

St Michaels

Piling Risk Assessment

Curtins Ref: 63068-CUR-00-XX-RP-GE-0002 St Michaels

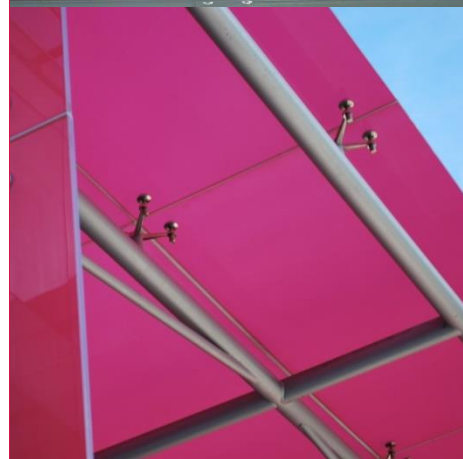
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Client Name: Bowmer & Kirkland

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Site Address: Bootle Street, Manchester, M2 5GU



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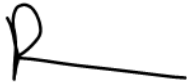
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Piling Risk Assessment

Rev	Description	Issued by	Checked	Date

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1.0 Introduction

Piled foundations are proposed for the developed at land off Bootle Street in Manchester, approximately centred on NGR SJ 83656 98006.

Given the sensitivity of the groundwater underlying the site, a piling risk assessment has been produced in order to identify the risk associated with a piled foundation solution to the underlying aquifer.

The purpose of the report is to confirm provide an assessment of risk presented by a piled foundation solution as requested by the Environmental Agency, to address a potential risk to the known bedrock aquifer. This report has been written to address this concern.

1.1 Scope

This piling risk assessment provides an overview of the site's ground and groundwater conditions and considers the potential risks associated with the adoption of Continuous Flight Auger (CFA) piling to groundwater. The report also identifies appropriate risk management and monitoring protocols that can be adopted to ensure any residual risk is brought within adequate and practicable limits.

1.2 References

In preparation of this report reference has been made to the following key guidance document:

- Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention National Groundwater & Contaminated Land Centre report NC/99/73 (EA Report 2001).

Reference is also made to the following geo-environmental reports:

- Curtins Consulting (December 2021) *St Michael's Phase 2 Ground Investigation*, report ref. 078847-CUR-00-XX-RP-GE-001-P01.

The findings of this report should be read in conjunction with the above. It is anticipated that readers of this risk assessment will have access to the above reports and hence a copy has not been included.

2.0 The Site

2.1 Site Location

The site is located off Bootle Street, Manchester, M2 5GU centred at the approximate NGR SJ 83656 98006 covering an area of approximately 0.3Ha. The site is currently occupied by a central area of hardstanding used for car parking, surrounded by unoccupied buildings to the north, east, south and west. The site is generally level and is bound to the north by Jackson's Row, east by Southmill Street and south by Bootle Street. The surrounding area is occupied by office blocks, restaurants and high-rise apartments.

2.2 Site History

Earliest mapping indicates building on site with no specific end use with Jackson's Row and Bootle Street present in their current arrangement. By 1850, several small buildings and associated courtyards are located on site. Between 1894 and 1896, a courtyard is noted in the centre of the site and by 1908, the courtyard is labelled as a Fire Station.

By WWII, the building in the south east corner of the site was damaged by a bomb strike. In 1948, a police station was recorded in the northeast, east and southeast of the site and a sunken tank in the north. In 1955, the Poster Services Ltd Print Works was recorded in the south east corner including a garage and petrol tank and demolished by 1970. In 2022, the site configuration remains unchanged.

2.3 Hydrogeology

Environment Agency data indicates that the superficial deposits are classified as Unproductive, with the underlying bedrock geology classified as a Principal Aquifer. A Principal Aquifer is defined as:

Layers of rock or drift deposits that have high intergranular and/or fracture permeability meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale. In most cases, Principal Aquifers are aquifers previously designated as Major Aquifers.

The site is not situated within a designated Source Protection Zone (SPZ).

2.4 Hydrology

The nearest surface water feature identified in the Rochdale Canal, approximately 270m south east of the site.

2.5 Made Ground

Made ground was encountered in all exploratory holes from ground level to depths between 0.20m and 1.40m bgl (37.19m to 33.16m AOD). In all positions, an upper layer of concrete was encountered with a thickness of 0.10m and 0.33m, except in WS108 where laminate floor (0.01m thickness) overlies concrete (0.19m thickness).

In RBH101, a made ground comprising brown sandy gravelly clay with intact brick was encountered, while in RBH102 and RBH103, the made ground was recorded as a reddish-brown gravelly slightly clayey fine to coarse sand with intact bricks. In WS105 and WS106, made ground comprising sandy angular to subangular fine to coarse gravel was encountered below the concrete.

In WS104 – WS107, the concrete directly overlies the natural stratum below. In WS109 and WS110, the made ground comprised a 0.10m thick layer of concrete, overlying a 0.02m thick layer of bitumen, followed by a 0.08m thick layer of intact bricks.

The sand is fine to coarse and the gravel across site is recorded as angular to subangular fine to coarse of sandstone, brick, ceramic, concrete, bitumen and coal.

2.6 Glacial Till

Deposits of Glacial Till were encountered below the Made Ground in all exploratory holes except WS108 underlying the Made Ground to maximum depths between 0.30m and 5.00m bgl (35.59m and 32.40m AOD).

Due to the variability in the composition of the Glacial Till (i.e., interbedded granular and cohesive materials) this report has classified the soils based on engineering behavior as opposed to the nomenclature used by the BGS. Therefore, the natural superficial deposits have been interpreted and assessed as either 'Cohesive Till' or 'Granular Till' in respect to their geotechnical assessment.

2.6.1 Cohesive Glacial Till

The cohesive Glacial Till was encountered in exploratory holes RBH102, RBH103 and WS104. It is recorded as a firm to very stiff reddish-brown slightly gravelly Clay. The gravel was found to comprise subrounded fine to coarse of sandstone and quartz.

In WS104 rounded cobbles of sandstone and mudstone are present.

2.6.2 Granular Glacial Till

The granular Glacial Till was encountered below the Made Ground, in RBH101, RBH102, RBH103, WS104, WS105, WS106, WS107, WS109 and WS110. It was recorded as a very dense reddish-brown slightly gravelly fine to coarse Sand in RBH101 to RBH103 and WS104,

and as a brown slightly gravelly coarse Sand in WS105, WS106, WS107, WS109 and WS110. The gravel was subangular to well-rounded fine to coarse of sandstone and quartz.

2.7 Chester Formation

The Chester Formation bedrock was encountered all exploratory hole locations except WS104.

The bedrock was encountered between depths of 0.20m and 5.00m bgl (34.18m and 32.40m AOD) to the maximum depth drilling of up to 50.50m bgl (-13.12m AOD).

The bedrock typically comprised interbedded variations of extremely weak to medium strong reddish-brown fine to coarse grained Sandstone. In RBH102 from 46.02m to 50.00m bgl (-8.62m to -12.60m AOD) the sandstone was recorded as strong.

In RBH101, RBH102 and RBH103 the sandstone was recorded to contain subangular to subrounded fine to medium gravel clasts at various depths. In RBH102 from 16.62m to 21.50m (20.75m to 15.87m AOD) a micaceous sandstone was noted

2.8 Groundwater

No groundwater strikes were recorded during the siteworks although they may have been concealed by use of the water flush in the boreholes. A summary of post investigation groundwater level monitoring is presented in *Table 2.8*.

Table 2.8 – Groundwater Monitoring Results

Borehole Ref.	Installation Strata	Response Zone m bgl (m AOD)	Depth, m bgl (m AOD)					
			17/08/21	02/09/21	16/09/21	29/09/21	21/10/21	05/11/21
RBH101	Sandstone	35.00 – 50.00 (2.38 – -12.62)	13.83 (23.55)	13.93 (23.45)	13.94 (23.44)	-	-	-
RBH102	Sandstone	20.00 – 35.00 (17.37 – 2.37)	-	13.03 (24.34)	13.24 (24.13)	13.28 (24.09)	13.12 (24.25)	13.21 (24.25)
RBH103	Sandstone	5.00 – 20.00 (32.41 – 17.41)	11.45 (25.96)	12.88 (24.53)	12.93 (24.48)	13.04 (24.37)	12.94 (24.47)	12.94 (24.47)
WS104	Cohesive Glacial Till	0.50 – 1.00 (36.91 – 36.41)	-	Dry	Dry	1.18 (36.23)	0.33 (37.08)	1.17 (36.24)

Based upon groundwater elevations and the underlying geology, the following considerations are given to the underlying groundwater regime:

- A variable groundwater table appears to be present below the site within the cohesive Glacial Till at an elevation range of between 37m and 36m AOD, and within the Sandstone bedrock between 26m and 23m AOD.
- It is evident that the groundwater levels within the cohesive Glacial Till in WS104 vary considerably. For example, it is noted as the installation pipework being flooded following

periods of heavy rain, and then the water level recorded as dry during drier weather conditions. This indicates that surface water inflows possibly due to heavy periods of rain may be impacting the borehole causing the large change in groundwater levels. This groundwater level is not considered to be representative of a shallow groundwater table across the site however further groundwater monitoring is recommended to confirm this

2.9 Contamination Summary

A total of 4No. soil samples were obtained from the boreholes and tested for Curtins Suite A, summarised in *Table 2.8*.

Table 2.8 – *Environmental Chemistry Analysis Suite: Soils*

Suite Ref.	Analyte	LOD
Soils Suite A	Asbestos Screen	-
	pH Value	0.1 pH
	2:1 Water Soluble Sulphate	0.01 g/l
	Soil Organic Matter (SOM)	0.4% w/w
	Arsenic, Chromium, Chromium VI, Copper, Lead, Nickel, Selenium	0.20 - 1 mg/kg
	Zinc	0.5 mg/kg
	Boron (water soluble)	0.4 mg/kg
	Cadmium	0.1 mg/kg
	Mercury	0.1 mg/kg
	Cyanide (total)	0.5 mg/kg
	Phenols (screen)	0.3 mg/kg
	PAHs (USEPA 16)	0.1 mg/kg
	TPH (Aro/Ali Split)	1 mg/kg

No visual or olfactory evidence of contamination was identified during the ground investigation to justify increasing the testing to incorporate VOC or SVOC analysis.

The chemical analysis results were compared against a *Commercial* end-use scenario. With respect to the *Commercial* thresholds, no exceedances of contamination GACs were recorded in any of the soil samples tested.

All samples tested were also screened for asbestos fibres with no asbestos positively identified in the laboratory. No suspected asbestos containing materials (ACMs) were identified within any of the exploratory holes excavated on site.

With regard to controlled waters, three groundwater samples were obtained from RBH101, RBH102 and RBH103. Given the presence of the Principal Aquifer underlying the site, the result of laboratory analysis were assessed against UK DWS and where these were not available for review, WHO guidelines.

With respect to the Principal Aquifer, one determinant was recorded at a concentration greater than the relevant UK DWS:

- Sulphate at 309mg/l (UK DW 250mg/l)

Marginally elevated concentrations of sulphate were recorded in RBH101 at 14.29m bgl. There is no indication the elevated concentration recorded were as a result of high concentrations in soils leaching in soil leaching to the underlying aquifer based on the chemical soil analysis from the made ground and glacial till above.

The marginally elevated concentrations are attributed to background concentrations within the sandstone bedrock.

2.10 Ground Gas

An initial programme of six gas monitoring visits over twelve weeks was proposed. Six gas monitoring visits have been undertaken between 17th August 2021 and 5th November 2021, with barometric pressure recorded between 1005 mb and 1031 mb.

Evaluation of the 'representative borehole' scenario (highest hazardous gas flow rate identified a single borehole) records a maximum Q_{hg} of 0.0039 l/hr for carbon dioxide where for the fifth visit the maximum steady state gas flow reading is -1.3 l/hr, and a maximum gas concentration is 0.30% v/v .

Evaluation of the 'worst case' scenario (highest Q_{hg} across the entire dataset irrespective of location and discrete monitoring events) recorded a maximum Q_{hg} of 0.0091 l/hr for carbon dioxide with the highest steady state flow rate of -1.3 l/hr and a maximum gas concentration of 0.70% v/v .

Considering the above, it is recommended that the site is characterised with CS1 classification, with no gas protection measures required for the proposed development.

2.11 Aggressive Ground Conditions

The site has been classified in accordance with BRE Special Digest 1 (Ref. 19) and laboratory testing undertaken accordingly in *Section 7.0*. Based on the laboratory test results obtained during the Curtins ground investigation, it is considered that a Design Sulphate Class may be undertaken as DS-1 with an ACEC class of AC-1 for made ground, glacial till and Chester Formation bedrock.

3.0 Piling Risk Assessment

At the current design stage, the adoption of CFA piles is considered to be the preferred piling solution. Current design information indicates 750mm to a depth of 10.00m bgl. This method should be considered with consideration of minimal ground vibration, as well as groundwater protection aspects.

CFA piles essentially involve driving a large auger into the ground, with soils within the radius of the auger brought to surface and replaced with concrete on withdrawal of the auger. The displacement of the surrounding ground is governed by the speed of rotation of the auger relative to the speed of vertical penetration. Theoretically, it is possible to adjust the speeds so that the volume of soils displaced laterally and removed as arisings is equal to the volume of concrete placed.

Within the EA Report (2001), the six Source-Pathway-Receptor scenarios are identified as:

- 1. Creation of preferential pathways, through a low permeability layer (an aquitard), to allow potential contamination of an underlying aquifer;*
- 2. Creation of preferential pathways, through a low permeability surface layer, to allow upward migration of landfill gas, soil gas or contaminant vapours to the surface;*
- 3. Direct contact of site workers and others with contaminated soil arising which have been brought to the surface;*
- 4. Direct contact of the piles or engineered structures with contaminated soil or leachate causing degradation of pile materials (where the secondary effects are to increase the potential for contaminant migration);*
- 5. The driving of solid contaminants down into an aquifer during pile driving; and*
- 6. Contamination of groundwater and, subsequently, surface waters by concrete, cement paste or grout.*

This piling risk assessment tabulated overleaf address aspects 1, 5 and 6 above only, in keeping with the objectives of this report. The risk assessment methodology follows that presented in *Appendix B*.

Piling Risk Assessment

TABULATED RISK ASSESSMENT: CFA Piles

Aspect	Potential Consequence	Potential Probability	Potential Risk	Risk Management Options Available	Resultant Risk
1. Creation of preferential pathways, through a low permeability layer (an aquitard), to allow potential contamination of an underlying aquifer.	Medium Pollution of sensitive water resources in groundwater, although not abstracted in the immediate vicinity and primary pathways likely to be to the nearby canal.	Unlikely - Limited Made Ground contamination identified; and - CFA piling method essentially self-sealing with concrete and therefore no resultant pathway.	Low	Not applicable.	Low
4. Direct contact of the piles or engineered structures with contaminated soil or leachate cause degradation of pile materials (where the secondary effects are to increase the potential for contamination migration)		Low Likelihood Soluble sulphate concentrations in soils meet a Design Sulphate Class of DS1 AC-1 for made ground soils and natural soils/bedrock	Moderate/ Low	Use suitably sulphate resistant concrete for all substructures.	Low
5. The driving of solid contaminants down into an aquifer during pile driving.		Low Likelihood Above considerations, plus: Low likelihood as arisings brought to surface in CFA method, with speed of auger rotation to be matched with downward force to avoid driving soils down.	Moderate/ Low	Speed of auger rotation needs to be matched with downward force to avoid driving soils down.	Low
6. Contamination of groundwater and, subsequently, surface waters by concrete, cement paste or grout.		Low Likelihood Above considerations.	Moderate/ Low	Cement content of the concrete will need to be closely monitored so that this in itself does not 'bleed' into groundwater.	Low

4.0 Summary and Recommendations

The risk assessment presented herein has concluded that there is a Low risk to contamination of groundwater beneath the site from the use of CFA piling, providing that the following risk management measures are put in place:

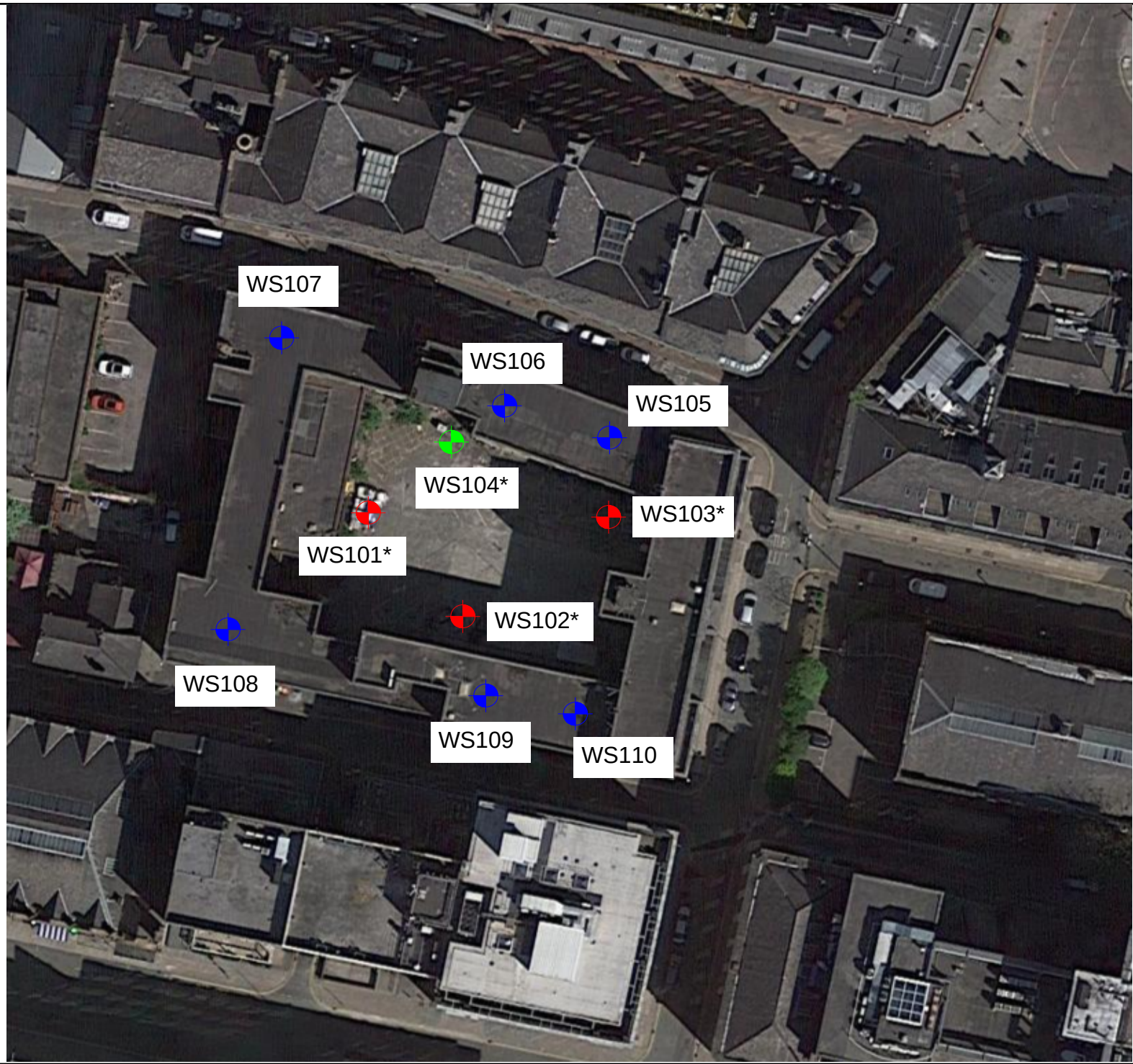
- *Speed of auger rotation needs to be matched with downward force to avoid driving soils down; and*
- *Cement content of the concrete will need to be closely monitored so that this in itself does not 'bleed' into groundwater.*

The following should also be considered:

- *The piling contractor should prepare and submit relevant method statements for approval prior to piling works commencing;*
- *Where arisings are generated, they should be classified, handled and disposed of in compliance with relevant best practice and regulatory requirements;*
- *The piling contractor should make allowance for the provision of appropriate PPE; and*
- *In the event of uncovering any areas of unexpected contamination during the piling works, including odorous or stained soils, works should be ceased with the advice of the appointed environmental consultant sought immediately.*

This document should be forwarded to the Planning Authority for discharge of the relevant planning condition before piling works commence.

Appendix A – Site Plan



PROPOSED SITE INVESTIGATION

-  WINDOW SAMPLE WITH ROTARY CORED FOLLOW ON TO 50.00M BGL
-  WINDOW SAMPLE - EXTERNAL
-  WINDOW SAMPLE - INTERNAL
-  INSTALLATION

Rev:	Description:	Date:	By:	Chkd:
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Status:

INFORMATION

Project:

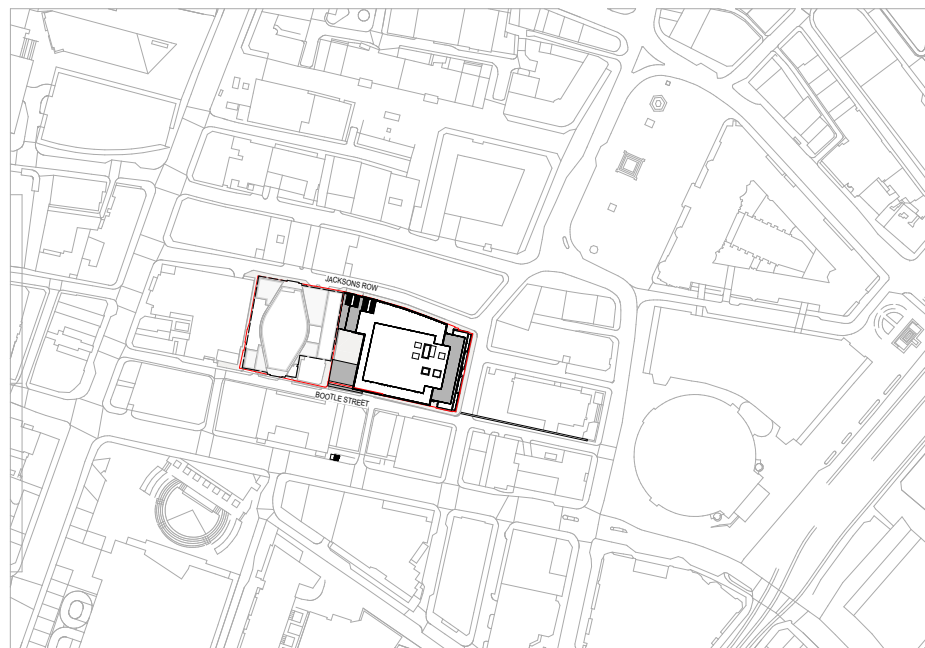
ST MICHAEL'S

Drg Title:

EXPLORATORY HOLE LOCATION PLAN

Scale: NTS	Size: A3	First Issue: 18/08/2021	Drawn: PN	Checked: RA
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Drg No: 078847-CUR-00-XX-DR-GE-002	Rev: P01
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GENERAL NOTES:

1. FOR ABBREVIATIONS, SYMBOLS, LEGENDS, GENERAL NOTES AND MATERIAL CODE LIST, REFER TO A-0-002

PMT	17-08-2021	Stage 2
ID:	DATE:	SSELE

Status	FOR INFORMATION
--------	-----------------

	Design Consultant	hodder+partners
Civil Engineer 		
Services Engineer 		
Fire Engineer 		
Client 	Landscape Designer 	
	Project Manager 	

Architect / Structural Engineer

SOM

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ST. MICHAELS DEVELOPMENT,
MANCHESTER

Drawing Title

SITE PLAN

Designed by	Designer	Drawn by	Author	Checked by	Checker	Approved by	Approver
Protocol Drawing No							
STM-SOM-ZZ-ZZ-DR-A-0011							
Project No		SOM Drawing No			Revision		
218739		A-011			P01		
Scale @ A0							
1 : 1000							

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Appendix B – Borehole Logs



Rotary Core Log

Borehole No.

RBH101

Sheet 1 of 6

Project Name: St Michael's

Project No.
078847

Co-ords: 383693.50 - 398018.32

Hole Type
RC

Location: Manchester

Level: 37.38

Scale
1:50

Client: Bowmer & Kirkland

Dates: 27/07/2021 - 02/08/2021

Logged By
PN

Well	Water Strikes	Depth (m)	Type / FI	Coring			Depth (m)	Level (m)	Legend	Stratum Description	
				TCR	SCR	RQD					
		0.35	ES				0.19	37.19		MADE GROUND: CONCRETE	
										MADE GROUND: Brown sandy gravelly clay with frequent intact bricks. Sand is fine to coarse. Gravel is angular to subangular fine to coarse including brick, ceramic and coal.	1
		2.00	D				1.40	35.98		Very dense reddish brown gravelly medium to coarse SAND.	2
											3
											4
		4.00 - 5.50	NI	65	23	0	4.60	32.78		Weak reddish brown medium to coarse grained SANDSTONE.	5
			NR							4.60 to 4.67m 0 - 10 degrees closely spaced planar rough From 4.67 to 4.89m recovered as non-intact core of angular cobbles. 4.89 to 4.98m 0 - 10 degrees closely spaced planar rough From 4.98 to 5.50m no recovery From 5.50 to 5.55m recovered as non-intact core of angular to subangular fine to coarse gravel. 5.55 to 6.82m 0 - 10 degrees very closely spaced to closely spaced planar rough.	6
		5.50 - 7.00	11	89	89	51					7
			NR							From 6.82 to 7.00m no recovery 7.00 to 7.81 10 - 45 degrees very closely spaced to closely spaced planar rough.	8
		7.00 - 8.50	12	92	85	35				From 7.81 to 7.90m recovered as non-intact core of angular cobbles. 7.90 to 8.37 0 - 10 degrees very closely spaced to closely spaced planar rough. From 8.37 to 8.58m no recovery From 8.58 to 8.63m recovered as non-intact core of angular cobbles. 8.63 to 9.90m 0 - 15 degrees very closely spaced to closely spaced planar rough.	9
		8.50 - 10.00	10	81	81	50	9.43	27.95		Weak reddish brown fine grained SANDSTONE. From 9.59 to 9.63m sand infill	10
			NI				10.00	27.38		Continued on next sheet	

Remarks

Service inspection pit hand excavated from GL to 1.20m. No groundwater encountered due to water flush.





Rotary Core Log

Borehole No.

RBH101

Sheet 2 of 6

Project Name: St Michael's

Project No.
078847

Co-ords: 383693.50 - 398018.32

Hole Type
RC

Location: Manchester

Level: 37.38

Scale
1:50

Client: Bowmer & Kirkland

Dates: 27/07/2021 - 02/08/2021

Logged By
PN

Well	Water Strikes	Depth (m)	Type / FI	Coring			Depth (m)	Level (m)	Legend	Stratum Description	
				TCR	SCR	RQD					
		10.00 - 11.50	23	86	77	13	11.68	25.70		From 9.90 to 10.00m recovered as non-intact core of angular to subangular fine to coarse gravel.	11
			NI							Very weak reddish brown medium to coarse grained SANDSTONE.	
			13							10.00 to 10.94m 0 - 10 degrees extremely closely spaced and closely spaced planar rough.	
			NI							From 10.94 to 11.00m recovered as non-intact core of sandy angular to subangular fine to coarse gravel.	
		11.50 - 13.00	9	100	88	66				11.00 to 11.16m 0 -10 degrees very closely spaced planar rough.	12
			NI							From 11.16 to 11.20 recovered as non-intact core of sandy angular to subangular fine to coarse gravel.	
			NR							From 11.27 to 11.50mn no recovery.	
			NI							From 11.50 to 11.55m recovered as non-intact core of sandy angular to subangular fine to coarse gravel.	
		13.00 - 14.50	<25	99	92	61				11.55 to 12.82m 0 - 15 degrees very closely spaced to medium spaced planar rough.	13
			NI							Medium strong reddish brown fine to medium grained SANDSTONE.	
			12							11.85 to 11.93m 1 No. discontinuity incipient fracture 90 degrees planar rough.	
			NR							From 12.82 to 13.00m recovered as non-intact core of stiff reddish brown clay	
		14.50 - 16.00	8	91	87	63				13.00 to 13.80m 0 - 20 degrees very closely spaced to medium spaced planar rough.	14
			NI							From 13.80 to 13.89m recovered as non-intact core of angular cobbles.	
			11							13.89 to 14.50m 10 - 45 degrees very closely spaced to medium spaced planar rough.	
			NR							From 14.50 to 14.58m no recovery.	
		16.00 - 17.50	11	90	83	28				14.58 to 15.22m 0 - 10 degrees closely spaced to medium spaced planar rough.	15
			NI							From 15.22 to 15.28m recovered as non-intact core of sandy angular to subangular fine to coarse gravel.	
			NR							15.28 to 16.49m 0 - 10 degrees very closely to medium spaced planar rough.	
			11							From 16.49 to 16.87m weak	
		17.50 - 19.00	11	91	80	41				From 17.21 to 17.29m recovered as non-intact core of sandy angular to subangular fine to coarse gravel.	16
			NI							17.29 to 17.35m 0 - 10 degrees closely spaced planar rough.	
			<25							From 17.35 to 17.50m no recovery.	
			NR							From 17.50 to 17.56m recovered as non-intact core of sandy angular to subangular fine to coarse gravel.	
		19.00 - 20.50	9	100	95	74	17.56 to 18.7m 0 - 10 degrees very closely spaced to medium spaced planar rough.	17			
			NI				From 17.68 to 17.72m clay infill.				
			<25				From 18.47 to 18.57m recovered as non-intact core of angular cobbles.				
			NR				18.57 to 18.92m 10 - 30 degrees very closely spaced to closely spaced planar rough.				
			9	100	95	74	From 18.92 to 19.00m no recovery.	18			
			NI				Medium strong reddish brown medium to coarse grained SANDSTONE.				
			13				19.00 to 20.44m 0 - 10 degrees very closely spaced to medium spaced planar rough.				
			NR								
			9	100	95	74		19			
			NI								
			13								
			NR								
			9	100	95	74		20			
			NI								
			13								
			NR								
Continued on next sheet											

Continued on next sheet

Remarks

Service inspection pit hand excavated from GL to 1.20m. No groundwater encountered due to water flush.





Rotary Core Log

Borehole No.

RBH101

Sheet 3 of 6

Project Name: St Michael's

Project No.
078847

Co-ords: 383693.50 - 398018.32

Hole Type
RC

Location: Manchester

Level: 37.38

Scale
1:50

Client: Bowmer & Kirkland

Dates: 27/07/2021 - 02/08/2021

Logged By
PN

Well	Water Strikes	Depth (m)	Type / FI	Coring			Depth (m)	Level (m)	Legend	Stratum Description	
				TCR	SCR	RQD					
			NE				20.71	16.67		From 20.44 to 20.50m recovered as non-intact core of angular cobbles.	21
			14							20.50 to 20.71m 0 - 10 degrees very closely spaced to closely spaced planar rough.	
		20.50 - 22.00	4	80	80	65	22.00	15.38		Medium strong reddish brown fine grained SANDSTONE. 20.71 to 21.70m 0 - 10 degrees closely spaced to medium spaced planar rough.	
										From 21.70 to 22.00m no recovery.	
		22.00 - 23.50	5	91	91	85				Medium strong reddish brown medium to coarse grained SANDSTONE with occasional subrounded to rounded coarse gravel. 22.00 to 23.32m 0 - 30 degrees closely spaced and medium spaced planar rough.	22
			NR								23
			3							From 23.32 to 23.50m no recovery.	
			NI							23.50 to 23.81m 0 degrees medium spaced planar rough.	
		23.50 - 25.00	5	100	70	64				From 23.81 to 24.00m recovered as non-intact core of angular cobbles. 24.00 to 24.82m 10 - 30 degrees closely spaced and medium spaced planar rough.	24
			NI								
			NI							From 24.82 to 25.00m recovered as non-intact core of sandy angular to subangular fine to coarse gravel and angular cobbles.	
		25.00 - 26.50	4	85	67	67				From 25.00 to 25.17m recovered as non-intact core of angular cobbles. 25.17 to 26.29m 0 - 10 degrees closely spaced to medium spaced planar rough. 25.57 - 25.68m 1 No. Discontinuity incipient fracture 90 degrees planar rough.	25
			NR								26
			9							From 26.29 to 26.50m no recovery.	
										26.50 to 29.96m 0 - 10 degrees very closely spaced to closely spaced planar rough.	
		26.50 - 28.00	4	94	94	51				From 26.96 to 27.00m recovered as non-intact core of sandy angular to subangular fine to coarse gravel. 27.00 to 27.91m 0 - 10 degrees closely spaced locally very closely planar rough.	27
			NR								28
		28.00 - 29.50	6	94	94	85					29
			NR								
			9							From 29.32 to 29.35m clay infill From 29.42 to 29.50m no recovery. 29.50 to 29.73m 0 - 10 degrees very closely spaced to closely spaced planar rough. From 29.73 to 31.00m no recovery.	
											30

Continued on next sheet

Remarks

Service inspection pit hand excavated from GL to 1.20m. No groundwater encountered due to water flush.





Rotary Core Log

Borehole No.

RBH101

Sheet 4 of 6

Project Name: St Michael's

Project No.
078847

Co-ords: 383693.50 - 398018.32

Hole Type
RC

Location: Manchester

Level: 37.38

Scale
1:50

Client: Bowmer & Kirkland

Dates: 27/07/2021 - 02/08/2021

Logged By
PN

Well	Water Strikes	Depth (m)	Type / FI	Coring			Depth (m)	Level (m)	Legend	Stratum Description	
				TCR	SCR	RQD					
		29.50 - 31.00	NR	16	16	13					
		31.00 - 32.50	6	21	21	18				31.00 to 31.33m 0 - 10 degrees very closely spaced to closely spaced planar rough.	31
			NR							From 31.33 to 32.50m no recovery.	32
		32.50 - 34.00	8	87	87	82				32.50 to 33.39m 0 - 10 degrees closely spaced to medium spaced locally very closely spaced planar rough.	33
			NI							From 33.39 to 33.50m recovered as non-intact as sandy angular to subangular fine to coarse gravel.	
			6							33.50 to 34.00m 0 - 10 degrees closely spaced to medium spaced planar rough.	
		34.00 - 35.50	11	100	87	87				From 33.94 to 34.00m no recovery.	34
			NI							34.00 to 34.19m 0 - 10 degrees closely spaced to medium spaced planar rough.	
										From 34.19 to 34.33m recovered as non-intact core of sandy angular to subangular fine to coarse gravel.	
							35.50	1.88		34.33 to 38.44m 0 - 10 degrees closely spaced to medium spaced locally very closely spaced planar rough. 34.33 to 34.48 1 No. Discontinuity incipient fracture 90 degrees planar rough.	35
		35.50 - 37.00	6	100	100	97				Medium strong reddish brown fine to medium grained SANDSTONE.	36
		37.00 - 38.50		100	100	87					37
		38.50 - 40.00	NR	93	93	88				From 38.44 to 38.50m no recovery.	
			5							38.50 to 39.90 0 - 10 degrees medium spaced locally very closely spaced planar rough.	39
			NR				40.00	-2.62			40

Continued on next sheet

Remarks

Service inspection pit hand excavated from GL to 1.20m. No groundwater encountered due to water flush.





Rotary Core Log

Borehole No.

RBH101

Sheet 5 of 6

Project Name: St Michael's

Project No.
078847

Co-ords: 383693.50 - 398018.32

Hole Type
RC

Location: Manchester

Level: 37.38

Scale
1:50

Client: Bowmer & Kirkland

Dates: 27/07/2021 - 02/08/2021

Logged By
PN

Well	Water Strikes	Depth (m)	Type / FI	Coring			Depth (m)	Level (m)	Legend	Stratum Description	
				TCR	SCR	RQD					
		40.00 - 41.50	7	92	92	75				From 39.90 to 40.00m no recovery. Medium strong reddish brown medium to coarse grained SANDSTONE. 40.00 to 41.58m 0 - 10 degrees closely spaced to medium spaced planar rough.	41
			NR								
		41.50 - 43.00		100	95	88				From 41.20 to 41.23m recovered as non-intact core of rounded fine to coarse gravel. From 41.38 to 41.50m no recovery. 41.50 to 44.10m 10 - 30 degrees closely spaced to medium spaced locally very closely spaced planar rough.	42
			7							From 42.54 to 42.63m clay infill	43
		43.00 - 44.50		77	77	42					44
			NR							From 44.10 to 44.16m recovered as non-intact core of angular cobbles. From 44.16 to 44.50m no recovery. 44.50 to 45.66m 0 - 10 degrees closely spaced to medium spaced planar rough.	45
		44.50 - 46.00	8	77	77	70					46
			NR							From 45.66 to 46.00m no recovery. 46.00 to 47.13m 0 - 10 degrees closely spaced locally very closely spaced planar rough.	47
		46.00 - 47.50	6	95	89	77				From 47.13 to 47.20m recovered as non-intact core of angular cobbles. 47.20 to 47.42m 0 - 10 degrees closely spaced planar rough. From 47.42 to 47.50m no recovery. 47.50 to 48.61m 0 - 10 degrees closely spaced to medium spaced locally very closely spaced planar rough.	48
			9								49
			NR							From 48.61 to 49.00m no recovery. 49.00 to 50.16m 0 - 10 degrees closely spaced to medium spaced planar rough.	50
		47.50 - 49.00	5	73	73	65					
			NR								
		49.00 - 50.50	5	77	77	77					

Continued on next sheet

Remarks

Service inspection pit hand excavated from GL to 1.20m. No groundwater encountered due to water flush.





Rotary Core Log

Borehole No.

RBH101

Sheet 6 of 6

Project Name: St Michael's

Project No.
078847

Co-ords: 383693.50 - 398018.32

Hole Type
RC

Location: Manchester

Level: 37.38

Scale
1:50

Client: Bowmer & Kirkland

Dates: 27/07/2021 - 02/08/2021

Logged By
PN

Well	Water Strikes	Depth (m)	Type / Fl	Coring			Depth (m)	Level (m)	Legend	Stratum Description	
				TCR	SCR	RQD					
							50.50	-13.12		From 50.16 to 50.50m no recovery.	
										End of borehole at 50.50 m	
											51
											52
											53
											54
											55
											56
											57
											58
											59
											60

Remarks

Service inspection pit hand excavated from GL to 1.20m. No groundwater encountered due to water flush.





Rotary Core Log

Borehole No.

RBH102

Sheet 2 of 5

Project Name: St Michael's

Project No.
078847

Co-ords: 383708.81 - 398005.21

Hole Type
RC

Location: Manchester

Level: 37.37

Scale
1:50

Client: Bowmer & Kirkland

Dates: 27/07/2021 - 13/08/2021

Logged By
TW

Well	Water Strikes	Depth (m)	Type / FI	Coring			Depth (m)	Level (m)	Legend	Stratum Description	
				TCR	SCR	RQD					
1		9.50 - 11.00	7	100	97	86	14.93	22.44		spaced locally medium spaced, planar rough From 9.61 to 9.70m locally extremely weak. From 9.97 to 10.03m recovered as non-intact core of sandy subangular coarse gravel. 10.03 to 11.50m 5 - 10 degrees closely spaced to medium spaced locally very closely spaced, planar rough.	11
		11.00 - 12.50	13	100	100	57				11.5 to 12.50m 5 - 15 degrees very closely spaced to closely spaced, planar and stepped and locally undulating rough.	12
		12.50 - 14.00	9	100	100	77				From 12.39 to 12.50m locally weak. 12.50 to 14.00m 0 - 15 degrees closely spaced to medium spaced locally extremely closely spaced, planar rough From 13.09 to 13.15m mudstone band. From 13.46 to 13.50m sandy clay band.	13
		14.00 - 15.50	7	100	100	79				14.00 to 15.50m 5 - 15 degrees closely spaced to medium spaced, locally very closely spaced, planar locally stepped rough.	14
		15.50 - 17.00	6	100	100	89				Weak, reddish brown medium to coarse grained SANDSTONE with occasional subangular to subrounded fine to medium gravel clasts. 15.5 to 17.5m 5 - 10 degrees closely spaced to medium spaced locally extremely closely spaced, planar and undulating rough. From 16.05 to 16.10m locally very weak.	15
		17.00 - 18.50	18 6	100	99	64				Medium strong reddish brown medium grained micaceous SANDSTONE with occasional subangular to subrounded fine to medium gravel clasts. 17.50 to 17.95m 0 - 5 degrees closely spaced to medium spaced, planar smooth locally rough and 1 No. discontinuity 75 - 80 degrees planar rough. From 17.95 to 17.97m recovered as non-intact core of sandy subangular fine to coarse gravel. 17.97 to 18.50m 0 - 5 degrees closely spaced to medium spaced, planar rough.	17
		18.50 - 20.00	7	100	100	84				18.50 to 20.00m 0 - 15 degrees closely spaced to medium spaced locally very closely spaced, planar and undulating rough. From 19.155 to 19.35m mudstone band.	19
							19.87	17.50			20
										Continued on next sheet	

Remarks

Service inspection pit hand excavated from GL to 1.20m. No groundwater encountered due to water flush.





Rotary Core Log

Borehole No.

RBH102

Sheet 3 of 5

Project Name: St Michael's

Project No.
078847

Co-ords: 383708.81 - 398005.21

Hole Type
RC

Location: Manchester

Level: 37.37

Scale
1:50

Client: Bowmer & Kirkland

Dates: 27/07/2021 - 13/08/2021

Logged By
TW

Well	Water Strikes	Depth (m)	Type / FI	Coring			Depth (m)	Level (m)	Legend	Stratum Description	
				TCR	SCR	RQD					
		20.00 - 21.50	15	98	94	70	21.50	15.87		Medium strong reddish brown fine grained micaceous SANDSTONE. 20.00 to 20.48m 5 - 10 degrees closely spaced to medium spaced, planar rough and 1 No. discontinuity 80 - 85 degrees, planar smooth. From 20.46 to 20.462m highly micaceous lamination. From 20.50 to 20.64m locally coarse grained and very weak. 20.64 to 21.47m 5 - 15 degrees closely spaced to medium spaced locally very closely spaced, planar rough.	21
			NI								
			7								
		21.50 - 23.00	6	100	100	91	23.22	14.15		From 21.47 to 21.50m no recovery. Medium strong reddish brown medium to coarse grained SANDSTONE with occasional subangular to subrounded fine to medium gravel clasts. 21.50 to 24.50m 0 - 10 degrees closely spaced to medium spaced locally very closely spaced, planar and undulating rough locally smooth. From 21.60 to 21.70m subangular to subrounded coarse gravel bed.	22
		23.00 - 24.50		100	100	92				Medium strong reddish brown fine grained SANDSTONE.	24
		24.50 - 26.00	4	89	100	79	24.90	12.47		24.50 to 25.86m 5 - 20 degrees closely spaced to medium spaced locally very closely, planar rough.	25
			NR								From 25.84 to 26.00m no recovery.
		26.00 - 27.50	8	100	100	79				26.00 to 27.20m 5 - 10 degrees very closely spaced to closely spaced locally extremely closely, planar and undulating rough.	27
			NI								From 27.20 to 27.30m recovered as non-intact core of sandy subangular medium to coarse gravel. 27.20 to 27.50m 5 - 15 degrees closely spaced, undulating rough.
		27.50 - 29.00	7	100	100	93				27.50 to 29.00m 0 - 10 degrees closely spaced to medium spaced, planar and undulating rough.	28
29.00 - 30.50	5	91	91	76				29.00 to 30.37m 0 - 5 degrees closely spaced to medium spaced locally very closely spaced, planar and locally undulating rough.	29		
								Continued on next sheet	30		

Remarks

Service inspection pit hand excavated from GL to 1.20m. No groundwater encountered due to water flush.





Rotary Core Log

Borehole No.

RBH102

Sheet 4 of 5

Project Name: St Michael's

Project No.
078847

Co-ords: 383708.81 - 398005.21

Hole Type
RC

Location: Manchester

Level: 37.37

Scale
1:50

Client: Bowmer & Kirkland

Dates: 27/07/2021 - 13/08/2021

Logged By
TW

Well	Water Strikes	Depth (m)	Type / FI	Coring			Depth (m)	Level (m)	Legend	Stratum Description	
				TCR	SCR	RQD					
			NR								
		30.50 - 32.00	5	96	96	84	31.52	5.85		From 30.37 to 30.50m no recovery. 30.50 to 31.94m 0 - 5 degrees closely spaced to medium spaced locally very closely spaced, planar smooth and 1 No. discontinuity 40 - 45 degrees, planar smooth.	31
			NR								
			NI				32.00	5.37		Medium strong reddish brown fine grained SANDSTONE.	
		32.00 - 33.50	7	100	89	77				From 31.94 to 32.00m no recovery. Medium strong reddish brown medium to coarse grained SANDSTONE with rare subangular to subrounded fine to medium gravel clasts. 32.00 to 32.10m 1 No. discontinuity 85 - 90 degrees, planar rough. From 32.10 to 32.23m recovered as non-intact core of subangular gravelly cobbles. 32.23 to 34.40m 5 - 20 degrees closely spaced to medium spaced locally very closely spaced, planar and locally undulating rough.	32 33
		33.50 - 35.00	7	100	100	92					34
			7							From 34.40 to 34.43m recovered as non-intact core of sandy gravel. 34.43 to 35.46m 0 - 10 degrees closely spaced to medium spaced locally very closely spaced, planar and undulating rough.	35
		35.00 - 36.50	5	100	97	64	35.90	1.47		From 35.46 to 35.51m recovered as non-intact core of sandy subangular medium to coarse gravel. 35.51 to 36.50m 0 - 10 degrees closely spaced to medium spaced locally very closely spaced, planar and undulating rough.	36
		36.50 - 38.00	6	100	100	90	36.45	0.92		Medium strong reddish brown fine grained SANDSTONE. From 36.27 to 36.32m mudstone band. Medium strong reddish brown medium to coarse grained SANDSTONE with rare subangular to subrounded fine to medium gravel clasts. 36.50 to 38.09m 0 - 5 degrees closely spaced to medium spaced locally extremely closely spaced, planar and locally undulating rough and 1 No. discontinuity 70 - 75 degrees, planar smooth.	37
		38.00 - 39.50	6	100	96	85				From 38.09 to 38.15m recovered as non-intact core of clayey sandy subangular fine to coarse gravel. 38.15 to 40.77m 10 - 20 degrees closely spaced to medium spaced locally very closely spaced, planar rough. From 38.97 to 39.01m mudstone band.	38 39
											40

Continued on next sheet

Remarks

Service inspection pit hand excavated from GL to 1.20m. No groundwater encountered due to water flush.





Rotary Core Log

Borehole No.

RBH102

Sheet 5 of 5

Project Name: St Michael's

Project No.
078847

Co-ords: 383708.81 - 398005.21

Hole Type
RC

Location: Manchester

Level: 37.37

Scale
1:50

Client: Bowmer & Kirkland

Dates: 27/07/2021 - 13/08/2021

Logged By
TW

Well	Water Strikes	Depth (m)	Type / FI	Coring			Depth (m)	Level (m)	Legend	Stratum Description	
				TCR	SCR	RQD					
		39.50 - 41.00		96	93	70	42.17	-4.80		From 40.77 to 40.90m recovered as non-intact core of sandy subangular medium to coarse gravel.	41
		NI				40.90 to 40.94m 1 No. discontinuity 0 - 5 degrees very closely spaced, planar rough.					
		NR				From 40.94 to 41.00m no recovery.					
		41.00 - 42.50	6	100	100	89				41.00 to 42.50m 5 - 10 degrees closely spaced to medium spaced locally very closely spaced, planar and locally stepped rough and 1 No. discontinuity 40 -45 degrees, planar rough.	42
		42.50 - 44.00	5	100	100	87				Medium strong reddish brown fine grained SANDSTONE.	
										42.50 to 45.50m 5 - 15 degrees closely spaced to medium spaced locally very closely spaced, planar and undulating rough and 1 No. discontinuity 40 - 45 degrees, planar smooth.	43
		44.00 - 45.50	100	100	91	From 44.14 to 44.16m subangular to subrounded coarse gravel bed.		44			
						From 44.47 to 44.49m mudstone band.					
		45.50 - 47.00	13	92	92	83		Strong reddish brown medium to coarse grained SANDSTONE with occasional subangular to subrounded fine to medium gravel clasts.		45	
								45.50 to 46.92m 5 - 10 degrees very closely spaced to closely spaced locally medium spaced, planar rough.			
47.00 - 48.50	6	100	99	99	From 46.92 to 47.00m no recovery.	47					
					47.00 to 47.54m 0 - 5 degrees closely spaced to medium spaced, planar rough.						
48.50 - 50.00	4	100	99	98	From 47.54 to 47.56m recovered as non-intact core of sandy subangular fine to medium gravel.	48					
					47.56 to 48.89m 0 - 5 degrees closely spaced to medium spaced, planar rough.						
	5	100	99		From 48.22 to 48.41m fine grained band with sedimentary structure.	49					
					From 48.89 to 48.91m recovered as non-intact core of sandy subangular fine to medium gravel.						
					48.91 to 50.00m 5 - 10 degrees closely spaced to medium spaced locally extremely closely spaced, planar rough.	50					
						50.00	-12.63		End of borehole at 50.00 m		

Remarks

Service inspection pit hand excavated from GL to 1.20m. No groundwater encountered due to water flush.





Rotary Core Log

Borehole No.

RBH103

Sheet 1 of 5

Project Name: St Michael's

Project No.
078847

Co-ords: 383717.15 - 398018.23

Hole Type
RC

Location: Manchester

Level: 37.41

Scale
1:50

Client: Bowmer & Kirkland

Dates: 27/07/2021 - 10/08/2021

Logged By
TW

Well	Water Strikes	Depth (m)	Type / FI	Coring			Depth (m)	Level (m)	Legend	Stratum Description	
				TCR	SCR	RQD					
		0.45	ES				0.21	37.20		MADE GROUND: CONCRETE	
							1.00	36.40		MADE GROUND: Reddish brown gravelly fine to coarse sand with frequent intact bricks. Gravel is angular to subrounded fine to coarse including coal and brick.	1
							1.35	36.06		Firm reddish brown slightly gravelly CLAY. Gravel is subrounded fine to coarse including sandstone.	
										Very dense reddish brown slightly gravelly medium to coarse SAND. Gravel is subrounded to well rounded fine to coarse including sandstone.	2
											3
											4
							5.00	32.40		Very weak reddish brown medium to coarse grained SANDSTONE. From 5.00 to 5.09m recovered as non-intact core of fine to medium sand. 5.04 to 5.30m 0 - 10 degrees closely spaced locally extremely closely spaced, planar rough and 1 No. discontinuity 80 - 90 degrees planar rough. From 5.30 to 5.38m recovered as non-intact core of sandy subangular fine to medium gravel. From 5.38 to 5.47m locally extremely weak. 5.38 to 5.95m 0 - 20 degrees very closely spaced to closely spaced, planar rough. From 5.95 to 6.50m no recovery. 6.50 to 7.25m 0 - 10 degrees closely spaced, planar rough.	5
		5.00 - 6.50	15 NI 12	63	55	23					6
		6.50 - 8.00	12 NR	50	50	35					7
		8.00 - 9.50	NI 10 25 25 15	100	89	35	8.00	29.40		Extremely weak reddish brown medium to coarse grained SANDSTONE. From 8.00 to 8.12m recovered as non-intact core of clayey medium to coarse sand. 8.12 to 8.20m 1 No. discontinuity 5 - 10 degrees, undulating rough From 8.20 to 8.25m recovered as non-intact core of sandy subangular coarse gravel. From 8.25 to 8.75m highly fractured.	8
							8.75	28.66		Very weak reddish brown medium to coarse grained SANDSTONE with occasional subangular fine to medium gravel clasts. 8.75 to 9.50m 0 - 15 degrees very closely spaced to closely spaced, planar rough	9
											10

Continued on next sheet

Remarks

Service inspection pit hand excavated from GL to 1.20m. No groundwater encountered due to water flush.





Rotary Core Log

Borehole No.

RBH103

Sheet 2 of 5

Project Name: St Michael's

Project No.
078847

Co-ords: 383717.15 - 398018.23

Hole Type
RC

Location: Manchester

Level: 37.41

Scale
1:50

Client: Bowmer & Kirkland

Dates: 27/07/2021 - 10/08/2021

Logged By
TW

Well	Water Strikes	Depth (m)	Type / FI	Coring			Depth (m)	Level (m)	Legend	Stratum Description				
				TCR	SCR	RQD								
		9.50 - 11.00	NR	0	0	0	16.83	20.58		From 9.00 to 11.00m no recovery.				
		11.00 - 12.50	>25	78	78	26				11.00 to 11.53m 0 - 10 degrees extremely closely spaced to very closely spaced locally closely spaced, planar and undulating rough.				
			10							From 11.40 to 11.53m locally extremely weak.				
			NR							11.53 to 12.17m 10 - 30 degrees closely spaced, planar and undulating rough.				
		12.50 - 14.00	17	80	80	48				From 12.17 to 12.50m no recovery.				
			NR							12.50 to 13.20m 0 - 10 degrees very closely spaced to closely spaced, planar rough				
		14.00 - 15.50	11	87	69	53				From 13.20 to 14.00m no recovery.				
			NI							14.00 to 14.09m 1 No. discontinuity 5 - 10 degrees, planar rough.				
			6							From 14.09 to 14.38m recovered as non-intact core of subangular cobbles.				
		15.50 - 17.00	NR	100	89	44				14.36 to 15.30m 0 - 10 degrees closely spaced to medium spaced locally very closely spaced, planar rough.				
			NI							From 15.30 to 15.50m no recovery.				
			12							From 15.50 to 15.60m recovered as non-intact core of sandy subangular coarse gravel and cobbles.				
17.00 - 18.50	9	100	100	79				15.60 to 16.29m 0 - 5 degrees very closely spaced to closely spaced, planar rough and 1 No. discontinuity from 15.00 to 16.00m 85 - 90 degrees, planar rough.						
	10							From 16.29 to 16.35m recovered as non-intact core of very sandy subangular coarse gravel.						
18.50 - 20.00	5	90	90	79				16.35 to 16.83m 5 - 10 degrees closely spaced to medium spaced locally very closely spaced, planar rough and 1 No. discontinuity 80 - 90 degrees, planar rough.						
	NR							Medium strong reddish brown fine grained SANDSTONE.						
		17.00 - 18.50	9	100	100	79				16.83 to 18.85m 0 - 10 degrees closely spaced to medium spaced locally very closely spaced, planar smooth.				
			NR							Weak reddish brown medium to coarse grained SANDSTONE with occasional subangular fine to medium gravel clasts.				
		18.50 - 20.00	5	90	90	79				18.85 to 19.85m 5 - 10 degrees very closely spaced to closely spaced, planar rough.				
			NR							From 19.85 to 20.00m no recovery.				
Continued on next sheet											20			

Continued on next sheet

Remarks

Service inspection pit hand excavated from GL to 1.20m. No groundwater encountered due to water flush.





Rotary Core Log

Borehole No.

RBH103

Sheet 3 of 5

Project Name: St Michael's

Project No.
078847

Co-ords: 383717.15 - 398018.23

Hole Type
RC

Location: Manchester

Level: 37.41

Scale
1:50

Client: Bowmer & Kirkland

Dates: 27/07/2021 - 10/08/2021

Logged By
TW

Well	Water Strikes	Depth (m)	Type / FI	Coring			Depth (m)	Level (m)	Legend	Stratum Description	
				TCR	SCR	RQD					
		20.00 - 21.50	5	100	100	85	26.85	10.56		20.00 to 23.00m 0 - 10 degrees closely spaced to medium spaced, planar locally stepped rough.	21
		21.50 - 23.00		100	100	100				22	
		23.00 - 24.50	6	100	100	85				23.00 to 25.87m 0 - 10 degrees closely spaced to medium spaced locally very closely spaced, planar and undulating rough and 1 No. discontinuity from 23.92 to 24.00m 85 - 90 degrees, planar rough.	23
		24.50 - 26.00		91	91	77				24	
			NR							From 25.87 to 26.00m no recovery. 26.00 to 26.85m 0 - 5 degrees closely spaced to medium spaced locally very closely spaced, planar rough.	25
		26.00 - 27.50	6	100	100	95					26
		27.50 - 29.00		7	100	100				98	Medium strong reddish brown fine grained SANDSTONE. 26.85 to 29.00m 5 - 10 degrees closely spaced to medium spaced locally very closely spaced, planar rough locally smooth. From 27.5 to 27.53m mudstone band.
		29.00 - 30.50	7		97	97				88	Medium strong reddish brown medium to coarse grained SANDSTONE with occasional subangular fine to medium gravel clasts.
								29.00 to 30.45m 0 - 10 degrees very closely spaced to medium spaced, planar rough.	29		
										30	

Remarks

Service inspection pit hand excavated from GL to 1.20m. No groundwater encountered due to water flush.





Rotary Core Log

Borehole No.

RBH103

Sheet 4 of 5

Project Name: St Michael's

Project No.
078847

Co-ords: 383717.15 - 398018.23

Hole Type
RC

Location: Manchester

Level: 37.41

Scale
1:50

Client: Bowmer & Kirkland

Dates: 27/07/2021 - 10/08/2021

Logged By
TW

Well	Water Strikes	Depth (m)	Type / FI	Coring			Depth (m)	Level (m)	Legend	Stratum Description					
				TCR	SCR	RQD									
							35.25	2.15		<u>From 30.45 to 30.50m no recovery.</u> 30.50 to 31.28m 5 - 10 degrees closely spaced to medium spaced locally very closely spaced, planar rough.	31				
		30.50 - 32.00	5	93	91	85				<u>From 31.28 to 31.32m recovered as non-intact core of clayey weathered subangular to subrounded fine to medium mudstone gravel.</u>	32				
			NR							<u>From 31.32 to 31.42m no recovery</u> 31.42 to 32.00m 5 - 10 degrees closely spaced to medium spaced locally very closely spaced, planar rough.					
			7							32.00 to 35.00m 0 - 5 degrees closely spaced to medium spaced, planar rough.					
		32.00 - 33.50	6	100	100	81				33					
											33.50 - 35.00	100	100	100	34
		35.00 - 36.50	4	100	100	89				<u>35.00 to 37.76m 0 - 10 degrees closely spaced to medium spaced, planar rough.</u>					
										36.50 - 38.00	84	84	65	Weak reddish brown medium to coarse grained SANDSTONE with occasional subangular fine to medium gravel clasts.	36
		38.00 - 39.50	6	<u>From 38.00 to 38.07m recovered as non-intact core of sandy subangular cobbles.</u> 38.07 to 38.42m 0 - 5 degrees very closely spaced, planar rough.	39										
NI	<u>From 38.42 to 38.50m recovered as non-intact core of sandy subangular cobbles.</u> 38.50 to 40.19m 0 - 5 degrees closely spaced to medium spaced, planar rough.														
4						Medium strong reddish brown fine grained SANDSTONE.	40								
							39.59	-2.18		Continued on next sheet	40				

Continued on next sheet

Remarks

Service inspection pit hand excavated from GL to 1.20m. No groundwater encountered due to water flush.





Rotary Core Log

Borehole No.

RBH103

Sheet 5 of 5

Project Name: St Michael's

Project No.
078847

Co-ords: 383717.15 - 398018.23

Hole Type
RC

Location: Manchester

Level: 37.41

Scale
1:50

Client: Bowmer & Kirkland

Dates: 27/07/2021 - 10/08/2021

Logged By
TW

Well	Water Strikes	Depth (m)	Type / FI	Coring			Depth (m)	Level (m)	Legend	Stratum Description	
				TCR	SCR	RQD					
		39.50 - 41.00		89	89	53	41.77	-4.36		40.19 to 40.83m 0 - 5 degrees very closely spaced to medium spaced, planar rough.	41
			23								
			NR								
		41.00 - 42.50	7	91	91	77			41.00 to 42.36m 5 - 10 degrees closely spaced to medium spaced locally extremely closely spaced, planar and undulating rough.		
			NR								
		42.50 - 44.00	4	82	70	56			42.30 to 43.73m 0 - 10 degrees very closely spaced to closely spaced, planar and locally stepped rough. From 42.36 to 42.50m no recovery.		
			NI						42.50 to 43.00m 5 - 10 degrees medium spaced, planar rough.		
			17						Weak reddish brown fine to medium grained SANDSTONE.		
			NI							From 43.00 to 43.11m recovered as non-intact core of sandy subangular medium to coarse gravel.	
			16							43.11 to 43.23m 0 - 5 degrees closely spaced, planar rough.	
			NR						From 43.23 to 43.30m recovered as non-intact core of sandy subangular cobbles.		
			44.00 - 45.50						7	92	
		NR		Medium strong reddish brown medium to coarse grained SANDSTONE with occasional subangular fine to medium gravel clasts.							
				44.00 to 45.38m 0 - 5 degrees closely spaced to medium spaced, planar rough.							
		45.50 - 47.00	6	100	91	85	45.50 to 46.02m 5 - 10 degrees closely spaced to medium spaced, planar and undulating rough.				
			NI				Strong reddish brown medium to coarse grained SANDSTONE with occasional subangular to subrounded fine to medium gravel clasts.				
								From 46.02 to 46.15m recovered as non-intact core of sandy subangular cobbles.			
		47.00 - 48.50	4	100	100	94	46.15 to 50.00m 5 - 20 degrees closely spaced to medium spaced locally very closely spaced, planar rough.				
48.50 - 50.00		100	100	97							
						50.00	-12.60		End of borehole at 50.00 m	50	

Remarks

Service inspection pit hand excavated from GL to 1.20m. No groundwater encountered due to water flush.





Borehole Log

Borehole No.

WS104

Sheet 1 of 1

Project Name: St Michael's

Project No.
078847

Co-ords: 383699.78 - 398028.48

Hole Type
WS

Location: Manchester

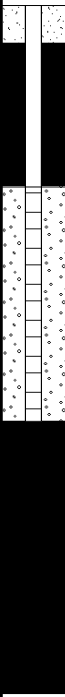
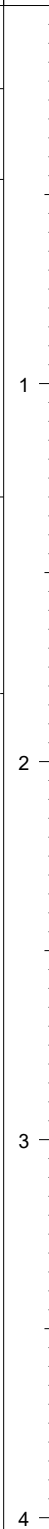
Level: 37.41

Scale
1:20

Client: Bowmer & Kirkland

Dates: 27/07/2021 - 27/07/2021

Logged By
PN

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		0.25	ES		0.22	37.19		MADE GROUND: CONCRETE	
					0.46	36.95		Light brown fine to coarse slightly gravelly SAND. Gravel is subangular to well rounded fine to coarse including sandstone.	
		1.20 1.20 - 1.35	D	N=61 (3,3/6,12,18,25)	1.30	36.11		Very stiff reddish brown mottled grey CLAY with frequent rounded cobbles of sandstone and mudstone.	
		1.56		50 (7,20/50 for 80mm)	1.82	35.59		Very dense reddish brown medium to coarse SAND.	
								End of borehole at 1.82 m	

Remarks

Service inspection pit hand excavated from GL to 1.20m. No groundwater encountered. Terminated at 1.82m due to SPT refusal.





Borehole Log

Borehole No.

WS107

Sheet 1 of 1

Project Name: St Michael's

Project No.
078847

Co-ords: 383684.61 - 398040.17

Hole Type
WS

Location: Manchester

Level: 33.53

Scale
1:20

Client: Bowmer & Kirkland

Dates: 28/07/2021 - 28/07/2021

Logged By
PN

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		0.33 - 0.36	D		0.33 0.36 0.40 0.42	33.20 33.16 33.12 33.10		MADE GROUND: CONCRETE	
								Greyish brown slightly gravelly coarse SAND. Gravel is subrounded fine of quartz.	
								Brown slightly gravelly coarse SAND. Gravel is subrounded fine to coarse of sandstone and quartz.	
								Reddish brown SANDSTONE.	
								End of borehole at 0.42 m	

1

2

3

4

Remarks

Hand excavated pit to 0.42m bgl in sandstone bedrock.





Borehole Log

Borehole No.

WS108

Sheet 1 of 1

Project Name: St Michael's

Project No.
078847

Co-ords: 383673.96 - 398010.14

Hole Type
WS

Location: Manchester

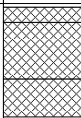
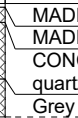
Level: 34.39

Scale
1:20

Client: Bowmer & Kirkland

Dates: 28/07/2021 - 28/07/2021

Logged By
PN

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		0.20 - 0.30	D		0.01	34.38		MADE GROUND: Laminated floor	
					0.05	34.34		MADE GROUND: CONCRETE	
					0.20	34.18		CONCRETE with gravel inclusions including quartz and flint.	
					0.30	34.08		Grey SILTSTONE	
End of borehole at 0.30 m									

Remarks

Hand excavated pit to 0.30m bgl in bedrock.





Borehole Log

Borehole No.

WS109

Sheet 1 of 1

Project Name: St Michael's

Project No.
078847

Co-ords: 383701.15 - 397998.97

Hole Type
WS

Location: Manchester

Level: 34.33

Scale
1:20

Client: Bowmer & Kirkland

Dates: 28/07/2021 - 28/07/2021

Logged By
PN

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		0.20 - 0.30	D		0.10 0.12 0.20 0.30 0.32	34.23 34.21 34.13 34.03 34.01	  	MADE GROUND: CONCRETE MADE GROUND: Bitumen MADE GROUND: Intact bricks Brown slightly gravelly coarse SAND. Gravel is subrounded fine to coarse of sandstone and quartz. Reddish brown SANDSTONE. End of borehole at 0.31 m	1 2 3 4

Remarks

Hand excavated pit to 0.32m bgl in sandstone bedrock.



Borehole Log

Borehole No.

WS110

Sheet 1 of 1

Project Name: St Michael's

Project No.
078847

Co-ords: 383717.32 - 397995.59

Hole Type	WS
1	1
2	2
3	3
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99	99
100	100

Location: Manchester

Level: 34.34

Scale
1:20

Client: Bowmer & Kirkland

Dates: 28/07/2021 - 28/07/2021

Logged By
PN

Well	Water Strikes	Samples and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
		0.20 - 0.30	D		0.10	34.24		MADE GROUND: CONCRETE
					0.12	34.22		MADE GROUND: Bitumen
					0.20	34.14		MADE GROUND: Intact bricks
					0.30	34.04		Brown slightly gravelly coarse SAND. Gravel is subrounded fine to coarse of sandstone and quartz.
					0.32	34.02		Reddish brown SANDSTONE.
								End of borehole at 0.32 m

Remarks

Hand excavated pit to 0.32m bgl in sandstone bedrock.



Appendix C – Risk Assessment Rationale

The qualitative risk assessment of environmental harm is designed to establish connecting links between a hazardous source to a potential receptor via an exposure pathway.

The qualitative risk assessment corresponds with the proposed piling operations on site.

Risk assessment is the process of collating known information on a hazard or set of hazards in order to estimate actual or potential risk to receptors. The receptor may be humans, a water resource, a sensitive local ecosystem or future construction materials. Receptors can be connected to the hazardous source by one or several exposure pathways such as direct contact for example. Risks are generally managed by isolating the receptor or intercepting the exposure pathway or by isolating or removing the hazard.

Without the three essential components of a source, pathway and receptor there can be no risk. Therefore, the presence of hazard on a site does not necessarily mean there is a risk.

By considering where a viable pathway exists which connects a source with a receptor the risk assessment in Section 3.0 and Table A4.1 identifies where pollutant linkage exists. If there is no pollutant linkage there is no risk and only where a pollutant linkage is established does the risk assessment, consider the level of risk.

The risk assessment considers the likelihood of a particular event taking place (accounting for the presence of the hazard and receptor and the integrity of the exposure pathway) in conjunction with the severity of the potential consequence (accounting for the potential severity of the hazard and the sensitivity of the receptor).

In the risk assessment the consequence of the hazard has been classified as severe or medium or mild or minor and the probability (likelihood) of the circumstances actually occurring classified as high likelihood or likely or low likelihood or unlikely.

The consequences and probabilities are subsequently cross-correlated to give a qualitative estimation of the risk using Department of the Environment risk classifications as detailed in the table below and as referenced in CIRIA C552.

		Consequence			
		Severe	Medium	Mild	Minor
Probability (Likelihood)	High Likelihood	Very High Risk	High Risk	Moderate Risk	Negligible Risk
	Likely	High Risk	Moderate Risk	Moderate/Low Risk	Negligible Risk
	Low Likelihood	High/Moderate Risk	Moderate/Low Risk	Low Risk	Negligible Risk
	Unlikely	Moderate/Low Risk	Low Risk	Negligible Risk	Negligible Risk

Piling Risk Assessment

In accordance with DoE guidance, the following categorisation of **consequence** has been developed.

Classification	Definition	Examples
Severe	Short-term (acute) risk to human health likely to result in "significant harm" as defined by the Environment Protection Act 1990, Part IIA. Short-term risk of pollution of sensitive water resource. Catastrophic damage to buildings/property. A short-term risk to a particular ecosystem or organisation forming part of such ecosystem.	High concentrations of cyanide on the surface of an informal recreation area. Major spillage of contaminants from site into controlled water. Explosion, causing building collapse (can also equate to a short-term human health risk if buildings are occupied).
Medium	Chronic damage to Human Health. Pollution of sensitive water resources. A significant change in a particular ecosystem or organism forming part of such ecosystem.	Concentration of a contaminant from site exceeds the generic or site-specific assessment criteria. Leaching of contaminants from a site to a Principal or Secondary A aquifer. Death of a species within a designated nature reserve. Lesser toxic and asphyxiate effects.
Mild	Pollution of non-sensitive water resources. Significant damage to crops, buildings, structures and services. Damage to sensitive buildings/structures/services or the environment.	Pollution of non-classified groundwater (inc. Secondary B aquifers). Damage to building rendering it unsafe to occupy (e.g. foundation damage resulting in instability).
Minor	Harm, although not necessarily significant harm, which may result in a financial loss or expenditure to resolve. Non-permanent health effects to human health (easily prevented by means such as personal protective clothing, etc). Easily repairable effects of damage to buildings, structures and services.	The presence of contaminants at such concentrations that protective equipment is required during site works. The loss of plants in a landscaping scheme. Discoloration of concrete.

Piling Risk Assessment

In accordance with DoE guidance, the following categorisation of **probability** has been developed.

Classification	Definition
High Likelihood	There is a pollution linkage and an event that either appears very likely in the short term and almost inevitable over the long term or there is evidence at the receptor of harm or pollution.
Likely	There is a pollution linkage and all the elements are present and in the right place, which means that it is probable that an event will occur. Circumstances are such that an event is not inevitable, but possible in the short term and likely over the long term.
Low Likelihood	There is a pollution linkage and circumstances are possible under which an event could occur. However, it is by no means certain that even over a longer period such event would take place and is less likely in the shorter term.
Unlikely	There is a pollution linkage, but circumstances are such that it is improbable that an event would occur even in the very long term.

In accordance with DoE guidance, the following categorisation of **risk** has been developed.

Classification	Definition
Very High Risk	There is a <i>high probability</i> that <i>severe harm</i> could arise to a designated receptor from an identified hazard at the site without appropriate further action.
High Risk	<i>Harm is likely to arise</i> to a designated receptor from an identified hazard at the site without appropriate further action.
Moderate Risk	<i>It is possible</i> that without appropriate further action <i>harm could arise</i> to a designated receptor. It is relatively <i>unlikely</i> that any such harm would be <i>severe</i> , and if any harm were to occur it is <i>more likely</i> that such harm would be <i>relatively mild</i> .
Low Risk	<i>It is possible</i> that <i>harm could arise</i> to a designated receptor from an identified hazard. It is <i>likely</i> that, at worst, if any harm was realised any effects would be <i>mild</i> .
Negligible Risk	The presence of an identified hazard does not give rise to the potential to cause harm to a designated receptor.

The term 'risk' in this instance refers to the risk that the source, pathway, receptor linkage for a given source of contamination is complete. It does not refer to immediate risk to individuals or features present on the site from potential contaminants and is intended to be used as a tool to assess the necessity of further investigation or risk management operations.

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