calculate*, RQDs range from very poor to fair and can typically be described as poor.
- 17.5.5 Average UCS values indicate that, where intact, the PMCM bedrock in close proximity to the geological fault inferred to be present in the east the site is of very weak intact rock strength, with the bedrock located further away being classed as weak rock. The difference in intact rock strength is attributed to increased weathering due to the disturbance of the bedrock that occurred adjacent to the fault.
- 17.5.6 The Nob End Sandstone indicated on geological plans to be present to the east of the inferred geological fault in the east of the site was not encountered during the investigation.

17.6 Groundwater

- 17.6.1 Two groundwater bodies were encountered during the investigation, a shallow groundwater body within the Glaciofluvial Sheet Deposits and a deeper groundwater body within the PMCM strata.
- 17.6.2 The shallow groundwater body present within the Glaciofluvial Sheet Deposits rests at depths of between 1.33m bgl (BH06) and 4.15m bgl (WS02) across the site and its piezometric surface falls from the north of the site (BH06) to the southwest of the site (WS02).
- 17.6.3 Groundwater levels recorded in the PMCM in BH07 indicate it is under sub-artesian pressure and resting at a level approximately 1.0m above the top of the PMCM at elevations of between 60.93 – 60.97m AOD. This is approximately 0.3-0.4m below the proposed floor level of the basement at the development (61.3m AOD).
- 17.6.4 IDG therefore recommend the well installed in BH07 be decommissioned (i.e. removed and grouted up) as part of the preparatory works for the site to remove a pathway for groundwater within the PMCM to enter any deep excavations made during redevelopment of the site (i.e. excavation for the construction of the basement areas) and also to mitigate any long term groundwater issues to the proposed development from the borehole.

17.7 Foundation Recommendations

- 17.7.1 Vinci have indicated the leisure and community centre will be constructed piled foundations. The following general comments relating to piling are provided for initial guidance and further advice should be sought from a specialist-piling contractor.
- 17.7.2 The ground at this site contains significant buried obstructions and it will be necessary for these to be excavated and removed prior to the commencement of piling.
- 17.7.3 Cohesive superficial deposits are present at the site, and it is recommended that the potential for negative skin friction is considered in the design of the piles.
- 17.7.4 The PMCM bedrock lies at depths of between 3.0m and 5.2m bgl beneath the site and has extremely variable rock mass characteristics. The PMCM bedrock was observed to be highly weathered with several thin bands within the strata noted to have weathered to a clay. Where intact, the PMCM Mudstone strata is of weak and very weak intact rock strength.
- 17.7.5 A sub-surface concrete classification of DS-2, AC-2 considered appropriate for the Made Ground, Glaciofluvial Sheet Deposits and PMCM Mudstone. However, should piled foundations need to be extended to depths in excess of 13m in the vicinity of BH06, or evidence of coal seams be encountered during the piling at the development then consideration should be given to increasing the sub-surface concrete classification to DS-5, AC-5m.
- 17.7.6 The installation of piles will induce some ground vibration and assessment of vibration risk to

adjacent structures and/or existing site features should be undertaken by the pile designer.

- 17.7.7 Ground conditions at this site will require provision of a piling mat (working platform) and further advice should be sought from the appointed piling contractor regarding the proposed plant loadings and resulting pressures. This information, together with a knowledge of the strength and variability of the near-surface ground conditions is required in order that design of a mat can be undertaken in accordance with guidance provided in BRE document *BR 470: Working platforms for tracked plant* (2004). IDG can provide further advice on this if required.
- 17.7.8 Pile design should be undertaken in accordance with guidance contained in the Environment Agency's booklet *Piling into Contaminated Sites*.
- 17.7.9 Calorific value testing of the PMCM strata recorded values above 7.0MJ/kg in several samples which indicate they may present a risk of spontaneous combustion. Whilst the affected samples were taken from depths in excess of 8m below ground level they may be disturbed during piling activities for the proposed development. IDG recommend the piling contractor are provided with a copy of this report in order to determine if any precautionary measures are required to mitigate the risk of spontaneous combustion of the PMCM strata during piling.

17.8 Preparatory Works

- 17.8.1 Where existing buildings are to be demolished, it is considered that all concrete slabs, foundations and service ducts will require breaking out and removal prior to re-development commencing.

17.9 Excavations

- 17.9.1 Granular Glaciofluvial Sheet Deposits are present across the entire site with a shallow groundwater body resting within it. Excavations that encounter these granular deposits are likely to be unstable and running sand should be anticipated.
- 17.9.2 Bedrock was encountered in several exploratory holes across the site at elevations ranging from 62.42m AOD in the north (BH06) to 59.25m AOD in the southwest (WS02). Should the proposed development require excavations to be extended into the bedrock, allowance should be made for difficult digging.
- 17.9.3 The groundwater body present within the PMCM bedrock at BH07 has been recorded at depths of between 3.16m – 3.20m bgl and is under sub-artesian pressure. IDG consider that provision for groundwater control should be made for any deep excavations required during development.

18 SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

18.1 General

- 18.1.1 Consideration is being given to redevelopment of the site with a three-storey leisure and community centre that will include a lower ground floor level (i.e. basement). The centre is to include a swimming pool, climbing wall, fitness suite, library and community rooms, with the floor level of the basement indicated to be at 61.3m AOD.
- 18.1.2 The conclusions below are summarised from the preceding sections of this report.

18.2 Ground Conditions

- 18.2.1 Made Ground between 0.6m – 1.8m thick is present across the site with several below ground obstructions associated with former buildings encountered during the investigation.
- 18.2.2 Glaciofluvial Sheet Deposits typically comprising low shear strength brown sandy gravelly clay underlain by medium dense grey gravelly sand were encountered directly beneath the Made Ground and were proven to depths ranging between 3.0m to 5.2m bgl.
- 18.2.3 Geotechnical testing indicates that cohesive Glaciofluvial Sheet Deposits at the site should be regarded as being of medium volume change potential.

18.2.4 PMCM bedrock comprising grey to dark grey thinly laminated Mudstone was encountered at depths ranging from 3.0m bgl to 5.2m bgl and were proven to a maximum depth of 18.0m in BH07. A thin band of coal was encountered in BH06 at a depth of 13.2-13.3m.

18.2.5 Average UCS values indicate the PMCM bedrock in close proximity to a geological fault inferred to be present in the east the site should be classed as having very weak intact rock strength, with the bedrock located further away being classed as weak rock.

18.3 Groundwater

18.3.1 Two groundwater bodies were encountered during the investigation, a shallow groundwater body within the Glaciofluvial Sheet Deposits and a deeper groundwater body within the PMCM strata.

18.3.2 The shallow groundwater body present within the Glaciofluvial Sheet Deposits rests at depths of between 1.33m bgl (BH06) and 4.15m bgl (WS02) across the site and its piezometric surface falls from the north of the site to the southwest of the site.

18.3.3 The deeper groundwater body in the PMCM in BH07 is under sub-artesian pressure and resting at a level approximately 1.0m above the top of the PMCM at elevations of between 60.93 – 60.97m AOD. This is approximately 0.3-0.4m below the proposed floor level of the basement at the development (61.3m AOD).

18.3.4 IDG therefore recommend the well installed in BH07 is decommissioned (i.e. removed and grouted up) as part of the preparatory works for the site.

18.4 Mining

18.4.1 Seven coal seams have been worked beneath the site from a depth of 103-486m with the Coal Authority commenting that there is no risk of probable unrecorded shallow mineworkings beneath the site.

18.4.2 The possibility of unrecorded shallow mine workings beneath the site have been discounted.

18.5 Hazardous Gas

18.5.1 No significant risk from landfill or mines gas has been identified.

18.5.2 The site is in an intermediate probability radon area (1 to 3% of homes are estimated to be at or above the Action Level) and current Building Control Regulations do not require radon protection measures to be installed in new buildings.

18.5.3 However, a radon assessment will be required after construction of the building which is likely to require the monitoring of radon in the building, therefore consideration should be given to the installation of basic radon protection measures during construction to mitigate any potential issue upon completion of the building.

18.6 Contamination and Remediation

18.6.1 No significant pollutant linkages have been identified at the site and a Remediation Strategy should not be required by the Local Planning Authority.

18.6.2 However, a dye works was present in the south of the site. Whilst no evidence of hydrocarbon contamination was encountered during the investigation, IDG consider this still represents a low risk of hydrocarbon contamination. It is therefore recommended that a watching brief be provided by a Geoenvironmental Consultant during any excavations that occur within the footprint of the dye works during re-development on the site.

18.7 Foundations

18.7.1 Vinci have indicated the leisure and community centre will require piled foundations.

18.7.2 The ground at this site contains significant buried obstructions and it will be necessary for these to be excavated and removed prior to the commencement of piling.

- 18.7.3 Cohesive superficial deposits are present at the site, and it is recommended that the potential for negative skin friction is considered in the design of the piles.
- 18.7.4 PMCM bedrock lies at depths of between 3.0m and 5.2m bgl beneath the site and has extremely variable rock mass characteristics. The PMCM bedrock was observed to be highly weathered with several thin bands within the strata noted to have weathered to a clay. Where intact, the PMCM mudstone strata is of weak and very weak intact rock strength.
- 18.7.5 A sub-surface concrete classification of DS-2, AC-2 considered appropriate for the Made Ground, Glaciofluvial Sheet Deposits and PMCM Mudstone. However, should piled foundations need to be extended to depths in excess of 13m in the vicinity of BH06, or evidence of coal seams be encountered during the piling at the development then consideration should be given to increasing the sub-surface concrete classification to DS-5, AC-5m.
- 18.7.6 The installation of piles will induce some ground vibration and assessment of vibration risk to adjacent structures and/or existing site features should be undertaken by the pile designer.
- 18.7.7 Calorific value testing of the PMCM strata recorded values above 7.0MJ/kg in several samples which indicate they may present a risk of spontaneous combustion. IDG recommend the piling contractor are provided with a copy of this report in order to determine if any precautionary measures are required to mitigate the risk of spontaneous combustion of the PMCM strata during piling.

18.8 Excavations

- 18.8.1 Granular Glaciofluvial Sheet Deposits are present across the entire site with a shallow groundwater body resting within it. Excavations that encounter these granular deposits are likely to be unstable and running sand should be anticipated.
- 18.8.2 Allowance should be made for difficult digging for any excavations that extend into the bedrock.
- 18.8.3 The groundwater body present within the PMCM bedrock at BH07 has been recorded at depths of between 3.16m – 3.20m bgl and is under sub-artesian pressure. Provision for groundwater control should be made for any deep excavations required during development.

18.9 Further Works

- 18.9.1 Decommissioning of BH07 is recommended during the preparatory works due to sub-artesian groundwater in the PMCM strata.
- 18.9.2 It is recommended that a watching brief be provided by a Geoenvironmental Consultant during any excavations that occur within the footprint of the former dye works buildings during re-development on the site.

Appendix A