Analytical Report Number : 15-66395

Project / Site name: Rifle Range St Andrews Park , Uxbridge

Water matrix abbreviations: Surface Water (SW) Potable Water (PW) Ground Water (GW)

Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
Asbestos identification in soil	Asbestos Identification with the use of polarised light microscopy in conjunction with disperion staining techniques.	In house method based on HSG 248	A001-PL	D	ISO 17025
Asbestos Quantification	The analysis was carried out using our documented in-house method based on HSE Contract Research Report No: 83/1996: Development and Validation of an analytical	HSE Contract Research Report No: 83/1996: Development and Validation of an analytical method to determine the amount of asbestos in soils and loose aggregates	A006	D	ISO 17025
BTEX and MTBE in soil	Determination of BTEX in soil by headspace GC-MS.	In-house method based on USEPA8260	L073S-PL	W	MCERTS
Hexavalent chromium in soil	Determination of hexavalent chromium in soil by extraction in water then by acidification, addition of 1,5 diphenylcarbazide followed by colorimetry.	In-house method	L080-PL	W	MCERTS
Metals by ICP-OES in leachate	Determination of metals in leachate by acidification followed by ICP-OES.	In-house method based on MEWAM 2006 Methods for the Determination of Metals in Soil.	L039-PL	W	ISO 17025
Metals in soil by ICP-OES	Determination of metals in soil by aqua-regia digestion followed by ICP-OES.	In-house method based on MEWAM 2006 Methods for the Determination of Metals in Soil.	L038-PL	D	MCERTS
Moisture Content	Moisture content, determined gravimetrically.	In-house method based on BS1377 Part 3, 1990, Chemical and Electrochemical Tests	L019-UK/PL	W	NONE
Monohydric phenols in soil	Determination of phenols in soil by extraction with sodium hydroxide followed by distillation followed by colorimetry.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton (skalar)	L080-PL	W	MCERTS
Organic matter in soil	Determination of organic matter in soil by oxidising with potassium dichromate followed by titration with iron (II) sulphate.	BS1377 Part 3, 1990, Chemical and Electrochemical Tests	L023-PL	D	MCERTS
PCBs WHO 12 in soil	Determination of PCBs (WHO-12 Congeners) by GC-MS.	In-house method based on USEPA 8082	L027-PL	D	NONE
pH in soil	Determination of pH in soil by addition of water followed by electrometric measurement.	In-house method based on BS1377 Part 3, 1990, Chemical and Electrochemical Tests	L005-PL	W	MCERTS
Speciated EPA-16 PAHs in soil	Determination of PAH compounds in soil by extraction in dichloromethane and hexane followed by GC-MS with the use of surrogate and internal standards.	In-house method based on USEPA 8270	L064-PL	D	MCERTS
Stones content of soil	Standard preparation for all samples unless otherwise detailed. Stones not passing through a 10 mm sieve is determined gravimetrically and reported as a percentage of the dry weight.	In-house method based on British Standard Methods and MCERTS requirements.	L019-UK/PL	D	NONE
Sulphate, water soluble, in soil	Determination of water soluble sulphate by extraction with water followed by ICP-OES. Results reported corrected for extraction ratio (soil equivalent) as g/l and mg/kg; and upon the 2:1	In-house method based on BS1377 Part 3, 1990, Chemical and Electrochemical Tests	L038-PL	D	MCERTS
Total cyanide in soil	Determination of total cyanide by distillation followed by colorimetry.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton (Skalar)	L080-PL	W	MCERTS
TPHCWG (Soil)	Determination of pentane extractable hydrocarbons in soil by GC-MS/GC-FID.	In-house method	L076-PL	W	MCERTS

For method numbers ending in 'UK' analysis have been carried out in our laboratory in the United Kingdom.
For method numbers ending in 'PL' analysis have been carried out in our laboratory in Poland.
Soil analytical results are expressed on a dry weight basis. Where analysis is carried out on as-received the results obtained are multiplied by a moisture correction factor that is determined gravimetrically using the moisture content which is carried out at a maximum of 30oC.

Laura Wilkinson
Ian Farmer Associates
Unit 1 Fairfield Court
Wheler Rd
Seven Stars Industrial Estate
Coventry
CV3 4LJ

t: 02476 303 422

e: laura.wilkinson@ianfarmer.co.uk

i2 Analytical Ltd.
7 Woodshots Meadow,
Croxley Green
Business Park,
Watford,
Herts,
WD18 8YS

t: 01923 225404
f: 01923 237404
e: reception@i2analytical.com

Analytical Report Number : 15-67733

Project / Site name:	St Andrews Park, Uxbridge	**Samples received on:**	26/02/2015
Your job number:	21311A	**Samples instructed on:**	27/02/2015
Your order number:	20317	**Analysis completed by:**	09/03/2015
Report Issue Number:	1	**Report issued on:**	09/03/2015
Samples Analysed:	6 water samples		

Signed: CCStone

Dr Claire Stone
Quality Manager
For & on behalf of i2 Analytical Ltd.

Signed: RRahman

Rexona Rahman
Reporting Manager
For & on behalf of i2 Analytical Ltd.

Other office located at: ul. Pionierów 39, 41 -711 Ruda Śląska, Poland

Standard sample disposal times, unless otherwise agreed with the laboratory, are :

soils	- 4 weeks from reporting
leachates	- 2 weeks from reporting
waters	- 2 weeks from reporting
asbestos	- 6 months from reporting

Excel copies of reports are only valid when accompanied by this PDF certificate.

Analytical Report Number: 15-67733

Project / Site name: St Andrews Park, Uxbridge

Your Order No: 20317

Lab Sample Number				421380	421381	421382	421383	421384
Sample Reference				CP802A	CP804	CP807	WS801	WS806
Sample Number				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Depth (m)				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Date Sampled				25/02/2015	25/02/2015	25/02/2015	25/02/2015	25/02/2015
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Water Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
General Inorganics								
pH	pH Units	N/A	ISO 17025	7.6	7.3	7.5	7.4	7.6
Free Cyanide	µg/l	10	ISO 17025	< 10	< 10	< 10	< 10	< 10
Sulphate as SO_4	µg/l	45	ISO 17025	335000	2240000	609000	1070000	850000
Chloride	mg/l	0.15	ISO 17025	170	1900	250	1600	71
Ammoniacal Nitrogen as N	µg/l	15	ISO 17025	1100	640	41	110	110
Total Organic Carbon (TOC)	mg/l	0.1	ISO 17025	2.77	6.64	6.15	17.5	24.0
Nitrate as N	mg/l	0.25	ISO 17025	0.4	0.7	0.9	1.1	110
Nitrate as NO_3	mg/l	1.1	ISO 17025	2.0	2.9	4.1	5.1	470
Chemical Oxygen Demand (Total)	mg/l	2	ISO 17025	34	94	70	190	1400
BOD (Biochemical Oxygen Demand)	mg/l	1	ISO 17025	12	4.4	< 1.0	< 1.0	1.7
Total Phenols								
Total Phenols (monohydric)	µg/l	10	ISO 17025	< 10	< 10	< 10	< 10	< 10
Speciated PAHs								
Naphthalene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Acenaphthylene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Acenaphthene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Fluorene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Phenanthrene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Anthracene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Fluoranthene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Pyrene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(a)anthracene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Chrysene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(b)fluoranthene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(k)fluoranthene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(a)pyrene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Indeno(1,2,3-cd)pyrene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Dibenz(a,h)anthracene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(ghi)perylene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Total PAH								
Total EPA-16 PAHs	µg/l	0.2	ISO 17025	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20
Heavy Metals / Metalloids								
Arsenic (dissolved)	µg/l	0.15	ISO 17025	1.02	2.34	0.64	2.29	1.24
Boron (dissolved)	µg/l	10	ISO 17025	1700	1300	86	440	120
Cadmium (dissolved)	µg/l	0.02	ISO 17025	< 0.02	0.03	< 0.02	0.14	0.08
Chromium (hexavalent)	µg/l	5	ISO 17025	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Chromium (dissolved)	µg/l	0.2	ISO 17025	0.2	< 0.2	0.4	0.2	3.6
Copper (dissolved)	µg/l	0.5	ISO 17025	11	11	8.7	18	17
Lead (dissolved)	µg/l	0.2	ISO 17025	0.4	0.7	0.5	3.3	1.0
Mercury (dissolved)	µg/l	0.05	ISO 17025	0.08	1.35	0.38	0.87	0.35
Nickel (dissolved)	µg/l	0.5	ISO 17025	1.6	7.7	3.0	10	7.5
Selenium (dissolved)	µg/l	0.6	ISO 17025	2.6	21	91	46	27
Zinc (dissolved)	µg/l	0.5	ISO 17025	9.1	8.9	25	7.6	7.8
Magnesium (dissolved)	mg/l	0.002	ISO 17025	96	530	110	280	60

Analytical Report Number: 15-67733

Project / Site name: St Andrews Park, Uxbridge

Your Order No: 20317

Lab Sample Number				421380	421381	421382	421383	421384
Sample Reference				CP802A	CP804	CP807	WS801	WS806
Sample Number				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Depth (m)				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Date Sampled				25/02/2015	25/02/2015	25/02/2015	25/02/2015	25/02/2015
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Water Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Monoaromatics								
Benzene	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Toluene	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethylbenzene	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
p & m-xylene	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-xylene	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
MTBE (Methyl Tertiary Butyl Ether)	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Petroleum Hydrocarbons								
TPH-CWG - Aliphatic >C5 - C6	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aliphatic >C6 - C8	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aliphatic >C8 - C10	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aliphatic >C10 - C12	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aliphatic >C12 - C16	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aliphatic >C16 - C21	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aliphatic >C21 - C35	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aliphatic (C5 - C35)	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aromatic >C5 - C7	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aromatic >C7 - C8	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aromatic >C8 - C10	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aromatic >C10 - C12	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aromatic >C12 - C16	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aromatic >C16 - C21	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aromatic >C21 - C35	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aromatic (C5 - C35)	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10

U/S = Unsuitable Sample   I/S = Insufficient Sample

Analytical Report Number: 15-67733

Project / Site name: St Andrews Park, Uxbridge

Your Order No: 20317

Lab Sample Number				421385				
Sample Reference				WS808				
Sample Number				None Supplied				
Depth (m)				None Supplied				
Date Sampled				25/02/2015				
Time Taken				None Supplied				
Analytical Parameter (Water Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
General Inorganics								
pH	pH Units	N/A	ISO 17025	7.4				
Free Cyanide	µg/l	10	ISO 17025	< 10				
Sulphate as SO_4	µg/l	45	ISO 17025	97900				
Chloride	mg/l	0.15	ISO 17025	130				
Ammoniacal Nitrogen as N	µg/l	15	ISO 17025	210				
Total Organic Carbon (TOC)	mg/l	0.1	ISO 17025	9.12				
Nitrate as N	mg/l	0.25	ISO 17025	< 0.3				
Nitrate as NO_3	mg/l	1.1	ISO 17025	< 1.1				
Chemical Oxygen Demand (Total)	mg/l	2	ISO 17025	220				
BOD (Biochemical Oxygen Demand)	mg/l	1	ISO 17025	< 1.0				
Total Phenols								
Total Phenols (monohydric)	µg/l	10	ISO 17025	< 10				
Speciated PAHs								
Naphthalene	µg/l	0.01	ISO 17025	< 0.01				
Acenaphthylene	µg/l	0.01	ISO 17025	< 0.01				
Acenaphthene	µg/l	0.01	ISO 17025	< 0.01				
Fluorene	µg/l	0.01	ISO 17025	< 0.01				
Phenanthrene	µg/l	0.01	ISO 17025	< 0.01				
Anthracene	µg/l	0.01	ISO 17025	< 0.01				
Fluoranthene	µg/l	0.01	ISO 17025	< 0.01				
Pyrene	µg/l	0.01	ISO 17025	< 0.01				
Benzo(a)anthracene	µg/l	0.01	ISO 17025	< 0.01				
Chrysene	µg/l	0.01	ISO 17025	< 0.01				
Benzo(b)fluoranthene	µg/l	0.01	ISO 17025	< 0.01				
Benzo(k)fluoranthene	µg/l	0.01	ISO 17025	< 0.01				
Benzo(a)pyrene	µg/l	0.01	ISO 17025	< 0.01				
Indeno(1,2,3-cd)pyrene	µg/l	0.01	ISO 17025	< 0.01				
Dibenz(a,h)anthracene	µg/l	0.01	ISO 17025	< 0.01				
Benzo(ghi)perylene	µg/l	0.01	ISO 17025	< 0.01				
Total PAH								
Total EPA-16 PAHs	µg/l	0.2	ISO 17025	< 0.20				
Heavy Metals / Metalloids								
Arsenic (dissolved)	µg/l	0.15	ISO 17025	1.06				
Boron (dissolved)	µg/l	10	ISO 17025	210				
Cadmium (dissolved)	µg/l	0.02	ISO 17025	0.09				
Chromium (hexavalent)	µg/l	5	ISO 17025	< 5.0				
Chromium (dissolved)	µg/l	0.2	ISO 17025	0.3				
Copper (dissolved)	µg/l	0.5	ISO 17025	13				
Lead (dissolved)	µg/l	0.2	ISO 17025	0.3				
Mercury (dissolved)	µg/l	0.05	ISO 17025	0.27				
Nickel (dissolved)	µg/l	0.5	ISO 17025	5.8				
Selenium (dissolved)	µg/l	0.6	ISO 17025	3.4				
Zinc (dissolved)	µg/l	0.5	ISO 17025	130				
Magnesium (dissolved)	mg/l	0.002	ISO 17025	38				

Analytical Report Number: 15-67733

Project / Site name: St Andrews Park, Uxbridge

Your Order No: 20317

Lab Sample Number				421385				
Sample Reference				WS808				
Sample Number				None Supplied				
Depth (m)				None Supplied				
Date Sampled				25/02/2015				
Time Taken				None Supplied				
Analytical Parameter (Water Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Monoaromatics								
Benzene	µg/l	1	ISO 17025	< 1.0				
Toluene	µg/l	1	ISO 17025	< 1.0				
Ethylbenzene	µg/l	1	ISO 17025	< 1.0				
p & m-xylene	µg/l	1	ISO 17025	< 1.0				
o-xylene	µg/l	1	ISO 17025	< 1.0				
MTBE (Methyl Tertiary Butyl Ether)	µg/l	1	ISO 17025	< 1.0				
Petroleum Hydrocarbons								
TPH-CWG - Aliphatic >C5 - C6	µg/l	10	NONE	< 10				
TPH-CWG - Aliphatic >C6 - C8	µg/l	10	NONE	< 10				
TPH-CWG - Aliphatic >C8 - C10	µg/l	10	NONE	< 10				
TPH-CWG - Aliphatic >C10 - C12	µg/l	10	NONE	< 10				
TPH-CWG - Aliphatic >C12 - C16	µg/l	10	NONE	< 10				
TPH-CWG - Aliphatic >C16 - C21	µg/l	10	NONE	< 10				
TPH-CWG - Aliphatic >C21 - C35	µg/l	10	NONE	< 10				
TPH-CWG - Aliphatic (C5 - C35)	µg/l	10	NONE	< 10				
TPH-CWG - Aromatic >C5 - C7	µg/l	10	NONE	< 10				
TPH-CWG - Aromatic >C7 - C8	µg/l	10	NONE	< 10				
TPH-CWG - Aromatic >C8 - C10	µg/l	10	NONE	< 10				
TPH-CWG - Aromatic >C10 - C12	µg/l	10	NONE	< 10				
TPH-CWG - Aromatic >C12 - C16	µg/l	10	NONE	< 10				
TPH-CWG - Aromatic >C16 - C21	µg/l	10	NONE	< 10				
TPH-CWG - Aromatic >C21 - C35	µg/l	10	NONE	< 10				
TPH-CWG - Aromatic (C5 - C35)	µg/l	10	NONE	< 10				

U/S = Unsuitable Sample   I/S = Insufficient Sample

Analytical Report Number : 15-67733

Project / Site name: St Andrews Park, Uxbridge

Water matrix abbreviations: Surface Water (SW) Potable Water (PW) Ground Water (GW)

Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
Ammoniacal Nitrogen as N in water	Determination of Ammonium/Ammonia/Ammoniacal Nitrogen by the colorimetric salicylate/nitroprusside method. Accredited matrices SW, GW, PW.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton	L082-PL	W	ISO 17025
Biological oxygen demand of water	Determination of biochemical oxygen demand in water (5 days). Accredited matrices: SW, PW, GW.	In-house method based on standard method 5210B. Samples received > 24 hrs after sampling, data may not be valid and should be interpreted with care.	L086-PL	W	ISO 17025
Boron in water	Determination of boron by acidification followed by ICP-MS. Accredited matrices: SW, GW.	In-house method based on USEPA Method 6020 & 200.8 "for the determination of trace elements in water by ICP-MS.	L012-PL	W	ISO 17025
BTEX and MTBE in water	Determination of BTEX and MTBE in water by headspace GC-MS. Accredited matrices: SW PW GW	In-house method based on USEPA8260	L073W-PL	W	ISO 17025
Chemical Oxygen Demand in Water (Total)	Determination of total COD in water by oxidation with acidified potassium dichromate at 150¦C.Reduced chromate ions assayed colorimetrically. Accredited matrices: Accredited matrices: SW, PW, GW.	HACH DR/890 Colorimeter Procedures Manual (48470-22) (Ref 0170.2)	L065-PL	W	ISO 17025
Chloride in water	Determination of Chloride in water by Gallery Discrete Analyser based on reaction with mercury (II) thiocyanate and acid solution with iron (III) nitrate to form a red/brown iron (III) thiocyanate complex; followed by spectrophotometrice measurementat a wavelenght of 480 nm.	Methods for the Examination of Water and Associated Materials Chloride in Waters, Sewage and Effluents 1981.ISBN 0117516260 Accredited matrices: SW, PW, GW.	L082 B	W	ISO 17025
Free cyanide in water	Determination of free cyanide by distillation followed by colorimetry.	In-house method	L080-PL	W	ISO 17025
Hexavalent chromium in water	Determination of hexavalent chromium in water by acidification, addition of 1,5 diphenylcarbazide followed by colorimetry.	In-house method by continuous flow analyser. Accredited Matrices SW, GW, PW.	L080-PL	W	ISO 17025
Metals in water by ICP-MS (dissolved)	Determination of metals in water by acidification followed by ICP-MS. Accredited Matrices: SW, GW, PW except B=SW,GW, Hg=SW,PW, Al=SW,PW.	In-house method based on USEPA Method 6020 & 200.8 "for the determination of trace elements in water by ICP-MS.	L012-PL	W	ISO 17025
Monohydric phenols in water	Determination of phenols in water by continuous flow analyser. Accredited matrices: SW PW GW	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton (skalar)	L080-PL	W	ISO 17025
Nitrate in water	Determination of nitrate in water by colorimetric assay. Accredited matrices SW, GW, PW.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton	L078-PL	W	ISO 17025
pH in water	Determination of pH in water by electrometric measurement. Accredited matrices: SW PW GW	In-house method based on BS1377 Part 3, 1990, Chemical and Electrochemical Tests	L005-PL	W	ISO 17025
Speciated EPA-16 PAHs in water	Determination of PAH compounds in water by extraction in dichloromethane followed by GC-MS with the use of surrogate and internal standards. Accredited matrices: SW PW GW	In-house method based on USEPA 8270	L070-UK	W	ISO 17025
Sulphate in water	Determination of sulphate in water by acidification followed by ICP-OES. Accredited matrices: SW PW GW	In-house method based on MEWAM 2006 Methods for the Determination of Metals in Soil.	L039-PL	W	ISO 17025
Total organic carbon in water	Determination of total organic carbon in water by the measurement on a non-dispersive infrared analyser of carbon dioxide released by acidification. Determination of nitrite in water by addition of sulphanilamide and NED followed by colorimetry.Accredited matrices SW, GW, PW.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton	L037-PL	W	ISO 17025
TPHCWG (Waters)	Determination of dichloromethane extractable hydrocarbons in water by GC-MS, speciation by interpretation.	In-house method	L070-UK	W	NONE

Analytical Report Number : 15-67733

Project / Site name: St Andrews Park, Uxbridge

Water matrix abbreviations: Surface Water (SW) Potable Water (PW) Ground Water (GW)

Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status

For method numbers ending in 'UK' analysis have been carried out in our laboratory in the United Kingdom.
For method numbers ending in 'PL' analysis have been carried out in our laboratory in Poland.
Soil analytical results are expressed on a dry weight basis. Where analysis is carried out on as-received the results obtained are multiplied by a moisture correction factor that is determined gravimetrically using the moisture content which is carried out at a maximum of 30oC.

APPENDIX 5

GAS AND GROUNDWATER

GAS AND GROUNDWATER MONITORING RESULTS

IAN FARMER ASSOCIATES
Geotechnical & Environmental Specialists

Contract Name :	**St Andrews Park**
Contract No :	**21311**
Date :	**12/11/2014**

Background Readings:							
O_2% v/v :	20.9	CO_2% v/v :	0.1	CH_4% v/v :	0.0	**Weather Conditions :**	Overcast
H_2S ppm :	0	CO ppm :	0	Pressure Trend :	997	**Ground Conditions :**	Wet

Location	Time	Atmospheric Pressure (mb)	O_2(% v/v)		CO_2 (% v/v)		CH_4 (% v/v)		H_2S (ppm)	CO (ppm)	Gas Flow Rate (l/hr)		Height Above Ground	Water Depth	Total Depth from top of pipe	Total Depth
			Low	Steady	High	Steady	High	Steady	Peak	Peak	Peak	Steady	(mbgl)	(mbgl)	(m)	(mbgl)
CP801	10:40	996	18.4	18.4	1.5	1.5	0.0	0.0	0	0	0.1	0.0	2.10	4.70	19.72	17.62
CP803	11:29	996	17.8	17.8	2.5	2.5	0.0	0.0	0	0	0.0	0.0	0.86	4.97	8.46	7.60
CP805	11:54	996	17.4	17.4	1.3	1.3	0.0	0.0	0	0	0.0	0.0	0.89	6.50	20.62	19.73
CP806	12:24	997	19.8	19.8	0.1	0.1	0.0	0.0	0	0	-3.5	0.0	1.58	6.73	17.82	16.24
WS802	10:57	996	20.8	20.8	0.2	0.2	0.0	0.0	0	0	3.6	0.0	1.05	0.81	2.94	1.89
WS804	11:06	996	14.1	14.1	2.4	2.4	0.0	0.0	0	0	0.0	0.0	1.09	2.73	3.9	2.81
WS805	10:25	996	19.4	19.4	1.4	1.4	0.0	0.0	0	0	0.0	0.0	1.07	1.48	4.89	3.82
WS807	11:20	996	20.4	20.4	1.9	1.9	0.0	0.0	0	0	0.0	0.0	0.51	0.91	4.44	3.93
WS810	11:42	996	13.5	13.5	1.9	1.9	0.0	0.0	0	0	0.0	0.0	1.40	0.71	2.6	1.20
WS811	12:05	997	2.0	2.0	0.0	0.0	0.0	0.0	0	0	-0.2	0.0	0.98	1.64	2.93	1.95
WS812	12:14	997	15.7	15.7	0.3	0.3	0.0	0.0	0	0	0.0	0.0	2.34	1.33	3.94	1.60
WS814	14:03	998	17.2	17.2	0.0	0.0	0.0	0.0	0	0	-0.2	0.0	1.24	0.92	2.57	1.33
WS903	0.43	997	18.4	18.4	0.0	0.0	0.1	0.1	0	0	0.3	0.0	1.23	1.62	4.88	3.65
WS904	09:53	997	3.9	3.9	0.0	0.0	0.1	0.1	0	0	0.3	0.0	0.62	0.94	2.8	2.18

Remarks : CP801 and WS812 - Reduced height of pipe above ground for subsequent monitoring.

IAN FARMER ASSOCIATES
Geotechnical & Environmental Specialists

GAS AND GROUNDWATER MONITORING RESULTS

Contract Name :	**St Andrews Park**
Contract No :	**21311**
Date :	**20/11/2014**

Background Readings:							
O_2% v/v :	20.1	CO_2% v/v :	0.0	CH_4% v/v :	0.0	**Weather Conditions :**	Dry, 10°C, 50% cloud, sunny, no wind.
H_2S ppm :	0	CO ppm :	0	Pressure Trend :		**Ground Conditions :**	Wet

Location	Time	Atmospheric Pressure (mb)	O_2(% v/v)		CO_2 (% v/v)		CH_4 (% v/v)		H_2S (ppm)	CO (ppm)	Gas Flow Rate (l/hr)		Height Above Ground	Water Depth	Depth to DNAPL	Total Depth
			Low	Steady	High	Steady	High	Steady	Peak	Peak	Peak	Steady	(mbgl)	(mbgl)	(mbgl)	(mbgl)
CP801	03:30	1019	16.7	16.7	2.0	2.0	0.0	0.0	0	0	0.3	0.1	2.10	3.60		17.51
CP803	02:20	1018	16.4	16.4	2.1	2.1	0.0	0.0	0	0	0.0	0.0	0.86	2.70		7.59
CP805	12:50	1018	13.7	13.7	2.1	2.1	0.0	0.0	0	0	0.0	0.0	0.89	5.21		20.04
CP806	11:20	1020	17.7	17.7	0.1	0.1	0.0	0.0	0	0	0.0	0.0	1.58	6.90		17.82
WS802	03:56	1018	19.7	19.7	0.5	0.5	0.0	0.0	0	0	0.3	0.1	1.05	0.78		1.80
WS804	04:05	1019	19.6	19.6	0.4	0.4	0.0	0.0	0	0	0.0	0.0	1.09	2.71		2.71
WS805	11:00	1021	18.3	18.3	1.3	1.3	0.0	0.0	0	0	0.0	0.0	1.07	1.31		4.89
WS807	03:00	1019	19.1	19.1	2.8	2.8	0.0	0.0	0	0	0.0	0.0	0.51	0.44		3.88
WS810	01:40	1018	12.4	12.4	2.0	2.0	0.0	0.0	0	0	0.0	0.0	1.40	0.64		1.16
WS811	12:45	1018	2.4	2.4	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.98	1.65		1.93
WS812	12:40	1020	14.4	14.4	0.2	0.2	0.0	0.0	0	0	0.0	0.0	2.34	1.39		3.94
WS814	COULDN'T GAIN ACCESS															
WS903	09:45	1024	19.8	19.8	0.0	0.0	0.0	0.0	0	0	0.6	0.1	1.23	0.51		4.88
WS904	10:30	1024	20.2	20.2	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.62	0.87		2.80

Remarks :

IAN FARMER ASSOCIATES
Geotechnical & Environmental Specialists

GAS AND GROUNDWATER MONITORING RESULTS

Contract Name :	**St Andrews Park**
Contract No :	**21311**
Date :	**02/12/2015**

Background Readings:							
O_2% v/v :	21.0	CO_2% v/v :	0.0	CH_4% v/v :	0.1	**Weather Conditions :**	Raining
H_2S ppm :	0	CO ppm :	0	Pressure Trend :		**Ground Conditions :**	Wet

Location	Time	Atmospheric Pressure (mb)	O_2(% v/v)		CO_2 (% v/v)		CH_4 (% v/v)		H_2S (ppm)	CO (ppm)	Gas Flow Rate (l/hr)		Height Above Ground	Water Depth	Total Depth from top of pipe	Total Depth
			Low	Steady	High	Steady	High	Steady	Peak	Peak	Peak	Steady	(mbgl)	(mbgl)	(m)	(mbgl)
CP801	13:43	1020	18.4	18.4	2.4	2.4	0.1	0.1	0	0	-0.3	0.0	2.10	3.28	19.68	17.58
CP803	11:41	1019	18.8	18.8	2.5	2.5	0.1	0.1	0	0	4.1	0.0	0.86	3.19	8.44	7.58
CP805	11:49	1019	15.4	15.4	4.0	4.0	0.1	0.1	0	0	-1.7	0.0	0.89	5.71	20.55	19.66
CP806	12:17	1019	18.6	18.6	0.1	0.1	0.1	0.1	0	0	-0.5	0.0	1.58	6.94	18.7	17.12
WS802	13:37	1020	16.3	16.3	3.2	3.2	0.1	0.1	0	0	-4.7	0.0	1.05	1.30	2.93	1.88
WS804	13:30	1020	6.7	6.7	5.5	5.5	0.1	0.1	0	0	-1.7	0.0	1.09	2.79	3.9	2.81
WS805	12:27	1020	19.4	19.4	1.4	1.4	0.1	0.1	0	0	0.0	0.0	1.07	1.44	4.88	3.81
WS807	11:33	1019	19.1	19.1	5.8	5.8	0.1	0.1	0	2	-2.9	0.0	0.51	0.70	4.26	3.75
WS810	11:55	1019	16.3	16.3	4.7	4.7	0.1	0.1	0	0	-2.1	0.0	1.40	0.72	2.6	1.20
WS811	12:01	1019	0.7	0.7	0.0	0.0	0.1	0.1	0	0	-0.7	0.0	0.98	1.61	2.92	1.94
WS812	12:10	1019	16.1	16.1	0.2	0.2	0.1	0.1	0	0	0.0	0.0	2.34	0.33	2.92	0.58
WS814	14:50	1020	18.1	18.1	0.0	0.0	0.1	0.1	0	0	-0.7	0.0	1.24	0.85	2.57	1.33
WS903	12.38	1021	20.6	20.6	0.0	0.0	0.0	0.0	0	0	-5.1	0.0	1.23	0.60	4.86	3.63
WS904	12:47	1021	2.7	2.7	0.0	0.0	0.1	0.1	0	0	0.0	0.0	0.62	1.01	3.08	2.46

Remarks :

GAS AND GROUNDWATER MONITORING RESULTS

Contract Name :	**St Andrews Park**
Contract No :	**21311**
Date :	**02/01/2015**

Background Readings:							
O_2% v/v :	20.1	CO_2% v/v :	0.0	CH_4% v/v :	0.0	**Weather Conditions :**	2°c, cloudy, dry
H_2S ppm :	0	CO ppm :	0	Pressure Trend :	SAME	**Ground Conditions :**	Wet/damp

Location	Time	Atmospheric Pressure (mb)	O_2(% v/v)		CO_2 (% v/v)		CH_4 (% v/v)		H_2S (ppm)	CO (ppm)	Gas Flow Rate (l/hr)		Height Above Ground	Water Depth	Total Depth from top of pipe	Total Depth
			Low	Steady	High	Steady	High	Steady	Peak	Peak	Peak	Steady	(mbgl)	(mbgl)	(m)	(mbgl)
CP801	10:50	1026	20.1	20.1	0.1	0.1	0.1	0.1	0	0	0.0	0.0	2.00	3.02	19.70	17.70
CP803	11:30	1026	18.6	18.6	2.8	2.8	0.0	0.0	0	1	0.0	0.0		1.73		7.55
CP805	12:56	1026	10.8	10.8	2.0	2.0	0.0	0.0	0	0	0.0	0.0		6.02		19.75
CP806	01:37	1026	16.8	16.8	0.0	0.0	0.0	0.0	0	0	0.0	0.0		7.01		17.24
WS802	10:40	1026	13.8	13.8	4.3	4.3	0.0	0.0	0	0	0.0	0.0		1.30		1.86
WS804	10:35	1026	21.6	21.6	0.2	0.2	0.0	0.0	0	0	0.0	0.0		2.83		2.83
WS805	10:30	1026	20.4	20.4	1.0	1.0	0.0	0.0	0	0	0.1	0.0		1.55		3.81
WS807	11:20	1026	20.1	20.1	6.1	6.1	0.1	0.1	0	0	0.0	0.0		0.45		3.87
WS810	12:45	1026	13.2	13.2	1.6	1.6	0.0	0.0	0	0	0.0	0.0		0.71		1.19
WS811	01:13	1026	2.6	2.6	0.0	0.0	0.0	0.0	0	0	0.0	0.0		1.54		1.91
WS812	01:24	1026	14.2	14.2	0.2	0.1	0.0	0.0	0	0	0.0	0.0		1.39		1.68
WS814	No access															
WS903	10.00	1026	20.8	20.8	0.1	0.0	0.0	0.0	0	0	-3.3	0.0		0.62		3.52
WS904	10:15	1026	4.4	4.4	0.1	0.1	0.0	0.0	0	0	0.0	0.0		1.31		2.36

Remarks :

GAS AND GROUNDWATER MONITORING RESULTS

IAN FARMER ASSOCIATES
Geotechnical & Environmental Specialists

Contract Name :	**St Andrews Park**
Contract No :	**21311**
Date :	**14/01/2015**

Background Readings:							
O_2% v/v :	21.2	**CO_2% v/v :**	0.1	**CH_4% v/v :**	0.1	**Weather Conditions :**	Dry, sunny, 1°C, 15% cloud
H_2S ppm :	0	**CO ppm :**	0	**Pressure Trend :**	Increasing	**Ground Conditions :**	Wet/damp

Location	Time	Atmospheric Pressure (mb)	O_2(% v/v)		CO_2 (% v/v)		CH_4 (% v/v)		H_2S (ppm)	CO (ppm)	Gas Flow Rate (l/hr)		Height Above Ground	Water Depth (From Top Of Pipe)	Depth to DNAPL	Total Depth
			Low	Steady	High	Steady	High	Steady	Peak	Peak	Peak	Steady	(mbgl)	(mbgl)	(mbgl)	(mbgl)
CP801	11:39	1004	18.2	18.2	2.0	2.0	0.0	0.0	0	0	0.0	0.0		2.12		17.63
CP803	10:11	1004	20.9	20.9	1.6	1.5	0.0	0.0	0	0	0.1	0.0		13.20		7.58
CP805	10:18	1001	19.4	19.4	1.6	1.6	0.0	0.0	0	2	0.0	0.0		6.18		19.71
CP806	10:45	1003	19.7	19.7	0.1	0.1	0.0	0.0	0	0	-0.2	-0.2		6.93		17.06
WS802	11:33	1003	15.7	15.8	4.2	3.8	0.0	0.0	0	0	0.1	0.1		1.35		1.86
WS804	11:29	1004	21.0	21.0	0.5	0.5	0.0	0.0	0	0	0.1	0.0		2.81		2.81
WS805	11:21	1004	21.0	21.0	1.1	1.1	0.0	0.0	0	0	0.0	0.0		1.25		3.80
WS807	10:03	1001	19.5	19.5	5.9	5.9	0.1	0.1	0	0	-0.1	0.0		0.22		3.83
WS810	10:27	1001	15.9	15.9	2.8	2.8	0.0	0.0	0	0	-0.1	0.0		0.54		1.21
WS811	10:31	1001	2.0	2.0	0.1	0.0	0.1	0.1	0	0	0.1	0.0		1.55		1.92
WS812	10:38	1003	18.5	18.5	0.4	0.4	0.0	0.0	0	0	-0.2	0.0		1.37		1.70
WS814	11:50	1004	17.9	17.9	0.0	0.0	0.0	0.0	0	0	-0.1	0.0		2.10		2.55
WS903	11.07	1004	21.6	21.6	0.0	0.0	0.0	0.0	0	1	0.1	0.0		0.45		3.64
WS904	10:57	1003	7.2	7.2	0.3	0.0	0.0	0.0	0	0	0.1	0.0		0.74		2.38

Remarks :

GAS AND GROUNDWATER MONITORING RESULTS

Contract Name :	**St Andrews Park**
Contract No :	**21311**
Date :	**30/01/2015**

Background Readings:							
O_2% v/v :	20.0	CO_2% v/v :	0.0	CH_4% v/v :	0.0	**Weather Conditions :**	Dry, 1°C, Sunny
H_2S ppm :	0	CO ppm :	0	Pressure Trend :		**Ground Conditions :**	Muddy

Location	Time	Atmospheric Pressure (mb)	O_2(% v/v)		CO_2 (% v/v)		CH_4 (% v/v)		H_2S (ppm)	CO (ppm)	Gas Flow Rate (l/hr)		Height Above Ground	Water Depth (From Top Of Pipe)	Depth to DNAPL	Total Depth
			Low	Steady	High	Steady	High	Steady	Peak	Peak	Peak	Steady	(mbgl)	(mbgl)	(mbgl)	(mbgl)
CP801		974	19.4	19.4	0.5	0.5	0.0	0.0	0	0	0.0	0.0		2.02		17.51
CP803		976	19.2	19.2	1.4	1.4	0.0	0.0	0	0	0.0	0.0		1.48		7.58
CP805		974	17.0	17.0	1.5	1.3	0.0	0.0	0	0	0.0	0.0		6.13		17.92
CP806		973	19.2	19.2	1.1	1.0	0.0	0.0	0	0	0.0	0.0		6.90		17.01
WS802		973	14.6	14.6	4.3	4.3	0.0	0.0	0	0	0.1	0.0		1.30		1.83
WS804		973	14.5	14.5	1.9	1.9	0.0	0.0	0	0	0.0	0.0		2.80		2.80
WS805		973	19.2	19.2	1.3	1.3	0.0	0.0	0	0	0.0	0.0		1.56		3.75
WS807		976	17.9	18.3	3.9	3.9	0.0	0.0	0	0	0.0	0.0		0.41		3.90
WS810		974	11.3	11.3	3.7	3.7	0.0	0.0	0	0	-0.1	0.0		0.71		0.80
WS811		974	1.9	2.0	0.0	0.0	0.0	0.0	0.4	0.4	0.0	0.0		1.59		1.94
WS812		974	17.4	17.4	0.4	0.3	0.0	0.0	0	0	0.0	0.0		1.33		1.66
WS814		976	11.2	11.2	0.0	0.0	0.0	0.0	0	0	0	0.0		0.77		0.3
WS903		973	18.6	18.6	0.0	0.0	0.0	0.0	0	0	0.0	0.0		0.61		3.61
WS904		973	13.9	13.9	0.0	0.0	0.0	0.0	0	0	0.0	0.0		1.19		2.34

Remarks :

IAN FARMER ASSOCIATES
Geotechnical & Environmental Specialists

GAS AND GROUNDWATER MONITORING RESULTS

Contract Name :	**St Andrews Park**
Contract No :	**21311**
Date :	**30/01/2015**

Background Readings:							
O_2% v/v :	20.0	**CO_2% v/v :**	0.0	**CH_4% v/v :**	0.0	**Weather Conditions :**	Dry, 1°C, Sunny
H_2S ppm :	0	**CO ppm :**	0	**Pressure Trend :**		**Ground Conditions :**	Muddy

Location	Time	Atmospheric Pressure (mb)	O_2(% v/v)		CO_2 (% v/v)		CH_4 (% v/v)		H_2S (ppm)	CO (ppm)	Gas Flow Rate (l/hr)		Height Above Ground	Water Depth (From Top Of Pipe)	Depth to DNAPL	Total Depth
			Low	Steady	High	Steady	High	Steady	Peak	Peak	Peak	Steady	(mbgl)	(mbgl)	(mbgl)	(mbgl)
CP802A		973	19.8	19.8	0.0	0.0	0.0	0.0	0	0	0.1	0.0		7.21		17.52
CP807		975	14.5	14.5	2.0	2.0	0.0	0.0	0	0	-0.1	0.0		15.77		18.13
CP804		975	19.8	19.8	0.0	0.0	0.0	0.0	0	0	0.1	0.0		8.21		12.02
WS801		975	18.9	18.9	0.8	0.8	0.0	0.0	0	0	0.0	0.0		0.86		2.56
WS806		973	19.6	19.7	0.2	0.0	0.0	0.0	0	0	0.0	0.0		0.81		4.99
WS808		975	19.8	19.8	0.2	0.2	0.0	0.0	0	0	0.0	0.0		0.33		1.22
WS809		973	19.0	19.1	0.0	0.0	0.0	0.0	0	0	2.0	0.0		3.44		4.84

Remarks :

GAS AND GROUNDWATER MONITORING RESULTS

IAN FARMER ASSOCIATES
Geotechnical & Environmental Specialists

Contract Name :	**St Andrews Park**
Contract No :	**21311**
Date :	**10/02/2015**

Background Readings:	**O_2% v/v :**	20.1	**CO_2% v/v :**	0.0	**CH_4% v/v :**	0.0	**Weather Conditions :**	Dry, 100% cloud, 5ºC
	H_2S ppm :	0	**CO ppm :**	0	**Pressure Trend :**	decreasing	**Ground Conditions :**	Damp and muddy

Location	Time	Atmospheric Pressure (mb)	O_2(% v/v)		CO_2 (% v/v)		CH_4 (% v/v)		H_2S (ppm)	CO (ppm)	Gas Flow Rate (l/hr)		Height Above Ground	Water Depth (From ground level)	Depth to DNAPL	Total Depth
			Low	Steady	High	Steady	High	Steady	Peak	Peak	Peak	Steady	(mbgl)	(mbgl)	(mbgl)	(mbgl)
CP802A	9.55	1029	19.8	19.9	0.3	0.3	0.0	0.0	0	0	0.0	0.0		9.13		17.24
CP807	9.15	1030	8.0	8.0	3.5	3.5	1.0	1.0	0	10	0.0	0.0		12.78		18.00
CP804	9.35	1029	7.9	7.9	3.3	3.3	0.0	0.0	0	10	0.1	0.0		6.09		11.96
WS801	9.45	1029	19.4	19.4	0.4	0.4	0.0	0.0	0	0	0.0	0.0		0.82		2.54
WS806	10.05	1028	20.0	20.0	0.2	0.2	0.0	0.0	0	0	0.0	0.0		1.05		3.98
WS808	9.26	1030	19.5	19.5	0.4	0.3	0.0	0.0	0	0	0.6	0.1		0.33		1.22
WS809	10.15	1028	19.6	19.6	0.2	0.2	0.0	0.0	0	0	0.0	0.0		3.27		4.89

Remarks :

GAS AND GROUNDWATER MONITORING RESULTS

Contract Name :	**St Andrews Park**
Contract No :	**21311**
Date :	**25/02/2015**

Background Readings:								
	O_2% v/v :	20.2	**CO_2% v/v :**	0.0	**CH_4% v/v :**	0.0	**Weather Conditions :**	Mild, sunny spells, 10ºC, slight wind.
	H_2S ppm :	0	**CO ppm :**	0	**Pressure Trend :**		**Ground Conditions :**	Damp and muddy

Location	Time	Atmospheric Pressure (mb)	O_2(% v/v)		CO_2 (% v/v)		CH_4 (% v/v)		H_2S (ppm)	CO (ppm)	Gas Flow Rate (l/hr)		Height Above Ground	Water Depth (From ground level)	Depth to DNAPL	Total Depth
			Low	Steady	High	Steady	High	Steady	Peak	Peak	Peak	Steady	(mbgl)	(mbgl)	(mbgl)	(mbgl)
CP802A		1012	20.5	20.5	0.1	0.1	0.0	0.0	0	0	11.6	0.0		8.46		17.37
CP803		1009	18.8	18.8	2.4	2.4	0.0	0.0	0	0	3.7	0.0		1.28		7.65
CP804		1009	15.2	15.2	1.0	1.0	0.0	0.0	0	0	6.5	0.0		5.67		12.20
WS801		1009	20.2	20.2	0.1	0.1	0.0	0.0	0	0	0.0	0.0		0.73		2.58
WS806		1012	17.7	17.7	0.5	0.5	0.0	0.0	0	0	0.0	0.0		0.98		4.00
WS807		1009	19.8	19.8	2.0	2.0	0.0	0.0	0	0	3.7	0.0		0.45		3.96
WS809		1009	20.1	20.1	0.0	0.0	0.0	0.0	0	0	0.0	0.0		DRY/BLOCKED		0.30

Remarks :

GAS AND GROUNDWATER MONITORING RESULTS

IAN FARMER ASSOCIATES
Geotechnical & Environmental Specialists

Contract Name :	**St Andrews Park**
Contract No :	**21311**
Date :	**10/03/2015**

Background Readings:							
O_2% v/v :	20.2	**CO_2% v/v :**	0.0	**CH_4% v/v :**	0.0	**Weather Conditions :**	Mild, sunny spells, 10ºC, slight wind.
H_2S ppm :	0	**CO ppm :**	0	**Pressure Trend :**		**Ground Conditions :**	Dry

Location	**Time**	**Atmospheric Pressure (mb)**	**O_2(% v/v)**		**CO_2 (% v/v)**		**CH_4 (% v/v)**		**H_2S (ppm)**	**CO (ppm)**	**Gas Flow Rate (l/hr)**		**Height Above Ground**	**Water Depth (From ground level)**	**Depth to DNAPL**	**Total Depth**
			Low	**Steady**	**High**	**Steady**	**High**	**Steady**	**Peak**	**Peak**	**Peak**	**Steady**	**(mbgl)**	**(mbgl)**	**(mbgl)**	**(mbgl)**
CP802A		1027	20.1	20.1	0.1	0.1	0.0	0.0	0	0	0.0	0.0	-	9.45	-	17.43
CP803		1024	19.3	19.3	1.9	1.9	0.0	0.0	0	0	3.2	0.0	-	1.54	-	7.59
CP804		1025	13.1	13.1	1.8	1.8	0.0	0.0	0	10	30.6	0.0	-	5.75	-	12.08
WS801		1025	20.2	20.2	0.4	0.4	0.0	0.0	0	0	0.0	0.0	-	0.82	-	2.56
WS806		1027	19.4	19.4	0.4	0.4	0.0	0.0	0	0	0.0	0.0	-	1.16	-	4.03
WS807		1024	19.8	19.8	1.7	1.7	0.0	0.0	0	0	0.0	0.0	-	0.59	-	3.96
WS809		1026	20.2	20.2	0.0	0.0	0.0	0.0	0	0	0.0	0.0	-	DRY/BLOCKED	-	0.30

Remarks :

GAS AND GROUNDWATER MONITORING RESULTS

IAN FARMER ASSOCIATES
Geotechnical & Environmental Specialists

Contract Name :	**St Andrews Park**
Contract No :	**21311**
Date :	**25/03/2015**

Background Readings:							
O_2% v/v :	20.8	**CO_2% v/v :**	0.0	**CH_4% v/v :**	0.0	**Weather Conditions :**	Cold, Sunny Spells, Slight Wind, 8℃
H_2S ppm :	0	**CO ppm :**	0	**Pressure Trend :**	1006	**Ground Conditions :**	Dry

Location	**Time**	**Atmospheric Pressure (mb)**	**O_2(% v/v)**		**CO_2 (% v/v)**		**CH_4 (% v/v)**		**H_2S (ppm)**	**CO (ppm)**	**Gas Flow Rate (l/hr)**		**Height Above Ground**	**Water Depth (From ground level)**	**Depth to DNAPL**	**Total Depth**
			Low	**Steady**	**High**	**Steady**	**High**	**Steady**	**Peak**	**Peak**	**Peak**	**Steady**	**(mbgl)**	**(mbgl)**	**(mbgl)**	**(mbgl)**
CP802A		1006	20.2	20.2	0.2	0.2	0.0	0.0	0	3	0.0	0.0	-	8.70	-	17.31
CP803		1006	20.6	20.6	0.5	0.5	0.0	0.0	0	0	0.0	0.0	-	1.29	-	7.61
CP804		1006	13.6	13.6	1.9	1.9	0.0	0.0	0	14	0.0	0.0	-	5.38	-	12.07
WS801		1006	20.5	20.5	0.4	0.4	0.0	0.0	0	0	0.0	0.0	-	0.71	-	2.55
WS806		1005	20.2	20.2	0.3	0.3	0.0	0.0	0	0	0.0	0.0	-	1.21	-	4.03
WS807		1006	20.4	20.4	1.3	1.3	0.0	0.0	0	0	0.0	0.0	-	0.66	-	3.94
WS809		1005	20.8	20.8	0.0	0.0	0.0	0.0	0	0	0.0	0.0	-	DRY/BLOCKED	-	0.31

Remarks :

IAN FARMER ASSOCIATES
Geotechnical & Environmental Specialists

GAS AND GROUNDWATER MONITORING RESULTS

Contract Name :	**St Andrews Park**
Contract No :	**21311**
Date :	**08/04/2015**

Background Readings:							
O_2% v/v :	20.7	**CO_2% v/v :**	0.1	**CH_4% v/v :**	0.1	**Weather Conditions :**	Fine, dry, 14°C
H_2S ppm :	0	**CO ppm :**	0	**Pressure Trend :**	1021	**Ground Conditions :**	Dry

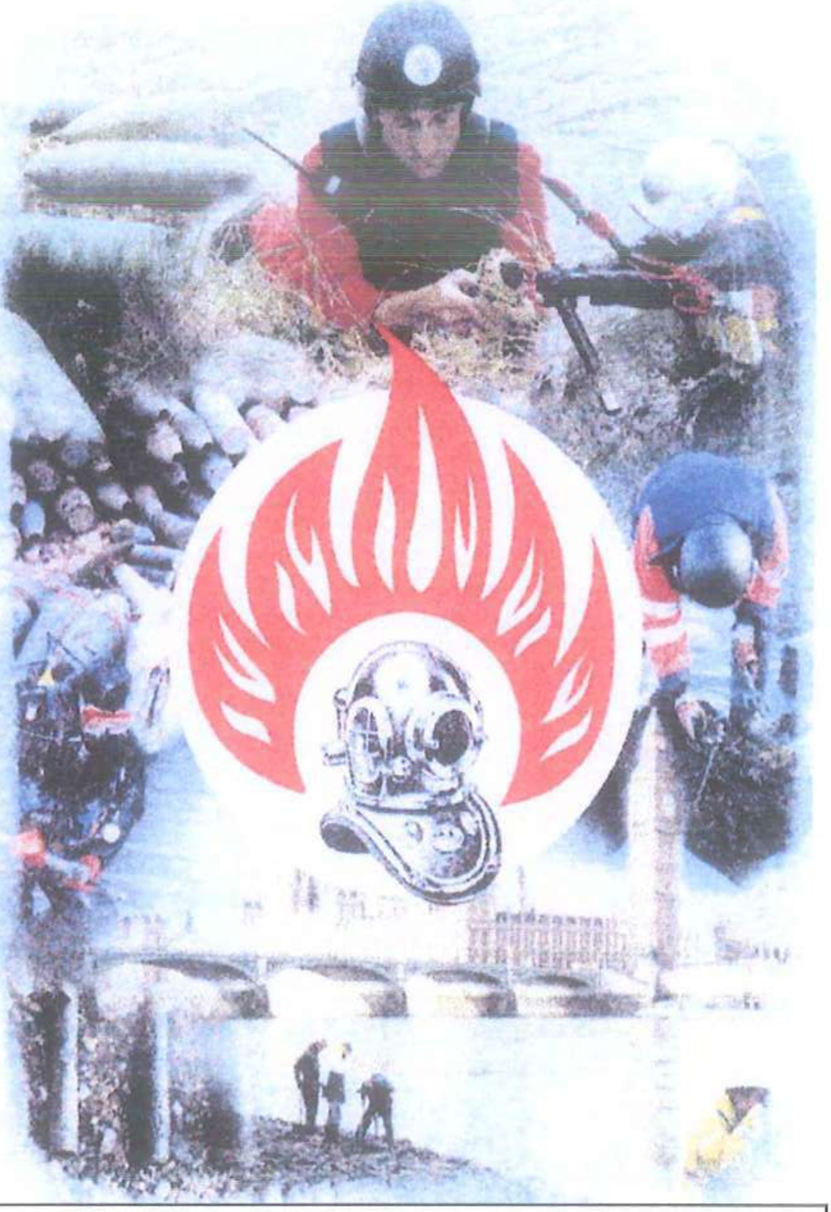
Location	**Time**	**Atmospheric Pressure (mb)**	**O_2(% v/v)**		**CO_2 (% v/v)**		**CH_4 (% v/v)**		**H_2S (ppm)**	**CO (ppm)**	**Gas Flow Rate (l/hr)**		**Height Above Ground**	**Water Depth (From ground level)**	**Depth to DNAPL**	**Total Depth**
			Low	**Steady**	**High**	**Steady**	**High**	**Steady**	**Peak**	**Peak**	**Peak**	**Steady**	**(mbgl)**	**(mbgl)**	**(mbgl)**	**(mbgl)**
CP802A		1029	20.7	20.7	0.1	0.1	0.0	0.0	0	3	0.0	0.0		8.67		17.05
CP807		1029	7.3	7.3	4.1	4.1	22.2	22.2	1	3	0.0	0.0		6.50		18.01
CP804		1029	15.3	15.3	1.3	1.3	0.0	0.0	0	13	0.2	0.1		5.39		12.00
WS801		1029	20.3	20.3	0.2	0.2	0.0	0.0	0	1	0.0	0.0		0.20		2.55
WS806		1029	20.9	20.9	0.1	0.1	0.0	0.0	0	3	0.0	0.0		1.55		4.00
WS808	COULD NOT LOCATE															
WS809		1029	20.1	20.1	0.1	0.1	0.0	0.0	0	0	0.0	0.0		DRY		0.29

Remarks :

APPENDIX 6

MUNITIONS CONTAMINATION

Fellows International Limited
Munitions – Contamination – Remediation



A
Report of Proceedings
On the
Munitions Contamination Survey
Of
Ground Investigation Locations
At
Old RAF Site, Hillingdon Road
Middlesex, UB10 0AE
For
Ian Farmer Associates (1998) Limited

FIL 1.5/1310-15 January 2015

Munitions Contaminations Survey Report

Contents

1. Introduction

Client: Ian Farmer Associates (1998) Limited.

Survey Objectives: To locate, using electromagnetic means, any munitions contamination that could endanger intrusive engineering ground works.

Location & Timing: Old RAF site, Hillingdon Road Uxbridge Middx UB10 0AE (See Daily Work Sheets for details).

Background: The area came under German bombing attack during WW11. No Military record or explosives clearance certificate is available for the site.

Assuming the worst-case scenario it was decided to conduct a munitions contamination survey around the location of the ground investigation works.

2. Equipment Specification

Positioning Equipment: Locations identified by Ross Maguire (Atkins) & Olivia Gatehouse (Ian Farmer).

Metal Locators: Magnex 120LW Metal Detector capable of detecting iron bombs.

3. Method

A single EOD Engineer using an Ebinger Magnex 120LW Magnetometer to identify possible targets surveyed the ground investigation works locations.

See the Daily Work Sheets at Annex B for details.

4. Results

See Daily Work Sheets at Annex B for details.

No evidence of unexploded ordnance was found in the surveyed areas. An Explosives Free Certificate is enclosed at Annex A.

NOTE:
Only the locations of the ground investigation shown on the Work Sheets at Annex B were certified free from explosive hazard. If it is intended to conduct intrusive ground engineering operations outside of these surveyed locations a danger from unexploded ordnance still exists and the site should be surveyed for any munitions contamination before any future ground work starts.

5 **Daily Work Sheet/Trial Pit Log.**

At Annex B.

Munitions Contamination Survey Report

Annex A

Explosives Free Certificate

Fellows International Limited

Unit 4, Ford Lane Business Park, Ford Lane,
Arundel, West Sussex BN18 0UZ
Phone: 01243 551025 Fax: 01243 555740
Email: info@fellowsint.com Web: www.fellowsint.com

EXPLOSIVES FREE CERTIFICATE (LAND).

Site name, location: Old RAF site, Hillingdon Road, Uxbridge, UB10 0AE.
FIL File No. 1.5/1310-15

This is to certify that the area, given below, is 99.5% free from all munitions to a depth of 6 metres or the impenetrable depth of an air dropped weapon within the geophysical layers.

The intrusive ground investigation areas on the site identified by Olivia Gatehouse (Ian Farmer)

Ground sampling positions on the attached Daily Work Sheet.

and/ or the GPS co-ordinates

The locations were marked out by Ross Olivia Gatehouse (Ian Farmer)

The locations cleared have been identified and confirmed to be the same.

Project Engineer Name: K Knipe **Signature:**

Comments relevant to the clearance.
Comments must be signed, and a line ruled beneath the last written line, by the Project Engineer. Use separate sheets of paper if necessary but sign each sheet.

Areas outside of the immediate zone of the ground investigation locations have not been surveyed for munitions contamination and remain a potential hazard from unexploded ordnance. Future intrusive engineering projects should keep this in mind.

Fellows International Limited Authorised Signature and Company Stamp.

Name: Michael G Fellows. MBE. DSC. BEM* .MSM. FIExpE. MWEODF. MSUT.

Signature:

Date: 22nd January 2015

Copy 1 To Client Copy 2 To FIL Site Log Copy 3 To FIL Head Office

ISO 9001 REGISTERED FIRM

Munitions Contamination Survey Report

Annex B

Daily Work Sheet & Log Sheets

Daily Site Record Sheet (FIL)

Sheet Number: 01 **Date: 21/01/2015**

Project & Location	A Munitions Contamination survey of G.I Positions Old RAF site, Hillingdon Road, Uxbridge UB10 0AE	
Client	Ian Farmer Associates	
Weather	Overcast	
Temperature (Centigrade)	Maximum 4	Minimum 1
Time Lost	Nil	
Consultant	Keith Knipe	

Time	Details Of Work In Progress
0730	Arrived on site
0750	Met with Ross Maguire (Atkins) and Olivia Gatehouse (Ian Farmer) Discussed requirements and visited locations
0835	Checked and carried out local calibration checks
0845	Commenced survey of locations
1210	Concluded survey
1220	Discussed survey results with Olivia Gatehouse (Ian Farmer)
1235	Carried out site safety checks and stowed equipment
1240	Departed site

Plant, MT and Boats Used etc Vito Van, Magnex 120LW	**Materials Used** Fuel & Batteries
Site Instructions Issued, & By Who Nil	**Site Personnel**
Equipment Defects, Damage or Loss (Be Sure To Fill In Form FIL S126) Nil	**Accident / Incidents** (Be Sure To Fill In Form FIL S333's) Nil

Team Leader's Name: K Knipe Signature: pp [signature]

Copy 1 To FIL Head Office **Copy 2** To Site Log (to be returned by hand to FIL on completion)

Trial Pits (TP)

TP No.	Cleared Yes/No Date	Search used/Modification	Original Position Moved	Reason for Moving	Location of New Position (from original)	Remarks
TP 914	Yes 21/01/2015	3m x 3m Magnex 120LW	NO	N/A	N/A	Clear
TP 911	Yes 21/01/2015	3m x 3m Magnex 120LW	NO	N/A	N/A	Clear
TP 968	Yes 21/01/2015	3m x 3m Magnex 120LW	NO	N/A	N/A	Clear
TP 910A	Yes 21/01/2015	3m x 3m Magnex 120LW	YES	Obstruction	Move 1M From original	Clear
TP 912	Yes 21/01/2015	3m x 3m Magnex 120LW	NO	N/A	N/A	Clear
TP 907	Yes 21/01/2015	3m x 3m Magnex 120LW	NO	N/A	N/A	Clear
TP 908	Yes 21/01/2015	3m x 3m Magnex 120LW	NO	N/A	N/A	Clear

St Andrew's Park - Phase 6 - Remediation and Reclamation Strategy

VSM Estates (Uxbridge) Limited

June 2015

ATKINS

Plan Design Enable

Notice

This report was produced by Atkins Limited (Atkins) for VSM Estates (Uxbridge) Limited for the specific purpose of presenting the Remediation and Reclamation Strategy in order to discharge planning conditions 72 and 73 for the Phase 6 area which forms part of the St. Andrews Park Development.

This report may not be used by any other person other than VSM Estates (Uxbridge) Limited without VSM Estates (Uxbridge) Limited’s express permission. In any event, Atkins accepts no liability for any costs, liabilities or losses arising as a result of the use of or reliance upon the contents of this report by any person other than VSM Estates (Uxbridge) Limited.

Document history

Job number: 5105977			**Document ref: 5105977/UXB/OUT/0856**			
Revision	Purpose description	Originated	Checked	Reviewed	Authorised	Date
Rev 1.0	For Issue	NT	RM	TA	MR	June 2015

Table of Contents

Tables

1. Introduction

1.1. Brief and Scope of Works

VSM has commissioned Atkins Ltd (Atkins) to prepare a Remediation and Reclamation Strategy to meet the planning requirements for Planning Conditions 72 and 73 of Outline Planning Permission reference 585/APP/2009/2752 relating to Contaminated Land. This has involved the review of existing 3rd party ground investigation data and reports, carrying out supplementary ground investigation to fill data gaps and the preparation of an environmental risk assessment and options appraisal in inform the Remediation and Reclamation Strategy.

VSM has developed a masterplan for the regeneration of the wider former RAF Uxbridge St Andrew's Park site in west London (Drawing No. 5105977/UXB/GE/0069 - Appendix A).

The wider St Andrew's Park development area has been divided into 'Phases'. The site referred to in this report relates to Phase 6; which is located in the north-western corner of the wider St Andrew's Park development. Phase 5 is located to the south and to the north is the St Andrew's Road; a new road allowing access to the new primary school. Hillingdon Road forms the boarder of the site to the west and the District Park defines the boundary to the east of Phase 6. The Phase 6 red line boundary for this report is presented on Drawing No. 5105977/UXB/REM/252 (Appendix A).

The western part of the 'Northern Access' phase falls within the north-western most corner of the site (formerly occupied by the Military Transport area), as illustrated on Drawing No. 5105977/UXB/REM/249 (Appendix A). The Northern Access phase was investigated, assessed and remediated between April and November 2013 (Ref. 28) to satisfy Planning Conditions 72, 73 and 75. Therefore, this report does not deal with human health or controlled water assessment of the north-western part of the site.

Phase 6 generally comprises areas of the site that was formerly occupied by buildings, areas of open space / landscaping, car parking and hardstanding.

The assessment presented within this report is based upon the proposed end uses presented on the masterplan for the site (Drawing No. 5105977/UXB/REM/250 - Appendix A); which is predominantly residential properties without gardens and a commercial area located in the west of the site.

Final site levels have not yet been developed for Phase 6 but it is understood that earthworks are likely to be required and will involve a combination of both cut and fill.

This report has been prepared in line with the National Planning Policy Framework 2012 (Ref. 1) (which has replaced PPS23 (Ref. 2)) that states:

- *the site should be suitable for its new use, taking account of ground conditions and land instability, including from natural hazards or former activities, pollution arising from previous uses;*
- *the development is suitable for its location, i.e. unacceptable risks from pollution and land instability are prevented and that unacceptable risks to human health, buildings and the environment are mitigated and;*
- *where a site is affected by contamination or land stability issues, responsibility for securing a safe development rests with the developer and/or landowner.*

Best practice guidance is given by the Environment Agency and DEFRA in CLR11 *Model Procedures for the Management of Land Contamination* (Ref. 3), which follows the approach outlined in *Guidelines for Environmental Risk Assessment and Management* (Ref. 4). CLR11 (Ref. 3) provides a technical framework for application of a risk management process when dealing with land affected by contamination. The assessment framework and guidance given within these documents have been applied to the development of the remedial options for the St. Andrews Park Phase 6 area of the site.

The future development may need to incorporate ground related issues (e.g. soil borne gas protection measures).

1.2. Project References

This remediation and reclamation strategy has been compiled based upon a review of the following reports:

- Enviros Consulting, September 2005. Defence Estates, Land Quality Assessment, Phase 1: Desk Study, Land Quality Assessment Report Final, Project No. 12694. (Ref. 5)
- Enviros Consulting, September 2005. Defence Estates, Land Quality Assessment, Phase 1: Desk Study, Technical Note Final, Project No. 12694. (Ref. 6)
- Planit, January 2010. Halcrow Group Limited, Explosive Ordnance (EO) Threat Assessment (EOTA), RAF Uxbridge, Middlesex, Doc Ref: 0123 Halcrow EOTA 01. (Ref. 7)
- Ian Farmer Associates Ltd, December 2010. VSM Estates Ltd, MoDEL RAF Uxbridge, Uxbridge, Factual Report on Site Investigation, Project No 20643. (Ref. 8)
- Halcrow Group Ltd, June 2011, VSM Estates, Phase 2 Geo-Environmental Ground Conditions, Project No. PDFMRU-RPT-003 Version: P02 (Ref. 9)
- Atkins Ltd, July 2013. Northern Access Ground Investigation. Reported in Atkins Ltd, September 2013. VSM Estates (Uxbridge) Ltd, St Andrew’s Park, Northern Access Remediation and Reclamation Strategy. 5105977/UXB/OUT/0621 rev.2.0 (Ref. 10)
- Ian Farmer Associates Ltd, April 2015. VSM Estates (Uxbridge) Ltd, St Andrew’s Park Phases 5, 6 & Rifle Range Uxbridge, Final Ground Investigation Report, Contract. 21311 (Ref. 11)

1.3. Limitations

In carrying out the appraisal and preparing this report, Atkins can accept no liability for the accuracy of any data supplied by the Client or from other sources, including previous site investigations; it has been assumed that the information is correct as no attempt has been made to verify this information.

The options appraisal and remediation & reclamation strategy presented in this report has been based on data obtained through a series of site investigations (Section 2.4) and pertinent information has been summarised and are presented within this remediation and reclamation strategy.

The assessments made in this report are based on the ground conditions identified by intrusive investigation, together with the results of any field or laboratory testing, assessment works undertaken by Atkins or third parties and other relevant data which may have been presented in previous reports. It should be noted that ground contamination often exists in discrete areas and there can therefore be no certainty that any or all such areas have been located and/or sampled.

While the report may express an opinion on potential ground conditions between or beyond trial pit or borehole locations, or on the possible presence of features based on visual, verbal or published evidence, this is for guidance only and no liability can be accepted for the accuracy thereof.

Comments on groundwater, ground gas and vapour conditions are based on observations made at the time of the investigation unless otherwise stated. These conditions may vary due to atmospheric, seasonal or other effects.

This report is prepared and written in the context of the agreed scope of work and should not be used in a different context. Furthermore, new information, improved practices and changes in legislation may necessitate a re-interpretation of the report in whole or part after its original submission.

The developer will be required to undertake development specific ground investigation for detailed foundation design, engineering structures and slope stability. Detailed geotechnical design is beyond the scope of this report.

This report has been produced in accordance with guidance currently accepted as best practice/industry standard.

In accordance with Atkins’ procedures and due to insurance purposes, this report does not advise on measures to deal with asbestos. Detailed advice should be sought from a specialist contractor, where necessary.

2. Site Setting

2.1. Site Location and Description

2.1.1. St Andrew's Park – Wider Development

The 'site' is located in the north-western part of the former RAF Uxbridge St Andrew's Park site. The former RAF Uxbridge St Andrew's Park site or 'wider site' is located in the Uxbridge area of the London Borough of Hillingdon in west London and is centred on National Grid Reference (NGR) 506410, 183660. The wider site is irregular in shape and covers an area of approximately 46.6 hectares.

The site location is shown on Drawing No. 5105977/DEMO/001 (Appendix A).

The River Pinn flows southwards through the centre of the wider site, and the land on either side slopes gradually downwards towards the river. The wider site is terraced in areas, most noticeable in the centre of the wider site. The majority of the central area; either sides of the River Pinn are open spaces covered in grass with trees and the remaining areas to the north, east and west have been developed or under construction with estate roads, areas of hardstanding and landscaping.

2.1.2. Phase 6

The Phase 6 area is irregular in shape and covers an area of approximately 4.68ha (11.56acres) and is centred on National Grid Reference (NGR) 506139, 183860. The site is situated immediately to the north of the Phase 5 area and is bordered by Hillingdon Road to the west and St Andrew's Road to the north. The buildings and structures within Phase 6 have been demolished or removed and the site is currently with a mix of loose gravels, demolition rubble with some areas of original hardstanding. The former buildings and structures included accommodation blocks, an officer's mess and tennis courts. Mature trees line the southern and western boundaries of the site and alongside the Gray's Road corridor; which runs north to south through the centre of the site.

Phase 6 is relatively flat, gradually sloping down from north west to south east (approximately 13.5m level drop) towards the River Pinn (situated approximately 120m east of the site). An embankment is present along Gray's Road which drops down approximately 2.0m from the east of the retained Tarmacadam surfaced road.

The Phase 6 area is shown on Drawing No. 5105977/UXB/REM/247 (Appendix A).

2.2. Surrounding Area

The wider site is bordered to the south-west by Hillingdon Road with residential housing and Brunel University beyond. Park Road lies along the wider site's north-western boundary with Uxbridge town centre beyond. The south-eastern and north-eastern boundary of the wider is formed by the River Pinn (which runs through the wider site) and Hillingdon golf course with residential areas beyond. The areas to the east and north are predominantly residential with schools and a recreation grounds to the east.

Uxbridge London Underground station is present approximately 1km north-west of the wider site; a terminus of the Piccadilly and Metropolitan Lines providing direct access to Central London. The A40 is located approximately 1.5km to the north of the wider site.

2.3. Previous Site Uses

A detailed description of the historical development of the wider site is presented within the Enviros Desk Study Report (Ref. 5 and 6) and the Halcrow Report (Ref. 9) and summarised below. It should be noted that there was no historical mapping coverage between 1930 and 1950s. A description of the historical structures recorded on the wider site is summarised on the Atkins Constraints Plan (Drawing No. 5105977-REM-100-001 – Appendix A).

2.3.1. Site History

The historical mapping (Refs. 5 & 6) shows that the site comprised open fields sloping down towards the River Pinn; located off-site to the east. The Phase 6 area remained undeveloped until sometime between 1935 and the 1960s when buildings of the RAF Station were recorded within the site and wider site. By 1999, the buildings in the north-east had been demolished but replaced by structures of a similar size. No other significant changes are recorded in the site (Refs. 5, 6 & 9).

Additional information presented in the Enviros Desk Study and Halcrow Reports (Refs. 5, 6 and 9) shows the buildings within Phase 6 include tennis courts, a Military Transport area in the north and a small church. The Halcrow (Ref. 6) refers to the facilities register which lists two storage tanks within the Military Transport area of the site; one 16,000 litre underground diesel tank (dated 1973) and one 9,000 litre above ground tank (dated 1984). The Military Transport area has been investigated, assessed and was remediated as part of the Northern Access (Ref. 28).

2.3.2. Wider Site History

The earliest published historical map is dated 1881 and shows the majority of the wider site as open fields with the buildings associated with Hillingdon House which is located in the east of the wider site. The River Pinn is shown as flowing southerly through the centre of the wider site.

The earliest recorded RAF buildings developed on the wider site is shown on the 1917 map and these were constructed on farmland and the grounds of Hillingdon House.

The RAF Station is labelled on the 1960 map showing extensive development had taken place with approximately 100 buildings with associated roadways present. Two rifle ranges were labelled on the western side of the River Pinn; towards the centre of the wider site. The width of the river channel running through the base had also decreased by this time.

Between 1964 and 1970 residential housing was constructed to the south-east and east of the wider site. The wider site remained broadly unchanged on the last map dated 1999.

The earlier reports (Refs. 5, 6 & 9) reveals RAF Uxbridge (the wider site) was largely used for accommodation, training and administration. Additional facilities included four rifle ranges, however, the Halcrow Report (Ref. 9) includes a historical plan supplied by the RAF, which reveals several previously unrecorded firing ranges also present in the wider site.

A number of storage tanks are noted on the facilities register (Ref. 9); including three 55,000 litre above ground tanks (dated 1971) located in the central boiler house building 210; one part-buried tank (dated 1939-45) for diesel located next to the standby generator house building 81 (located in the south-east of the wider site area); one 16,000 litre underground tank (dated 1973) in Military Transport area (Section 2.3.1) and one further 9,000 litre above ground tank (dated 1984) also in Military Transport (Section 2.3.1). No explosives, chemicals or gas stores are noted.

An underground bunker is present in the south-east of the wider site and is reported as being constructed in the late 1930s (Refs. 5 and 6).

The Planit report (Ref. 7) reveals the station was bombed in 1940 with a delayed action landmine that was defused, and a bomb that caused damage to the residential quarters.

2.3.3. Off-site History

Historical mapping from the early 1880s shows the site and surrounding area to be largely farmland located within the town of Uxbridge. By 1920, Hillingdon House Farm was shown directly to the north of the wider site and approximately 300m beyond the Metropolitan Railway had developed.

The Ordnance Survey maps dated 1934 shows residential developments to the east; by the 1960s residential development to the west of the wider site had also been developed. This housing has been extended further by 1970. The immediate surroundings areas remained relatively unchanged from the 1970s to recent times.

2.4. Historical Data / Reports

Reference has been made to pertinent information presented within the following reports:

2.4.1. Enviros Consulting, Land Quality Assessment Phase 1: Desk Study Land Quality Assessment Report Final & Technical Note Final – 2005

These reports were prepared by Enviros Consulting (Enviros) (Refs. 5 and 6) for the wider site in 2005.

The Phase 1 Land Quality Assessment (LQA – Ref. 5) presents the factual information and other evidence gathered through desk-based assessment relating to the environmental condition of the wider site.

The purpose of the Enviros LQA (Ref. 5) was to:

- determine the environmental quality of the land at the site;
- review the potential for future ground contamination to occur as a result of demolition of the existing buildings; and
- assess the potential for any health and environmental risks at the site.

The Enviros Technical Note (Ref. 6) presents the results of the environmental risk assessment to identify the options available for addressing land quality issues. Recommendations were made for further work, where required, to manage risks from contamination present at the wider site to the environment and human health.

Specific information presented within the Enviros Desk Study Report (Ref. 5) relating to the Phase 6 site, reveals the site as being located within *"Zone 2": Royal Air Force (RAF) station buildings, facilities* and on *land located in the central-west area*. Facilities within the site included: offices, messes, a Military Transport (MT) section with Petroleum, Oil and Lubricants store (POL) and sports pitches.

2.4.2. Planit, Explosive Ordnance Threat Assessment – 2010

An explosive ordnance threat assessment (Ref. 7) was undertaken in January 2010 by Planit on behalf of Halcrow Group Limited (HGL). The report considers the potential threat from Small Arms Ammunition (SAA), High Explosive (HE) Air-dropped Bombs, and Anti-Aircraft Artillery (AAA) Projectiles; prior to the commencement of the ground investigation in June 2010 (Ref. 8) within the wider site.

The findings of the report indicate that the London Borough of Hillingdon was subject to relatively low levels of aerial bombing during WWII. The wider site itself sat within an area recorded as having been directly damaged by HE bombs during the war but it had not been affected by small incendiary bombs.

Based upon the findings of the assessment undertaken by Planit, it was determined that the wider site lies within an area considered to present a low risk from the threat of unexploded ordnance (UXO) and explosive ordnance (EO). The risk levels associated with EO are in part due to the inherently dangerous nature of EO and the high risk involved in any encounter. However, as a RAF facility of strategic importance, the site would have been subjected to thorough and expert post-raid bomb surveys (Ref. 7).

As the records clearly indicate that bombs fell only in the west side of the facility Planit zoned the site in terms of Ordnance Threat Level. Planit considered there to be an EO risk predominantly in the north-west corner of the wider site; which includes a section of the recently constructed School Site (located north0east of the site).

Based on historical data, no former rifle ranges are recorded within the Phase 6 site.

2.4.3. Ian Farmer Associates, Ground Investigation – 2010

The IFA ground investigation was commissioned by HGL on behalf of VSM Estates. The site investigation and monitoring programme (June to October 2010) was undertaken within the wider site and factual report was prepared (December 2010 – Ref. 8) for the purposes of Halcrow's (Ref. 9) geotechnical design and land contamination assessment.

The work was carried out in two stages within the wider site; the first stage (Phase 1) was conducted between 1 June and 26 June 2010 and second stage (Phase 2) was conducted between 30 September and 8 October 2010.

The following exploratory holes where undertaken within the site; five cable percussion boreholes (BH112, BH114, BH139, BH148 & BH149), eleven window sample boreholes (WS208, WS209, WS269, WS268, WS253, WS287, WS221, WS252, WS251, WS251A & WS302) and two trial pits (TP401 & TP411).

Gas and groundwater monitoring wells were installed in eleven boreholes and were monitored on six occasions following completion of the site work. Groundwater samples were recovered and were tested.

2.4.4. Halcrow Group Limited, Phase 2 Geo-Environmental Ground Conditions – 2011

Halcrow prepared a ground conditions report for the wider site based on the findings of the IFA 2010 site investigation (Ref. 8). The report summarised ground conditions encountered during the investigation to enable foundation and road/hardstanding design and included a contamination risk assessment and a review of ground gas results. The results of the assessment are provided in the Halcrow Report issued in June 2011 (Ref. 9) and key information is summarised below.

The shallow ground materials encountered comprised the following (but not all units were encountered):

- Hard surfacing, topsoil or Made Ground; overlying
- Alluvium (comprising soft silt/clays and loose silt/sands); overlying
- River Terrace Deposits (RTD) and glacial sand and gravel.

The Superficial Deposits are underlain by solid strata of the London Clay Formation and the Lambeth Group Formations.

Groundwater was encountered at depths of 1.2m but was generally greater than 3mbgl within the wider site.

Potential foundation solutions included conventional shallow strips or pads where Made Ground or Alluvium is very thin or absent and imparted loads are only modest. Deep strip foundations, typically up to 2.5m were recommended where deeper Made Ground and/ or Alluvium are present, where groundwater control is easily achievable. Ground improvements (stone or concrete columns and piles) were recommended through the Made Ground and Alluvium to transfer loads to the more competent strata below where higher foundation loads are required, or groundwater control is problematic.

2.4.5. Atkins Ltd, Ground Investigation - 2013

In 2013, Atkins was commissioned by VSM Estates to design and monitor a site investigation (July 2013) to inform the geotechnical design and land contamination assessment for the Northern Access phase.

The western part of the 'Northern Access phase' area falls within the north-western most corner of the site. The works were carried out between 4 July and 8 July 2013 of which the following, nine exploratory holes are present; TP601 to TP604, TP604A and TP605 to TP608.

The results of the site investigation are summarised in the Atkins Report issued in September 2013 (Ref. 10).

2.4.6. Ian Farmer Associates, Final Factual Ground Investigation Report - 2015

A supplementary ground investigation was undertaken by IFA for Atkins, on behalf of VSM Estates Limited. The ground investigation was carried out in two stages; the first stage was conducted between 13th and 24th October 2014 and the second stage was conducted between 19th and 23rd January 2015, as part of a broader ground investigation for the wider site.

2.5. Hydrogeology and Hydrology

The London Clay Formation is classified by the Environment Agency (EA) as Unproductive Strata (formerly a non-aquifer). Unproductive strata include rock layers or drift deposits with low permeability that have 'negligible significance for water supply of river base flow'.

The Superficial Deposits comprising Alluvium, Head Deposits and River Terrace Deposits (Boyn Hill Gravel Member) are classified by the EA as Secondary A Aquifers (Ref. 12). The Lambeth Group underlies the London Clay Formation and is classified as a Secondary A Aquifer. Secondary A Aquifers comprise 'permeable layers capable of supporting water supplies at a local rather than a strategic scale and may form an important base flow to rivers'. These deposits are considered to have a high leaching potential, a worst case assumption as soil information for urban areas is less reliable and based on fewer observations.

A review of the pollution incidents on the EA website (Ref. 12) indicates that significant or major pollution to groundwater has not been recorded within the wider site. The wider site is not located within a groundwater Source Protection Zone and there are no licensed groundwater abstractions located within 500m of the wider site. The wider site is located within a nitrate vulnerable zone (Ref. 12).

The nearest surface watercourse is the River Pinn, which flows southwards through the centre of the wider site. Central parts of the wider site, adjacent to the River Pinn are located within the EA indicative flood plain.

2.6. Radon

The Health Protection Agency's (HPA) UK radon online mapping database (Ref. 13), reveals the site is in an area where less than 1% of homes are above the action level. Therefore no radon protection measures are required in the construction of new dwellings or extensions.

2.7. Preliminary Ground Model

The available ground investigation data identifies the geology of the site as comprising Made Ground overlying River Terrace Deposits, London Clay Formation and the Lambeth Group. Groundwater is generally shallow (within these units) and flows towards the River Pinn.

2.8. Preliminary Conceptual Site Model

Based upon the information contained within the historical reports (Section 2.4) a simplified Preliminary Conceptual Site Model (PCSM) was developed to identify potential sources of contamination, pathways and receptors for the site. The Preliminary Conceptual Model applies a residential end-use with the consumption of home grown produce scenario to the site. This scenario is considered to be the most appropriate model for Phase 6.

The risks to construction workers from short-term exposure to potentially contaminated soil, groundwater or ground borne gas will be mitigated specifically through the requirements of the Control of Substances Hazardous to Health Regulations (COSHH) and application of the CDM Regulations and their associated risk assessments and safe systems of work. The contractor's proposed methods of work will identify the appropriate mitigation measures in accordance with best practice including the hierarchy of control measures such as avoiding, controlling and monitoring the risk and adopting suitable measures such as PPE and good hygiene to deal with residual risks. Consequently, it is not considered appropriate to include construction workers as receptors in the context of the Conceptual Site Model which is concerned with chronic exposures for which mitigation measures may need to be identified.

Significant off-site sources of contamination have not been identified in close proximity to the site.

2.8.1. Sources

The historical reports show that industries have not been recorded within the within, or within close proximity to the Phase 6 site. However, the historical maps and earlier investigations (Refs. 5, 6, 8 and 10) show a number of former buildings/structures and potential sources present within the site. Made Ground (a further source) has also been imported to the site to raise levels during earlier development.

2.8.2. Receptors

The following receptors have been identified:

- River Pinn to the east of the site;
- Secondary ‘A’ aquifer;
- Proposed residential buildings including foundations and services; and
- Future end-users (0-6 year old female child is the primary human health receptor).

2.8.3. Pathways

A number of potential pathways relating to end-use, controlled waters, buildings and services have been identified:

- Dermal contact with soil and dust;
- Ingestion of home grown produce;
- Ingestion and inhalation of soil and soil derived dust;
- Inhalation of outdoor vapours and gases;
- Direct contact (buildings);
- Build-up of soil borne gas;
- Surface water run-off;
- Leaching/migration in the unsaturated zone;
- Migration via impacted groundwater;
- Migration of contamination soil leachate and groundwater along a preferential pathway; and
- Movement along engineering structures (drains, culverts, etc.).

2.8.4. Potential Pollutant Linkages

Potential pollutant linkages were identified between sources of contamination (Section 2.8.1), pathways and receptors and as a result, further supplementary geo-environmental ground investigation was undertaken as detailed in Section 3.

3. Supplementary Ground Investigation

3.1. General

A supplementary ground investigation was undertaken in October 2014 and January 2015. The purpose of the investigation was to confirm and supplement the findings of the earlier investigations in terms of the presence and lateral / vertical extent of the Made Ground, determine ground conditions post demolition works, to characterise the natural geology and to undertake a selected programme of contamination and geotechnical testing.

The design of the investigation accounted for the findings of the historical investigations (Section 2.0). Further development specific ground investigation will need to be undertaken for detailed foundation design.

The ground investigation was carried out in accordance with ‘Site Investigation in Construction, UK Specification for Ground Investigation’ (Ref. 14). An IFA Engineer and an Atkins Engineer attended the site full time to supervise and direct the site operations. A factual report has been prepared by IFA (Ref. 11). The investigation was undertaken in general accordance with BS: 10175 ‘Code of Practice: Investigation of Potentially Contaminated Sites’ (Ref. 15), BS 5930 ‘Code of practice for site investigations’ (Ref. 16) and Eurocode 7 (Ref. 17).

3.2. Scope of Ground Investigation

The following exploratory holes were advanced within the site.

- 27 No. Machine excavated observation or trial pits (TP819, TP820, TP823 to TP844, TP846 to TP848);
- 5 No. cable percussion excavated boreholes (CP803 to CP807);
- 6 No. window sample excavated boreholes (WS807 to WS812);
- 11No. Gas and groundwater monitoring installations.
- In situ Standard Penetration Tests (SPTs);
- Gas and groundwater level monitoring (6 monitoring visits following site works);
- Geotechnical laboratory testing; and
- Chemical testing of soils, leachate and groundwater.

Cable detection searches were carried out and hand-dug inspection pits were excavated at the location of each exploratory hole to check for the presence of services.

The sampling strategy was designed to obtain representative soil samples from each stratum encountered. Representative soil samples were stored in containers under appropriate conditions prior to onward transmission to the laboratory, with chain of custody documentation for environmental samples.

Gas and groundwater monitoring visits were undertaken following the completion of the works and groundwater samples obtained as part of the monitoring exercise were stored in containers under appropriate conditions prior to onward transmission to the laboratory, with chain of custody documentation.

A composite exploratory hole location plan is presented as Drawing No. 5105977/UXB/REM/247 (Appendix A) and the exploratory hole logs are presented within the IFA Factual Report (Ref. 11).

3.3. Instrumentation Details

The follow is a summary of the information obtained from two site investigations; the IFA / Halcrow 2010 Investigation (Ref. 8) and the IFA / Atkins 2015 Investigation (Ref. 11).

A total of twenty three gas and groundwater monitoring standpipes have been constructed. Twelve as part of the 2010 investigation and eleven as part of the 2015 investigation. Construction details are summarised within the table below. The findings of the gas and groundwater monitoring visits are summarised within Section 4.0 and factual results are presented within IFA Reports (Ref. 8 and 11). Borehole locations are presented on Drawing No. 5105977/UXB/REM/247 (Appendix A) and the groundwater and gas monitoring data is presented in the IFA Reports (Ref. 8 and 11).

Table 1. Standpipe Installation Details of Exploratory Holes

Location	Response Zone (mbgl)		Response Zone (mAOD)		Stratum Monitored
	Top	Bottom	Top	Bottom	
2010 Investigation					
BH112B	0.5	1.5	41.01	40.01	Topsoil / London Clay
BH112A	14.0	15.0	27.51	26.51	London Clay
BH114	7.0	19.7	40.16	27.46	London Clay
BH139	0.5	1.3	47.28	46.48	Made Ground / River Terrace Deposits / London Clay
BH149	0.5	1.5	45.64	44.34	Made Ground / London Clay
WS208	1.1	1.9	48.10	47.30	River Terrace Deposits
WS209	1.0	2.9	47.13	45.23	River Terrace Deposits / London Clay
WS221	0.50	1.4	46.76	45.86	Made Ground / River Terrace Deposits
WS251A	3.0	3.4	39.50	39.10	River Terrace Deposits
WS252	0.5	1.55	44.24	43.19	River Terrace Deposits
WS253	1.0	2.8	47.05	45.25	River Terrace Deposits
WS287	0.5	1.4	47.54	46.64	Made Ground / River Terrace Deposits
2015 Investigation					
CP803	2.0	7.5	45.57	47.07	London Clay
CP804	8.0	12.0	39.12	35.12	London Clay
CP805	12.0	20.0	34.24	26.24	London Clay
CP806	15.0	20.0	26.18	21.18	London Clay
CP807	13.0	18.0	32.73	25.73	London Clay
WS807	1.0	5.0	45.67	41.67	London Clay
WS808	0.5	1.2	46.90	46.20	Made Ground
WS809	2.0	5.0	42.23	39.23	London Clay
WS810	0.5	1.2	45.46	44.76	Made Ground / River Terrace Deposits
WS811	1.0	2.0	43.10	42.10	Made Ground
WS812	0.7	1.7	41.56	40.56	Made Ground

3.4. Geotechnical Laboratory Testing

The following summarises the geotechnical laboratory tests undertaken on samples retrieved as part of the three investigations (Refs. 8, 10 and 11):

- 124No. Moisture content determination;
- 81No. Atterberg limit determination;
- 32No. Particle size distribution by wet sieving
- 2No. Particle size distribution by sedimentation;
- 29No. Dry density / moisture content relationship using (using 2.5kg rammer);
- 19No. California bearing ratio on recompacted disturbed sample;

- 50No. Determination of Bulk Density
- 9No. Single stage quick undrained triaxial compression tests
- 11No. Multistage quick undrained triaxial compression tests
- 40No. BRE SD1 suite of analysis;
- 77No. Organic content
- 10No. Oedometer consolidation tests.

The testing was undertaken in accordance with BS1377:1990 (Ref. 18).

3.5. Contamination Testing

The following testing was undertaken as part of the 2015 investigation (Ref. 11).

3.5.1.1. Soil

A total of 48No. (42No. Made Ground and 5No. London Clay) samples were selected for contamination testing and tested in accordance with MCERTS and UKAS requirements. Testing was targeted at areas not previously investigated in the historical reports and areas of contamination historically identified requiring delineation.

Table 2. Soil - List of Determinands

pH (43No.)	Cyanide (45No.)	Water Soluble Sulphate (44No.)
Organic Matter (40No.)	Asbestos (26No.)	Arsenic (48No.)
Cadmium (48No.)	Chromium (Hexavalent) (48No.)	Chromium (48No.)
Copper (48No.)	Lead (48No.)	Mercury (48No.)
Nickel (48No.)	Selenium (48No.)	Zinc (48No.)
Total Petroleum Hydrocarbons – CWG (TPH) (29No.)	USEPA 16 Polycyclic Aromatic Hydrocarbons (PAH) (25No.)	

3.5.1.2. Leachate

A total of 24No. samples of the Made Ground were selected for leachability testing. The samples were tested for the following determinands:

Table 3. Leachate - List of Determinands

Arsenic (24No.)	Boron (16No.)	Cadmium (24No.)
Chromium (Hexavalent) (16No.)	Chromium (24No.)	Copper (24No.)
Lead (24No.)	Mercury (24No.)	Nickel (24No.)
Selenium (24No.)	Zinc (24No.)	

3.5.1.3. Groundwater

Eight groundwater samples were obtained from the 2015 standpipes during the second and third monitoring visits of the 1st and 2nd stages of ground investigation, respectively and tested for the following determinands:

Table 4. Groundwater - List of Determinands

pH	Arsenic Dissolved	Boron Dissolved
Cadmium Dissolved	Chromium, Dissolved	Copper Dissolved
Mercury Dissolved	Nickel Dissolved	Lead Dissolved
Selenium Dissolved	Zinc Dissolved	Chromium Hexavalent
Magnesium	Total Petroleum Hydrocarbons – CWG (TPH)	USEPA 16 Polycyclic Aromatic Hydrocarbons (PAH)
Cyanide	Sulphate as SO4	Chloride

Ammoniacal Nitrogen as N	Dissolved Organic Carbon	Nitrate as N
Chemical Oxygen Demand (Total)	Biochemical Oxygen Demand (BOD)	Nitrate as NO3

3.5.2. 2010 Investigation

3.5.2.1. Soil

7 No. (1No. Topsoil, 5No. Made Ground and 2No. London Clay) samples were tested as part of the historical investigation for the following contaminants:

Table 5. Soil - List of Determinands

pH (5No.)	Asbestos (6No.)	Arsenic (5No.)
Cadmium (5No.)	Chromium (5No.)	Copper (5No.)
Lead (5No.)	Mercury (5No.)	Nickel (5No.)
Selenium (5No.)	Zinc (5No.)	Total Petroleum Hydrocarbons – CWG (TPH) (2No.)
USEPA 16 Polycyclic Aromatic Hydrocarbons (PAH) (3No.)		

3.5.2.2. Leachate

A sample of the Made Ground sample was selected for leachability testing and tested for the following determinands:

Table 6. Leachate - List of Determinands

Arsenic	Boron	Cadmium
Chromium	Copper	Lead
Nickel	Selenium	Zinc

3.5.2.3. Groundwater

No groundwater samples were tested from the Phase 6 area during the 2010 investigation.

4. Ground Conditions

4.1. General

The 2010 investigation confirms the presence of Made Ground and natural ground conditions comprising Superficial River Terrace Deposits of Boyn Hill Gravel Member; the Boyn Hill Gravel Member, is not however shown as being present within the site on the online British Geological Survey map (Ref. 19). The Superficial Deposits are underlain by the London Clay Formation and the Lambeth Group.

The ground conditions encountered are discussed in the following sections and are based upon the available information from both the historical and recent investigations within the site (Refs. 8, 10 and 11).

It should be noted that a number of geological units described as part of the 2010 investigation (Ref. 8) have been reviewed and have been altered following review of the material descriptions, lack of organic material and results of Atterberg limit determinations: i.e. units previously described as Alluvium have been re-classed as River Terrace Deposits.

Exploratory hole locations are shown on Drawing No. 5105977/UXB/REM/247 (Appendix A).

4.2. Available Intrusive Data

The existing ground conditions have been assessed based on a total of 64 exploratory holes, comprising 10 cable percussive boreholes, 47 trial pits and 17 window sample boreholes from the 2010, 2013 and 2015 investigations (Refs. 8, 10 and 11) as summarised in Table 7. The exploratory holes pertinent to the Phase 6 site area are shown on Drawing No. 5105977/UXB/REM/247 (Appendix A).

Table 7. Summary of Exploratory Holes

2015 Investigation	2010 & 2013 Investigations
CP803	BH112
CP804	BH114
CP805	BH139
CP806	BH148
CP807	BH149
TP819	TP401
TP820	TP601
TP823	TP602
TP824	TP603
TP825	TP604
TP826	TP604A
TP827	TP605
TP828	TP606
TP829	TP607
TP830	TP608
TP831	WS208
TP832	WS209
TP833	WS221
TP834	WS251
TP835	WS251A
TP836	WS252
TP837	WS253

2015 Investigation	2010 & 2013 Investigations
TP838	WS268
TP839	WS269
TP840	WS287
TP841	WS302
TP842	
TP843	
TP844	
TP846	
TP847	
TP848	
WS807	
WS808	
WS809	
WS810	
WS811	
WS812	

4.3. Surfacing

Made Ground described as Topsoil is present at 11 of the 64 exploratory hole locations within Phase 6 and ranges in thickness between 0.1m and 0.4m and generally comprises brown slightly silty slightly sandy gravelly clay. Gravel comprise flint with brick fragments and other anthropogenic inclusions. Roots and rootlets were frequently noted. A further four locations have been described as grass overlying Made Ground comprising material of a similar description.

Historical exploratory holes, particularly in the northern section of the site, identified hardstanding surfacing in a number of locations, however this has since been removed during demolition works. Hardstanding has been recorded at 4 locations across the remainder of the site; Tarmacadam at locations TP820 and TP829, and concrete at locations TP824 and TP825.

4.4. Made Ground

Made Ground was recorded within all 64 of the exploratory holes at depths from ground level to between 0.3m and 3.2mbgl.

The Made Ground is both cohesive and granular in nature, described as black grey / grey brown, clayey gravelly sand / sandy gravel and brown / orange brown, silty gravelly sandy clay. The gravel component comprise quartz, flint, brick, concrete, ash, clinker, coal, quartzite, limestone and timber.

The full thickness of the Made Ground was not penetrated in TP840, which terminated at 3.2mbgl due to the presence of a concrete pile of a former building in the centre of the pit.

Visual and olfactory evidence of potential hydrocarbon contamination was noted in the Made Ground within TP601, TP602, TP604 and WS268 between depths of 0.1m to 1.3m bgl. These holes are located in the north-western most corner of the site but was assessed and remediated as part of the North Access site (Ref. 28).

4.5. River Terrace Deposits

River Terrace Deposits have been recorded at 15 locations at depths of between 1.3m and 2.3m (0.3m to 2.0m thick). The base of the deposit was not penetrated in WS810 where the borehole was terminated at 2.5mbgl due to refusal on dense ground.

The deposits are generally firm to stiff / medium dense to dense, orange brown / grey brown / brown, clayey sand and gravel / sandy gravelly clay and gravelly clayey sand. Gravel is flint and quartz with occasional calcareous inclusions

It should be noted that soils that have been described as Alluvium within the 2010 investigation (Ref. 8) have been re-interpreted by Atkins as cohesive bands of the River Terrace Deposits (Boyn Hill Gravel Member). Following comparison of the soil descriptions from the 2015 investigation and review of the 2010 classification results, for the purposes of this assessment, the Alluvium recorded 15 locations (BH148, TP820, TP823, TP825, TP826, TP833, TP834, TP836, TP841, TP848, WS208, WS251A, WS252, WS253 & WS810) has been interpreted as the Boyn Hill Gravel Member..

4.6. London Clay Formation

London Clay was encountered within all but 5 of the 64 exploratory holes which penetrated the Made Ground and Superficial Deposits. It was encountered at depths of between 0.3m and 3.1mbgl and its base was proven within CP806 at 19.5mbgl, overlying the Lambeth Group.

The London Clay is described as soft to very stiff orange brown and blue grey fissured clay and silty clay with occasional rootlet, sub-angular to sub-rounded gravels of flint, sandstone, selenite and calcareous inclusions. Bands of very weak grey mottled yellow siltstone / sandstone were identified at depths between 2.0m and 4.0mbgl.

An upper soft weathered layer was recorded at isolated locations on the site (BH148, BH149, CP807 and TP401). This is reflected within the soil descriptions.

The London Clay was recorded as being friable within BH148, TP401, TP839, TP843 and TP844.

4.7. Lambeth Group

The Lambeth Group was encountered within CP806 underlying and London Clay at 19.5m but was not proven beyond 20.45mbgl.

The Lambeth Group at this location was described as stiff grey silty gravelly very sandy clay with occasional silt and fine sand lenses. Gravel is fine to coarse sub-angular to sub-rounded of green-blue siltstone and purple mudstone.

4.8. Summary of Ground Conditions

Table 8. Summary of Ground Conditions

Strata	Range in Depth to Top where present; mbgl (m AOD)	Range in depth to base where present; mbgl (m AOD)	Range in thickness where penetrated; m
Surfacing / Topsoil	0.00	0.05 – 2.00	0.05 – 2.00
Made Ground	0.00	0.30 – 3.20	0.30 – 3.20
River Terrace Deposits	0.40 – 2.10	1.30 – 3.10	0.30 – 2.00
London Clay Formation	0.30 – 3.10	19.50 - +20.45	+0.30 – 19.00
Lambeth Group	19.50	not proven	+0.95

4.9. Hydrogeology / Hydrology

4.9.1. General

Available EA information and liaison with the EA for other phases of the wider reveals the underlying London Clay Formation is classified as Unproductive Strata.

Secondary A Aquifers are present to areas surrounding the Phase 6 site where Superficial Deposits of Alluvium, Head Deposits, Black Park Gravel Member and Boyn Hill Gravel Member are recorded.

A Principal Aquifer is present to the west of the site where Superficial Deposits of Lynch Hill Gravels were recorded.

The site is not located within a groundwater Source Protection Zone and there are no licensed groundwater abstractions located within 500m of the site.

The nearest surface watercourse is the River Pinn, which flows southwards through the centre of the wider site to the east beyond Phase 6.

Central parts of the wider site adjacent to the River Pinn are located within the Environment Agency indicative floodplain and therefore it is possible that these areas could flood under one in one hundred year conditions.

4.9.2. Groundwater

Groundwater seepages and strikes recorded during the ground investigations are summarised in the table below:

Table 9. Groundwater Strikes / Seepages

Exploratory Hole Number	Groundwater Strikes (m bgl)	Comments	Stratum Encountered
2010 Investigation			
BH112	14.5	Seepage	London Clay
BH148	12.0	Rising to 11.90mbgl after 20 minutes	River Terrace Deposit
WS251A	3.0	Damp	London Clay
WS253	5.0	Water strike	London Clay
WS268	3.2	Water strike	London Clay
2015 Investigation			
TP823	0.5	Seepage	Made Ground
TP833	2.8	Water strike	London Clay
TP836	0.6	Seepage	Made Ground
TP836	2.1	Water strike	River Terrace Deposits
TP837	2.9	Water strike	London Clay
TP840	2.9	Seepage	Made Ground
TP843	2.0	Water strike	London Clay
TP846	0.6	Seepage	Made Ground
TP847	0.6	Seepage	Made Ground
TP848	0.1	Seepage	Made Ground
WS807	2.0	Rising to 0.6mbgl after 20 minutes	London Clay
WS808	0.2	Water strike	Made Ground
WS811	1.0	Water strike	Made Ground

Monitoring of groundwater was undertaken during six visits following 2010 investigation and between 2 and 9 visits following the 2015 ground investigation. The findings are summarised in Table 10 below.

Table 10. Groundwater Monitoring

Borehole	Response Zone		No. of Visits	Groundwater Levels Monitored (mbgl)		Groundwater Levels Monitored (mAOD)		Stratum Monitored
	Top	Base		Range	Avg	Range	Avg	
2010 Investigation								
BH112A	14.0	15.0	6	5.79-5.97	5.87	35.54-35.72	35.64	London Clay
BH114	7.0	19.7	6	5.37-6.44	5.81	40.72-41.79	41.35	London Clay
BH139	0.5	1.3	6	DRY	DRY	DRY	DRY	Made Ground / London Clay
BH149	0.5	1.5	6	DRY	DRY	DRY	DRY	Made Ground / London Clay
WS208	1.1	1.9	6	DRY	DRY	DRY	DRY	River Terrace Deposits
WS209	1.0	2.9	6	0.67-1.25	0.97	46.88-47.46	47.16	London Clay
WS221	0.5	1.4	6	0.5-1.75	1.18	45.51-46.76	46.08	Made Ground / London Clay
WS251A	3.0	3.4	6	2.05-2.25	2.16	40.25-40.45	40.35	River Terrace Deposits
WS252	0.5	1.55	6	0.82-DRY	-	43.78-DRY	-	River Terrace Deposits
WS253	1.0	2.8	6	1.02-1.75	1.25	46.30-47.03	46.80	River Terrace Deposits
WS287	0.5	1.4	6	1.36-DRY	-	46.64-DRY	-	Made Ground / London Clay
2015 Investigation								
CP803	2.0	7.5	9	1.28-4.97	2.38	42.6-46.3	45.1	London Clay
CP804	8.0	12.0	6	5.38-8.21	6.08	38.91-41.74	41.04	London Clay
CP805	12.0	20.0	6	5.21-6.50	5.96	39.74-41.03	40.28	London Clay
CP806	15.0	20.0	6	6.73-7.01	6.90	34.17-34.45	34.28	London Clay / Lambeth Group
CP807	10.0	18.0	3	6.50-15.77	11.68	33.40-49.17	43.33	London Clay
WS807	1.0	5.0	6	0.22-0.91	0.52	45.76-46.45	46.15	London Clay
WS808*	0.5	1.2	2	0.33	0.33	47.07	47.07	Made Ground
WS809*	2.0	5.0	2	3.27-3.44	3.36	40.79-40.96	40.88	London Clay
WS810	0.5	1.2	6	0.54-0.72	0.67	45.24-45.42	45.29	Made Ground / London Clay
WS811	1.0	2.0	6	1.54-1.65	1.60	42.45-42.56	42.50	Made Ground
WS812	0.7	1.7	6	1.33-1.39	1.36	40.87-40.93	40.90	Made Ground

*Monitoring standpipe was destroyed by construction plant following the second visit

Based on the available results, it is considered likely that the groundwater flows within the River Terrace Deposits in an easterly direction towards the River Pinn in the centre of the wider site.

4.10. Soil Borne Gas

The findings of the soil borne gas monitoring are summarised and reported within Table 11:

Table 11. Gas Monitoring Visits

Borehole	No. of Visits	CH_4 (%vol)		CO_2 (%vol)		O_2 (%vol)		Flow Rate (l/hr)	
		Range	Avg	Range	Avg	Range	Avg	Range	Avg
IFA / Halcrow 2010									
BH112A	6	0.0	0.0	0.0-0.1	0.02	19.7-20.8	20.13	0.0	0.0
BH114	6	0.0	0.0	0.0-1.5	0.83	18.1-20.3	19.4	-0.1-0.1	0.0
BH139	6	0.0	0.0	0.5-2.2	1.0	17.9-19.5	19.07	-0.1-0.0	-0.02
BH149	6	0.0	0.0	0.4-1.8	0.8	18.3-19.9	19.22	0.0	0.0
WS208	6	0.0	0.0	1.5-3.3	2.43	16.5-19.0	17.52	0.0	0.0
WS209	5	0.0	0.0	0.1-0.8	0.28	19.2-20.8	20.02	0.0	0.0
WS221	6	0.0	0.0	0.2-0.4	0.3	19.3-20.4	19.73	-0.1-0.0	-0.02
WS251A	6	0.0	0.0	3.6-4.6	4.02	16.6-17.2	16.95	0.0	0.0
WS252	6	0.0	0.0	0.4-0.6	0.55	19.2-20.3	19.68	-0.1-0.1	0.0
WS253	6	0.0	0.0	0.3-1.1	0.65	19.2-20.2	19.68	-1.2-0.1	-0.18
WS287	6	0.0	0.0	0.4-2.1	1.45	18.2-20.3	19.13	-0.1-0.0	-0.02
IFA / Atkins 2015									
CP803	9	0.0-0.1	0.01	0.5-4.0	2.12	15.4-20.9	18.6	0.0	0.0
CP804	6	0.0	0.00	0.0-3.3	1.6	7.9-19.8	14.2	0.0-0.1	0.0
CP805	6	0.0-0.10	0.02	1.3-4.0	2.1	10.8-19.4	15.6	0.0	0.0
CP806	6	0.0-0.1	0.0	0.0-1.0	0.23	16.8-19.8	18.6	-0.2-0.0	-0.03
CP807	4	0.0-22.2	8.6	1.8-4.1	2.9	7.3-17.5	11.8	0.0-0.5	0.1
WS807	6	0.0-0.1	0.05	1.9-6.1	4.4	18.3-20.4	19.4	0.0	0.0
WS808*	2	0.0	0.0	0.2-0.3	0.25	19.5-19.8	19.7	0.0-0.1	0.05
WS809*	2	0.0	0.0	0.0-0.2	0.1	19.0-19.6	19.3	0.0	0.0
WS810	6	0.0-0.1	0.02	1.6-4.7	2.78	11.3-16.3	13.77	0.0	0.0
WS811	6	0.0-0.1	0.03	0.0	0.0	0.7-2.60	1.93	0.0	0.0
WS812	6	0.0-0.1	0.02	0.1-0.4	0.28	14.2-18.5	16.05	0.0	0.0

*Monitoring standpipe was destroyed by construction plant following the second visit

5. Geotechnical Laboratory and Field Test Data

5.1. General

Geotechnical test data is available from the 2010, 2013 and 2015 (Refs. 8, 10 & 11) ground investigation and has been summarised where appropriate within this section.

5.2. Made Ground

Table 12. Made Ground – Geotechnical Testing Summary

	Number of Tests	Values	Average	Assessment (average)
Natural Moisture Content (%)	13	11-47	24	-
Liquid Limit (%)	7	40-74	62	Modified plasticity Index of low to medium volume change potential
Plastic Limit (%)	7	22-41	33	
Plasticity Index (%)	7	18-35	29	
% passing 425 sieve	7	22-100	63	
Modified Plasticity Index (%)	7	6-34	19	
SPT N Values	10	4-26	10	Loose to medium dense (loose) Very soft to stiff (firm)
Hand Vanes (kN/m2) – Field Tested	2	75-103	89	High
Bulk Density (Mg/m^3)	16	1.69 – 2.19	1.95	-
Dry Density (Mg/m^3)	16	1.2 - 1.92	1.57	-

The results of ten SPT tests were carried out within the Made Ground and were consistent with the engineers’ log description.

Twelve particle size distribution tests have been undertaken on samples of the Made Ground. The results show high variability, described as a sand and gravel in six samples and as silt and clays in the remaining six samples.

Eight compaction tests (2.5kg rammer) were carried out on samples of cohesive Made Ground obtained from depths ranging between 0.5m and 1.4mbgl, the results are summarised in the table below:

Table 13. Made Ground - Compaction Testing Results

Parameter	Results							
	CP803 (0.5m)	CP805 (0.5m)	CP806 (0.5m)	TP819 (1.4m)	TP825 (0.7m)	TP837 (1.1m)	TP841 (1.2m)	TP846 (1.4m)
Optimum Moisture Content (%)	17	24	18	13	14	23	16	12
Natural Moisture Content (%)	20	27	22	16	27	26	16	14
Variance between the natural and optimum	3	3	4	3	13	3	0	2

Parameter	Results							
	CP803 (0.5m)	CP805 (0.5m)	CP806 (0.5m)	TP819 (1.4m)	TP825 (0.7m)	TP837 (1.1m)	TP841 (1.2m)	TP846 (1.4m)
moisture contents (%)								
Maximum Dry Density (Mg/m3)	1.69	1.55	1.73	1.84	1.63	1.6	1.72	1.82

Based on the findings of the compaction testing result in the table above, the moisture content is generally wet of the optimum moisture content hence will need to managed and may require localised treatment to reduce the moisture content prior to re-use.

California Bearing Ratio (CBR) testing was undertaken on fourteen samples. The results are summarised in the table below:

Table 14. Made Ground – CBR Testing Results

Borehole	Depth	Description of Sample	Dry Density (Mg/ m^3)	Bulk Density (Mg/ m^3)	Moisture Content Top (%)	Moisture Content Bottom (%)	CBR Top (%)	CBR Bottom (%)
CP803	**0.5**	Gravelly sandy clay	1.65	1.98	20	20	4.1	5.5
CP805	**0.5**	Gravelly sandy clay	1.5	1.9	27	27	3.9	4.8
CP806	**0.5**	Gravelly sandy clay	1.64	2	22	22	1.8	2.2
TP819	**1.4**	Sandy silty clayey gravel	1.75	2.06	18	18	3.2	3.7
TP820	**0.6**	Gravelly sandy silty clay	1.37	1.79	32	29	1.9	1.9
TP825	**0.7**	Sandy silty gravelly clay	1.52	1.95	29	27	0.48	0.52
TP828	**0.5**	Sandy silty clay	1.63	1.98	23	20	2.3	2.2
TP829	**0.6**	Gravelly clayey sandy silt	1.2	1.69	41	40	0.96	1.2
TP830	**0.5**	Sandy gravelly clay	1.42	1.85	29	32	0.69	0.65
TP831	**0.6**	Sandy silty clay	1.67	2.01	20	20	2.9	3.8
TP835	**0.5**	Sandy silty clay	1.66	2	20	21	0.98	0.8
TP838	**0.6**	Sandy silty gravelly clay	1.5	1.94	28	30	2.8	2.3
TP846	**1.4**	Clayey silty sandy gravel	1.92	2.19	14	14	9.5	15
TP848	**0.6**	Gravelly sandy silty clay	1.5	1.92	28	28	3.7	4.3

5.3. River Terrace Deposits

Table 15. River Terrace Deposits – Geotechnical Testing Summary

	Number of Tests	Range	Mean	Assessment (average)
Natural Moisture Content (%)	6	8-20	11	-
Liquid Limit (%)	3	72-77	74	Modified plasticity Index of low to medium volume change potential
Plastic Limit (%)	3	18-37	28	
Plasticity Index (%)	3	37-54	46	
Modified Plasticity Index (%)	3	7-13	10	
% passing 425 sieve	3	13-36	22	
SPT N Values	1	14	14	Medium dense
Hand Vanes (kN/m2) – Field Tested	2	175-200	188	Very high
Bulk Density (Mg/m^3)	1	1.77 – 2.11	1.98	-
Dry Density (Mg/m^3)	1	1.50 – 1.69	1.59	-

One SPT test was carried out within the River Terrace Deposits (BH114 at 1.3m) due to the thickness of this stratum. The result of SPT N was 14 (medium dense).

Five particle size distribution (PSD) tests have been undertaken on granular samples of the River Terrace Deposits recovered from BH114 (1.3mbgl), TP826 (1.7mbgl), TP833 (1.2mbgl), TP834 (1.2mbgl), TP836 (2.5m) and TP848SE (2.2m). The results confirm the River Terrace Deposits is a sandy gravel in BH114, TP826, TP836 and TP848SE and a gravelly sand recorded in TP833. The results of the PSD tests confirm the descriptions on the respective engineer's logs with the exception of BH114 which was originally described as a sandy, gravelly clay. No particle size distribution tests were undertaken on the cohesive River Terrace Deposits.

One compaction test (2.5kg rammer) was carried out on a sample of cohesive River Terrace Deposits from TP833 at 1.2mbgl, the results are summarised in the Table 16 below:

Table 16. River Terrace Deposits - Compaction Testing Results

Parameter	Results
	TP833 (1.2m)
Optimum Moisture Content (%)	16
Natural Moisture Content (%)	20
Variance between the natural and optimum moisture contents (%)	4
Maximum Dry Density (Mg/m3)	1.75

Based on the findings of the compaction testing result in the table above, the moisture content is wet of the optimum moisture content hence may need to managed and may require localised treatment to reduce the moisture content prior to re-use.

5.4. London Clay Formation

Table 17. London Clay Formation – Geotechnical Testing Summary

	Number of Tests	Values	Average	Assessment
Natural Moisture Content (%)	102	5.5-45	27	-
Liquid Limit (%)	68	31-80	67	Modified plasticity Index of low to high volume change potential
Plastic Limit (%)	68	8-39	25	
Plasticity Index (%)	68	12-52	42	
% passing 425 sieve	68	23-100	92	
Modified Plasticity Index (%)	68	9-50	38	
SPT N Values	95	6 - 59	23	Soft to very stiff (stiff)
Hand Vanes (kN/m2) – Field Tested	50	22 - 191	114	Low to very high (high)
Hand Vanes (kN/m2) – Laboratory Tested	15	39 - >212	148	Low to very high (high)
Bulk Density (Mg/m3)	32	1.73 – 2.12	1.99	-
Dry Density (Mg/m3)	32	1.4 – 1.75	1.58	-

*Eight readings of >140 and five readings of >212 have been converted to 140 and 212, respectively, for the purposes of this assessment

Twenty particle size distribution tests have been undertaken on samples of the London Clay recovered from depths of between 1.2m and 19.5mbgl. The results show a slight variability in the London Clay with samples described as slightly gravelly sandy silt clay and slightly gravelly sandy clayey silt.

Nine compaction (2.5kg rammer) tests were carried out on the cohesive London Clay from depths between 1.2m and 4.5mbgl, the results are summarised in Table 18 below:

Table 18. London Clay - Compaction Testing Results

Parameter	Results								
	CP803 (4.5m)	CP805 (4.5m)	CP806 (4.5m)	TP606 (1.2m)	TP824 (1.2m)	TP832 (1.5m)	TP839 (1.2m)	TP843 (2.0m)	TP844 (1.5m)
Optimum Moisture Content (%)	27	26	24	18	11	25	18	21	19
Natural Moisture Content (%)	31	29	30	30	27	25	22	27	22
Variance between the natural and optimum moisture contents (%)	4	3	6	12	16	0	4	6	3
Maximum Dry Density (Mg/m3)	1.5	1.53	1.52	1.67	1.76	1.55	1.71	1.67	1.69

Based on the findings of the compaction testing result in the table above, the moisture content is generally wet of the optimum moisture content hence will need to managed and may require localised treatment to reduce the moisture content prior to re-use.

Nineteen undrained triaxial shear Strength test were undertaken within the London Clay Formation the results for which are summarised below:

Table 19. London Clay Formation – Undrained Triaxial Testing Summary

Borehole	Depth (m)	Undrained Triaxial Shear Strength Cu (Measured Cell Pressure)			Moisture Content (%)	Bulk Density (Mg/m^3)	Dry Density (Mg/m^3)
BH112	1.2	11 (25kPa)	13 (50kPa)	20 (100kPa)	23	2.12	1.73
BH112	13.0	142 (200kPa)			22	2.03	1.66
BH112	15.0	171 (300kPa)			21	2.08	1.72
BH114	6.5	135 (130kPa)			16	2.04	1.75
BH114	10.5	126 (210kPa)			25	2.03	1.62
BH114	15	191 (300kPa)			27	2.05	1.61
BH139	2.0	57 (40kPa)			30	1.97	1.51
BH139	6.0	109 (120kPa)			27	2.03	1.60
BH139	8.0	141 (160kPa)			27	2.08	1.64
BH148	10.0	134 (200kPa)			22	2.08	1.71
CP803	9.5	166 (80kPa)	184 (160kPa)	206 (240kPa)	27	1.98	1.56
CP803	15.5	144 (200kPa)			26	1.97	1.56
CP804	7.5	109 (100kPa)	122 (200kPa)	137 (400kPa)	28	2.01	1.57
CP805	9.5	150 (80kPa)	165 (160kPa)	179 (240kPa)	26	2.02	1.61
CP805	12.5	139 (100kPa)	156 (200kPa)	177 (400kPa)	26	2.00	1.58
CP805	18.5	178 (100kPa)			23	2.04	1.66
CP806	6.5	103 (80kPa)	135 (160kPa)	174 (240kPa)	27	2.01	1.59
CP806	11.0	124 (100kPa)	140 (200kPa)	158 (400kPa)	25	1.98	1.58
CP806	17.0	123 (100kPa)	166 (200kPa)	192 (400kPa)	24	2.06	1.67
CP807	5.0	87 (50kPa)	98 (100kPa)	110 (200kPa)	27	1.9	1.5
CP807	7.5	98 (100kPa)	121 (200kPa)	145 (400kPa)	26	1.97	1.56

California Bearing Ratio (CBR) testing was undertaken on five recompacted samples during the compaction test. The results are summarised in the table below:

Table 20. London Clay Formation - CBR Testing Results

Borehole	Depth	Description of Sample	Dry Density (Mg/ m^3)	Bulk Density (Mg/ m^3)	Moisture Content Top (%)	Moisture Content Bottom (%)	CBR Top (%)	CBR Bottom (%)
CP803	**4.5**	Gravelly sandy clay	1.44	1.89	31	31	3.8	3.6
CP805	**4.5**	Gravelly sandy clay	1.49	1.92	30	29	5.8	6.0
CP806	**4.5**	Gravelly sandy clay	1.47	1.92	30	30	6.7	5.7
TP606	**1.2**	Gravelly sandy silty clay	1.57	2.02	28	29	5.0	5.9
TP824	**1.2**	Gravelly sandy silty clay	1.47	1.91	30	30	3.1	3.5

Nine consolidation tests were undertaken within samples of the London Clay Formation the results for which are summarised below:

Table 21. London Clay Formation - Consolidation Testing Results

Exploratory Hole Location	Depth (m)	Estimated effective overburden pressure (p'₀)	p'₀+100	Void ratio at p'₀ (e₀)	Void ratio at p'₀+100 (e₁)	$m_v = \frac{(e_0-e_1)}{(1+e_0)100}$ (m²/mN)	Compressibility
CP803	9.5	190	290	0.72	0.70	0.09	Low
CP803	15.5	310	410	0.66	0.65	0.08	Low
CP805	9.5	190	290	0.66	0.64	0.10	Medium
CP805	12.5	250	350	0.68	0.66	0.09	Low
CP805	18.5	376	476	0.56	0.54	0.09	Low
CP806	6.5	130	230	0.68	0.65	0.16	Medium
CP806	11.0	220	320	0.64	0.63	0.09	Low
CP806	17.0	340	440	0.56	0.54	0.11	Medium
CP807	5.0	100	200	0.72	0.68	0.23	Medium

The uncorrected coefficient of volume compressibility (mv) for the samples indicate that the London Clay ranges between low and medium compressibility.

5.5. Lambeth Group

Table 22. Lambeth Group – Geotechnical Testing Summary

	Number of Tests	Range	Mean	Assessment (average)
Natural Moisture Content (%)	1	20	20	-
Liquid Limit (%)	1	37	37	Modified plasticity Index of very low volume change potential
Plastic Limit (%)	1	18	18	
Plasticity Index (%)	1	19	19	
Modified Plasticity Index (%)	1	19	19	
% passing 425 sieve	1	100	100	
Hand Vanes (kN/m2) – Laboratory Tested	1	9	9	Extremely low
Bulk Density (Mg/m3)	1	1.91	1.91	-
Dry Density (Mg/m3)	1	1.45	1.45	-

One consolidation test was undertaken within the Lambeth Group the result from which is summarised in the table below:

Table 23. Lambeth Group – Consolidation Testing Results

Borehole	Depth (m)	Estimated effective overburden pressure (p'₀) (kPa)	p'₀+100 (kPa)	Void ratio at p'₀ (e₀)	Void ratio at p'₀+100 (e₁)	$m_v = \frac{(e_0-e_1)}{(1+e_0)100}$ (m²/mN)	Compressibility
CP806	20.0	400	500	0.72	0.68	0.23	Medium

The sample is described as stiff on the engineers exploratory hole log, and the uncorrected coefficient of volume compressibility (mv) indicates the sample if the Lambeth Group is of medium compressibility.

One undrained triaxial shear strength test was undertaken within the Lambeth Group, the results for which are summarised below:

Table 24. Lambeth Group – Undrained Shear Strength Testing Summary

Borehole	Depth (m)	Undrained Triaxial Shear Strength Cu (Measured Cell Pressure)			Moisture Content (%)	Bulk Density (Mg/m^3)	Dry Density (Mg/m^3)
CP806	20.0	7 (100kPa)	11 (200kPa)	17 (400kPa)	32	1.87	1.42

5.6. Sulphate Testing

Soil testing conducted in accordance with BRE Special Digest 1 (Ref. 20) gave the following results.

Table 25. BRE Concrete Classification Testing Results

Strata	Details	Range	Concrete Class
Made Ground	Number of Tests	53	DS3 – AC3
	Water Soluble Sulphate (mg/l)	22 - 3700 (2000)	
	pH	6.3 – 11.3 (9.2)	
River Terrace Deposits	Number of Tests	2	DS1 – AC1
	Water Soluble Sulphate (mg/l)	15 – 72 (100)	
	pH	7.1 - 7.8 (7.4)	
London Clay	Number of Tests	28	DS2 – AC2
	Water Soluble Sulphate (mg/l)	33 – 1500 (900)	
	pH	7.5 – 9.1 (8.5)	
Lambeth Group	Number of Tests	1*	DS2 – AC2
	Water Soluble Sulphate (mg/l)	610	
	pH	8.5	
Groundwater	Number of Tests	8	DS3 – AC3
	Sulphate SO_4 (mg/l)	72 – 2240 (1900)	
	pH	7.0 - 7.9 (7.7)	

* - Data only available for one sample of Lambeth Group within the Phase 6 site, result not considered representative

In accordance with BRE SD1 (Ref. 20), where there are less than 5 tests, the results have been based upon the highest value obtained. Where 5 to 9 samples are tested, the mean of the highest two results has been used. Where 10 or more results are available, the mean of the highest 20% of results (rounded to the nearest 100mg/l) has been used. Results used in the assessment are shown in the brackets.

It should be noted that the groundwater samples were obtained from standpipes with response zones spanning the Made Ground, River Terrace Deposits, London Clay and Lambeth Group.

6. Contamination Assessment

6.1. General

The following preliminary assessment has been based on the proposed redevelopment of the Phase 6 into residential properties (without gardens) and a commercial development in the west as shown on the masterplan (Drawing No. 5105977/UXB/REM/250 - Appendix A). It should be noted that the north-western most corner of the site has been assessed and remediated as part of the Northern Access and has therefore been excluded from this assessment.

6.1.1. Generic Assessment Criteria – Human Health

Detailed guidance on human health risk assessment is available within a number of documents, published by the Environment Agency and DEFRA, which comprise the *Contaminated Land Exposure Assessment (CLEA) Model Procedures for the Management of Contaminated Land* and the National Planning Policy Framework (Refs. 4 and 3).

A Tier 2 generic quantitative risk assessment (GQRA) has been carried out for the potential human health pollutant linkages, based on the screening of soil contamination data against relevant Generic Assessment Criteria (GAC) where these are available, including:

- **Environment Agency Soil Guideline Values** - the Environment Agency has an ongoing programme of publication of GACs for human health known as Soil Guideline Values (SGVs). These are for the CLEA standard land-uses; residential housing with gardens where food may be grown; allotments; and commercial land-uses.
- **Atkins Soil Screening Values** - to supplement the SGVs, Atkins has derived a set of GACs following the CLEA Model guidance that are referred to as Soil Screening Values (SSVs). SSVs are available for the CLEA standard land-uses for a wide range of typical indicator contaminants. SSVs have also been derived for land-uses not given in the CLEA Model, but which have been modelled by Atkins following the methodologies given in the CLEA guidance.

The GAC for a residential without the consumption of home grown produce (based on SGVs and Atkins SSVs which take into specific SGVs) has been used for the majority of the site except for the western part of the site adjacent to Hillingdon Road which is being considered for commercial development; and as such the contamination results have been screened against the GACs for commercial end use.

It should be noted that in some cases the soil analytical results for organics have been compared to Atkins SSVs which are based on the lower of the aqueous or vapour saturation limit, rather than the health-based value modelled using CLEA. The results compared to the lower of the aqueous or vapour saturation limit is based on there being visual / olfactory evidence of contamination or free product.

The average Soil Organic Matter (SOM) for the site is 1.22% however adopting a conservative approach the most current SSVs (dated March 2011) for a SOM of 1% are considered appropriate for use and have been adopted in the assessment.

It should be noted that the GACs are liable to change as new policy and technical guidance, including toxicological data, are published by the Environment Agency and other authoritative sources. Further to this, a Detailed Quantitative Risk Assessment (DQRA) may be required by the developer to review the level of conservatism in the screening values, depending upon the outcome of the generic data screening exercise at detailed design stage.

A revision to the Statutory Guidance of Part 2A of the Environmental Protection Act 1990 was published in April 2012 introducing a new category based system for dealing with risk assessment including the assessment of the 'significant possibility of significant harm' (SPOSH) whereby

Category 1 sites are clearly contaminated and represent a high risk and Category 4 sites are clearly identifiable as low risk and not Contaminated Land.

Category 4 Screening Levels (C4SLs) for six contaminants for a sandy loam soil with 6% SOM were issued by Defra in their Policy Companion Document SP1010 (Ref. 21) in March 2014 to provide an indication of “low risk” (i.e. the site is clearly within Category 4). GAC, such as SGVs / SSVs, are based on “minimal risk”. If concentrations exceed the C4SLs then further assessment is required to confirm whether site is still within Category 4, or should be in Category 1-3. C4SLs were primarily developed by Defra for use in the assessment of Contaminated Land under Part 2A of the Environmental Protection Act 1995, but Defra indicated that the C4SLs could also potentially be used under the planning regime. However, policy responsibility for the National Planning Policy Framework (NPPF) and associated Planning Practice Guidance falls to the Department for Communities and Local Government, who has not yet published any policy guidance to confirm their opinion on this. Thus there is currently uncertainty within the land contamination assessment community as to whether or not C4SLs should be used under the planning regime.

Therefore, for this site the Atkins SSVs/SGVs have been used instead of the C4SLs, with the exception of lead due to the toxicological data that formed the basis of the lead SSVs being withdrawn by Defra as part of their C4SL derivation.

6.1.2. Controlled Waters

The assessment of the chemical data for controlled waters is based on the potential impacts from soil and free phase contaminants (e.g. Made Ground) on surface and groundwater receptors. Potential impacts on groundwater have been assessed by the testing of groundwater samples obtained during the monitoring programme and by reviewing the potential for contaminants in the soil to mobilise and impact on groundwater. The groundwater results and the soil leachable contaminant results were assessed against both the Drinking Water Standard (DWS) (Ref. 22) and Environmental Quality Standard (EQS) within the Environment Agency chemical database (Ref. 23).

6.1.3. Soil Borne Gases

The results of the gas monitoring have been assessed using the classification system contained within CIRIA C665 (Ref. 24) and the NHBC guidance (Ref. 25). The classification systems considers gas concentrations and recorded flow rates for methane and carbon dioxide to determine a gas screening value (GSV). The GSV is calculated by multiplying the maximum recorded flow rate (l/hr) against the maximum recorded gas concentration (%) determining a value reflecting the worst case scenario. The GSV is used in turn to determine a characteristic situation for the site. Depending upon the designation, gas protection measures may be required.

6.2. Soil Contamination Assessment

Table 26 below lists the soil samples tested from Phase 6 during the recent and historical ground investigations. The samples also tested for soil leachability are marked with a (*).

Table 26. Soil Samples Tested for the Presence of Contamination

Exploratory Hole and Depth (m)		Strata
Recent Investigation		
CP803	0.2*	Made Ground
CP803	1.0	London Clay
CP804	0.5	Made Ground
CP804	1.0	Made Ground
CP805	0.3*	Made Ground
CP805	1.0	Made Ground
CP806	1.0*	Made Ground

Exploratory Hole and Depth (m)		Strata
TP819	0.2*	Made Ground
TP819	0.8	Made Ground
TP820	0.3*	Made Ground
TP820	0.5*	Made Ground
TP823	0.6	Made Ground
TP824	0.4	Made Ground
TP825	0.7	Made Ground
TP826	0.7	Made Ground
TP827	0.3	Made Ground
TP828	0.6	Made Ground
TP829	0.4*	Made Ground
TP829	0.6	Made Ground
TP830	0.5*	Made Ground
TP831	0.85*	Made Ground
TP832	0.5	Made Ground
TP833	0.2*	Made Ground
TP834	0.5*	Made Ground
TP835	0.7*	Made Ground
TP835	1.0	London Clay
TP836	0.1	Made Ground
TP837	1.1*	Made Ground
TP837	2.9	London Clay
TP838	0.5*	Made Ground
TP838	2.4	London Clay
TP839	0.5*	Made Ground
TP840	0.5	Made Ground
TP840	1.55	Made Ground
TP841	0.3*	Made Ground
TP841	1.1	Made Ground
TP842	0.7	Made Ground
TP842	1.7	London Clay
TP843	0.5	Made Ground
TP844	0.6*	Made Ground
WS807	0.4*	Made Ground
WS808	0.6*	Made Ground
WS808	1.0*	Made Ground
WS809	0.7*	Made Ground
WS809	1.0	Made Ground
WS810	0.5*	Made Ground
WS811	0.3*	Made Ground
WS812	0.2*	Made Ground
Previous Investigations		
BH112	0.5	London Clay
BH114	0.5*	Made Ground
BH149	0.3	Made Ground
TP401	0.3	Made Ground
WS221	0.5	Made Ground
WS251A	0.5	Made Ground
WS252	0.2	Made Ground

6.3. Risk Assessment

6.3.1. Human Health

A total of 55 soil samples were selected for testing and the majority (49 out of 55) were taken between ground level and 1m below existing ground level. Table 27 presents the exceedances of the generic assessment criteria using Atkins SSVs and available C4SLs for residential end-use without the consumption of home grown produce. The exceedances are summarised in the table below. The samples denoted with (*) are samples taken from area of land which will be the commercial area of Phase 6 and have been assessed further in Table 28.

Table 27. Exceedances of Generic Screening Criteria (residential without the consumption of home grown produce)

	Contaminants	Screening Criteria (mg/kg)	No. of Exceedances	Range of Exceedances	Locations of Exceedances	Strata Exceedances identified
PAHs	Naphthalene	0.598	1	0.77	TP826 0.7m	Made Ground
	Benzo(a)anthracene	5.42	6	5.5-36.0	TP820 0.3m* TP826 0.7m TP833 0.2m TP835 0.7m TP836 0.1m WS251A 0.2m	Made Ground
	Benzo(b)fluoranthene	9.68	5	14-28	TP820 0.3m* TP826 0.7m TP833 0.2m TP835 0.7m WS251A 0.5m	Made Ground
	Benzo(a)pyrene	5.3	5	11-27	TP820 0.3m* TP826 0.7m TP833 0.2m TP835 0.7m WS251A 0.5m	Made Ground
	Indeno(1,2,3-cd)pyrene	9.53	1	11	TP826 0.7m	Made Ground
	Dibenz(a,h)anthracene	0.949	4	1.2-3.0	TP820 0.3m* TP826 0.7m TP833 0.2m WS251A 0.5m	Made Ground
Heavy Metals	Lead	310	2	400-2100	TP820 0.3m* TP829 **0**.4m	Made Ground
	Arsenic	40	1	110	TP820 0.3m*	Made Ground
	Asbestos	N/A	7	-	CP804 0.5m CP805 0.3m TP827 0.3m TP833 0.2m TP840 0.5m WS808 0.6m WS809 0.7m	Made Ground

The laboratory results show elevated concentrations of arsenic, lead, PAHs and the presence of asbestos in 12 locations within the residential areas. The exceedances are all recorded within the Made Ground deposits or at depths of less than or equal to 0.7m bgl.

Reference to the exploratory hole logs suggests the exceedances are associated with anthropogenic inclusions within the Made Ground. The greatest number of exceedances were recorded in TP826 at 0.7mbgl where ash and timber was recorded as present within the Made Ground. Visual or olfactory evidence of contamination was not reported during the investigation or noted by the contractor during the demolition phase.

The above exceedances and samples which detected asbestos are illustrated on Drawing No. 5105977/UXB/REM/251 (Appendix A).

Table 28. Exceedances of Generic Screening Criteria (residential without the consumption of home grown produce) within proposed Commercial land

	Contaminants	Range of Exceedances	Residential without Screening Criteria (mg/kg)	No. of Exceedances	Commercial Screening Criteria (mg/kg)	No. of Exceedances
PAH	Benzo(a)anthracene	17.0	5.42	1 (TP820 – 0.3m)	131	0
	Benzo(b)fluoranthene	21.0	9.68	1 (TP820 – 0.3m)	142	0
	Benzo(a)pyrene	16.0	5.3	1 (TP820 – 0.3m)	76	0
	Dibenz(a,h)anthracene	1.2	0.949	1 (TP820 – 0.3m)	14.3	0
Metals	Lead	2100	310	1 (TP820 – 0.3m)	2330	0
	Arsenic	110	40	1 (TP820 – 0.3m)	640	0

Asbestos was detected within 7 of the 49 Made Ground samples tested within the site. Quantification testing was undertaken on three of the samples. There was insufficient sample to undertake further testing on the remaining four which tested positive.

Table 29. Locations Containing the Presence of Asbestos

Borehole	Depth	Asbestos Identification	Total % of Asbestos in Sample
TP827	0.3	Chrysotile- Loose fibres	-
TP833	0.2	Chrysotile- Loose fibres, Amosite- Insulation lagging	-
TP840	0.5	Chrysotile- Loose fibres	-

Borehole	Depth	Asbestos Identification	Total % of Asbestos in Sample
WS808	0.6	Chrysotile, Crocidolite- Loose fibres	< 0.001
WS809	0.7	Amosite- Insulation lagging	0.006
CP804	0.5	Chrysotile - Loose Fibres	0.006
CP805	0.3	Chrysotile - Loose fibres	-

Further assessment was undertaken by a specialist contractor to VSM; Institute of Occupational Medicine (IOM). The report details the assessment of analysis results in relation to asbestos in Made Ground for the samples taken across the wider site (Ref. 29). A DQRA was undertaken and IOM recommend the following where asbestos is present:

- At levels ≥0.02% within the top 0.5m, the location should undergo further excavation. The arisings should either go for off-site disposal or if there is capability on site for re-use they can be retained beneath a capping layer with a geo-marker at a greater depth
- At levels <0.02% and ≥0.001%, it should be covered with a clean cap (this material should be verified as clean prior to use on site) of a minimum of 0.6m and / or hardstanding and / or buildings. This is particularly important for residential developments.

The location of each excavated area should be recorded and form part of the handover health and safety documentation for the site. A site plan showing all of the sample locations with the analysis (quantification) results along with a description of remediation works would also be beneficial as part of the handover (Ref. 29).

6.3.2. Controlled Waters

6.3.2.1. Soil Leachability Testing Results

When compared to DWS (Ref. 22) and EQS (Ref. 23), the soil leachability test data reveals elevated concentrations of arsenic within 3 of the 25 samples tested. There were no other exceedances recorded. Where available the EQS standards under the Water Framework Directive (WFD) have been adopted.

Table 30. Leachability Testing - Exceedances of DWS

Contaminant	Maximum Conc. Recorded (µg/l)	Number of Exceedances – DWS	Locations of Exceedances	DWS (µg/l)
Arsenic	11	3 of 25	TP835 0.7m TP837 1.1m TP841 0.3m	10

6.3.2.2. Groundwater Testing Results

Eight groundwater samples were recovered from the recent ground investigation and when the results were compared against the DWS (Ref. 22) and EQS (Ref. 23), the following exceedances were reported.

Table 31. Groundwater Testing - Exceedances of EQS / DWS

Contaminant	Maximum Conc. Recorded (µg/l)	Locations of Exceedances	EQS Freshwater (µg/l)	DWS (µg/l)	Number of Exceedances – EQS	Number of Exceedances – DWS
Boron	1300	CP804	2000	1000	0 of 8	1 of 8
Mercury	1.35	CP804	1	1	1 of 8	1 of 8
Nickel	28	CP805	50	20	0 of 8	1 of 8
Selenium	50	CP807	1000	10	0 of 8	4 of 8

6.3.2.3. Controlled Waters Assessment

Three marginal exceedances of arsenic were reported in the leachates. Reference to the exploratory hole logs reveal the exceedances are likely to be associated with anthropogenic inclusions within Made Ground. The Made Ground at these locations and within the site is underlain by River Terrace Deposits and in turn by London Clay. The concentrations of arsenic in the groundwater samples tested are low and the site is underlain by relatively impermeable London Clay. Therefore, based on the relatively low concentrations recorded in leachate, the low concentrations in soil and groundwater and the underlying London Clay, the risks posed to the controlled waters is considered low.

Concentrations of boron, nickel and selenium exceed the DWS, but fall below the EQS levels; which are considered to be more appropriate for the site. Therefore, based on the available information, it is considered unlikely that the exceedances will pose a significant risk to controlled waters.

Marginally elevated concentration of mercury is recorded at one of the eight groundwater locations tested. Reference to the exploratory hole logs show very low concentrations in soils and leachability testing. Therefore the risk to controlled waters is considered low.

6.3.3. Soil Borne Gas

The results of the gas monitoring (Section 4.8) were assessed using the classification system presented within CIRIA C665 (Ref. 24) and NHBC guidance 'traffic light system' (Ref. 25). The classification system uses gas concentrations and recorded flow rates for methane and carbon dioxide to determine a gas screening value (GSV). The GSV is calculated by multiplying the maximum recorded flow rate (l/hr) against the maximum recorded gas concentration (%) determining a value reflecting the worst case scenario. The GSV is used in turn to determine a characteristic situation for the site.

No significant sources of gas have been identified within the site, except those potentially associated with Made Ground. Testing indicates the organic matter content was typically <4.0% and the average was 1.22% in samples with no usual evidence of organic material. A summary of the gas data is shown in Table 32.

Table 32. Gas Data Summary

Lowest O_2 (%)	Highest CH_4 (%)	Highest CO_2 (%)	Flow Rate (l/hr)	GSV (l/hr)	Wilson Card / NHBC Traffic Light Classifications
0.7 (WS811)	0.1 CP803, CP806, WS807, WS810, WS811, WS812)	6.1 (WS807)	0.1 (BH114, WS252, WS253, CP804, WS808)	0.0061 (CO_2)	CS1

Based on the data available (excluding CP807), the highest gas concentration for carbon dioxide (6.1%) and maximum flow (0.1l/hr) have been used giving a GSV of 0.006l/hr for carbon dioxide which classifies the site as Characteristic Situation increases to 2 (CS2) (Ref. 24) owing to the concentration of carbon dioxide (>5%) or, Amber 1 based on NHBC guidance (Ref. 25).

CS2 will require:

a) Reinforced concrete cast *in situ* floor slab (suspended, non-suspended or raft) with at least 1200 g DPM2 and underfloor venting.
b) Beam and block or pre-cast concrete and 2000 g DPM/ reinforced gas membrane and underfloor venting.

All joints and penetrations sealed.

An Amber 1 classification will require low level gas protection measures, typically comprising a membrane and ventilated sub-floor void to create a permeability contrast to limit the ingress of gas into buildings. Ventilation of the sub-floor void should facilitate a minimum of one complete volume change per 24 hours.

The gas monitoring results from CP807 have been removed from the initial assessment due to intermittent high methane and carbon monoxide readings. An initial review has been of the exploratory hole log and other data such as groundwater levels, soil and groundwater testing results, the response zone, the results of adjacent boreholes and results at a range of atmospheric pressures; the lowest readings were recorded during low atmospheric pressures. This suggests the elevated readings in CP807 are attributed to a mechanical fault and as a result, further monitoring is currently being undertaken.

Depleted oxygen was recorded in WS811 to a minimum of 0.7%. The response zone in WS811 targets the Made Ground, however reference to the exploratory log does not reveal a potential source of the depleted oxygen levels (such as hydrocarbon contamination) and groundwater was not recorded. The concentrations of the other gases were very low and no flow was reported. Whilst this area has recently been subjected to earthworks during demolition works, visual or olfactory evidence of contamination were not recorded.

At this stage, it is unclear whether the results is anomalous therefore, further monitoring is currently undertaken.

Carbon monoxide was generally below detection limits except in CP804 of 14ppm but these fall below the EH40/2005 Workplace Long-Term Exposure Limit of 30ppm (Ref. 27).

6.3.4. Property and Services Risk Assessment

London Clay is typically characterised as having elevated levels of sulphates, therefore there may be a potential risk to buildings from sulphate attack hence appropriate concrete design classification is required.

The presence of soil borne gas may potentially impact infrastructure services and buildings, and has been discussed in Section 6.3.3 above.

It is essential that the risks to these structures and services are managed appropriately as outlined below.

The key risks identified are related to:-

- Contact with perched water;
- Contact with contaminated soil;
- Contact with soil;
- Migration along existing or proposed services; and
- Build-up of explosive gas.

These risks can be readily managed by:-

- Appropriate concrete design for foundations and services;
- Removal or sealing of former site infrastructure where encountered;
- Sealing proposed drainage and ensuring that services are bedded in clean inert material;
- Ensuring appropriate practices and procedures are in place during site works to control waters generated in accordance with best practice, and
- Installation of gas protection membranes if found to be required after further monitoring is completed.

7. Conceptual Site Model

7.1. Human Health Conceptual Site Model

Soil contamination testing and site observations have identified the following:

- The presence of lead and PAHs generally associated with anthropogenic inclusions within the Made Ground.
- The presence of asbestos containing materials.
- Elevated soil borne gas concentrations for carbon dioxide.

These areas are shown on Drawing No. 5105977/UXB/REM/251 (Appendix A). The risks to human health require remedial or mitigation measures.

The risks associated with asbestos are discussed further in the IOM Report (Ref. 29).

7.2. Hydrogeological Conceptual Site Model

Marginally elevated concentrations of arsenic have been identified in leachates when compared to DWS (Ref. 22) and EQS (Ref. 23) screening criteria. River Terrace Deposits, which may provide a base flow to the River Pinn to the east, are present in the vicinity of the site. However, low concentrations are generally reported in soil and groundwater samples. The site is also underlain by Unproductive Strata (London Clay and Lambeth Group Formations).

Slightly elevated concentrations of mercury was recorded in groundwater in one out of the eight groundwater samples tested. Levels exceeding screening criteria have not been identified within soil and leachability testing so it is assumed that the source of the exceedance is offsite.

Based on the available information, the risk posed to the controlled waters is considered low.

7.3. Property Risk Assessment

7.3.1. Services and Foundations

Elevated concentrations of sulphate were identified within the soil samples tested. Appropriate design measures are required to protect against concrete attack in buried concrete for foundations and services.

7.3.2. Soil Borne Gas

A summary of the findings of the soil borne gas monitoring undertaken during the 2010 and 2015 ground investigations is presented in Section 6.3.3.

The GSV for the Phase 6 site has been calculated as 0.06l/hr however the carbon dioxide exceeds 5% hence the site is classified as Characteristic Situation 2 (CS2) and Amber 1 (Refs. 24 and 25).

Further monitoring of CP807 and WS811 is on-going monitoring and will include monitoring over a range of atmospheric pressures.

7.4. Summary of Pollutant Linkages

Table 33. Revised Conceptual Site Model

Sources	Pathways	Receptors
Lead and PAHs within the Made Ground	Direct contact Dermal contact with soil and dust Ingestion and inhalation of soil and soil derived dust	Future end-users (residents) Adjacent site users

Sources	Pathways	Receptors
	Inhalation of soil and soil derived dust Consumption of home-grown produce	
Soil borne gases associated with the Made Ground	Build-up of explosive gases and / or asphyxiating gases	Future end-users (residents) Adjacent site users Proposed residential buildings including foundations and services
Sulphate content of soils and perched groundwater	Contact with perched groundwater Contact with contaminated soil Contact with soil	Proposed residential buildings including foundations and services
Asbestos within the Made Ground	Inhalation of soil and soil derived dust	Future end-users (residents) Adjacent site users

8. Remediation Assessment

8.1. Approach to identifying Remedial Options

Under instruction from VSM Estates (VSM), Atkins has reviewed the available reports and carried out a supplementary ground investigation in order to investigate potential ground constraints arising due to historical development, to develop the ground model further inform the chemical conditions within the site. The data obtained has been used to determine the engineering properties of near surface materials and to carry out human health and controlled waters risk assessments for the site. Human health and controlled waters assessment of the north-western most part of the site has been excluded.

In accordance with published guidance (Refs. 3 & 4), a revised Conceptual Site Model (CSM) has been prepared and is presented in Section 7.4.

The risk assessments have revealed elevated concentrations of lead and PAHs in soils, and the presence of asbestos (Ref. IOM report 29) within the Made Ground. These contaminants are considered to pose a potential risk to human health. Potential risks to the property associated with sulphate attack on foundations and soil borne gases have also been identified.

In developing the remedial options for the site, careful consideration has been given to determine the most appropriate and effective approach to breaking the Source Pathway Receptor linkages. Remedial options selected for the site will address human health and property linkages.

8.2. Remediation Objectives

The primary objective of the remedial works is to mitigate the risks to site end-users and property, as summarised below:

Table 34. Summary of Remediation Objectives

Unacceptable Risks	Preliminary Remedial Objectives
Human health effects through consumption of home-grown produce, direct contact, ingestion, inhalation of with contamination soil and dust	Prevent the exposure of humans to contaminated soil using cover system and or excavation of impacted material
Build-up of explosive gases and / or human asphyxiation caused by gas ingress into buildings/enclosed spaces	Prevent gas migration into enclosed areas
Concrete attack on proposed building foundations and services	Appropriate concrete class of proposed foundations into the perched groundwater table

The objectives of the strategy are to set out measures to mitigate potential risks to human health and buildings arising due to future development from geo-environmental contamination issues at the site.

Contamination remediation objectives will be based on the site conceptual model and define the desired site conditions. Agreement on the approach (and remedial targets) will be sought from the appropriate regulatory bodies. This will include a review of the validation protocol.

8.3. Remediation Criteria

Based upon the findings of the risk assessments, the remediation criteria for the site has been based upon the human health combined assessment criteria or the theoretic aqueous or vapour saturation limit produced using the CLEA model (where evidence of hydrocarbon contamination) initially for a residential end-use without the consumption of home grown produce and SOM of 1% as the most appropriate scenario to allow for the maximum re-use of materials. The assessment of the contamination data has been undertaken using the more conservative screening criteria out of the proposed end-uses within Phase 6, however the validation of each area within the Phase 6 site will be undertaken in accordance with the proposed end-use, i.e. residential without consumption of home grown produce and commercial.

Gas protection measures within proposed buildings are considered likely to be necessary based on the gas monitoring data available to date. Further monitoring and assessment of CP807 is required to determine whether additional gas protection measures are required and to confirm the trends in WS811. Depending on the results of the on-going monitoring, it may be necessary to undertake further monitoring of CP807 either during the remediation phase or prior to development (by the developer) to confirm these initial findings.

Concrete foundations for the buildings will require an appropriate design of concrete classification based upon the elevated concentrations of sulphate identified within the soils recorded underlying the site.

Derivation of the remediation criteria has been carried out using appropriate, recognised methodologies, and regulatory approval of the criteria will be sought. The basis of the criteria will be that they are appropriate with regard to the remediation objectives outlined above.

9. Options Appraisal

9.1. Approach to Remediation

The contaminants of concern have been identified in Sections 6.3 and 7. The potential remediation technologies and options under consideration will selectively address the presence of those contaminants and enable mitigation of identified risks to human health and property and service receptors.

There are three broad approaches which can be adopted in order to break the pollutant linkages identified at the site:

- Remove or treat the (source) of pollutants;
- Remove or modify the migration pathway; or
- Remove or modify the behaviour of the receptor.

The most appropriate approach is considered to be a combination of source treatment and removal / modification of the migration pathway.

The chemical analyses data indicates that there are localised areas of lead, PAH and asbestos contamination present on the site. Remedial measures and mitigation of the soil is required to protect human health, controlled water and property and service receptors when these are introduced through redevelopment.

9.2. Feasible Remediation Options

Feasible remedial techniques for the site include both in-situ and ex-situ civil engineering based and process based solutions.

9.2.1. Excavate and Dispose

(Civil Engineering Based Solution)

This technique simply involves excavating the source of contaminated material. It has the advantage that it is an observational technique and contaminated material identified by visual and olfactory means may be removed with some confidence. The disposal option is an expensive and environmentally unsustainable solution requiring disposal of the contaminated material to a suitable facility, a source of clean inert material to backfill the excavation, and transport of the waste and fill materials.

9.2.2. Excavate and Removal to a Soil Treatment Facility

(Civil Engineering Based Solution)

This technique involves excavating the source of contaminated material. This is an observational technique based on visual / olfactory evidence of contamination which will be confirmed by validation testing. This material will then will be disposed of off-site to a registered Soil Treatment Facility (STF) for treatment and re-use off-site. Based upon the volume of contaminated material, this may prove to be a more cost effective approach than treatment on site.

9.2.3. Ex-situ Bio-remediation

(Process Based Solution)

This technique is suitable for TPH contamination (not metals or PAHs) and ranges in complexity from simply placing and turning over excavated contaminated source material in windrows, adding spent compost or seeding it with bacteria and allowing biological degradation of the contaminants. It has the advantage that treatment progress can be observed and visual and olfactory contaminated material may be removed with confidence. Once treated and validated the material can be placed back into the excavation and compacted to an engineering specification. However it is a time based solution and requires a temporary impermeable working area to store material during treatment. Surface water runoff and leachate are collected for treatment.

This technique is considered suitable for the site.

9.2.4. Monitored Natural Attenuation (MNA)

(In-situ Based Process Solution)

This technique relies upon natural processes occurring in the groundwater zone e.g. degradation or sorption which result in the natural reduction of the size of plumes i.e. natural attenuation. Hydrocarbon contamination is readily biodegradable and suitable for the use of monitored natural attenuation. This technique has the advantage of not requiring excavation thus not producing waste, etc. however there remains a risk to human health receptors during the period due to vapour exposure.

This technique is not a solution that has sufficient merit to be considered any further for the site.

9.2.5. Chemical Techniques

(Process Based Solution)

This technique ranges in complexity with regards the application of chemical compounds introduced to the site to initiate a reaction with the contaminants in the soil and convert the contaminants to harmless products that pose little or no risk to end users. Chemical treatment is applicable to organic and inorganic contamination, the final chemical selection being based on both contaminant and the specific ground conditions. The technique includes options such as oxidation, reactive walls, solidification and stabilisation. In the same way as biological degradation of contaminants, it has the advantage that treatment progress can be observed and visual and olfactory contaminated material may be removed with some confidence. Once treated and validated the material can be placed back into the excavation and compacted to an engineering specification. However some treatment can render materials unsuitable for engineering re-use

The prevailing ground conditions on site mean that this technique is not a solution that has sufficient merit to be considered any further for the site.

9.2.6. Phytoremediation

(In-situ Based Process Solution)

This technique relies upon the use of flora to remediate contaminated soil and groundwater. It has the advantage of avoiding excavation, transportation and disposal of excavated materials, however it requires a period of long duration as growth, etc. is slow, is limited to the surface area and depth occupied by roots. This option is best suited to sites with an open space end use and leaves the human health receptor exposed to the source.

This technique is not a solution that has sufficient merit to be considered any further for the site.

9.2.7. Materials Management and Cover Systems/Barriers

(Civil Engineering Based Solution)

This technique introduces an appropriate barrier and by severing the pathway to the receptor breaking the pollutant linkage. Import of clean materials or on-site management of appropriate materials is required for construction of the barrier. Systems range from simple cover layers to provide a reduction of the hazard to human health and to provide a suitable medium for plant growth; through to engineered systems designed to provide a complete separation of the receptor from the hazard and to perform a number of functions including limiting upward migration of contaminants due to capillary rise and controlling the downward infiltration of water.

9.3. Preferred Remediation Option

Based upon literature review, consultation with a number of specialist contractors, and from direct experience on the wider site and other sites of similar complexity, it is considered that an appropriate and cost-effective approach can be adopted using excavation and disposal/ materials management and cover system technologies.

Proposed site levels and the development layout have not been finalised, however it is considered likely that levels within the site will be raised.

Based on the available data the preferred remedial option comprises the following:

Human Health

- Lead and PAH Contamination

  The elevated concentrations of lead and organic (PAH) contaminants are generally associated with anthropogenic inclusions within the Made Ground. The remediation strategy will comprise materials management such as excavate and re-use in a more suitable area within the wider site or on-site management of appropriate materials is required for construction of the barrier, to ensure 600mm of suitable clean cover is present within the proposed landscaped areas. It should be ensured that the upper 600mm is validated in accordance with the proposed end-use (Table 35) and the soil are monitored for the presence of vapour.

- Asbestos containing materials (ACM)

  Reference should be made to the approach outlined within the IOM report (Ref. 29). ACMs within 0.6m of future finished ground level will require removal from residential and soft landscape areas within the future development. ACM contaminated materials will be removed by trained operatives in accordance with appropriate guidance.

Buildings

- Gas migration

  The potential presence of elevated ground borne gas such as carbon dioxide will be considered upon completion of the remedial works. Measures to protect buildings from ground borne gas migration (if required) are likely to comprise the installation of passive systems to vent gas below buildings together with gas impermeable membranes unless the developer confirms otherwise with additional monitoring to satisfy Building Control.

  Further monitoring is required in the location of WS811 during development to explore a possible cause of the depleted oxygen levels and assess further assess the risk.

- Foundations

  Elevated concentrations of sulphate have been identified within the soils and perched groundwater underlying the site. The concrete foundations for the buildings will require an appropriate design of concrete classification.

- Services

  Elevated concentrations of sulphate have been identified within the soils and perched groundwater underlying the site. The services will require an appropriate design of concrete classification in accordance with the findings.

9.4. Remediation Targets

The remediation targets are based upon the human health risk assessment (Section 6.0).

The findings of the human health risk assessment identified localised areas of lead and PAHs associated with the shallow Made Ground. Asbestos recorded in Made Ground should be managed in accordance with the recommendations presented in IOM Report (Ref. 29).

The preferred remedial measures comprise materials management and cover system / barrier techniques for elevated concentrations of lead and PAHs.

9.4.1. Material Management

Materials within the upper 600mm of final finished formation level will be required to achieve the following criteria (Table 35) for the identified contaminants of concern based upon a residential without the re-use of home grown produce scenario (SSVs and C4SLs), as identified through human health risk assessment (Section 6.3). The validation testing should include the contaminants presented in Appendix D.

Table 35. Clean Cover Requirements (top 600mm) – Residential without the consumption of home grown produce

Determinand	Units	Assessment criteria	Source of assessment criteria
Naphthalene	mg/kg	0.598	SSV
Benzo(a)anthracene	mg/kg	4.52	SSV
Benzo(a)pyrene	mg/kg	5.3	C4SL
Benzo(b)fluoranthene	mg/kg	7.72	SSV
Dibenzo(a,h)anthracene	mg/kg	0.838	SSV
Indeno(1,2,3-cd)pyrene	mg/kg	9.53	SSV
Lead	mg/kg	310	C4SL

9.5. Visual and Olfactory

The evaluation and verification of remediation areas will comprise an initial screening exercise comprising visual and olfactory surveying of all exposed or excavated soils; a typical example is presented in Appendix C.

10. Reclamation / Engineering Assessment

10.1. Proposed Development

The Phase 6 site is being assessed based on the masterplan (Drawing No. 5105977/UXB/GE/0069 – Appendix) which shows the redevelopment to predominantly comprise residential houses without gardens with a small commercial area in the west. The final masterplan, levels, plot layout and building loading criteria is unknown therefore, recommendations for foundation options are for indicative purposes only.

The developer will be required to undertake development specific ground investigation for detailed foundation design, engineering structures and slope stability. Detailed geotechnical design is beyond the scope of this report.

The site has been subjected to cut and fill to create building platforms (Drawing No. 5105977-REM-100-001) with a slight slope down eastwards towards the River Pinn.

It is recommended that the re-use of on-site soils and import/transfer of materials is carried out under the CL:AIRE Code of Practice (Ref. 26) in accordance with the St Andrew's Park Materials Management Plan (MMP) (Ref. 30).

10.2. Ground Abnormals / Development Constraints

Based upon the available data, the following ground abnormals and development constraints have been identified:

- Variable thickness and strength/density of Made Ground.
- The presence of trees and medium to high volume change potential clays suggest the potential for shrinkage and swelling of clays associated with the retention and or, removal of existing trees and future planting.
- River Terrace Deposits is present underlying the site at variable locations and depths introducing potential for differential settlement where foundations may span across cohesive and granular strata.
- Locally the surface of London Clay is described as soft.
- Elevated soil borne gas concentrations for carbon dioxide.
- Elevated concentrations of sulphate.

10.3. Reclamation

Engineering reclamation objectives will be based on the requirement to improve, maintain or modify the engineering properties and performance of the physical ground conditions. The reclaimed site will minimise development constraints and promote the adoption of conventional foundation solutions where possible. Earthworks, where undertaken should be carried out in accordance with an engineering specification.

Appropriate classification should be undertaken of the materials and suitable testing proving that the materials have been placed down in a sufficient manner achieving the required criteria.

10.4. Site Clearance

Buildings within the site were demolished between 2013 and 2015 and comprised the removal of buildings and buried foundations down to 2.00m bgl within existing building footprints only. Hardstanding areas were also removed.

Trees that are not to be retained within the future development will be removed. The root zone of these trees will be excavated and voids backfilled in accordance with an engineering specification with suitably validated site won materials.

A BT cable and foul drain currently run through the site. These services remain active at the time of writing this report and supply the residential properties beyond the boundary of the wider site and the new school located in the north of the wider site. These services will be temporarily retained during remediation and reclamation works but it is understood that they will be diverted prior to re-development

10.5. Ground Conditions

The site is predominantly currently surfaced with Made Ground, in part associated with the demolition works. During site investigations, Made Ground has been identified to depths of between 0.3m and 3.2mbgl and is described as both cohesive and granular in nature, described as black grey / grey brown, clayey gravelly sand / sandy gravel and brown / orange brown, silty gravelly sandy clay. The gravel component comprises quartz, flint, brick, concrete, ash, clinker, coal, quartzite, limestone and timber.

River Terrace Deposits have been recorded in Phase 6 and consist of both cohesive and granular materials. The cohesive bands have been previously described as Alluvium but have been interpreted as the cohesive bands of the River Terrace Deposits.

River Terrace Deposits (Boyn Hill Gravel Member) has been identified 15No. holes to depths of between 1.3m and 2.3m (0.3m to 2.0m thick). The base of the deposit was not penetrated in WS810 where the borehole was terminated at 2.5mbgl due to refusal on dense ground.

The deposit is generally firm to stiff (where cohesive) and medium dense to dense (where granular), orange brown / grey brown / brown, clayey sand and gravel / sandy gravelly clay and gravelly clayey sand. Gravel is flint and quartz with occasional calcareous inclusions.

London Clay was encountered within all but 5 of the 64 exploratory holes which penetrated the Made Ground and Superficial Deposits. The surface of the London Clay was encountered at depths between 0.3m and 3.1mbgl. The London Clay is described as soft (where it is weathered at the surface) to very stiff orange brown and blue grey fissured clay and silty clay with occasional rootlet tracks, sub-angular to sub-rounded gravels of flint, sandstone, selenite and calcareous inclusions. Bands of very weak grey mottled yellow siltstone / sandstone were identified at depths between 2.0m and 4.0mbgl.

The Lambeth Group was only encountered within CP806 underlying the London Clay between 19.5m and 20.45mbgl, the base was not proven. The Lambeth Group is described as stiff grey silty gravelly very sandy clay with occasional silt and fine sand lenses. Gravel is fine to coarse sub-angular to sub-rounded of green-blue siltstone and purple mudstone.

10.6. Contamination

Soil contamination testing and site observations have identified the following:

- The presence of lead and PAHs generally associated with anthropogenic inclusions within the Made Ground.
- The presence of localised asbestos containing materials.
- Elevated soil borne gas concentrations for carbon dioxide.

The areas of contamination risk are shown on Drawing No. 5105977/UXB/REM/251 (Appendix A).

The above may pose a risk to human health and construction workers.

The risks to human health from heavy metals and PAHs will require remedial measures.

10.7. Foundations

It is understood that multi storey residential properties and a commercial are proposed within the site.

In general, the site is underlain by Made Ground of variable thickness (0.3m and 3.2m) overlying River Terrace Deposits / London Clay/ Lambeth Group. The existing Made Ground deposits are unlikely to have been placed in accordance with an engineering specification and as such are considered an unsuitable founding stratum due to the variable nature of the deposits and the risks associated with low and variable bearing capacity and the potential for high levels of total and differential settlement.

River Terrace Deposits are present beneath the Made Ground comprising predominantly medium dense to dense granular deposits, with some firm to stiff cohesive deposits present. These are variable in strength but medium dense to dense sands and gravels and firm to still clays and maybe considered to be a competent founding strata depending on the thickness of the unit and proposed loadings.

The Made Ground and Superficial Deposits are underlain by generally competent London Clay Formation; however the upper surface is locally described as soft. The soft clays are considered to be an unsuitable founding stratum, however the clays become firm and stiff relatively quickly hence foundations should be extended through the soft materials into firm to stiff clay. This firm and stiff material is also typical of the Lambeth Group silts and clays.

Medium dense sands and gravels and firm to stiff London Clay and Lambeth Group are generally considered to be suitable as founding strata for small or lightly loaded structures. In areas of deeper fill, loose sands and gravels and soft weathered London Clay or where more heavily loaded structures are proposed, piled foundations are likely to be required.

Foundation design should take into account the presence of any trees being retained on site.

10.8. Underground Obstructions

Brick and concrete cobbles were recorded in a number of locations within Made Ground during the ground investigation; notably in areas of demolished buildings. Due to the former uses and potential for unrecorded obstructions elsewhere within the site associated with the demolition, it should be assumed that further brick / concrete cobbles and underground obstructions may be present.

The Enviros reports (Ref. 5 and 6) contain historic OS maps that show locations of previous buildings. Drawing No. PDFMRU-P-DWG-101 (Appendix A) presents the location of structures removed as part of the wider demolition works.

10.9. BRE Concrete Classification

Chemical testing of soils for concrete classification, as detailed in Section 5.0, indicates that a concrete classification of sulphate class ranging between DS-2 to DS-3 and Aggressive Chemical Environment for Concrete (ACEC) class ranging between AC-2 and AC-3 should be suitable for structures within the site.

Chemical testing of the perched groundwater on the site indicates that a concrete classification of sulphate class of DS3 and Aggressive Chemical Environment for Concrete (ACEC) class AC3 will be required for foundations into the shallow perched groundwater table across the site, except where Made Ground is present for which the more conservative concrete classification of sulphate class of DS4 and ACEC class AC4 will be required, as detailed in Section 5.0.

It is recommended that the more conservative sulphate class is used on the site.

10.10. Excavations for Development and Services

Based upon the works undertaken on the site, excavations for foundations and services should be possible using normal hydraulic plant. It is considered that excavations are unlikely to remain stable in the short term and will require support or battering. The base of all excavations should be blinded in order to prevent the deterioration of the cohesive materials.

Shallow localised seepages of perched water and groundwater ingress should be anticipated. Sump pumping should be suitable to remove groundwater from excavations. Appropriate consents will be required to pump the perched water to sewer. If not suitable, the perched groundwater may require collection for treatment or be tankered off to a treatment facility.

Elevated concentrations of carbon dioxide and depleted oxygen concentrations have been reported. These are being monitored further but should be considered during assessments for working in excavations and other confined spaces.

Slip surfaces were not identified during the ground investigation; however they have been recorded previously in the wider site and where encountered, will require appropriate design of excavations for structures and services.

The effect of relict shear surfaces reduces the shear resistance in the soils. Therefore particular attention to the potential effect of relict shear surfaces is needed where excavations are carried out (particularly in sloping ground) in drained conditions for ground engineering design or where fill is placed so that the underlying ground does not fail due to lack of support or increased load.

10.11. Earthworks

The final development levels and the earthworks model, have not yet been finalised but it is anticipated that materials management will be employed to maximise re-use of materials in accordance with the remediation strategy under the CL:AIRE Voluntary Code of Practice (CoP) (Ref. 26), by ensuring chemically suitable materials are placed in appropriate locations and depths within the future development.

10.12. Pavements and Hardstanding

The proposed pavement and road levels will be formed in both cut and fill areas hence the formation level / sub-grade materials will vary across the site but is likely to comprise a mix of Made Ground, Superficial Deposits and London Clay.

A total of fourteen CBR tests have been carried out within samples of the Made Ground. Values ranged between 0.5% and 12%. This represents the variability of the Made Ground within the site.

Five CBR tests have been undertaken within samples of the London Clay. Values of between 3.3% and 6.4% have been reported. This is typical of cohesive material near the surface across the site which is expected to achieve CBR values of <2% to 5%.

Soft and hard spots should be excavated and replaced with suitable materials. For the purposes of preliminary pavement design at this stage as formation levels are not known, design CBRs should be anticipated to range between <2% to 5% and the formation will be frost susceptible. The design CBR values should take into account both construction conditions and long-term equilibrium CBR values based on classification and should be re-evaluated at the time of pavement construction. These recommendations should be confirmed by testing at formation level.

Long term groundwater monitoring has identified that levels are typically greater than 1.0m bgl.

10.13. Soil Borne Gases

The assessment has revealed the site is as Characteristic Situation 2 (CS2) in accordance with CIRIA C665 (Ref. 24), or Amber 1 when compared to the NHBC guidance 'traffic light system' (Ref. 25), and gas protection measures be required.

Further monitoring is on-going at the location of CP807 to confirm whether a further level of gas protection measure is required and in WS811 to review the levels of oxygen.

10.14. Trees – Shrinking and Swelling Clays

The London Clay Formation comprises intermediate to very high plasticity clay and are therefore subject to shrinkage and swelling. There are a number of semi–mature and mature trees on the site hence there are risks associated with shrinking and swelling clays. Consideration will need to be given to the presence of existing trees that are removed, retained trees and the planting of future trees when considering the depths of the foundations. Foundation design should be undertaken in accordance with the NHBC guidance (Ref. 25) for high volume change potential clay materials. In areas where trees are removed, consideration should be given to the potential for heave as potentially desiccated materials are re-hydrated.

Prior to re-development, a vegetation survey should be undertaken in order to determine the height and species of the trees present. Further development specific investigation and geotechnical testing will need to be undertaken by the developer in order to determine the degree and depth of desiccation around trees for detailed foundation design.

11. Remediation and Reclamation Strategy

The remediation and reclamation strategy is intended to define the preferred works required to remediate and reclaim the site in accordance with the findings of the ground investigation and preliminary generic quantitative risk assessment and in accordance with the remediation objectives outlined in Section 8.2 of this report.

11.1. Clearance Phase

Based on the findings of the ground investigations to date the presence of significant underground obstructions or structures is not anticipated outside of the existing and known historical building footprints. All existing buildings have been demolished and foundations within the building footprints removed to a depth of 2.0mbgl. Underground obstructions may be present outside the footprint of existing buildings. Arisings shall be crushed for re-use within the site and wider development.

There is a low risk of UXO (unexploded ordnance) on the site according to Planit 2010 report (Ref. 7), however consideration of the risk should be given and a watching brief be maintained during excavation works.

Visual and olfactory evidence of potential contamination will need to be recorded during the works. The findings will be used to update this remediation strategy.

Trees which are not being retained as part of the development will need to be cut down and the root zone will be removed.

Voids and excavations generated during the removal of tree roots and redundant services/ structures will need to be backfilled, in accordance with an engineering specification to ensure suitability of earthworks materials and compaction during earthworks.

11.2. Remediation and Reclamation Phase

11.2.1. Remedial Measures

Elevated lead and PAHs and isolated asbestos has been identified associated with anthropogenic inclusions within the Made Ground. Lead, PAHs and ACMs within 0.6m of current ground level will require removal from residential areas and soft landscape areas within the future development.

Future earthworks to re-profile the site will involve the mechanical management of soft and hard spots and should be replaced with suitable materials. Where suitable, cut materials will be placed and re-used in the fill areas located in accordance with an Engineering Specification. Sufficient clean cover is to be provided within residential and soft landscaped areas and that the upper 600mm of Made Ground shall be validated in accordance with the proposed end-use (Table 35).

Asbestos will be removed where visually identified within 600mm of current ground levels (as finished levels have not been confirmed), bagged and disposed of offsite in accordance with appropriate guidance and in accordance with the contractor's method statements and risk assessments.

11.2.2. Reclamation Works

Reclamation works are anticipated to involve the re-profiling of the site through localised cutting and filling however, proposed site levels are not available for Phase 6.

Materials will be placed in accordance with an Engineering Specification. The materials will be placed in accordance with the proposed final formation levels in line with the remediation strategy under the CL:AIRE Voluntary Code of Practice (CoP) (Ref. 26).

12. Verification and Monitoring

12.1. Validation Protocol

The development of a defined validation protocol is an essential part of the successful implementation of any remediation scheme. Key to the success is the inclusion of validation and verification activities throughout the whole period that remediation works are ongoing.

The over-riding objective of the programme of monitoring and validation is to collate sufficient information and evidence to substantiate the achievement of the remediation/reclamation objectives. For some processes, such as the removal of lead and PAH impacted soils and the placement non-vaporous contaminated materials in areas considered to pose a low risk to the proposed development, sampling and analysis will be required to confirm that validated materials are placed at formation in sensitive areas in line with the proposed end-use.

The validation protocol will also provide an indication of any shortfall in the intended process to achieve the remediation objective in the anticipated timeframe. It will also permit an early warning notice to define remedial actions should a change in strategy be required.

12.2. Sampling

A programme of monitoring, sampling and analysis will be carried out for the duration of the works. Monitoring to be carried out by the Contractor will specifically include:

- Atmospheric monitoring of fugitive dusts and volatile compounds linked to the COSHH assessment and air monitoring strategy;
- Noise, related to equipment operations and working methods,
- Sampling of soils, perched groundwater (where encountered in excavations) for validation of the remediation works;
- Soil borne gas levels within CP807 and WS811; and
- Vapour monitoring of Made Ground.

All samples will be retrieved and tested in a laboratory which is UKAS accredited and MCERTS compliant.

All field and laboratory analytical results will be presented in a verification report, which will cover the entire remediation and reclamation period (pre, during and post-site works).

The progress and verification testing programme will utilise a combination of on-site olfactory and visual observation, combined with more comprehensive off-site laboratory analysis of selected samples.

It is proposed that excavated materials will be sampled and tested based upon the proposed end-use of the material on the site.

Materials for use within the 600mm barrier in residential and soft landscaping areas: soil contamination testing will be undertaken at a rate of 1 per 250m^3 for site generated materials

General Excavated Arisings for placement within the site works: soil contamination testing will be undertaken at a rate of 1 per 1000 m^3 and site generated materials

Sides and base of lead, PAH and asbestos impacted excavations: testing will be undertaken at a rate of 1 per 100 m^3.

12.3. Environmental Monitoring of Works

Monitoring will involve off-site analysis by an approved laboratory on a fortnightly basis. The details of the programme of work will appear in the Monitoring Plan. The plan will provide the direction for the programme of monitoring and would typically include:

- Scope and context of the monitoring
- Specification for the works
- Location, frequency and duration of monitoring
- Criteria for evaluation of the data
- Criteria for acceptance and confirmation of data for inclusion in the Verification Report

The Contractor will ensure appropriately qualified specialist environmental staff will carry out the monitoring works and audits will be undertaken to maintain quality assurance.

12.4. Soil Testing and Monitoring

The soil evaluation and verification exercise has one main objective; to ensure sufficient material has been removed from lead, PAH and asbestos contaminated areas to validate the risk to human health is removed and that materials re-used in any fill and barrier cover operations are suitable for use.

The frequency of testing to be provide has been highlighted previously in Section 12.2.

All soils shall undergo an initial screening exercise comprising visual and olfactory surveying of excavated materials and any exposed surface.

The suite of testing for re-used material will include as a minimum:

- Metals – arsenic, cadmium, chromium, nickel, lead, mercury, selenium, copper and zinc
- TPH (aliphatic/aromatic split with carbon banding as per the TPH Criteria Working Group suite) (detection limit of 10mg/kg) (barrier materials)
- USEPA 16 Polycyclic Aromatic Hydrocarbons (barrier materials)
- Asbestos (barrier materials)

12.5. Vapour Monitoring

A vapour monitoring strategy will be developed and assessed as a part of the validation process.

12.6. Engineering Verification

An engineering specification will be prepared as necessary for the earthworks. Verification requirements will be set out in the specification.

12.7. Verification Report

A verification report for the remediation works will be prepared in accordance with CLR11 to show compliance with remediation objectives and criteria. The verification report will provide a complete record of the remediation activities on site and the data collected. It will include detailed descriptions of the works with associated as built drawings.

The verification reports will include:

- Background information – project and site details, Employer's requirements and remediation objectives,

- Remediation – design, techniques, methodology, programme, verification emissions controls, chemical and physical testing, priority contaminants,
- Monitoring – status, outstanding risks further works,
- Final site conditions i.e. an account of the state of the site following works,
- Results of vapour monitoring,
- Third party contacts – correspondence and approvals/agreements from regulators, site visits, statutory guidance, third party agreements,
- Supporting information – plans, as–built drawings, progress photographs and reports, analytical results, H&S, QA, environmental monitoring, method statements

12.8. Site Development

On excavation, removal and verification of contaminated areas, and or placement of a suitable cover system within residential and soft landscaping area, the site is ready for development.

13. Waste Management

13.1. Management of Soils

It is anticipated that all materials excavated on site will be re-used as a part of the proposed development.

Soils with elevated concentrations of contaminants which are considered to pose a risk to human health and controlled waters will be managed in accordance with the remediation strategy.

Excavated materials that need to be stored on site for re-use at a later date will need to be tested and assessed in terms of risks to human health. If suitable, this will need to be stored and covered until required for re-use.

13.2. Waste Management

It is not anticipated that there will be materials surplus to requirements for the wider development.

The re-use of on-site excavated soils should be undertaken under the CL:AIRE Voluntary Code of Practice (CoP) which was published in March 2011 (Ref. 26). Under the CoP materials excavated on-site are not deemed contaminated if suitable for re-use at specified locations or generally within the site. A ‘Qualified Person’ as defined under the CoP will review the development of the Materials Management Plan, Risk Assessments and Remediation Strategy/Design Statement together with documentation relating to Planning and Regulatory issues will sign a Declaration which is forwarded to the Environment Agency and which confirms compliance with the CoP.

To maximise re-use of materials within the site, materials requiring off-site disposal will be classified and subject to pre-treatment to minimise volumes.

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Appendix A. Drawings

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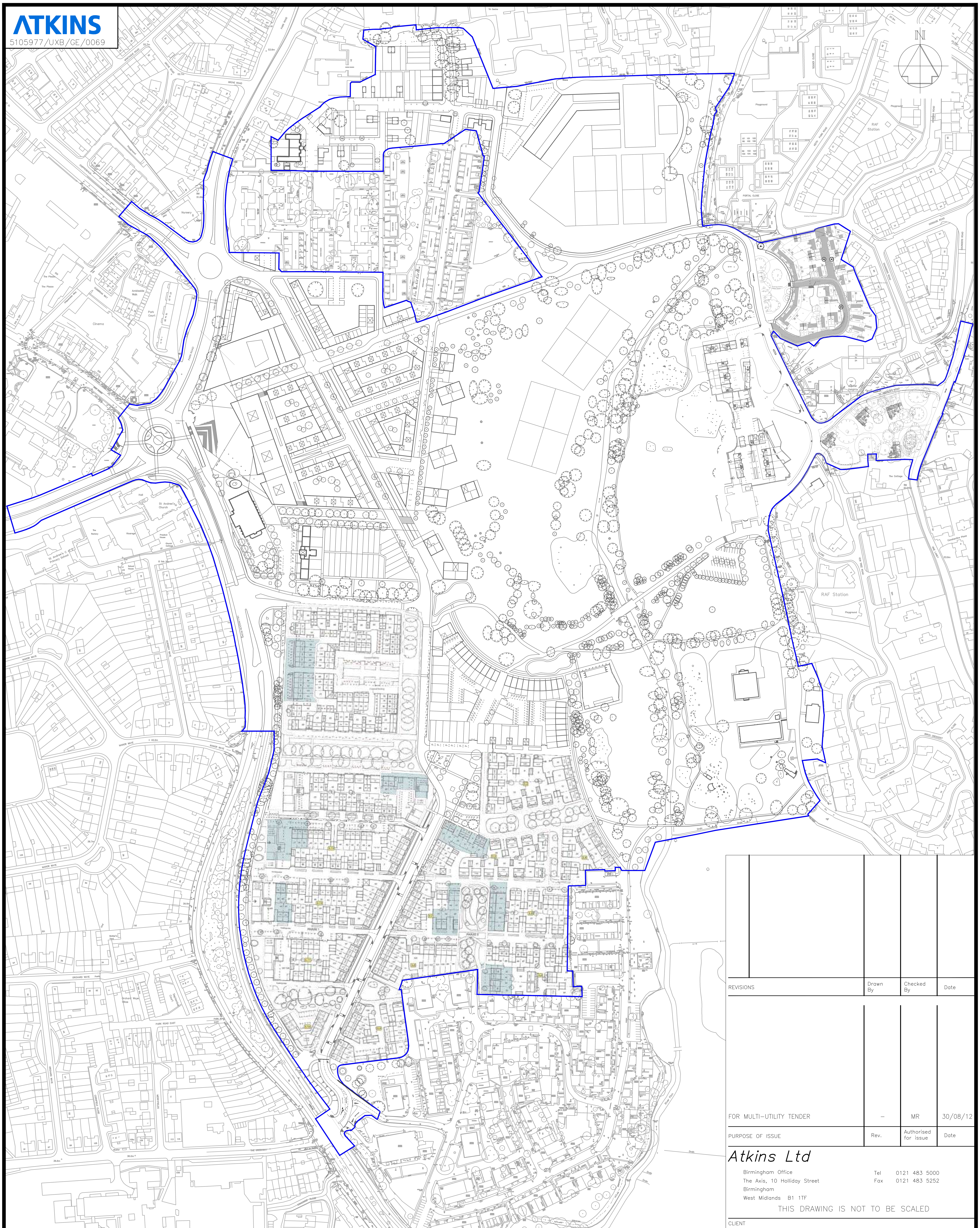
5105977/UXB/GE/0069



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NOTES

1. TOPOGRAPHICAL SURVEY (OUTSIDE OF PLANNING BOUNDARY) TAKEN FROM DRAWING NUMBER 10179-147-HAL125_2DT_RevE "RAF UXBRIDGE, MIDDLESEX UB10 0RZ - TOPOGRAPHICAL SURVEY 2D" BY MET SURVEYS LTD.
2. MASTERPLAN TAKEN FROM DRAWING NUMBER 3300-10-101 REV O BY SHEPPARD ROBSON.
3. PROPOSED HOUSING LAYOUT FOR EASTERN DEVELOPMENT TAKEN FROM DRAWING NUMBERS:
   - P433 SITE LAYOUT 09-08-12 BY TROWER DAVIES LTD
   - PL120401-SL.01 Rev E "SITE LAYOUT - PHASE 1B" BY TETLOW KING
4. PROPOSED HOUSING LAYOUT FOR SOUTHERN DEVELOPMENT TAKEN FROM DRAWING NUMBER PJ732-PH1&5-SKL-Opt1-RevA "PHASES 1&5 - SKETCH LAYOUT - OPTION 1 (LIFETIME HOMES COMPLIANT) BY TETLOW KING.
5. PROPOSED HOUSING LAYOUT FOR CENTRAL DEVELOPMENT TAKEN FROM DRAWING NUMBER PJ732-PH2-SKL-Opt1-RevA "PHASE 2 - SKETCH LAYOUT - OPTION 1 (LIFETIME HOMES COMPLIANT) BY TETLOW KING.

KEY

OUTLINE PLANNING APPLICATION BOUNDARY

REVISIONS	Drawn By	Checked By	Date

PURPOSE OF ISSUE	Rev.	Authorised for issue	Date
FOR MULTI-UTILITY TENDER	-	MR	30/08/12

Atkins Ltd

Birmingham Office
The Axis, 10 Holliday Street
Birmingham
West Midlands B1 1TF

Tel 0121 483 5000
Fax 0121 483 5252

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CLIENT
VSM ESTATES LTD

PROJECT
UXBRIDGE

DRAWING TITLE
INDICATIVE SITE LAYOUT

Scales	DRAWN	CHECKED	CO-ORD CHECK
NOT TO SCALE	CEO	CN	KMR
	DATE 29/08/12	DATE 29/08/12	DATE 29/08/12
0		SHEET A1	PLOT DATE 30/08/12

DRAWING NO 5105977/UXB/GE/0069 REV –

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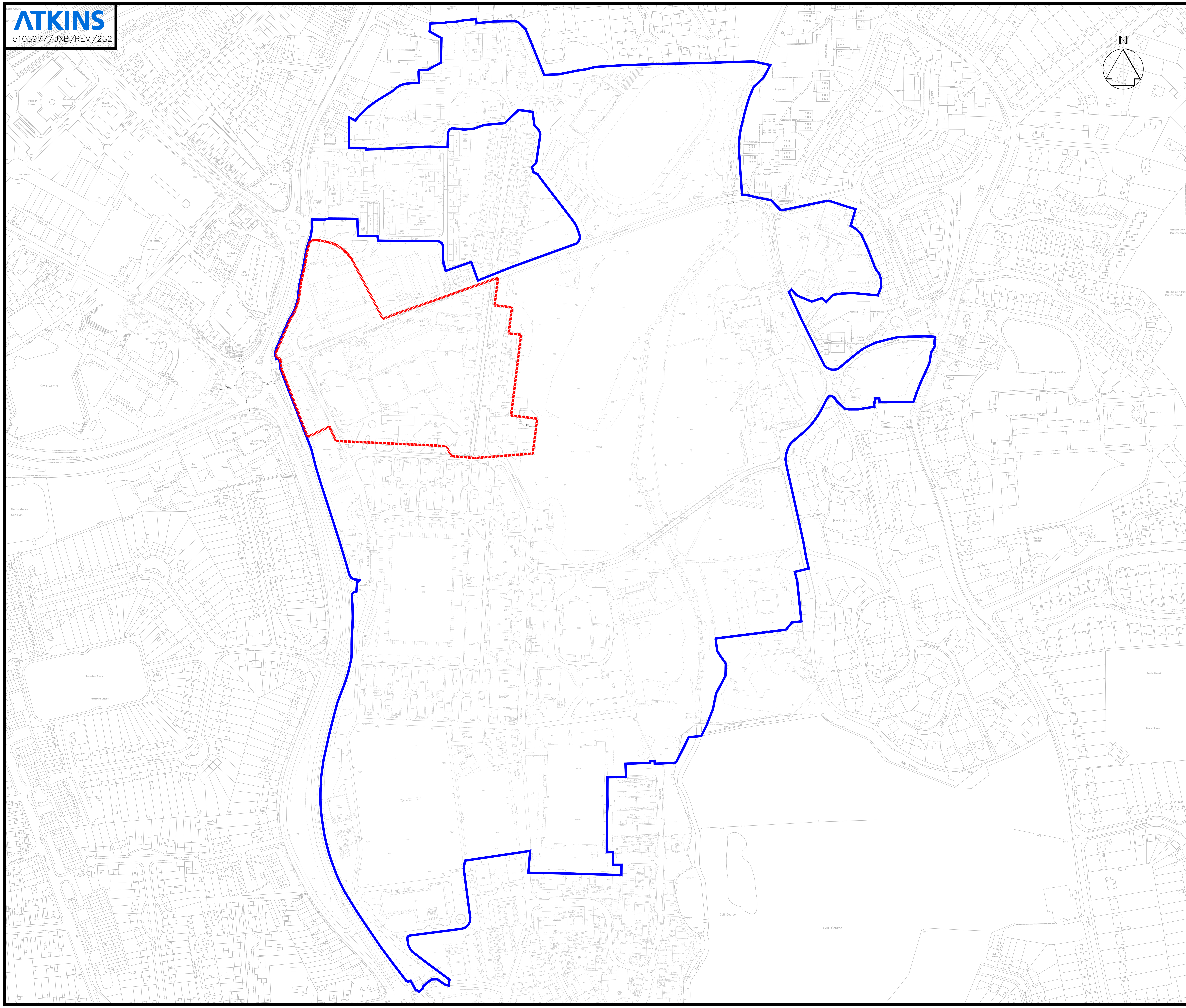

KEY
SITE BOUNDARY
PHASE 6 BOUNDARY

REVISIONS	Drawn By	Checked By	Date

PURPOSE OF ISSUE	Rev.	Authorised for issue	Date

Atkins Ltd
Consulting Engineers
The Axis, 10 Holliday Street, Birmingham, West Midlands B1 1TF
Tel 0121 483 5000
Fax 0121 483 5252

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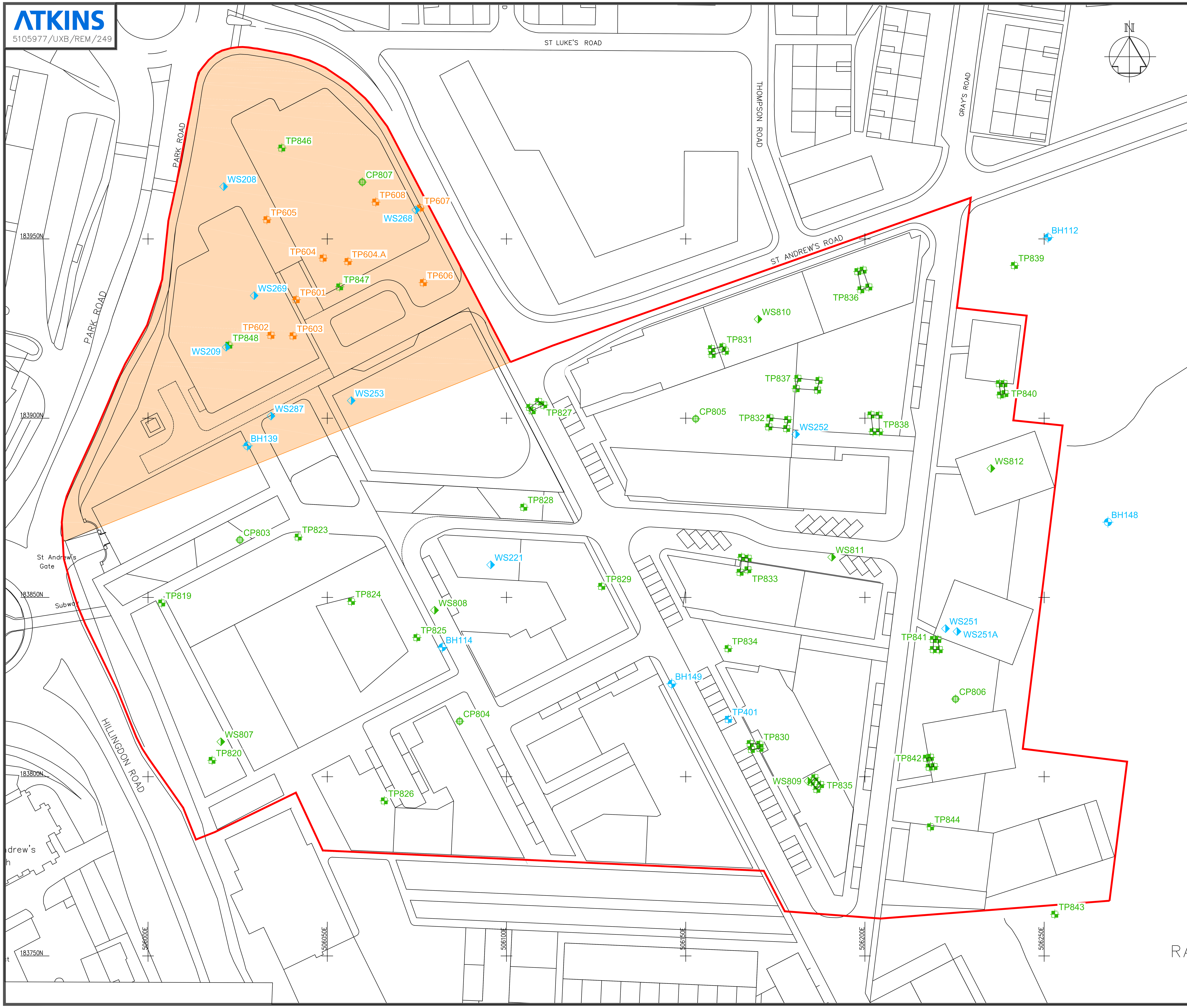
CLIENT
VSM ESTATES (UXBRIDGE) LTD

PROJECT
ST ANDREWS PARK, UXBRIDGE

DRAWING TITLE
PHASE 6 LOCATION PLAN

Scales	DRAWN	CHECKED	CO-ORD CHECK
1:2000	RJ	RM	
	DATE 01/06/15	DATE 01/06/15	DATE
0	SHEET A1	PLOT DATE 03/06/15	

DRAWING NO 5105977/UXB/REM/252
REV –



KEY

PHASE 6 AREA

AREA THAT HAS SATISFIED PLANNING CONDITIONS 72, 73 AND 75

TRIAL PIT LOCATION

BOREHOLE

CABLE PERCUSSION BOREHOLE

WINDOW SAMPLE LOCATION

GROUND INVESTIGATION SURVEYS

IFA ATKINS 2015 INVESTIGATION

ATKINS 2013 GROUND INVESTIGATION

IFA HALCROW 2010 GROUND INVESTIGATION

REVISIONS	Drawn By	Checked By	Date

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Atkins Ltd

Consulting Engineers

The Axis, 10 Holliday Street, Birmingham West Midlands B1 1TF

Tel 0121 483 5000
Fax 0121 483 5252

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VSM ESTATES (UXBRIDGE) LTD

PROJECT
ST ANDREW'S PARK, UXBRIDGE

DRAWING TITLE
NORTHERN ACCESS AREA THAT HAS PREVIOUSLY UNDERGONE REMEDIATION

Scales	DRAWN	CHECKED	CO-ORD CHECK
1:500	JSD	RM	–
	DATE 11/05/15	DATE 11/05/15	DATE –
0		SHEET A1	PLOT DATE 27/05/15

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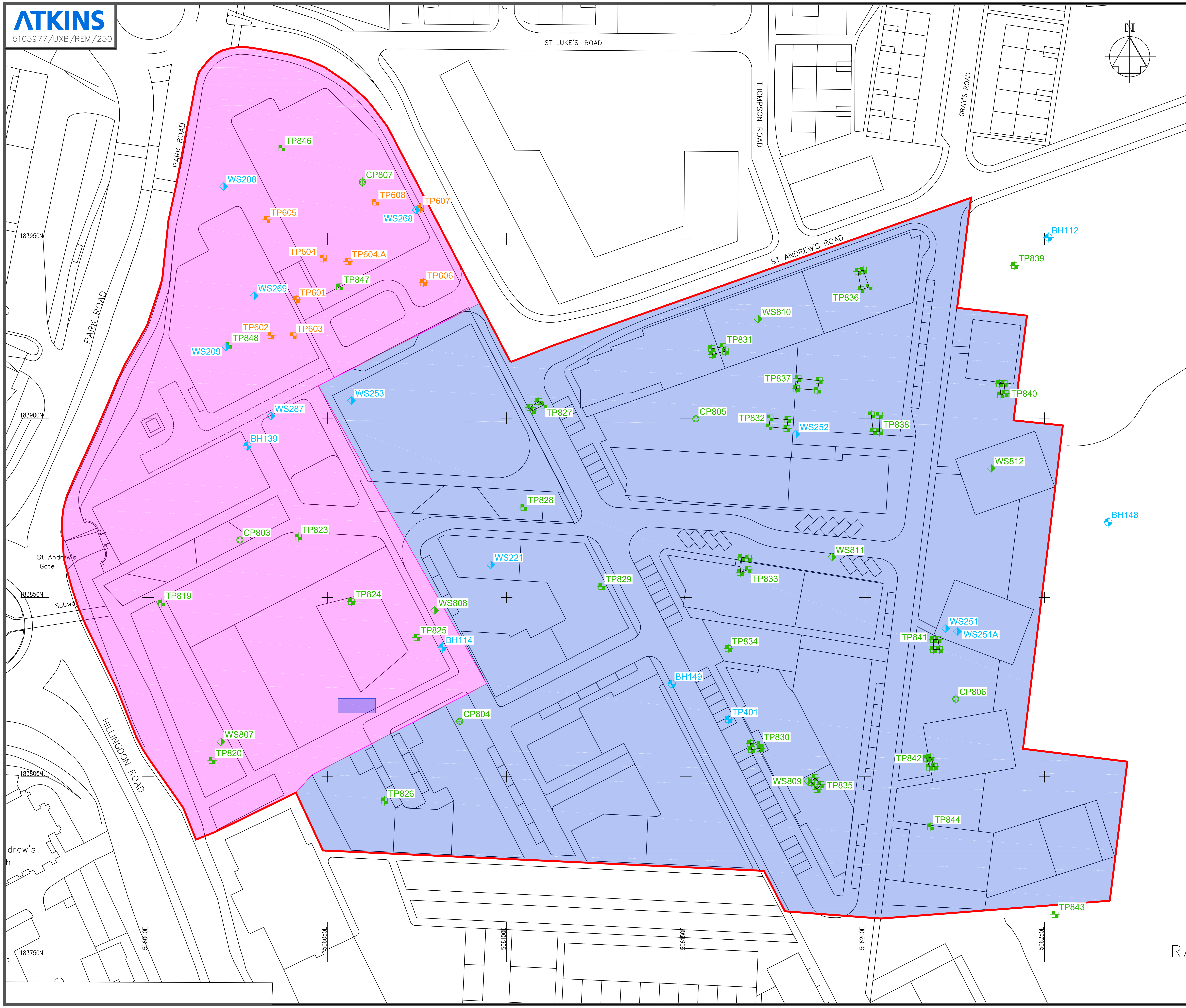

KEY

- PHASE 6 AREA
- PROPOSED COMMERCIAL END–USE
- PROPOSED RESIDENTIAL WITHOUT GARDENS END–USE
- TRIAL PIT LOCATION
- BOREHOLE
- CABLE PERCUSSION BOREHOLE
- WINDOW SAMPLE LOCATION

GROUND INVESTIGATION SURVEYS

- IFA ATKINS 2015 INVESTIGATION
- ATKINS 2013 GROUND INVESTIGATION
- IFA HALCROW 2010 GROUND INVESTIGATION

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Atkins Ltd
Consulting Engineers
The Axis, 10 Holliday Street
Birmingham West Midlands B1 1TF
Tel 0121 483 5000
Fax 0121 483 5252

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DRAWING TITLE
PHASE 6 PROPOSED END–USES

Scales	DRAWN	CHECKED	CO–ORD CHECK
1:500	JSD	RM	–
	DATE 11/05/15	DATE 11/05/15	DATE –
0		SHEET A1	PLOT DATE 27/05/15

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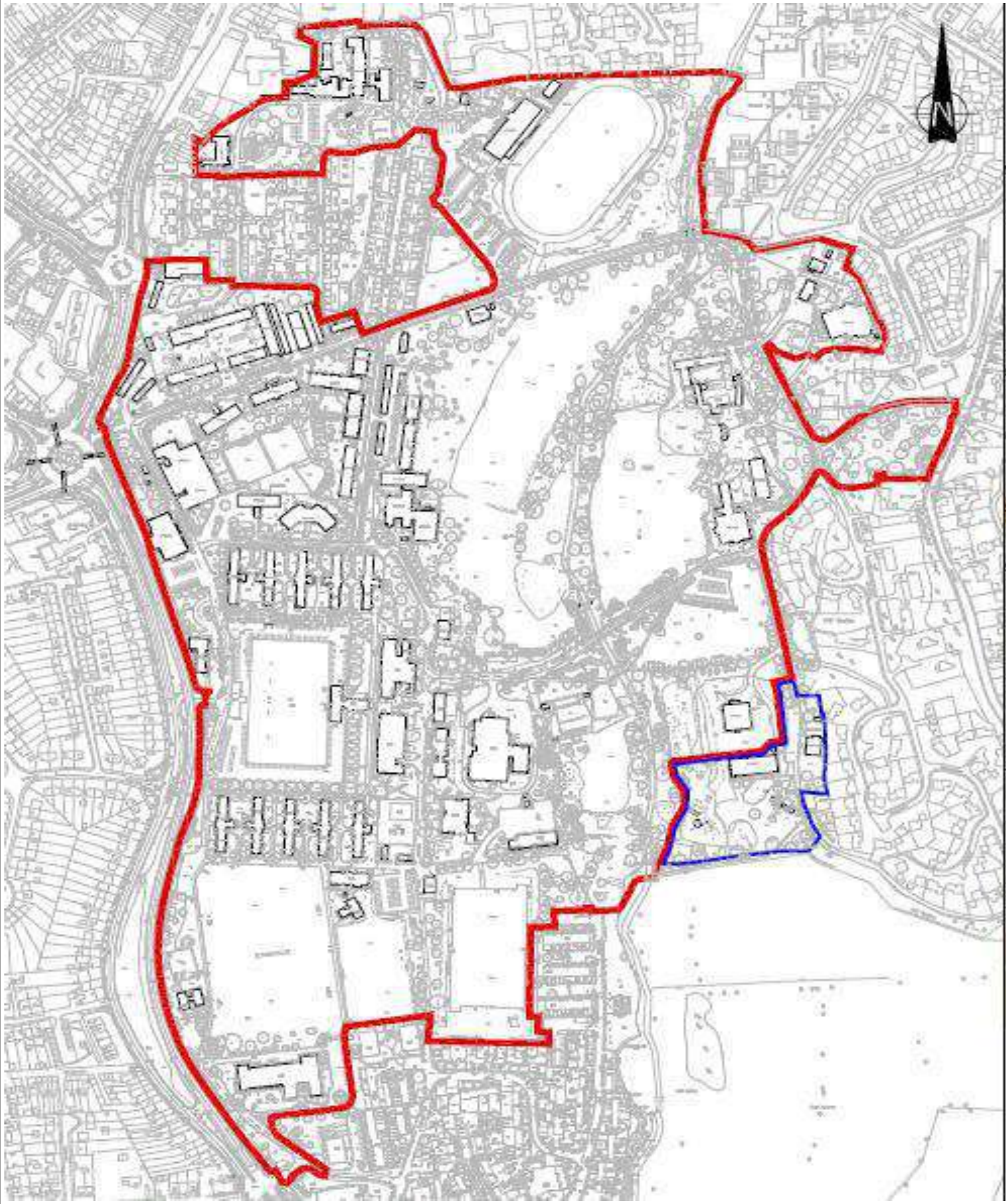
ATKINS
5705977/DEMO/001



REVISIONS	Drawn by	Checked by	Date
Final Report	A	GMcC	15/12/2009
PURPOSE OF ISSUE	Rev.	Authorised for issue	Date

Atkins Ltd

Consulting Engineers

200 Broomielaw
Glasgow, G1 4RU

Tel 0141 220 2000
Fax 0141 220 2001

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PROJECT

RAF Uxbridge

DRAWING TITLE

SITE LOCATION PLAN

SCALES	DRAWN	CHECKED	CO-ORD CHECK
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	DATE 15/02/2012	DATE	DATE
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5705977/DEMO/001	A


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ST LUKE'S ROAD
THOMPSON ROAD
GRAY'S ROAD
PARK ROAD
ST ANDREW'S ROAD
HILLINGDON ROAD
St Andrew's Gate
Subway
183950N
183900N
183850N
183800N
183750N
506000E
506050E
506100E
506150E
506200E
506250E
TP846
CP807
WS208
TP608
TP607
WS268
TP605
TP604
TP604.A
TP606
WS269
TP847
TP601
TP602
TP603
TP848
WS209
WS253
WS287
BH139
TP827
TP828
CP803
TP823
TP819
TP824
WS221
TP829
WS808
TP825
BH114
WS807
TP820
CP804
TP826
BH149
TP401
TP830
WS809
TP835
TP836
WS810
TP831
TP837
CP805
TP832
WS252
TP838
WS811
TP833
TP834
BH112
TP839
TP840
WS812
BH148
WS251
WS251A
TP841
CP806
TP842
TP844
TP843
KEY
PHASE 6 AREA
TRIAL PIT LOCATION
BOREHOLE
CABLE PERCUSSION BOREHOLE
WINDOW SAMPLE LOCATION
GROUND INVESTIGATION SURVEYS
IFA ATKINS 2015 INVESTIGATION
ATKINS 2013 GROUND INVESTIGATION
IFA HALCROW 2010 GROUND INVESTIGATION
REVISIONS
Drawn By
Checked By
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PURPOSE OF ISSUE
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The Axis, 10 Holliday Street
Birmingham West Midlands B1 1TF
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Fax 0121 483 5252
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PROJECT
ST ANDREW'S PARK, UXBRIDGE
DRAWING TITLE
PHASE 6 GROUND INVESTIGATION LOCATIONS
Scales
1:500
DRAWN
JSD
CHECKED
RM
CO-ORD CHECK
DATE
11/05/15
DATE
11/05/15
DATE
SHEET
A1
PLOT DATE
22/05/15
DRAWING NO
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5105977-REM-100-001

KEY

- Site Boundary
- Asbestos Containing Materials
- Heavy Metal Contamination
- Total Petroleum Hydrocarbon Contamination
- Poly Aromatic Hydrocarbon Contamination
- Vapour Risk Areas
- Fuel Storage Areas (Current & Historical)
- Areas of Historical Earthworks Infilling
- FB Historical Buildings/ Structures
- Watercourses (Current & Historical)
- SS Electricity Substations
- Location of Underground Bunker
- Areas of Historical Incinerators
- Listed Buildings/ Areas of Heritage Importance
- Areas of Former Fuel Spillage

NOTES: The areas of contamination identified are based on a initial screen of existing data from the Halcrow ground investigation.

Areas of vapour risk have been identified based upon the presence of volatile hydrocarbons.

The locations of the former buildings and structures are approximate.

Japanese knotweed and Hogweed has been recorded in the northern part of the site. Exact location is unknown.

REVISIONS		Drawn By	Checked By	Date
FOR INFORMATION	–		RG	26.03.12
PURPOSE OF ISSUE	Rev.		Authorised for issue	Date

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Atkins Ltd
Environmental Planning
The Axis, 10 Holliday Street
Birmingham West Midlands B1 1TF
Tel 0121 483 5000
Fax 0121 483 5252

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CLIENT: ST. MODWEN

PROJECT: RAF UXBRIDGE

DRAWING TITLE: SITE CONSTRAINTS PLAN

SCALES	DRAWN	CHECKED	COORD CHECK
1:2000	DMC	RG	JM
	DATE 23.03.12	DATE 26.03.12	DATE 26.03.12
		SHEET A1	PLOT DATE

DRAWING NO: 5105977-REM-100-001

REV: -

DRAFT