Polycyclic Aromatic Hydrocarbons
GC/MS (SIM)

Customer and Site Details:	Hyder Consulting UK Ltd: LNO1323		
Sample Details:	BH23 0.5	**Job Number:**	S10_0786
LIMS ID Number:	CL1003533	**Date Booked in:**	15-Feb-10
QC Batch Number:	0499	**Date Extracted:**	19-Feb-10
Quantitation File:	Initial Calibration	**Date Analysed:**	19-Feb-10
Directory:	\0219PAHGC5\	**Matrix:**	Soil
Dilution:	1.0	**Ext Method:**	Ultrasonic

UKAS accredited?: Yes

Target Compounds	CAS #	R.T. (min)	Concentration mg/kg	% Fit
Naphthalene	91-20-3	-	< 0.08	-
Acenaphthylene	208-96-8	-	< 0.08	-
Acenaphthene	83-32-9	-	< 0.08	-
Fluorene	86-73-7	-	< 0.08	-
Phenanthrene	85-01-8	-	< 0.08	-
Anthracene	120-12-7	-	< 0.08	-
Fluoranthene	206-44-0	-	< 0.08	-
Pyrene	129-00-0	-	< 0.08	-
Benzo[a]anthracene	56-55-3	-	< 0.08	-
Chrysene	218-01-9	-	< 0.08	-
Benzo[b]fluoranthene	205-99-2	-	< 0.08	-
Benzo[k]fluoranthene	207-08-9	-	< 0.08	-
Benzo[a]pyrene	50-32-8	-	< 0.08	-
Indeno[1,2,3-cd]pyrene	193-39-5	-	< 0.08	-
Dibenzo[a,h]anthracene	53-70-3	-	< 0.08	-
Benzo[g,h,i]perylene	191-24-2	-	< 0.08	-
Total (USEPA16) PAHs	-	-	< 1.28	-

"M" denotes that % fit has been manually interpreted

Internal Standards	% Area
1,4-Dichlorobenzene-d4	NA
Naphthalene-d8	86
Acenaphthene-d10	80
Phenanthrene-d10	70
Chrysene-d12	64
Perylene-d12	62

Surrogates	% Rec
Nitrobenzene-d5	NA
2-Fluorobiphenyl	104
Terphenyl-d14	106

Concentrations are reported on a wet weight basis.

The Total PAH result is the sum of non-rounded individual PAH results and therefore may differ to the sum of the rounded individual PAH results printed above. By convention, where any one or more result is a "less than", the total is expressed as a "less than" and includes the "less than" concentration within the total.

Where individual results are flagged see report notes for status.

Polycyclic Aromatic Hydrocarbons
GC/MS (SIM)

Customer and Site Details:	Hyder Consulting UK Ltd: LNO1323		
Sample Details:	TP20 0.5	**Job Number:**	S10_0786
LIMS ID Number:	CL1003534	**Date Booked in:**	15-Feb-10
QC Batch Number:	0499	**Date Extracted:**	19-Feb-10
Quantitation File:	Initial Calibration	**Date Analysed:**	19-Feb-10
Directory:	\0219PAHGC5\	**Matrix:**	Soil
Dilution:	1.0	**Ext Method:**	Ultrasonic

UKAS accredited?: Yes

Target Compounds	CAS #	R.T. (min)	Concentration mg/kg	% Fit
Naphthalene	91-20-3	-	< 0.08	-
Acenaphthylene	208-96-8	-	< 0.08	-
Acenaphthene	83-32-9	-	< 0.08	-
Fluorene	86-73-7	-	< 0.08	-
Phenanthrene	85-01-8	-	< 0.08	-
Anthracene	120-12-7	-	< 0.08	-
Fluoranthene	206-44-0	-	< 0.08	-
Pyrene	129-00-0	-	< 0.08	-
Benzo[a]anthracene	56-55-3	-	< 0.08	-
Chrysene	218-01-9	-	< 0.08	-
Benzo[b]fluoranthene	205-99-2	-	< 0.08	-
Benzo[k]fluoranthene	207-08-9	-	< 0.08	-
Benzo[a]pyrene	50-32-8	-	< 0.08	-
Indeno[1,2,3-cd]pyrene	193-39-5	-	< 0.08	-
Dibenzo[a,h]anthracene	53-70-3	-	< 0.08	-
Benzo[g,h,i]perylene	191-24-2	-	< 0.08	-
Coronene	191-07-1 *	-	< 0.08	-
Total (USEPA16) PAHs	-	-	< 1.28	-

* Denotes compound is not UKAS accredited

"M" denotes that % fit has been manually interpreted

Internal Standards	% Area
1,4-Dichlorobenzene-d4	NA
Naphthalene-d8	86
Acenaphthene-d10	80
Phenanthrene-d10	73
Chrysene-d12	67
Perylene-d12	67

Surrogates	% Rec
Nitrobenzene-d5	NA
2-Fluorobiphenyl	100
Terphenyl-d14	101

Concentrations are reported on a wet weight basis.

The Total PAH result is the sum of non-rounded individual PAH results and therefore may differ to the sum of the rounded individual PAH results printed above. By convention, where any one or more result is a "less than", the total is expressed as a "less than" and includes the "less than" concentration within the total.

Where individual results are flagged see report notes for status.

Polycyclic Aromatic Hydrocarbons
GC/MS (SIM)

Customer and Site Details:	Hyder Consulting UK Ltd: LNO1323		
Sample Details:	TP20 1.2	**Job Number:**	S10_0786
LIMS ID Number:	CL1003535	**Date Booked in:**	15-Feb-10
QC Batch Number:	0499	**Date Extracted:**	19-Feb-10
Quantitation File:	Initial Calibration	**Date Analysed:**	19-Feb-10
Directory:	\0219PAHGC5\	**Matrix:**	Soil
Dilution:	1.0	**Ext Method:**	Ultrasonic

UKAS accredited?: Yes

Target Compounds	CAS #	R.T. (min)	Concentration mg/kg	% Fit
Naphthalene	91-20-3	-	< 0.08	-
Acenaphthylene	208-96-8	-	< 0.08	-
Acenaphthene	83-32-9	-	< 0.08	-
Fluorene	86-73-7	-	< 0.08	-
Phenanthrene	85-01-8	-	< 0.08	-
Anthracene	120-12-7	-	< 0.08	-
Fluoranthene	206-44-0	-	< 0.08	-
Pyrene	129-00-0	-	< 0.08	-
Benzo[a]anthracene	56-55-3	-	< 0.08	-
Chrysene	218-01-9	-	< 0.08	-
Benzo[b]fluoranthene	205-99-2	-	< 0.08	-
Benzo[k]fluoranthene	207-08-9	-	< 0.08	-
Benzo[a]pyrene	50-32-8	-	< 0.08	-
Indeno[1,2,3-cd]pyrene	193-39-5	-	< 0.08	-
Dibenzo[a,h]anthracene	53-70-3	-	< 0.08	-
Benzo[g,h,i]perylene	191-24-2	-	< 0.08	-
Total (USEPA16) PAHs	-	-	< 1.28	-

"M" denotes that % fit has been manually interpreted

Internal Standards	% Area
1,4-Dichlorobenzene-d4	NA
Naphthalene-d8	85
Acenaphthene-d10	81
Phenanthrene-d10	81
Chrysene-d12	77
Perylene-d12	76

Surrogates	% Rec
Nitrobenzene-d5	NA
2-Fluorobiphenyl	103
Terphenyl-d14	110

Concentrations are reported on a wet weight basis.

The Total PAH result is the sum of non-rounded individual PAH results and therefore may differ to the sum of the rounded individual PAH results printed above. By convention, where any one or more result is a "less than", the total is expressed as a "less than" and includes the "less than" concentration within the total.

Where individual results are flagged see report notes for status.

Polycyclic Aromatic Hydrocarbons
GC/MS (SIM)

Customer and Site Details:	Hyder Consulting UK Ltd: LNO1323		
Sample Details:	TP21 0.5	**Job Number:**	S10_0786
LIMS ID Number:	CL1003536	**Date Booked in:**	15-Feb-10
QC Batch Number:	0499	**Date Extracted:**	19-Feb-10
Quantitation File:	Initial Calibration	**Date Analysed:**	19-Feb-10
Directory:	\0219PAHGC5\	**Matrix:**	Soil
Dilution:	1.0	**Ext Method:**	Ultrasonic

UKAS accredited?: Yes

Target Compounds	CAS #	R.T. (min)	Concentration mg/kg	% Fit
Naphthalene	91-20-3	-	< 0.08	-
Acenaphthylene	208-96-8	-	< 0.08	-
Acenaphthene	83-32-9	-	< 0.08	-
Fluorene	86-73-7	-	< 0.08	-
Phenanthrene	85-01-8	-	< 0.08	-
Anthracene	120-12-7	-	< 0.08	-
Fluoranthene	206-44-0	-	< 0.08	-
Pyrene	129-00-0	-	< 0.08	-
Benzo[a]anthracene	56-55-3	-	< 0.08	-
Chrysene	218-01-9	-	< 0.08	-
Benzo[b]fluoranthene	205-99-2	-	< 0.08	-
Benzo[k]fluoranthene	207-08-9	-	< 0.08	-
Benzo[a]pyrene	50-32-8	-	< 0.08	-
Indeno[1,2,3-cd]pyrene	193-39-5	-	< 0.08	-
Dibenzo[a,h]anthracene	53-70-3	-	< 0.08	-
Benzo[g,h,i]perylene	191-24-2	-	< 0.08	-
Total (USEPA16) PAHs	-	-	< 1.28	-

"M" denotes that % fit has been manually interpreted

Internal Standards	% Area
1,4-Dichlorobenzene-d4	NA
Naphthalene-d8	87
Acenaphthene-d10	82
Phenanthrene-d10	84
Chrysene-d12	83
Perylene-d12	83

Surrogates	% Rec
Nitrobenzene-d5	NA
2-Fluorobiphenyl	103
Terphenyl-d14	111

Concentrations are reported on a wet weight basis.

The Total PAH result is the sum of non-rounded individual PAH results and therefore may differ to the sum of the rounded individual PAH results printed above. By convention, where any one or more result is a "less than", the total is expressed as a "less than" and includes the "less than" concentration within the total.

Where individual results are flagged see report notes for status.

Polycyclic Aromatic Hydrocarbons
GC/MS (SIM)

Customer and Site Details:	Hyder Consulting UK Ltd: LNO1323		
Sample Details:	TP22 1.2	**Job Number:**	S10_0786
LIMS ID Number:	CL1003537	**Date Booked in:**	15-Feb-10
QC Batch Number:	0499	**Date Extracted:**	19-Feb-10
Quantitation File:	Initial Calibration	**Date Analysed:**	19-Feb-10
Directory:	\0219PAHGC5\	**Matrix:**	Soil
Dilution:	1.0	**Ext Method:**	Ultrasonic

UKAS accredited?: Yes

Target Compounds	CAS #	R.T. (min)	Concentration mg/kg	% Fit
Naphthalene	91-20-3	-	< 0.08	-
Acenaphthylene	208-96-8	-	< 0.08	-
Acenaphthene	83-32-9	-	< 0.08	-
Fluorene	86-73-7	-	< 0.08	-
Phenanthrene	85-01-8	-	< 0.08	-
Anthracene	120-12-7	-	< 0.08	-
Fluoranthene	206-44-0	-	< 0.08	-
Pyrene	129-00-0	-	< 0.08	-
Benzo[a]anthracene	56-55-3	-	< 0.08	-
Chrysene	218-01-9	-	< 0.08	-
Benzo[b]fluoranthene	205-99-2	-	< 0.08	-
Benzo[k]fluoranthene	207-08-9	-	< 0.08	-
Benzo[a]pyrene	50-32-8	-	< 0.08	-
Indeno[1,2,3-cd]pyrene	193-39-5	-	< 0.08	-
Dibenzo[a,h]anthracene	53-70-3	-	< 0.08	-
Benzo[g,h,i]perylene	191-24-2	-	< 0.08	-
Total (USEPA16) PAHs	-	-	< 1.28	-

"M" denotes that % fit has been manually interpreted

Internal Standards	% Area
1,4-Dichlorobenzene-d4	NA
Naphthalene-d8	85
Acenaphthene-d10	80
Phenanthrene-d10	75
Chrysene-d12	76
Perylene-d12	72

Surrogates	% Rec
Nitrobenzene-d5	NA
2-Fluorobiphenyl	104
Terphenyl-d14	115

Concentrations are reported on a wet weight basis.

The Total PAH result is the sum of non-rounded individual PAH results and therefore may differ to the sum of the rounded individual PAH results printed above. By convention, where any one or more result is a "less than", the total is expressed as a "less than" and includes the "less than" concentration within the total.

Where individual results are flagged see report notes for status.

Polycyclic Aromatic Hydrocarbons
GC/MS (SIM)

Customer and Site Details:	Hyder Consulting UK Ltd: LNO1323		
Sample Details:	TP24 0.5	**Job Number:**	S10_0786
LIMS ID Number:	CL1003538	**Date Booked in:**	15-Feb-10
QC Batch Number:	0499	**Date Extracted:**	19-Feb-10
Quantitation File:	Initial Calibration	**Date Analysed:**	19-Feb-10
Directory:	\0219PAHGC5\	**Matrix:**	Soil
Dilution:	1.0	**Ext Method:**	Ultrasonic

UKAS accredited?: Yes

Target Compounds	CAS #	R.T. (min)	Concentration mg/kg	% Fit
Naphthalene	91-20-3	-	< 0.08	-
Acenaphthylene	208-96-8	-	< 0.08	-
Acenaphthene	83-32-9	-	< 0.08	-
Fluorene	86-73-7	-	< 0.08	-
Phenanthrene	85-01-8	5.69	0.10	94
Anthracene	120-12-7	-	< 0.08	-
Fluoranthene	206-44-0	7.03	0.61	95
Pyrene	129-00-0	7.31	0.62	98
Benzo[a]anthracene	56-55-3	8.99	0.45	89
Chrysene	218-01-9	9.04	0.44	93
Benzo[b]fluoranthene	205-99-2	10.53	0.81	99
Benzo[k]fluoranthene	207-08-9	10.56	0.30	97
Benzo[a]pyrene	50-32-8	10.95	0.61	98
Indeno[1,2,3-cd]pyrene	193-39-5	12.33	0.48	100
Dibenzo[a,h]anthracene	53-70-3	-	< 0.08	-
Benzo[g,h,i]perylene	191-24-2	12.63	0.49	94
Total (USEPA16) PAHs	-	-	< 5.39	-

"M" denotes that % fit has been manually interpreted

Internal Standards	% Area
1,4-Dichlorobenzene-d4	NA
Naphthalene-d8	83
Acenaphthene-d10	77
Phenanthrene-d10	73
Chrysene-d12	67
Perylene-d12	68

Surrogates	% Rec
Nitrobenzene-d5	NA
2-Fluorobiphenyl	104
Terphenyl-d14	103

Concentrations are reported on a wet weight basis.

The Total PAH result is the sum of non-rounded individual PAH results and therefore may differ to the sum of the rounded individual PAH results printed above. By convention, where any one or more result is a "less than", the total is expressed as a "less than" and includes the "less than" concentration within the total.

Where individual results are flagged see report notes for status.

Polycyclic Aromatic Hydrocarbons
GC/MS (SIM)

Customer and Site Details:	Hyder Consulting UK Ltd: LNO1323		
Sample Details:	TP25 1.2	**Job Number:**	S10_0786
LIMS ID Number:	CL1003539	**Date Booked in:**	15-Feb-10
QC Batch Number:	0499	**Date Extracted:**	19-Feb-10
Quantitation File:	Initial Calibration	**Date Analysed:**	19-Feb-10
Directory:	\0219PAHGC5\	**Matrix:**	Soil
Dilution:	1.0	**Ext Method:**	Ultrasonic

UKAS accredited?: Yes

Target Compounds	CAS #	R.T. (min)	Concentration mg/kg	% Fit
Naphthalene	91-20-3	-	< 0.08	-
Acenaphthylene	208-96-8	-	< 0.08	-
Acenaphthene	83-32-9	-	< 0.08	-
Fluorene	86-73-7	-	< 0.08	-
Phenanthrene	85-01-8	-	< 0.08	-
Anthracene	120-12-7	-	< 0.08	-
Fluoranthene	206-44-0	7.03	0.19	95
Pyrene	129-00-0	7.32	0.18	99
Benzo[a]anthracene	56-55-3	8.99	0.13	92
Chrysene	218-01-9	9.04	0.13	94
Benzo[b]fluoranthene	205-99-2	10.53	0.31	77
Benzo[k]fluoranthene	207-08-9	10.56	0.12	80
Benzo[a]pyrene	50-32-8	10.96	0.23	93
Indeno[1,2,3-cd]pyrene	193-39-5	12.33	0.23	75
Dibenzo[a,h]anthracene	53-70-3	-	< 0.08	-
Benzo[g,h,i]perylene	191-24-2	12.63	0.24	95
Coronene	191-07-1 *	-	< 0.08	-
Total (USEPA16) PAHs	-	-	< 2.32	-

* Denotes compound is not UKAS accredited

"M" denotes that % fit has been manually interpreted

Internal Standards	% Area
1,4-Dichlorobenzene-d4	NA
Naphthalene-d8	82
Acenaphthene-d10	77
Phenanthrene-d10	73
Chrysene-d12	66
Perylene-d12	66

Surrogates	% Rec
Nitrobenzene-d5	NA
2-Fluorobiphenyl	104
Terphenyl-d14	104

Concentrations are reported on a wet weight basis.

The Total PAH result is the sum of non-rounded individual PAH results and therefore may differ to the sum of the rounded individual PAH results printed above. By convention, where any one or more result is a "less than", the total is expressed as a "less than" and includes the "less than" concentration within the total.

Where individual results are flagged see report notes for status.

Polycyclic Aromatic Hydrocarbons
GC/MS (SIM)

Customer and Site Details:	Hyder Consulting UK Ltd: LNO1323		
Sample Details:	TP25 2.0	**Job Number:**	S10_0786
LIMS ID Number:	CL1003540	**Date Booked in:**	15-Feb-10
QC Batch Number:	0499	**Date Extracted:**	19-Feb-10
Quantitation File:	Initial Calibration	**Date Analysed:**	19-Feb-10
Directory:	\0219PAHGC5\	**Matrix:**	Soil
Dilution:	1.0	**Ext Method:**	Ultrasonic

UKAS accredited?: Yes

Target Compounds	CAS #	R.T. (min)	Concentration mg/kg	% Fit
Naphthalene	91-20-3	-	< 0.08	-
Acenaphthylene	208-96-8	-	< 0.08	-
Acenaphthene	83-32-9	-	< 0.08	-
Fluorene	86-73-7	-	< 0.08	-
Phenanthrene	85-01-8	-	< 0.08	-
Anthracene	120-12-7	-	< 0.08	-
Fluoranthene	206-44-0	-	< 0.08	-
Pyrene	129-00-0	-	< 0.08	-
Benzo[a]anthracene	56-55-3	-	< 0.08	-
Chrysene	218-01-9	-	< 0.08	-
Benzo[b]fluoranthene	205-99-2	-	< 0.08	-
Benzo[k]fluoranthene	207-08-9	-	< 0.08	-
Benzo[a]pyrene	50-32-8	-	< 0.08	-
Indeno[1,2,3-cd]pyrene	193-39-5	-	< 0.08	-
Dibenzo[a,h]anthracene	53-70-3	-	< 0.08	-
Benzo[g,h,i]perylene	191-24-2	-	< 0.08	-
Total (USEPA16) PAHs	-	-	< 1.28	-

"M" denotes that % fit has been manually interpreted

Internal Standards	% Area
1,4-Dichlorobenzene-d4	NA
Naphthalene-d8	87
Acenaphthene-d10	81
Phenanthrene-d10	82
Chrysene-d12	83
Perylene-d12	80

Surrogates	% Rec
Nitrobenzene-d5	NA
2-Fluorobiphenyl	102
Terphenyl-d14	110

Concentrations are reported on a wet weight basis.

The Total PAH result is the sum of non-rounded individual PAH results and therefore may differ to the sum of the rounded individual PAH results printed above. By convention, where any one or more result is a "less than", the total is expressed as a "less than" and includes the "less than" concentration within the total.

Where individual results are flagged see report notes for status.

Polycyclic Aromatic Hydrocarbons
GC/MS (SIM)

Customer and Site Details:	Hyder Consulting UK Ltd: LNO1323		
Sample Details:	TP26 0.5	**Job Number:**	S10_0786
LIMS ID Number:	CL1003541	**Date Booked in:**	15-Feb-10
QC Batch Number:	0499	**Date Extracted:**	19-Feb-10
Quantitation File:	Initial Calibration	**Date Analysed:**	19-Feb-10
Directory:	\0219PAHGC5\	**Matrix:**	Soil
Dilution:	1.0	**Ext Method:**	Ultrasonic

UKAS accredited?: Yes

Target Compounds	CAS #	R.T. (min)	Concentration mg/kg	% Fit
Naphthalene	91-20-3	-	< 0.08	-
Acenaphthylene	208-96-8	-	< 0.08	-
Acenaphthene	83-32-9	-	< 0.08	-
Fluorene	86-73-7	-	< 0.08	-
Phenanthrene	85-01-8	-	< 0.08	-
Anthracene	120-12-7	-	< 0.08	-
Fluoranthene	206-44-0	7.03	0.32	95
Pyrene	129-00-0	7.31	0.31	96
Benzo[a]anthracene	56-55-3	9.00	0.21	89
Chrysene	218-01-9	9.04	0.22	92
Benzo[b]fluoranthene	205-99-2	10.53	0.43	92
Benzo[k]fluoranthene	207-08-9	10.56	0.16	92
Benzo[a]pyrene	50-32-8	10.95	0.27	99
Indeno[1,2,3-cd]pyrene	193-39-5	12.33	0.24	94
Dibenzo[a,h]anthracene	53-70-3	-	< 0.08	-
Benzo[g,h,i]perylene	191-24-2	12.63	0.24	96
Total (USEPA16) PAHs	-	-	< 2.96	-

"M" denotes that % fit has been manually interpreted

Internal Standards	% Area
1,4-Dichlorobenzene-d4	NA
Naphthalene-d8	85
Acenaphthene-d10	80
Phenanthrene-d10	82
Chrysene-d12	83
Perylene-d12	83

Surrogates	% Rec
Nitrobenzene-d5	NA
2-Fluorobiphenyl	102
Terphenyl-d14	110

Concentrations are reported on a wet weight basis.

The Total PAH result is the sum of non-rounded individual PAH results and therefore may differ to the sum of the rounded individual PAH results printed above. By convention, where any one or more result is a "less than", the total is expressed as a "less than" and includes the "less than" concentration within the total.

Where individual results are flagged see report notes for status.

Polycyclic Aromatic Hydrocarbons
GC/MS (SIM)

Customer and Site Details:	Hyder Consulting UK Ltd: LNO1323		
Sample Details:	TP27 0.3	**Job Number:**	S10_0786
LIMS ID Number:	CL1003542	**Date Booked in:**	15-Feb-10
QC Batch Number:	0499	**Date Extracted:**	19-Feb-10
Quantitation File:	Initial Calibration	**Date Analysed:**	19-Feb-10
Directory:	\0219PAHGC5\	**Matrix:**	Soil
Dilution:	1.0	**Ext Method:**	Ultrasonic

UKAS accredited?: Yes

Target Compounds	CAS #	R.T. (min)	Concentration mg/kg	% Fit
Naphthalene	91-20-3	3.31	0.13	97
Acenaphthylene	208-96-8	-	< 0.08	-
Acenaphthene	83-32-9	-	< 0.08	-
Fluorene	86-73-7	-	< 0.08	-
Phenanthrene	85-01-8	5.69	0.55	98
Anthracene	120-12-7	5.75	0.23	96
Fluoranthene	206-44-0	7.03	0.68	96
Pyrene	129-00-0	7.31	0.54	96
Benzo[a]anthracene	56-55-3	8.99	0.39	92
Chrysene	218-01-9	9.04	0.41	95
Benzo[b]fluoranthene	205-99-2	10.52	0.84	100
Benzo[k]fluoranthene	207-08-9	10.56	0.25	96
Benzo[a]pyrene	50-32-8	10.95	0.31	91
Indeno[1,2,3-cd]pyrene	193-39-5	12.33	0.43	96
Dibenzo[a,h]anthracene	53-70-3	12.36	0.14	76
Benzo[g,h,i]perylene	191-24-2	12.63	0.49	97
Total (USEPA16) PAHs	-	-	< 5.63	-

"M" denotes that % fit has been manually interpreted

Internal Standards	% Area
1,4-Dichlorobenzene-d4	NA
Naphthalene-d8	82
Acenaphthene-d10	76
Phenanthrene-d10	71
Chrysene-d12	73
Perylene-d12	75

Surrogates	% Rec
Nitrobenzene-d5	NA
2-Fluorobiphenyl	103
Terphenyl-d14	110

Concentrations are reported on a wet weight basis.

The Total PAH result is the sum of non-rounded individual PAH results and therefore may differ to the sum of the rounded individual PAH results printed above. By convention, where any one or more result is a "less than", the total is expressed as a "less than" and includes the "less than" concentration within the total.

Where individual results are flagged see report notes for status.

Polycyclic Aromatic Hydrocarbons
GC/MS (SIM)

Customer and Site Details:	Hyder Consulting UK Ltd: LNO1323		
Sample Details:	TP27 1.85	**Job Number:**	S10_0786
LIMS ID Number:	CL1003543	**Date Booked in:**	15-Feb-10
QC Batch Number:	0499	**Date Extracted:**	19-Feb-10
Quantitation File:	Initial Calibration	**Date Analysed:**	19-Feb-10
Directory:	\0219PAHGC5\	**Matrix:**	Soil
Dilution:	1.0	**Ext Method:**	Ultrasonic

UKAS accredited?: Yes

Target Compounds	CAS #	R.T. (min)	Concentration mg/kg	% Fit
Naphthalene	91-20-3	-	< 0.08	-
Acenaphthylene	208-96-8	-	< 0.08	-
Acenaphthene	83-32-9	-	< 0.08	-
Fluorene	86-73-7	-	< 0.08	-
Phenanthrene	85-01-8	-	< 0.08	-
Anthracene	120-12-7	-	< 0.08	-
Fluoranthene	206-44-0	-	< 0.08	-
Pyrene	129-00-0	-	< 0.08	-
Benzo[a]anthracene	56-55-3	-	< 0.08	-
Chrysene	218-01-9	-	< 0.08	-
Benzo[b]fluoranthene	205-99-2	-	< 0.08	-
Benzo[k]fluoranthene	207-08-9	-	< 0.08	-
Benzo[a]pyrene	50-32-8	-	< 0.08	-
Indeno[1,2,3-cd]pyrene	193-39-5	-	< 0.08	-
Dibenzo[a,h]anthracene	53-70-3	-	< 0.08	-
Benzo[g,h,i]perylene	191-24-2	-	< 0.08	-
Total (USEPA16) PAHs	-	-	< 1.28	-

"M" denotes that % fit has been manually interpreted

Internal Standards	% Area
1,4-Dichlorobenzene-d4	NA
Naphthalene-d8	84
Acenaphthene-d10	80
Phenanthrene-d10	80
Chrysene-d12	92
Perylene-d12	93

Surrogates	% Rec
Nitrobenzene-d5	NA
2-Fluorobiphenyl	101
Terphenyl-d14	122

Concentrations are reported on a wet weight basis.

The Total PAH result is the sum of non-rounded individual PAH results and therefore may differ to the sum of the rounded individual PAH results printed above. By convention, where any one or more result is a "less than", the total is expressed as a "less than" and includes the "less than" concentration within the total.

Where individual results are flagged see report notes for status.

Polycyclic Aromatic Hydrocarbons
GC/MS (SIM)

Customer and Site Details:	Hyder Consulting UK Ltd: LNO1323		
Sample Details:	TP28 0.5	**Job Number:**	S10_0786
LIMS ID Number:	CL1003544	**Date Booked in:**	15-Feb-10
QC Batch Number:	0499	**Date Extracted:**	19-Feb-10
Quantitation File:	Initial Calibration	**Date Analysed:**	20-Feb-10
Directory:	\0219PAHGC5\	**Matrix:**	Soil
Dilution:	1.0	**Ext Method:**	Ultrasonic

UKAS accredited?: Yes

Target Compounds	CAS #	R.T. (min)	Concentration mg/kg	% Fit
Naphthalene	91-20-3	-	< 0.08	-
Acenaphthylene	208-96-8	-	< 0.08	-
Acenaphthene	83-32-9	-	< 0.08	-
Fluorene	86-73-7	-	< 0.08	-
Phenanthrene	85-01-8	-	< 0.08	-
Anthracene	120-12-7	-	< 0.08	-
Fluoranthene	206-44-0	-	< 0.08	-
Pyrene	129-00-0	-	< 0.08	-
Benzo[a]anthracene	56-55-3	-	< 0.08	-
Chrysene	218-01-9	-	< 0.08	-
Benzo[b]fluoranthene	205-99-2	-	< 0.08	-
Benzo[k]fluoranthene	207-08-9	-	< 0.08	-
Benzo[a]pyrene	50-32-8	-	< 0.08	-
Indeno[1,2,3-cd]pyrene	193-39-5	-	< 0.08	-
Dibenzo[a,h]anthracene	53-70-3	-	< 0.08	-
Benzo[g,h,i]perylene	191-24-2	-	< 0.08	-
Total (USEPA16) PAHs	-	-	< 1.28	-

"M" denotes that % fit has been manually interpreted

Internal Standards	% Area
1,4-Dichlorobenzene-d4	NA
Naphthalene-d8	84
Acenaphthene-d10	78
Phenanthrene-d10	70
Chrysene-d12	68
Perylene-d12	63

Surrogates	% Rec
Nitrobenzene-d5	NA
2-Fluorobiphenyl	102
Terphenyl-d14	109

Concentrations are reported on a wet weight basis.

The Total PAH result is the sum of non-rounded individual PAH results and therefore may differ to the sum of the rounded individual PAH results printed above. By convention, where any one or more result is a "less than", the total is expressed as a "less than" and includes the "less than" concentration within the total.

Where individual results are flagged see report notes for status.

Polycyclic Aromatic Hydrocarbons
GC/MS (SIM)

Customer and Site Details:	Hyder Consulting UK Ltd: LNO1323		
Sample Details:	TP28 2.9	**Job Number:**	S10_0786
LIMS ID Number:	CL1003545	**Date Booked in:**	15-Feb-10
QC Batch Number:	0499	**Date Extracted:**	19-Feb-10
Quantitation File:	Initial Calibration	**Date Analysed:**	20-Feb-10
Directory:	\0219PAHGC5\	**Matrix:**	Soil
Dilution:	1.0	**Ext Method:**	Ultrasonic

UKAS accredited?: Yes

Target Compounds	CAS #	R.T. (min)	Concentration mg/kg	% Fit
Naphthalene	91-20-3	-	< 0.08	-
Acenaphthylene	208-96-8	-	< 0.08	-
Acenaphthene	83-32-9	-	< 0.08	-
Fluorene	86-73-7	-	< 0.08	-
Phenanthrene	85-01-8	-	< 0.08	-
Anthracene	120-12-7	-	< 0.08	-
Fluoranthene	206-44-0	-	< 0.08	-
Pyrene	129-00-0	-	< 0.08	-
Benzo[a]anthracene	56-55-3	-	< 0.08	-
Chrysene	218-01-9	-	< 0.08	-
Benzo[b]fluoranthene	205-99-2	-	< 0.08	-
Benzo[k]fluoranthene	207-08-9	-	< 0.08	-
Benzo[a]pyrene	50-32-8	-	< 0.08	-
Indeno[1,2,3-cd]pyrene	193-39-5	-	< 0.08	-
Dibenzo[a,h]anthracene	53-70-3	-	< 0.08	-
Benzo[g,h,i]perylene	191-24-2	-	< 0.08	-
Total (USEPA16) PAHs	-	-	< 1.28	-

"M" denotes that % fit has been manually interpreted

Internal Standards	% Area
1,4-Dichlorobenzene-d4	NA
Naphthalene-d8	86
Acenaphthene-d10	80
Phenanthrene-d10	78
Chrysene-d12	73
Perylene-d12	68

Surrogates	% Rec
Nitrobenzene-d5	NA
2-Fluorobiphenyl	105
Terphenyl-d14	108

Concentrations are reported on a wet weight basis.

The Total PAH result is the sum of non-rounded individual PAH results and therefore may differ to the sum of the rounded individual PAH results printed above. By convention, where any one or more result is a "less than", the total is expressed as a "less than" and includes the "less than" concentration within the total.

Where individual results are flagged see report notes for status.

Polycyclic Aromatic Hydrocarbons
GC/MS (SIM)

Customer and Site Details:	Hyder Consulting UK Ltd: LNO1323		
Sample Details:	TP29 0.5	**Job Number:**	S10_0786
LIMS ID Number:	CL1003546	**Date Booked in:**	15-Feb-10
QC Batch Number:	0499	**Date Extracted:**	19-Feb-10
Quantitation File:	Initial Calibration	**Date Analysed:**	20-Feb-10
Directory:	\0219PAHGC5\	**Matrix:**	Soil
Dilution:	1.0	**Ext Method:**	Ultrasonic

UKAS accredited?: Yes

Target Compounds	CAS #	R.T. (min)	Concentration mg/kg	% Fit
Naphthalene	91-20-3	-	< 0.08	-
Acenaphthylene	208-96-8	-	< 0.08	-
Acenaphthene	83-32-9	-	< 0.08	-
Fluorene	86-73-7	-	< 0.08	-
Phenanthrene	85-01-8	-	< 0.08	-
Anthracene	120-12-7	-	< 0.08	-
Fluoranthene	206-44-0	7.03	0.21	77
Pyrene	129-00-0	7.31	0.20	97
Benzo[a]anthracene	56-55-3	8.99	0.12	90
Chrysene	218-01-9	9.04	0.13	94
Benzo[b]fluoranthene	205-99-2	10.53	0.22	99
Benzo[k]fluoranthene	207-08-9	10.56	0.10	95
Benzo[a]pyrene	50-32-8	10.95	0.15	98
Indeno[1,2,3-cd]pyrene	193-39-5	12.34	0.15	44
Dibenzo[a,h]anthracene	53-70-3	-	< 0.08	-
Benzo[g,h,i]perylene	191-24-2	12.63	0.17	93
Total (USEPA16) PAHs	-	-	< 2.01	-

"M" denotes that % fit has been manually interpreted

Internal Standards	% Area
1,4-Dichlorobenzene-d4	NA
Naphthalene-d8	83
Acenaphthene-d10	79
Phenanthrene-d10	84
Chrysene-d12	88
Perylene-d12	90

Surrogates	% Rec
Nitrobenzene-d5	NA
2-Fluorobiphenyl	101
Terphenyl-d14	112

Concentrations are reported on a wet weight basis.

The Total PAH result is the sum of non-rounded individual PAH results and therefore may differ to the sum of the rounded individual PAH results printed above. By convention, where any one or more result is a "less than", the total is expressed as a "less than" and includes the "less than" concentration within the total.

Where individual results are flagged see report notes for status.

Polychlorinated Biphenyls (congeners)

Customer and Site Details: Hyder Consulting UK Ltd: LNO1323
Job Number: S10_0786
QC Batch Number: 100498
Directory: 0219PCB.GC8
Method: Ultrasonic

Matrix: SOIL
Date Booked in: 15-Feb-10
Date Extracted: 19-Feb-10
Date Analysed: 23-Feb-10

*** This sample data is not UKAS accredited.**

	Sample ID	Customer ID	Concentration, (µg/kg)						
			PCB28	PCB52	PCB101	PCB118	PCB153	PCB138	PCB180
*	CL1003534	TP20 0.5	<5.0	<5.0	6.4	<5.0	<5.0	7.3	<5.0
*	CL1003539	TP25 1.2	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0

Where individual results are flagged see report notes for status.

Total Petroleum Hydrocarbons (TPH) Carbon Ranges

Customer and Site Details: Hyder Consulting UK Ltd : LNO1323
Job Number: S10_0786
QC Batch Number: 100499
Directory: D:\TES\DATA\Y2010\0219TPH_GC3\079B4401.D
Method: Ultra Sonic

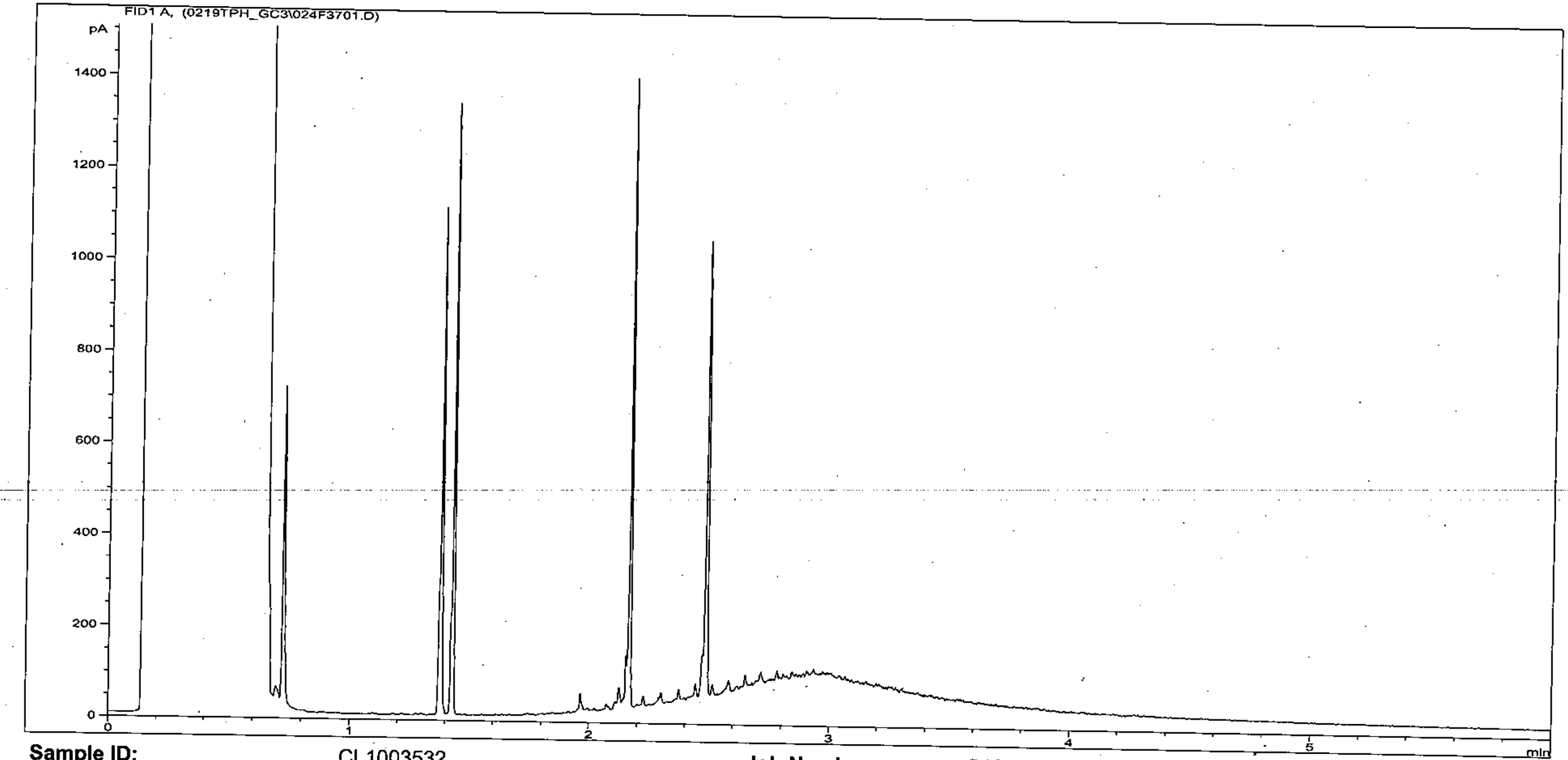
Matrix: Soil
Date Booked in: 15-Feb-10
Date Extracted: 19-Feb-10
Date Analysed: 19-Feb-10

*** Sample data with an asterisk are not UKAS accredited.**

Sample ID	Client ID	Concentration, (mg/kg) - as wet weight				
		>C8 - C10	>C10 - C12	>C12 - C16	>C16 - C21	>C21 - C35
CL1003532	BH20 0.75	<2	<2	<2	16.3	232
CL1003533	BH23 0.5	<2	<2	3.09	17.9	48.6
CL1003534	TP20 0.5	<2	<2	<2	8.84	62.4
CL1003535	TP20 1.2	<2	<2	2.28	3.9	10.5
CL1003536	TP21 0.5	<2	<2	2.65	9.9	39.7
CL1003537	TP22 1.2	<2	<2	2.92	5.93	22.4
CL1003538	TP24 0.5	<2	<2	2.04	18.3	359
CL1003539	TP25 1.2	<2	<2	<2	7.11	71.2
CL1003540	TP25 2.0	<2	<2	<2	2.35	13
CL1003541	TP26 0.5	<2	<2	<2	8.73	88.7
CL1003542	TP27 0.3	<2	<2	4.35	23.6	308
CL1003543	TP27 1.85	<2	<2	<2	<2	7.48
CL1003544	TP28 0.5	<2	<2	<2	2.11	4.88
CL1003545	TP28 2.9	<2	<2	<2	<2	<4.38
CL1003546	TP29 0.5	<2	<2	<2	5.75	62.5

Where individual results are flagged see report notes for status.

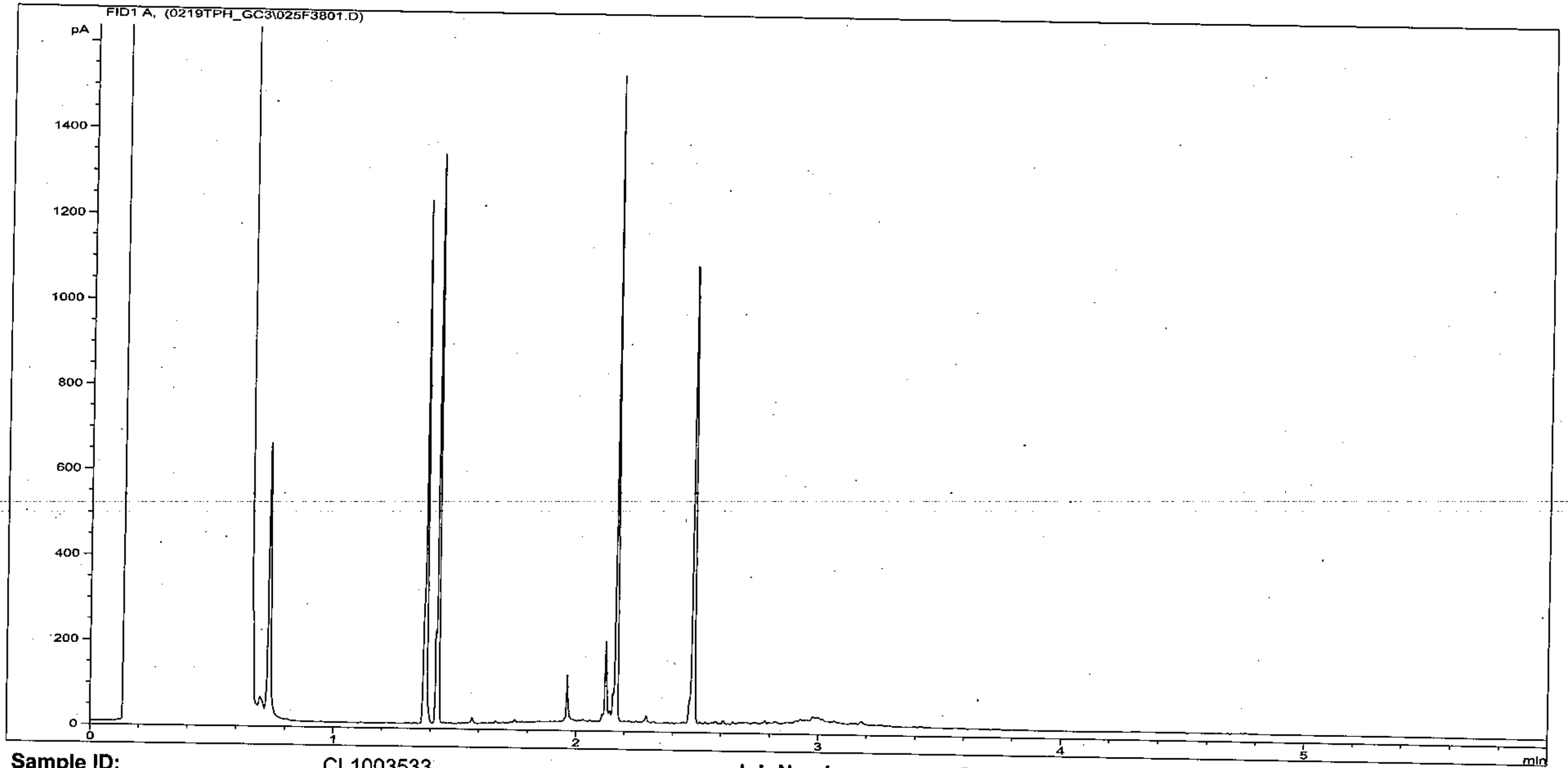
Petroleum Hydrocarbons (C8 to C40) by GC/FID



Sample ID:	CL1003532	**Job Number:**	S10_0786
Multiplier:	8	**Client:**	Hyder Consulting UK Ltd
Dilution:	1	**Site:**	LNO1323
Acquisition Method:	5UL_RUNF.M	**Client Sample Ref:**	BH20 0.75
Acquisition Date/Time:	19-Feb-10		
Datafile:	D:\TES\DATA\Y2010\0219TPH_GC3\024F3701.D		

Where individual results are flagged see report notes for status.

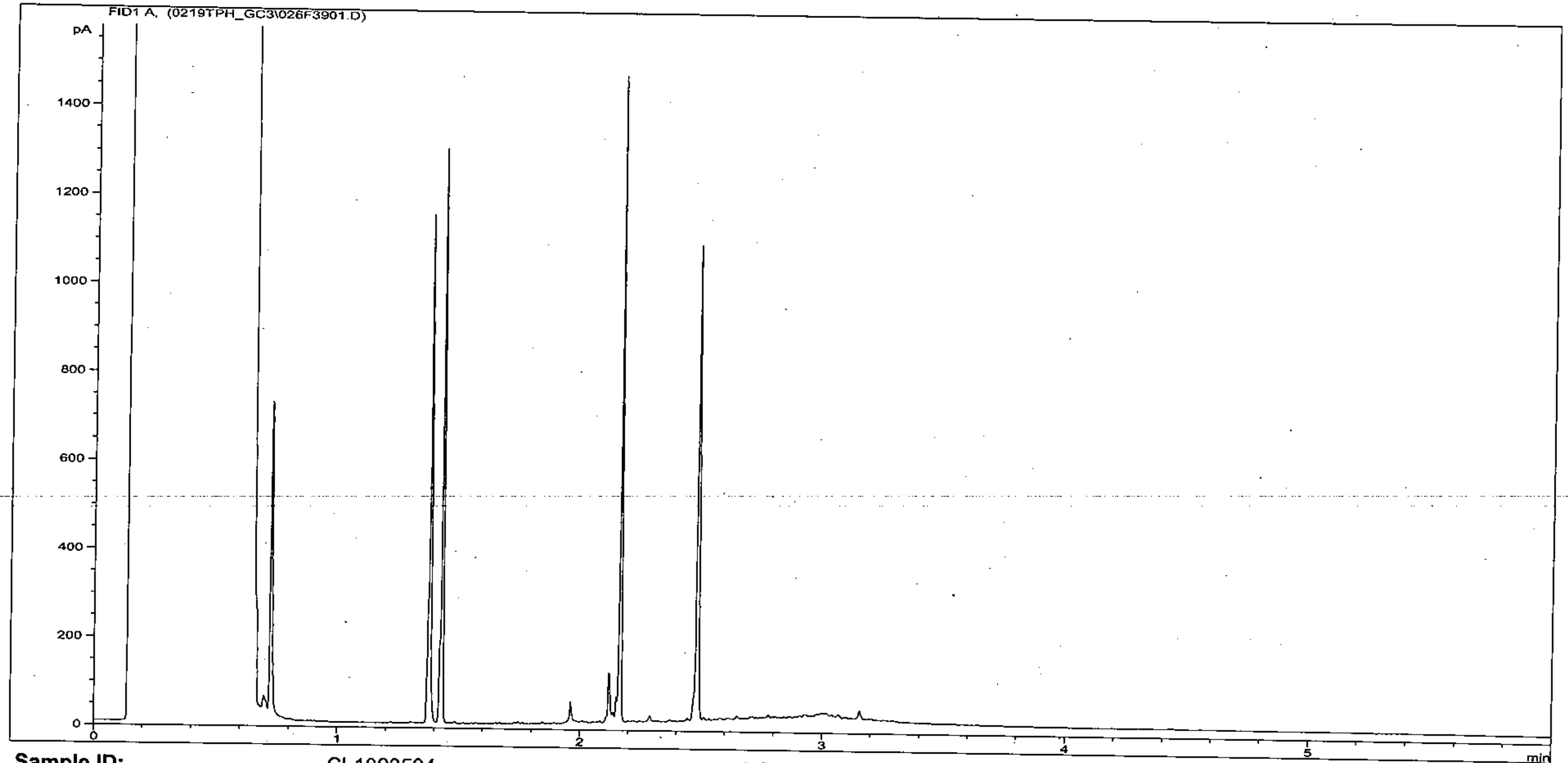
Petroleum Hydrocarbons (C8 to C40) by GC/FID



Sample ID:	CL1003533	**Job Number:**	S10_0786
Multiplier:	8	**Client:**	Hyder Consulting UK Ltd
Dilution:	1	**Site:**	LNO1323
Acquisition Method:	5UL_RUNF.M	**Client Sample Ref:**	BH23 0.5
Acquisition Date/Time:	19-Feb-10		
Datafile:	D:\TES\DATA\Y2010\0219TPH_GC3\025F3801.D		

Where individual results are flagged see report notes for status.

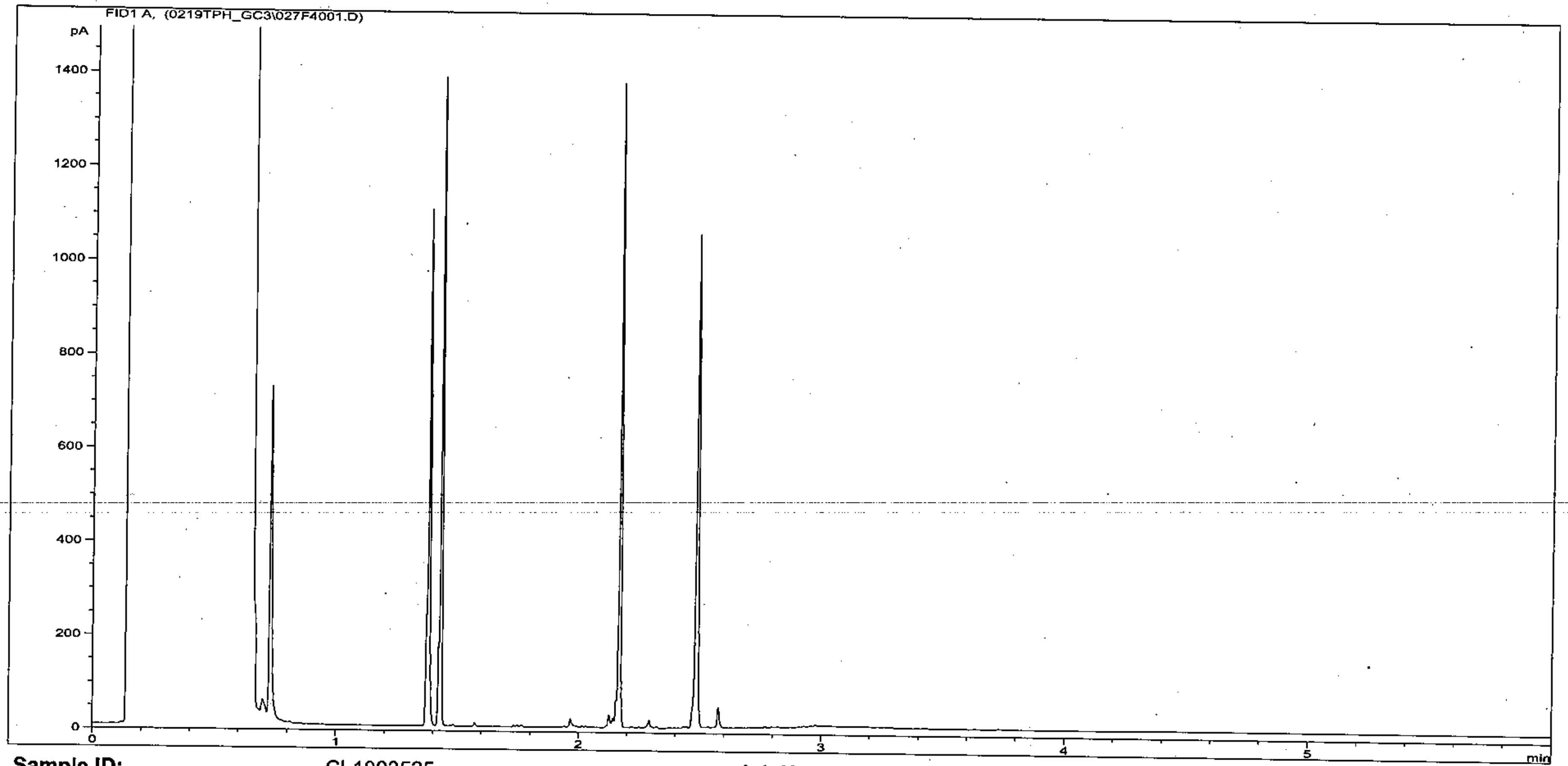
Petroleum Hydrocarbons (C8 to C40) by GC/FID



Sample ID:	CL1003534	**Job Number:**	S10_0786
Multiplier:	8	**Client:**	Hyder Consulting UK Ltd
Dilution:	1	**Site:**	LNO1323
Acquisition Method:	5UL_RUNF.M	**Client Sample Ref:**	TP20 0.5
Acquisition Date/Time:	19-Feb-10		
Datafile:	D:\TES\DATA\Y2010\0219TPH_GC3\026F3901.D		

Where individual results are flagged see report notes for status.

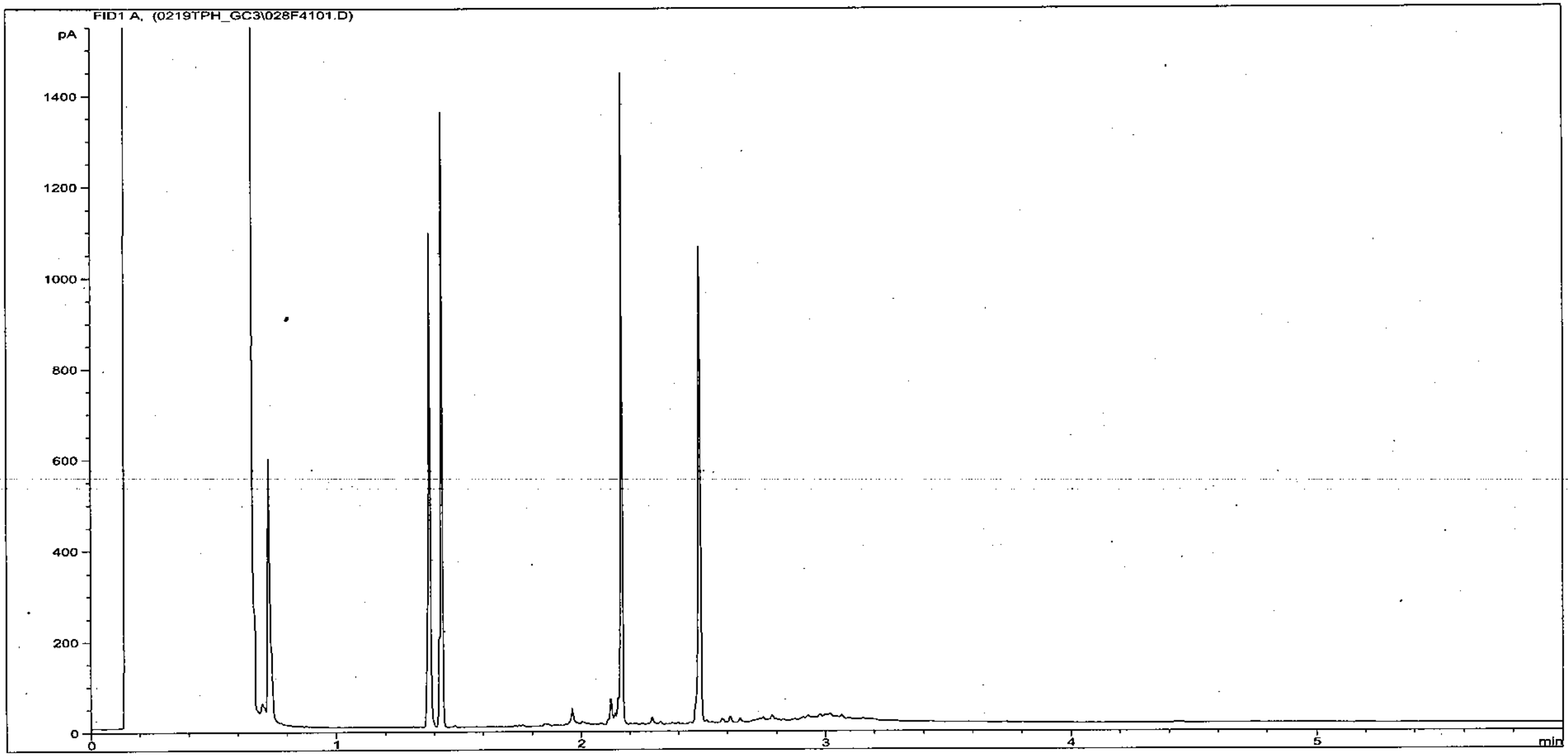
Petroleum Hydrocarbons (C8 to C40) by GC/FID



Sample ID:	CL1003535	**Job Number:**	S10_0786
Multiplier:	8	**Client:**	Hyder Consulting UK Ltd
Dilution:	1	**Site:**	LNO1323
Acquisition Method:	5UL_RUNF.M	**Client Sample Ref:**	TP20 1.2
Acquisition Date/Time:	19-Feb-10		
Datafile:	D:\TES\DATA\Y2010\0219TPH_GC3\027F4001.D		

Where individual results are flagged see report notes for status.

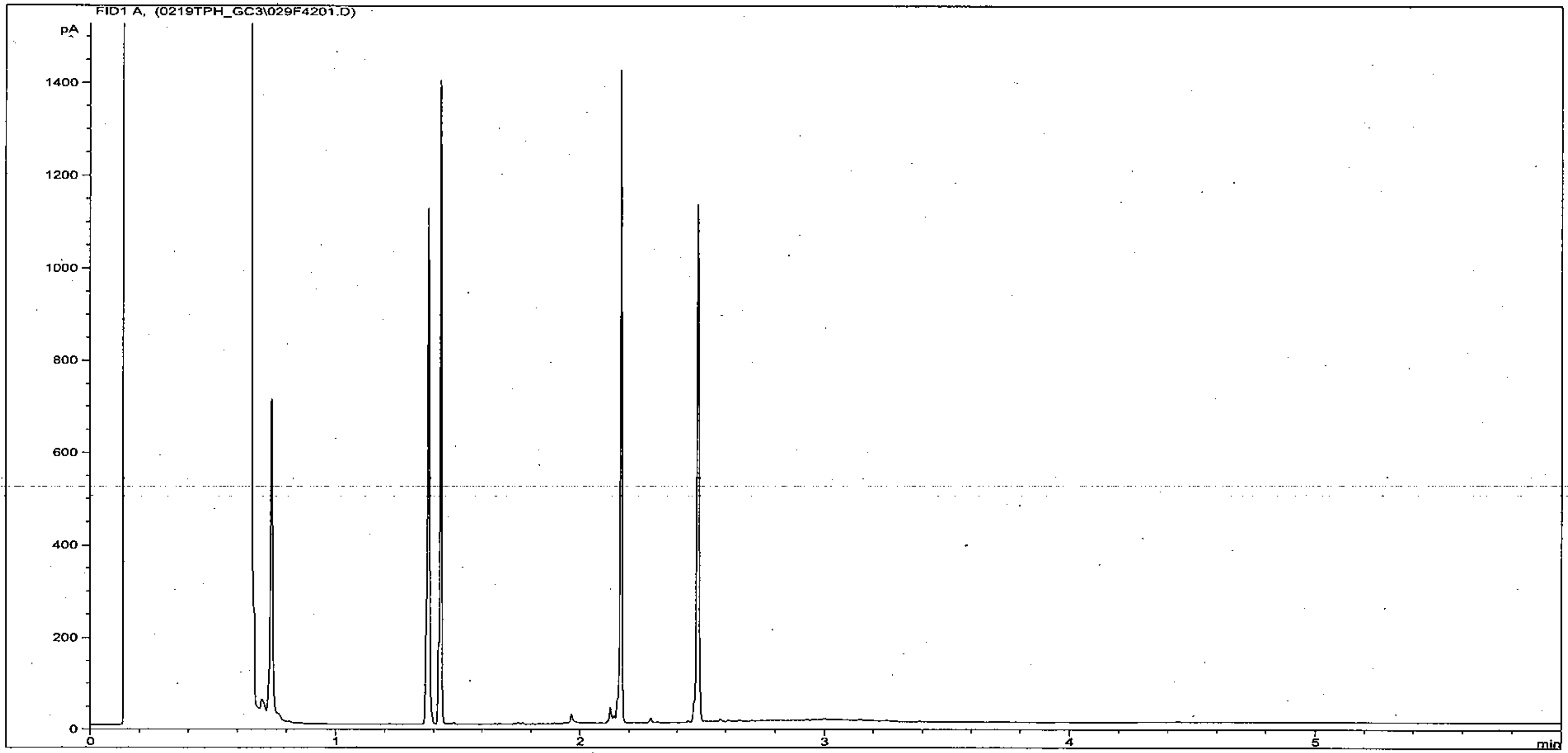
Petroleum Hydrocarbons (C8 to C40) by GC/FID



Sample ID:	CL1003536	**Job Number:**	S10_0786
Multiplier:	8	**Client:**	Hyder Consulting UK Ltd
Dilution:	1	**Site:**	LNO1323
Acquisition Method:	5UL_RUNF.M	**Client Sample Ref:**	TP21 0.5
Acquisition Date/Time:	19-Feb-10		
Datafile:	D:\TES\DATA\Y2010\0219TPH_GC3\028F4101.D		

Where individual results are flagged see report notes for status.

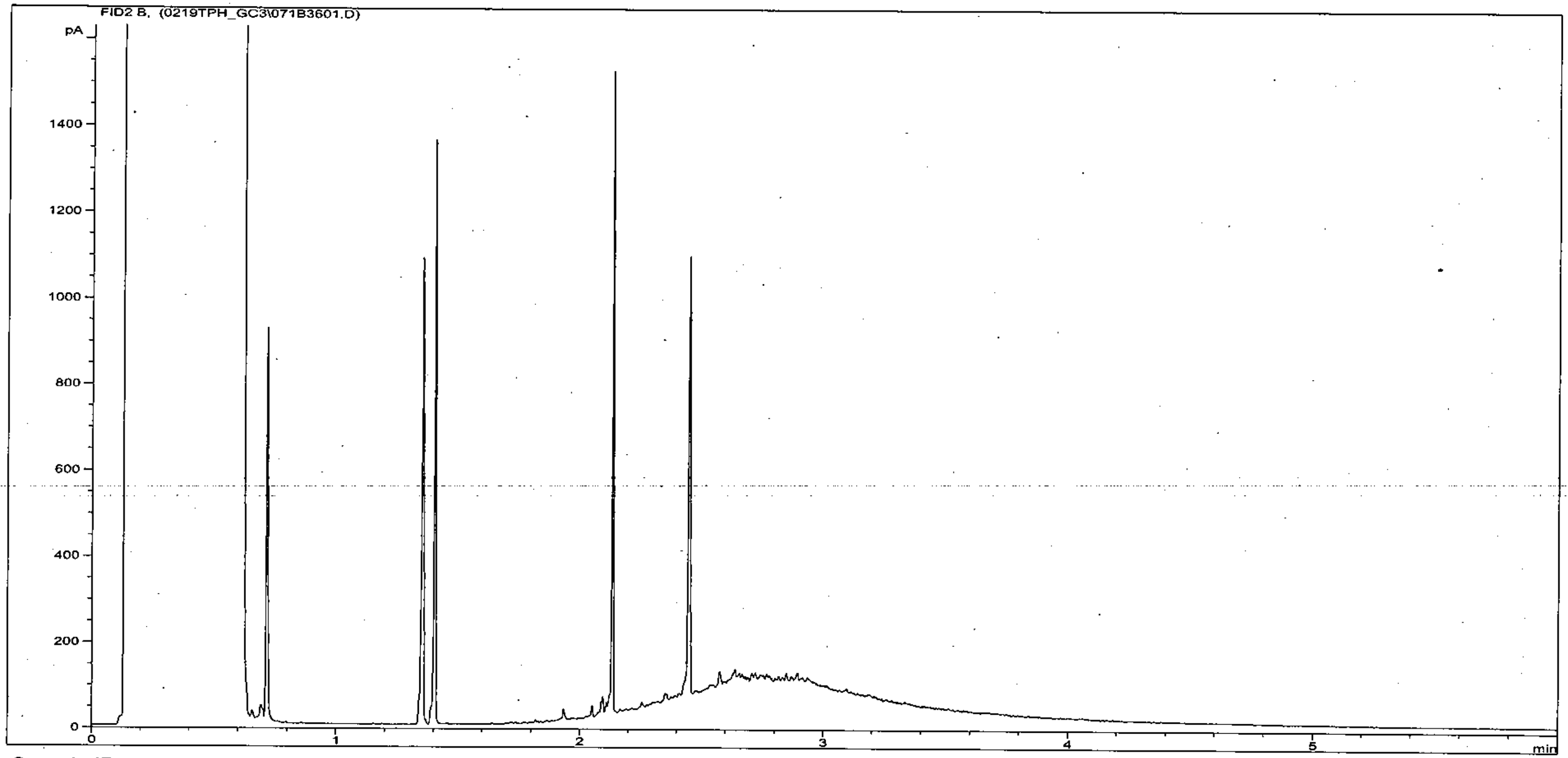
Petroleum Hydrocarbons (C8 to C40) by GC/FID



Sample ID:	CL1003537	**Job Number:**	S10_0786
Multiplier:	8	**Client:**	Hyder Consulting UK Ltd
Dilution:	1	**Site:**	LNO1323
Acquisition Method:	5UL_RUNF.M	**Client Sample Ref:**	TP22 1.2
Acquisition Date/Time:	19-Feb-10		
Datafile:	D:\TES\DATA\Y2010\0219TPH_GC3\029F4201.D		

Where individual results are flagged see report notes for status.

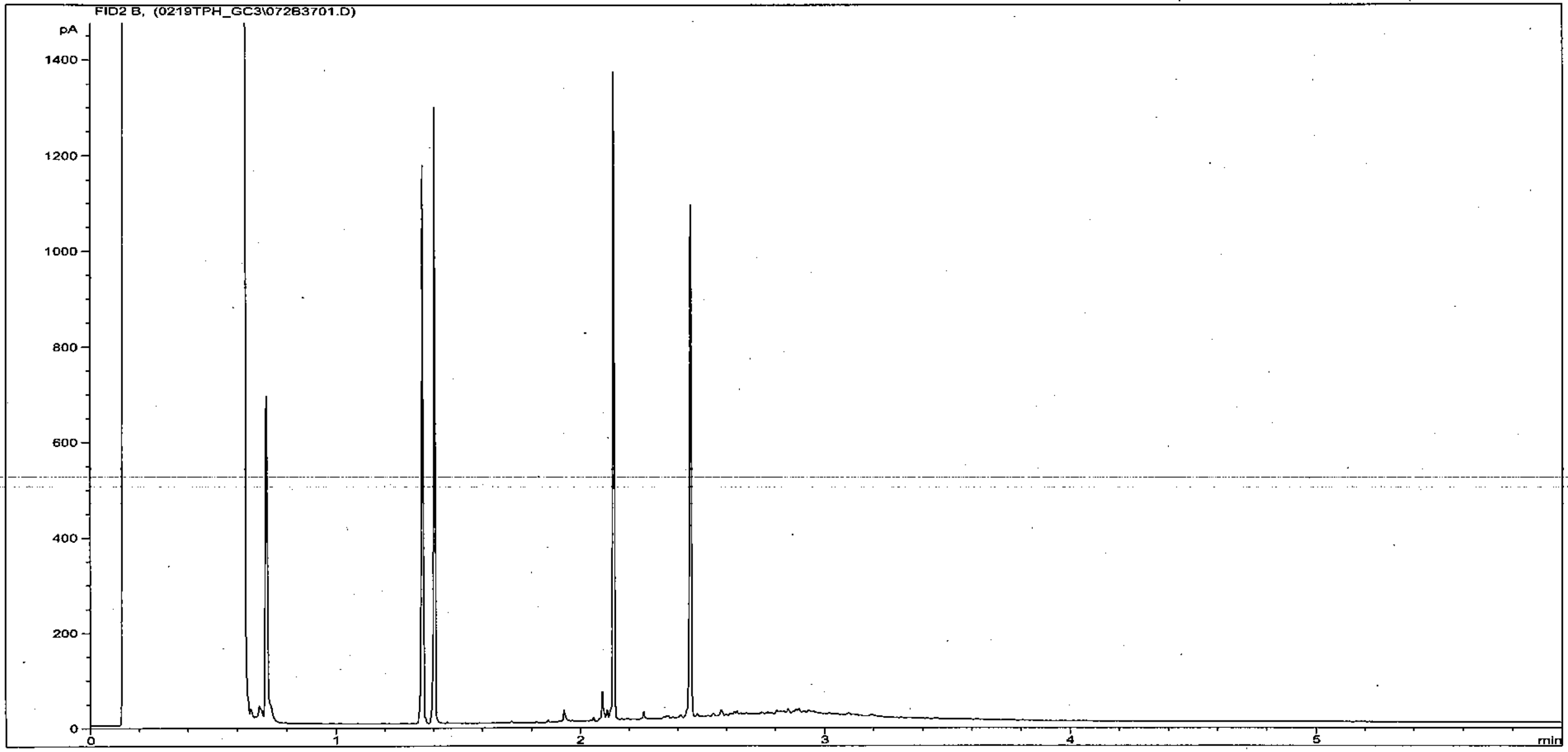
Petroleum Hydrocarbons (C8 to C40) by GC/FID



Sample ID:	CL1003538	**Job Number:**	S10_0786
Multiplier:	8	**Client:**	Hyder Consulting UK Ltd
Dilution:	1	**Site:**	LNO1323
Acquisition Method:	5UL_RUNF.M	**Client Sample Ref:**	TP24 0.5
Acquisition Date/Time:	19-Feb-10		
Datafile:	D:\TES\DATA\Y2010\0219TPH_GC3\071B3601.D		

Where individual results are flagged see report notes for status.

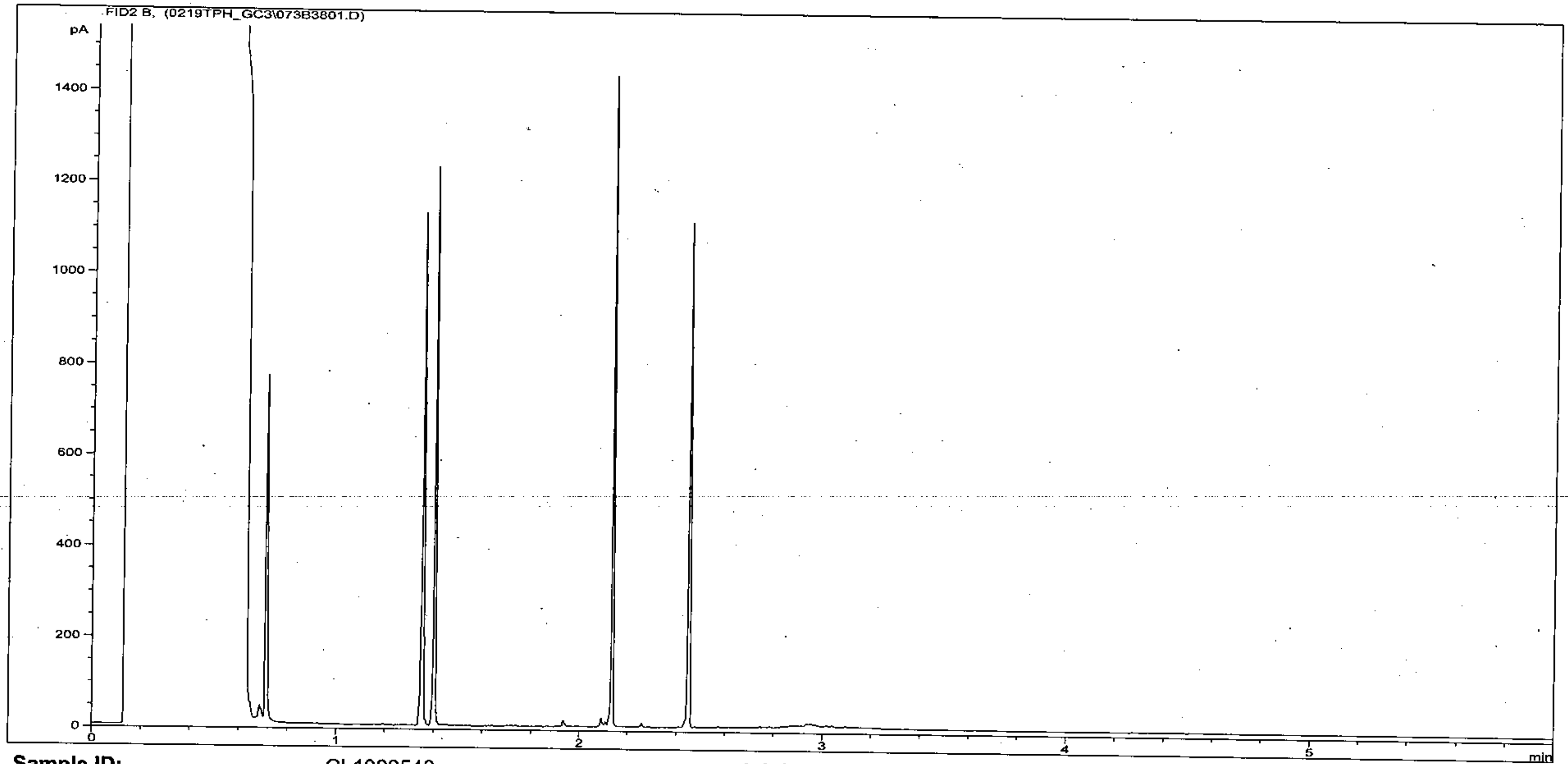
Petroleum Hydrocarbons (C8 to C40) by GC/FID



Sample ID:	CL1003539	**Job Number:**	S10_0786
Multiplier:	8	**Client:**	Hyder Consulting UK Ltd
Dilution:	1	**Site:**	LNO1323
Acquisition Method:	5UL_RUNF.M	**Client Sample Ref:**	TP25 1.2
Acquisition Date/Time:	19-Feb-10		
Datafile:	D:\TES\DATA\Y2010\0219TPH_GC3\072B3701.D		

Where individual results are flagged see report notes for status.

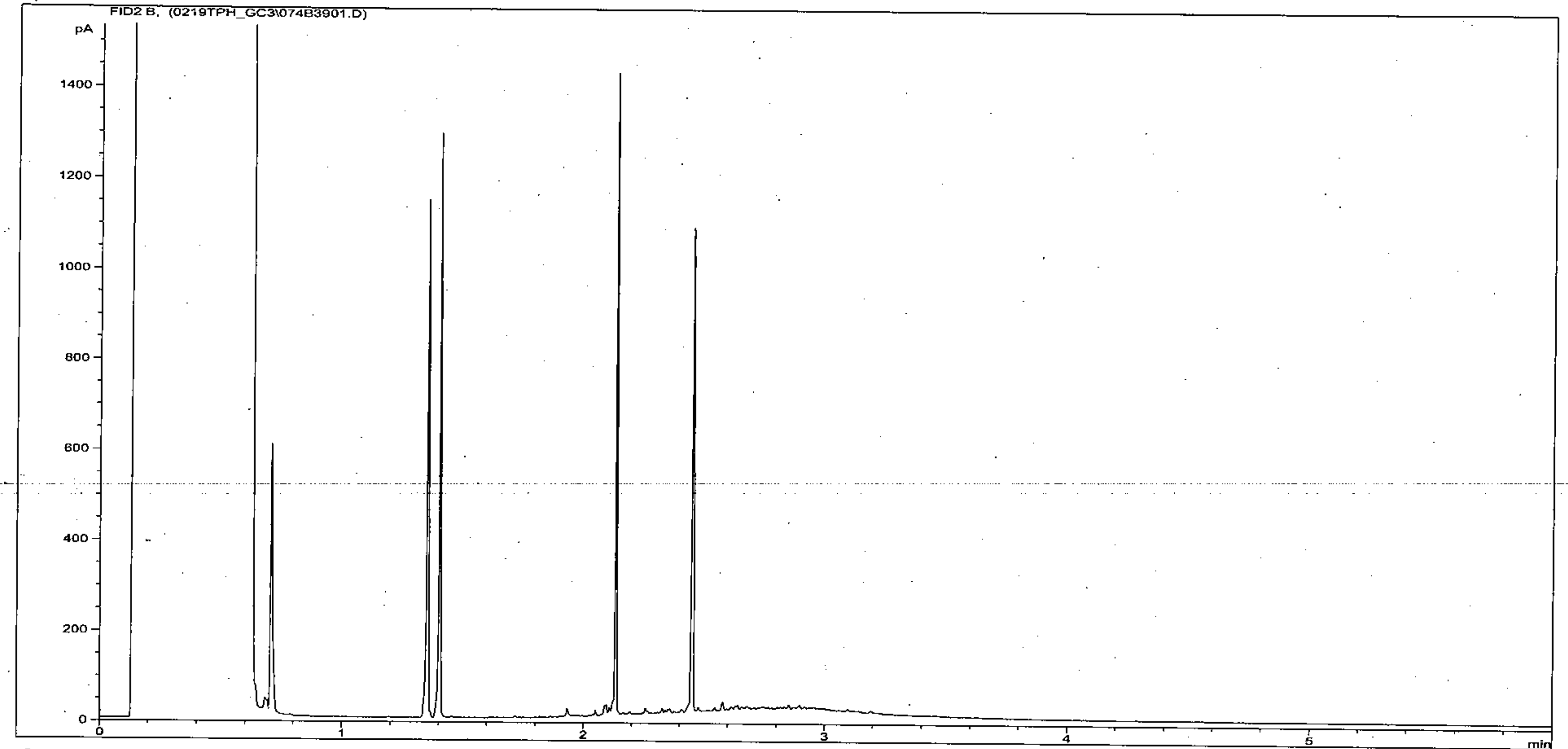
Petroleum Hydrocarbons (C8 to C40) by GC/FID



Sample ID:	CL1003540	**Job Number:**	S10_0786
Multiplier:	8	**Client:**	Hyder Consulting UK Ltd
Dilution:	1	**Site:**	LNO1323
Acquisition Method:	5UL_RUNF.M	**Client Sample Ref:**	TP25 2.0
Acquisition Date/Time:	19-Feb-10		
Datafile:	D:\TES\DATA\Y2010\0219TPH_GC3\073B3801.D		

Where individual results are flagged see report notes for status.

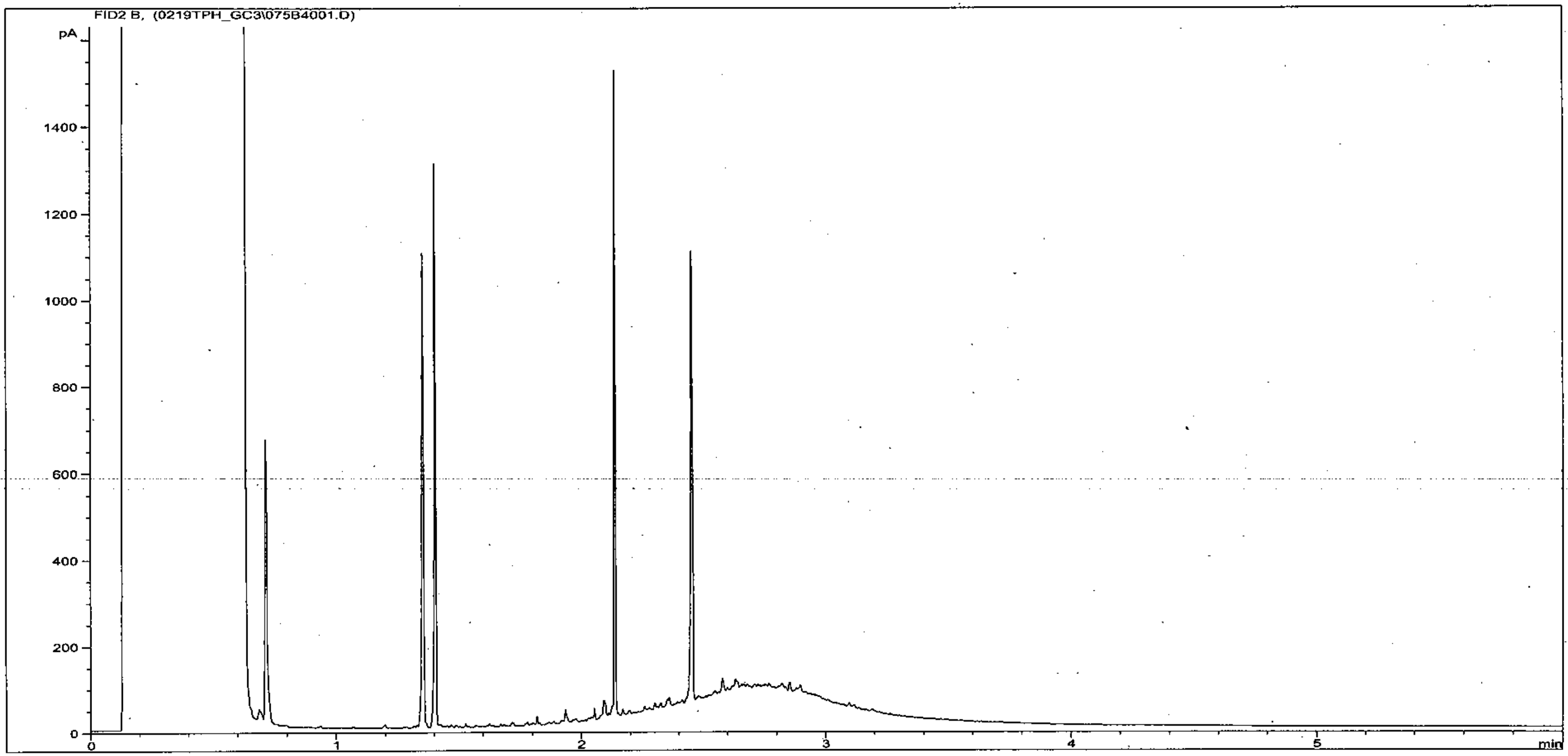
Petroleum Hydrocarbons (C8 to C40) by GC/FID



Sample ID:	CL1003541	**Job Number:**	S10_0786
Multiplier:	8	**Client:**	Hyder Consulting UK Ltd
Dilution:	1	**Site:**	LNO1323
Acquisition Method:	5UL_RUNF.M	**Client Sample Ref:**	TP26 0.5
Acquisition Date/Time:	19-Feb-10		
Datafile:	D:\TES\DATA\Y2010\0219TPH_GC3\074B3901.D		

Where individual results are flagged see report notes for status.

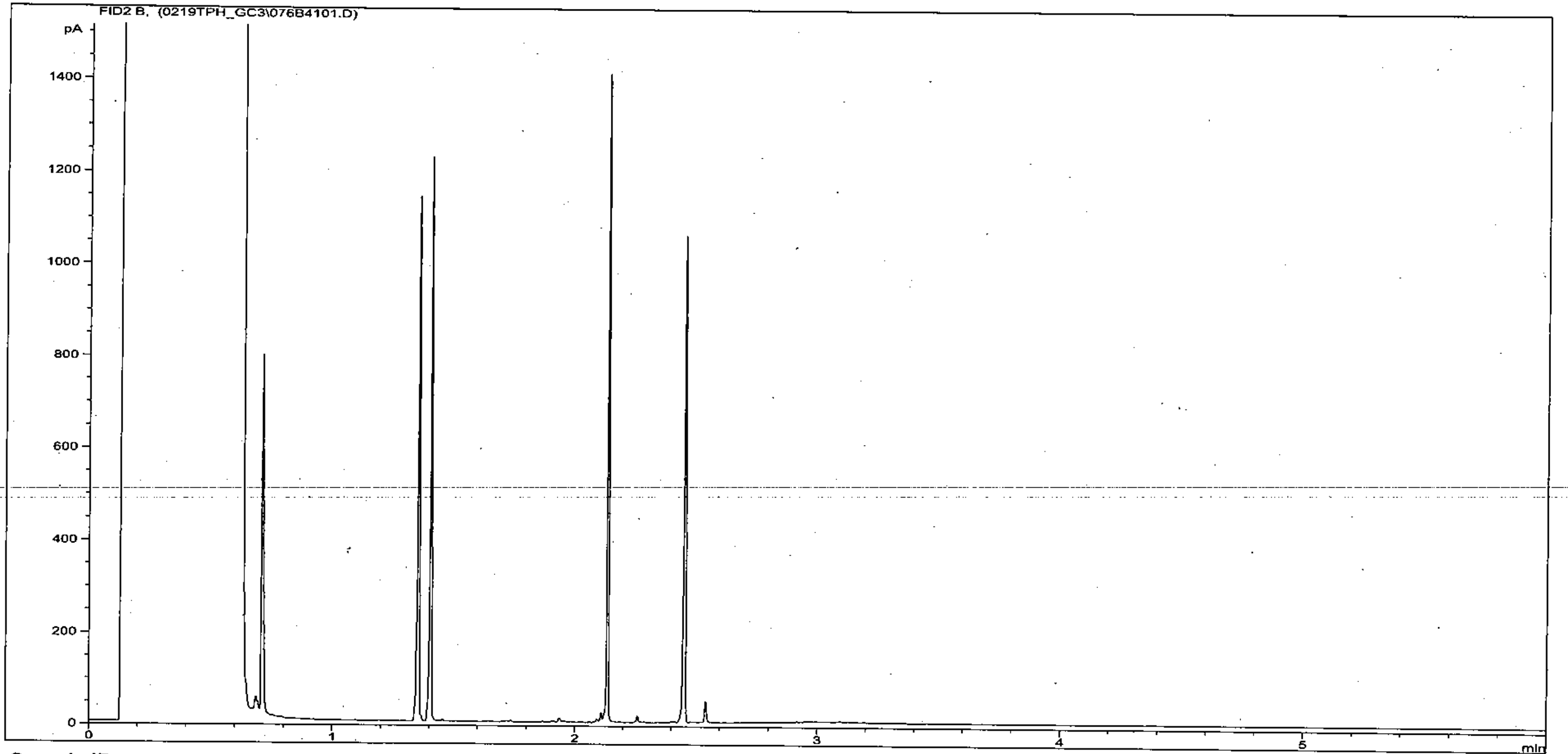
Petroleum Hydrocarbons (C8 to C40) by GC/FID



Sample ID:	CL1003542	**Job Number:**	S10_0786
Multiplier:	8	**Client:**	Hyder Consulting UK Ltd
Dilution:	1	**Site:**	LNO1323
Acquisition Method:	5UL_RUNF.M	**Client Sample Ref:**	TP27 0.3
Acquisition Date/Time:	19-Feb-10		
Datafile:	D:\TES\DATA\Y2010\0219TPH_GC3\075B4001.D		

Where individual results are flagged see report notes for status.

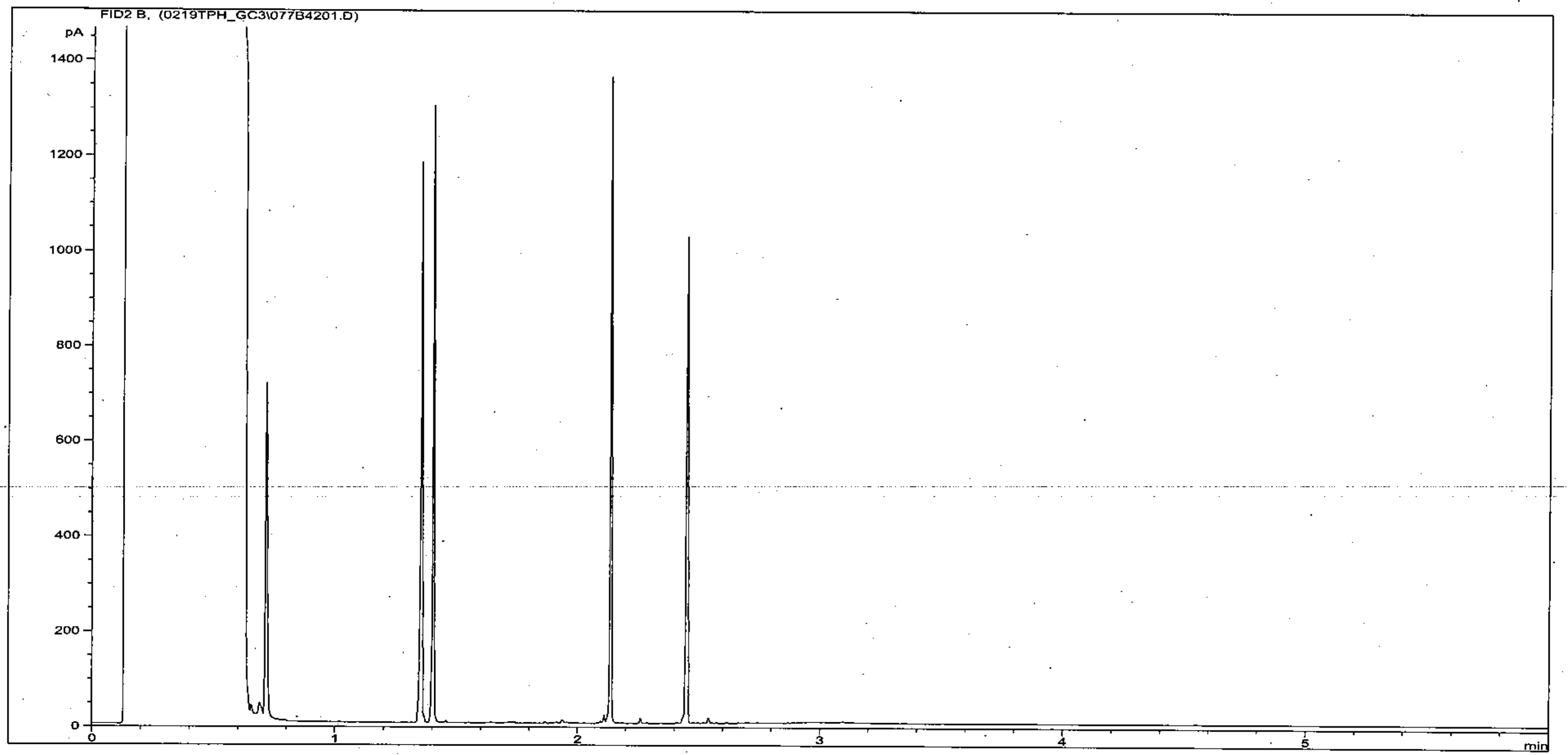
Petroleum Hydrocarbons (C8 to C40) by GC/FID



Sample ID:	CL1003543	**Job Number:**	S10_0786
Multiplier:	8	**Client:**	Hyder Consulting UK Ltd
Dilution:	1	**Site:**	LNO1323
Acquisition Method:	5UL_RUNF.M	**Client Sample Ref:**	TP27 1.85
Acquisition Date/Time:	19-Feb-10		
Datafile:	D:\TES\DATA\Y2010\0219TPH_GC3\076B4101.D		

Where individual results are flagged see report notes for status.

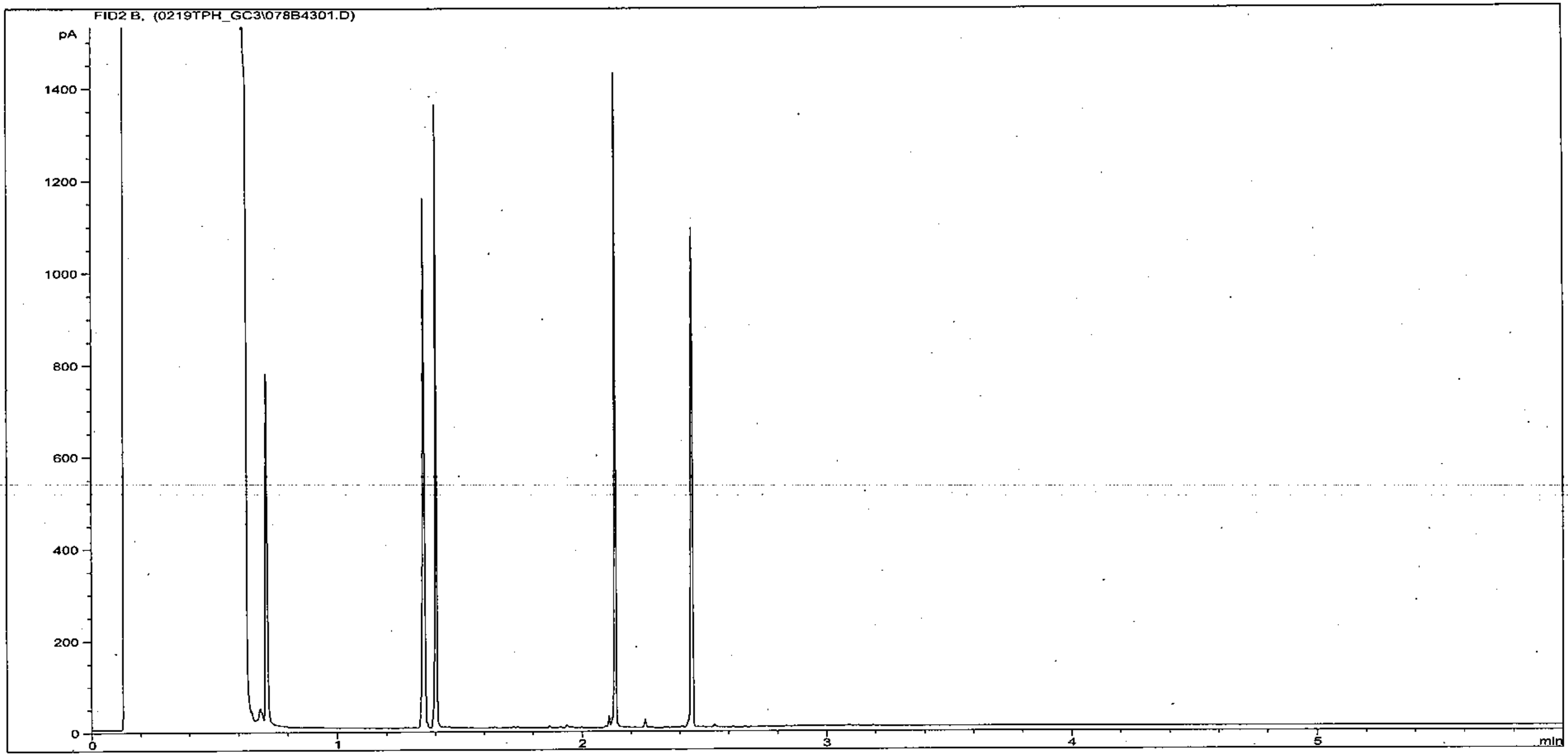
Petroleum Hydrocarbons (C8 to C40) by GC/FID



Sample ID:	CL1003544	**Job Number:**	S10_0786
Multiplier:	8	**Client:**	Hyder Consulting UK Ltd
Dilution:	1	**Site:**	LNO1323
Acquisition Method:	5UL_RUNF.M	**Client Sample Ref:**	TP28 0.5
Acquisition Date/Time:	19-Feb-10		
Datafile:	D:\TES\DATA\Y2010\0219TPH_GC3\077B4201.D		

Where individual results are flagged see report notes for status.

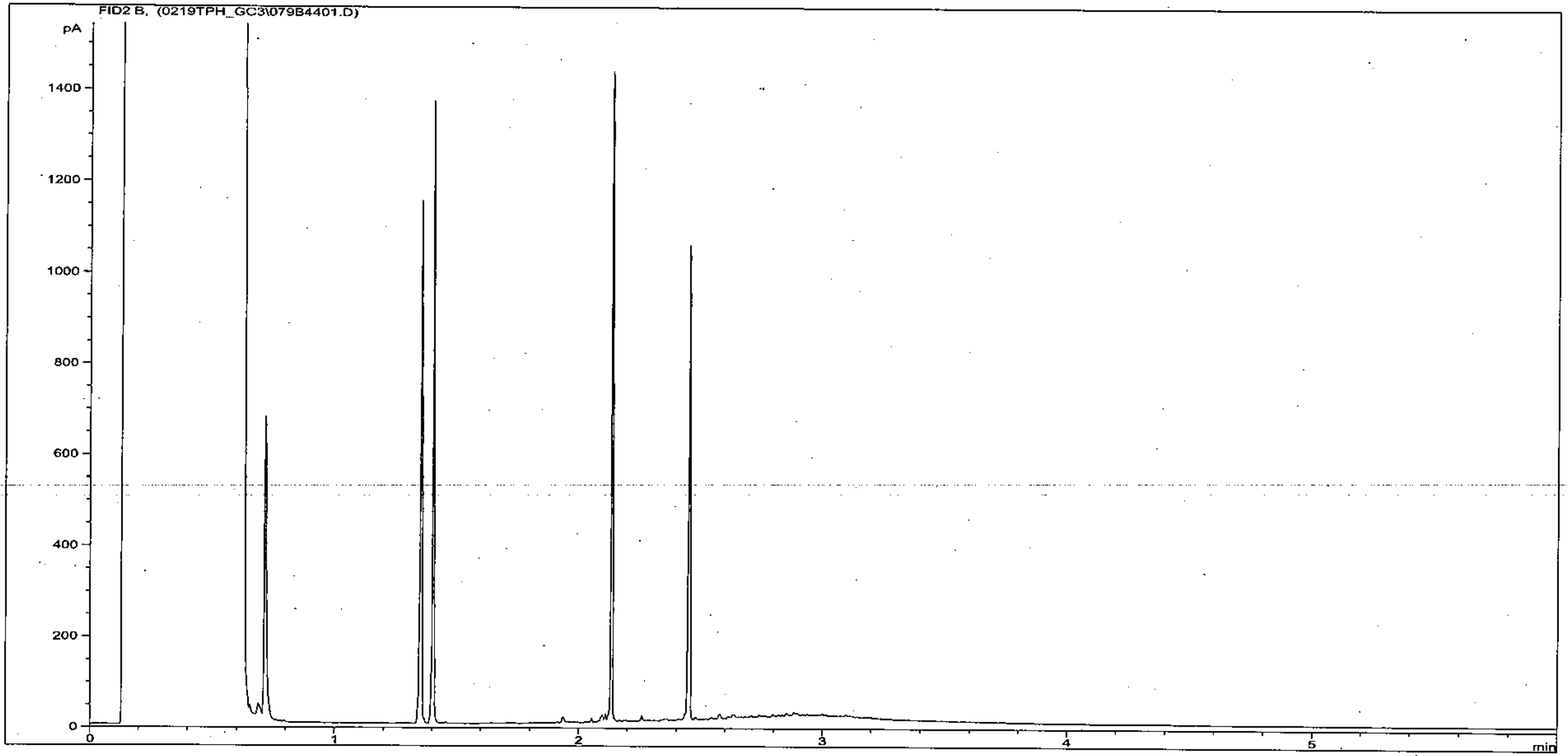
Petroleum Hydrocarbons (C8 to C40) by GC/FID



Sample ID:	CL1003545	**Job Number:**	S10_0786
Multiplier:	8	**Client:**	Hyder Consulting UK Ltd
Dilution:	1	**Site:**	LNO1323
Acquisition Method:	5UL_RUNF.M	**Client Sample Ref:**	TP28 2.9
Acquisition Date/Time:	19-Feb-10		
Datafile:	D:\TES\DATA\Y2010\0219TPH_GC3\078B4301.D		

Where individual results are flagged see report notes for status.

Petroleum Hydrocarbons (C8 to C40) by GC/FID



Sample ID:	CL1003546	**Job Number:**	S10_0786
Multiplier:	8	**Client:**	Hyder Consulting UK Ltd
Dilution:	1	**Site:**	LNO1323
Acquisition Method:	5UL_RUNF.M	**Client Sample Ref:**	TP29 0.5
Acquisition Date/Time:	19-Feb-10		
Datafile:	D:\TES\DATA\Y2010\0219TPH_GC3\079B4401.D		

Where individual results are flagged see report notes for status.

WASTE ACCEPTANCE CRITERIA TESTING
BSEN 12457/3

Client	Hyder Consulting UK Ltd			
Contact	[redacted]			
Site	LNO1323			
Sample Description		**Report No**	**Sample No**	**Issue Date**
TP20 0.5		s10_0786	CL/1003534	23-Feb-10

Leaching Data	
Weight of sample (kg)	0.225
Moisture content @ 105℃ (%)	25.9
Equivalent Weight based on drying at 105℃ (kg)	0.167
Volume of water required to carry out 2:1 stage (litres)	0.275
Weight of Sieved Soil to carry out 2:1 stage (kg)	0.304
Weight of Deionised water to carry out 2:1 stage (kg)	0.371
Volume to undertake analysis (2:1 Stage) (litres)	0.300
Weight of Deionised water to carry out 8:1 stage (kg)	1.299

Accreditation	Method Code	Solid Waste Analysis (Dry Basis)	Concentration in Solid (Dry Weight Basis)	Landfill Waste Acceptance Criteria Limit Values: Inert Waste Landfill	Stable Non-reactive Hazardous Waste in Non-Hazardous Landfill	Hazardous Waste Landfill
N	WSLM59	Total Organic Carbon (% M/M)	8.68	3	5	6
	LOI450	Loss on Ignition (%)				10
U	BTEXHSA	Sum of BTEX (mg/kg)	<0.06	6		
N	PCBUSECD	Sum of 7 Congener PCB's (mg/kg)	<0.0451	1		
U	TPHFIDUS	Mineral Oil (mg/kg)	127	500		
N	PAHMSUS	PAH Sum of 17 (mg/kg)	<1.84	100		
	WSLM3	pH (pH units)			>6	
	ANC	Acid Neutralisation Capacity (mol/kg) @pH 7			To be evaluated	To be evaluated

Accreditation	Method Code	Leachate Analysis	2:1 Leachate	8:1 Leachate	Calculated amount leached @ 2 1	Calculated cumulative amount leached @ 10 1	Landfill Waste Acceptance Criteria Limit Values for BSEN 12457/3 @ L/S 10 litre kg-1 mg/kg (dry weight)		
			mg/l except ∞		mg/kg (dry weight)				
U	WSLM3	pH (pH units) ∞	8	7.8	Calculated data not UKAS Accredited				
U	WSLM2	Conductivity (µs/cm) ∞	474	200					
U	ICPMSW	Arsenic	0.002	0.002	0.004	0.02	0.5	2	25
N	ICPWATVAR	Barium	0.29	0.24	0.58	2.5	20	100	300
U	ICPMSW	Cadmium	0.0003	<0.0001	0.0006	<0.001	0.04	1	5
U	ICPMSW	Chromium	0.003	0.004	0.006	0.04	0.5	10	70
U	ICPMSW	Copper	0.011	0.007	0.022	0.08	2	50	100
U	ICPMSW	Mercury	0.0001	<0.0001	0.0002	<0.001	0.01	0.2	2
U	ICPMSW	Molybdenum	0.035	0.014	0.07	0.18	0.5	10	30
U	ICPMSW	Nickel	0.004	0.002	0.008	0.02	0.4	10	40
U	ICPMSW	Lead	<0.001	0.016	<0.002	<0.13	0.5	10	50
U	ICPMSW	Antimony	0.033	0.023	0.066	0.25	0.06	0.7	5
U	ICPMSW	Selenium	0.002	<0.001	0.004	<0.01	0.1	0.5	7
U	ICPMSW	Zinc	0.072	0.037	0.144	0.43	4	50	200
U	KONENS	Chloride	10	2	20	34	800	15000	25000
U	ISEF	Fluoride	0.9	0.8	1.8	8	10	150	500
U	ICPWATVAR	Sulphate as SO4	128	31	256	485	1000	20000	50000
N	WSLM27	Total Dissolved Solids	370	156	740	1946	4000	60000	100000
U	SFAPI	Phenol Index	<0.05	0.08	<0.1	<0.7	1		
N	WSLM13	Dissolved Organic Carbon	8.9	7.4	17.8	77	500	800	1000

Template Ver. 1

Landfill Waste Acceptance Criteria limit values correct as of 11th March 2009.

Where individual results are flagged see report notes for status.

EFS/100786 Ver. 1

WASTE ACCEPTANCE CRITERIA TESTING
BSEN 12457/3

					Leaching Data	
Client	Hyder Consulting UK Ltd				Weight of sample (kg)	0.225
					Moisture content @ 105°C (%)	18.1
Contact	[redacted]				Equivalent Weight based on drying at 105°C (kg)	0.185
					Volume of water required to carry out 2:1 stage (litres)	0.329
Site	LNO1323				Weight of Sieved Soil to carry out 2:1 stage (kg)	0.274
Sample Description		Report No	Sample No	Issue Date	Weight of Deionised water to carry out 2:1 stage (kg)	0.401
TP25 1.2		s10_0786	CL/1003539	23-Feb-10	Volume to undertake analysis (2:1 Stage) (litres)	0.300
					Weight of Deionised water to carry out 8:1 stage (kg)	1.407

Accreditation	Method Code	Solid Waste Analysis (Dry Basis)	Concentration in Solid (Dry Weight Basis)	Landfill Waste Acceptance Criteria Limit Values: Inert Waste Landfill	Stable Non-reactive Hazardous Waste in Non-Hazardous Landfill	Hazardous Waste Landfill
N	WSLM59	Total Organic Carbon (% M/M)	1.75	3	5	6
	LOI450	Loss on Ignition (%)				10
U	BTEXHSA	Sum of BTEX (mg/kg)	<0.05	6		
N	PCBUSECD	Sum of 7 Congener PCB's (mg/kg)	<0.035	1		
U	TPHFIDUS	Mineral Oil (mg/kg)	125	500		
N	PAHMSUS	PAH Sum of 17 (mg/kg)	<2.9	100		
	WSLM3	pH (pH units)			>6	
	ANC	Acid Neutralisation Capacity (mol/kg) @pH 7			To be evaluated	To be evaluated

Accreditation	Method Code	Leachate Analysis	2:1 Leachate	8:1 Leachate	Calculated amount leached @ 2 1	Calculated cumulative amount leached @ 10 1	Landfill Waste Acceptance Criteria Limit Values for BSEN 12457/3 @ L/S 10 litre kg-1 mg/kg (dry weight)		
			mg/l except ∞		mg/kg (dry weight)				
U	WSLM3	pH (pH units) ∞	7.8	8.3	Calculated data not UKAS Accredited				
U	WSLM2	Conductivity (µs/cm) ∞	188	115					
U	ICPMSW	Arsenic	0.005	0.002	0.01	0.02	0.5	2	25
N	ICPWATVAR	Barium	0.2	0.26	0.4	2.5	20	100	300
U	ICPMSW	Cadmium	0.0001	<0.0001	0.0002	<0.001	0.04	1	5
U	ICPMSW	Chromium	0.009	0.003	0.018	0.04	0.5	10	70
U	ICPMSW	Copper	0.017	0.011	0.034	0.12	2	50	100
U	ICPMSW	Mercury	<0.0001	<0.0001	<0.0002	<0.001	0.01	0.2	2
U	ICPMSW	Molybdenum	0.006	0.003	0.012	0.03	0.5	10	30
U	ICPMSW	Nickel	0.004	0.001	0.008	0.01	0.4	10	40
U	ICPMSW	Lead	0.019	0.001	0.038	0.04	0.5	10	50
U	ICPMSW	Antimony	0.004	0.003	0.008	0.03	0.06	0.7	5
U	ICPMSW	Selenium	<0.001	<0.001	<0.002	<0.01	0.1	0.5	7
U	ICPMSW	Zinc	0.118	0.055	0.236	0.65	4	50	200
U	KONENS	Chloride	3	<1	6	<13	800	15000	25000
U	ISEF	Fluoride	1.3	0.9	2.6	10	10	150	500
U	ICPWATVAR	Sulphate as SO4	9	4	18	48	1000	20000	50000
N	WSLM27	Total Dissolved Solids	147	90	294	993	4000	60000	100000
U	SFAPI	Phenol Index	<0.05	0.06	<0.1	<0.6	1		
N	WSLM13	Dissolved Organic Carbon	8.1	8.6	16.2	85	500	800	1000

Template Ver. 1

Landfill Waste Acceptance Criteria limit values correct as of 11th March 2009.

Where individual results are flagged see report notes for status.

Report Notes

Generic Notes

Soil/Solid Analysis

Unless stated otherwise,
- Results expressed as mg/kg have been calculated on an air dried basis
- Sulphate analysis not conducted in accordance with BS1377
- Water Soluble Sulphate is on a 2:1 water:soil extract

Waters Analysis

Unless stated otherwise results are expressed as mg/l

Oil analysis specific

Unless stated otherwise,
- Results are expressed as mg/kg
- SG is expressed as g/cm^3@ 15°C

Gas (Tedlar bag) Analysis

Unless stated otherwise, results are expressed as ug/l

Asbestos Analysis

CH Denotes Chrysotile
CR Denotes Crocidolite
AM Denotes Amosite
NADIS Denotes No Asbestos Detected In Sample
NBFO Denotes No Bulk Fibres Observed

Symbol Reference

^ Sub-contracted analysis
$$ Unable to analyse due to the nature of the sample
¶ Samples submitted for this analyte were not preserved on site in accordance with laboratory protocols.
This may have resulted in deterioration of the sample(s) during transit to the laboratory.
Consequently the reported data may not represent the concentration of the target analyte present in the sample at the time of sampling
¥ Results for guidance only due to possible interference
& Blank corrected result
I.S Insufficient sample to complete requested analysis
I.S(g) Insufficient sample to re-analyse, results for guidance only
Intf Unable to analyse due to interferences
N.D Not determined
N.Det Not detected
Req Analysis requested, see attached sheets for results
Þ Raised detection limit due to nature of the sample
* All accreditation has been removed by the laboratory for this result
‡ MCERTS accreditation has been removed for this result

Note: The Laboratory may only claim that data is accredited when all of the requirements of our Quality System have been met. Where these requirements have not been met the laboratory may elect to include the data in its final report and remove the accreditation from individual data items if it believes that the validity of the data has not been affected. If further details are required of the circumstances which have led to the removal of accreditation then please do not hesitate to contact the laboratory.

END OF REPORT

Where individual results are flagged see report notes for status.

Summary of Laboratory Sample Descriptions

Hole Number	Sample Number	Type	Depth (m)	Description of Sample*
BH23			1.00-2.00	Brown sandy (fine to coarse) silty CLAY.
BH23			2.00	Brown gravelly silty CLAY.
BH23			4.00-5.00	Brown gravelly silty clayey (fine to coarse) SAND.
BH23			6.50-7.50	Brown gravelly silty CLAY.
BH24			2.00	Brown gravelly silty CLAY.
BH24			2.00-3.00	Brown gravelly silty CLAY.
BH24			4.00-5.00	Brown gravelly sandy (fine to coarse) silty CLAY.
BH24			7.00-8.00	Brown gravelly sandy (fine to coarse) silty CLAY.
BH25			2.00-3.00	Brown gravelly sandy (fine to coarse) silty CLAY.
BH25			2.50	Brown gravelly silty CLAY.
BH25			6.50-8.00	Brown gravelly sandy (fine to coarse) silty CLAY.
BH26			1.00-2.00	Brown gravelly sandy (fine to coarse) silty CLAY.
BH26			3.00	Brown gravelly sandy (fine to coarse) silty CLAY.
BH26			5.00-6.50	Brown gravelly sandy (fine to coarse) clayey SILT.
BH26			6.50-7.90	Brown gravelly sandy (fine to coarse) silty CLAY.
TP27			1.85	Brown gravelly sandy (fine to coarse) silty CLAY.
TP27			2.80	
TP27			3.50	Brown silty clayey sandy (fine to coarse) GRAVEL.
TP27			4.00	
TP27			5.50	Brown gravelly silty CLAY.
TP28			1.20	Brown gravelly sandy (fine to coarse) silty CLAY.
TP28			2.00	
TP28			2.90	Brown gravelly silty CLAY.
TP28			3.90	Brown silty clayey sandy (fine to coarse) GRAVEL.
TP28			5.50	Brown gravelly silty CLAY.

Note Results on this table are in summary format and may not meet the requirements of the relevant standards, additional information is held by the laboratory

[signature] 5/3/10 — Checked by — Date

Alan Walters 5/3/10 — Approved by — Date

LABORATORY TESTING SERVICES LIMITED

EnviRecover Hartlebury

Contract No.: 9513-190210

Client ref: LN01323

Summary of Soil Classification Tests

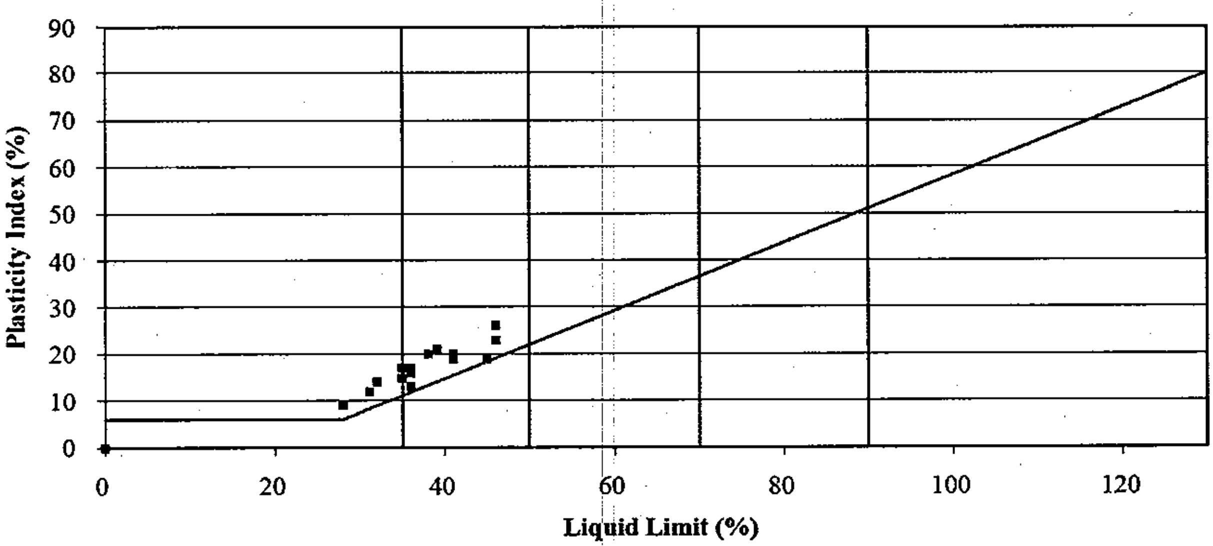
BS 1377:Part 2:1990

Hole/ Sample Number	Sample Type	Depth m	Moisture Content % Cl. 3.2	Liquid Limit % Cl. 4.3/4.4	Plastic Limit % Cl. 5.	Plasticity Index % Cl. 6.	% Passing .425mm	Remarks
BH23		1.00 - 2.00	21	41	22	19	97	CI Intermediate Plasticity
BH23		4.00 - 5.00	23	32	18	14	74	CL Low Plasticity
BH23		6.50 - 7.00	22	28	19	9	90	CL Low Plasticity
BH24		2.00 - 3.00	20	41	21	20	100	CI Intermediate Plasticity
BH24		4.00 - 5.00	20	38	18	20	96	CI Intermediate Plasticity
BH24		7.00 - 8.00	23	35	18	17	76	CL/I Low/Inter. Plasticity
BH25		2.00 - 3.00	21	35	20	15	84	CL/I Low/Inter. Plasticity
BH25		6.50 - 8.00	18	31	19	12	54	CL Low Plasticity
BH26		1.00 - 2.00	25	39	18	21	78	CI Intermediate Plasticity
BH26		3.00	35	46	23	23	93	CI Intermediate Plasticity
BH26		6.50 - 7.90	21	36	20	16	69	CI Intermediate Plasticity
TP27		1.85	24	36	23	13	68	CI Intermediate Plasticity
TP27		5.50	25	46	20	26	100	CI Intermediate Plasticity
TP28		1.20	28	45	26	19	97	CI Intermediate Plasticity
TP28		5.50	18	36	19	17	92	CI Intermediate Plasticity

Symbols: NP : Non Plastic # : Liquid Limit and Plastic Limit Wet Sieved

PLASTICITY CHART FOR CASAGRANDE CLASSIFICATION.

BS 5930:1999



Alan Walters 05/03/10 — Checked by Date

Alan Walters 05/03/10 — Approved by Date

GEO LABORATORY TESTING SERVICES LIMITED

EnviRecover Hartlebury

Contract No.: 9513/190210

Client Ref No: LN01323

UKAS TESTING 2788

SUMMARY OF SOIL CLASSIFICATION TESTS

(B.S. 1377 : PART 2 : 1990)

Hole Number	Sample Number	Depth m	Moisture Content % Clause 3 2	Bulk Density Mg/m^3 Clause 7 2	Dry Density Mg/m^3 Clause 7 2	Particle Density Mg/m^3 Clause 8 *				Remarks
BH24		2.00-3.00				2.75				
BH24		4.00-5.00				2.73				
BH25		2.00-3.00				2.73				
BH26		6.50-7.90				2.74				
TP27		2.80								
TP27		4.00								
TP28		2.00								
TP28		3.90								

Checked By [signature] 05/03/10 Date

Approved By [signature] 05/03/10 Date

LABORATORY TESTING SERVICES LIMITED

EnviRecover Hartlebury

Contract No.
9513-180210
Client Ref No.
LN01323

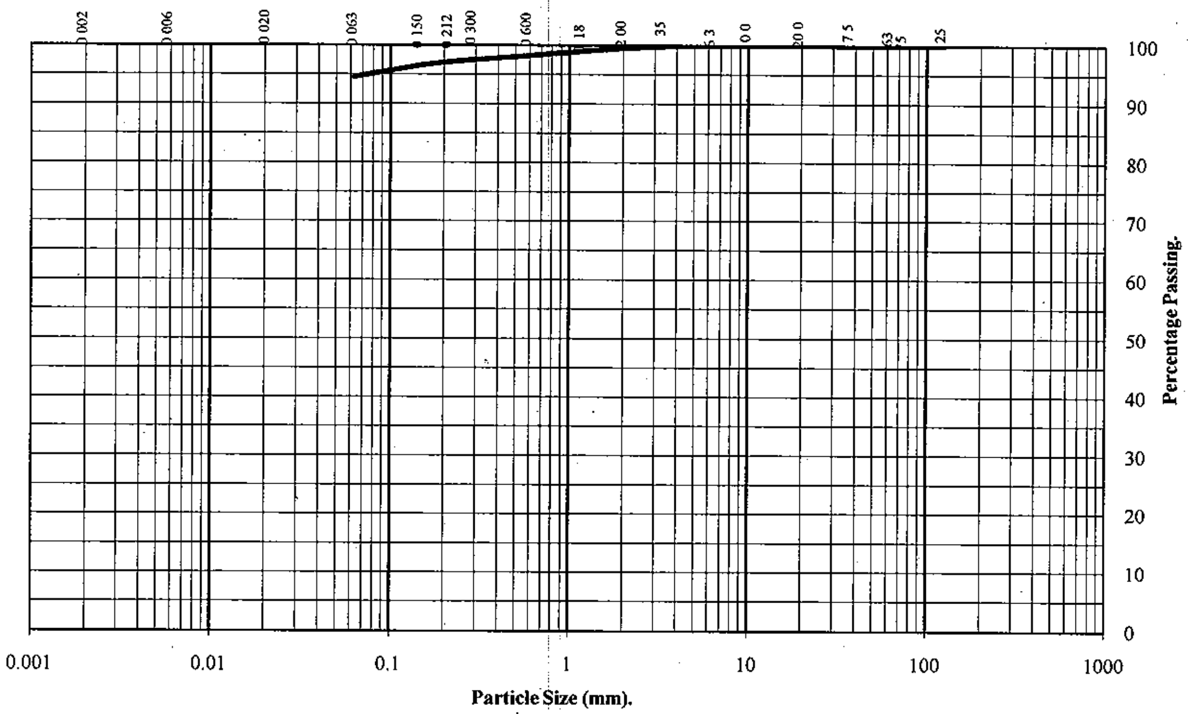
Page **of**

PARTICLE SIZE DISTRIBUTION TEST

BS 1377 Part 2:1990.

Wet Sieve, Clause 9.2

Hole Number: **BH23** Type: **B** Depth (m): **1.00** to **2.00**



BS Test Sieve	Percentage Passing
125	100
75	100
63	100
37.5	100
20	100
10	100
6.3	100
3.35	100
2.00	100
1.18	99
0.60	98
0.300	97
0.212	97
0.150	97
0.063	95

Particle Diameter	Percentage Passing
0.02	#
0.006	#
0.002	#

Soil Fraction	Total Percentage
Cobbles	0
Gravel	0
Sand	5
Silt and Clay	95

Remarks:

#- not determined

05/03/2010 05/03/2010

Checked by **Date** **Approved by** **Date**

LABORATORY TESTING SERVICES LIMITED

EnviRecover Hartlebury

Contract No.:
9513-190210
Client Ref No:
LN01323

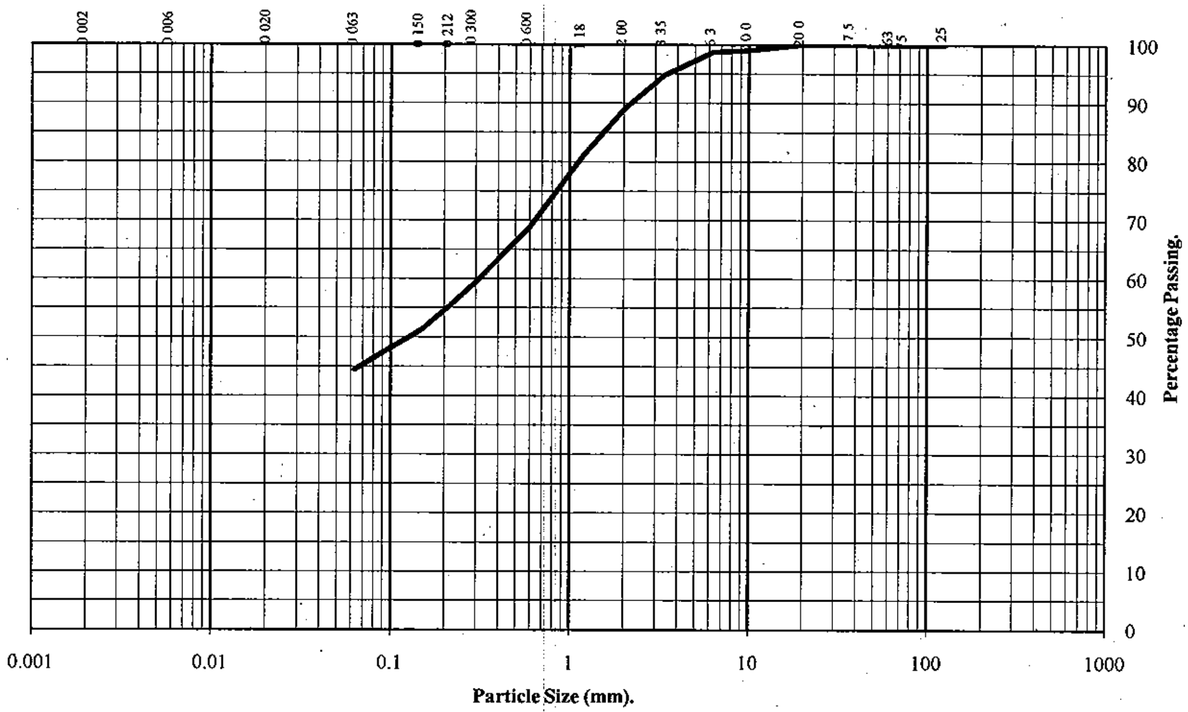
UKAS TESTING 2788

PARTICLE SIZE DISTRIBUTION TEST

BS 1377 Part 2:1990.

Wet Sieve, Clause 9.2

Hole Number: **BH23** Type: **B** Depth (m): **4.00** to **5.00**



BS Test Sieve	Percentage Passing
125	100
75	100
63	100
37.5	100
20	100
10	99
6.3	99
3.35	95
2.00	89
1.18	81
0.60	69
0.300	59
0.212	55
0.150	51
0.063	44

Particle Diameter	Percentage Passing
0.02	#
0.006	#
0.002	#

Soil Fraction	Total Percentage
Cobbles	0
Gravel	11
Sand	45
Silt and Clay	44

Remarks:

#- not determined

05/03/2010 05/03/2010

Checked by **Date** **Approved by** **Date**

LABORATORY TESTING SERVICES LIMITED

EnviRecover Hartlebury

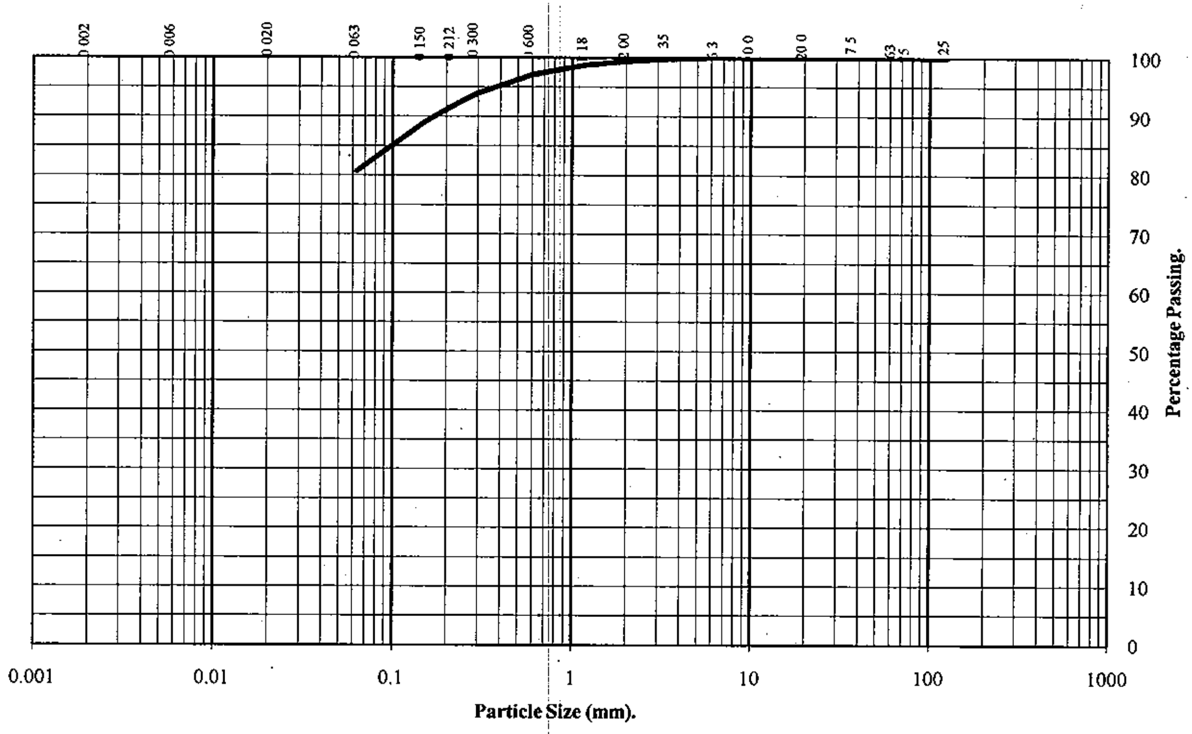
Contract No.:
9513-190210
Client Ref No:
LN01323

UKAS TESTING 2788

PARTICLE SIZE DISTRIBUTION TEST

BS 1377 Part 2:1990.
Wet Sieve, Clause 9.2

Hole Number: **BH24** Type: **B** Depth (m): **4.00** to **5.00**



BS Test Sieve	Percentage Passing
125	100
75	100
63	100
37.5	100
20	100
10	100
6.3	100
3.35	100
2.00	99
1.18	99
0.60	97
0.300	94
0.212	92
0.150	89
0.063	81

Particle Diameter	Percentage Passing
0.02	#
0.006	#
0.002	#

Soil Fraction	Total Percentage
Cobbles	0
Gravel	1
Sand	18
Silt and Clay	81

Remarks:
#- not determined

05/03/2010 05/03/2010
Checked by **Date** **Approved by** **Date**

LABORATORY TESTING SERVICES LIMITED

EnviRecover Hartlebury

Contract No.:
9513-190210
Client Ref No:
LN01323

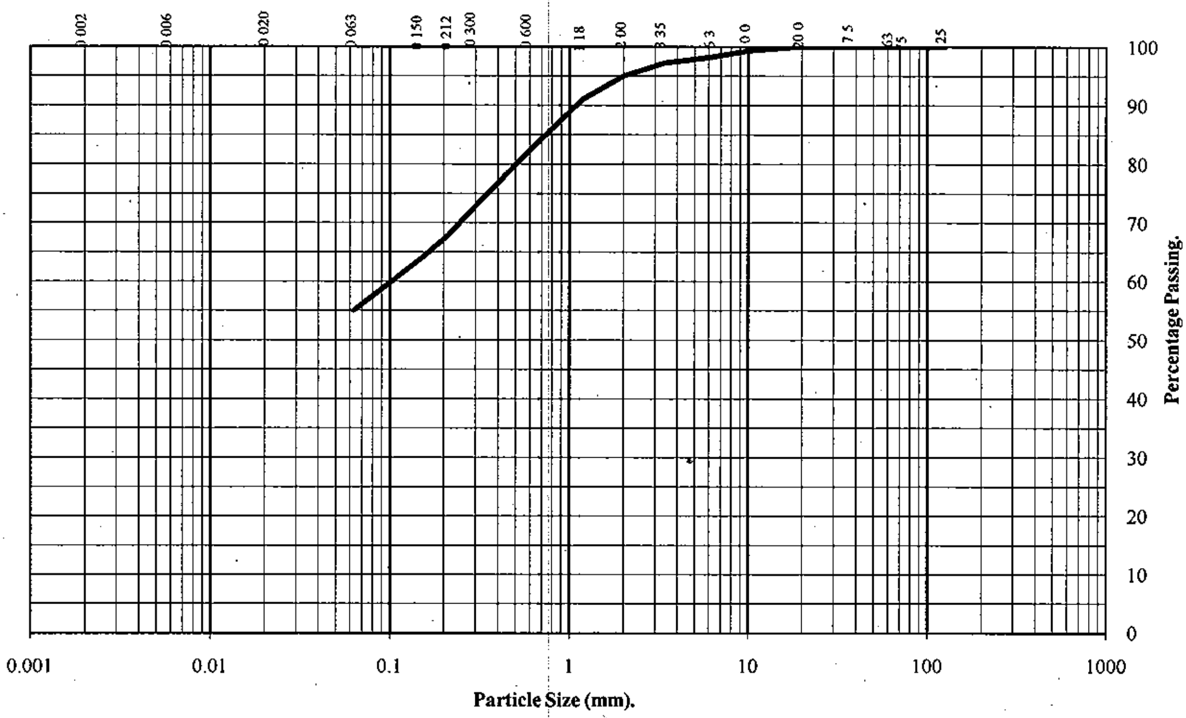
UKAS TESTING 2788

PARTICLE SIZE DISTRIBUTION TEST

BS 1377 Part 2:1990.

Wet Sieve, Clause 9.2

Hole Number: **BH24** Type: **B** Depth (m): **7.00** to **8.00**



BS Test Sieve	Percentage Passing
125	100
75	100
63	100
37.5	100
20	100
10	99
6.3	98
3.35	97
2.00	95
1.18	91
0.60	82
0.300	73
0.212	68
0.150	64
0.063	55

Particle Diameter	Percentage Passing
0.02	#
0.006	#
0.002	#

Soil Fraction	Total Percentage
Cobbles	0
Gravel	5
Sand	40
Silt and Clay	55

Remarks:

#- not determined

05/03/2010 05/03/2010

Checked by **Date** **Approved by** **Date**

LABORATORY TESTING SERVICES LIMITED

EnviRecover Hartlebury

Contract No.: **9513-190210**

Client Ref No: **LN01323**

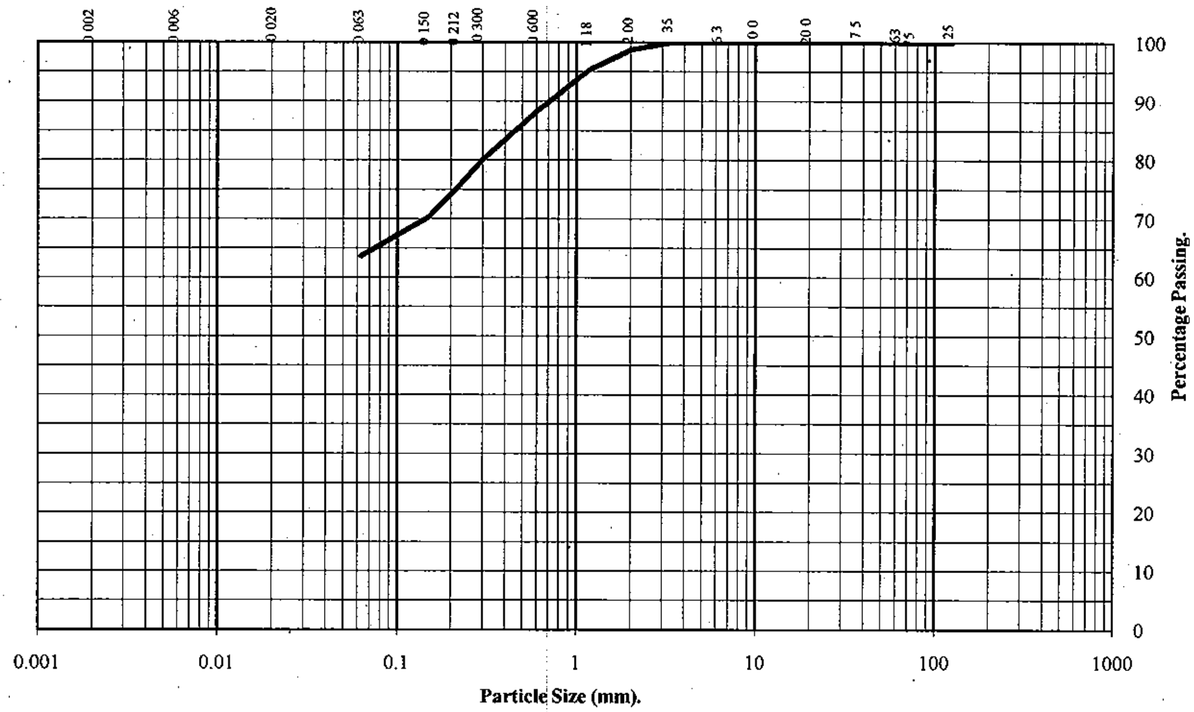
UKAS TESTING 2788

PARTICLE SIZE DISTRIBUTION TEST

BS 1377 Part 2:1990.

Wet Sieve, Clause 9.2

Hole Number: **BH25** Type: **B** Depth (m): **2.00** to **3.00**



BS Test Sieve	Percentage Passing
125	100
75	100
63	100
37.5	100
20	100
10	100
6.3	100
3.35	100
2.00	99
1.18	95
0.60	88
0.300	80
0.212	75
0.150	70
0.063	64

Particle Diameter	Percentage Passing
0.02	#
0.006	#
0.002	#

Soil Fraction	Total Percentage
Cobbles	0
Gravel	1
Sand	35
Silt and Clay	64

Remarks:

#- not determined

05/03/2010 — **Checked by** — **Date**

05/03/2010 — **Approved by** — **Date**

LABORATORY TESTING SERVICES LIMITED

EnviRecover Hartlebury

Contract No.: 9513-190210

Client Ref No: LN01323

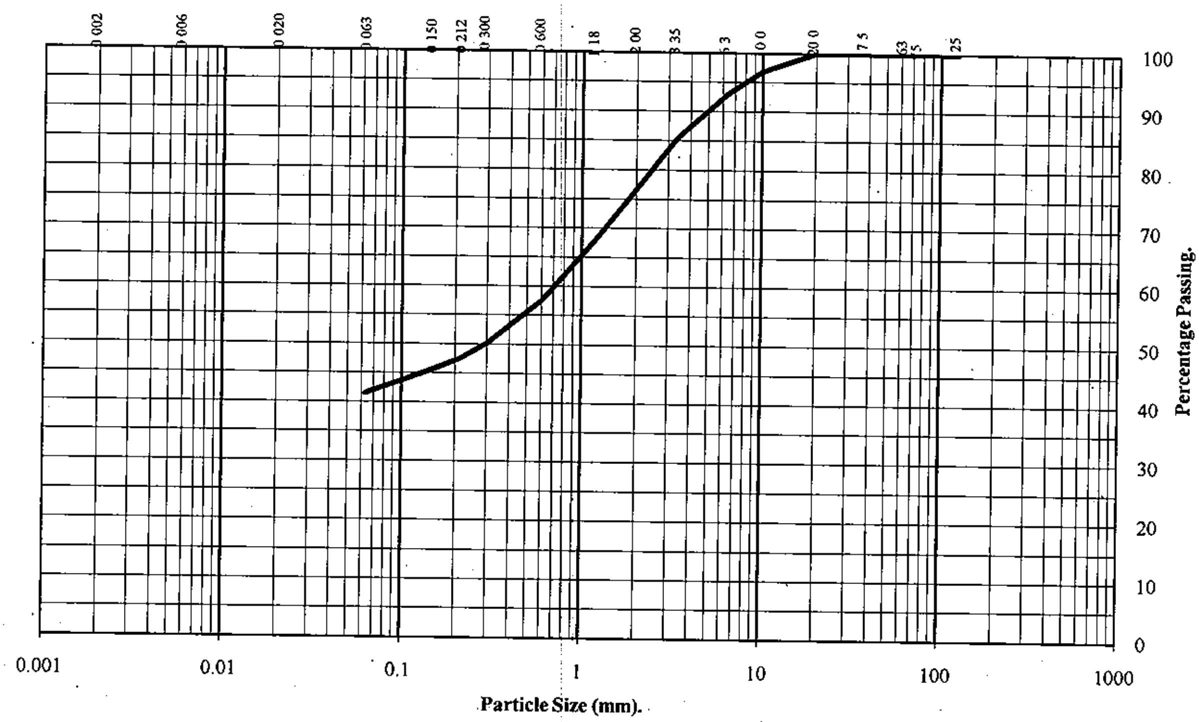
UKAS TESTING 2788

PARTICLE SIZE DISTRIBUTION TEST

BS 1377 Part 2:1990.

Wet Sieve, Clause 9.2

Hole Number: **BH25** Type: **B** Depth (m): **6.50** to **8.00**



BS Test Sieve	Percentage Passing
125	100
75	100
63	100
37.5	100
20	100
10	97
6.3	93
3.35	85
2.00	77
1.18	68
0.60	58
0.300	50
0.212	47
0.150	46
0.063	41

Particle Diameter	Percentage Passing
0.02	#
0.006	#
0.002	#

Soil Fraction	Total Percentage
Cobbles	0
Gravel	23
Sand	36
Silt and Clay	41

Remarks:

#- not determined

05/03/2010 05/03/2010

Checked by **Date** **Approved by** **Date**

LABORATORY TESTING SERVICES LIMITED

EnviRecover Hartlebury

Contract No.: **9513-190210**

Client Ref No: **LN01323**

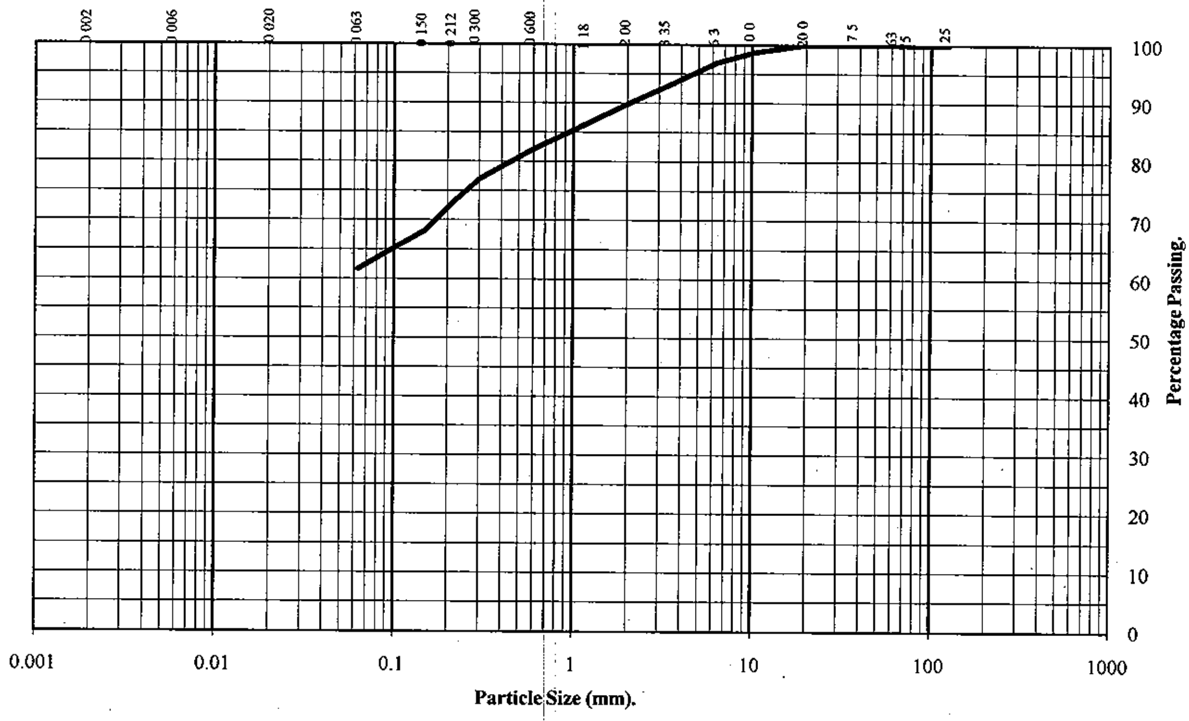
UKAS TESTING 2788

PARTICLE SIZE DISTRIBUTION TEST

BS 1377 Part 2:1990.

Wet Sieve, Clause 9.2

Hole Number: **BH26** Type: **B** Depth (m): **1.00** to **2.00**



BS Test Sieve	Percentage Passing
125	100
75	100
63	100
37.5	100
20	100
10	99
6.3	97
3.35	93
2.00	90
1.18	86
0.60	82
0.300	77
0.212	73
0.150	68
0.063	62

Particle Diameter	Percentage Passing
0.02	#
0.006	#
0.002	#

Soil Fraction	Total Percentage
Cobbles	0
Gravel	10
Sand	28
Silt and Clay	62

Remarks:

#- not determined

05/03/2010 05/03/2010

Checked by **Date** **Approved by** **Date**

LABORATORY TESTING SERVICES LIMITED

EnviRecover Hartlebury

Contract No.:
9513-190210
Client Ref No:
LN01323

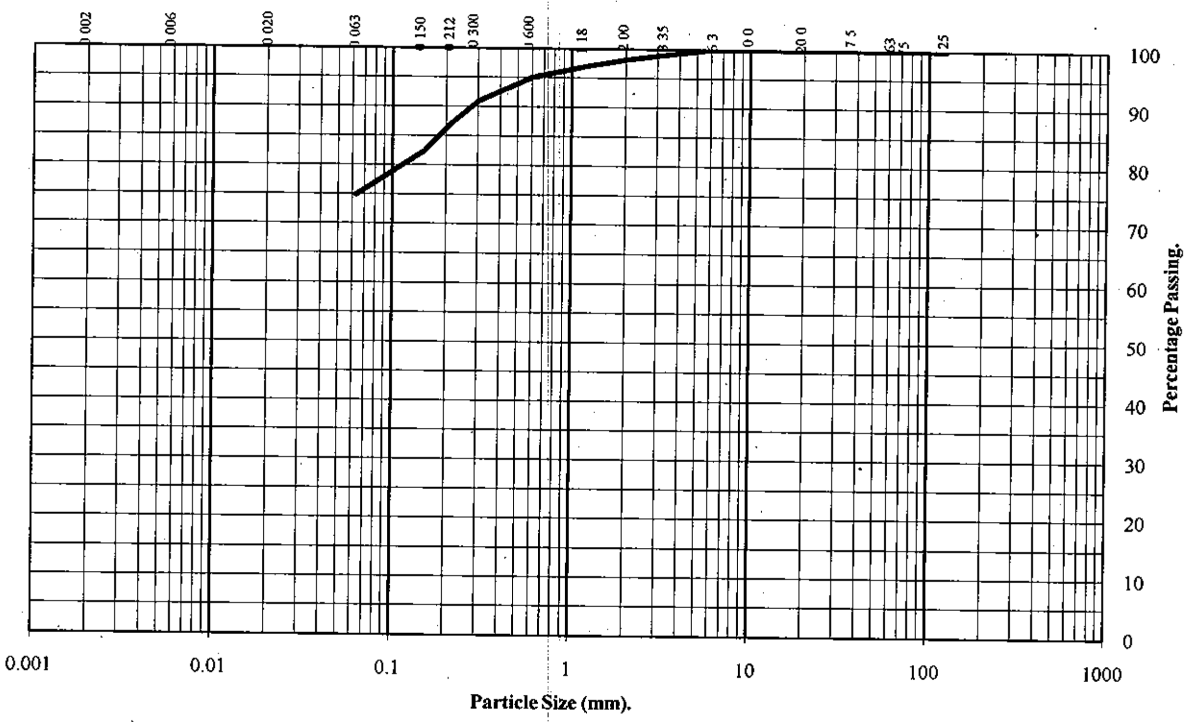
UKAS TESTING 2788

PARTICLE SIZE DISTRIBUTION TEST

BS 1377 Part 2:1990.

Wet Sieve, Clause 9.2

Hole Number: **BH26** Type: **B** Depth (m): **3.00**



BS Test Sieve	Percentage Passing
125	100
75	100
63	100
37.5	100
20	100
10	100
6.3	100
3.35	99
2.00	98
1.18	97
0.60	95
0.300	91
0.212	87
0.150	82
0.063	75

Particle Diameter	Percentage Passing
0.02	#
0.006	#
0.002	#

Soil Fraction	Total Percentage
Cobbles	0
Gravel	2
Sand	23
Silt and Clay	75

Remarks:

#- not determined

05/03/2010 05/03/2010

Checked by **Date** **Approved by** **Date**

LABORATORY TESTING SERVICES LIMITED

EnviRecover Hartlebury

Contract No.: **9513-190210**

Client Ref No: **LN01323**

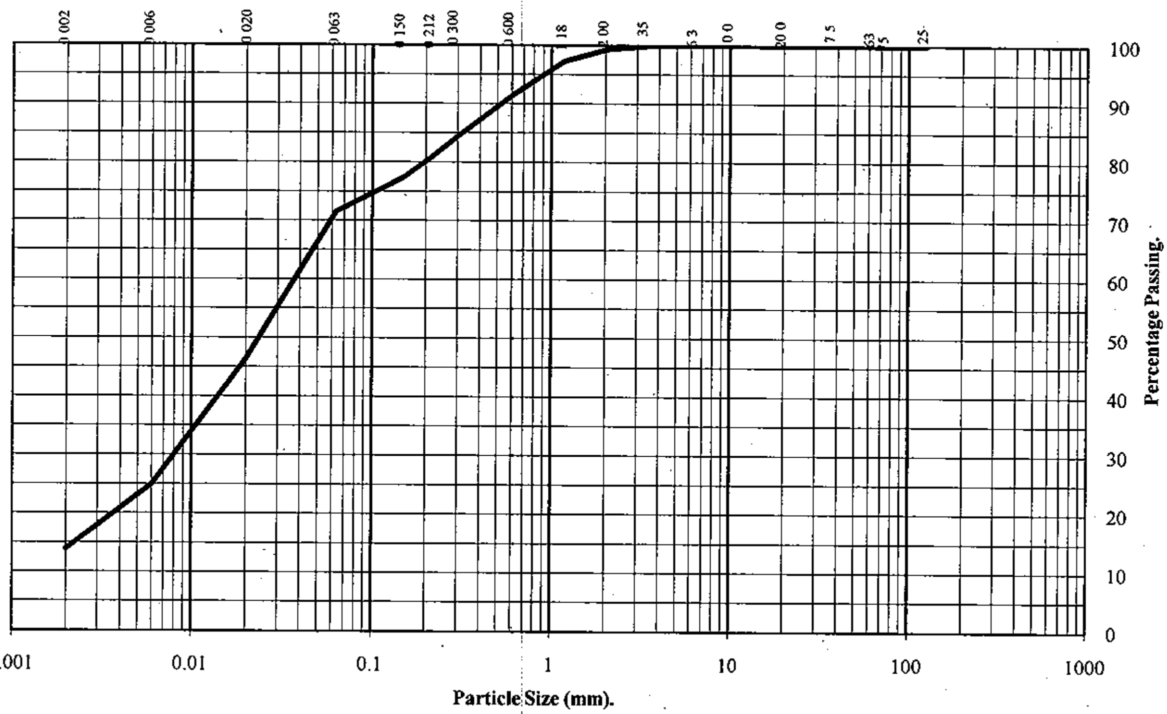
UKAS TESTING 2788

PARTICLE SIZE DISTRIBUTION TEST

BS 1377 Part 2:1990.

Wet Sieve & Pipette Analysis, Clause 9.2 & 9.4

Hole Number: **BH26** Type: **B** Depth (m): **5.00** to **6.50**



BS Test Sieve	Percentage Passing
125	100
75	100
63	100
37.5	100
20	100
10	100
6.3	100
3.35	100
2.00	99
1.18	97
0.60	91
0.300	84
0.212	81
0.150	77
0.063	72

Particle Diameter	Percentage Passing
0.02	46
0.006	25
0.002	14

Soil Fraction	Total Percentage
Cobbles	0
Gravel	1
Sand	27
Silt	58
Clay	14

Remarks:

Cl 9.4.8 - Sample has not been pretreated

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LABORATORY TESTING SERVICES LIMITED

EnviRecover Hartlebury

Contract No.: **9513-190210**

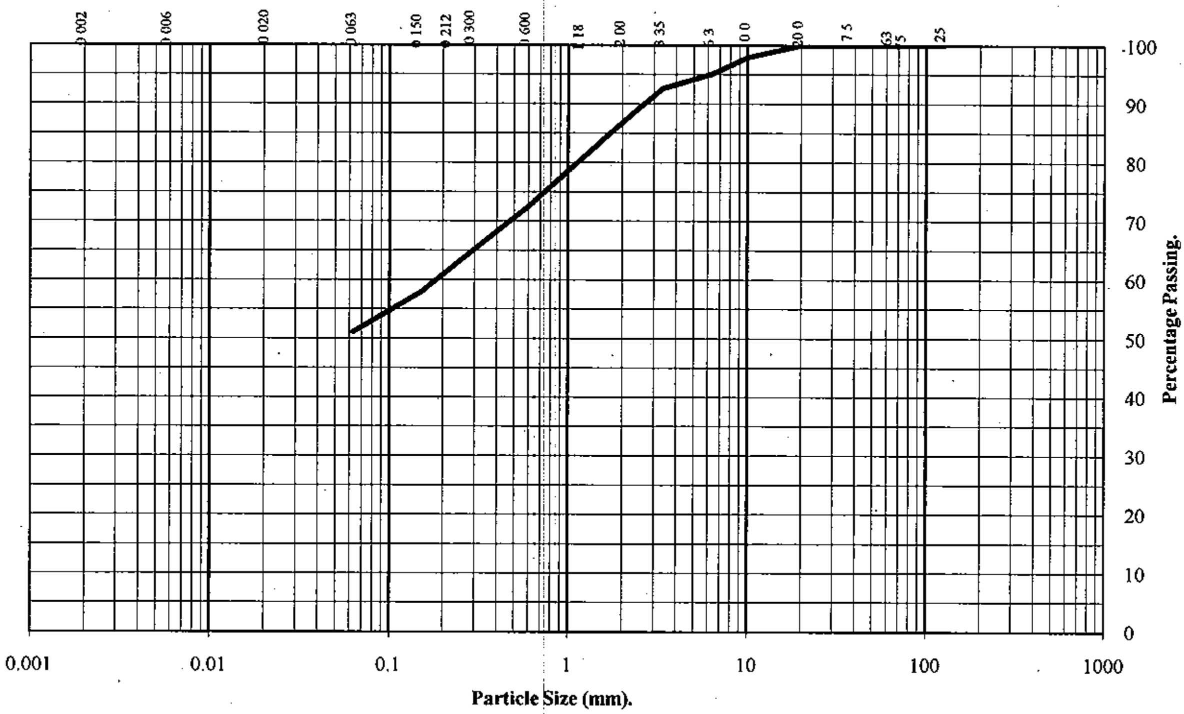
Client Ref No: **LN01323**

UKAS TESTING 2788

PARTICLE SIZE DISTRIBUTION TEST

BS 1377 Part 2:1990.
Wet Sieve, Clause 9.2

Hole Number: **BH26** Type: **B** Depth (m): **6.50** to **7.90**



BS Test Sieve	Percentage Passing
125	100
75	100
63	100
37.5	100
20	100
10	98
6.3	95
3.35	93
2.00	87
1.18	81
0.60	73
0.300	65
0.212	62
0.150	58
0.063	51

Particle Diameter	Percentage Passing
0.02	#
0.006	#
0.002	#

Soil Fraction	Total Percentage
Cobbles	0
Gravel	13
Sand	36
Silt and Clay	51

Remarks:
#- not determined

05/03/2010 05/03/2010
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LABORATORY TESTING SERVICES LIMITED

EnviRecover Hartlebury

Contract No.:
9513-190210
Client Ref No:
LN01323

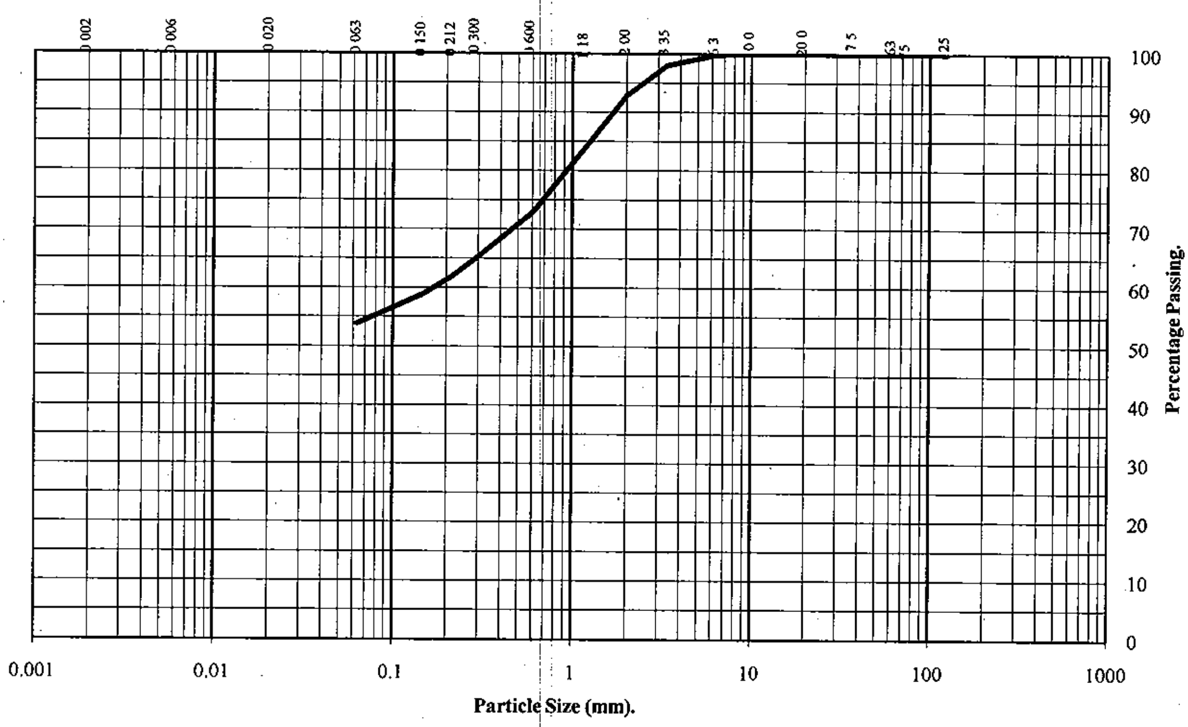
UKAS TESTING 2788

PARTICLE SIZE DISTRIBUTION TEST

BS 1377 Part 2:1990.

Wet Sieve, Clause 9.2

Hole Number: **TP27** Type: **B** Depth (m): **1.85**



BS Test Sieve	Percentage Passing
125	100
75	100
63	100
37.5	100
20	100
10	100
6.3	100
3.35	98
2.00	93
1.18	84
0.60	73
0.300	65
0.212	62
0.150	59
0.063	54

Particle Diameter	Percentage Passing
0.02	#
0.006	#
0.002	#

Soil Fraction	Total Percentage
Cobbles	0
Gravel	7
Sand	39
Silt and Clay	54

Remarks:

#- not determined

Checked by: [signature] Date: 05/03/2010

Approved by: [signature] Date: 05/03/2010

GEO LABORATORY TESTING SERVICES LIMITED

EnviRecover Hartlebury

Contract No.: 9513-190210

Client Ref No: LN01323

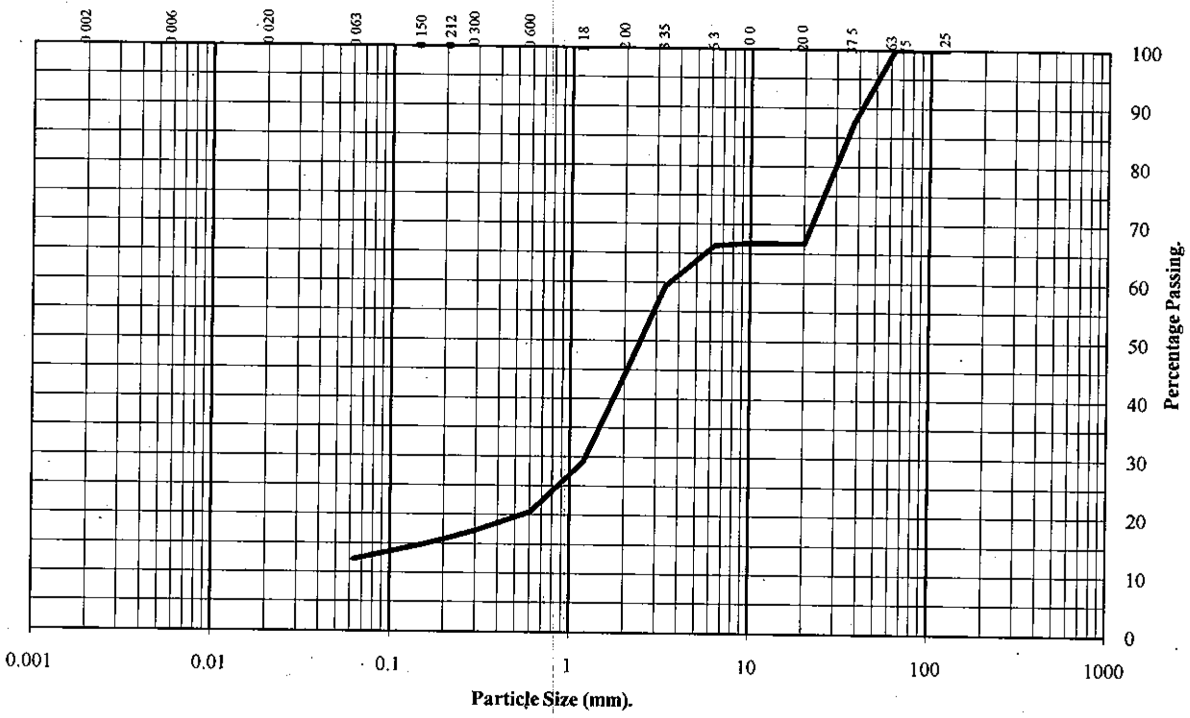
UKAS TESTING 2788

PARTICLE SIZE DISTRIBUTION TEST

BS 1377 Part 2:1990.

Wet Sieve, Clause 9.2

Hole Number: **TP27** Type: **B** Depth (m): **3.50**



BS Test Sieve	Percentage Passing
125	100
75	100
63	100
37.5	88
20	67
10	67
6.3	66
3.35	59
2.00	44
1.18	29
0.60	20
0.300	17
0.212	16
0.150	15
0.063	12

Particle Diameter	Percentage Passing
0.02	#
0.006	#
0.002	#

Soil Fraction	Total Percentage
Cobbles	0
Gravel	56
Sand	32
Silt and Clay	12

Remarks:

#- not determined

[signature] 05/03/2010 — **Checked by** **Date**

[signature: Alan Walters] 05/03/2010 — **Approved by** **Date**

LABORATORY TESTING SERVICES LIMITED

EnviRecover Hartlebury

Contract No.: **9513-190210**

Client Ref No: **LN01323**

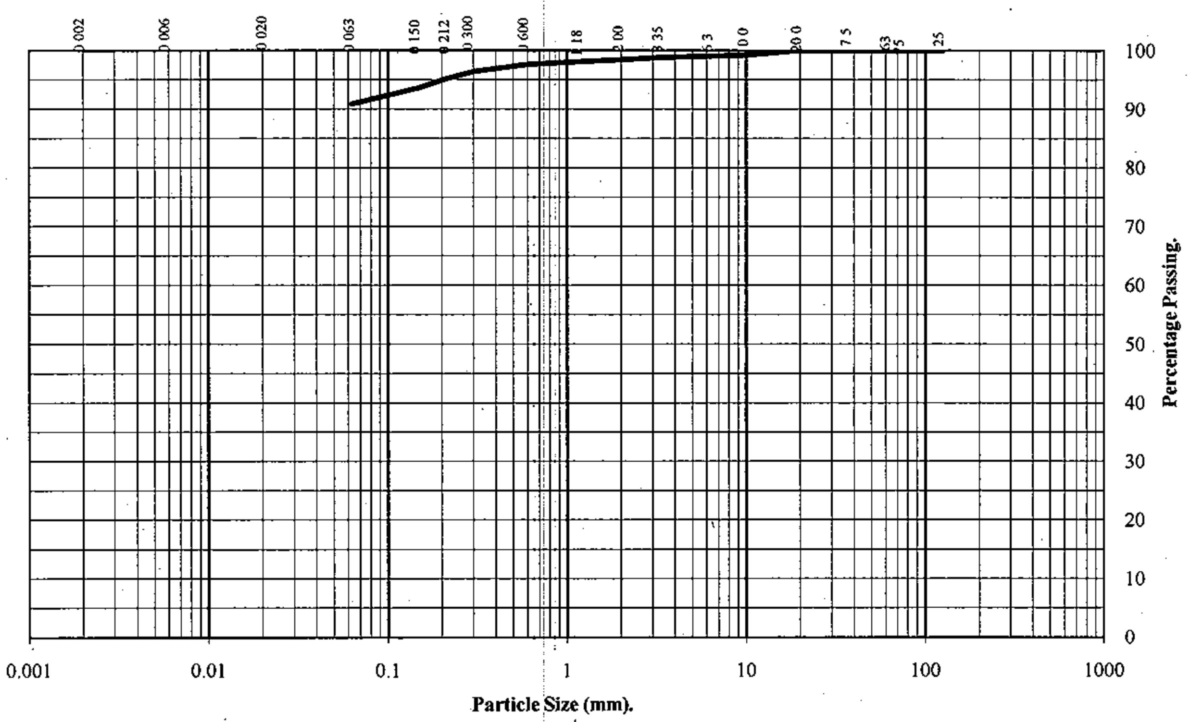
UKAS TESTING 2788

PARTICLE SIZE DISTRIBUTION TEST

BS 1377 Part 2:1990.

Wet Sieve, Clause 9.2

Hole Number: **TP28** Type: **B** Depth (m): **1.20**



BS Test Sieve	Percentage Passing
125	100
75	100
63	100
37.5	100
20	100
10	99
6.3	99
3.35	99
2.00	98
1.18	98
0.60	98
0.300	96
0.212	95
0.150	94
0.063	91

Particle Diameter	Percentage Passing
0.02	#
0.006	#
0.002	#

Soil Fraction	Total Percentage
Cobbles	0
Gravel	2
Sand	7
Silt and Clay	91

Remarks:

#- not determined

05/03/2010 05/03/2010

Checked by **Date** **Approved by** **Date**

LABORATORY TESTING SERVICES LIMITED

EnviRecover Hartlebury

Contract No.: 9513-190210

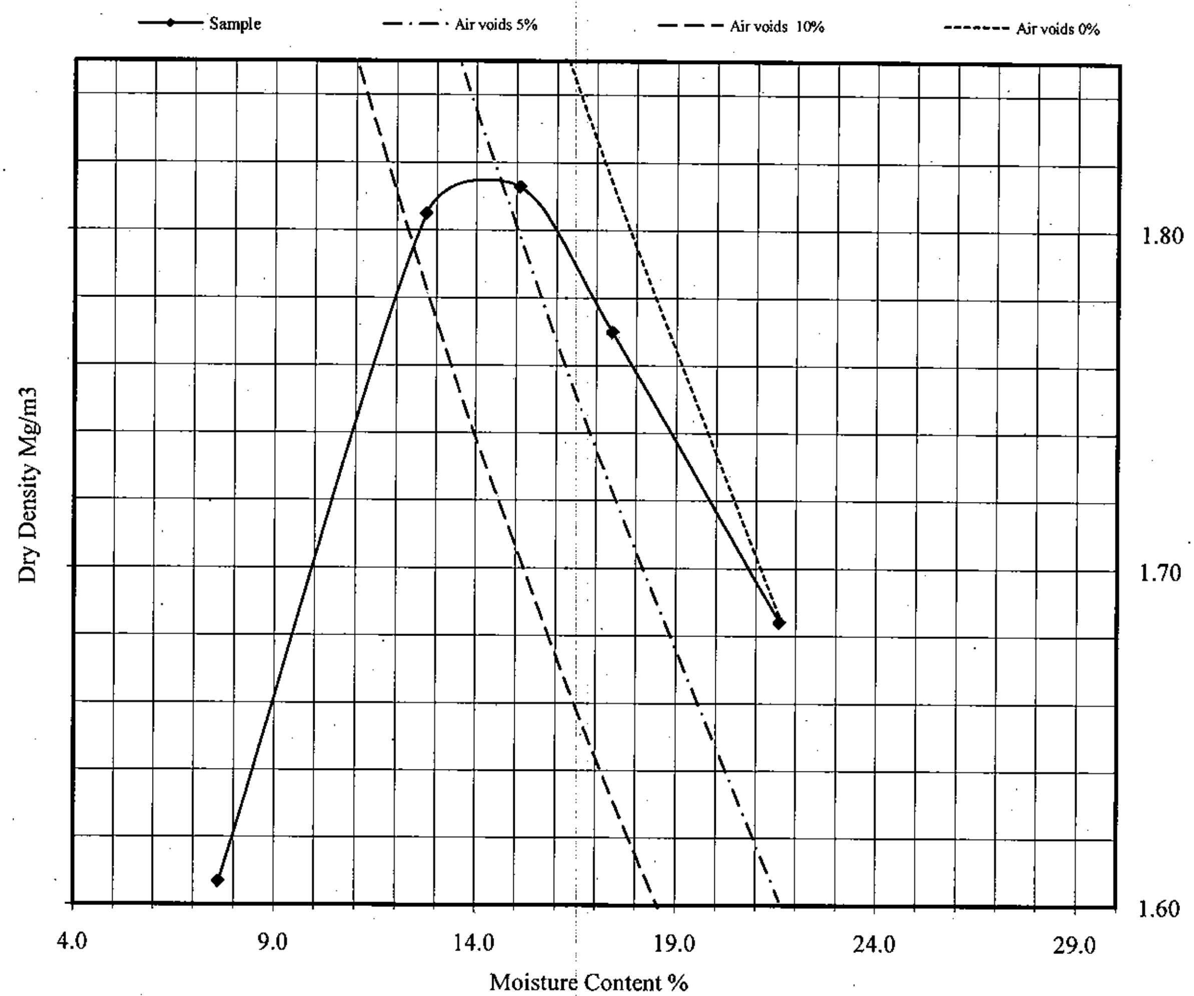
Client Ref No: LN01323

UKAS TESTING 2788

Dry Density/Moisture Content Relationship

BS 1377:Part 4:1990

Hole Number: **BH25** **Type :** **B** **Depth (m):** **6.50-8.00**



Initial Moisture Content:	22	Method of Compaction	2.5Kg Rammer / Single Sample
Particle Density (Mg/m3):	2.65 Assumed	Material Retained on 37.5 mm Test Sieve (%):	0
Maximum Dry Density (mg/m3):	1.81	Material Retained on 20.0 mm Test Sieve (%):	0
Optimum Moisture Content (%):	15	Sample Preparation Clause :	3.2.4.1

Remarks

05/03/10 05/03/10

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LABORATORY TESTING SERVICES LIMITED

EnviRecover Hartlebury

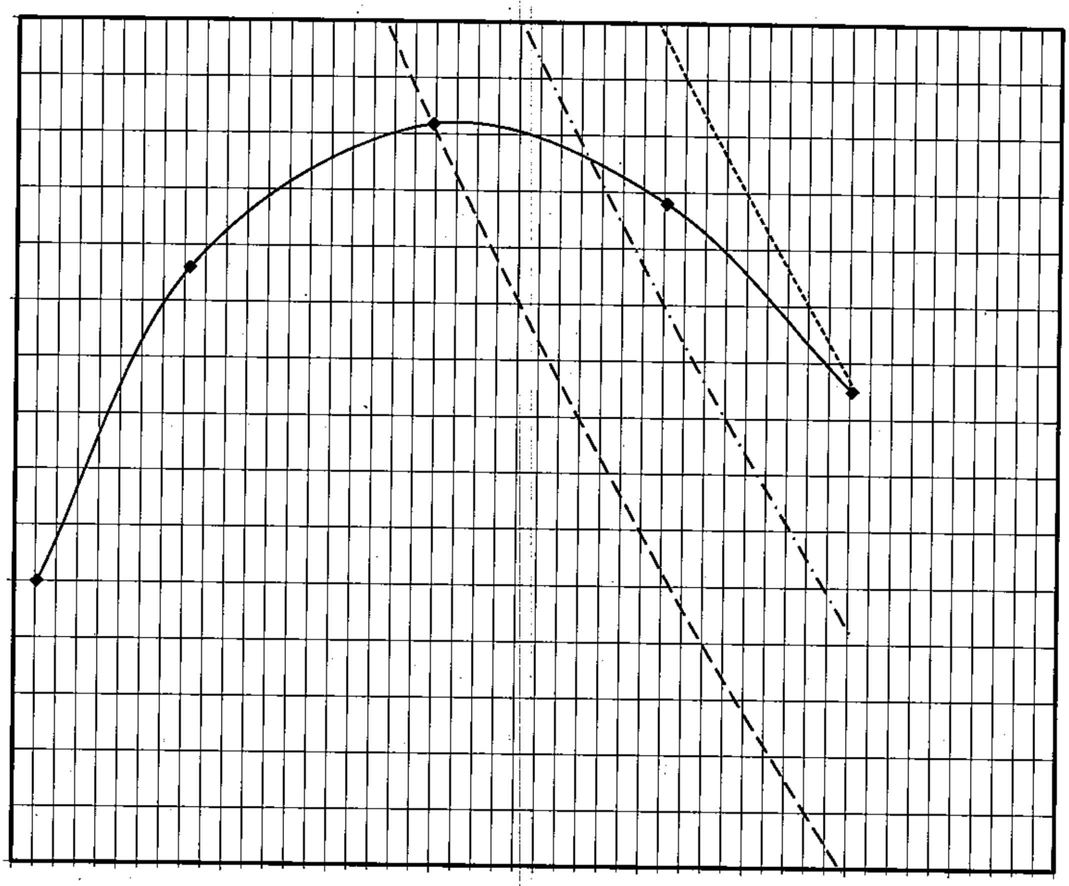
Contract No.: **9513-190210**
Client Ref No: **LN01323**

UKAS TESTING 2788

Dry Density/Moisture Content Relationship

BS 1377:Part 4:1990

Hole Number: **TP27** **Type :** **B** **Depth (m):** **3.50**



Initial Moisture Content:	18	Method of Compaction	2.5Kg Rammer / Single Sample
Particle Density (Mg/m3):	2.75 Assumed	Material Retained on 37.5 mm Test Sieve (%):	12
Maximum Dry Density (mg/m3):	1.86	Material Retained on 20.0 mm Test Sieve (%):	33
Optimum Moisture Content (%):	12	Sample Preparation Clause :	Non-Standard

Remarks

05/03/10 05/03/10

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LABORATORY TESTING SERVICES LIMITED

EnviRecover Hartlebury

Contract No.: **9513-190210**
Client Ref No: **LN01323**

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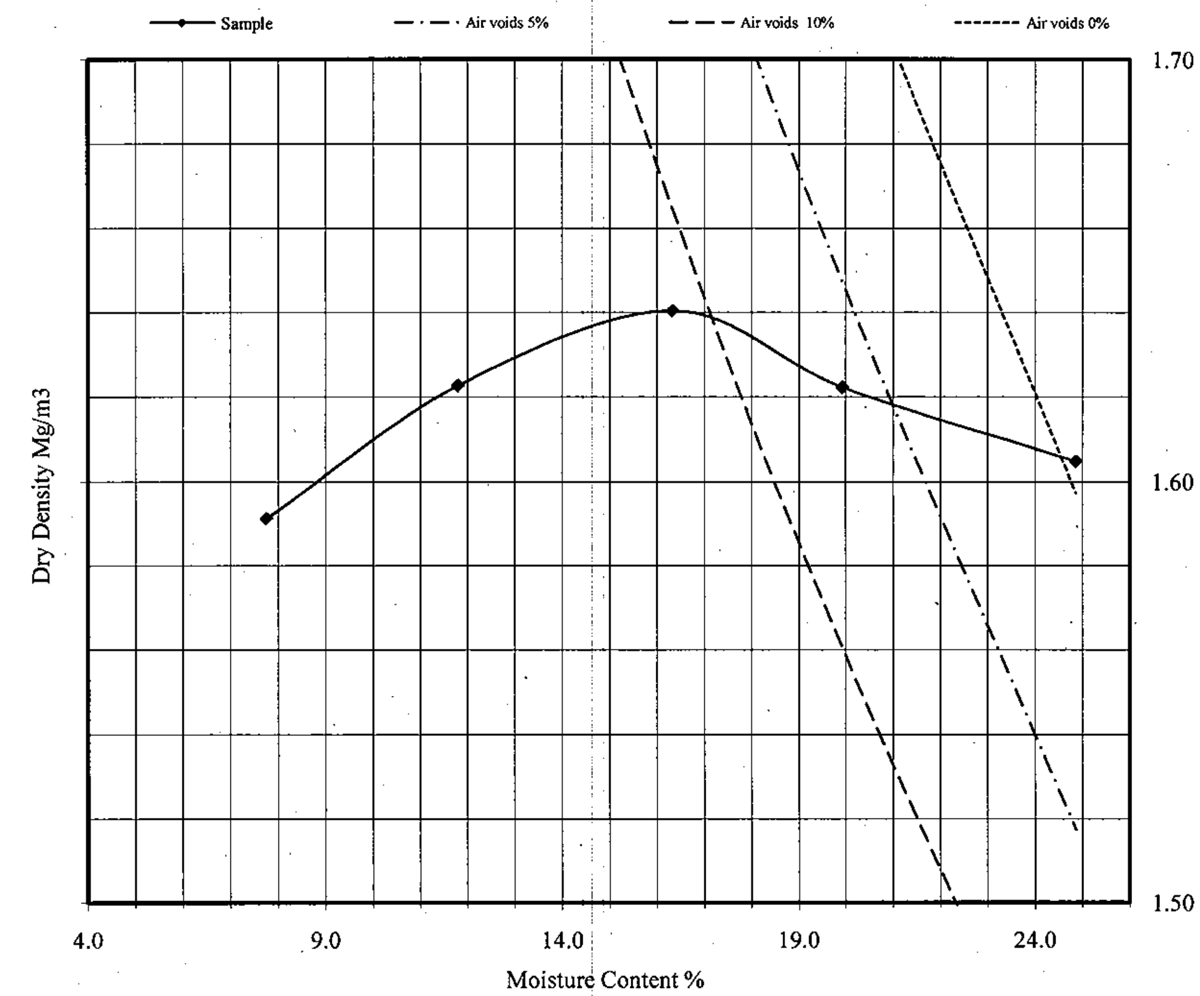
Dry Density/Moisture Content Relationship

BS 1377:Part 4:1990

Hole Number: **TP27** **Type :** **B** **Depth (m):** **5.50**



Initial Moisture Content:	25	Method of Compaction	2.5Kg Rammer / Single Sample
Particle Density (Mg/m3):	2.65 Assumed	Material Retained on 37.5 mm Test Sieve (%):	0
Maximum Dry Density (mg/m3):	1.64	Material Retained on 20.0 mm Test Sieve (%):	0
Optimum Moisture Content (%):	16	Sample Preparation Clause :	3.2.4.1

Remarks

05/03/10 05/03/10

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LABORATORY TESTING SERVICES LIMITED

EnviRecover Hartlebury

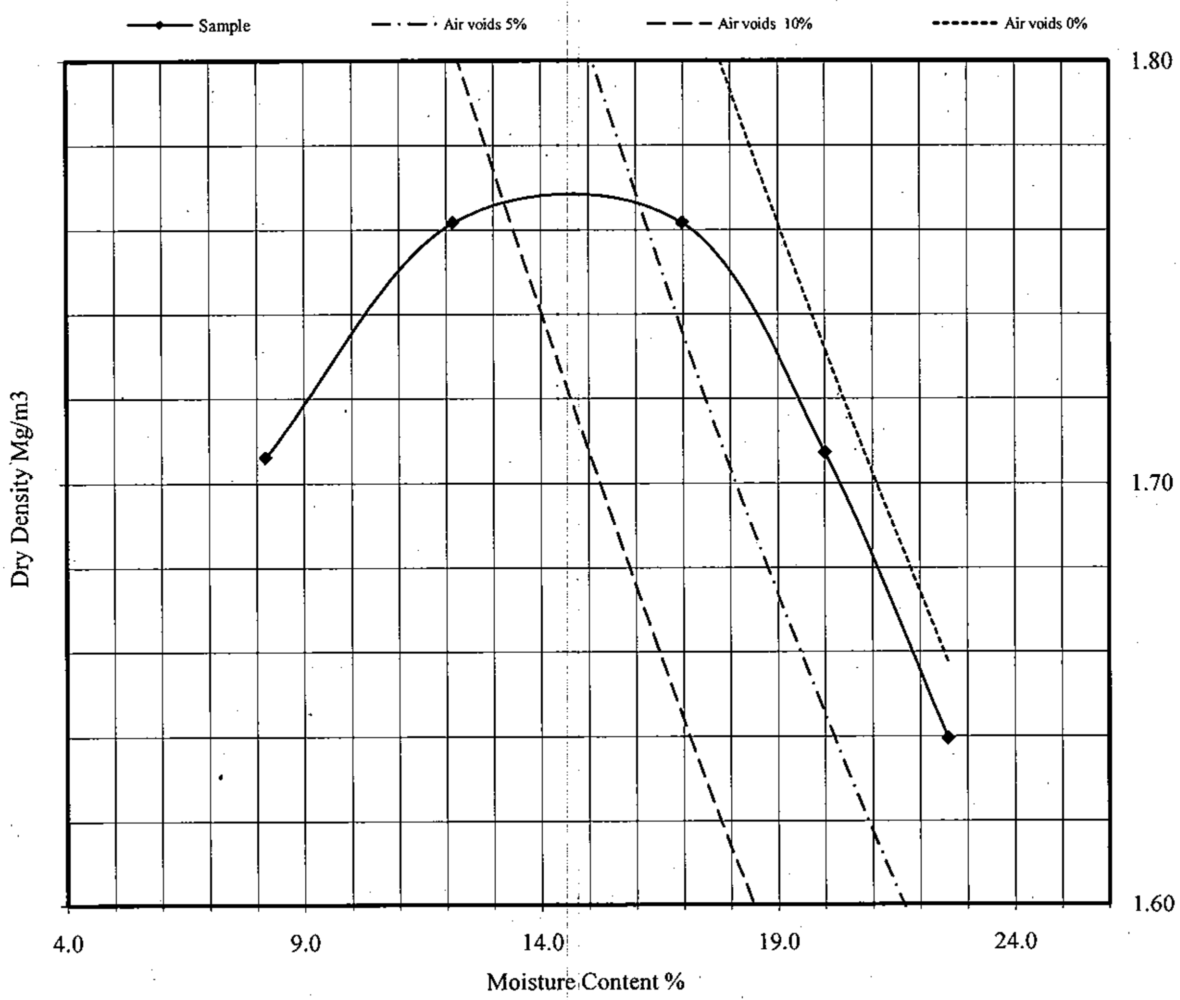
Contract No.: **9513-190210**
Client Ref No: **LN01323**

UKAS TESTING 2788

Dry Density/Moisture Content Relationship

BS 1377:Part 4:1990

Hole Number: **TP28** **Type :** **B** **Depth (m):** **2.90**



Initial Moisture Content:	23	Method of Compaction	2.5Kg Rammer / Single Sample
Particle Density (Mg/m3):	2.65 Assumed	Material Retained on 37.5 mm Test Sieve (%):	0
Maximum Dry Density (mg/m3):	1.76	Material Retained on 20.0 mm Test Sieve (%):	0
Optimum Moisture Content (%):	17	Sample Preparation Clause :	3.2.4.1

Remarks

05/03/10 05/03/10

Checked by **Date** **Approved by** **Date**

LABORATORY TESTING SERVICES LIMITED

EnviRecover Hartlebury

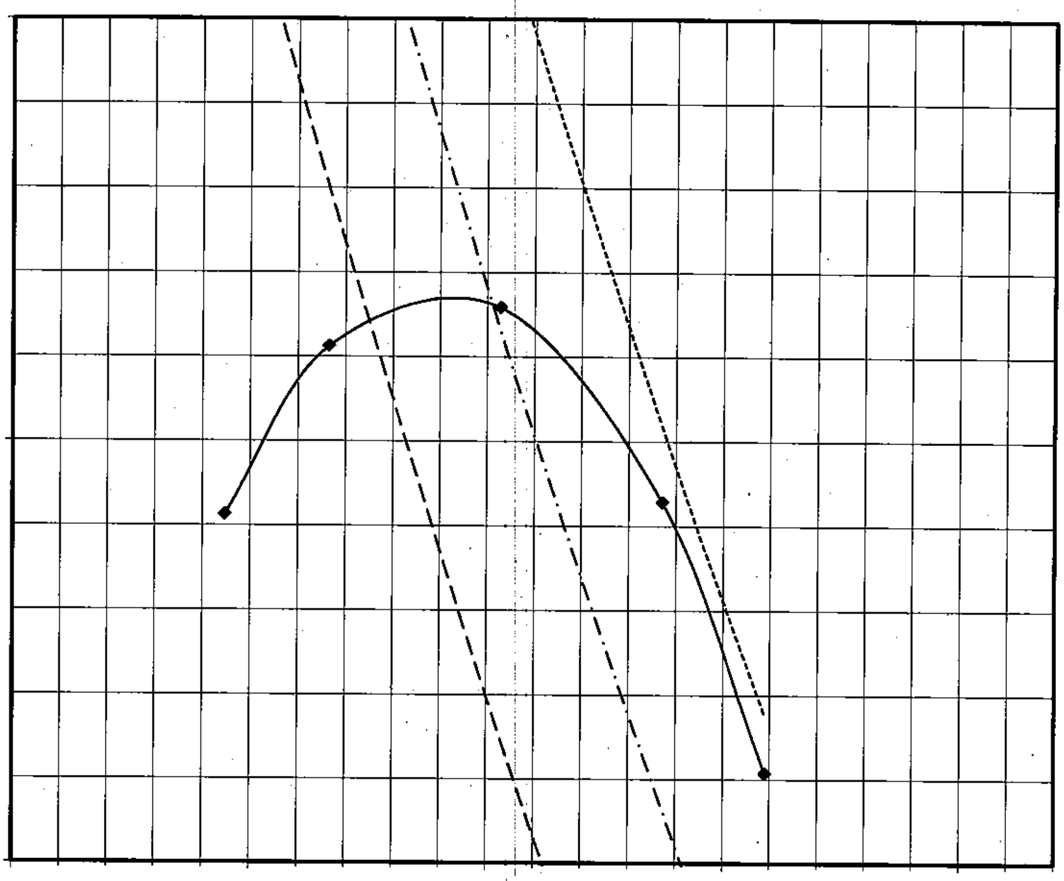
Contract No.:
9513-190210
Client Ref No:
LN01323

UKAS TESTING 2788

Dry Density/Moisture Content Relationship

BS 1377:Part 4:1990

Hole Number: **TP28** **Type :** **B** **Depth (m):** **5.50**



Initial Moisture Content:	18	Method of Compaction	2.5Kg Rammer / Single Sample	
Particle Density (Mg/m3):	2.65 Assumed	Material Retained on 37.5 mm Test Sieve (%):		0
Maximum Dry Density (mg/m3):	1.83	Material Retained on 20.0 mm Test Sieve (%):		0
Optimum Moisture Content (%):	14	Sample Preparation Clause :		3.2.4.1

Remarks

05/03/10 05/03/10

Checked by **Date** **Approved by** **Date**

LABORATORY TESTING SERVICES LIMITED

EnviRecover Hartlebury

Contract No.:
9513-190210
Client Ref No:
LN01323

UKAS TESTING 2788

LABORATORY TESTING SERVICES LIMITED

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Delta Lakes
Llanelli
Carmarthenshire
SA15 2DS
tel: +44 (0)1554 749720 / 757734
fax: +44 (0)1554 749845 / 775107
e-mail: info@geolab.org.uk

Certificate of Analysis

Date:	05/03/2010
Client:	Hyder Consulting
Our Reference:	9513-190210
Client Reference:	LN01323
Contract Title:	Envi Recover Hartley
Description: (Total Samples)	12
Date Received:	19/02/2010
Date Started:	02/03/2010
Date Completed:	04/03/2010
Test Procedures:	(B.S. 1377 : PART 3 : 1990)

Notes:

Solid samples will be disposed 1 month and liquids 2 weeks after the date of issue of this test certificate

Approved By:

Authorised Signatories:

Vaughan Edwards	W. Honey Wayne Honey	Alun Walters Alun Walters
Managing Director	Laboratory Technician	Technical Manager

Contract No: 9513-190210
Client Ref: LN01323
Location: Envi Recover Hartley
Date: 04/03/2010

LABORATORY TESTING SERVICES LIMITED

SUMMARY OF CHEMICAL ANALYSES

(B.S. 1377 : PART 3 : 1990)

Hole Number	Sample Number	Depth m	Sulphate Content SO3 (as SO_4)			Chloride Content		pH Value @ 25°C	Organic Matter Content %	Loss on Ignition %	Remarks
			Acid Soluble Sulphate as % SO_4 Clause 5.5.	Aqueous Extract Sulphate as g/l SO_4 Clause 5.5.	Ground-water g/l Clause 5.4.	Soluble Chloride as % equiv. NaCl Clause 7.3	Ground-water g/l Clause 7 2	Clause 9.	Clause 3.	Clause 4.	
BH23		1.20		0.02 (0.02)				7.77			
BH23		5.00		0.03 (0.03)				7.86			
BH24		2.00		0.03 (0.04)				8.07			
BH24		4.00		0.03 (0.03)				8.09			
BH24		5.00		0.02 (0.02)				8.20			
BH24		8.00		0.02 (0.02)				8.25			
BH25		2.00		0.05 (0.07)				7.81			
BH25		4.00		0.03 (0.04)				7.97			
BH25		8.00		0.05 (0.06)				8.02			
BH26		7.90		0.03 (0.03)				8.02			
TP27		3.30		0.01 (0.02)				7.96			
TP28		2.90		<.01 (<.01)				8.04			

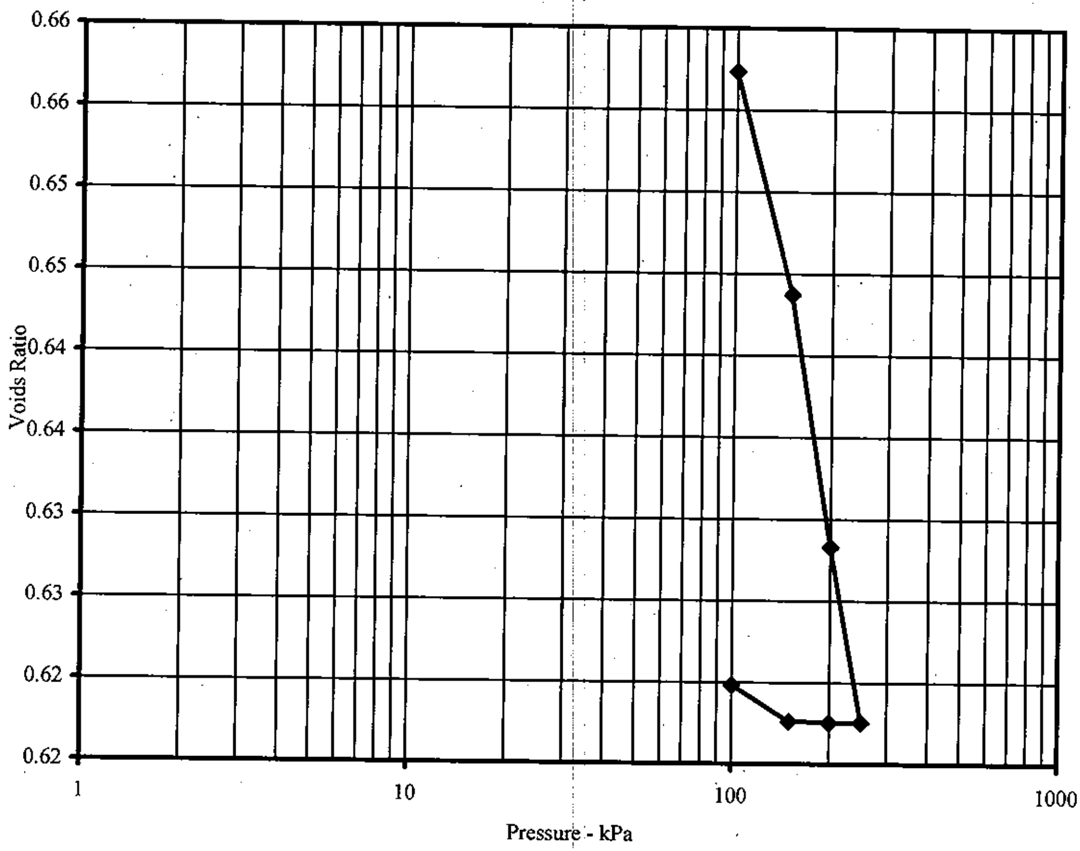
NCP - No Chloride present

ONE DIMENSIONAL CONSOLIDATION

BS1377: Part 5: 1990

Hole Number: **BH23** Sample Number: **N/A** Depth (m): **2.00**

Initial Conditions		Pressure Range kPa			Mv m2/MN	Cv m2/yr	Method of time fitting used Cv Calculated using t90
Moisture Content (%):	20						
Bulk Density (Mg/m3):	1.87	0	-	100	0.247	6.445	Nominal Laboratory Temperature 20'C
Dry Density (Mg/m3):	1.56	100	-	150	0.164	4.432	
Voids Ratio:	0.6993	150	-	200	0.187	1.531	Location of specimen with sample Top
Degree of saturation:	74.4	200	-	250	0.132	0.626	
Height (mm):	19.85	250	-	200	0.000	4.289	Remarks:
Diameter (mm)	75.08	200	-	150	0.001	9.596	
Particle Density (Mg/m3): Assumed	2.65	150	-	100	0.028	6.582	



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LABORATORY TESTING SERVICES LIMITED

EnviRecover Hartlebury

Contract No. 9513-190210

Client Ref No. LN01323

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ONE DIMENSIONAL CONSOLIDATION

BS1377: Part 5: 1990

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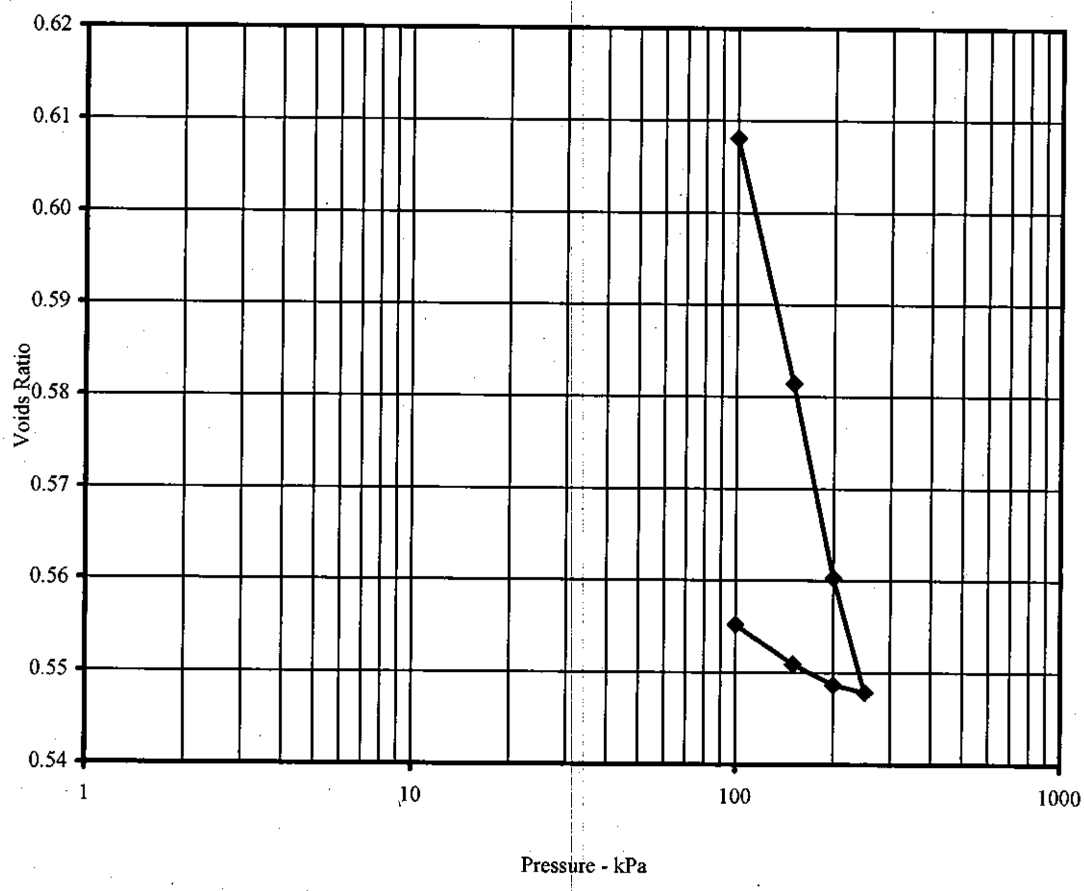
ONE DIMENSIONAL CONSOLIDATION

BS1377: Part 5: 1990

Hole Number: **BH24** Sample Number: **N/A** Depth (m): **2.00**

Initial Conditions		Pressure Range kPa			Mv m2/MN	Cv m2/yr	Method of time fitting used Cv Calculated using t90
Moisture Content (%):	20						
Bulk Density (Mg/m3):	1.92	0	-	100	0.264	6.545	Nominal Laboratory Temperature 20'C
Dry Density (Mg/m3):	1.60	100	-	150	0.331	4.402	
Voids Ratio:	0.6517	150	-	200	0.268	1.519	Location of specimen with sample Top
Degree of saturation:	80	200	-	250	0.160	1.044	
Height (mm):	19.9	250	-	200	0.011	5.906	Remarks:
Diameter (mm)	74.35	200	-	150	0.029	4.188	
Particle Density (Mg/m3): Assumed	2.65	150	-	100	0.055	3.212	



05/03/10 05/03/10

Checked By Date Approved By Date

LABORATORY TESTING SERVICES LIMITED

EnviRecover Hartlebury

Contract No. **9513-190210**
Client Ref No. **LN01323**

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ONE DIMENSIONAL CONSOLIDATION

BS1377: Part 5: 1990

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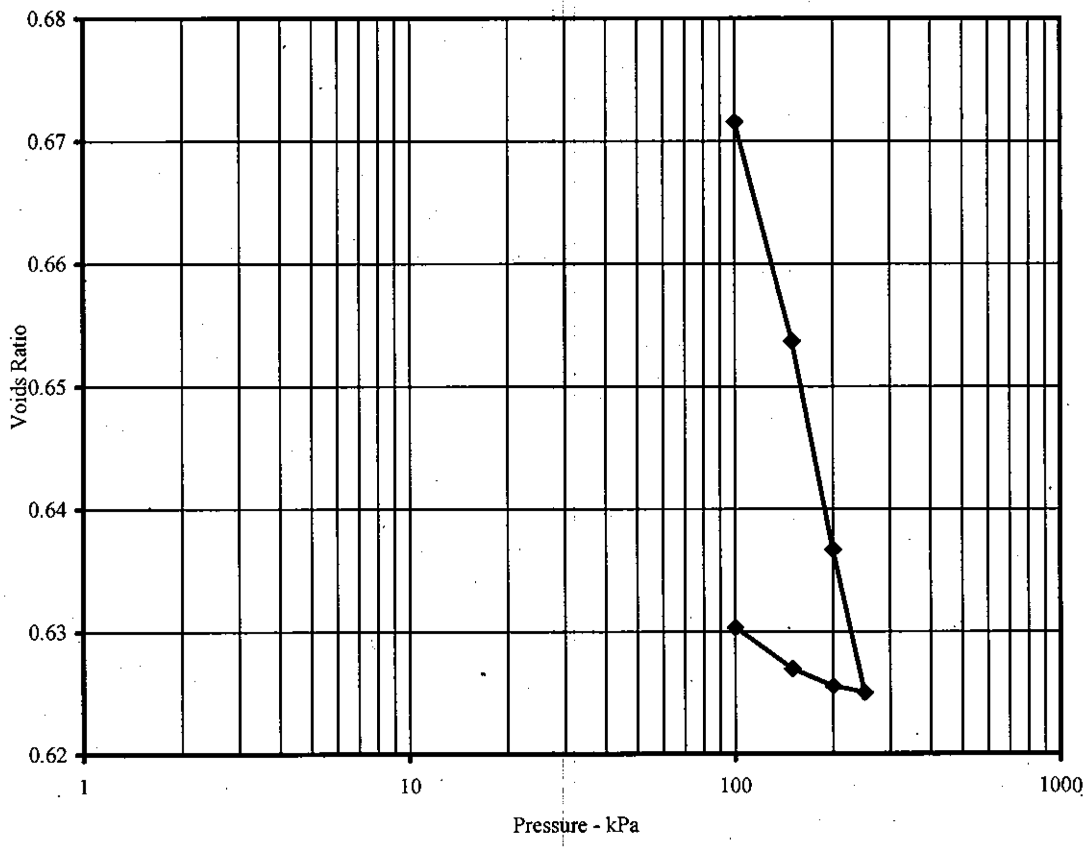
ONE DIMENSIONAL CONSOLIDATION

BS1377: Part 5: 1990

Hole Number: **BH25** Sample Number: **N/A** Depth (m): **2.50**

Initial Conditions		Pressure Range kPa			Mv m2/MN	Cv m2/yr	Method of time fitting used
Moisture Content (%):	28						Cv Calculated using t90
Bulk Density (Mg/m3):	1.95	0	-	100	0.371	1.618	Nominal Laboratory Temperature
Dry Density (Mg/m3):	1.53	100	-	150	0.214	1.690	20'C
Voids Ratio:	0.7361	150	-	200	0.206	1.110	Location of specimen with sample
Degree of saturation:	99	200	-	250	0.143	0.811	Top
Height (mm):	19.9	250	-	200	0.006	5.820	Remarks:
Diameter (mm)	75.26	200	-	150	0.017	2.468	
Particle Density (Mg/m3): Assumed	2.65	150	-	100	0.042	3.197	



Checked By: [signature] Date: 05/03/10

Approved By: [signature] Date: 05/03/10

LABORATORY TESTING SERVICES LIMITED

EnviRecover Hartlebury

Contract No. **9513-190210**

Client Ref No. **LN01323**

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ONE DIMENSIONAL CONSOLIDATION

BS1377: Part 5: 1990

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Consolidated Undrained Triaxial Compression Test
BS 1377 : Part 8 : 1990

Specimen Details

Borehole		BH24
Sample No.		
Depth	m	6.5
Date		04/03/2010
Disturbed / Undisturbed		Undisturbed

Description of Specimen

Reddish brown slightly gravelly silty CLAY

Initial Specimen Conditions

Height	mm	203.00
Diameter	mm	106.00
Area	mm^2	8824.73
Volume	cm^3	1791.42
Mass	g	3939.30
Dry Mass	g	3528.80
Density	Mg/m^3	2.20
Dry Density	Mg/m^3	1.97
Moisture Content	%	12
Specific Gravity	kN/m^3	2.65
	(assumed/measured)	assumed

Final Specimen Conditions

Moisture Content	%	13
Density	Mg/m^3	2.26
Dry Density	Mg/m^3	2.00

Checked and Approved By

05/03/10
Date

Client Ref
LN01323

LABORATORY TESTING SERVICES LIMITED

EnviRecover - Hartlebury

Contract No
9513-250210

Consolidated Undrained Triaxial Compression Test
BS 1377 : Part 8 : 1990

Specimen Details

Borehole		BH24
Sample No.		
Depth	m	6.5
Date		04/03/2010

Test Setup

Date started	23/02/2010
Date Finished	03/03/2010
Top Drain Used	y
Base Drain Used	y
Side Drains Used	y
Pressure System Number	P2
Cell Number	C2

Saturation

Cell Pressure Incr.	kPa	100.00
Back Pressure Incr.	kPa	95.00
Differential Pressure	kPa	5.00
Final Cell Pressure	kPa	500.00
Final Pore Pressure	kPa	493.00
Final B Value		0.98

Consolidation

Effective Pressure	kPa	50.00	100.00	200.00
Cell Pressure	kPa	500.00	500.00	500.00
Back Pressure	kPa	450.00	400.00	300.00
Excess Pore Pressure	kPa	43.00	29.00	99.00
Pore Pressure at End	kPa	450.00	400.00	300.00
Consolidated Volume	cm^3	1778.32	1773.42	1761.52
Consolidated Height	mm	202.51	195.52	191.19
Consolidated Area	mm^2	8781.71	9070.28	9213.47
Vol. Compressibility	m^2/MN	0.01625	0.00689	0.02237
Consolidation Coef.	$m^2/yr.$	11.86643	4.41197	3.35741

Alan Walters
Checked and Approved By

05/03/10
Date

Client Ref
LN01323

EnviRecover - Hartlebury

Contract No
9513-250210

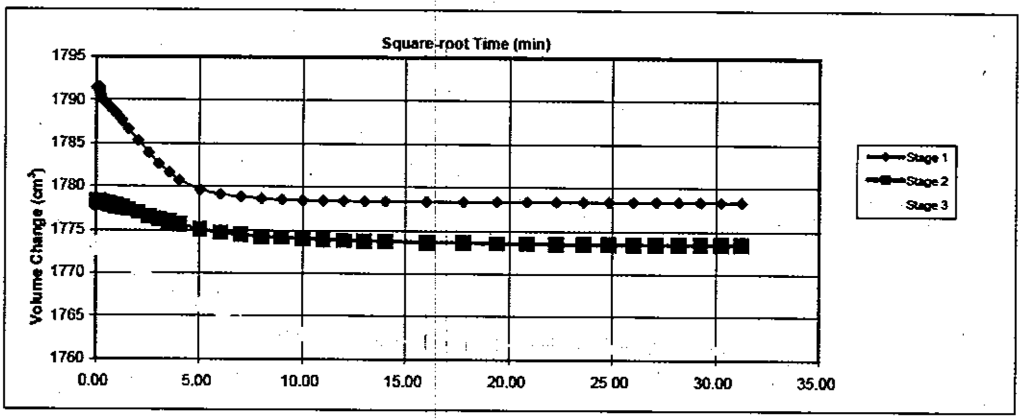
LABORATORY TESTING SERVICES LIMITED

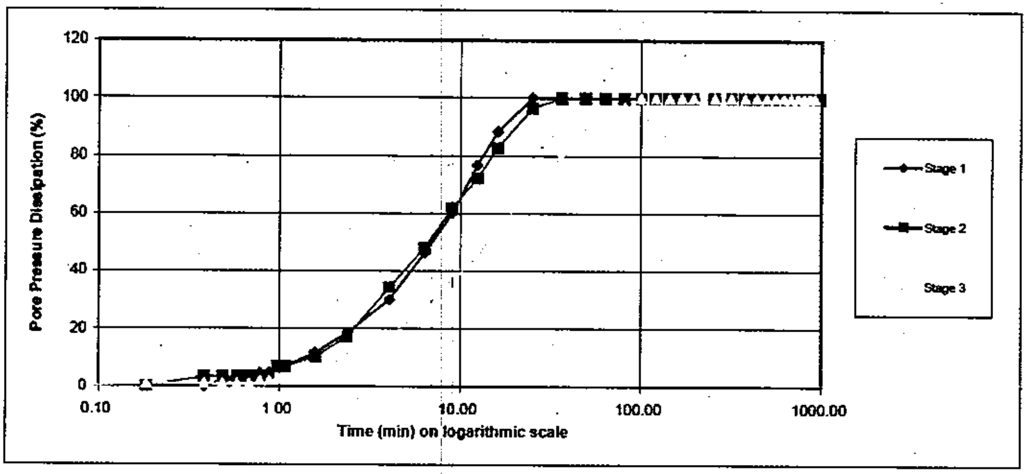
Consolidated Undrained Triaxial Compression Test
BS 1377 : Part 8 : 1990

Specimen Details

Borehole		BH24
Sample No.		
Depth	m	6.5
Date		04/03/2010

Consolidation Stage





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Date

Client Ref
LN01323

EnviRecover - Hartlebury

Contract No
9513-250210

LABORATORY TESTING SERVICES LIMITED

Consolidated Undrained Triaxial Compression Test
BS 1377 : Part 8 : 1990

Specimen Details

Borehole		BH24
Sample No.		
Depth	m	6.5
Date		04/03/2010

Shearing

Initial Cell Pressure	kPa	500	500	500
Initial Pore Pressure	kPa	450	400	300
Rate of Strain	mm/min	0.2254	0.0809	0.0602
Max Deviator Stress				
Axial Strain		3.699	5.947	7.320
Axial Stress	kPa	230.179	250.00	347.31
Cor. Deviator stress	kPa	227.263	245.92	343.08
Effective Major Stress	kPa	289.263	330.92	483.08
Effective Minor Stress	kPa	63.000	85.00	140.00
Effective Stress Ratio		4.591	3.893	3.45
s'	kPa	176.132	207.96	311.54
t'	kPa	113.132	122.96	171.54
Max Effective Priciple Stress Ratio				
Axial Strain		0.963	4.229	6.248
Axial Stress	kPa	161.834	235.121	342.477
Cor. Deviator stress	kPa	161.736	231.166	338.307
Effective Major Stress	kPa	186.736	296.166	466.307
Effective Minor Stress	kPa	25.000	65.000	128.000
Effective Stress Ratio		7.469	4.556	3.643
s'	kPa	105.868	180.583	297.153
t'	kPa	80.868	115.583	169.153
Shear Resistance Angle	degs			28.0
Cohesion c'	kPa			35

Checked and Approved By

05/03/10
Date

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EnviRecover - Hartlebury

Client Ref
LN01323

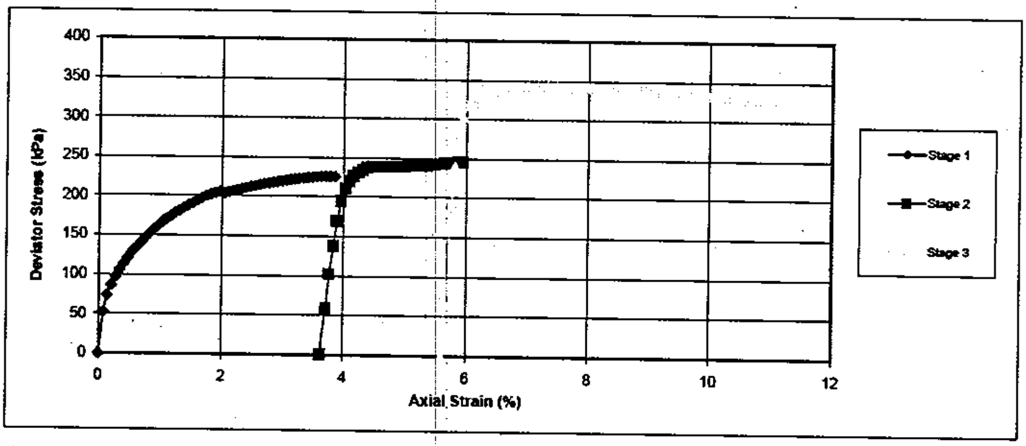
Contract No
9513-250210

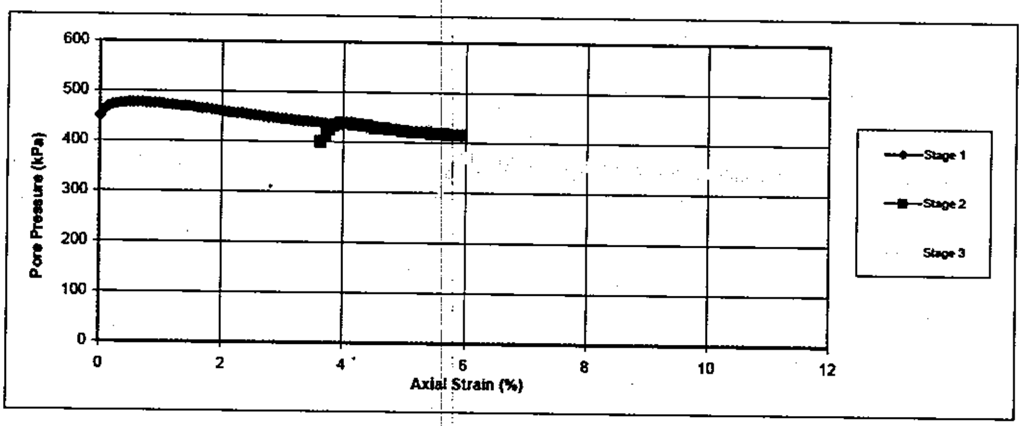
Consolidated Undrained Triaxial Compression Test
BS 1377 : Part 8 : 1990

Specimen Details

Borehole		BH24
Sample No.		
Depth	m	6.5
Date		04/03/2010

Shearing Stage





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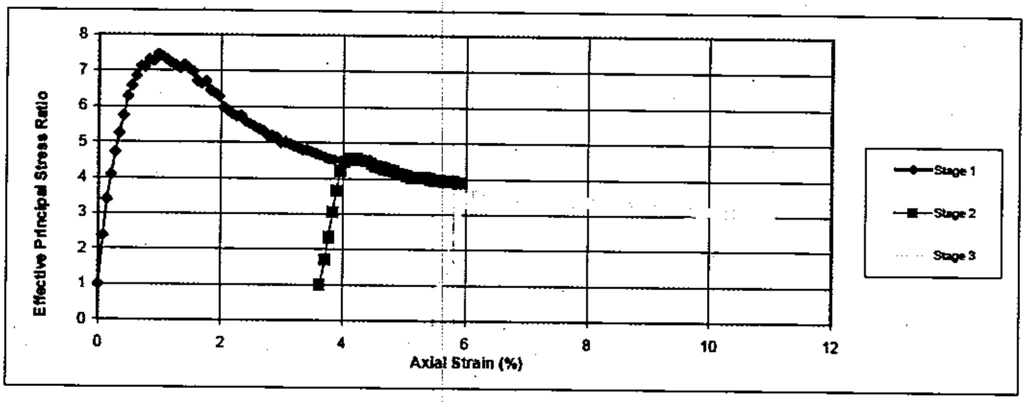
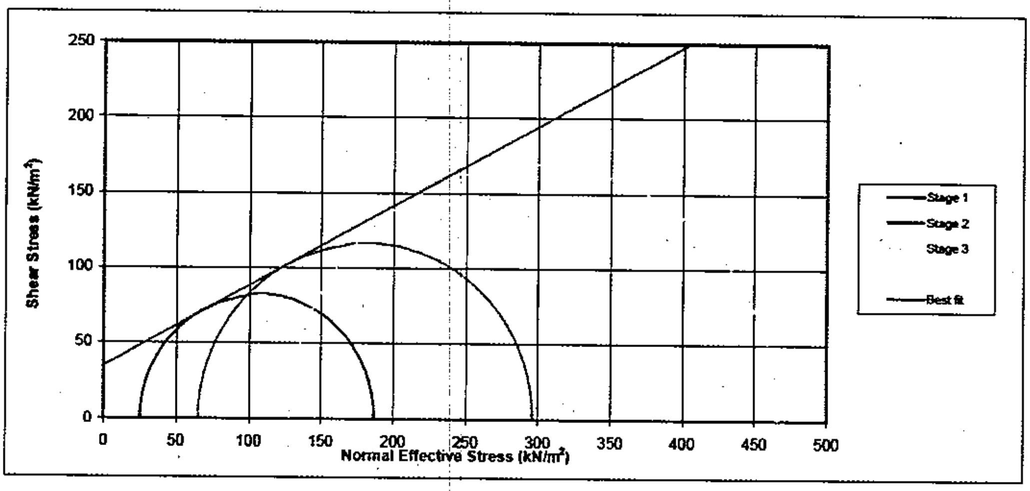
Specimen Details

Borehole		BH24
Sample No.		
Depth	m	6.5
Date		04/03/2010

Shearing Stage





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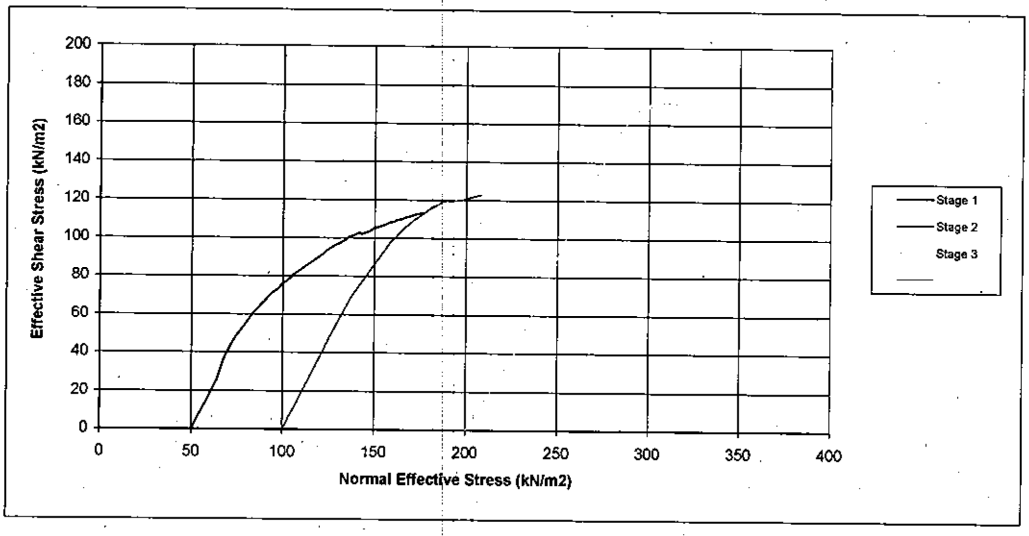
Sample No.		
Depth	m	6.5
Date		04/03/2010

Shearing Stage



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Contract No

9513-250210

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Consolidated Undrained Triaxial Compression Test

BS 1377 : Part 8 : 1990

Specimen Details

Borehole		BH24
Sample No.		
Depth	m	4
Date		05/03/2010
Disturbed / Undisturbed		Undisturbed

Description of Specimen

Reddish brown slightly gravelly silty CLAY

Initial Specimen Conditions

Height	mm	203.00
Diameter	mm	106.00
Area	mm^2	8824.73
Volume	cm^3	1791.42
Mass	g	3739.20
Dry Mass	g	3280.70
Density	Mg/m^3	2.09
Dry Density	Mg/m^3	1.83
Moisture Content	%	14
Specific Gravity	kN/m^3	2.65
(assumed/measured)		assumed

Final Specimen Conditions

Moisture Content	%	15
Density	Mg/m^3	2.17
Dry Density	Mg/m^3	1.90

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EnviRecover - Hartlebury

Contract No

9513-250210

Consolidated Undrained Triaxial Compression Test
BS 1377 : Part 8 : 1990

Specimen Details

Borehole		BH24
Sample No.		
Depth	m	4
Date		05/03/2010

Test Setup

Date started	23/02/2010
Date Finished	04/03/2010
Top Drain Used	y
Base Drain Used	y
Side Drains Used	y
Pressure System Number	P5
Cell Number	C5

Saturation

Cell Pressure Incr.	kPa	100.00
Back Pressure Incr.	kPa	95.00
Differential Pressure	kPa	5.00
Final Cell Pressure	kPa	400.00
Final Pore Pressure	kPa	396.00
Final B Value		1.00

Consolidation

Effective Pressure	kPa	50.00	100.00	200.00
Cell Pressure	kPa	400.00	400.00	400.00
Back Pressure	kPa	350.00	300.00	200.00
Excess Pore Pressure	kPa	46.00	22.00	93.00
Pore Pressure at End	kPa	350.00	300.00	200.00
Consolidated Volume	cm^3	1751.52	1746.22	1730.12
Consolidated Height	mm	201.49	197.41	194.93
Consolidated Area	mm^2	8693.70	8845.64	8875.78
Vol. Compressibility	m^2/MN	0.06364	0.01009	0.04610
Consolidation Coef.	$m^2/yr.$	4.63532	3.66248	3.08893

Checked and Approved By

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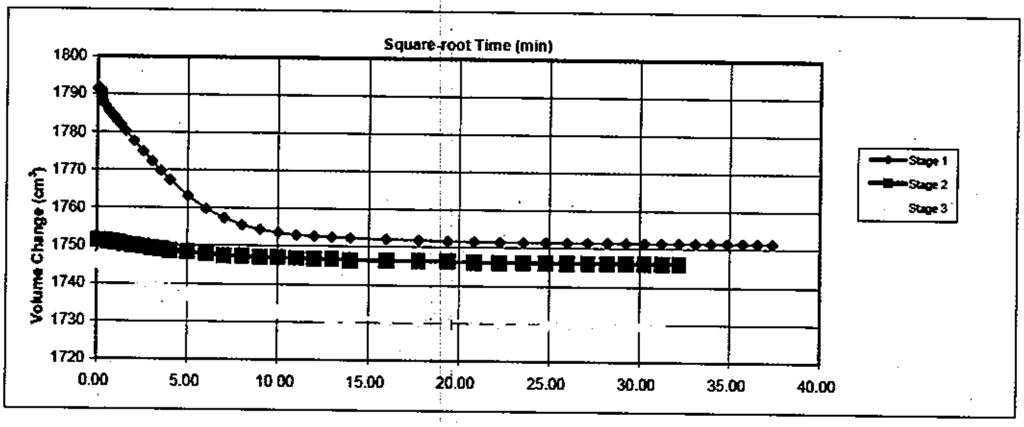
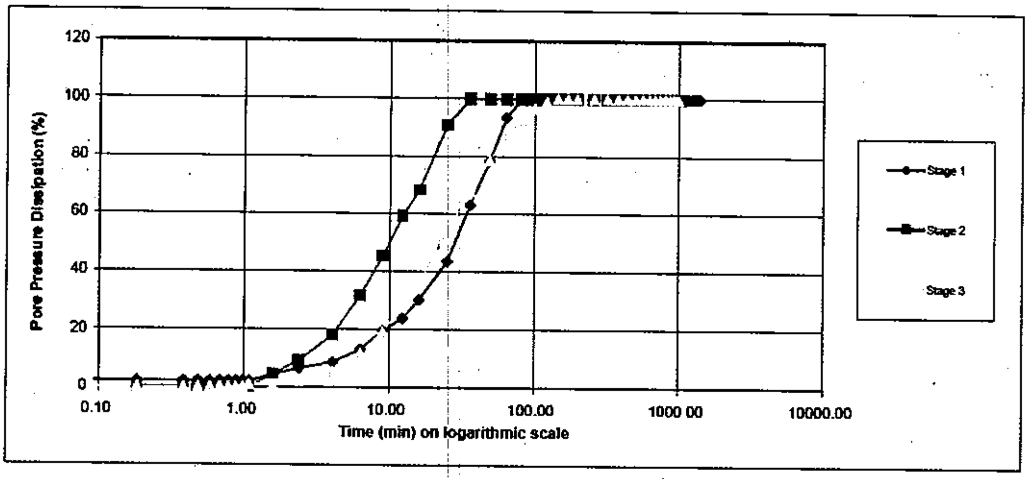
Consolidated Undrained Triaxial Compression Test
BS 1377 : Part 8 : 1990

Specimen Details

Borehole		BH24
Sample No.		
Depth	m	4
Date		05/03/2010

Consolidation Stage





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Consolidated Undrained Triaxial Compression Test

BS 1377 : Part 8 : 1990

Specimen Details

Borehole		BH24
Sample No.		
Depth	m	4
Date		05/03/2010

Shearing

Initial Cell Pressure	kPa	400	400	400
Initial Pore Pressure	kPa	350	300	200
Rate of Strain	mm/min	0.0876	0.0678	0.0565
Max Deviator Stress				
Axial Strain		3.410	4.154	5.546
Axial Stress	kPa	258.761	274.10	382.35
Cor. Deviator stress	kPa	255.867	270.15	378.22
Effective Major Stress	kPa	330.867	353.15	531.22
Effective Minor Stress	kPa	76.000	83.00	153.00
Effective Stress Ratio		4.354	4.255	3.47
s'	kPa	203.433	218.08	342.11
t'	kPa	127.433	135.08	189.11
Max Effective Priciple Stress Ratio				
Axial Strain		1.251	3.349	4.643
Axial Stress	kPa	188.100	235.132	369.583
Cor. Deviator stress	kPa	187.973	231.242	365.505
Effective Major Stress	kPa	224.973	293.242	499.505
Effective Minor Stress	kPa	37.000	62.000	134.000
Effective Stress Ratio		6.080	4.730	3.728
s'	kPa	130.986	177.621	316.753
t'	kPa	93.986	115.621	182.753
Shear Resistance Angle	degs			29.0
Cohesion c'	kPa			36

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EnviRecover - Hartlebury

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Consolidated Undrained Triaxial Compression Test
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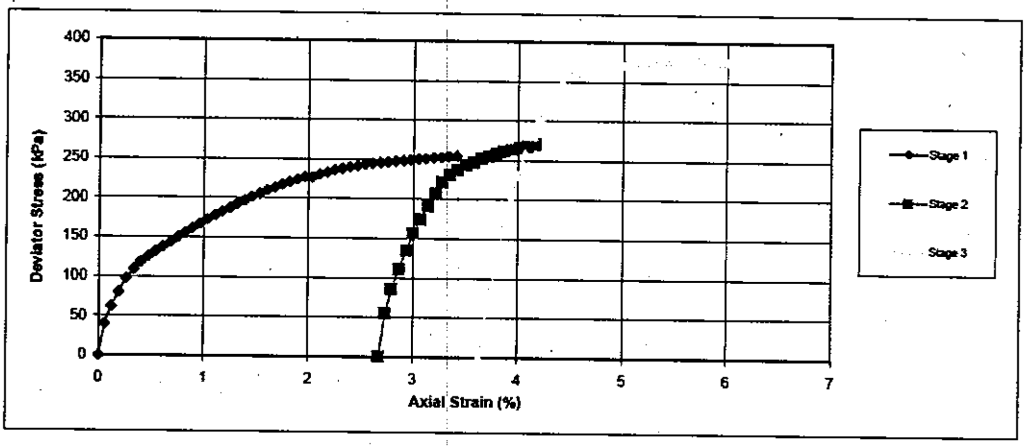
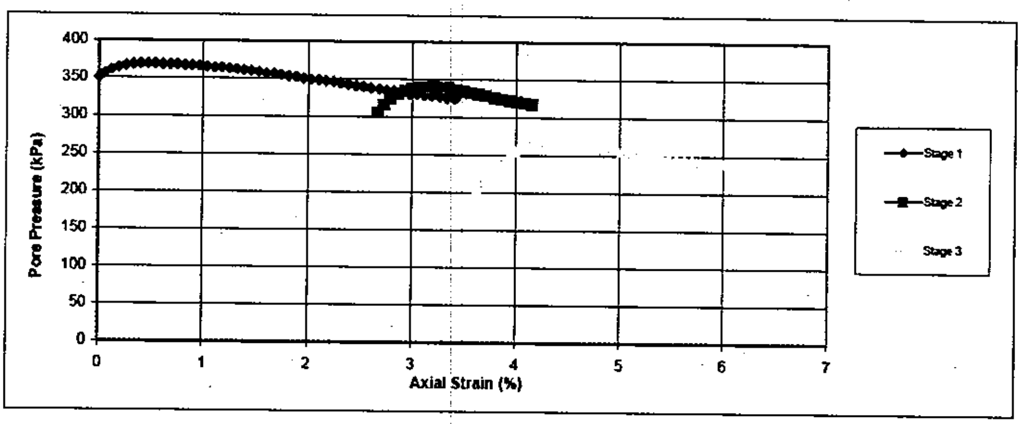
Specimen Details

Borehole		BH24
Sample No.		
Depth	m	4
Date		05/03/2010

Shearing Stage





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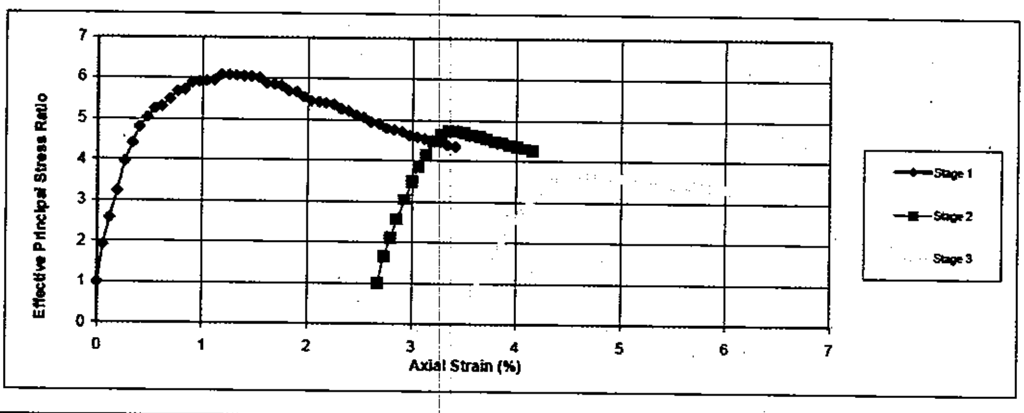
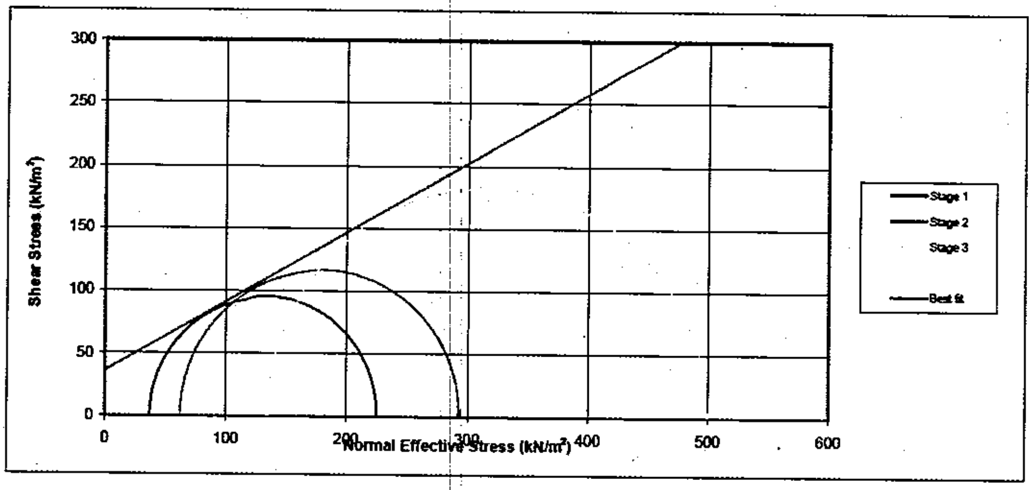
Borehole		BH24
Sample No.		
Depth	m	4
Date		05/03/2010

Shearing Stage





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Contract No
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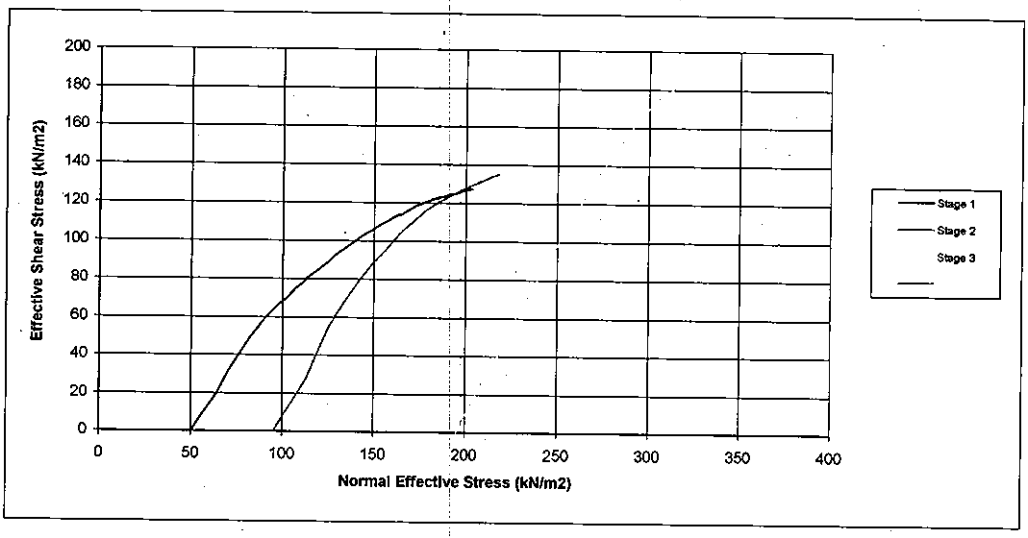
BS 1377 : Part 8 : 1990

Specimen Details

Borehole		BH24
Sample No.		
Depth	m	4
Date		05/03/2010

Shearing Stage



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Client Ref
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EnviRecover - Hartlebury

Contract No
9513-250210

GEO LABORATORY TESTING SERVICES LIMITED

Consolidated Undrained Triaxial Compression Test
BS 1377 : Part 8 : 1990

Specimen Details

Borehole		BH25
Sample No.		
Depth	m	4
Date		05/03/2010
Disturbed / Undisturbed		Undisturbed

Description of Specimen

Reddish brown slightly gravelly silty CLAY

Initial Specimen Conditions

Height	mm	204.00
Diameter	mm	104.00
Area	mm^2	8494.87
Volume	cm^3	1732.95
Mass	g	3948.10
Dry Mass	g	3587.60
Density	Mg/m^3	2.28
Dry Density	Mg/m^3	2.07
Moisture Content	%	10
Specific Gravity	kN/m^3	2.65
(assumed/measured)		assumed

Final Specimen Conditions

Moisture Content	%	11
Density	Mg/m^3	2.32
Dry Density	Mg/m^3	2.09

[signature]
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EnviRecover - Hartlebury

Contract No

9513-250210

Consolidated Undrained Triaxial Compression Test
BS 1377 : Part 8 : 1990

Specimen Details

Borehole		BH25
Sample No.		
Depth	m	4
Date		05/03/2010

Test Setup

Date started	23/02/2010
Date Finished	04/03/2010
Top Drain Used	y
Base Drain Used	y
Side Drains Used	y
Pressure System Number	P4
Cell Number	C4

Saturation

Cell Pressure Incr.	kPa	100.00
Back Pressure Incr.	kPa	95.00
Differential Pressure	kPa	5.00
Final Cell Pressure	kPa	500.00
Final Pore Pressure	kPa	495.00
Final B Value		-

Consolidation

Effective Pressure	kPa	50.00	100.00	200.00
Cell Pressure	kPa	500.00	500.00	500.00
Back Pressure	kPa	450.00	400.00	300.00
Excess Pore Pressure	kPa	45.00	20.00	82.00
Pore Pressure at End	kPa	450.00	400.00	300.00
Consolidated Volume	cm^3	1723.35	1721.85	1713.45
Consolidated Height	mm	203.62	199.46	195.94
Consolidated Area	mm^2	8463.49	8632.48	8744.70
Vol. Compressibility	m^2/MN	0.01231	0.00218	0.01626
Consolidation Coef.	m^2/yr.	5.21497	0.42902	1.41624

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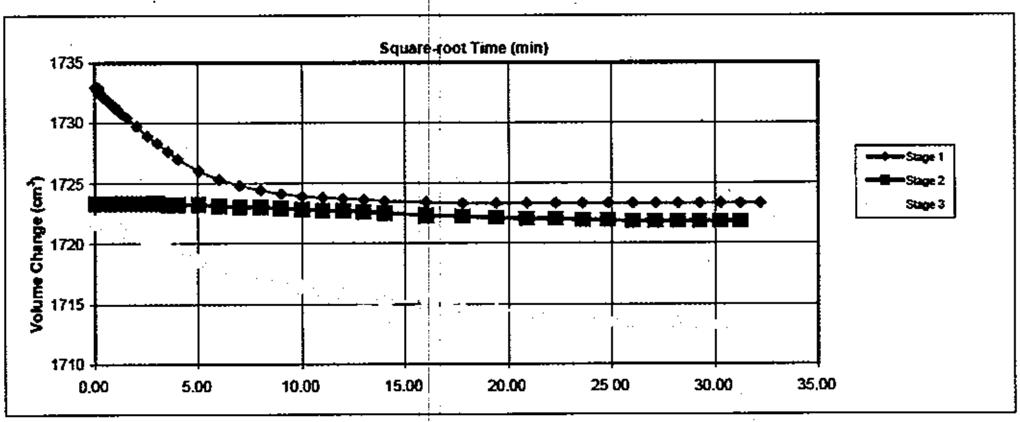
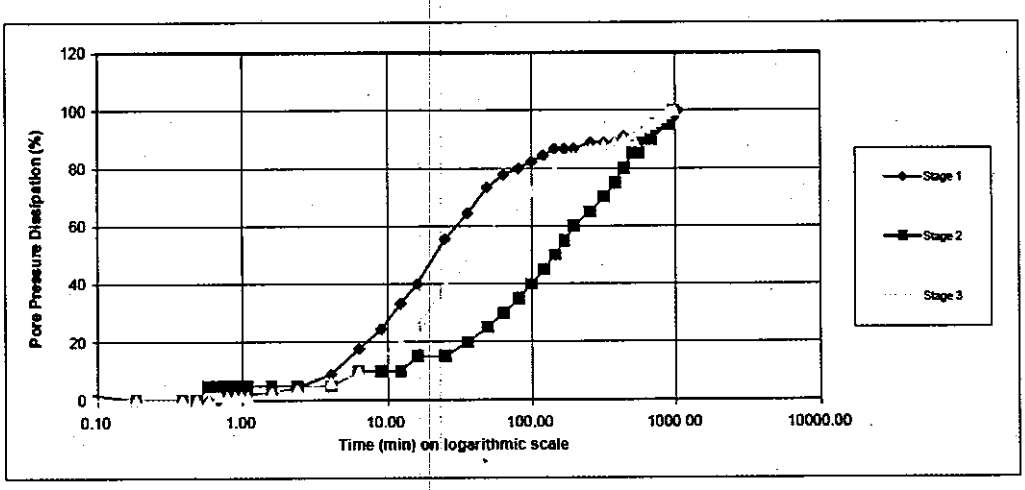
Specimen Details

Borehole		BH25
Sample No.		
Depth	m	4
Date		05/03/2010

Consolidation Stage





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Consolidated Undrained Triaxial Compression Test
BS 1377 : Part 8 : 1990

Specimen Details

Borehole		BH25
Sample No.		
Depth	m	4
Date		05/03/2010

Shearing

Initial Cell Pressure	kPa	500	500	500
Initial Pore Pressure	kPa	450	400	300
Rate of Strain	mm/min	0.1035	0.0083	0.0270
Max Deviator Stress				
Axial Strain		2.814	4.351	5.973
Axial Stress	kPa	511.910	564.48	698.32
Cor. Deviator stress	kPa	509.053	560.51	694.15
Effective Major Stress	kPa	586.053	666.51	869.15
Effective Minor Stress	kPa	78.000	106.00	175.00
Effective Stress Ratio		7.514	6.288	4.97
s'	kPa	332.027	386.26	522.08
t'	kPa	254.027	280.26	347.08
Max Effective Priciple Stress Ratio				
Axial Strain		0.918	3.118	4.927
Axial Stress	kPa	291.854	468.068	651.176
Cor. Deviator stress	kPa	291.758	464.188	647.071
Effective Major Stress	kPa	322.758	536.188	794.071
Effective Minor Stress	kPa	31.000	72.000	147.000
Effective Stress Ratio		10.412	7.447	5.402
s'	kPa	176.879	304.094	470.535
t'	kPa	145.879	232.094	323.535
Shear Resistance Angle	degs			38.0
Cohesion c'	kPa			49

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Specimen Details

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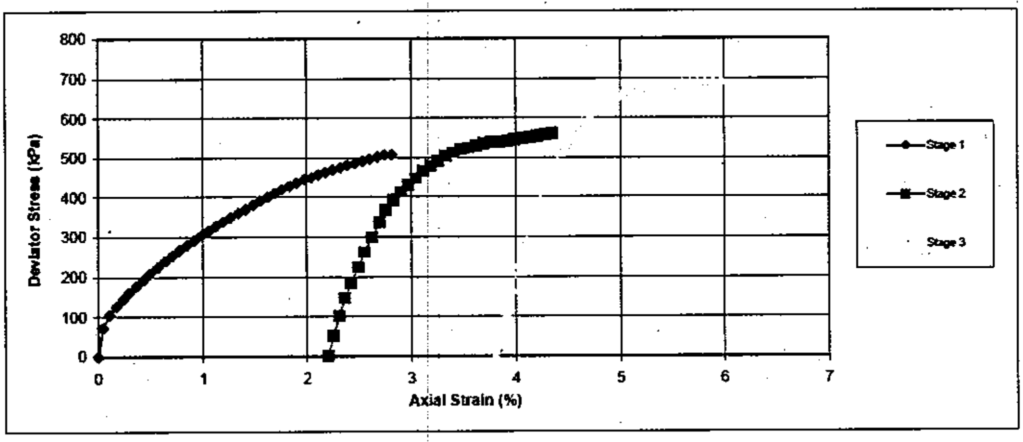
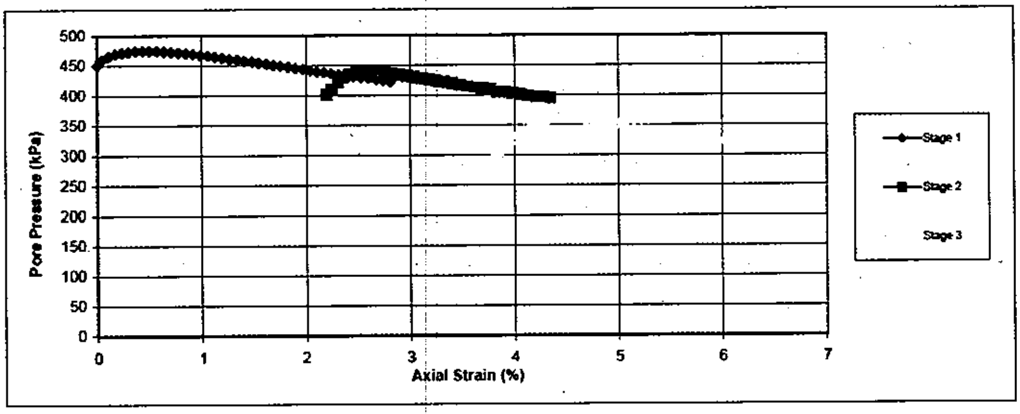
Sample No.		
Depth	m	4
Date		05/03/2010

Shearing Stage





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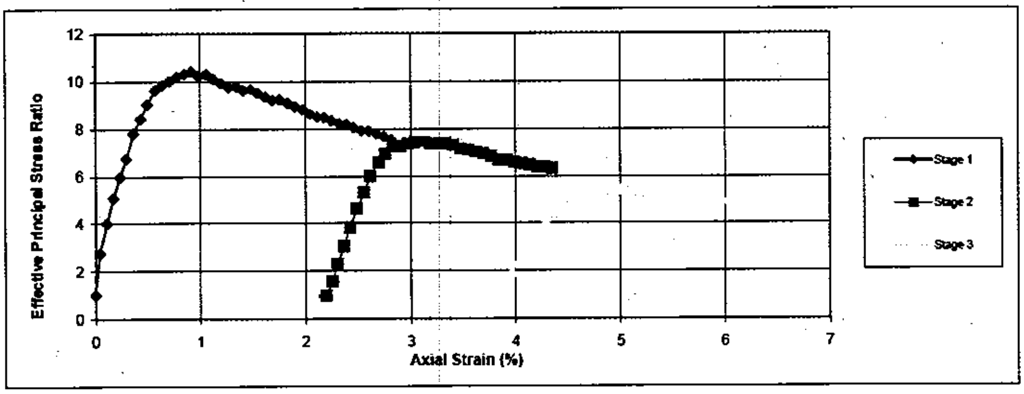
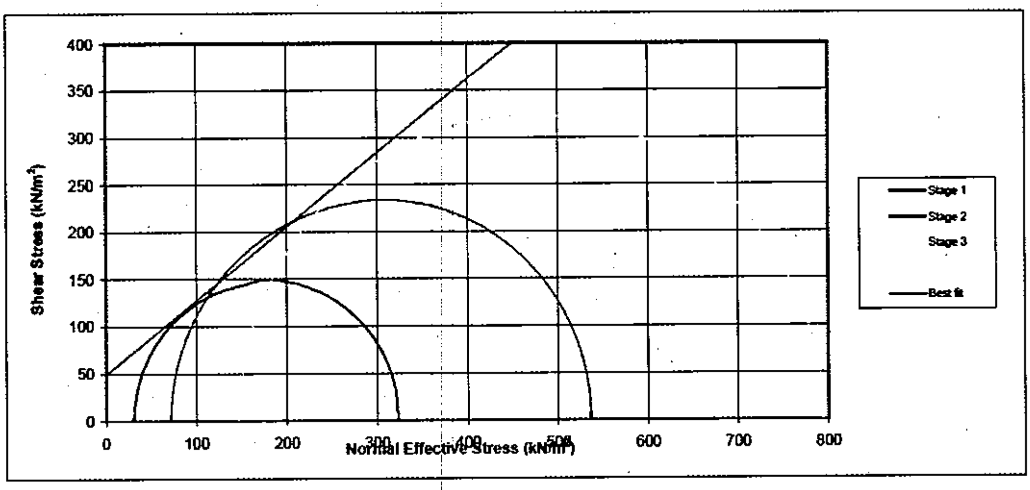
Specimen Details

Borehole		BH25
Sample No.		
Depth	m	4
Date		05/03/2010

Shearing Stage





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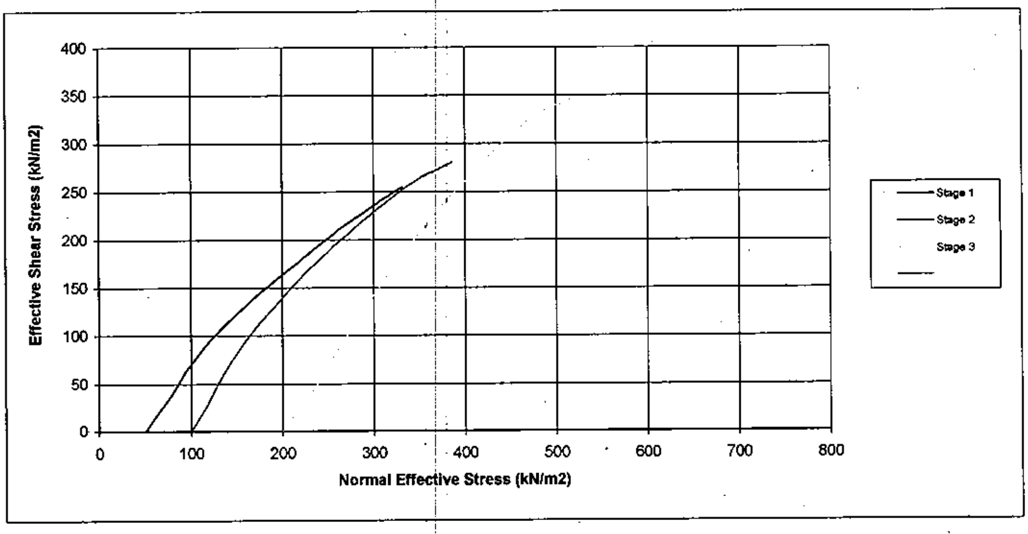
Borehole		BH25
Sample No.		
Depth	m	4
Date		05/03/2010

Shearing Stage



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Contract No
9513-250210

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Appendix E – Hyder Contaminated Land Interpretative Report

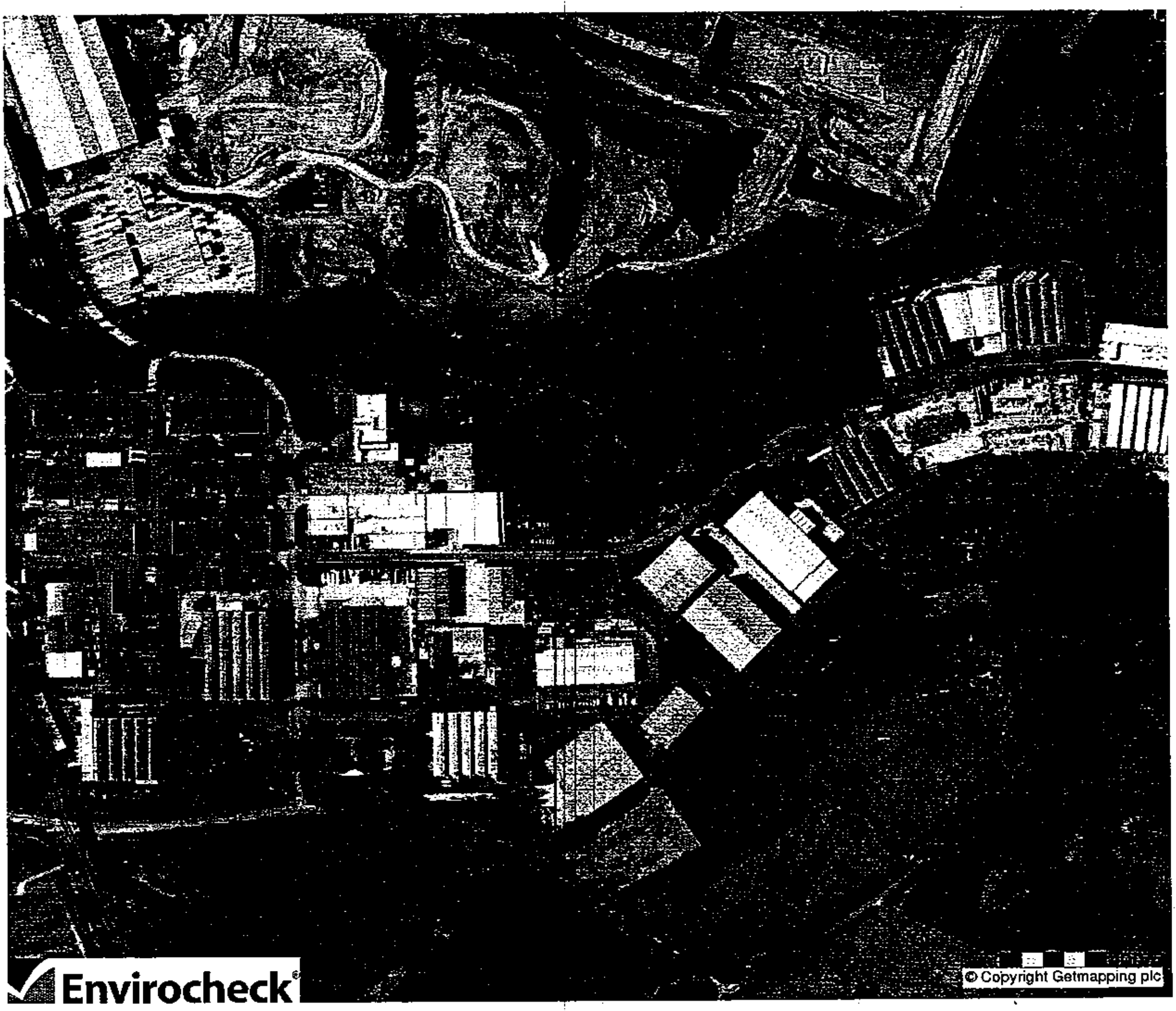
Hyder

mercia
waste management

Mercia Waste Management

Mercia EnviRecover Renewable Energy Facility

Contaminated Land Interpretative Report



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Mercia Waste Management

Mercia EnviRecover Renewable Energy Facility

Contaminated Land Interpretative Report

Author [redacted]

Checker [redacted]

Approver [redacted]

[redacted]

Report No 5005-LN01323-NER-01

Date 15 April 2010

This report has been prepared for the Mercia Waste Management in accordance with the terms and conditions of appointment for the Mercia EnviRecover Renewable Energy Facility contract dated 14th January 2010. Hyder Consulting (UK) Limited (2212959) cannot accept any responsibility for any use of or reliance on the contents of this report by any third party.

CONTENTS

Appendices

Executive Summary

Introduction:

1. Hyder Consulting (UK) Limited (HCL) has been instructed by Mercia Waste Management (Mercia) to undertake a Geotechnical and Geo-Environmental desk study, an Environmental Impact Statement, plus preliminary Factual and Interpretative Reports for a proposed 15.5MW renewable energy facility located at the Hartlebury Trading Estate in Worcestershire.
2. This report presents an interpretative summary of data collected during an initial preliminary ground investigation undertaken on site in February 2010 and provides advice relating to the physical and chemical nature of the ground based on interpretation of this data to support the EIA submission document.
3. Reference should also be made to the associated Desk Study Report (Ref. 1) and Factual Ground Investigation Report (Ref.6) for this development, also produced by HCL.

Site Location and Description:

4. The site is located approximately 9km south-south-east of Kidderminster, within the Hartlebury Trading Estate, Worcestershire and is centred on OS National Grid Reference 385950,269850.
5. The site encompasses an unoccupied area of disused land with open access from the south via Oak Drive, and is covered mainly by rough grass, bramble and low shrubs. A stream flows in culvert through the centre of the site. The site is bordered to the north by Biffa landfill site, and to the west by a small waste-water treatment works and large warehouse.

Hydrological and Environmental Sensitivity:

6. The site does not lie within a Groundwater Source Protection Zone, there are no licensed groundwater abstractions recorded within a 500m radius of the site and the site overlies a non-aquifer. The site therefore can be regarded as having low groundwater sensitivity.
7. The nearest primary river feature is located approximately 800m south-east, and is named the Elmley Brook. The stream flowing through the site discharges into this brook, so the site should be regarded as having high surface water sensitivity. There are no known water quality sampling points recorded for the brook.
8. There are no recorded major pollution incidents to controlled waters within 1km of the site.
9. Information contained within the Envirocheck Report shows that the site is not within the zone of potential flooding from fluvial watercourses.
10. The site can be regarded as having a low ecological sensitivity, though it should be noted that there is a small stand of Japanese knotweed on site, which will impose some constraints on the timing and methods of site clearance.

Geological Information:

11. Published geological information shows the solid geology directly beneath the site area to comprise the Mercia Mudstone Group (MMG) of Permo-Triassic geological age. A previous ground investigation undertaken on the site indicates this solid geology to be overlain by Superficial Deposits of re-worked natural soils, which in turn are overlain by Made Ground.
12. A preliminary ground investigation has been undertaken by HCL between 4th and 16th of February 2010 comprising boreholes (cable percussive and rotary cored) and trial pits, with associated geotechnical and contamination laboratory testing. This investigation has encountered a strata sequence in general accordance with those anticipated based on the desk study data, with a sequence comprising Made Ground over Superficial Deposits over Weathered (becoming unweathered) Mercia Mudstone material.

Continued ./...

Geological Information (continued):

13. In the northern part of the site, the Made Ground is typically 1-2m thick and generally granular in nature. In the southern part it is thicker (typically 2-2.5m) and more cohesive with many inclusions of construction waste including localised asbestos cement board.
14. The superficial soils are typically present to 1.5-2.5m and comprise soft/firm slightly gravelly clay.
15. The weathered Mercia Mudstone stratum initially comprises firm to stiff clay, that becomes rapidly very stiff/hard with depth (≈ 4m) grading into very weak mudstone at approximately7m depth.
16. Summaries of the pertinent engineering properties of these soils are provided and discussed within the text of the report for outline design.

Groundwater Levels:

17. Groundwater monitoring to date indicates levels that have fluctuated with time between 45.5 and 46.8 mAOD (1.0-2.5m bgl). These fluctuations may be linked to periods of rainfall variation, though evidence to date is insufficient to be conclusive. These water levels infer a groundwater flow direction from north to south across the site with a hydraulic gradient calculated to be ≈0.01.
18. Localised high water pressure conditions have been identified at a depth of 13-16m in Borehole BH20. However, because the artesian water pressures identified in this hole equalised over-night may indicate either that the layer and/or zone of material with elevated water pressures is confined and of relatively limited extent and/or that the permeability of the zone is sufficiently low to prevent maintenance of the artesian pressure for any length of time. The artesian effect is attributed to water pressure not volume; therefore significant water containment is not expected to be a major concern.

Contamination Assessment:

19. Analytical testing was undertaken on Made Ground and natural soils for soil totals and leachate. Groundwater was also analysed.
20. The soil results were compared to screening values for a standard CLEA commercial end use and only Lead was found to be elevated. Potential Asbestos containing material was encountered in the shallow Made Ground in one location.
21. Leachate and Groundwater results were compared to appropriate EQS or Drinking Water Standards. Whilst some contaminants (Copper, Ammoniacal Nitrogen and organics) were found to be elevated in the soils leachate analysis, this was not reflected in the groundwater results, which were generally found to be below the guidelines values.
22. Ground Gas monitoring is ongoing however to date no methane has been encountered. Carbon dioxide has been detected with a maximum of 10.5% volume. Flow rates are generally low and the maximum reading was 0.2l/hr. The atmospheric pressure during the monitoring was between 900 and 1018mb. Using the maximum data available, the Gas Screening Value is 0.021l/hr which equates to Characteristic Situation 1 Very low risk. This will be reviewed once all the data has been collected.
23. A pollutant linkage assessment was undertaken and is presented in Table 11.2. This indicates that there is a moderate to low risk from the elevated Lead concentration and a moderate risk from asbestos containing material in the Made Ground. A low risk is presented for risk to controlled waters.

Contamination Considerations:

24. It is recommended that the elevated Lead concentrations encountered in BH20 at 0.75m depth are removed to reduce the risk to the construction workers and to future site users. This should be undertaken prior to works beginning to ensure that the material is not spread across the site.

25. A watching brief/discovery strategy should be maintained with regards to the potential presence of currently unknown contamination. If encountered during the site enabling works, an experienced Geo Environmental Engineer should be contacted and analysis undertaken on the suspected material.

Waste Management:

26. Due consideration should be given to the UK Landfill Directive when disposing of material to landfill. If material is to be re-used on site principles in the CL:AIRE document Definition of Waste: Development Industry Code of Practice should be followed.

27. Results of the total soil analysis were put into CATWASTESOIL and the majority were showed to be non-hazardous with 2 being hazardous.

28. Waste Acceptance Criteria (WAC) testing was undertaken on 2 samples which were shown to be non-hazardous. This indicated that one sample is likely to be considered as Inert and one as non-hazardous.

29. It is recommended that the excavated material is stockpiled and if disposal to landfill is required, testing should be undertaken at this stage to confirm the correct waste classification. During stockpiling Made Ground and natural soils and contaminated and non contaminated material should be separated as different disposal routes may be appropriate for each type.

30. The Duty of Care for waste disposal falls with the waste producer.

1 INTRODUCTION

Hyder Consulting (UK) Limited (HCL) has been instructed by Mercia Waste Management (Mercia) to undertake a Geotechnical and Geo-Environmental desk study, an Environmental Impact Statement, plus preliminary Factual and Interpretative Reports for a proposed 15.5MW renewable energy facility located at the Hartlebury Trading Estate in Worcestershire.

This Interpretative report presents a summary of data collected during an initial preliminary ground investigation undertaken on site in February 2010 and provides advice relating to the physical and chemical nature of the ground based on interpretation of this data. Prior to undertaking the ground investigation, a Desk Study Report (Ref. 1) was produced by HCL, which should be read in conjunction with this document and the associated Factual Ground Investigation Report (Ref.6).

1.1 Background to the Proposed Development

The Joint Municipal Waste Management Strategy (JMWMS) for Herefordshire and Worcestershire, 2004-2034, has highlighted the need for dealing more effectively with the waste left over after recycling (referred to as 'residual waste').

In a review of the JMWMS undertaken by the Joint Members Waste Forum, a number of scenarios for managing residual waste were examined using a computer model called WRATE. Following this assessment, the option of a single site Energy-from-Waste plant with combined heat and power (CHP) capabilities was identified as the optimum solution, resulting in the Mercia EnviRecover 15.5MW renewable energy facility.

As such, a planning application is required plus a ground and groundwater assessment for inclusion in a chapter of an EIA submission document. This chapter will pick up salient points of the contamination conceptual model and achievability of the current construction development based on the recovered technical information obtained from an intrusive ground investigation.

1.2 Objectives of the Report

The principal objective of the report is to provide an assessment of the current geotechnical and geo-environmental conditions of the proposed site. To this end, this report aims to :

- Establish likely ground and groundwater conditions beneath the site;
- Identify the potential presence of contaminants within the soil;
- Provide a series of construction phase options for the scheme;
- Identify health and safety issues arising as a result of the ground conditions; and
- Discuss materials management and waste disposal issues.

In order to meet these objectives, a site-specific intrusive preliminary ground investigation was undertaken and supervised by HCL utilising CJ Associates Ltd. (CJA) as drilling / plant provision subcontractors.

2 SITE SETTING

2.1 Site Location

The site is located approximately 9km south-south-east of Kidderminster, within the Hartlebury Trading Estate, Worcestershire.

The site comprises of a small parcel of land with an estimated surface area of 3.3 hectares. The Ordnance Survey National Grid Reference at the centre of the site is 385950,269850.

A site location plan is shown in Figure 1.

2.2 Site Description

The site encompasses an unoccupied area of disused land with open access from the south via Oak Drive. To the east, the site is immediately bordered by copse woodland, to the north by a pond and Biffa landfill site, and to the west by a small waste-water treatment works and large warehouse. The site is covered mainly by rough grass, bramble and low shrubs.

The waste-water treatment works in the west is accessed by a track that traverses north-west to south-east through the centre of the site. A stream flows from the waste-water treatment works, through the centre of the site and then off-site to the south. In general this stream flows within in a ditch, though it is culverted across the centre of the site and also further off-site to the south.

2.3 Public Register and Historical Information

Publically available information is usually obtained from agencies that have licences to reproduce data held by the UK Government and other such bodies. Landmark Information Group Ltd., who are the pre-eminent supplier of such data were approached to provide information for this study.

A full review of public register and historical information can be seen in the Desk Study Report (Ref. 1).

2.4 Geology and Hydrology

The 1:50,000 scale British Geological Survey (BGS) Sheet 182 (1976) shows the solid geology directly beneath the site area to comprise the Mercia Mudstone Group (MMG), a strata formerly referred to as the Keuper Marl.

Superficial deposits are not shown on the BGS Sheet 182, as the thickness of any localised deposits is considered insignificant at the mapped scale.

The former Lower Keuper Sandstone outcrops between one and two kilometres from the site to the north, south, east and west. To the east and west a faulted contact is postulated that suggests the site is on a downthrown block.

The dip of the sandstone to the west suggests that it may be present at approximately 40m bgl beneath the site.

Further details on the ground conditions on site and in the vicinity of the site (1km to the NW), have been obtained from an on-site ground investigation (undertaken in 2006, Ref. 2) and from a BGS report on the Hartlebury Landfill site located 800m to 1km north-west (Ref. 3). These sources indicate that the Hartlebury Landfill site is underlain by between 5m and 7m of superficial deposits (average of 6.2m), comprising an uppermost stratum of Made Ground, overlying weathered Mercia Mudstone. Bedrock is initially comprised of weak, red-brown mudstone (as part of the Mercia Mudstone Group).

More detailed geological classification for the area is obtained from the BGS report, which interprets the solid geology of the MMG in the area as comprising an upper sub-stratum of the Sidmouth Mudstone Formation (~up to 30m thick) and a lower sub-stratum of the Tarporley Siltstone Formation (~up to 20m thick). The MMG is underlain by the Bromsgrove Sandstone Formation at depths ranging from 30m to 60m below ground level (bgl).

While there has been little development on the site historically, the ground levels have been artificially raised, particularly in the south-west of the site, where approximately 3m of Made Ground is reported. Adjacent to this area is a mound, approximately 3m high, from which in excess of 4.3m of Made Ground was encountered in a trial pit excavated on top of the mound. Elsewhere on the site, the thickness of Made Ground is significantly reduced, to the order 1m to 2m. The site is therefore not level in places, with a mounded area in the south-west and a ditch up to 2m deep in the centre.

The National Soil Resources Institute Soils Site Report (Appendix D of Ref. 1) indicates that the surface soils in the area of site are likely to comprise reddish, loamy or fine, silty over clayey soils with slowly permeable subsoils and slight seasonal waterlogging.

2.4.1 Groundwater Vulnerability

The National Soil Resources Institute Soils Site Report classifies the soil in the area of the site as having an intermediate leaching potential. These are soils, which have a moderate ability to attenuate a wide range of diffuse source pollutants but in which it is possible that some non-adsorbed diffuse source pollutants and liquid discharges could penetrate the soil layer.

The underlying Mercia Mudstone Group is classified as a Non-Aquifer (negligibly permeable), which would correspond with the identified geology. Non-aquifers (now reclassified as Unproductive Strata) are formations, which are generally regarded as containing insignificant quantities of groundwater. However, groundwater flow through such rocks, although imperceptible, does take place and needs to be considered in assessing the risk associated with persistent pollutants and subsurface construction. Beneath the Mercia Mudstone Group lies the Sherwood Sandstone aquifer which was formerly classified as a Major Aquifer (now classified as a Principal Aquifer).

The site does not lie within a Groundwater Source Protection Zone.

No licensed groundwater abstractions are recorded within a 500m radius of the site.

The Catchment Abstraction Management Strategy (CAMS) for the Worcestershire Middle Severn determined the groundwater in the catchment to be over licensed.

It is reported that the groundwater levels in the Triassic Sandstone are regionally depressed due to over abstraction.

The site is located within a Nitrate Vulnerable Zone.

2.4.2 Nearby Surface Water Features

A stream/drainage ditch is shown to issue at the western site boundary, which then heads eastward to the centre of the site, before turning southward (the culverted drain) and flowing off-site, southward within a culvert.

The nearest primary river feature is located approximately 800m south-east, and is named the Elmley Brook. There are no known water quality sampling points recorded for the brook.

2.4.3 Pollution Incidents to Controlled Waters

There have been a total of 11 recorded pollution incidents to controlled waters within 1km of the site. All were regarded as Category 3 (Minor Incidents) and related mainly to the release of oils, solvents and detergents.

A full list of the incidents is located within the datasheets of the Envirocheck Report contained within Appendix B of the Desk Study Report (Reference 1).

2.4.4 Flooding

Information contained within the Envirocheck Report shows that the site is not within the zone of potential flooding from fluvial watercourses. There are no recorded flood defences or floodwater storage areas shown within 1km of the site.

2.5 Environmental Sensitivity summary

Groundwater sensitivity: low

The site overlies a non-aquifer, there are no groundwater abstractions within a 500m radius of the site and the site is not located within a groundwater source protection zone.

Surface Water Sensitivity: High

A stream/drainage ditch is located in the centre of the site, which discharges to a watercourse via a series of culverts, approximately 600m south-west of the site.

Ecological Sensitivity: Low

The site itself is not designated for its ecological importance and an ecological assessment undertaken on the site in 2004 (Refs. 4 and 5) states the following:

- No evidence of Water Vole activity in or adjacent to the north to south running ditch in the centre of the site;
- Holes and crevices that were accessible within the study area did not demonstrate any evidence of being used by bat species, though bat roosts are anticipated in the woodland to the east of the site;
- There are no waterbodies on site suitable for great crested newt; a partly culverted ditch running through the site does not constitute suitable habitat;
- A careful search of the site produced no evidence of use by any other protected species;
- No species with special protection under Schedule 1 of the 1981 Wildlife and Countryside Act, or Annex I of the EU Birds Directive were recorded on or in the vicinity of the site;
- The field surveys work did not identify the presence of any plant species or habitats protected by law, or considered rare in the UK;
- There is a small stand of Japanese knotweed on site, which will impose some constraints on the timing and methods of site clearance.

3 GROUND INVESTIGATION

The preliminary ground investigation was carried out between 4th and 16th of February 2010. It was undertaken and supervised by HCL on behalf of Mercia Waste Management. The purpose of the investigation was to identify the ground and groundwater conditions across the site and provide key information for the production of the Environmental Impact Assessment chapter by identifying the likely impact on the environment of the development. The ground investigation will also provide preliminary information for foundation design, excavation (and its support) and contamination issues surrounding the development of the Mercia EnviRecover energy facility.

A plan showing the exploratory hole locations is presented within Appendix B.

The site specific ground investigation has addressed the objectives identified within Section 1.2 of this report. The findings of the ground investigation are summarised below and are detailed in the HCL Factual Report (Ref. 6).

3.1 Site Works

The completed scope of the ground investigation is as follows:

- 4 no. cable percussive boreholes to maximum depth of 10m below ground level (bgl) with alternating Standard Penetration test (SPTs) and undisturbed soil samples (U100) at 1m intervals to 5m bgl, and where possible at 1.5m intervals at depth greater than 5m bgl.
- 3 no. rotary cored boreholes to maximum depth of 20m bgl, with SPTs at 1m intervals to 5m bgl and at 1.5m intervals below 5m bgl.
- 4 no. trial pits to depths of 5m bgl.
- 6 no. trial pits to depths of 2m bgl.

The depth, thickness and descriptions of the strata (including depths of sampling points) are given on the relevant exploratory logs, presented within the HCL Factual Report (Ref. 6).

Upon their completion, the boreholes (that were not completed with groundwater monitoring installations) and trial pits were safely backfilled and compacted and the ground re-instated, as far as practicable.

3.2 Sampling

A Geotechnical Engineer from HCL logged the boreholes and trial pits in accordance with the recommended procedures provided by document BS5930:1999 "Code of Practice for Site Investigations" (Ref. 7) and in general accordance with CIRIA C570 "Engineering in Mercia Mudstone" 2001 (Ref. 8). Disturbed, undisturbed and environmental samples were collected from the exploratory holes, which were subsequently sent for geotechnical, chemical and contamination analysis with the testing scheduled by HCL.

Groundwater was encountered in all of the seven boreholes. This has been subsequently sampled and sent for chemical analysis.

Furthermore all boreholes have been installed with groundwater and gas monitoring standpipes and an ongoing programme of monitoring is currently taking place over a three month period to allow groundwater and gas levels to stabilise and to be recorded over a range of (short-term) climatic variations. The results of this monitoring will be issued as a separate addendum to this report.

3.3 Laboratory Testing

Geotechnical and chemical laboratory testing was undertaken on selected samples taken from the boreholes and trial pits and are summarised in Table 3.1. Testing of all samples was scheduled by HCL and undertaken by an HCL appointed laboratory. The test results are discussed within Sections 5 to 7 of this report and are presented in full within the HCL Factual Report (Ref. 6).

Asbestos presence was analysed as a precautionary health and safety measure. Waste Acceptance Criteria (WAC) testing was carried out at the UK lower detection limits for inert waste to enable an assessment of Waste Management on-site and off-site to be undertaken.

Table 3.1: Summary of Analysis Undertaken on Scheduled Samples

Type of Test	Standard	Number of Samples
	Geotechnical & Chemical Tests	
moisture contents	BS1377:1990 Part 2:3	15
atterberg tests	BS1377:1990 Part 2:4 & 5	15
particle density	BS1377:1990 Part 4	4
density tests	BS1377:1990 Part 4:5	7
PSDs (Particle Size Distribution)	BS1377:1990 Part 2:9	13
sedimentation tests	BS1377:1990 Part 2	1
compaction tests	BS1377:1990 Part 4	6
one-dimensional consolidation tests	BS1377:1990 Part 6	3
consolidated undrained triaxial tests	BS1377:1990 Part 6	3
pH	BS1377:1990 Part 3	13
2:1 soil/water extract	BS1377:1990 Part 3	13

Table 3.1: Summary of Analysis Undertaken on Scheduled Samples (continued)

Type of Test	Standard	Number of Samples
	Contamination Tests	
Soil		
Metals (arsenic, cadmium, chromium, nickel, lead copper zinc, mercury and selenium)	MCERTS Accredited	15
Speciated PAH (USEPA 16)	MCERTS Accredited	15
TPH (Total Petroleum Hydrocarbons) 6 banded	MCERTS Accredited	15
Asbestos Screen and Microscopy	MCERTS Accredited	5
Soil Organic Matter (SOM)	MCERTS Accredited	6
Leachate		
Metals (arsenic, cadmium, chromium, nickel, lead copper zinc, mercury and selenium)	MCERTS Accredited	15
Speciated PAH	MCERTS Accredited	15
TPHCWG	MCERTS Accredited	15
Chloride	MCERTS Accredited	15
Ammonia		15
Groundwater		
Metals (arsenic, cadmium, chromium, nickel, lead copper zinc, mercury and selenium)	MCERTS Accredited	5
Speciated PAH (USEPA 16	MCERTS Accredited	5
TPH CWG	MCERTS Accredited	5
Chloride	MCERTS Accredited	5
Ammonia (Ammoniacal nitrogen as N)	MCERTS Accredited	5

4 GROUND CONDITIONS ENCOUNTERED

4.1 Previous Investigations

A previous Investigation has been carried out by Ground Investigation and Piling Limited (GIP) in May 2006 (Ref. 2). The findings of this report are incorporated into the following discussions.

Made ground was found to depths of up to 4.30m bgl containing ash brick mudstone among other man made substances including asbestos board. The cohesive made ground was found to have intermediate plasticity and medium volumetric change potential. Superficial Deposits were encountered to depth of between 0.7-3.0m as firm sometimes stiff gravelly CLAY. These Superficial deposits were identified to have up to very high plasticity and high volumetric change potential. Mercia Mudstone formation was found directly underlying this stratum, initially as a firm to stiff CLAY. Mudstone was then found from 5m bgl with up to intermediate plasticity and medium volumetric change potential.

Groundwater strikes were noted in the four boreholes drilled on site in 2006 (see Ref. 2) at depths ranging from 4m to 5m bgl within Residual Mercia Mudstone clays. In the shallower trial pits, groundwater was encountered in a limited number of the excavations at depths around 1m bgl, ranging from slow seepage to fast seepage. These inflows are considered likely to be derived from perched groundwater within the Made Ground soils.

4.2 Summary of Strata Sequence

Ground conditions were found to be in general accordance with those anticipated based on the desk study data, and the general strata sequence can be summarised below:

- Made Ground
- Superficial Deposits: Weathered Mercia Mudstone material re-worked by geological (e.g glacial) processes.
- Weathered Mercia Mudstone Group (soil material)
- Mercia Mudstone Group (rock material)

The strata descriptions used in the factual report are in accordance with BS 5930:1990 (Ref. 7). The weathering grades and terminology assigned to the Mercia Mudstone stratum in the factual report and this interpretation ("fully", "partially" and "unweathered") are in accordance with those recommended in CIRIA C570 "Engineering in Mercia Mudstone", 2001 (Ref. 8).

The typical strata sequence encountered at the proposed Mercia EnviRecover energy facility site has been summarised within Table 4.1 with the full borehole and trial pit logs presented within the HCL Factual Report (Ref. 6). The material properties and engineering considerations of the strata encountered are discussed respectively in Sections 5 and 6 of this report and the contamination testing is discussed in Section 7.

Table 4.1: General Sequence of Strata

Stratum	General description of Stratum	Typical Depth Range of Strata (m bgl)
Made Ground – (northern part of the site).	Typically granular material (loose black silty gravelly sand) containing gravel and cobble sized pieces of coal, ash, clinker and brick. This is underlain by soft red sandy gravelly clay (reworked Mercia Mudstone Material?).	GL to <1.0m (Max. 2.0m)
Made Ground – (southern part of the site).	Typically predominantly cohesive material (Soft brown silty cobbly gravelly clay), with gravel and cobbles comprising demolition debris (wall sections), metal (steel mesh and iron bars), ash and brick. GIP investigation also identified asbestos cement board.	GL to 2.7m (Max. 4.3m in GIP investigation of localised 'mound', which also documents 5.5m in a further previous investigation)
Superficial Deposits (localised)	Soft / firm brown/grey silty CLAY, with occasional medium rounded gravel of chert, quartz and sandstone.	1.5 to 2.5 (0.7 – 3.0 in GIP)
Fully weathered Mercia Mudstone (Grade IVb).	Firm to stiff red CLAY.	1.5 to 4.5
Partially Weathered Mercia Mudstone (Grade IVa to Grade II)	Very stiff CLAY becoming very weak MUDSTONE. (recovered as mudstone gravel in some locations).	4.5 to 17.5
Unweathered Mercia Mudstone (Grade I)	Weak to Moderately weak MUDSTONE with medium spaced fractures and localised bands/lenses/pockets of gypsum (Grade I).	>17.5

Two illustrative geological cross sections across the site are shown within Appendix C with the cross section lines orientated in a generally west to east direction. The ground level varies by a maximum of 3m across the site.

As shown on the cross sections, the weathered Mercia Mudstone is encountered at approximately 4.5m bgl across the site, and perched groundwater levels are present within the Made Ground at approximately 1 to 2m bgl.

Superimposed onto these cross sections is an approximate outline of the current proposed area of excavation for the construction of the proposed Energy-from-Waste plant.

4.3 Groundwater

4.3.1 Groundwater Encountered

Groundwater strikes were encountered and recorded during the present ground investigation in the following exploratory holes:

Table 4.2: Groundwater Strikes (present investigation)

Exploratory Hole	Level of Water Strike (mOD)	Comment(s)
BH20	46.16	
BH21	47.96	Possibly perched GW in the Made Ground?
BH22	45.59	
BH23	46.79	Possibly perched GW in the Made Ground?
BH24	47.04	Possibly perched GW in the Made Ground?
BH25	46.02	
BH26	46.03	
TP27	42.84	Seepage
TP28	44.58	Seepage
TP29	44.24	Seepage

Although observations made during the February 2010 site investigation record that groundwater was rarely present during drilling and trial pitting, it is considered that this may be due to the relative low permeability of the majority of the soils and the time periods the excavation sides were left exposed rather than the absence of any perched groundwater or phreatic surface. In the majority of cases, the boreholes were cased through the upper soil horizons, and the trial pits were left open for limited time periods.

In the GIP ground investigation, groundwater was recorded at slightly lower levels in following the exploratory holes:

Table 4.3: Groundwater Strikes (GIP investigation, March 2006)

Exploratory Hole	Level of Water Strike (mOD)	Comment(s)
BH1	43.90	
BH2	43.82	
BH3	43.42	
BH4	43.71	

4.3.2 Groundwater Levels

Groundwater levels on-site have been monitored since the ground investigation was undertaken.

Table 4.4: Groundwater Levels

Borehole	Eastings	Northings	GL (mAOD)	11/02/2010 (mAOD)	24/02/2010 (mAOD)	12/03/2010 (mAOD)
BH20	385957	269904	47.79	_	46.16	45.83
BH21	385913	269856	48.43	_	45.96	44.53
BH22	386000	269796	47.98	45.59	45.63	45.46
BH23	385914	269899	47.61	46.66	46.84	46.55
BH24	386031	269915	47.64	46.75	46.70	46.68
BH25	385961	269806	47.12	45.97	46.18	45.71
BH26	385857	269817	50.04	46.03	46.18	45.89

Rest groundwater levels in the mudstone were recorded between 45.59 and 46.75 mAOD on 11th February 2010. On 24th February 2010, these levels generally seem to have risen slightly to between 45.63 and 46.84 mAOD, but on 12th March 2010 they have dropped again to between 44.53 and 46.68 mAOD. These fluctuations may be linked to periods of rainfall variation.

4.3.3 Groundwater Hydraulics

Confining conditions have been identified at depth. During the drilling of BH20, at depth 15m bgl, an uncased section of the borehole hole collapsed, and continued to do as the borehole was progressed. Consequently, the hole was then further cased to 8.0m bgl, but falling water was audible at the bottom of the borehole (possibly indicating a significant water strike had developed between 8m and 15m depth). At this point, water was introduced into the borehole up to ground level in preparation for conducting a falling head permeability head test. However, once ground level was reached the water continued to rise and overflow the top of the casing (approximately 1m agl), a situation indicative of potential artesian water pressures in a stratum between approximately ~13.0 to 16.0m depth. However, the following morning the water pressure was seen to have equalised at approximately 2.90m bgl (45.09mAOD), suggesting either that the layer and/or zone of material with elevated water pressures is confined and of relatively limited extent and/or that the permeability of the zone is sufficiently low to prevent maintenance of the artesian pressure for any length of time.

None of the other boreholes undertaken on this site to date have encountered similar groundwater conditions to those encountered in BH20, again indicating that the layer and/or zone of material with potential artesian water pressures may be of limited lateral extent possibly a relict buried channel of more granular material within the Mercia Mudstone Formation stratigraphy. Note that this effect is attributed to water pressure which is expected to be fracture controlled and is not water volume; as such water containment in attenuation ponds, etc is not expected to be a major concern during construction.

Notwithstanding that elevated water pressures may only be present in isolated locations, the presence of such localised pressures will have significant consequence on the detailed design of the walls and floor to the deep excavation (in the temporary and permanent works cases). As a result, the detailed design stage ground investigation will need to specifically gather data to ascertain the extent and/or significance of this phenomenon on the construction of the deep excavation,

Given the rest water level elevations, further potential inflow horizons may coincide with depths at which it is noted on the logs that there was 'no recovery' or where the mudstone was noted to be heavily fractured and veined with gypsum.

The measured rest water levels infer a groundwater flow direction from north to south across the site (see note below with regard to BH20).

The hydraulic gradient is calculated to be 0.0098 (11/02/2010) and 0.01 (24/02/2010).

The influence of the geological faulted boundaries to the east and west of the site on groundwater flow is unknown.

4.3.4 Permeability Testing

Rising head permeability tests were conducted in the upper 8m of strata in three of the boreholes. After one hour of monitoring, BH20 showed no rise in water level and BH25 and BH26 had recovered by 33 and 46%, respectively.

The lack of response in BH20 does not reflect the observations made during the drilling of the borehole. Although the water level in the borehole has since risen to 1.63 mbgl, it is assumed that the lack of aquifer structure may have been compensated by the borehole construction. Further it is noted that the measured groundwater level (24/02/2010) is 1.23 m lower than that measured prior to the permeability test (0.4 mbgl). In addition, the observation that the borehole was artesian during drilling, leads to the assumption that the measured groundwater level in the installation is more representative of the phreatic surface in the near-surface (<10mbgl) strata and is not a true reflection of the aquifer conditions that may be encountered at depth in the vicinity of this borehole.

Table 4.5: Permeability Test Results

Borehole	Eastings	Northings	GL (mAOD)	RWL (mbgl)	WL start of test (mbgl)	WL end of test (mbgl)	k (m/d)
BH20	385957	269904	47.79	0.1 magl	15.5	15.5	-
BH25	385961	269806	47.12	1.15	8.20	5.99	0.017
BH26	385857	269817	50.04	3.65	9.00	6.59	0.059

These values are comparable with the range quoted in, 'BGS Engineering geology of British rocks and soils – Mudstones of the Mercia Mudstone Group', of 10^{-1} to 10^{-3} m/d, parallel to bedding and 10^{-3} to 10^{-5} m/d for compacted mudstone.

4.3.5 Groundwater/Surface Water Interaction

The environment agency has a Triassic sandstone numerical model for the area which assumes the River Stour to be in hydraulic continuity with groundwater. The relative elevations of the watertable beneath the site and the culverted stream that runs across the site suggest that hydraulic continuity between surface water and groundwater is possible. In practice this is likely to be limited by the low permeability of the superficial clay and underlying mudstone.

5 GEOTECHNICAL PROPERTIES

5.1 Introduction

A testing programme for soil samples recovered from the exploratory borehole and trial pit locations was scheduled by HCL and carried out by a designated laboratory as specified by document BS1377:1990 "Methods of Tests for Soils for Civil Engineering Purposes" (Ref. 9). The results are included in the factual report provided by HCL (Ref. 6).

5.2 Made Ground

The made ground is spatially variable across the north and south of the site in both composition and depth:

a **North** - Within the northern half of the site, made ground generally comprises a layer of fly ash with gravel of coal to 0.5m bgl underlain by approximately 1.5m of re-worked red clay (re-worked Mercia Mudstone).

b **South** - To the south, the topography is more undulating, this is likely to be due to infilling and discarding of waste across this area of the site. An upper layer of made ground comprises waste items in a matrix of red clay. Waste found during trial pitting include demolition rubble (a section of wall five courses thick), metal containers, metal mesh, concrete and unspecified scrap metal to approximately 1.5m bgl.

Index Properties

Two Atterberg Limit tests have been carried out on the cohesive Made Ground in this investigation, to supplement those undertaken in the previous GIP investigation. The results indicate the cohesive Made Ground to have a Plasticity Index of between 19% and 21%, and therefore to be of intermediate plasticity with a low volume change potential.

5.3 Superficial Deposits

Superficial deposits have been identified on-site in localised areas across much of the site, to typical depths in the present investigation of between 1.50m and 2.5mbgl. In the previous GIP investigation, this stratum was encountered to more variable depths of between 0.70m and 3.0m bgl.

Index Properties

One Atterberg Limit test has been carried out on a sample of this stratum in this ground investigation, to supplement the 7 tests undertaken in GIP the investigation. These tests produced Plasticity Index values of between 26% and 50%, and therefore to be of intermediate to high plasticity with a medium to high volume change potential.

5.4 Weathered (Grade IVb to Grade II) Mercia Mudstone

Fully weathered Mercia Mudstone (Grade IVb) was encountered below the made ground to approximate depths ranging between 1.5 - 4.5m bgl.

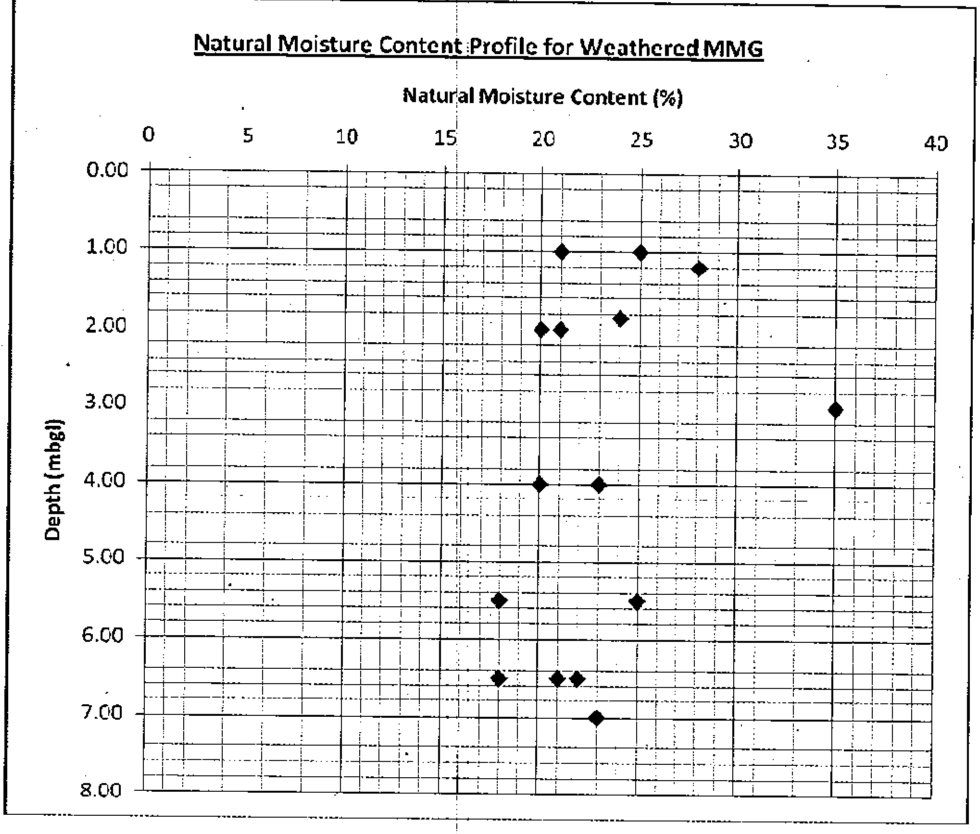
In general, immediately underlying the made ground/superficial deposits this sub-stratum is encountered as soft to firm, red clay that becomes increasingly more firm to stiff with depth.

At approximately 4.5m bgl this sub-stratum becomes a very stiff and fissile material recovered as medium gravel sized lithorelicts of weak mudstone in a clay matrix (weathering Grade III material). The weathering profile within this material is likely to be better defined within the trial pit excavations than the boreholes, because the mass soil structure is more clearly discernable in the trial pit sidewalls.

5.4.1 Index Properties

Natural Moisture Content test results obtained from samples of the fully and partially weathered MMG material are summarised graphically in Figure 5.1.

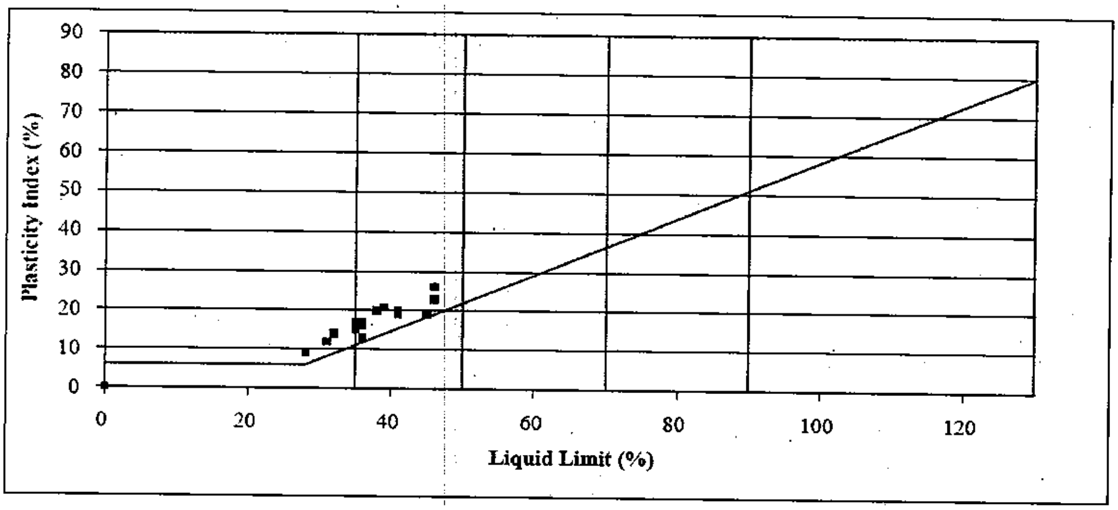
Figure 5.1: Natural Moisture Content Profile for Weathered MMG material



These tests indicate the natural moisture content to generally be in the range 18% to 25%, with isolated samples with slightly elevated moisture content. Although there is clearly appreciable scatter in the results, in general terms it shows a slight gradual reduction in moisture content with depth (progressively less weathering) typical of that provided in table 3.3 of CIRIA C570. However, towards the base of the sub-stratum (in the less weathered material) the moisture contents are slightly high relative to typical values for Grade II-III material given in this reference.

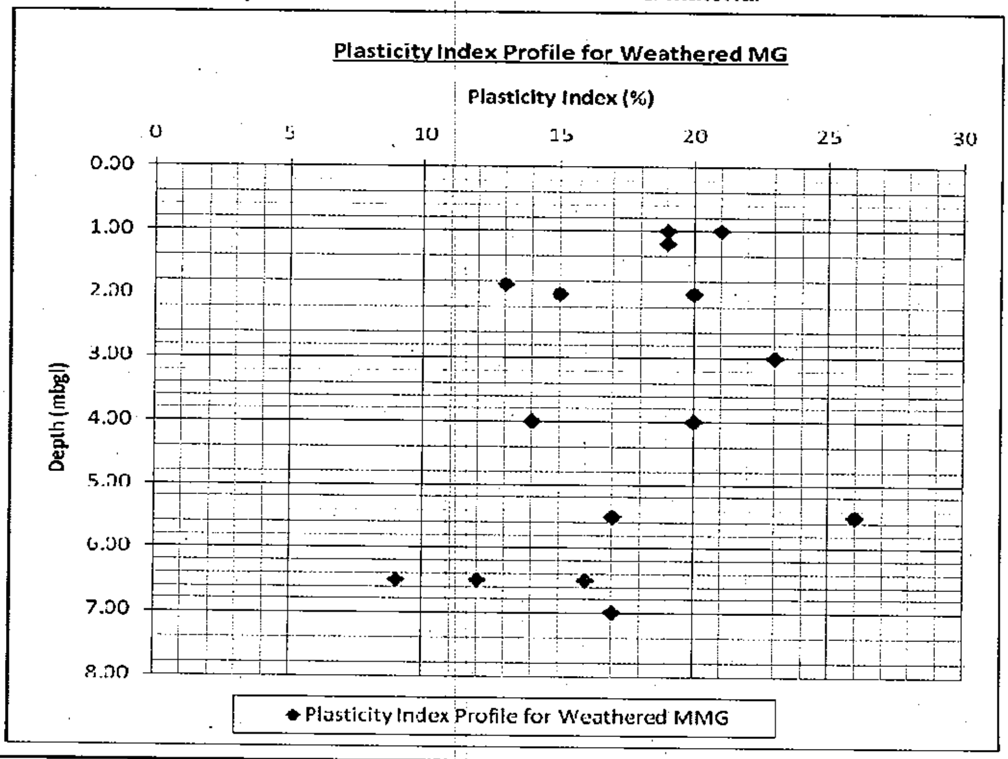
Atterberg Limit test results obtained from samples of the fully and partially weathered MMG material are summarised graphically in Figure 5.2. These tests produced Plasticity Index values of between 9% and 26% (average 17.4%) indicating these soils to be low/intermediate plasticity clay with low to medium volume change potential.

Figure 5.2: Casagrande classification plot for Weathered MMG material



A depth profile of the Plasticity Index values obtained in this sub-stratum is shown graphically as Figure 5.2. Although there is clearly some scatter in the results, in general terms it shows a gradual reduction in plasticity with depth from ≈20% near-surface (1-2m bgl) to 10-15% at greater depth (6-7m bgl). This range of values and trend in line with progressively less weathering is typical of that provided in table 3.3 of CIRIA C570.

Figure 5.3: Plasticity Index Profile for Weathered MMG material



5.4.2 Undrained Shear Strength

Insitu hand shear vane tests carried out in the fully weathered (Grade IVb) Mercia Mudstone to depths of up to 3.7m bgl produced estimated undrained shear strengths of between 39 and 77 kPa.

Figure 5.4 shows a depth profile of 'N' values obtained from insitu Standard Penetration Tests (SPTs) undertaken in both the present and previous (GIP) ground investigations. Tests with 'N' values above 50 have been extrapolated (to a capped value of 100) to provide better definition of the strength of the less weathered (deeper) soils in the strata sequence.

The profile illustrates how the 'N' value increase steady from ≈10 at 2-3m bgl to ≥100 at a depth of approximately 8.0m bgl.

This SPT data has been converted into estimated equivalent undrained shear strength (SU) using a correlation of SU = 5 x N based on section 5.1 of CIRIA C570, and is shown graphically in Figure 5.5. This graph suggests an undrained shear profile rapidly increasing from ≈50kN/m2 at 1.0m bgl to ≈500kN/m2 at 7.0mbgl, with hard clay (SU = 300kN/m2) occurring at about 6.0m bgl. Below 7.0m depth the shear strength continues to increase at a slower rate to ≈1000kN/m^2 at 20.0m bgl.

Figure 5.4: Profile of SPT 'N' Values

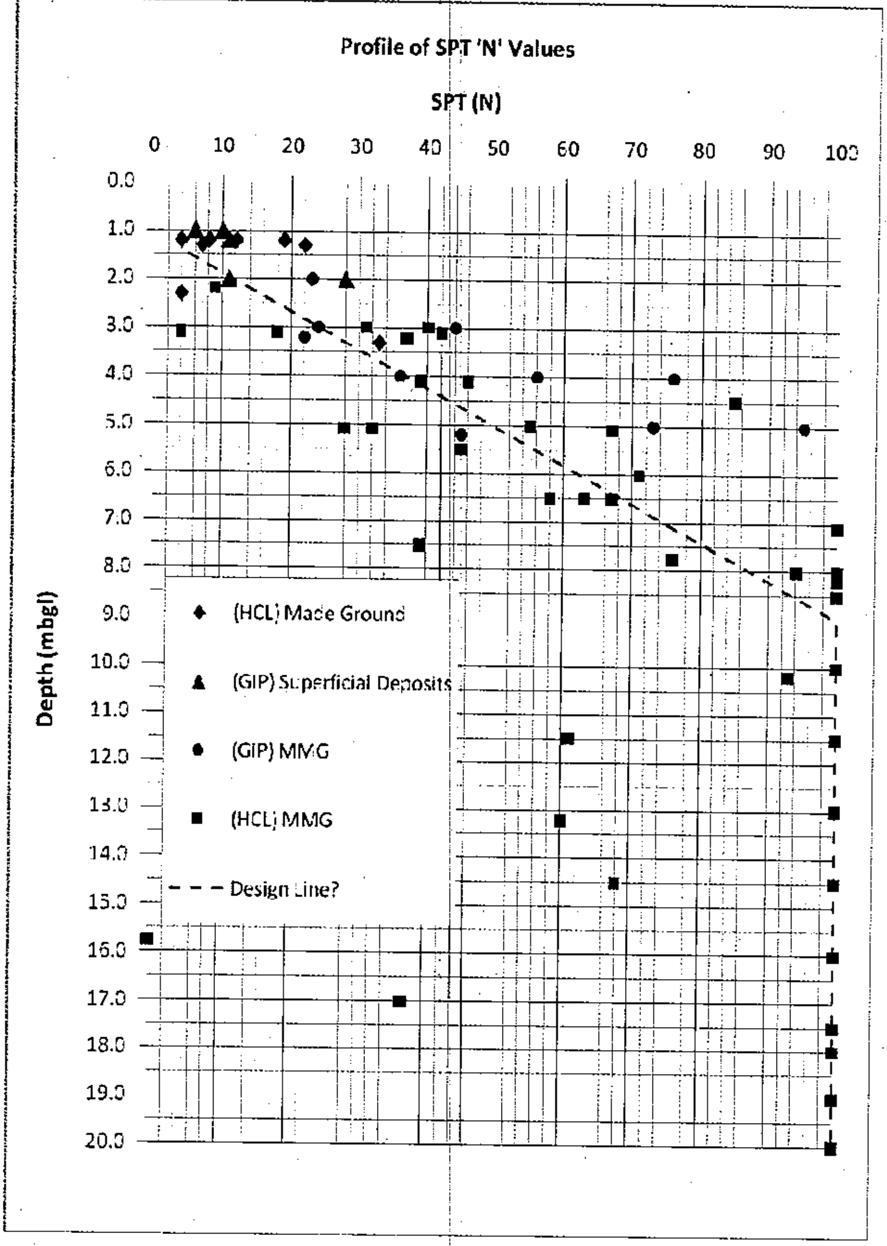
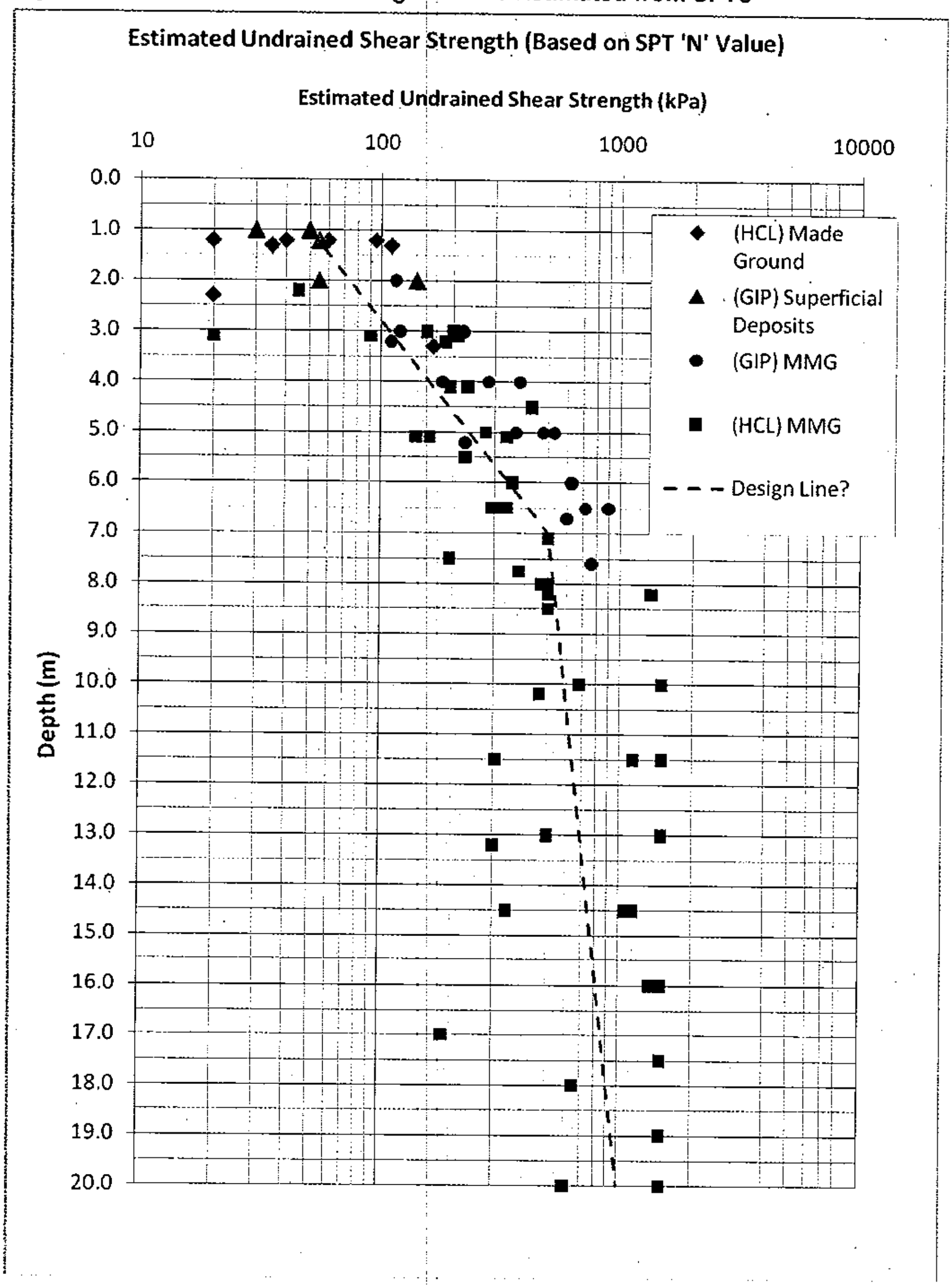


Figure 5.5: Undrained Shear Strength Profile Estimated from SPTs



5.4.3 Drained Shear Strength

Three consolidated undrained triaxial tests performed on these sub-soils produced the following results:

Sample Ref.	Φ' (°)	c' (kN/m²)
BH24 / 4.00m	29	36
BH24 / 6.50m	28	35
BH25 / 4.00m	38	49

Based on published correlations, the Plasticity Index test results suggest φ' value of 28° - 30°, which is in good agreement with two of the triaxial test results and with typical published values for Grade IV MMG material given in Table 7.1 of CIRIA C570.

The high φ' value of 38° obtained from sample ref BH25 at 4.00m is more typical of Grade III material.

Whilst the high c' values obtained in the triaxial tests are indicative peak values for a very stiff heavily-overconsolidated clay, they are very high in relation to the published typical values for this stratum, and significantly lower 'long-term' values are recommended for the design of piles and retaining walls, particularly when the engineering characteristics of the overall soil mass (e.g. blocky mudstone lithorelicts in a clay matrix) will also need to be considered. To this end, it is recommended the following drained shear strength parameters are used for preliminary design:

Weathering Grade.	Φ' (°)	c' (kN/m²)
Grade IV – III	28	20
Grade II	38	25

For detailed design, it is recommended that further appropriate investigation and laboratory testing is undertaken to establish drained shear strength design parameters with more certainty. In particular, consideration could be given to undertaking effective stress testing to establish residual c' values to replicate the lower boundary properties at the interface between mudstone 'blocks' in the soil mass structure.

5.4.4 Consolidation Characteristics

Three samples of Grade IV Mercia Mudstone were tested for one dimensional consolidation properties by Oedometer consolidation.

These tests produced coefficient of volume compressibility (m_v) values over the stress increase range 100 – 200kPa of between 0.18 and 0.30m²/MN. Over the same stress range, they produced coefficient of consolidation (c_v) values of between 1.0 and 1.3 m²/yr.

These coefficient of volume compressibility (m_v) values results are high relative to most very stiff heavily over-consolidated clay soils, and very high compared with the relationship proposed in section 5.2 of CIRIA C570 of $E' = N_{60}$ (MPa).

For example,

Taking $E' = 1/m_v = N_{60}$, based on Figure 5.4 SPT 'N' = 35 at 4.00m depth equates to

$m_v = 1/N_{60} = 1/35 \approx 0.03$ (about 1/10th the value of the laboratory derived result)

This discrepancy might be explained by the physical sample disturbance that is known to potentially lead to over-measurement of laboratory compressibility characteristics in Mercia Mudstone material, due to its heavily over-consolidated and bonded nature. Consequently, for outline design it is suggested that the following design parameters are used for estimates of foundation settlement:

Weathering Grade.	m_v (m^2/MN)	Comment(s)
Grade IV	0.2	Based on laboratory test results
Grade II – III	$= 1/N_{60}$	Based on correlation in CIRIA C570

5.5 Unweathered (Grade I) Mercia Mudstone

At depth the Mercia Mudstone stratum becomes Grade I unweathered material. Based on visual description of the material recovered in the boreholes, this boundary occurs at approximately 15-17.5m bgl, though this may be affected by physical disturbance of the material by the drilling / sampling process.

Based on the SPT 'N' profile, and CIRIA C570, whereby the distinction between Grade II and I material is approximately at N = 80, the boundary occurs considerably higher at approximately 7-9m bgl (Figure 5.4).

This sub-stratum typically occurs as a very weak becoming weak (locally moderately weak/moderately strong) Mudstone with medium spaced fractures and localised frequent spaced lenses/bands of gypsum.

5.5.1 Undrained Shear Strength

Based on the SPT 'N' profile provided as Figure 5.4, with the exception of a few localised exceptions, the 'N' value in this material is consistently ≥100 below a depth of approximately 8.0mbgl. Converting this into estimated equivalent undrained shear strength (S_U) suggests a profile increasing from ≈525kN/m^2 at 8.0mbgl to ≥1500kN/m^2 at 20.0m bgl (refer Figure 5.5).

These figures equate to a material that is typically very week, but with occasional bands of very weak, weak and moderately weak material.

5.5.2 Drained Shear Strength

Based on the discussion provided in section 5.4, it is recommended the following drained shear strength parameters are used for preliminary design:

Weathering Grade.	Φ' (°)	c' (kN/m^2)
Grade I	38	25

Again, it is recommended that further appropriate investigation and laboratory testing is undertaken to establish drained shear strength design parameters with more certainty for detailed design.

5.5.3 Consolidation Characteristics

Based on the discussion provided in section 5.4, it is recommended the following design parameters are used for estimates of foundation settlement in the outline design:

Weathering Grade.	m_v (m^2/MN)	Comment(s)
Grade I	= $1/N_{60}$	Based on correlation in CIRIA C570

6 CONCEPTUAL MODEL & QUALITATIVE RISK ASSESSMENT

6.1 Introduction

Irrespective of the degree of contamination, current guidelines require a systematic approach to the assessment of contamination. This is achieved by developing a conceptual model.

The conceptual model identifies the pollutant linkages that may exist by highlighting the relationships between the contaminants, pathways and receptors and how these are linked together.

A **contaminant** may be defined as

A substance which is in, on or under the land and which appears to be causing significant harm or may cause significant harm to receptors, or pollution of controlled waters is being caused or is likely to be caused.

A **receptor** may be defined as either:

(a) *Human Health*

(b) *A living organism, a group of organisms or an ecological system.*

(c) *A piece of property which is being, or could be, harmed, by a contaminant;* or

(d) *Controlled waters, which are being, or could be polluted by a contaminant.*

A **pathway** may be defined as

One or more routes or means by, or through, which a receptor:

(a) Is being exposed to, or affected by a contaminant, or

(b) Could be so exposed or affected.

Where a pathway can expose an identified receptor to an identified contaminant, a pollution linkage is formed. All three elements must be present for a pollutant linkage to exist.

The following sections detail the method of assessment and the conceptual model assessing the potential contaminative sources, the potential pathways and the identified receptors.

6.2 Qualitative Risk Assessment

Risk assessment is the process of collating known information on a hazard or set of hazards (to determine the potential severity of any impact) along with details on the likelihood of impact on detailed receptors. Risks are generally managed by isolating the receptor or by intercepting or interrupting the exposure pathway, so no pollutant linkages are formed and there can be no risk. The following section focuses on the potential hazards or contaminants identified on site and indicate whether they may be able to impact a nearby receptor.

The assessment of risk presented is based upon the procedure outlined in the Department for Environment, Food and Rural Affairs (DEFRA), Statutory Guidance on Contaminated Land.

The guidance states that the designation of risk is based upon a consideration of both:

- The likelihood of an event (probability); [takes into account both the presence of the hazard and the receptor and the integrity of the pathway], and
- The severity of the potential consequence [takes into account both the potential severity of the hazard and the sensitivity of the receptor].

Under such a classification system, the following categorisation of risk has been developed and the terminology adopted as follows:

Table 6.1 Summary of Risk Classification Categories

Term	Description
Very High Risk	There is a high probability that severe harm could arise to a designated receptor from an identified hazard at the site without appropriate remedial action.
High Risk	Harm is likely to arise to a designated receptor from an identified hazard at the site without appropriate remedial action.
Moderate Risk	It is possible that without appropriate remedial action, harm could arise to a designated receptor but it is relatively unlikely that any such harm would be severe and if any harm were to occur it is likely that such harm would be relatively mild.
Low Risk	It is possible that harm could arise to a designated receptor from an identified hazard but it is likely that at worst this harm, if realised, would normally be mild.
Negligible Risk	The presence of an identified hazard does not give rise to the potential to cause significant harm to a designated receptor.

The risk assessment has been undertaken to determine the likely levels of environmental risk associated with development of the site. More general environmental risks arising from the land associated with current use are outside the scope of this work.

6.3 Conceptual Model

6.3.1 Potential Contaminative Sources

Potential contaminative sources identified as relevant to the site are identified as follows:

- Existing off-site waste-water treatment works;
- Existing off-site Biffa landfill;
- Former on-site railway;

6.3,2 Receptors

Environmentally sensitive receptors are considered to include:

- **Human Health**

  At this stage, construction workers will be the focus of the conceptual model, which will then be refined following a ground investigation in order to re-assess the risks to these workers and to long-term site end-users.

- **Controlled waters (groundwater and surface water)**

  An unnamed stream flowing through the middle of the site is considered to be a highly sensitive receptor.

  As the site is underlain by a non-aquifer, groundwater is considered to be a receptor of low sensitivity.

6.3.3 Pathways

Table 6.2 Potential Pathways for the Sites

Receptor	Pathways
Human Health Construction and maintenance workers	Accidental ingestion of contaminants in soil Dermal contact with contaminants within soil and dust Accidental inhalation of contaminants within soil vapour and dust
Controlled Waters Unnamed stream in centre of site	Direct discharge to surface water via spills and leaks on site
Controlled Waters Groundwater	Vertical and horizontal migration of contaminants through soils into groundwater

6.3.4 Pollutant Linkages

Based on the potential contaminant sources identified on-site and off-site, Table 6.3 assesses each of the three components of the conceptual model within the context of pollutant linkages to establish any potential risk to human health, the environment and buildings or underground services.

Table 6.3 Assessment of Pollutant Linkages for the Site

Potential Contaminative Source	Receptor	Potential Pathway	Hazard (Severity)	Likelihood of Occurrence	Potential Risk
Soil and groundwater on site – excavated material that will be stockpiled during proposed works Potential contaminants include those associated with the adjacent waste-water treatment works, landfill and on-site former railway. (faecal coliforms & other pathogens, heavy metals, arsenic, sulphates, hydrocarbons, PCBs, dioxins, furans, other inorganic and organic chemicals and asbestos)	Human beings (Construction workers)	Accidental ingestion/ inhalation and dermal contact with contaminants (including asbestos) within soil, dust, and liquids	Moderate - Potential for more acute rather than chronic health risks through exposure to contaminants during construction works	Possible Excavation and stockpiling will be required	**Moderate to High Risk** Risks can be mitigated through investigation prior to site works, the use of suitable PPE and suitable site management procedures
	Controlled Waters (unnamed stream)	Direct flow of leached contaminants to stream via spills and leaks on site	Mild - Stream already presumably carries treated sewage effluent from the waste-water treatment works, therefore it is not likely to be a high quality water feature (this does not discount the stream as a sensitive receptor)	Possible Leaching from stockpiled materials and flow into drainage system	**Low Risk** Risks can be minimised by using correct site management procedures
	Controlled Waters (groundwater)	Vertical and horizontal migration of contaminants through soils into groundwater	Mild - Movement of contaminants into groundwater will be hindered by the relatively impermeable geology	Possible	**Low Risk** Risks can be minimised by using correct site management procedures

6.4 Protection of Workers

The risks from contamination posed to humans, are considered to be moderate to high until proven otherwise by an intrusive ground investigation. While workers could potentially be exposed to contaminants during construction and excavation works, this would be an acute rather than a chronic risk.

The risk from asbestos is considered viable, as a single piece of asbestos cement board was encountered in trial pit TP6 at a depth of 2.4m bgl. This raises the possibility that other fragments may be present elsewhere across the site. In which case, if suspect material is encountered, this should be treated as per appropriate guidelines.

In general, the risks to site workers from any contamination can be minimised by appropriate site management measures during the works. It is advisable to ensure that all construction workers are adequately protected with appropriate Personal Protective Equipment (PPE) and that a suitable health and safety scheme is adopted during any construction activities. Refer to document HSG (66) "Protection of Workers and the General Public During Development of Contaminated Land" published by the HSE for further guidance.

6.5 Summary of Environmental Risk

Given the minimum amount of historical development on site, it is anticipated that any contamination may be correspondingly slight. Therefore, the environmental risks to the identified receptors are generally classified as low; however, the potential risks to human health are classified as moderate to high until proven otherwise through intrusive ground investigation.

7 POLLUTANT LINKAGES

7.1 Introduction

The following sections detail the potential receptors, pathways, and contaminants that may be present at the site. The definitions of a receptor, a pathway and a contaminant source are provided in the box below. A pollutant linkage is a term used to describe a particular combination of contaminant-pathway-receptor which is the basis for any contaminated land assessment.

A **receptor** may be defined as either:

(a) a living organism, a group of organisms, an ecological system or a piece of property which is being, or could be, harmed, by a contaminant; or

(b) controlled waters which are being, or could be polluted by a contaminant.

A **pathway** may be defined as

A route, or routes, by which a receptor:

(a) is being exposed to, or affected by a contaminant, or

(b) could be so exposed or affected.

A pathway can only be identified if it can expose an identified receptor to an identified contaminant.

A **contaminant source** may be defined as

a substance which is in, on or under the land and which has the potential to cause harm or to cause pollution of controlled waters and/or pose a risk to human health.

The relationship between the above three elements is called a 'pollutant linkage'. All three elements must be present for a pollutant linkage to exist.

7.2 Potential Receptors

The potential receptors detailed below takes into consideration the proposed development of the site in to a renewable energy facility.

Human Beings

- Site Users (maintenance workers and contractors).

Controlled Waters (groundwater and surface water)

- An unnamed stream flowing through the middle of the site considered to be a highly sensitive receptor.
- As the site is underlain by a non-aquifer, groundwater is considered to be a receptor of low sensitivity.

Buildings

- Underground building services (water pipes, concrete).

Flora and Fauna

- The small area of woodland copse off site to the east is considered to be a receptor of low sensitivity due to the direction of groundwater flow and the relatively low permeability of the underlying strata. This is therefore not considered to be a significant receptor and is not considered further in this report.

7.3 Potential Pathways

Pathways are the routes that link the receptor to the contamination. The potential pathways for this site are, therefore, considered to be:

Table 7.1 Identified contaminant pathways

Receptor	Pathways
Human Beings	Accidental ingestion of contaminants within soil and dust. Indoor and outdoor inhalation of vapours and ground gases Dermal contact with contaminants within soil and dust.
Controlled Waters	Vertical migration of soluble contaminants through the unsaturated zone into groundwater beneath the site. Horizontal and down-slope migration of contaminated groundwater into the local surface water environment. Leaching of contaminants into surface waters Direct Discharge to surface water via spills and leaks on site
Buildings	Direct contact of building services with contaminants in the soil.

7.4 Potential Contaminant Sources

An assessment of the potential sources of contamination at the site has been compiled based upon the information taken from the Envirocheck Report, Environment Agency and other available sources of information as detailed above.

Potential contaminative sources identified as relevant to the site are discussed in Section 2.4 and 4.4 of the desk study report and are identified as follows:

- Existing off-site waste-water treatment works;
- Existing off-site Biffa landfill
- Former on-site railway,
- Former on site RAF depot
- Former on site lorry park
- Current use as access to waste water treatment works

The main potential contaminants are therefore considered to be metals, hydrocarbons (Total Petroleum Hydrocarbons, Polycyclic Aromatic Hydrocarbons, BTEX), asbestos and PCBs.

8 RESULT OF CONTAMINANT ANALYSIS

8.1 Risk to Human Health – Soil Assessment

Soil samples (comprising 11 Made Ground and 4 natural soils) were collected from across the site area and analysed for a suite of contaminants in order to assess the degree to which contamination is present and to determine the potential risk to site end users and the water environment. The laboratory sheets are included in the Appendices of the factual report and the results are discussed below:

8.1.1 Soil Screening Value (SSV)

The proposed use of the site is as a Energy from Waste plant. As there is no standard land use for such a development, the CLEA Commercial land use exposure model has been used as Tier 1 screening values.

In recent months, the Environment Agency has published several new Soil Guideline Values (SGVs) under the CLEA regime. These values will be used where appropriate. Where no published values are available, the CLEA model will be used to derive values. The toxicological data will be taken from authoritative sources and physchem input data used will be from authoritative sources such as the EA report *Compilation of Data for Priority Organic Pollutants for Derivation of Soil Guidelines Values (SC050021/SR7).*

For organic contaminants SSVs for a 1 % Soil Organic Matter (SOM) have been used as Tier 1 screening values. This is considered to be a precautionary approach.

8.1.2 Averaging Areas

On the basis of the site wide historic uses, the EnviRecover site has been considered as one averaging area. The chemical results have been separated into different soil strata such as Made Ground and natural soils and assessed separately.

8.2 Soil Results – Tier 1 Screening

8.2.1 Made Ground – Commercial End Use

Eleven soil samples were analysed from the Made Ground. Below is a summary of the findings with the site maximum compared to the appropriate SSV.

Table 8.1 Tier 1 screening of inorganic contaminants for a commercial end use

Contaminant	Concentration Range (mg/kg)	SSV (mg/kg)	Exceedance (Yes/No)
Arsenic	5.8 – 28.9	640 (1)	No
Cadmium	0.11 – 45.09	230(1)	No
Chromium	29.4 – 183.2	6250(3)	No
Copper	18.4 – 34,500	45,800(3)	No
Lead	12.6 – 4,839	750(4)	Yes (BH20 - 0.75m)
Mercury	0.1 – 0.22	3,600(1)	No
Nickel	28.5 – 216.6	1,800(1)	No
Selenium	0.5 – 3.6	13,000(1)	No
Zinc	74.5 – 14,950	667,000(3)	No
pH Value	7.7 – 9	6 – 9	No

1 EA published Soil Guideline Values
2 LQM/CIEH published value
3 Hyder Derived Value (HyGAC)
4 Previous Soil Guideline Value (Currently withdrawn)

All the contaminant concentrations are below the relevant SSVs except for Lead which will require further consideration.

Table 8.2 Tier 1 Screening for PAH contaminants in Made Ground

Contaminant	Concentration Range (mg/kg)	SSV (mg/kg)	Exceedence (Yes/No)
Naphthalene	<0.08 – 0.13	76.4(1)	No
Acenaphthylene	<0.08	91500(1)	No
Acenaphthene	<0.08	157(1)	No
Fluorene	<0.08	153(1)	No
Phenanthrene	<0.08 – 0.55	73100(1)	No
Anthracene	<0.08 – 0.23	54900(1)	No
Fluoranthene	<0.08 – 0.68	73200(1)	No
Pyrene	<0.08 – 0.62	54900(1)	No
Benz(a)anthracene	<0.08 – 0.45	130(1)	No
Chrysene	<0.08 – 0.44	1370(1)	No
Benzo(b)fluoranthene	<0.08 – 0.84	140(1)	No
Benzo(k)fluoranthene	<0.08 – 0.3	141(1)	No
Benzo(a)pyrene	<0.08 – 0.61	14.1(1)	No
Indeno(123cd)pyrene	<0.08 – 0.48	140(1)	No

Table 8.2 Tier 1 Screening for PAH contaminants in Made Ground (continued)

Contaminant	Concentration Range (mg/kg)	SSV (mg/kg)	Exceedence (Yes/No)
Dibenzo(ah)anthracene	<0.08 – 0.14	14.1[1]	No
Benzo(ghi)perylene	<0.08 – 0.49	54900[1]	No
PAH 16 Total	<1.28 – 5.63	NA	

Values in blue are soil saturation limits.

1 Hyder Derived Value (HyGAC)

Table 8.3 Tier 1 Screening for TPH contaminants in Made Ground

Contaminant	Concentration Range (mg/kg)	SSV (mg/kg)	Exceedance (Yes/No)
TPH >C8 – C10	<2	84.7[1]	No
TPH >C10 – C12	<2	37.2[1]	No
TPH >C12 – C16	<2 – 4.35	22.2[1]	No
TPH >C16 – C21	2.11 – 23.6	28600[1]	No
TPH >C21 - C35	4.88 – 359	28600[1]	No

Values in blue are soil saturation limits.

1 Hyder Derived Criteria (HyGAC)

All the contaminants concentrations are below the relevant SSV. Therefore PAH and TPH compounds are not considered to be contaminants of concern.

BTEX

Two soil samples from the Made Ground were analysed for BTEX (Benzene, Toluene, Ethylbenzene and Xylene). Concentrations were recorded below the laboratory limit of detection in both the soil samples.

PCBs

Two soil samples from the Made Ground were analysed for 7 PCB (Polychlorinated Biphenyls) congeners. Concentrations were recorded below the laboratory limit of detection in one soil sample, whilst the other soil sample (TP20 at 0.5m) recorded low concentrations for PCB 101 (6.4ug/kg) and PCB138 (7.3ug/kg). As a guide, the published SGV for Dioxin- like PCBs, Dioxins and Furans is 240ug/kg for a commercial end use. These values are significantly lower and therefore are not considered to pose a risk to site end users. No further consideration is required.

Asbestos

Five soil samples were analysed for asbestos and no fibres were detected. However, during the excavation of one trial pit TP24 (0.0 and 0,5m bgl), potential asbestos containing material was found. This will require further consideration.

8.2.2 Statistics Analysis

From the above Tier 1 screening, Lead is elevated in one sample from BH20. Lead concentrations have therefore been assessed statistically using current UK guidance published by CIEH and CL:AIRE *Guidance on Comparing Soil Contamination Data with a Critical Concentration.*

In this guidance the chemical data is assessed using a hypothesis approach depending on whether the site is to be redeveloped for planning or is to be considered under the Part 2a regime. The EnviRecover site will be assessed under the planning scenario. The CL:AIRE guidance uses a null and alternative hypothesis approach in order to assess the data. Depending on which scenario is being assessed, the null and alternative hypothesis can mean different things.

Under the planning scenario the key question that needs to be addressed is therefore

Is there sufficient evidence that the true mean concentration of the contaminant (x) is less than the critical concentration (Cc)?

The hypotheses are therefore

Null Hypothesis (Ho) the true mean concentration is equal to or greater than the critical concentration ($x \geq Cc$)

Alternative Hypothesis (H1) the true mean concentration is less than the critical concentration ($x < Cc$)

If the Null Hypothesis (Ho) cannot be rejected then assessment of risk at higher tiers (DQRA) or remediation of the site may be required prior to development of the site. If Ho can be rejected then the Alternative Hypothesis (H1) must be true and no further consideration is required.

For the lead concentrations encountered on site the following table illustrates the statistical analysis

Table 8.4 Statistical analysis for lead

Contaminant	SSV	Average	ko	UCL	Reject Ho	P1 (level against Ho)
Lead	750mg/kg	519mg/kg	-0.532	2406.4mg/kg	No	51%

The above analysis indicates that the null hypothesis cannot be rejected and therefore the elevated Lead concentrations are considered a contaminant of concern.

8.2.3 Natural Soils – Commercial End Use

Four soil samples were analysed from the natural soils during the ground investigation on the EnviRecover site. Below is a summary of the findings compared to the appropriate SSVs.

Table 8.5 Tier 1 screening of inorganic contaminants

Contaminant	Concentration Range (mg/kg)	SSV (mg/kg)	Exceedance (Yes/No)
Arsenic	4.9 – 7.1	640(1)	No
Cadmium	0.1 – 0.19	230(1)	No
Chromium	47.9 – 70.9	6250(3)	No
Copper	13.4 – 43.5	45,800(3)	No
Lead	7 – 12.7	750(4)	No
Mercury	0.1	3,600(1)	No
Nickel	44.2 – 64.4	1,800(1)	No
Selenium	0.5	13,000(1)	No
Zinc	80.2 – 91.4	667,000(3)	No
pH Value	8.2 – 8.9	6 – 9	No

1 EA published Soil Guideline Values
2 LQM/CIEH published value
3 Hyder Derived Value (HyGAC)
4 Previous Soil Guideline Value (currently withdrawn)

Table 8.6 Tier 1 screening for TPH Contaminants in natural soils

Contaminant	Concentration Range (mg/kg)	SSV (mg/kg)	Exceedance (Yes/No)
TPH C8 – C10	<2	84.7(1)	No
TPH >C10 – C12	<2	37.2(1)	No
TPH >C12 – C16	<2 – 2.28	22.2(1)	No
TPH >C16 – C21	<2 – 3.9	28600(1)	No
TPH >C21 – C35	4.38 – 13	28600(1)	No

Values in blue are soil saturation limits
1 Hyder Derived Criteria (HyGAC)

All the samples were analysed for PAH compounds and all the results were below the limit of laboratory detection (0.08mg/kg).

All the inorganic and organic contaminant concentrations in the natural soils are below the SSVs for a commercial land use. No further consideration is warranted with regards to the natural soils.

9 RISK TO CONTROLLED WATERS – LEACHATE AND GROUNDWATER ASSESSMENT

Five groundwater and eleven leachate samples were analysed across the EnviRecover site. The samples were analysed for a range of contaminants to determine the potential risk to Controlled Waters. The laboratory sheets are included in the Appendices of the factual report.

9.1 Water Quality Standards

To assess the leachate analysis and the groundwater in terms of its potential as a source of contamination, each contaminant concentration has been compared against appropriate Water Quality Standards (WQS), such as Environmental Quality Standards (EQS) for freshwater and UK Drinking Water Standards (DWS). EQS are considered protective of surface water and DWS are protective of groundwater which may be used as a potable supply.

For a number of contaminants, the hardness of the receiving water must be considered to determine the EQS. In the Kidderminster area the groundwater is considered to be moderately hard (150-200mg/l). Therefore the EQS values for this banding have been used in the assessment below.

The site is not within a Source Protection Zone and there are no water abstractions within 500m of the site. Therefore EQS values are considered as appropriate for the assessment.

Please note that for PAH compounds there is only an EQS value published for Naphthalene. There is a guideline value for Total PAH within the Surface Water Abstraction regulations. These values have been used as an initial screen to determine if there is a risk to water environment from PAH compounds in the leachate or groundwater. Other WQS values in the table (in grey) are values derived using toxic equivalent factors derived for Benzo(a)pyrene which has a drinking water standard of 10ng/l.

9.2 Leachate Results

9.2.1 Tier 1 Screening – Made Ground

Eleven soil samples from the Made Ground were subject to leachate analysis (CEN BS12457 2:1 ratio). A summary of the results and comparison to appropriate WQS is detailed below.

Table 9.1 Inorganic Leachate Results

Contaminant	Concentration Range (mg/l)	WQS (mg/l)	Exceedance (Yes/No)
Arsenic	<0.001-0.012	0.05[1]	No
Cadmium	<0.0001-0.0015	0.05[1]	No
Chromium	0.003-0.101	0.2[1]	No
Copper	0.003-0.098	0.01[1]	YES
Mercury	0.0003-0.001	0.001[1]	No
Nickel	0.002-0.043	0.15[1]	No
Lead	<0.001-0.06	0.25[1]	No
Selenium	<0.001-0.007	0.01[2]	No
Zinc	0.019-0.241	0.25[1]	No
Chloride (mg/l)	1-20	250[1]	No
Ammonical Nitrogen	<0.01-1.1	0.015[1]	YES

1 Environmental Quality Standard (EQS) for freshwater

2 Drinking Water Standards (DWS)

All the contaminant concentrations are below the relevant WQS except for Copper and Ammoniacal Nitrogen. The Copper leachate is exceeded in 9 of the 11 samples analysed, whilst the Ammoniacal Nitrogen is exceeded in 4 of the 11 samples.

Leachate results are available for organic compounds. Whilst many of the compounds were below the limit of laboratory detection, a number were above and are detailed in the table below with the appropriate guideline values.

Table 9.2 Organic Leachate Results above limit of laboratory detection

Contaminant	Concentration Range (mg/l)	WQS (mg/l)	Exceedance (Yes/No)
Naphthalene	<0.01-0.047	0.01	Yes
Acenaphthylene	<0.010-0.017	0.001	Yes
Acenaphthene	<0.01-0.061	0.01	Yes
Fluorene	<0.01-0.369	0.01	Yes
Phenanthrene	<0.01-0.982	0.01	Yes
Anthracene	<0.01-0.04	0.01	Yes

Table 9.2 Organic Leachate Results above limit of laboratory detection (continued)

Contaminant	Concentration Range (mg/l)	WQS (mg/l)	Exceedance (Yes/No)
Fluoranthene	0.011-0.101	0.001	Yes
Pyrene	0.01-0.134	0.01	Yes
Benzo(a)anthracene	<0.01-0.024	0.0001	Yes
Chrysene	<0.01-0.013	0.001	Yes
Benzo(b)fluoranthene	<0.01-0.013	0.0001	Yes
TPH Aliphatics C12-16	<0.01-0.013	0.01	Yes
TPH Aliphatics C16-21	<0.01-0.079	0.01	Yes
TPH Aromatics C16-21	<0.01-0.034	0.01	Yes
TPH Aliphatics C21-35	<0.01-0.047	0.01	Yes
TPH Aromatics C21-35	<0.01-0.025	0.01	Yes

Due to the stringent WQS used for organic contaminants, several concentrations are found to be above the guideline values and may warrant further consideration.

9.3 Groundwater Results

9.3.1 Tier 1 Screening

Five groundwater samples obtained from wells screened into the Mercia Mudstone were analysed during the ground investigation by Hyder. Samples were taken from BH22, BH23, BH24, BH25 and BH26. All the results are summarised below in Table 9.3.

Table 9.3 Summary of inorganic groundwater results

Contaminant	Concentration Range (mg/l)	WQS (mg/l)	Exceedance (Yes/No)
Chloride	29-120	250(1)	No
Nickel	0.003-0.007	0.150(1)	No
Chromium	0.006-0.011	0.2(1)	No
Cadmium	<0.0001-0.0002	0.05(1)	No
Copper	0.001-0.004	0.01(1)	No
Lead	<0.001	0.25(1)	No
Zinc	<0.002-0.011	0.25(1)	No
Arsenic	<0.001-0.004	0.05(1)	No
Mercury	<0.0001	0.001(1)	No

Table 9.3 Summary of inorganic groundwater results (continued)

Contaminant	Concentration Range (mg/l)	WQS (mg/l)	Exceedance (Yes/No)
Selenium	<0.001 – 0.033	0.010[(2)]	YES
Ammoniacal Nitrogen as N	<0.1 – 1.1	0.015[1)]	YES

1 Environmental Quality Standard (EQS) for freshwater

2 Drinking Water Standards (DWS)

All the contaminants are below the WQS except for Ammoniacal Nitrogen and Selenium. The Ammoniacal Nitrogen is above the WQS in 4 of the 5 groundwater samples, whilst Selenium is only elevated in 1 sample.

Both the WQS for Ammoniacal Nitrogen and Selenium are DWS and are therefore considered to be conservative for the water environment on site. The levels of Ammoniacal Nitrogen recorded are considered not to be indicative of landfill leachate which would typical be concentrations experienced are in the order of 20 to 30 mg/l.

Given the environmental setting and the conservative WQS, Ammoniacal Nitrogen and Selenium are not considered to be contaminants of concern and do not warrant further consideration.

The groundwater samples were analysed for PAH compounds and all were below the limit of laboratory detection except Benzo(a)anthracene in BH26 which had a concentration of 0.012ug/l. This concentration is below the WQS of 0.1ug/l and therefore is not considered to be of concern.

The groundwater samples were analysed for TPH using the TPHCWG method. All the results including those of BTEX compounds were found to be below the laboratory detection limit except for the Aromatic fraction C21-35 which had concentrations of 0.011mg/l in BH22 and BH24. This concentration is only very slightly above the DWS of 0.01mg/l for oils and hydrocarbons and therefore is not considered to pose a significant risk and does not warrant further consideration.

It should be noted that groundwater concentrations of Copper and several organic compounds were below the WQS but were found to be elevated in leachate analysis. The leachate analysis is a method of testing undertaken in a laboratory to determine if a risk is posed from contaminants in the soil, but it may not demonstrate what is actually occurring on site. As the groundwater is not significantly impacted by these contaminants it would indicate that leaching is not readily occurring on site. The elevated leachate results are therefore not considered to pose a significant risk to the water environment. For completeness they are however considered in the risk assessment that follows in Section 11.

9.4 Summary of Contamination

From the above sections, the following are considered to be contaminant sources and need consideration in the risk assessment which follows:

- Lead in the Made Ground
- Potential Asbestos containing material in the Made Ground.
- PAH, Copper and Ammoniacal Nitrogen in the leachate

10 GROUND GAS MONITORING

10.1 Gas Assessment

Due to the proximity of the site to a landfill, gas monitoring is necessary. Subsequently Hyder is in the process of an ongoing monitoring phase using the seven installed boreholes on-site. At present 2 monitoring rounds have been undertaken over the course of 1 month.

It should be noted that this is part of an ongoing phase of monitoring occurring twice every month for 3 months. The full ground gas assessment will therefore be provided as an addendum to this report.

To date no methane has been detected on site and the maximum readings are below:

- Methane 0%
- Carbon dioxide 10.5% (BH22)
- Oxygen 0.3% (BH22) (minimum)
- Flow rate 0.2l/hr (BH26)

The atmospheric pressure during the monitoring visit was between 900mb and 1018mb.

The results indicate that carbon dioxide gas is present on site and therefore is a potential risk that should be considered further and assessed again after monitoring process is complete.

Gas Characterisation Situation

CIRIA guidance (*Assessing risk posed by hazardous ground gases to buildings, CIRIA C659, 2006 now revised as CIRIA C665*) has been released which sets out the latest way of undertaking gas risk assessments.

As part of the CIRIA report **Situation A** covers *all development types except low rise housing with gardens,* which adopts the method proposed by Wilson and Card (1995).

The GSV are calculated using the formula:

GSV = borehole flow rate (l/hr) x gas concentration (v/v %)

This calculation is carried out for both the maximum methane, carbon dioxide and flow rates which would illustrate the measured worst-case-scenario on site over the monitoring period. The GSV is then compared with the Characteristic Situation (Modified Wilson and Card classification) detailed in the CIRIA guidance and from this an assessment of the risk can be established.

Due to the likely presence of a landfill adjacent to the site, there is the potential for migration of carbon dioxide and methane towards the surface.

The ground investigation identified a maximum carbon dioxide concentration of 10.5% and a worst case flow rate of 0.2 l/hr. The GSV for carbon dioxide (to date) is therefore calculated as 0.021l/hr.

No concentrations of methane were found. Based on these results the site could be characterised as Characteristic situation 1; Very low risk. This will be reviewed once all the gas monitoring data is available.

11 RISK ASSESSMENT

11.1 Methodology

Risk assessment is the process of collating known information on a hazard or set of hazards (to determine the potential severity of any impact) along with details on the likelihood of impact on detailed receptors. Risks are generally managed by isolating the sensitive receptor or by intercepting or interrupting the exposure pathway, thus no pollutant linkages are formed and there is no risk. The following risk assessment focuses on the potential contaminants identified on the site and the proposed development of the site.

CIRIA guidance (C552) states that the designation of risk is based upon a consideration of both:

- The likelihood of an event (probability); (takes into account both the presence of the hazard and the receptor and the integrity of the pathway).
- The severity of the potential consequence (takes into account both the potential severity of the hazard and the sensitivity of the receptor).

Under such a classification system the following categorisation of risk has been developed and the terminology adopted as follows:

Table 11.1 Summary of risk classification categories

Term	Description
Very High Risk	There is a high probability that significant harm could arise to a designated receptor from an identified hazard at the site with appropriate remedial action.
High Risk	Significant Harm is likely to arise to a designated receptor from an identified hazard at the site without appropriate remedial action.
Moderate Risk	It is possible that without appropriate remedial action, harm could arise to a designated receptor but it is relatively unlikely that any such harm would be severe and if any harm were to occur, it is likely that such harm would be relatively mild.
Low Risk	It is possible that significant harm could arise to a designated receptor from an identified hazard but it is likely that at worst this harm if realised would normally be mild.
Very Low Risk	There is a low possibility that harm could arise to a receptor. In the event of such harm being realised, it is not likely to be severe.

Further risk assessment definitions are located in Appendix D.

11.2 Pollutant Linkages

Based on the potential contaminant source and the potential receptors and pathways identified above, Table 11.2 provides an assessment of each identified pollutant linkage to establish the potential risk to the sensitive receptors. The proposed development has been taken into consideration and the risk assessment has been developed based on the site being developed as a Energy to Waste site.

Table 11.2: Pollutant Linkages

Pollutant Linkage	Contaminant Source	Sensitive Receptor	Pathway	Hazard (Severity)	Likelihood	Potential Risk	Further Assessment/ Remediation Required
1	Lead in the Made Ground	Human Health – site end users, site workers and maintenance workers.	Direct contact / accidental ingestion of contamination within soil or inhalation of dust.	Long term health effects to humans – blood poisoning. (Severe)	Unlikely. Elevated Lead above the relevant SSV was only encountered in one location at shallow depth. Site construction workers by the nature of the work are unlikely to come into long term contact with the contamination and any exposure is likely to be short term.	Moderate/low risk.	Yes, subject to regulatory approval.
2		Controlled Waters (unnamed stream onsite and groundwater beneath the site)	Leaching from contaminants within the made ground and subsequent percolation through the underlying weathered Mercia Mudstone.	Reduction in Water Quality (Medium)	Unlikely. Groundwater was encountered during the ground investigation and 5 groundwater samples were taken for analysis. Concentrations of Lead were not recorded to be elevated in the groundwater beneath the site.	Low Risk	No, subject to regulatory approval.
3	Copper, Ammoniacal Nitrogen and PAH in leachate	Controlled Waters (unnamed stream on site and groundwater beneath the site)	Leaching of contaminants within the made ground and percolation through the unsaturated strata into the groundwater /surface water	Reduction in Water Quality (Medium)	Unlikely. Whilst leachate analysis of the Made Ground indicated exceedances, the concentrations in the groundwater were generally shown to be below the appropriate guidelines. It is therefore considered that leaching is not readily occurring and therefore these concentrations are not considered to pose a risk to the water environment.	Low Risk	No, subject to regulatory approval.
4	Possible Asbestos containing material in the Made Ground	Human health (construction workers, site end users and, maintenance workers)	Accidental ingestion and/or inhalation of soil dust	Potential Carcinogenic health risks (Severe).	Low Likelihood. A piece of potential asbestos board was encountered in the Made Ground at shallow depth. Asbestos testing was carried out on samples of Made Ground but no asbestos fibres were positively identified, therefore there is a limited occurrence of potential asbestos containing materials which can be visually identified.	Moderate Risk	Yes, subject to regulatory approval

Pollutant Linkage	Contaminant Source	Sensitive Receptor	Pathway	Hazard (Severity)	Likelihood	Potential Risk	Further Assessment/ Remediation Required
5	Ground Gas (Carbon Dioxide and Methane)	Human Health /Buildings	Migration of ground gases and via ground voids and build up in confined spaces	Explosion, asphyxiation and build up of gases in confined spaces (Severe)	Low Risk. Carbon dioxide readings have been recorded to date but at a relatively low concentration and flow rate.	Moderate Risk	Further Monitoring is being undertaken and a full assessment will be in an addendum report.

12 CONTAMINATION CONSIDERATIONS

12.1 Protection of Workers

Contamination from materials brought on to site (e.g. fuel and lubricating oils for plant) during the construction phase must be considered harmful to human health, the environment and controlled waters. The risks posed from all imported substances must be adequately addressed within a comprehensive site management plan.

Additionally, in accordance with good practice procedures, it is advisable to utilise the document HSG 66: *"Protection of Workers and the General Public During Development of Contaminated Land"* published by the HSE (Ref. 8) to ensure that all construction workers are adequately protected (using appropriate Personal Protective Equipment) and that a suitable health and safety scheme is adopted during any construction activities.

12.2 Elevated Lead Concentrations

Whilst the risk from the Lead concentrations is considered to be low, it would be prudent to remove the elevated Lead concentration from BH20 at 0.75m. The concentration at this location is significantly higher than the other Lead concentrations recorded on site. From the borehole log the contamination is within the Made Ground strata which contains coal fragments and is to a depth of 1.2m.

Validation work should be undertaken of the area after excavation to ensure that all the Lead contamination has been removed from site. The contaminated material should be removed to a suitably licensed landfill facility

12.3 Watching Brief / Discovery Strategy

During the site enabling works, a watching brief should be maintained with regards to the potential presence of currently unknown contaminant sources. If visually contaminated material is encountered analysis should be undertaken by an experienced Geo Environmental Engineer to confirm if the soil meets the required criteria to be protective of human health and controlled waters. Work in the affected area should cease until the analysis results are received and a solution is approved.

Across the site in areas of Made Ground the work force should remain aware of the possibility of encountering asbestos containing material. If any asbestos containing materials are discovered, disposal to a suitably licensed or permitted waste facility should be undertaken. Appropriate health and safety measures should also be adopted.

13 WASTE MANAGEMENT

As part of any development or construction works, it must be noted that should any material require off-site disposal to an appropriately licensed landfill (for example, material generated due to excavation works associated with any development/construction) due consideration should be given to the UK Landfill Directive. Furthermore, any materials without a defined re-use on-site can be considered as waste. If material is to be re-used on site, then the principles included in the draft CL:AIRE document "Definition of Waste: Development Industry Code of Practice" (Ref. 9) should be followed.

Due to the introduction of the Landfill Directive in July 2004, waste must be characterised prior to being sent to an appropriately licensed landfill site. Landfills are categorised into one of three types; inert, non-hazardous and hazardous and can only accept waste they are licensed for. The characterisation is therefore to ensure that the landfill is suitably licensed to accept the excavated soil (i.e. the waste) from the site.

Waste producers have a duty to classify and describe their waste correctly; this includes selecting the most appropriate six-digit code from the European Waste Catalogue (EWC). Appropriate hauliers with waste handling licences must be sought for removal of material off-site.

13.1.1 Waste Disposal CATWASTE^{soil}

The results from the Made Ground of the investigation have been input into CATWASTE^{soil} which determines from the total concentrations if the material is non-hazardous or hazardous. The results indicated that of the 11 made ground samples 2 were found to be HAZARDOUS and the others were non-hazardous. The output spreadsheet is included in Appendix E.

The 2 samples (BH20 at 0.75m and TP26 at 0.5m) which are hazardous due to elevated lead, copper and zinc results.

Please note that CATWASTE does not consider the Total Organic Carbon (TOC) content of the soil samples. This will need to be taken account of before disposal in a landfill can take place. This will need to be taken account of before disposal in a landfill can take place. The maximum value allowed in a hazardous landfill is 6% TOC.

13.2 Waste Acceptance Criteria (WAC)

13.2.1 Waste Acceptance Criteria Testing

Two samples (TP20 at 0.5m and TP25 at 1.2m) were analysed for WAC, with the full results included within the Factual Report. Using the CATWASTE results, both these samples are considered to be non-hazardous. The WAC results are therefore compared to the Inert leaching criteria to determine if this material would be considered to be Inert.

The soil sample from TP20 at 0.50m bgl exceeded the Total Organic Matter criteria and Antimony for inert material and therefore is likely to be considered as non-hazardous.

The WAC results from the soil sample from TP25 at 1.2m bgl were all below the inert leaching criteria and therefore is likely to be considered as inert.

It is recommended that material that is excavated which requires disposal off site to an appropriate landfill site, should be re-tested from the stockpile to determine the correct disposal route.

When stockpiling Made Ground/Natural Soils and contaminated/non contaminated material should be kept separate whenever possible as the material may have different waste classifications and therefore could be disposed at different landfill sites. This will ensure minimum cost for disposal for the project.

The duty of care for waste disposal falls with the waste producer. Above is an indication of the likely classification.

14 REFERENCES

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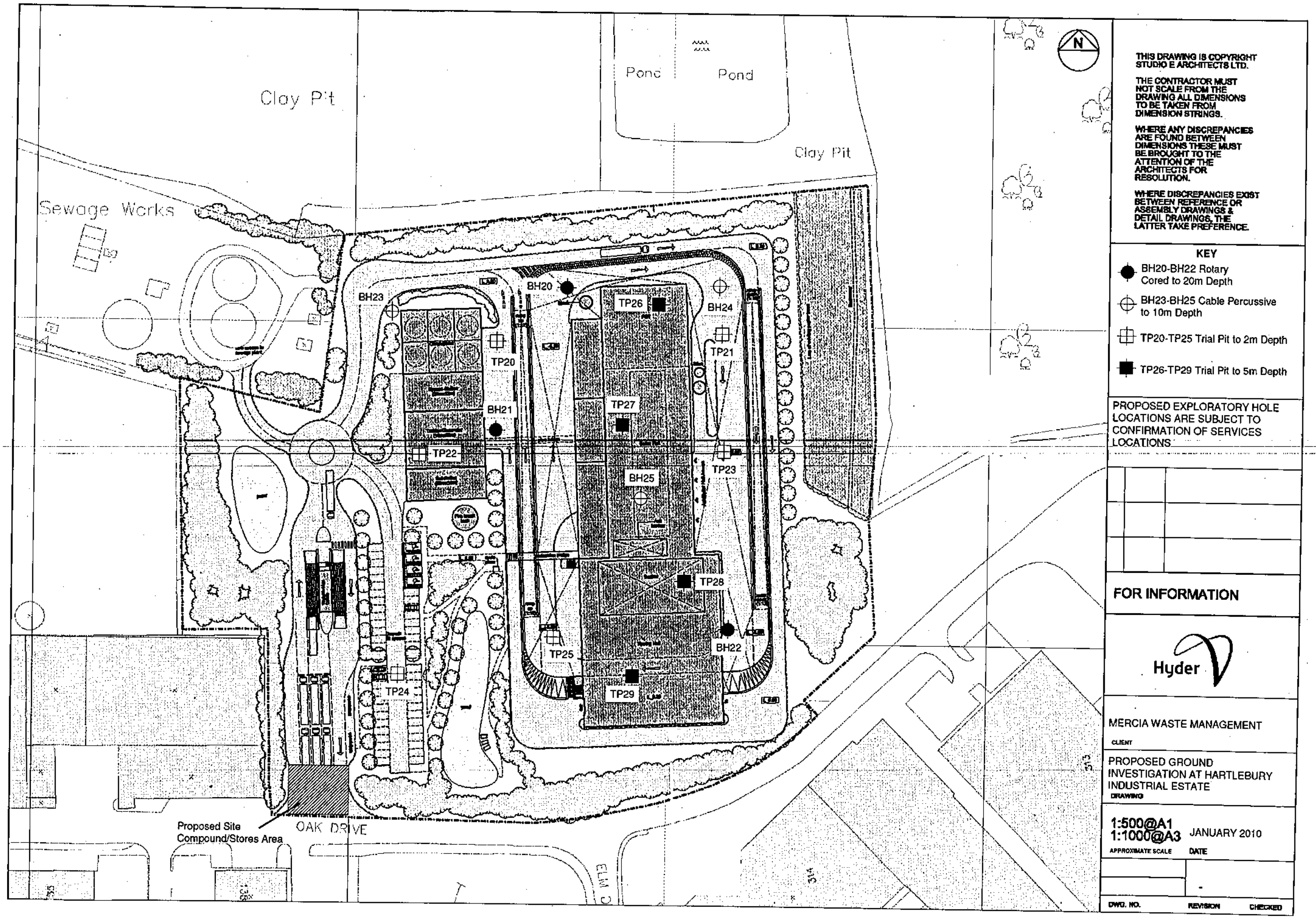
22 CIRIA Report 140, Water-resisting Basements (Summary Report) (1995)

Appendix A

Site Location Plan



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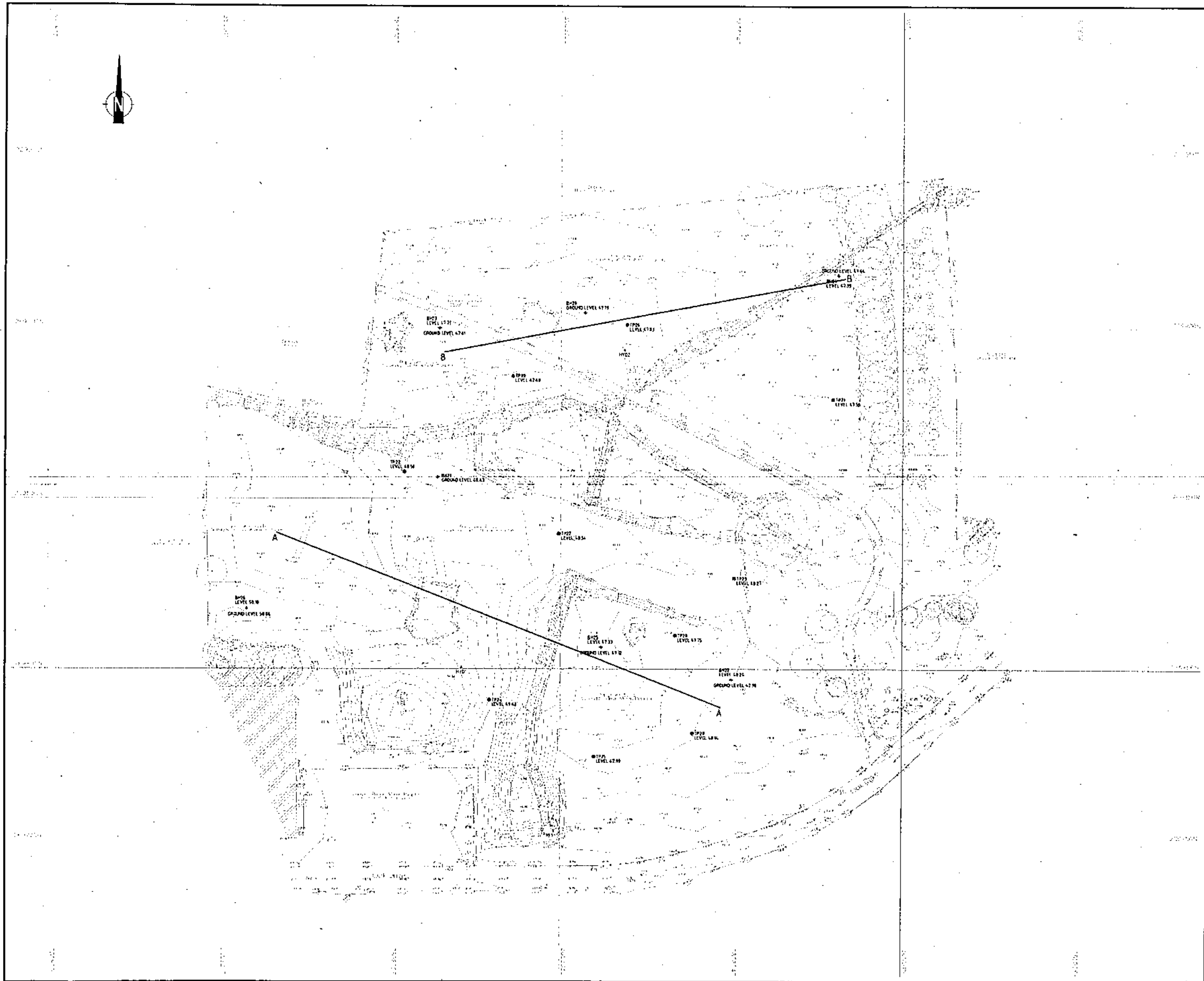
WHERE DISCREPANCIES EXIST BETWEEN REFERENCE OR ASSEMBLY DRAWINGS & DETAIL DRAWINGS, THE LATTER TAKE PREFERENCE.
KEY
BH20-BH22 Rotary Cored to 20m Depth
BH23-BH25 Cable Percussive to 10m Depth
TP20-TP25 Trial Pit to 2m Depth
TP26-TP29 Trial Pit to 5m Depth
PROPOSED EXPLORATORY HOLE LOCATIONS ARE SUBJECT TO CONFIRMATION OF SERVICES LOCATIONS
FOR INFORMATION
Hyder
MERCIA WASTE MANAGEMENT
CLIENT
PROPOSED GROUND INVESTIGATION AT HARTLEBURY INDUSTRIAL ESTATE
DRAWING
1:500@A1
1:1000@A3
APPROXIMATE SCALE
JANUARY 2010
DATE
-
DWG. NO.
REVISION
CHECKED
N
Clay Pit
Pond
Pond
Clay Pit
Sewage Works
BH20
BH21
BH22
BH23
BH24
BH25
TP20
TP21
TP22
TP23
TP24
TP25
TP26
TP27
TP28
TP29
Proposed Site Compound/Stores Area
OAK DRIVE
ELM C
314
313

Appendix B

Exploratory Hole Location Plan



Stations Schedule

Station	Easting	Northing	Level	Notes
[illegible]	[illegible]	[illegible]	[illegible]	PEG
HY02	[illegible]	[illegible]	[illegible]	PEG

Borehole Schedule

Point	Easting	Northing	Level
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[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	68.244
BH23	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

Issue	Description	Amc	Apr	Date

Status: **FINAL**

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Original Size	A1	Checker: A WHITE	12/02/10
Height Datum	OS	Approver: A WHITE	12/02/10
Grid	OS	© Copyright reserved	

Filename

Client: SEVERN WASTE SERVICES

Hyder Consulting Ltd

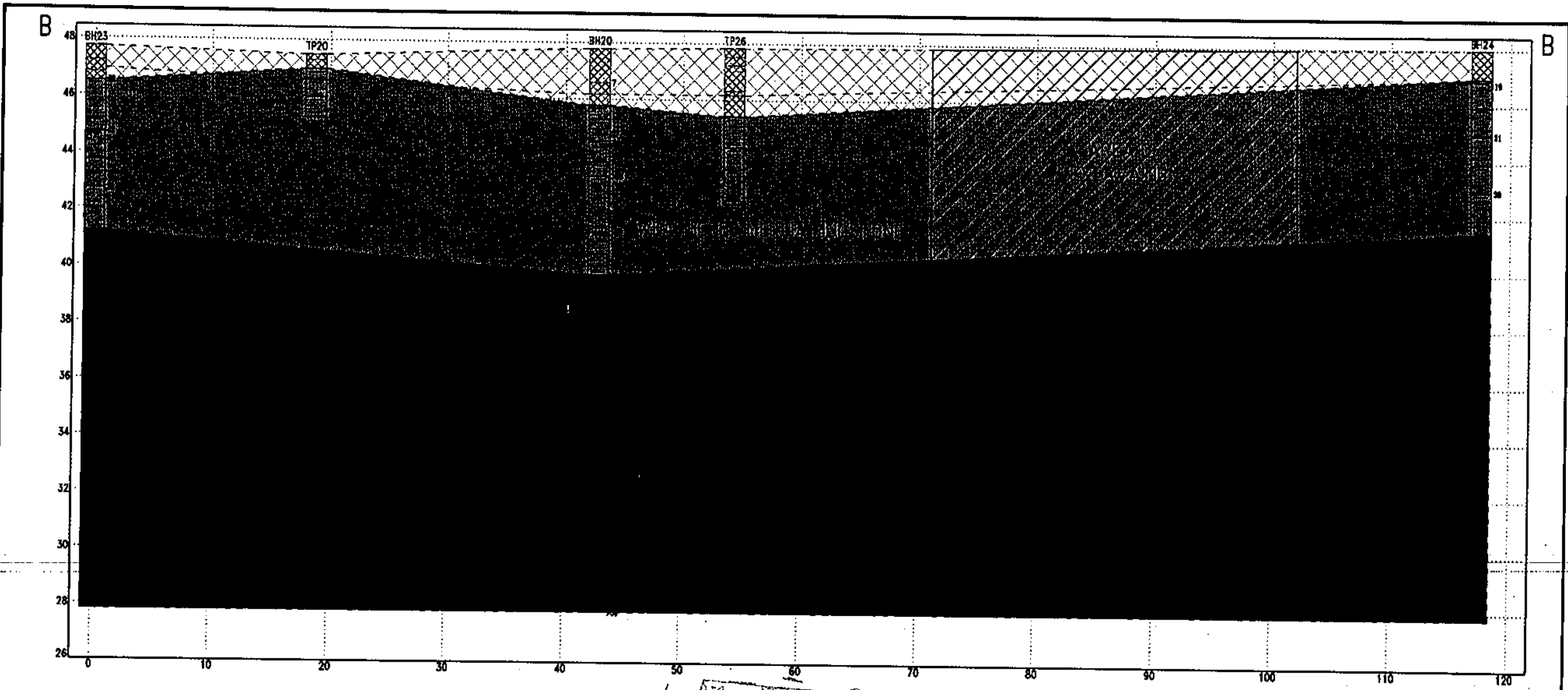
Project: HARTLEBURY, LAND OFF OAK DRIVE, HARTLEBURY TRADING ESTATE

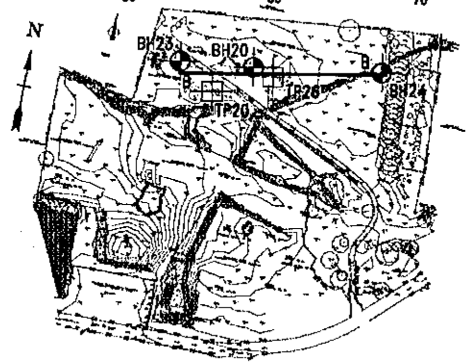
Title: EXPLORATORY HOLE LOCATION PLAN

Drawing No	Project No	Issue
G010	LN01323	01

Appendix C

Geological Cross Sections





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KEY

- CLAY
- MADE GROUND
- AREA OF EXCAVATION
- MUDSTONE

N.B. SUPERFICIAL DEPOSITS HAVE BEEN INCLUDED IN THE MADE GROUND HORIZON

Issue	Description	Date
01	FIRST ISSUE	26/03/10

50mm on Original

Client: MERCIA WASTE MANAGEMENT

Status: **PRELIMINARY** NOT TO BE USED FOR CONSTRUCTION

		Current Issue Signatures
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Original Size	A3	Checker C.GILLET
Height Datum	DATUM	Approver M.LUNDIE
Grid	GRID	© Copyright reserved
Filename:	G002-LN01323-WXD-01 B'B.DWG	

Project: ENVIRECOVER

Title: CROSS SECTION "B-B"

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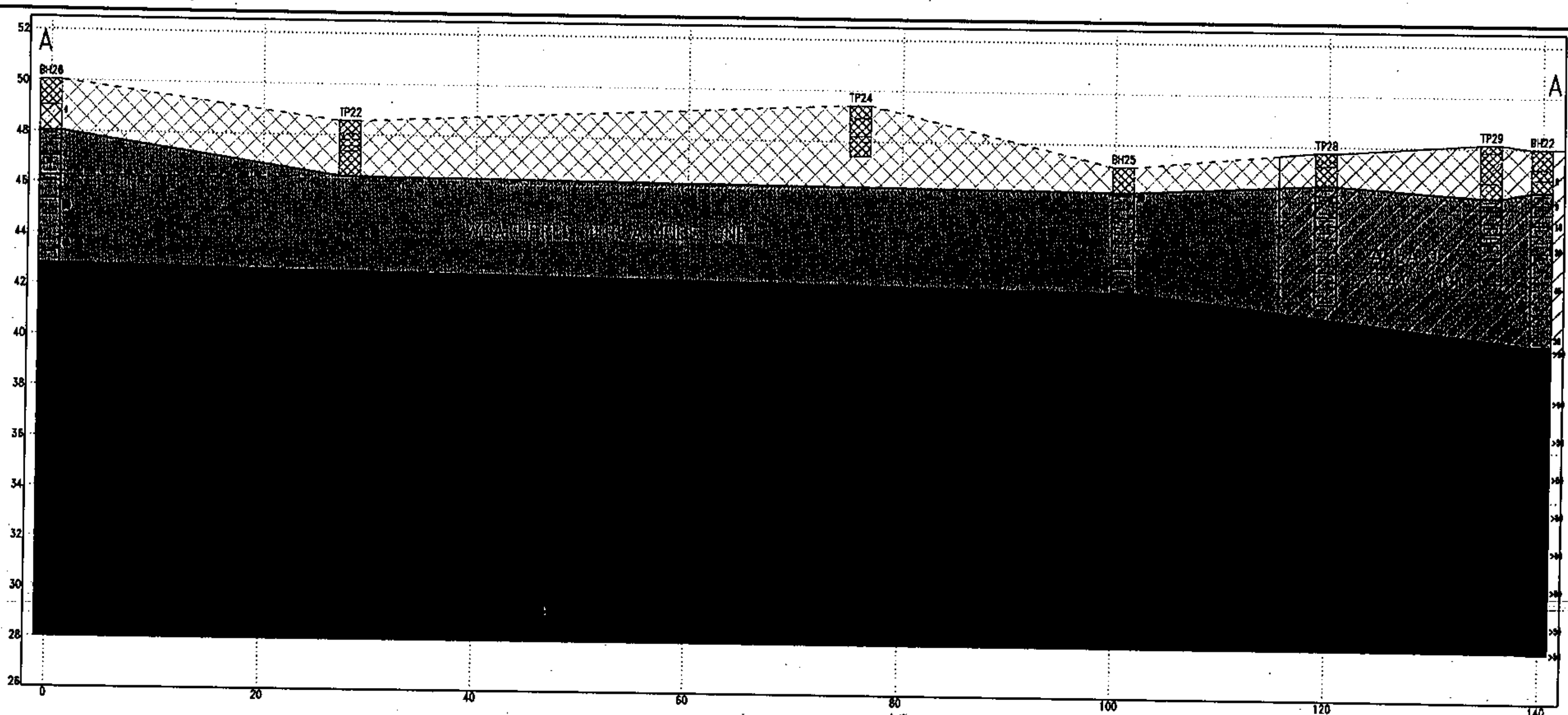
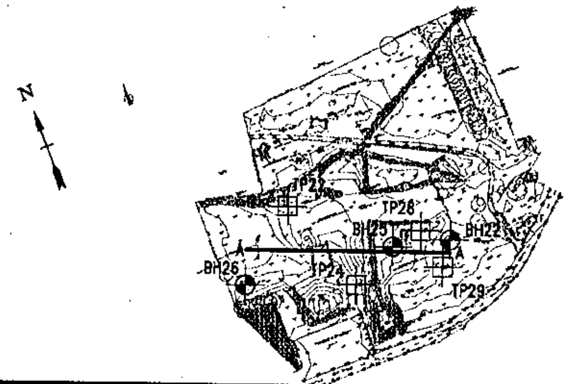
Drawing No.	Project No.	Issue
G002	LN01323	01

Plot Date: 08/Apr/2010 2:53:00 PM File Location: K:\PROJECTS\LN01323 – ENVIRECOVER\E-OURDRAWINGS\CURRENT\G002-LN01323-WXD-01 B'B.DWG V1





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KEY

- CLAY
- MADE GROUND
- AREA OF EXCAVATION
- MUDSTONE

N.B. SUPERFICIAL DEPOSITS HAVE BEEN INCLUDED IN THE MADE GROUND HORIZON

Issue	Description	Date
01	FIRST ISSUE	26/03/10

50mm on Original

Client: MERCIA WASTE MANAGEMENT

Status: **PRELIMINARY**
NOT TO BE USED FOR CONSTRUCTION

Scales	1:1000	Current Issue Signatures	
		Author R.JORDAN	
Original Size	A3	Checker C.GILLET	
Height Datum	DATUM	Approver M.LUNDIE	
Grid	GRID	© Copyright reserved	
Filename:	G001-LN01323-WXD-01 A'A.DWG		

Project: ENVIRECOVER

Title: CROSS SECTION "A-A"

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Drawing No.		Project No.		Issue
G001	–	LN01323	–	01

Plot Date: 08/Apr/2010 12:25:31 PM File Location: K:\PROJECTS\LN01323 – ENVIRECOVER\E-DURDRAWINGS\CURRENT\G001-LN01323-WXD-01 A'A.DWG V1

Appendix D

Risk Assessment Definitions

Risk assessment considers the identified sources, the potential receptors and the pathways linking them together.

In the pollutant linkage table of this report, the column designated as 'Hazard (severity)' gives an indication of the sensitivity of a given receptor to a particular source being considered. It is a worst case classification and is based on full exposure via the particular linkage being examined. The derivation of the classes used to rank this particular aspect are given in the table below

Classification of Potential Consequence (Severity)

Classification	Human Health	Controlled Water	Built Environment	Ecosystems
Severe	Irreversible damage to human health. Short term (acute) risk to human health likely to result in "significant harm" as defined by Part 2a.	Substantial pollution of sensitive water resources	Catastrophic damage to buildings, structures or the environment	A short-term risk to a particular ecosystem or organism forming part of such ecosystem.
Medium	Chronic damage to human health. Non-permanent health effects to humans	Pollution of sensitive water resources or small scale pollution of sensitive water resources	Damage to buildings, structures or the environment	A significant change in a particular ecosystem or forming part of such ecosystem
Mild	Slight short term health effects to humans	Pollution to non-sensitive water resources	Damage to sensitive buildings, structures services or the environment.	Significant damage to crops
Minor	Non permanent health effects to human health (easily prevented by means such as personal protective clothing etc)	Insubstantial pollution to non-sensitive water resources	Easily repairable effects of damage to buildings or structures	Harm (although not necessarily significant harm which may result in financial loss or expenditure to resolve. eg loss of plants in a landscape scheme.

Subsequently, in the column entitled 'Likelihood of Occurrence", in the Pollutant Linkage table, an assessment is made of the probability of the selected source and receptor being linked by the identified pathway. This assessment is ranked based on site specific conditions as detailed in the table that follows

Appendix E

CATWASTE

Classification of probability

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

In the Pollutant Linkage table of this report, the 'Potential Risk' column is an overall assessment of the actual risk, which considers the likely consequence of a given risk being realised and the likelihood of that risk being realised. The risk classifications are assigned using the following consequence/likelihood matrix:

Potential Consequence				
Severe	Moderate/Low	Moderate	High	Very High
Medium	Low	Moderate/Low	Moderate	High
Mild	Very Low	Low	Moderate/Low	Moderate
Minor	Very Low	Very Low	Low	Moderate/Low
Likelihood	**Unlikely**	**Low**	**Likely**	**High**

Table below describes the risk classifications

Risk Term	**Description**
Very High Risk	There is a high probability that significant harm could arise to a designated receptor from an identified hazard at the site without appropriate remedial action.
High Risk	Harm is likely to arise to a designated receptor from an identified hazard at the site without appropriate remedial action.
Moderate Risk	It is possible that without appropriate remedial action harm could arise to a designated receptor from an identified hazard. However it is either relatively unlikely that any such harm would be severe or if any harm were to occur it is more likely that such harm would be relatively mild.
Low Risk	It is possible that harm could arise to a designated receptor from an identified hazard but it is likely that this harm if realised would at worst normally be mild.
Very Low Risk	There is a low possibility that harm could arise to a receptor. In the event of such harm being realised it is not likely to be severe.

Appendix F – Hyder Geotechnical Interpretative Report

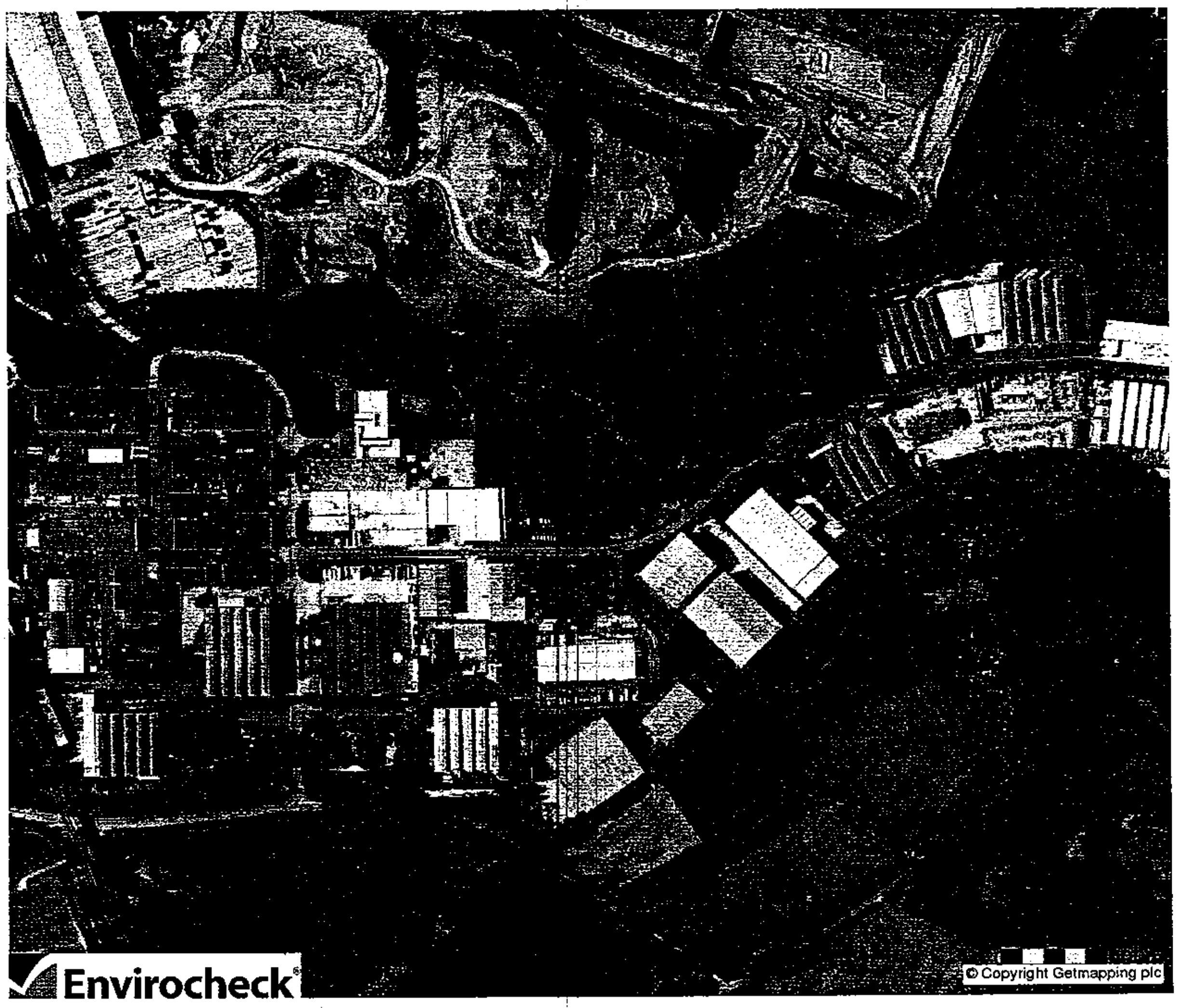
Hyder

mercia
waste management

Mercia Waste Management

Mercia EnviRecover Renewable Energy Facility

Geotechnical Interpretative Report (Outline Design)



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Mercia Waste Management

Mercia EnviRecover Renewable Energy Facility

Geotechnical Interpretative Report (Outline Design)

[redacted]

Author [redacted]

Checker [redacted]

Approver [redacted]

Report No 5003-LN01323-NER-01

Date 09 April 2010

This report has been prepared for the Mercia Waste Management in accordance with the terms and conditions of appointment for the Mercia EnviRecover Renewable Energy Facility contract dated 14th January 2010. Hyder Consulting (UK) Limited (2212959) cannot accept any responsibility for any use of or reliance on the contents of this report by any third party.

CONTENTS

Appendices

Executive Summary

Introduction:

1. Hyder Consulting (UK) Limited (HCL) has been instructed by Mercia Waste Management (Mercia) to undertake a Geotechnical and Geo-Environmental desk study, an Environmental Impact Statement, plus preliminary Factual and Interpretative Reports for a proposed 15.5MW renewable energy facility located at the Hartlebury Trading Estate in Worcestershire.
2. This report presents an interpretative summary of data collected during an initial preliminary ground investigation undertaken on site in February 2010 and provides advice relating to the physical and chemical nature of the ground based on interpretation of this data to support the EIA submission document.
3. Reference should also be made to the associated Desk Study Report (Ref. 1) and Factual Ground Investigation Report (Ref.6) for this development, also produced by HCL.

Site Location and Description:

4. The site is located approximately 9km south-south-east of Kidderminster, within the Hartlebury Trading Estate, Worcestershire and is centred on OS National Grid Reference 385950,269850.
5. The site encompasses an unoccupied area of disused land with open access from the south via Oak Drive, and is covered mainly by rough grass, bramble and low shrubs. A stream flows in culvert through the centre of the site. The site is bordered to the north by Biffa landfill site, and to the west by a small waste-water treatment works and large warehouse.

Hydrological and Environmental Sensitivity:

6. The site does not lie within a Groundwater Source Protection Zone, there are no licensed groundwater abstractions recorded within a 500m radius of the site and the site overlies a non-aquifer. The site therefore can be regarded as having low groundwater sensitivity.
7. The nearest primary river feature is located approximately 800m south-east, and is named the Elmley Brook. The stream flowing through the site discharges into this brook, so the site should be regarded as having high surface water sensitivity. There are no known water quality sampling points recorded for the brook.
8. There are no recorded major pollution incidents to controlled waters within 1km of the site.
9. Information contained within the Envirocheck Report shows that the site is not within the zone of potential flooding from fluvial watercourses.
10. The site can be regarded as having a low ecological sensitivity, though it should be noted that there is a small stand of Japanese knotweed on site, which will impose some constraints on the timing and methods of site clearance.

Geological Information:

11. Published geological information shows the solid geology directly beneath the site area to comprise the Mercia Mudstone Group (MMG) of Permo-Triassic geological age. A previous ground investigation undertaken on the site indicates this solid geology to be overlain by Superficial Deposits of re-worked natural soils, which in turn are overlain by Made Ground.
12. A preliminary ground investigation has been undertaken by HCL between 4th and 16th of February 2010 comprising boreholes (cable percussive and rotary cored) and trial pits, with associated geotechnical and contamination laboratory testing. This investigation has encountered a strata sequence in general accordance with those anticipated based on the desk study data, with a sequence comprising Made Ground over Superficial Deposits over Weathered (becoming unweathered) Mercia Mudstone material.

Continued ./...

Geological Information (continued):

13. In the northern part of the site, the Made Ground is typically 1-2m thick and generally granular in nature. In the southern part it is thicker (typically 2-2.5m) and more cohesive with many inclusions of construction waste including localised asbestos cement board.
14. The superficial soils are typically present to 1.5-2.5m and comprise soft/firm slightly gravelly clay.
15. The weathered Mercia Mudstone stratum initially comprises firm to stiff clay, that becomes rapidly very stiff/hard with depth (≈ 4m) grading into very weak mudstone at approximately7m depth.
16. Summaries of the pertinent engineering properties of these soils are provided and discussed within the text of the report for outline design.

Groundwater Levels:

17. Groundwater monitoring to date indicates levels that have fluctuated with time between 45.5 and 46.8 mAOD (1.0-2.5m bgl). These fluctuations may be linked to periods of rainfall variation, though evidence to date is insufficient to be conclusive. These water levels infer a groundwater flow direction from north to south across the site with a hydraulic gradient calculated to be ≈0.01.
18. Localised high water pressure conditions have been identified at a depth of 13-16m in Borehole BH20. However, because the artesian water pressures identified in this hole equalised over-night may indicate either that the layer and/or zone of material with elevated water pressures is confined and of relatively limited extent and/or that the permeability of the zone is sufficiently low to prevent maintenance of the artesian pressure for any length of time. The artesian effect is attributed to water pressure not volume; therefore significant water containment is not expected to be a major concern.

Engineering Considerations (structures outside the deep excavation):

19. Shallow (strip / pad) foundations will be suitable for most structures, with foundations taken down to at least 300mm below any Made Ground soils into the underlying natural soils. Recommended safe net bearing pressures for preliminary design are provided within the report for foundations placed at 1m, 2m and 3m depth in either superficial soils or weathered Mercia Mudstone to limit post-construction total and differential settlements to 25mm and 15mm respectively.
20. The underlying soils are clays with a high to medium volume change potential. Consequently, a minimum foundation depth of 0.90m should be adopted to prevent potential problems associated with the seasonal shrinkage and swelling of the clay soils. Across much of the site, however, the thickness of made ground will result in shallow foundations being at greater depth than this minimum requirement. In the vicinity of existing, proposed or recently removed trees, the foundation depth will need to be increased in accordance with the guidelines given in NHBC Chapter 4.2 'Building Near Trees'. Related to this recommendation, it is understood that several high water demand species trees used to be present in the centre of the site, which may necessitate the use of a pile or a raft foundation solution for units in their immediate vicinity.
21. Formation soils should be carefully inspected by a suitable qualified / experienced person to identify the nature of the formation stratum (eg whether made ground, superficial soils or weathered Mercia Mudstone) and/or the presence of any soft/loose zones. Any such zones should be over-excavated and replaced with a well-compacted well-graded granular fill or lean mix concrete.
22. The superficial soils and weathered Mercia Mudstone strata are likely to be very susceptible to softening in the presence of excess water. Consequently, it is crucial to ensure that proposed formations are not exposed to significant and/or prolonged rainfall.
23. For structures imposing higher loads and/or with more stringent settlement tolerances, piled foundations are recommended. Bored, augered or driven piles would be suitable in these soils, though pile type selection should take cognisance of the presence of buried large obstructions in the made ground soils. Consideration also should be given to the requirement to dispose of arisings comprising (in part) made ground soils if non-displacement piles are adopted.

Continued ./...

Engineering Considerations (structures outside the deep excavation) (continued):

24. Suspended floor construction is likely to be appropriate for most structures, because of the presence of made ground and/or medium shrinkage potential cohesive soils. For structures not in close proximity to existing, proposed or recently removed trees and where the made ground is of limited thickness, it may be economic to excavate out the made ground and re-compacted it to a suitable engineering earthworks specification and then utilise a ground bearing floor.
25. For larger structures, where suspended floors are uneconomic, an excavation and re-compaction solution is likely to be the most favourable and cost-effective though consideration could be given to combining a suitable method of ground treatment (e.g. vibro-stone or vibro-concrete columns) with a ground bearing slab.
26. In the ground investigations, groundwater was generally encountered as seepages from within the made ground or just below its interface with the natural soils. Some of these instances may be perched waters within the made ground soils, though some may be in hydraulic continuity with the stream flowing through the site.
27. Groundwater monitoring indicates seepages are likely in excavations below 1.0-2.5m and appropriate provisions for groundwater control should be anticipated in this respect.
28. With the exception of localised large pieces of rubble within the made ground soils, excavation for the construction of shallow foundations etc. should be possible using conventional hydraulic excavators.

Engineering Considerations (deep excavation area):

29. The base of the excavation is approximately at the interface between weathering Grade IIII and Grade II material, and bearing capacity may be limited more by the drained shear strength and settlement characteristics of the underlying soils than undrained shear strength. A safe net bearing pressure of 500kN/m2 is recommended for preliminary design based on published literature, though this will need to be confirmed depending on groundwater control measures incorporated into the permanent works design.
30. Although pronounced variability in the formation soils is less likely at this depth, they should be carefully inspected by a suitable qualified / experienced person to identify the presence of any weaker zones (particularly in areas of anticipated high structural loads). Any such zones should be over-excavated and replaced with lean mix concrete.
31. The low plasticity soils are likely to be very susceptible to softening in the presence of free or standing excess water and it is crucial that excavations for structural foundations are covered without delay (e.g. with blinding concrete) to prevent softening by any water that may enter the excavation.
32. Excavation for the deep basement should be relatively straight-forward using conventional hydraulic plant, though towards the base of the excavation plant capable of 'hard digging' may be required, and localised use of plant capable of 'easy ripping' may be required in the more competent bands of harder mudstone and sandstone.
33. Detailed discussion is provided in the report for various options of excavation support and groundwater control for the deep excavation area in the temporary works and permanent works condition. For the purposes of design, the water table classification (BS 8102 : 2009) should be regarded as 'high', and it is anticipated that a Grade 2 environment performance level is appropriate.

Continued ./...

Engineering Considerations (deep excavation area):

34. The presence of a high groundwater table and potential localised artesian water pressures just below the proposed excavation formation level, are critical issues to the design of any temporary works, the permanent basement walls and groundwater control measures. Although a number of potential options are feasible, and the ultimate decision will involve a detailed assessment of relative cost for the alternatives, the following recommendations are provided:

- A solution involving some form of cut-off wall is favoured over open excavation, not only to control lateral groundwater inflow but also to limit the extent of any peripheral groundwater drawdown. This form of solution can be combined to form Type 'B' 'structurally integral protection' to the permanent works basement, but is likely to make construction using a monolithic R.C. box less cost-effective.
- The stiffness of the soils at depth is likely to preclude the use of sheet piles, and a secant pile or diaphragm wall is considered more suitable. It is likely that these walls will need to be propped with struts or anchors (though in the early temporary works case the use of soil berms could be considered), which would have the benefit of reducing the internal steel reinforcement and/or the toe embedment depth required.
- The installation of pressure relief wells is considered to represent the simplest and most cost-effective way of controlling the risk of heave of the base of the excavation due to hydraulic uplift. These could be incorporated into the permanent works design of the basal slab to control hydraulic uplift and form part of the Type 'C' drainage protection measures.
- The design of the basal slab needs to be designed taking cognisance of the potentially very high long-term hydraulic pressures to prevent the risk of catastrophic heave which might then lead to failure of the surrounding retaining walls. Based on preliminary data available to date, in the absence of any groundwater control measures these pressures could be of the order of 90kN/m^2 at the proposed formation level. The size and geometry of the proposed basement structure, means it is very unlikely that these forces can be accommodated by shear resistance on the side walls, and it is recommended that outline design comprises a combination solution of basal pressure relief wells, thickened basal slab and (if required) supplementary ground anchorages and/or tension piles.

35. Groundwater regime aspects will have very significant implications on the cost of the design and construction of the deep basement. Consequently, as part of the ground investigation to provide data for detailed design, it is imperative that sufficient instrumentation and monitoring of the groundwater regime is undertaken to provide data for economic and safe construction. It is anticipated that this will include the installation of vibrating wire piezometers at discrete levels around the proposed structure, linked to datalogger systems to enable any fluctuations in groundwater levels and artesian water pressures to be ascertained.

Re-use of Excavated Materials:

36. The majority of the soils likely to be excavated on the site are likely to be suitable for re-use as either landscape fill or general earthworks materials,

37. It is important that the various stratum groups are appropriately segregated (particularly the made ground) to prevent the risk of cross contamination.

38. Preliminary test results indicate that the Superficial Deposit soils and Mercia Mudstone materials will be suitable for re-use as SHW Class 1 or Class 2 general fill (Class 1A, 2A/2B/2C depending on stone content and/or moisture content). The majority of these materials will fall into Class 2B dry cohesive, and very stiff/hard clay material excavated from deeper levels may need to be improved by the addition of water (via spray irrigation) to soften them sufficiently to facilitate adequate re-compaction.

Continued ./...

Re-use of Excavated Materials (continued):

39. Material from shallow depth may be too soft (wet) in its 'as-excavated' condition to be suitable for re-compaction as engineered fill, but (subject to further testing) it is likely these soils may be improved by the addition of lime (or cement) to render them suitable for re-use as engineered earthworks materials.

40. The Mercia Mudstone stratum soils are likely to be very susceptible to softening in the presence of free or standing excess water and it is crucial that any excavations are kept free of ponding water (if at all possible) and that excavation for material proposed for re-use as engineered materials is not undertaken during periods of prolonged and/or heavy rainfall.

41. A proportion of the material likely to be excavated from the basement area will comprise made ground soils. Preliminary laboratory tests undertaken in the GIP investigation indicates that the cohesive made ground soils would be suitable for re-use as general cohesive fill (though soft material may need to be improved) and granular made ground is likely to be suitable for re-use as Class 1 fill. All of the made ground soils will need to be carefully screened to remove unsuitable inclusions (e.g. timber, concrete blocks, textile, metal, etc).

42. Chemical testing indicates that the vast majority of the made ground soils are likely to be suitable for re-use, with the exception of one sample that provided unacceptably high levels of lead content. Consequently, as part of the detailed design ground investigation, additional testing of samples should be undertaken in this area to delimit the extent of this contamination.

43. None of the soils likely to be won from site are likely to be suitable for re-use as selected (Class 6) fill material.

44. It is understood that enquiries have been made by Mercia Waste Management to companies to make use of the excavated natural materials for specialist re-use as brick manufacture and/or landfill site capping materials. Some samples were provided for specialist testing by the brick manufacturer company though at the time of writing this report we have received no feedback in the suitability or otherwise of the soils in this regard.

Other Considerations:

45. **Buried Concrete Classification:** Buried concrete should be designed to Sulphate Design Class DS-1, ACEC Class AC-1s, as defined within the BRE guidelines.

46. **Road Pavement Design Considerations:** A preliminary subgrade CBR value of 2.5% is recommended for outline design. Because the subgrade soils will be vary variable, the incorporation of appropriate geogrid reinforcement at the base of the pavement foundation is recommended to ameliorate any variations and enable the thickness of capping / sub-base to be reduced. Some of the likely subgrade soils are likely to be very susceptible to softening in the presence of excess water, so formations should not be exposed to significant and/or prolonged rainfall.

47. **Soakaway Drainage:** In-situ percolation tests indicate that soakways will not represent a suitable form of surface water disposal on this site.

48. **Former Well:** A possible well is detailed within the north eastern part of the site, in the previous ground investigation report, that is believed to be an open well full of water and brick rubble. It is not believed to have been stabilised and this will require further consideration prior to development. In particular, if the well is relatively deep, treatment involving grouting and capping may be necessary. Also, depending on the depth of the well and the backfill material, it may form a receptor for groundwater and should therefore be considered further in respect of groundwater contamination once additional information is obtained.

Contamination Assessment:

49. Analytical testing was undertaken on Made Ground and natural soils for soil totals and leachate. Groundwater was also analysed.

50. The soil results were compared to screening values for a standard CLEA commercial end use and only Lead was found to be elevated. Potential Asbestos containing material was encountered in the shallow Made Ground in one location.

51. Leachate and Groundwater results were compared to appropriate EQS or Drinking Water Standards. Whilst some contaminants (Copper, Ammoniacal Nitrogen and organics) were found to be elevated in the soils leachate analysis, this was not reflected in the groundwater results, which were generally found to be below the guidelines values.

52. Ground Gas monitoring is ongoing however to date no methane has been encountered. Carbon dioxide has been detected with a maximum of 10.5% volume. Flow rates are generally low and the maximum reading was 0.2l/hr. The atmospheric pressure during the monitoring was between 900 and 1018mb. Using the maximum data available, the Gas Screening Value is 0.021l/hr which equates to Characteristic Situation 1 Very low risk. This will be reviewed once all the data has been collected.

53. A pollutant linkage assessment was undertaken and is presented in Table 13.2. This indicates that there is a moderate to low risk from theielevated Lead concentration and a moderate risk from asbestos containing material in the Made Ground. A low risk is presented for risk to controlled waters.

Contamination Considerations:

54. It is recommended that the elevated Lead concentrations encountered in BH20 at 0.75m depth is removed to reduce the risk to the construction workers and to future site users. This should be undertaken prior to works beginning to ensure that the material is not spread across the site.

55. A watching brief/discovery strategy should be maintained with regards to the potential presence of currently unknown contamination. If encountered during the site enabling works, an experienced Geo Environmental Engineer should be contacted and analysis undertaken on the suspected material.

Waste Management:

56. Due consideration should be given to the UK Landfill Directive when disposing of material to landfill. If material is to be re-used on site principles in the CL:AIRE document Definition of Waste: Development Industry Code of Practice should be followed.

57. Results of the total soil analysis were put into CATWASTESOIL and the majority were showed to be non-hazardous with 2 being hazardous.

58. Waste Acceptance Criteria (WAC) testing was undertaken on 2 samples which were shown to be non-hazardous. This indicated that one sample is likely to be considered as Inert and one as non-hazardous.

59. It is recommended that the excavated material is stockpiled and if disposal to landfill is required, testing should be undertaken at this stage to confirm the correct waste classification. During stockpiling Made Ground and natural soils and contaminated and non contaminated material should be separated as different disposal routes may be appropriate for each type.

60. The Duty of Care for waste disposal falls with the waste producer.

1 INTRODUCTION

Hyder Consulting (UK) Limited (HCL) has been instructed by Mercia Waste Management (Mercia) to undertake a Geotechnical and Geo-Environmental desk study, an Environmental Impact Statement, plus preliminary Factual and Interpretative Reports for a proposed 15.5MW renewable energy facility located at the Hartlebury Trading Estate in Worcestershire.

This Interpretative report presents a summary of data collected during an initial preliminary ground investigation undertaken on site in February 2010 and provides advice relating to the physical and chemical nature of the ground based on interpretation of this data. Prior to undertaking the ground investigation, a Desk Study Report (Ref. 1) was produced by HCL, which should be read in conjunction with this document and the associated Factual Ground Investigation Report (Ref.6)

1.1 Background to the Proposed Development

The Joint Municipal Waste Management Strategy (JMWMS) for Herefordshire and Worcestershire, 2004-2034, has highlighted the need for dealing more effectively with the waste left over after recycling (referred to as 'residual waste').

In a review of the JMWMS undertaken by the Joint Members Waste Forum, a number of scenarios for managing residual waste were examined using a computer model called WRATE. Following this assessment, the option of a single site Energy-from-Waste plant with combined heat and power (CHP) capabilities was identified as the optimum solution, resulting in the Mercia EnviRecover 15.5MW renewable energy facility.

As such, a planning application is required plus a ground and groundwater assessment for inclusion in a chapter of an EIA submission document. This chapter will pick up salient points of the contamination conceptual model and achievability of the current construction development based on the recovered technical information obtained from an intrusive ground investigation.

1.2 Objectives of the Report

The principal objective of the report is to provide an assessment of the current geotechnical and geo-environmental conditions of the proposed site. To this end, this report aims to :

- Establish likely ground and groundwater conditions beneath the site;
- Identify the potential presence of contaminants within the soil;
- Provide a series of construction phase options for the scheme;
- Identify health and safety issues arising as a result of the ground conditions; and
- Discuss materials management and waste disposal issues.

In order to meet these objectives, a site-specific intrusive preliminary ground investigation was undertaken and supervised by HCL utilising CJ Associates Ltd. (CJA) as drilling / plant provision subcontractors.

2 SITE SETTING

2.1 Site Location

The site is located approximately 9km south-south-east of Kidderminster, within the Hartlebury Trading Estate, Worcestershire.

The site comprises of a small parcel of land with an estimated surface area of 3.3 hectares. The Ordnance Survey National Grid Reference at the centre of the site is 385950,269850.

A site location plan is shown in Figure 1.

2.2 Site Description

The site encompasses an unoccupied area of disused land with open access from the south via Oak Drive. To the east, the site is immediately bordered by copse woodland, to the north by a pond and Biffa landfill site, and to the west by a small waste-water treatment works and large warehouse. The site is covered mainly by rough grass, bramble and low shrubs.

The waste-water treatment works in the west is accessed by a track that traverses north-west to south-east through the centre of the site. A stream flows from the waste-water treatment works, through the centre of the site and then off-site to the south. In general this stream flows within in a ditch, though it is culverted across the centre of the site and also further off-site to the south.

2.3 Public Register and Historical Information

Publically available information is usually obtained from agencies that have licences to reproduce data held by the UK Government and other such bodies. Landmark Information Group Ltd., who are the pre-eminent supplier of such data were approached to provide information for this study.

A full review of public register and historical information can be seen in the Desk Study Report (Ref. 1).

2.4 Geology and Hydrology

The 1:50,000 scale British Geological Survey (BGS) Sheet 182 (1976) shows the solid geology directly beneath the site area to comprise the Mercia Mudstone Group (MMG), a strata formerly referred to as the Keuper Marl.

Superficial deposits are not shown on the BGS Sheet 182, as the thickness of any localised deposits is considered insignificant at the mapped scale.

The former Lower Keuper Sandstone outcrops between one and two kilometres from the site to the north, south, east and west. To the east and west a faulted contact is postulated that suggests the site is on a downthrown block.

The dip of the sandstone to the west suggests that it may be present at approximately 40m bgl beneath the site.

Further details on the ground conditions on site and in the vicinity of the site (1km to the NW), have been obtained from an on-site ground investigation (undertaken in 2006, Ref. 2) and from a BGS report on the Hartlebury Landfill site located 800m to 1km north-west (Ref. 3). These sources indicate that the Hartlebury Landfill site is underlain by between 5m and 7m of superficial deposits (average of 6.2m), comprising an uppermost stratum of Made Ground, overlying weathered Mercia Mudstone. Bedrock is initially comprised of weak, red-brown mudstone (as part of the Mercia Mudstone Group).

More detailed geological classification for the area is obtained from the BGS report, which interprets the solid geology of the MMG in the area as comprising an upper sub-stratum of the Sidmouth Mudstone Formation (~up to 30m thick) and a lower sub-stratum of the Tarporley Siltstone Formation (~up to 20m thick). The MMG is underlain by the Bromsgrove Sandstone Formation at depths ranging from 30m to 60m below ground level (bgl).

While there has been little development on the site historically, the ground levels have been artificially raised, particularly in the south-west of the site, where approximately 3m of Made Ground is reported. Adjacent to this area is a mound, approximately 3m high, from which in excess of 4.3m of Made Ground was encountered in a trial pit excavated on top of the mound. Elsewhere on the site, the thickness of Made Ground is significantly reduced, to the order 1m to 2m. The site is therefore not level in places, with a mounded area in the south-west and a ditch up to 2m deep in the centre.

The National Soil Resources Institute Soils Site Report (Appendix D of Ref. 1) indicates that the surface soils in the area of site are likely to comprise reddish, loamy or fine, silty over clayey soils with slowly permeable subsoils and slight seasonal waterlogging.

2.4.1 Groundwater Vulnerability

The National Soil Resources Institute Soils Site Report classifies the soil in the area of the site as having an intermediate leaching potential. These are soils, which have a moderate ability to attenuate a wide range of diffuse source pollutants but in which it is possible that some non-adsorbed diffuse source pollutants and liquid discharges could penetrate the soil layer.

The underlying Mercia Mudstone Group is classified as a Non-Aquifer (negligibly permeable), which would correspond with the identified geology. Non-aquifers (now reclassified as Unproductive Strata) are formations, which are generally regarded as containing insignificant quantities of groundwater. However, groundwater flow through such rocks, although imperceptible, does take place and needs to be considered in assessing the risk associated with persistent pollutants and subsurface construction. Beneath the Mercia Mudstone Group lies the Sherwood Sandstone aquifer which was formerly classified as a Major Aquifer (now classified as a Principal Aquifer).

The site does not lie within a Groundwater Source Protection Zone.

No licensed groundwater abstractions are recorded within a 500m radius of the site.

The Catchment Abstraction Management Strategy (CAMS) for the Worcestershire Middle Severn determined the groundwater in the catchment to be over licensed.

It is reported that the groundwater levels in the Triassic Sandstone are regionally depressed due to over abstraction.

The site is located within a Nitrate Vulnerable Zone.

2.4.2 Nearby Surface Water Features

A stream/drainage ditch is shown to issue at the western site boundary, which then heads eastward to the centre of the site, before turning southward (the culverted drain) and flowing off-site, southward within a culvert.

The nearest primary river feature is located approximately 800m south-east, and is named the Elmley Brook. There are no known water quality sampling points recorded for the brook.

2.4.3 Pollution Incidents to Controlled Waters

There have been a total of 11 recorded pollution incidents to controlled waters within 1km of the site. All were regarded as Category 3 (Minor Incidents) and related mainly to the release of oils, solvents and detergents.

A full list of the incidents is located within the datasheets of the Envirocheck Report contained within Appendix B of the Desk Study Report (Reference 1).

2.4.4 Flooding

Information contained within the Envirocheck Report shows that the site is not within the zone of potential flooding from fluvial watercourses. There are no recorded flood defences or floodwater storage areas shown within 1km of the site.

2.5 Environmental Sensitivity summary

Groundwater sensitivity: low

The site overlies a non-aquifer, there are no groundwater abstractions within a 500m radius of the site and the site is not located within a groundwater source protection zone.

Surface Water Sensitivity: High

A stream/drainage ditch is located in the centre of the site, which discharges to a watercourse via a series of culverts, approximately 600m south-west of the site.

Ecological Sensitivity: Low

The site itself is not designated for its ecological importance and an ecological assessment undertaken on the site in 2004 (Refs. 4 and 5) states the following:

- No evidence of Water Vole activity in or adjacent to the north to south running ditch in the centre of the site;
- Holes and crevices that were accessible within the study area did not demonstrate any evidence of being used by bat species, though bat roosts are anticipated in the woodland to the east of the site;
- There are no waterbodies on site suitable for great crested newt; a partly culverted ditch running through the site does not constitute suitable habitat;
- A careful search of the site produced no evidence of use by any other protected species;
- No species with special protection under Schedule 1 of the 1981 Wildlife and Countryside Act, or Annex I of the EU Birds Directive were recorded on or in the vicinity of the site;
- The field surveys work did not identify the presence of any plant species or habitats protected by law, or considered rare in the UK;
- There is a small stand of Japanese knotweed on site, which will impose some constraints on the timing and methods of site clearance.

3 GROUND INVESTIGATION

The preliminary ground investigation was carried out between 4th and 16th of February 2010. It was undertaken and supervised by HCL on behalf of Mercia Waste Management. The purpose of the investigation was to identify the ground and groundwater conditions across the site and provide key information for the production of the Environmental Impact Assessment chapter by identifying the likely impact on the environment of the development. The ground investigation will also provide preliminary information for foundation design, excavation (and its support) and contamination issues surrounding the development of the Mercia EnviRecover energy facility.

A plan showing the exploratory hole locations is presented within Appendix B.

The site specific ground investigation has addressed the objectives identified within Section 1.2 of this report. The findings of the ground investigation are summarised below and are detailed in the HCL Factual Report (Ref. 6).

3.1 Site Works

The completed scope of the ground investigation is as follows:

- 4 no. cable percussive boreholes to maximum depth of 10m below ground level (bgl) with alternating Standard Penetration test (SPTs) and undisturbed soil samples (U100) at 1m intervals to 5m bgl, and where possible at 1.5m intervals at depth greater than 5m bgl.
- 3 no. rotary cored boreholes to maximum depth of 20m bgl, with SPTs at 1m intervals to 5m bgl and at 1.5m intervals below 5m bgl.
- 4 no. trial pits to depths of 5m bgl.
- 6 no. trial pits to depths of 2m bgl.

The depth, thickness and descriptions of the strata (including depths of sampling points) are given on the relevant exploratory logs, presented within the HCL Factual Report (Ref. 6).

Upon their completion, the boreholes (that were not completed with groundwater monitoring installations) and trial pits were safely backfilled and compacted and the ground re-instated, as far as practicable.

3.2 Sampling

A Geotechnical Engineer from HCL logged the boreholes and trial pits in accordance with the recommended procedures provided by document BS5930:1999 "Code of Practice for Site Investigations" (Ref. 7) and in general accordance with CIRIA C570 "Engineering in Mercia Mudstone" 2001 (Ref. 8). Disturbed, undisturbed and environmental samples were collected from the exploratory holes, which were subsequently sent for geotechnical, chemical and contamination analysis with the testing scheduled by HCL.

Groundwater was encountered in all of the seven boreholes. This has been subsequently sampled and sent for chemical analysis.

Furthermore all boreholes have been installed with groundwater and gas monitoring standpipes and an ongoing programme of monitoring is currently taking place over a three month period to allow groundwater and gas levels to stabilise and to be recorded over a range of (short-term) climatic variations. The results of this monitoring will be issued as a separate addendum to this report.

3.3 Laboratory Testing

Geotechnical and chemical laboratory testing was undertaken on selected samples taken from the boreholes and trial pits and are summarised in Table 3.1. Testing of all samples was scheduled by HCL and undertaken by an HCL appointed laboratory. The test results are discussed within Sections 5 to 7 of this report and are presented in full within the HCL Factual Report (Ref. 6).

Asbestos presence was analysed as a precautionary health and safety measure. Waste Acceptance Criteria (WAC) testing was carried out at the UK lower detection limits for inert waste to enable an assessment of Waste Management on-site and off-site to be undertaken.

Table 3.1: Summary of Analysis Undertaken on Scheduled Samples

Type of Test	Standard	Number of Samples
	Geotechnical & Chemical Tests	
moisture contents	BS1377:1990 Part 2:3	15
atterberg tests	BS1377:1990 Part 2:4 & 5	15
particle density	BS1377:1990 Part 4	4
density tests	BS1377:1990 Part 4:5	7
PSDs (Particle Size Distribution)	BS1377:1990 Part 2:9	13
sedimentation tests	BS1377:1990 Part 2	1
compaction tests	BS1377:1990 Part 4	6
one-dimensional consolidation tests	BS1377:1990 Part 6	3
consolidated undrained triaxial tests	BS1377:1990 Part 6	3
pH	BS1377:1990 Part 3	13
2:1 soil/water extract	BS1377:1990 Part 3	13

Table 3.1: Summary of Analysis Undertaken on Scheduled Samples (continued)

Type of Test	Standard	Number of Samples
	Contamination Tests	
Soil		
Metals (arsenic, cadmium, chromium, nickel, lead copper zinc, mercury and selenium)	MCERTS Accredited	15
Speciated PAH (USEPA 16)	MCERTS Accredited	15
TPH (Total Petroleum Hydrocarbons) 6 banded	MCERTS Accredited	15
Asbestos Screen and Microscopy	MCERTS Accredited	5
Soil Organic Matter (SOM)	MCERTS Accredited	6
Leachate		
Metals (arsenic, cadmium, chromium, nickel, lead copper zinc, mercury and selenium)	MCERTS Accredited	15
Speciated PAH	MCERTS Accredited	15
TPHCWG	MCERTS Accredited	15
Chloride	MCERTS Accredited	15
Ammonia		15
Groundwater		
Metals (arsenic, cadmium, chromium, nickel, lead copper zinc, mercury and selenium)	MCERTS Accredited	5
Speciated PAH (USEPA 16	MCERTS Accredited	5
TPH CWG	MCERTS Accredited	5
Chloride	MCERTS Accredited	5
Ammonia (Ammoniacal nitrogen as N)	MCERTS Accredited	5

4 GROUND CONDITIONS ENCOUNTERED

4.1 Previous Investigations

A previous Investigation has been carried out by Ground Investigation and Piling Limited (GIP) in May 2006 (Ref. 2). The findings of this report are incorporated into the following discussions.

Made ground was found to depths of up to 4.30m bgl containing ash brick mudstone among other man made substances including asbestos board. The cohesive made ground was found to have intermediate plasticity and medium volumetric change potential. Superficial Deposits were encountered to depth of between 0.7-3.0m as firm sometimes stiff gravelly CLAY. These Superficial deposits were identified to have up to very high plasticity and high volumetric change potential. Mercia Mudstone formation was found directly underlying this stratum, initially as a firm to stiff CLAY. Mudstone was then found from 5m bgl with up to intermediate plasticity and medium volumetric change potential.

Groundwater strikes were noted in the four boreholes drilled on site in 2006 (see Ref. 2) at depths ranging from 4m to 5m bgl within Residual Mercia Mudstone clays. In the shallower trial pits, groundwater was encountered in a limited number of the excavations at depths around 1m bgl, ranging from slow seepage to fast seepage. These inflows are considered likely to be derived from perched groundwater within the Made Ground soils.

4.2 Summary of Strata Sequence

Ground conditions were found to be in general accordance with those anticipated based on the desk study data, and the general strata sequence can be summarised below:

- Made Ground
- Superficial Deposits: Weathered Mercia Mudstone material re-worked by geological (e.g glacial) processes.
- Weathered Mercia Mudstone Group (soil material)
- Mercia Mudstone Group (rock material)

The strata descriptions used in the factual report are in accordance with BS 5930:1990 (Ref. 7). The weathering grades and terminology assigned to the Mercia Mudstone stratum in the factual report and this interpretation ("fully", "partially" and "unweathered") are in accordance with those recommended in CIRIA C570 "Engineering in Mercia Mudstone", 2001 (Ref. 8).

The typical strata sequence encountered at the proposed Mercia EnviRecover energy facility site has been summarised within Table 4.1 with the full borehole and trial pit logs presented within the HCL Factual Report (Ref. 6). The material properties and engineering considerations of the strata encountered are discussed respectively in Sections 5 and 6 of this report and the contamination testing is discussed in Section 7.

Table 4.1: General Sequence of Strata

Stratum	General description of Stratum	Typical Depth Range of Strata (m bgl)
Made Ground – (northern part of the site).	Typically granular material (loose black silty gravelly sand) containing gravel and cobble sized pieces of coal, ash, clinker and brick. This is underlain by soft red sandy gravelly clay (reworked Mercia Mudstone Material?).	GL to <1.0m (Max. 2.0m)
Made Ground – (southern part of the site).	Typically predominantly cohesive material (Soft brown silty cobbly gravelly clay), with gravel and cobbles comprising demolition debris (wall sections), metal (steel mesh and iron bars), ash and brick. GIP investigation also identified asbestos cement board.	GL to 2.7m (Max. 4.3m in GIP investigation of localised 'mound', which also documents 5.5m in a further previous investigation)
Superficial Deposits (localised)	Soft / firm brown/grey silty CLAY, with occasional medium rounded gravel of chert, quartz and sandstone.	1.5 to 2.5 (0.7 – 3.0 in GIP)
Fully weathered Mercia Mudstone (Grade IVb).	Firm to stiff red CLAY.	1.5 to 4.5
Partially Weathered Mercia Mudstone (Grade IVa to Grade II)	Very stiff CLAY becoming very weak MUDSTONE. (recovered as mudstone gravel in some locations).	4.5 to 17.5
Unweathered Mercia Mudstone (Grade I)	Weak to Moderately weak MUDSTONE with medium spaced fractures and localised bands/lenses/pockets of gypsum (Grade I).	>17.5

Two illustrative geological cross sections across the site are shown within Appendix C with the cross section lines orientated in a generally west to east direction. The ground level varies by a maximum of 3m across the site.

As shown on the cross sections, the weathered Mercia Mudstone is encountered at approximately 4.5m bgl across the site, and perched groundwater levels are present within the Made Ground at approximately 1 to 2m bgl.

Superimposed onto these cross sections is an approximate outline of the current proposed area of excavation for the construction of the proposed Energy-from-Waste plant.

4.3 Groundwater

4.3.1 Groundwater Encountered

Groundwater strikes were encountered and recorded during the present ground investigation in the following exploratory holes:

Table 4.2: Groundwater Strikes (present investigation)

Exploratory Hole	Level of Water Strike (mOD)	Comment(s)
BH20	46.16	
BH21	47.96	Possibly perched GW in the Made Ground?
BH22	45.59	
BH23	46.79	Possibly perched GW in the Made Ground?
BH24	47.04	Possibly perched GW in the Made Ground?
BH25	46.02	
BH26	46.03	
TP27	42.84	Seepage
TP28	44.58	Seepage
TP29	44.24	Seepage

Although observations made during the February 2010 site investigation record that groundwater was rarely present during drilling and trial pitting, it is considered that this may be due to the relative low permeability of the majority of the soils and the time periods the excavation sides were left exposed rather than the absence of any perched groundwater or phreatic surface. In the majority of cases, the boreholes were cased through the upper soil horizons, and the trial pits were left open for limited time periods.

In the GIP ground investigation, groundwater was recorded at slightly lower levels in following the exploratory holes:

Table 4.3: Groundwater Strikes (GIP investigation, March 2006)

Exploratory Hole	Level of Water Strike (mOD)	Comment(s)
BH1	43.90	
BH2	43.82	
BH3	43.42	
BH4	43.71	

4.3.2 Groundwater Levels

Groundwater levels on-site have been monitored since the ground investigation was undertaken.

Table 4.4: Groundwater Levels

Borehole	Eastings	Northings	GL (mAOD)	11/02/2010 (mAOD)	24/02/2010 (mAOD)	12/03/2010 (mAOD)
BH20	385957	269904	47.79	_	46.16	45.83
BH21	385913	269856	48.43	_	45.96	44.53
BH22	386000	269796	47.98	45.59	45.63	45.46
BH23	385914	269899	47.61	46.66	46.84	46.55
BH24	386031	269915	47.64	46.75	46.70	46.68
BH25	385961	269806	47.12	45.97	46.18	45.71
BH26	385857	269817	50.04	46.03	46.18	45.89

Rest groundwater levels in the mudstone were recorded between 45.59 and 46.75 mAOD on 11th February 2010. On 24th February 2010, these levels generally seem to have risen slightly to between 45.63 and 46.84 mAOD, but on 12th March 2010 they have dropped again to between 44.53 and 46.68 mAOD. These fluctuations may be linked to periods of rainfall variation.

4.3.3 Groundwater Hydraulics

Confining conditions have been identified at depth. During the drilling of BH20, at depth 15m bgl, an uncased section of the borehole hole collapsed, and continued to do as the borehole was progressed. Consequently, the hole was then further cased to 8.0m bgl, but falling water was audible at the bottom of the borehole (possibly indicating a significant water strike had developed between 8m and 15m depth). At this point, water was introduced into the borehole up to ground level in preparation for conducting a falling head permeability head test. However, once ground level was reached the water continued to rise and overflow the top of the casing (approximately 1m agl), a situation indicative of potential artesian water pressures in a stratum between approximately ~13.0 to 16.0m depth. However, the following morning the water pressure was seen to have equalised at approximately 2.90m bgl (45.09mAOD), suggesting either that the layer and/or zone of material with elevated water pressures is confined and of relatively limited extent and/or that the permeability of the zone is sufficiently low to prevent maintenance of the artesian pressure for any length of time.

None of the other boreholes undertaken on this site to date have encountered similar groundwater conditions to those encountered in BH20, again indicating that the layer and/or zone of material with potential artesian water pressures may be of limited lateral extent possibly a relict buried channel of more granular material within the Mercia Mudstone Formation stratigraphy. Note that this effect is attributed to water pressure which is expected to be fracture controlled and is not water volume; as such water containment in attenuation ponds, etc is not expected to be a major concern during construction.

Notwithstanding that elevated water pressures may only be present in isolated locations, the presence of such localised pressures will have significant consequence on the detailed design of the walls and floor to the deep excavation (in the temporary and permanent works cases). As a result, the detailed design stage ground investigation will need to specifically gather data to ascertain the extent and/or significance of this phenomenon on the construction of the deep excavation,

Given the rest water level elevations, further potential inflow horizons may coincide with depths at which it is noted on the logs that there was 'no recovery' or where the mudstone was noted to be heavily fractured and veined with gypsum.

The measured rest water levels infer a groundwater flow direction from north to south across the site (see note below with regard to BH20).

The hydraulic gradient is calculated to be 0.0098 (11/02/2010) and 0.01 (24/02/2010).

The influence of the geological faulted boundaries to the east and west of the site on groundwater flow is unknown.

4.3.4 Permeability Testing

Rising head permeability tests were conducted in the upper 8m of strata in three of the boreholes. After one hour of monitoring, BH20 showed no rise in water level and BH25 and BH26 had recovered by 33 and 46%, respectively.

The lack of response in BH20 does not reflect the observations made during the drilling of the borehole. Although the water level in the borehole has since risen to 1.63 mbgl, it is assumed that the lack of aquifer structure may have been compensated by the borehole construction. Further it is noted that the measured groundwater level (24/02/2010) is 1.23 m lower than that measured prior to the permeability test (0.4 mbgl). In addition, the observation that the borehole was artesian during drilling, leads to the assumption that the measured groundwater level in the installation is more representative of the phreatic surface in the near-surface (<10mbgl) strata and is not a true reflection of the aquifer conditions that may be encountered at depth in the vicinity of this borehole.

Table 4.5: Permeability Test Results

Borehole	Eastings	Northings	GL (mAOD)	RWL (mbgl)	WL start of test (mbgl)	WL end of test (mbgl)	k (m/d)
BH20	385957	269904	47.79	0.1 magl	15.5	15.5	-
BH25	385961	269806	47.12	1.15	8.20	5.99	0.017
BH26	385857	269817	50.04	3.65	9.00	6.59	0.059

These values are comparable with the range quoted in, 'BGS Engineering geology of British rocks and soils – Mudstones of the Mercia Mudstone Group', of 10^{-1} to 10^{-3} m/d, parallel to bedding and 10^{-3} to 10^{-5} m/d for compacted mudstone.

4.3.5 Groundwater/Surface Water Interaction

The environment agency has a Triassic sandstone numerical model for the area which assumes the River Stour to be in hydraulic continuity with groundwater. The relative elevations of the watertable beneath the site and the culverted stream that runs across the site suggest that hydraulic continuity between surface water and groundwater is possible. In practice this is likely to be limited by the low permeability of the superficial clay and underlying mudstone.

5 GEOTECHNICAL PROPERTIES

5.1 Introduction

A testing programme for soil samples recovered from the exploratory borehole and trial pit locations was scheduled by HCL and carried out by a designated laboratory as specified by document BS1377:1990 "Methods of Tests for Soils for Civil Engineering Purposes" (Ref. 9). The results are included in the factual report provided by HCL (Ref. 6).

5.2 Made Ground

The made ground is spatially variable across the north and south of the site in both composition and depth:

a **North** - Within the northern half of the site, made ground generally comprises a layer of fly ash with gravel of coal to 0.5m bgl underlain by approximately 1.5m of re-worked red clay (re-worked Mercia Mudstone).

b **South** - To the south, the topography is more undulating, this is likely to be due to infilling and discarding of waste across this area of the site. An upper layer of made ground comprises waste items in a matrix of red clay. Waste found during trial pitting include demolition rubble (a section of wall five courses thick), metal containers, metal mesh, concrete and unspecified scrap metal to approximately 1.5m bgl.

Index Properties

Two Atterberg Limit tests have been carried out on the cohesive Made Ground in this investigation, to supplement those undertaken in the previous GIP investigation. The results indicate the cohesive Made Ground to have a Plasticity Index of between 19% and 21%, and therefore to be of intermediate plasticity with a low volume change potential.

5.3 Superficial Deposits

Superficial deposits have been identified on-site in localised areas across much of the site, to typical depths in the present investigation of between 1.50m and 2.5mbgl. In the previous GIP investigation, this stratum was encountered to more variable depths of between 0.70m and 3.0m bgl.

Index Properties

One Atterberg Limit test has been carried out on a sample of this stratum in this ground investigation, to supplement the 7 tests undertaken in GIP the investigation. These tests produced Plasticity Index values of between 26% and 50%, and therefore to be of intermediate to high plasticity with a medium to high volume change potential.

5.4 Weathered (Grade IVb to Grade II) Mercia Mudstone

Fully weathered Mercia Mudstone (Grade IVb) was encountered below the made ground to approximate depths ranging between 1.5 - 4.5m bgl.

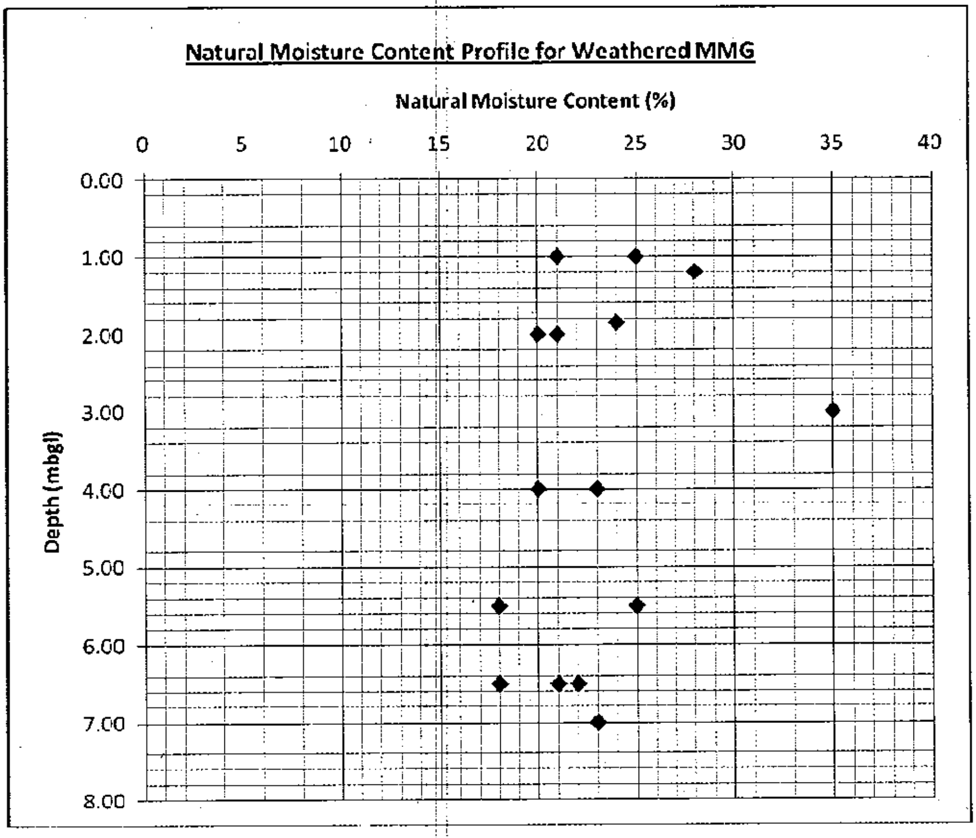
In general, immediately underlying the made ground/superficial deposits this sub-stratum is encountered as soft to firm, red clay that becomes increasingly more firm to stiff with depth.

At approximately 4.5m bgl this sub-stratum becomes a very stiff and fissile material recovered as medium gravel sized lithorelicts of weak mudstone in a clay matrix (weathering Grade III material). The weathering profile within this material is likely to be better defined within the trial pit excavations than the boreholes, because the mass soil structure is more clearly discernable in the trial pit sidewalls.

5.4.1 Index Properties

Natural Moisture Content test results obtained from samples of the fully and partially weathered MMG material are summarised graphically in Figure 5.1.

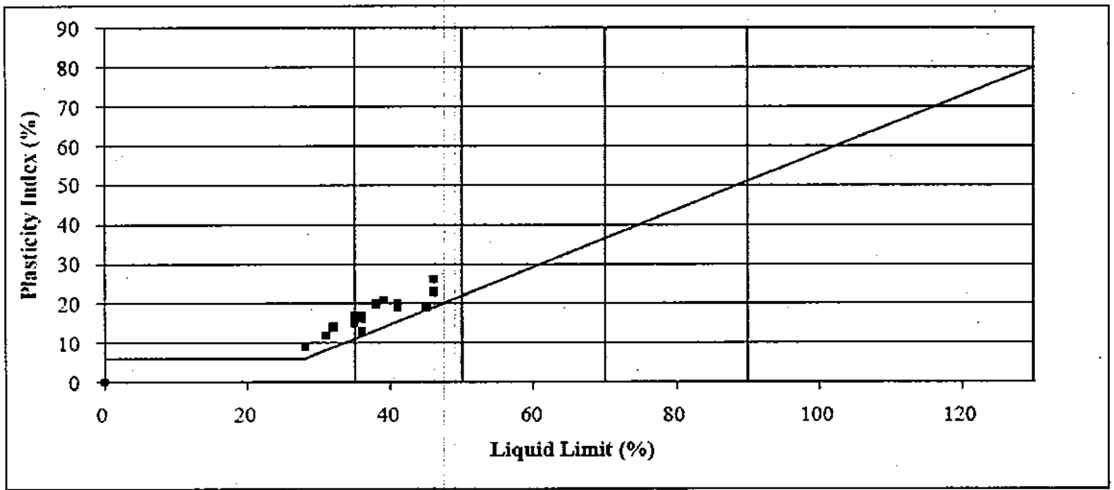
Figure 5.1: Natural Moisture Content Profile for Weathered MMG material



These tests indicate the natural moisture content to generally be in the range 18% to 25%, with isolated samples with slightly elevated moisture content. Although there is clearly appreciable scatter in the results, in general terms it shows a slight gradual reduction in moisture content with depth (progressively less weathering) typical of that provided in table 3.3 of CIRIA C570. However, towards the base of the sub-stratum (in the less weathered material) the moisture contents are slightly high relative to typical values for Grade II-III material given in this reference.

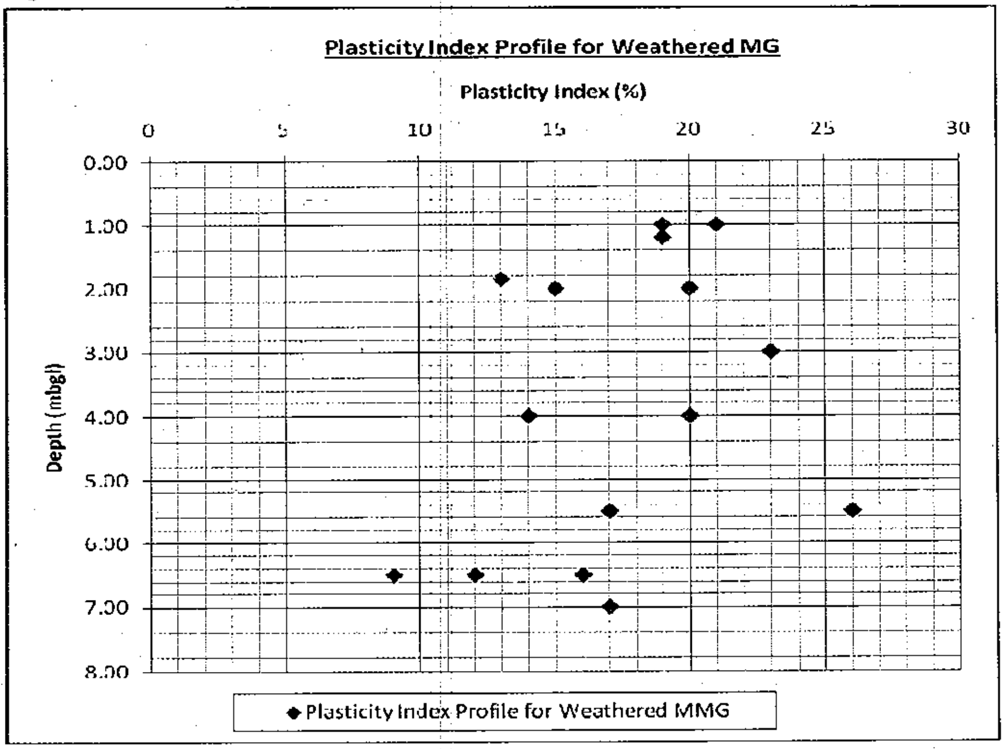
Atterberg Limit test results obtained from samples of the fully and partially weathered MMG material are summarised graphically in Figure 5.2. These tests produced Plasticity Index values of between 9% and 26% (average 17.4%) indicating these soils to be low/intermediate plasticity clay with low to medium volume change potential.

Figure 5.2: Casagrande classification plot for Weathered MMG material



A depth profile of the Plasticity Index values obtained in this sub-stratum is shown graphically as Figure 5.2. Although there is clearly some scatter in the results, in general terms it shows a gradual reduction in plasticity with depth from ≈20% near-surface (1-2m bgl) to 10-15% at greater depth (6-7m bgl). This range of values and trend in line with progressively less weathering is typical of that provided in table 3.3 of CIRIA C570.

Figure 5.3: Plasticity Index Profile for Weathered MMG material



5.4.2 Undrained Shear Strength

Insitu hand shear vane tests carried out in the fully weathered (Grade IVb) Mercia Mudstone to depths of up to 3.7m bgl produced estimated undrained shear strengths of between 39 and 77 kPa.

Figure 5.4 shows a depth profile of 'N' values obtained from insitu Standard Penetration Tests (SPTs) undertaken in both the present and previous (GIP) ground investigations. Tests with 'N' values above 50 have been extrapolated (to a capped value of 100) to provide better definition of the strength of the less weathered (deeper) soils in the strata sequence.

The profile illustrates how the 'N' value increase steady from ≈10 at 2-3m bgl to ≥100 at a depth of approximately 8.0m bgl.

This SPT data has been converted into estimated equivalent undrained shear strength (SU) using a correlation of SU = 5 x N based on section 5.1 of CIRIA C570, and is shown graphically in Figure 5.5. This graph suggests an undrained shear profile rapidly increasing from ≈50kN/m2 at 1.0m bgl to ≈500kN/m2 at 7.0mbgl, with hard clay (SU = 300kN/m2) occurring at about 6.0m bgl. Below 7.0m depth the shear strength continues to increase at a slower rate to ≈1000kN/m^2 at 20.0m bgl.

Figure 5.4: Profile of SPT 'N' Values

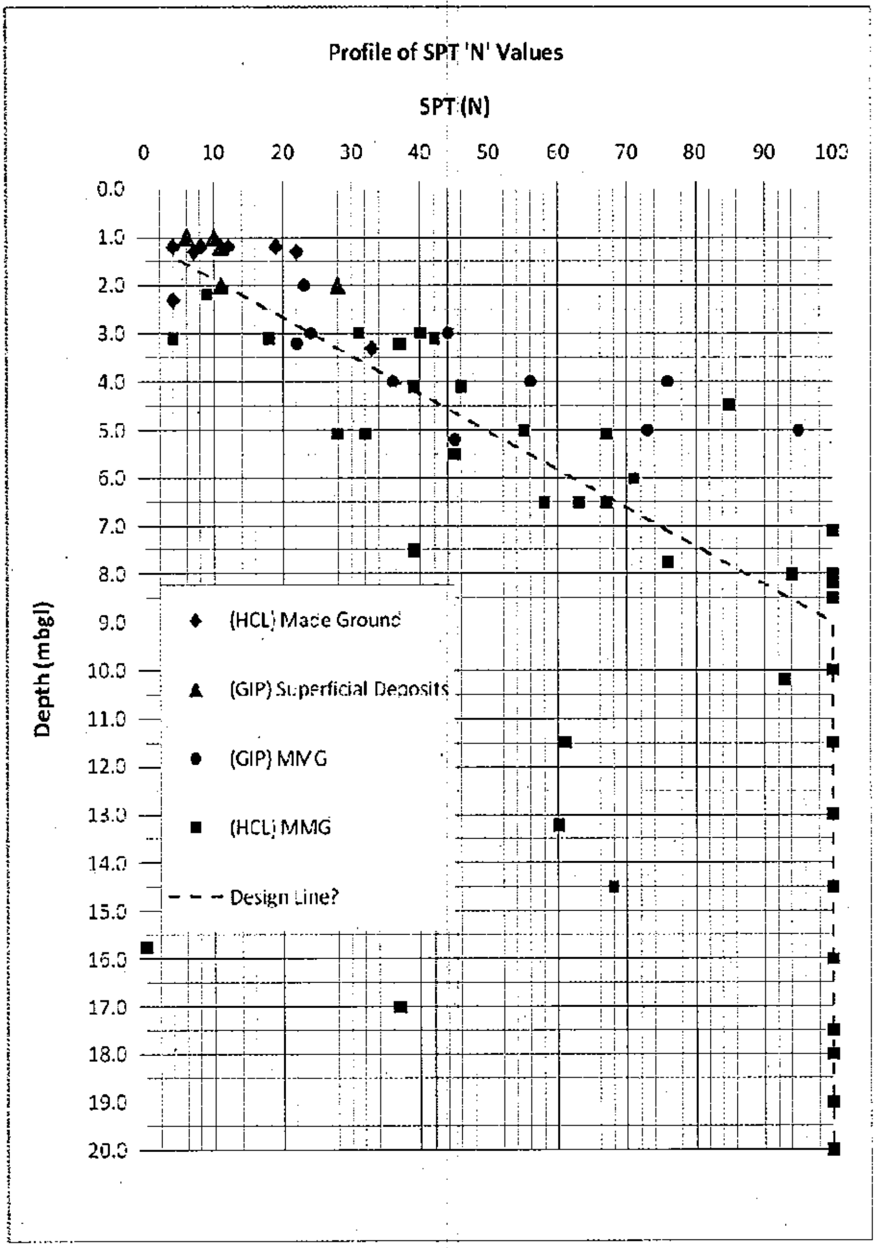
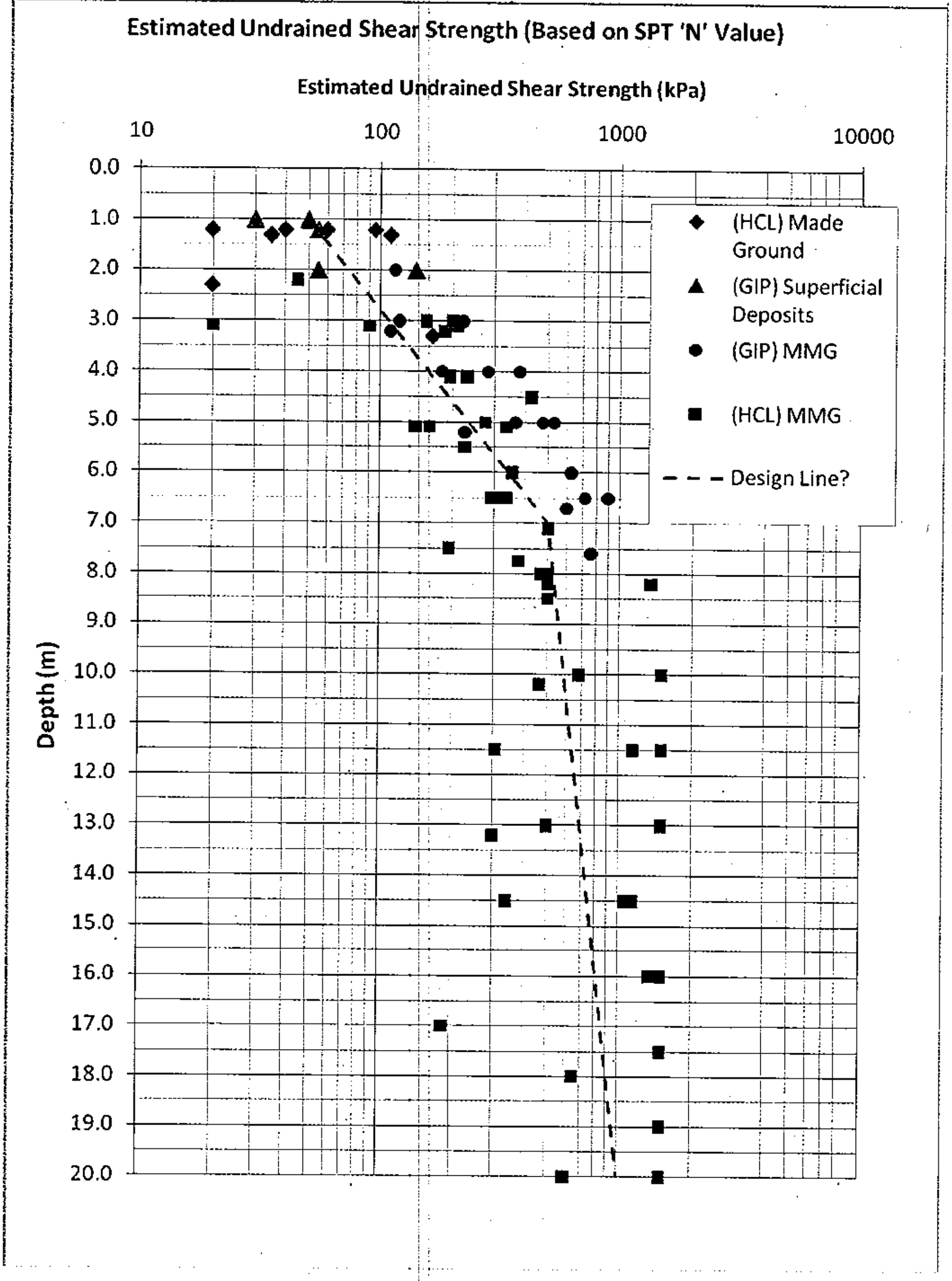


Figure 5.5: Undrained Shear Strength Profile Estimated from SPTs



5.4.3 Drained Shear Strength

Three consolidated undrained triaxial tests performed on these sub-soils produced the following results:

Sample Ref.	Φ' (°)	c' (kN/m²)
BH24 / 4.00m	29	36
BH24 / 6.50m	28	35
BH25 / 4.00m	38	49

Based on published correlations, the Plasticity Index test results suggest φ' value of 28° - 30°, which is in good agreement with two of the triaxial test results and with typical published values for Grade IV MMG material given in Table 7.1 of CIRIA C570.

The high φ' value of 38° obtained from sample ref BH25 at 4.00m is more typical of Grade III material.

Whilst the high c' values obtained in the triaxial tests are indicative peak values for a very stiff heavily-overconsolidated clay, they are very high in relation to the published typical values for this stratum, and significantly lower 'long-term' values are recommended for the design of piles and retaining walls, particularly when the engineering characteristics of the overall soil mass (e.g. blocky mudstone lithorelicts in a clay matrix) will also need to be considered. To this end, it is recommended the following drained shear strength parameters are used for preliminary design:

Weathering Grade.	Φ' (°)	c' (kN/m²)
Grade IV – III	28	20
Grade II	38	25

For detailed design, it is recommended that further appropriate investigation and laboratory testing is undertaken to establish drained shear strength design parameters with more certainty. In particular, consideration could be given to undertaking effective stress testing to establish residual c' values to replicate the lower boundary properties at the interface between mudstone 'blocks' in the soil mass structure.

5.4.4 Consolidation Characteristics

Three samples of Grade IV Mercia Mudstone were tested for one dimensional consolidation properties by Oedometer consolidation.

These tests produced coefficient of volume compressibility (m_v) values over the stress increase range 100 – 200kPa of between 0.18 and 0.30m²/MN. Over the same stress range, they produced coefficient of consolidation (c_V) values of between 1.0 and 1.3 m²/yr.

These coefficient of volume compressibility (m_v) values results are high relative to most very stiff heavily over-consolidated clay soils, and very high compared with the relationship proposed in section 5.2 of CIRIA C570 of $E' = N_{60}$ (MPa).

For example,

Taking E' = 1/ m_v = N_{60}, based on Figure 5.4 SPT 'N' = 35 at 4.00m depth equates to

$m_v = 1/N_{60} = 1/35 \approx 0.03$ (about 1/10th the value of the laboratory derived result)

This discrepancy might be explained by the physical sample disturbance that is known to potentially lead to over-measurement of laboratory compressibility characteristics in Mercia Mudstone material, due to its heavily over-consolidated and bonded nature. Consequently, for outline design it is suggested that the following design parameters are used for estimates of foundation settlement:

Weathering Grade.	m_v (m^2/MN)	Comment(s)
Grade IV	0.2	Based on laboratory test results
Grade II – III	= $1/N_{60}$	Based on correlation in CIRIA C570

5.5 Unweathered (Grade I) Mercia Mudstone

At depth the Mercia Mudstone stratum becomes Grade I unweathered material. Based on visual description of the material recovered in the boreholes, this boundary occurs at approximately 15-17.5m bgl, though this may be affected by physical disturbance of the material by the drilling / sampling process.

Based on the SPT 'N' profile, and CIRIA C570, whereby the distinction between Grade II and I material is approximately at N = 80, the boundary occurs considerably higher at approximately 7-9m bgl (Figure 5.4).

This sub-stratum typically occurs as a very weak becoming weak (locally moderately weak/moderately strong) Mudstone with medium spaced fractures and localised frequent spaced lenses/bands of gypsum.

5.5.1 Undrained Shear Strength

Based on the SPT 'N' profile provided as Figure 5.4, with the exception of a few localised exceptions, the 'N' value in this material is consistently ≥100 below a depth of approximately 8.0mbgl. Converting this into estimated equivalent undrained shear strength (S_U) suggests a profile increasing from ≈525kN/m^2 at 8.0mbgl to ≥1500kN/m^2 at 20.0m bgl (refer Figure 5.5).

These figures equate to a material that is typically very week, but with occasional bands of very weak, weak and moderately weak material.

5.5.2 Drained Shear Strength

Based on the discussion provided in section 5.4, it is recommended the following drained shear strength parameters are used for preliminary design:

Weathering Grade.	Φ' (°)	c' (kN/m^2)
Grade I	38	25

Again, it is recommended that further appropriate investigation and laboratory testing is undertaken to establish drained shear strength design parameters with more certainty for detailed design.

5.5.3 Consolidation Characteristics

Based on the discussion provided in section 5.4, it is recommended the following design parameters are used for estimates of foundation settlement in the outline design:

Weathering Grade.	m_v (m^2/MN)	Comment(s)
Grade I	= 1/N_{60}	Based on correlation in CIRIA C570

6 ENGINEERING CONSIDERATIONS (Structures Outside the Deep Excavation)

6.1 Shallow Foundation Design

The made ground soils across the site are highly variable in both content and engineering characteristics. The data available suggests that they have not been placed to any engineering specification, and therefore in their present condition their bearing capacity and settlement characteristics cannot be relied on. Consequently, they are not considered suitable as a reliable formation material for shallow foundations, and it is recommended all foundations are taken down to at least 300mm into the underlying natural soils.

Based on shallow strip or pad foundations with a formation in the superficial deposits, it is recommended that the following safe net bearing capacities are used for preliminary design:

Table 6.1: Recommended Preliminary Safe Net Bearing Pressures for Shallow Foundations (Superficial Soils)

Foundation Depth (m bgl)	Preliminary Safe Net Bearing Pressure (kN/m^2)			
	1.0m strip	2m x 2m Pad	2m x 2m Pad	3m x 3m Pad
1.0	100	125	115	110
2.0	125	150	145	140
3.0	160	190	185	185

For shallow strip or pad foundations with a formation in the weathered Mercia Mudstone stratum, where the increase in undrained shear strength with depth is greater and more reliable, the following preliminary safe net bearing capacities are appropriate:

Table 6.2: Recommended Preliminary Safe Net Bearing Pressures for Shallow Foundations (Weathered Mercia Mudstone)

Foundation Depth (m bgl)	Presumed Safe Net Bearing Pressure (kN/m^2)			
	1.0m strip	2m x 2m Pad	2m x 2m Pad	3m x 3m Pad
1.0	100	125	115	110
2.0	160	190	185	175
3.0	215	255	245	245

The bearing pressures provided above assume that the acceptable post-construction total and differential settlement does not exceed 25mm and 15mm respectively.

Because the underlying soils are indicated to be high to medium plasticity clays with a high to medium volume change potential, a minimum foundation depth of 0.90m should be adopted to prevent potential problems associated with the seasonal shrinkage and swelling of the clay soils based on NHBC guidelines (including climate zone correction). Across much of the site, however, the thickness of made ground will result in shallow foundations being at greater depth than this minimum requirement.

In the vicinity of existing, proposed or recently removed trees, the minimum foundation depth will need to be increased in accordance with the guidelines given in NHBC Chapter 4.2 'Building Near Trees'. This depth will be a function of the tree species and height and/or mature height depending on whether it has been recently (or is to be) removed or proposed planting.

Related to this recommendation, from the previous GIP report, it is understood that several trees used to be present in the centre of the site, which included high water demand species such as oak and willow. Although these trees were removed some years ago, without further detailed investigation in these areas it is not possible to be certain that the soil moisture content profiles have equalised and that further volume change is no longer a potential problem. Consequently, until further data is available deeper foundations will be needed in these areas in accordance with the NHBC guidelines. In very close proximity to such former trees, this may necessitate the use of a pile or a raft foundation solution, depending on the nature of the structure, the anticipated structural loads and the presence (or absence) of made ground.

As a result of the variable ground conditions, the formation soils should be carefully inspected by a suitable qualified / experienced person to identify the nature of the formation stratum (e.g. whether made ground, superficial soils or weathered Mercia Mudstone) and/or the presence of any soft/loose zones. Any such zones should be over-excavated and replaced with a well-compacted well-graded granular fill or lean mix concrete.

The superficial soils and weathered Mercia Mudstone strata are likely to be very susceptible to softening in the presence of excess water. Consequently, it is crucial to ensure that proposed formations are not exposed to significant and/or prolonged rainfall.

6.2 Piled Foundation Design

For structures imposing loads and/or with settlement tolerances that cannot be accommodated by the shallow foundation recommendations made in section 6.1 above, piled foundations represent the most practicable foundation solution.

Bored, augered or driven piles would be suitable in these soils, though reference should be made to a reputable specialist piling contractor for advice on the most suitable and cost-effective pile solution in these soils, which should include the potential presence of buried large obstructions in the made ground soils.

In deciding the type of pile, consideration should be given to the requirement to dispose of arisings comprising (in part) made ground soils if non-displacement piles (bored/augered) are adopted.

Once the requirement for any structures to have piled foundations has been ascertained, because the engineering characteristics of the Mercia Mudstone stratum can be extremely variable both with depth and laterally, further ground investigation should be undertaken in the location of the specific structure upon the site. This will enable the detailed design of the pile foundation(s) to be optimised.

6.3 Floor Design

Floor design for units (other than the deep excavation area) will be dictated by:

1. The presence of near-surface non-engineered made ground soils, which could result in excessive settlement of ground bearing floors.
2. The presence of high-medium shrinkage clay soils, which could result in potential heave of ground bearing floors.

Consequently, the following recommendations are made at this outline design stage.

a. For structures underlain by made ground, a suspended floor is recommended.

b. For structures not underlain by made ground but located within the zone of influence of existing, proposed or recently removed trees based on NHBC Chapter 4.2, a suspended floor is recommended.

c For structures not underlain by made ground and not located in close proximity to existing, proposed or recently removed trees a ground bearing floor is suitable.

Given the extensive cover of made ground across the site, it is considered that most structures will fall into category (a) above. However, in areas of the site not located in close proximity to existing, proposed or recently removed trees and where the made ground is of limited thickness, it may be economic to excavate out the made ground and re-compacted it to a suitable engineering earthworks specification and then utilise a ground bearing floor.

For larger structures that fall into category (a) or (b) above, where suspended floors are uneconomic, an excavation and re-compaction solution is likely to be the most favourable and cost-effective (depending on how much of the made ground needs improvement treatment to make it suitable for re-compaction). Alternatively, combining a suitable method of ground treatment of the made ground soils (such as vibro-stone or vibro-concrete columns (VSCs/VSCs)) with a ground bearing slab may represent the more economic and lower risk solution.

6.4 Groundwater Considerations

In the ground investigations, groundwater was generally encountered as seepages from within the made ground or just below its interface with the natural soils. Some of these instances may be perched waters within the made ground soils, though some may be in hydraulic continuity with the stream flowing through the site.

Monitoring of the groundwater installations indicates water levels in the range1.0-2.5m below existing ground level (m begl).

On this basis, appropriate provisions for groundwater control should be anticipated in this respect.

6.5 Excavatability

With the exception of localised large pieces of rubble within the made ground soils, excavation of the trial pits using conventional hydraulic excavators was achieved without any difficulty. Therefore, excavation for the construction of shallow foundations etc. should not require specialist ripping plant, though progress below 3.0m will reduce once the stiff/very stiff soils.

7 ENGINEERING CONSIDERATIONS (Deep Excavation Area)

7.1 Foundation Design

For the proposed deep excavation associated with the Energy-from-Waste Plant at a depth of approximately 8m below existing ground level (≈39.8mOD), the investigation data indicates the formation to be in Mercia Mudstone material with an SPT 'N' value ≈80 for which an estimated equivalent undrained shear strength of 500kN/m^2. Based on table 3.3 of CIRIA C570 this places the base of the excavation approximately at the interface between weathering Grade III and Grade II material. As a result, bearing capacity may be limited more by the drained shear strength and settlement characteristics of the underlying soils than undrained shear strength. On this basis, until more detailed data is available on the strain characteristics of the soils at very high stress levels, it is recommended that a safe net bearing pressure of 500kN/m^2 is used for preliminary design as indicated by table 8.2 of CIRIA C570 and table 2.3(b) of Tomlinson (Ref. 10).

Although pronounced variability in the formation soils is less likely at this depth, they should be carefully inspected by a suitable qualified / experienced person to identify the presence of any weaker zones (particularly in areas of anticipated high structural loads). Any such zones should be over-excavated and replaced with lean mix concrete.

The low plasticity of the less weathered Mercia Mudstone stratum soils means they are likely to be very susceptible to softening in the presence of free or standing excess water (even the weak mudstone variants). Consequently, it is crucial to ensure that any excavations for structural foundations are covered without delay (e.g. with blinding concrete) to prevent softening by any water that may enter the excavation.

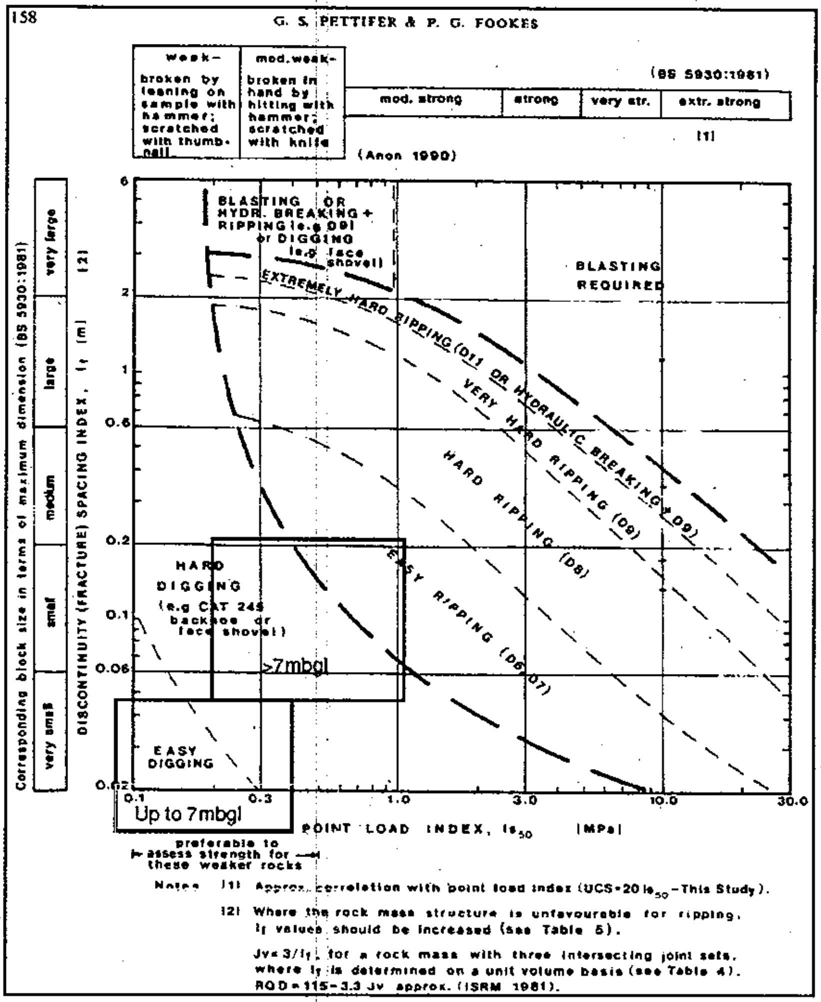
7.2 Excavatability

The proposed floor level of the EnviRecover incinerator will be constructed at a formation level of approximately 8m begl (≈39.8mOD), and is likely to require excavation to depths in excess of 9m begl for construction of the slab structure etc.

From the ground investigation it has been identified that the excavation will be predominantly into material ranging from (typically) firm clay (undrained shear strength of 50kN/m^2) to very week/weak mudstone at 9.0m depth (undrained shear strength varying widely between ≈400kN/m^2 - ≈1600kN/m^2) (refer to figure 5.5).

In general, excavation through these materials should be relatively straight-forward using conventional hydraulic plant (see Figure 7.1 based on the work by Pettifer and Fookes, Ref. 11). However, towards the base of the excavation, plant capable of 'hard digging' may be required, and localised use of plant capable of 'easy ripping' may be required in the more competent bands of harder mudstone and sandstone.

Figure 7.1: Estimate of Material Excavatibility (based on Pettifer and Fookes)



7.3 Excavation Support and Groundwater Control Considerations

7.3.1 General Design Considerations

The cost-effective design of the deep excavation area will require the structural design, overall weatherproofing design, waterproofing design and construction processes to be considered together, because of the close interaction of these crucial design elements. Similarly, strategies for controlling groundwater, soil gases and contaminants need to be considered as early as possible in the planning and design process to ensure project success.

Protection against water ingress from the following sources need to be considered in the basement design:

a. inflow of surface water (e.g. rainfall, surface water runoff, burst adjacent water main);

b. water pressures acting on the external retaining wall system (lateral groundwater pressures);

c. water pressures below the base slab (hydrostatic uplift pressures).

For each of these cases, the water-resisting design needs to provide sufficient protection against a pre-determined head and/or volume of water.

7.3.2 Waterproofing Protection

Waterproofing protection of a basement construction typically utilises one or a combination of the following types of protection measure:

a. Type A (barrier) protection;

b. Type B (structurally integral) protection;

c. Type C (drained) protection.

The decision on the best type of protection (or combination of protections) needs to consider the following:

1. The category of basement involved;
2. The water table classification and required performance level required;
3. Any need for combined protection;
4. The need (or otherwise) for continuity in the protection;
5. Practicality of construction;
6. Cost.
7. Risks to construction programme.

Basement Category

Given that the excavation will comprise an excavation approximately 8-9m deep and be subject to hydrostatic pressures, it should be categorised as 'deep' based on CIRIA Report 140 (Ref. 22).

Water Table Classification

Based on Table 1 of BS 8102 : 2009, the water table classification is 'high' because the water table (or perched water table) is assessed to be permanently above the underside of the base slab.

On this basis a Type 'A', 'B' or 'C' waterproofing protection system is acceptable provided:

a. A Type 'A' (barrier) protection system (only) utilises an appropriate cementitious multi-coated render (or cementitious coatings) are used and the wall is of concrete to BS EN 1992.

b. A Type 'B' (structurally integral) protection system (only) utilises either a reinforced concrete wall to BS EN 1992, or a piled wall that:

   (i) is directly accessible for repair and maintenance from inside the structure; or

   (ii) is combined with a fully-bonded waterproofing barrier (i.e. Type 'A' protection); of

   (iii) is faced internally with a concrete wall to BS EN 1992.

Performance level Required

Based on Table 2 of BS 8102 : 2009, it is anticipated that the proposed structure for this development falls into 'Grade 2' that requires a performance level whereby no water penetration is acceptable but damp areas are tolerable and ventilation might be required.

This basement grade approximates to the former Grade 2 'better utility' protection of BS 8102 : 1990, with typical usage as a workshop, plant room or storage area.

Type 'A': Tanking Protection

Type 'A' protection is designed to provide a continuous barrier system which excludes water and/or water vapour and may exclude gases. Its reliability is reliant on the formation or adequate joints (where sheet systems are used), the prevention of damage during construction and achieving a satisfactory bond to the substrate.

Generally, the main structure to be 'tanked' needs to be monolithic with a minimum of movement (especially transverse) at joints. Consequently, for large deep basements with a permanent hydrostatic head (such as this development), tanking is only practicable if combined with a reinforced box construction (except where walls are cast onto sheet piling), which limits the options with respect to temporary works excavation stability with potential consequences to construction cost and/or programme. As result, such basements would normally be designed to resist water penetration (Type 'B' protection).

Type 'B': Structurally Integral Protection

Type 'B' protection relies on the ability of the structure, by itself, to minimise water penetration. As a result, where practicable these basements are usually constructed as a reinforced concrete box designed to resist hydrostatic pressure (and other loadings).

Because the level of protection with this option relies on the design and construction of high-quality concrete (with cracking controlled to prevent the penetration of moisture to an acceptable degree), the degree of water (and vapour) resistance achievable generally increases with construction costs. In practice, complete (or a high-level of) environment control cannot be guaranteed using Type 'B' protection alone using any retaining construction method.

In general, retaining solutions with a large number of joint interfaces (e.g. piled walls) are more likely to result in water penetration, and in such circumstances it may be more practical to accept some water penetration and design a system of combined protection incorporating a Type 'A' (barrier) protection (e.g. internal RC lining wall) and/or Type 'C' precautions..

Options for various retaining solutions are discussed further in section 7.3.3 below.

Type 'C': Drained Cavity Protection

Type 'C' protection involves the incorporation of drained cavities to the structural walls and/or floor to collect any moisture that penetrates and discharge it to a sump. Consequently, the inner wall to drained cavities is generally non-load bearing and may need to be designed to be free-standing. The cavity should not be used to conceal large leaks.

Cavities under floors can be formed using no-fines concrete (if the seepage inflow is relatively slight) or proprietary systems (e.g. profiled drainage sheets).

Based on CIRIA Report 139 (Ref. 21), the principal advantages of drained protection are:

- Less dependent on primary construction processes, which may be more difficult to control, and hence this protection system may be more reliable in achieving the required environment.
- Installation may be undertaken in more favourable conditions outside the construction programme critical path.
- Water ingress through the primary structure may be checked and remedied before final installation of the inner wall.

- The principal disadvantages are:
- Reduction in useable floor area.
- Pumps will need to be installed to remove accumulated water.
- If the outer skin is of masonry or plain concrete, under a high hydrostatic pressure (which may be the case with this development), water may penetrate in excessive quantities which may not be efficiently drained.
- Access to the external wall for repair is prevented after the inner wall has been built.
- Long-term costs operation and maintenance costs (e.g. pumps, cleaning of cavities).

7.3.3 Basement Perimeter Wall Construction Options

There are a number of options available to form the basement perimeter walls to form Type 'B; protection and range from temporary support methods, which allow 'traditional' construction techniques to be adopted (e.g. monolithic R.C. box structure), to wall types that can be used for temporary and/or permanent works. Methods of basement construction that can be incorporated into the permanent works, using reinforced concrete, include:

- Steel sheet pile wall
- Contiguous bore pile wall.
- Secant pile wall
- Hard/soft pile wall
- Diaphragm wall.

The considerations for each of these methods is summarised as table 3.4 of CIRIA Report 139 and IStructE report on the Design and Construction of Deep Basements (2004), and is condensed in tables 7.1 to 7.3 below.

Table 7.1: Suitability of various wall types to form a water-retaining barrier.

Stabilisation/ Wall Type	Suitability as a Water-Retaining Barrier	
	Temporary Works Condition	Permanent Works Condition
King Post Wall	Not suitable	Not suitable
Sheet Piled Wall	Suitable[1]	Suitable[2]
Contiguous Piled Wall	Not suitable	Not suitable
Secant Piled Wall		
Hard / Soft	Suitable	Not usually suitable
Hard / Firm	Suitable	Suitable[2]
Hard / Hard	Suitable	Suitable[2]
Diaphragm Wall	Suitable	Suitable[2]

Notes:

(1) Some form of seal between sheets may be required depending on water pressures encountered. Potential de-clutching in coarse-grained soils may affect performance.

(2) Structural facing and/or drained cavities should also be provided for high-grade substructures/basements.

Table 7.2: Wall types for temporary and permanent soil support in basement construction.

Wall Construction (and brief description)	Temporary/ Permanent Support	Typical Wall depth	Typical Retained Height	Groundwater Control	Advantages	Disadvantages	Remarks
Steel Sheet Piling (can be used in combination with steel tubular piles to form combi-wall if increased flexural strength is required)	Temporary or permanent Support	10 to 15m (but very dependent on driveability) Max pile length 30m	8 to 12m as single propped wall	Wall can be designed to form a barrier to water	Can provide an economic solution. If used in the temporary case, sheet piles could be re used on completion.	Vibration and noise. Risk of declutching by obstructions. Considered very unlikely that sufficient embedment could be achieved	Large embedment will be required for sheet piles to resist retained soil and water levels. **The ability to achieve this embedment within the bedrock remains a significant risk item**
Contiguous R.C. piles (closely spaced bored in-situ concrete piles installed by Continuous Flight Auger (CFA)	Temporary and permanent support	12 to 20m	6 to 15m, propped or anchored	Not a water resistant wall. Additional groundwater control measures required in the temporary and permanent case such as facing with a reinforced concrete wall.	Economic when installed using CFA equipment. Minimal noise and vibration.	May not be appropriate where free groundwater flow is present. Additional thickness of overall wall construction to achieve water-exclusion must be considered when considering available area.	Unlikely to provide an appropriate solution for this basement structure in the permanent case due to the presence of free draining water from fissures in the mudstone.
Secant R.C. Piles. Hard/soft or Hard/firm secant (formed by installing over-lapping concrete piles. Male piles cut through the female pairs to form a solid wall)	Temporary and permanent support	12 to 20m propped or anchored	6 to 15m	Only water resistant in the short term unless stronger mixes of concrete are used for female piles	Favourable option in granular or water bearing soils where contiguous piles are unsatisfactory.	Limited durability unless a stronger mix of concrete is used for female piles.	Recommended as an option (for temporary and permanent support) further consideration. Assessment of durability required.
Diaphragm Wall (slurry-supported trench operations filled with tremied concrete)	Permanent (if temporary, will be left in place)	15 to 30m	12 to 25, propped or anchored	Water retaining	Wall surface may serve as the final finished surface. Water retaining	Minimum job size influenced by large mobilisation and demobilisation costs. Solution is appropriate for variable soil conditions.	Recommended as an option (for temporary and permanent support) further consideration. Assessment of durability required.

Table 7.3: Considerations of various basement construction types.

Construction Type	Construction Method	Floors	Walls	Resistance to water / Vapour Penetration		Comment(s)
				Primary	Secondary	
R.C. Box	Open Excavation	Monolithic	Integral	Low permeability concrete	Type 'A': External membrane	
R.C. Box	Temporary steel sheet piling	Monolithic	Integral	Low permeability concrete	Type 'C': Drained protection	Large embedment will be required for sheet piles to resist retained soil and water levels.
Steel sheet piling	Excavate after installation	Become struts	Concrete facing	Weld joints	Type 'C': Drained protection	**The ability to achieve this embedment within the bedrock remains a significant risk item**
Contiguous piles	Excavate after installation	Become struts	Substantial facing	Substantial facing	Type 'C': Drained protection	
Secant piles	Excavate after installation	Become struts	Facing	Facing	Type 'C': Drained protection	
Diaphragm wall	Excavate after installation	Become struts	As cast or faced	Low permeability concrete	Type 'C': Drained protection	

As may be apparent from table 7.2 and 7.3 above, a decision whether to rely entirely upon structurally integral (Type B) protection is crucial to the design and cost-effective construction of the basement.

Requirements for Deep Excavation Support (Temporary and Permanent Works)

In general, excavations in unweathered (Grade I) Mercia Mudstone give few stability problems when dry (though normal supports for excavations need to be provided or the side battered to a safe slope). However, CIRIA C570 states that "difficulties can occur when ground water inflows are allowed to soften the mudstone" and "a good knowledge of the ground water regime is thus essential before starting to excavate."

Excavation in the more weathered materials (Grades II – IVb) presents even more difficulties, when seepages from more sandy horizons can create internal erosion and potential failure of unsupported faces in excavations.

Vertical excavations will not remain stable for any length of time, and some form of support will need to be provided in the Temporary Works and Permanent Works situations. Therefore, excavation faces in these soils will need to be either battered back to a gradient that has adequate stability during the construction phase or supported by some form of retaining solution.

Given the high ground water levels present at this site (circa 1.0-2.5m begl) it is crucial that any stability support considerations incorporates appropriate ground water control systems to maintain adequate support in the short-term (Temporary Works condition) and the long-term (Permanent Works condition).

Monolithic Box Construction

This option involves structurally integral reinforced (or possibly pre-stressed) concrete floors and walls within open excavation or some form of appropriate temporary support mechanism. At this site, temporary works options could include:

- Open cut excavation
- Steepened slope open cut excavation.
- Contiguous piles

Whilst ordinarily steel sheet piles would also be considered suitable for temporary works support, given the large embedment likely to be required for the sheet piles to resist retained soil and water levels (even if appropriately strutted/anchored), the ability to achieve this embedment within the bedrock remains a significant risk item.

As discussed above (and tables 7.1 to 7.3) each of these options will require some additional form of groundwater control in the temporary works case, to maintain stability and/or facilitate construction. Temporary works support using secant piles or diaphragm wall would also be suitable (and could be constructed to provide sufficient groundwater control), though it is more likely that the cost-effective solution in these instances is to use the wall as the Type 'B' groundwater control mechanism in the Permanent Works case also.

Open cut excavation is applicable where the site has room to accommodate a safe soil batter (which is a function of the soil strength, groundwater conditions and appropriate analysis/risk assessment of the consequences of slope failure). A de-watering system will be required to depress the groundwater levels during construction period.

A reduced plan area of excavation could be achieved by increasing the inclination of the open cut excavation by using crib walls, gabion walls or soil nails/anchors. Whilst at first glance this option may appear expensive, given the depth of excavation required for this project, it may prove cost-effective relative to the requirements to provide lateral support to a vertical excavation method.

For this proposed development, given the relatively high groundwater level, the additional groundwater control measures and/or excavation volume is likely to make this option less cost-effective.

Steel Sheet Pile Wall

Steel Sheet Pile walling involves a series of interlocked steel sheet panels driven into the ground to provide structural support and (if required) a groundwater cut-off to the excavation.

The depth of excavation for this proposed development will be too high for a sheet pile wall to work in pure cantilever, and some form of additional lateral support will be necessary. This could take the form of temporary struts with waling beams, temporary/permanent anchors with waling beams, or temporary soil berms on the inside of the excavation.

Lateral groundwater control (both temporary and permanent) could be achieved by welding the joints between sheets, though in the permanent works condition the incorporation of an inner low-permeability concrete wall and/or Type 'C' drainage protection.

For this proposed development, even allowing for appropriate struts / anchors to reduce the necessary toe embedment required to achieve adequate wall stability, based on the SPT 'N' profile (figure 5.4) it is doubtful that the sheets can be driven to sufficient depth for this retention option to work, though it would be prudent to discuss this with a reputable specialist contractor prior to detailed design.

Contiguous Pile Wall

Contiguous piled walling involves a series of closely spaced bored in-situ concrete piles (installed by auger or continuous flight auger (cfa)). It tends to be used in clay soils where free-groundwater is limited.

By its very nature, this form of construction does not exclude groundwater inflow into the excavation and therefore:

- In the Temporary Works condition, additional groundwater control measures will be necessary and/or the gaps between piles plugged with in-situ concrete or jet grouting.
- In the Permanent Works condition, a substantial facing (e.g. Type 'B' R.C. wall) and/or drainage protection (Type 'C') will be required.

For this proposed development, the relatively high groundwater level, additional groundwater control measures and/or space required to accommodate an inner R.C. wall is likely to make this option less cost-effective.

Secant Pile Wall

Secant piled walls replace the requirement for 'structural' internal walls by installing augered and cased (or cfa) piles that are over-lapped to form a line of intermarried piles with a good structural bond. True secant walling (oscillator-formed piles) is accepted as a reasonable alternative to diaphragm walling in terms of forming a 'watertight' barrier, whilst pseudo-secant piled walls are not considered to be so effective.

The initial (female) piles may be concreted with 'normal' mix concrete (to form a hard-hard secant wall) or with a weaker grade concrete allowing the later (male) piles to cut into the female piles with less effort (hard-soft secant wall) thereby creating less deformation and potentially a more watertight interlock. Walls with an intermediate strength female pile component are also used (hard-firm secant).

Secant piles are usually preferred in granular water-bearing soils, which may be present in localised discrete horizons in this proposed excavation.

Hard-soft secant pile walls, installed by cfa rigs, often provide a competitive solution for temporary and permanent soil retention in water-bearing free-draining soils, though the cost and time required to install guide walls for secant pile installation should also be taken into account.

Secant pile walls can either be constructed in pure cantilever or, if required, incorporating lateral support in the form of (temporary or permanent) struts / anchorages or temporary soil berms to reduce the internal steel reinforcement and/or the toe embedment depth.

Diaphragm Wall

Diaphragm walls involve the use of a slurry-supported trench filled with tremied concrete to provide a wall for both temporary and permanent soil retention. They are well-suited to situations that require large-dimension wall sections and are appropriate for permeable and impermeable soils. Care needs to be taken in detailing the interlock between diaphragm panels, and with the implications of wall construction tolerances.

Diaphragm walls can either be constructed in pure cantilever or, if required, incorporating lateral support in the form of (temporary or permanent) struts / anchorages or temporary soil berms to reduce the internal steel reinforcement and/or the toe embedment depth.

Recommendation(s)

- Based on the preliminary data available, it is considered that the most practicable solution to the basement perimeter wall construction is either a secant pile or a diaphragm wall. Both these form of wall will provide support in the temporary and permanent stages, with a reasonable level of Type 'B' water-exclusion.
- Depending on more detailed groundwater analysis, consideration will need to be given to the incorporation of appropriate Type 'C' drainage protection measures into the design, though this carries long-term disadvantages as detailed in 7.3.2.
- Depending on the design detailing, if required, consideration could be given to incorporating lateral support to the retaining wall in the form of (temporary or permanent) struts / anchorages or temporary soil berms to reduce the internal steel reinforcement and/or the toe embedment depth.

- An alternative proposal would be the adoption of a monolithic box construction. This would enable Type 'A' barrier protection to be incorporated into the design thereby negating the long-term disadvantages of a Type 'C' drainage protection system. However, it would require more elaborate and expensive groundwater control measures particularly in the temporary works condition if constructed in open cut. As discussed below, the most effective groundwater measures may represent some form of cut-off wall (e.g. diaphragm wall).
- Given that the costs of excavation and construction to the proposed depth are likely to be considerable (whichever construction methodology is utilised), an alternative proposal would be to reduce the depth of excavation required (if possible) by selecting alternative plant for the energy recovery processing.

7.3.4 Groundwater Control Considerations

As detailed above, an understanding of the groundwater regime is crucial to cost-effective design of the proposed construction of both the temporary and permanent works.

The preliminary ground investigation has identified a groundwater table varying between ≈44.5mOD and ≈46.8mOD (average ≈46.0mOD), with a slight hydraulic gradient from north to south across the site. In general, groundwater strikes occurred as discrete seepages from the made ground soils (possibly perched groundwater) and seepages/inflows through fissures in the weathered Mercia Mudstone stratum.

In addition to the above data, as discussed in section 4.3 'Groundwater Hydraulics', BH20 encountered potential confined groundwater conditions with potential artesian water pressures at a depth of approximately ~13.0 to 16.0m bgl (≈34.8-31.8mOD).

Groundwater will influence the design and construction of the basement and its excavation in the following ways:

- Increased lateral forces on any excavation retaining walls.
- Increased instability of any open cut excavation(s).
- Requirements for groundwater exclusion / control in the permanent works (as discussed above).
- Requirements to prevent heave of the excavation (temporary works) and/or floor slab (permanent works).

On the basis of the existing groundwater data, assuming an excavation depth of ≈9.0mbegl (38.8mOD), in the absence of any de-watering measures the walls to the basement excavation may have to withstand ≈8-9m head of water and the floor slab a hydraulic uplift pressure of ≈90kN/m^2. Based on the highest artesian pressure measure to date in BH20 of ≈48.7mOD, this equates to an hydraulic uplift pressure of ≈139kN/m2 at 34.8mOD below the base of the excavation with ≈4m of overburden (≈80kN/m^2) in the temporary works condition and 104kN/m^2 in the permanent works condition (assuming 1.om thickness slab and no plant loadings).

Therefore, on the basis of the existing groundwater data and present proposed excavation depth, the excavation for and construction of the floor slab needs to accommodate either some form of groundwater de-watering measures and/or structural measures to prevent hydraulic uplift (heave) in the temporary and permanent works conditions.

Pumping From Sumps

Whilst pumping from sumps is the most widely used form of groundwater control, in the context of this site with deep excavation combined with high head of water its use to control groundwater to facilitate open cut or contiguous piled wall excavation may only result in internal erosion and potential failure of unsupported faces / sections in excavations.

The greatest depth to which the water table may be lowered using this technique is generally about 6m, so the existing proposed excavation will require staged lowering of the pumping level and/or submersible deep-well pumping.

Pumping from sumps will also provide only limited contribution to alleviate hydraulic uplift pressures at the base of the excavation.

On its own pumping from sumps is unlikely to comprise an adequate form of groundwater control for the deep excavation though, as discussed below, it can be of use if combined with other forms of control (e.g. partial cut-off).

Well-pointing

Well-pointing involves lowering the groundwater table by installing a number of filter wells outside the excavation. It has the advantage that water is drawn away from the excavation face, thus increasing the stability of the sides and (potentially) permitting open cut excavation. However, unless also installed at a level below the base of the excavation this technique will provide little contribution to alleviate hydraulic uplift pressures at the base of the excavation due to any underlying zones of (sub-)artesian water pressure.

This methodology is also most effective in granular soils with moderate permeability, and is therefore unlikely to be particularly effective in the relatively impermeable cohesive soils underlying this site, where water ingress into the excavation is likely to be predominantly via fissures than mass (primary) permeability.

Creation of a cut-off

The adoption of a seepage cut-off around the perimeter of the excavation is likely to be feasible to control groundwater pressures beneath the excavation in the temporary works condition, particularly if combined with groundwater pressure relief / drainage wells on the inside of the excavation.

Because it will probably enable groundwater to be controlled within the limits of the excavation, the creation of a cut-off has other benefits when combined with some other form of de-watering:

- It will limit the extent of any potential drawdown effects on adjacent structures/vegetation beyond the excavation.
- Pumping volumes (and hence costs) may be considerably reduced (though the economics of this needs to be balanced against the costs of extra cut-off walling).

However, because the existing data suggest it will be difficult to create a total rather than a partial cut-off in the underlying strata, a cut-off solution on its own will not reduce potential hydraulic uplift pressures on the floor slab in the permanent condition unless combined with long-term groundwater pressure relief / drainage wells.

The creation of a cut-off lends itself to a diaphragm wall or secant piled wall form of construction solution.

Pressure Relief Wells

Given the relative low permeability of the underlying soils (even the localised potential artesian layer encountered in BH20), the installation of pressure relief wells probably represents the simplest and most cost-effective way of controlling the risk of heave of the base of the excavation due to hydraulic uplift. They comprise a series of boreholes (or trenches) filled with gravel constructed into the base of the excavation. These are then connected to a layer of coarse gravel at formation level, allowing water flowing up the wells to escape to a pumping sump.

The flow, and therefore the pressure relief, must be maintained while casting the base slab and until an appropriate solution to problem of basal heave in the permanent works condition is completed. Alternatively, they can be incorporated into the permanent works design of the basal slab to control hydraulic uplift and form part of the Type 'C' drainage protection measures.

Ground Freezing

Ground freezing may represent a potential method to control groundwater inflow during the construction phase. However, not only is it an extremely expensive form of ground treatment but it may also cause considerable heave in the near-surface silty clay soils, which may have a significant effect on the design of the adjacent structures.

Drilling and Grouting

The method involves drilling a series of holes around the perimeter (and base) of the excavation and infilling them with liquid grout under pressure. The grout permeates into the fissures/fractures in the soil/rock in the vicinity of the drillhole, thereby reducing the permeability of the ground. By undertaking this form of ground treatment in a series of rows around the excavation (eg 2 rows of primary holes, followed by a set of intermediary secondary and possibly even tertiary holes) it is possible to create a near-impermeable grout curtain around the entire excavation. The depth of this curtain could also be extended below the depth of the excavation to reduce potential groundwater inflow from the base.

This methodology is also most effective in high permeability granular soils or fractured rock formations, and is therefore unlikely to be particularly effective in the relatively impermeable cohesive soils underlying this site, where water ingress into the excavation is likely to be predominantly via fissures than mass (primary) permeability.

Recommendation(s)

- At present the data available on the groundwater regime beneath the site is only preliminary. Clearly, there are aspects that potentially will have very significant implications on the cost of the design and construction of the proposals to limit risks to an accepted level. Consequently, as part of the ground investigation to provide data for detailed design, it is imperative that sufficient instrumentation and monitoring of the groundwater regime is undertaken to provide data for economic and safe construction. It is anticipated that this will include the installation of vibrating wire piezometers at discrete levels around the proposed structure, linked to datalogger systems to enable any fluctuations in groundwater levels and artesian water pressures to be ascertained.
- Based on the preliminary data available, it is considered that the most practicable solution to the control of groundwater in the temporary works condition is a partial cut-off wall (which can form the permanent basement perimeter wall) combined with basal pressure relief wells.

- This combination has the advantage that the pressure relief wells may be incorporated into the permanent works design of the basal slab to control hydraulic uplift and form part of the Type 'C' drainage protection measures.
- As part of the recommendation made in section 7.3.3, it is clear that the costs of excavation, construction and de-watering of the excavation are likely to be considerable. Consequently, it may be economic to consider an alternative proposal that involves a reduced the depth of excavation (if possible) by selecting alternative plant for the energy recovery processing.

7.3.5 Basal Slab Design

As discussed above, the design of the basal slab needs to be designed taking cognisance of the potentially very high long-term hydraulic pressures to prevent the risk of catastrophic heave which might then lead to failure of the surrounding retaining walls.

In the absence of any groundwater control measures, based on preliminary data available to date, these pressures could be of the order of $90kN/m^2$ at the proposed formation level.

The magnitude of these forces, and the geometry of the proposed basement structure, means it is very unlikely that these forces can be accommodated by shear resistance on the side walls.

Whilst it would be possible to withstand the uplift pressures by anchoring the basal slab via anchorages and/or tension piles constructed on a grid basis, given the magnitude of the uplift forces it is likely that the basal slab will need considerable reinforcement to span between each anchorage point.

Based on the highest water pressures measured to date, in the absence of any groundwater control measures, to prevent hydraulic uplift by mass of basal slab alone (i.e. excluding any plant loads), would require a formation level of ≈32.8mOD (i.e. a 7m thick slab) which is very unlikely to be cost-effective.

At this stage, therefore, it is recommended that outline design of the permanent works solution comprises a combination of:

- Basal pressure relief wells.
- Thickened basal slab.
- (if required) supplementary ground anchorages and/or tension piles.

Clearly, to enable cost-effective and safe detailed design of these elements it is crucial that further appropriate ground investigation is undertaken to gain more detailed understanding of the groundwater regime beneath this site.

8 OTHER CONSIDERATIONS

8.1 Re-Use Of Excavated Materials

If the re-use of site won material is proposed, either on-site or for other purposes off-site, it is important that the various stratum groups are appropriately segregated (particularly the made ground) to prevent the risk of cross contamination

Furthermore the fully weathered/partially weathered Mercia Mudstone and unweathered Mercia Mudstone should remain segregated to allow for separate re-use strategies. If they are mixed then the material may be rendered unsuitable for particular end-uses.

Stockpiling and storage of the excavated topsoil, superficial deposits and weathered bedrock will be required in order that these may be re-used. The stockpile should be sealed to prevent rainfall infiltration into the material and preventative measures for control of excavated material and suspended solids from entering any water courses must also be considered. These measures may include temporary drainage ditches, stockpile sheets, geo-textile wrap, straw bales and silt traps.

Preliminary test results indicate that the fully weathered/partially weathered Mercia Mudstone will be suitable for re-use as Class 2 general fill in accordance with the Specification for Highway Works Series 600 Earthworks criterion (Class 2A/2B/2C depending on stone content and/or moisture content). It is anticipated the majority of these materials will fall into Class 2B dry cohesive, and very stiff/hard clay material excavated from deeper levels may need to be improved by the addition of water (via spray irrigation) to soften them sufficiently to facilitate adequate re-compaction.

Superficial Deposits and near-surface weathered Mercia Mudstone material may be too soft (wet) in its 'as-excavated' condition to be suitable for re-compaction as engineered fill. Preliminary laboratory tests undertaken in the GIP investigation indicates that these soils may be improved by the addition of lime (or cement) to render them suitable for re-use as engineered earthworks materials, though it is recommended additional testing be undertaken at the detailed design stage to further clarify this issue.

Unweathered Mercia Mudstone material is likely to be suitable for re-use as either Class 2C (stony cohesive) or Class 1 (general granular) fill depending on the strength of the rock and its response to crushing by compaction plant.

The relatively low plasticity of the Mercia Mudstone stratum soils means they are likely to be very susceptible to softening in the presence of free or standing excess water (even the weak mudstone variants). Consequently, it is crucial to ensure that any excavations are kept free of ponding water (if at all possible) and that excavation for material proposed for re-use as engineered materials is not undertaken during periods of prolonged and/or heavy rainfall.

Based on a very approximate estimate from the preliminary ground investigation data available, approximately 20-25% of the material likely to be excavated from the basement area will comprise made ground soils.

Preliminary laboratory tests undertaken in the GIP investigation indicates that the cohesive made ground soils would be suitable for re-use as general cohesive fill, though again material that is too soft (wet) in its 'as-excavated' condition may be improved by the addition of lime (or cement) to render them suitable for re-compaction. Testing on samples of granular made ground indicated it to be suitable for re-use as Class 1 general granular fill. All of the made ground soils will need to be carefully screened to remove unsuitable inclusions (e.g. timber, concrete blocks, textile, metal) that will prohibit adequate re-compaction.

The chemical test results indicate that the vast majority of the made ground soils are likely to be suitable for re-use as engineering or landscape fill material, with the exception of one sample that provided unacceptably high levels of lead content. Consequently, as part of the ground investigation for detailed design, it is recommended that additional testing of samples be undertaken in this area to further delimit the extent of this contamination.

None of the soils likely to be won from site are likely to be suitable for re-use as selected (Class 6) fill material.

It is understood that enquiries have been made by Mercia Waste Management to companies to make use of the excavated natural materials for specialist re-use as brick manufacture and/or landfill site capping materials. Some samples were provided for specialist testing by the brick manufacturer company though at the time of writing this report we have received no feedback in the suitability or otherwise of the soils in this regard.

8.2 Protection of Buried Concrete

In accordance with BRE Special Digest SD1 (Ref. 12), sulphate content and pH value testing was carried out on selected soil samples between 0-8m bgl.

The test results lie within the limit of Sulphate Design Class DS-1, as defined within the BRE guidelines. The minimum pH value is 7.77 and the maximum sulphate value is 50 mg/l. The groundwater regime is considered as static between 1-8m bgl, therefore an Aggressive Chemical Environment for Concrete (ACEC) classification of AC-1s is considered appropriate.

8.3 Road Pavement Design Considerations

Five in-situ California Bearing Ratio (CBR) Tests were carried out on near-surface soils within the GIP ground investigation, on made ground (granular and cohesive) and cohesive natural soils. These tests produced CBR values of between 3.1% and 4.4%, indicative of cohesive soils with undrained shear strength of 75-100kN/m^2.

The majority of the descriptions and insitu tests (SPTs, HSVs) of the cohesive near-surface (<1.0m) soils suggest undrained shear strength of 50-60 kN/m^2, indicative of a CBR value of ≈2%.

Based on an upper bound Plasticity Index value for the cohesive near-surface (<1.0m) soils of 40%, an equilibrium CBR value of ≈2.5% is estimated based on a high-water table and poor-average construction conditions.

On the basis of the above, it is recommended that a preliminary subgrade CBR value of 2.5% is adopted for outline design. Because the made ground soils will be vary variable in their deformation modulus value (stiffness), consideration should be given to the incorporation of appropriate geogrid reinforcement at the base of the pavement foundation to ameliorate any variations. This will also enable the thickness of capping / sub-base to be reduced.

Some of the likely subgrade soils are likely to be very susceptible to softening in the presence of excess water. Consequently, it is crucial to ensure that formations are not exposed to significant and/or prolonged rainfall.

8.4 Soakaway Drainage

Two in-situ percolation tests carried out in general accordance with BRE Digest 365 "Soakaway Design" as part of the GIP ground investigation produced negligible percolation, indicating that soakways will not represent a suitable form of surface water disposal on this site.

8.5 Former Well

Within the GIP report, a possible well is detailed within area 600A. It states that previous works identified what was believed to be an open well which was full of water and brick rubble. It is not believed to have been stabilised and this will require further consideration prior to development.

The GIP report provides recommendations such as if the well is shallow (less than 3.0m) it may be possible to excavate out and replace it with a suitable well compacted granular material. If the well is deeper then backfilling may require grouting and capping of the feature.

Further investigation should be undertaken in the area of this possible well to determine the appropriate measures required to backfill this feature. Depending on the depth of the well and the backfill material, this may form a receptor for groundwater and should therefore be considered further in respect of groundwater contamination once additional information is obtained.

9 POLLUTANT LINKAGES

9.1 Introduction

The following sections detail the potential receptors, pathways, and contaminants that may be present at the site. The definitions of a receptor, a pathway and a contaminant source are provided in the box below. A pollutant linkage is a term used to describe a particular combination of contaminant-pathway-receptor which is the basis for any contaminated land assessment.

A **receptor** may be defined as either:

(a) a living organism, a group of organisms, an ecological system or a piece of property which is being, or could be, harmed, by a contaminant; or

(b) controlled waters which are being, or could be polluted by a contaminant.

A **pathway** may be defined as

A route, or routes, by which a receptor:

(a) is being exposed to, or affected by a contaminant, or

(b) could be so exposed or affected.

A pathway can only be identified if it can expose an identified receptor to an identified contaminant.

A **contaminant source** may be defined as

a substance which is in, on or under the land and which has the potential to cause harm or to cause pollution of controlled waters and/or pose a risk to human health.

The relationship between the above three elements is called a 'pollutant linkage'. All three elements must be present for a pollutant linkage to exist.

9.2 Potential Receptors

The potential receptors detailed below takes into consideration the proposed development of the site in to a renewable energy facility.

Human Beings

- Site Users (maintenance workers and contractors).

Controlled Waters (groundwater and surface water)

- An unnamed stream flowing through the middle of the site considered to be a highly sensitive receptor.
- As the site is underlain by a non-aquifer, groundwater is considered to be a receptor of low sensitivity.

Buildings

- Underground building services (water pipes, concrete).

Flora and Fauna

- The small area of woodland copse off site to the east is considered to be a receptor of low sensitivity due to the direction of groundwater flow and the relatively low permeability of the underlying strata. This is therefore not considered to be a significant receptor and is not considered further in this report.

9.3 Potential Pathways

Pathways are the routes that link the receptor to the contamination. The potential pathways for this site are, therefore, considered to be:

Table 9.1 Identified contaminant pathways

Receptor	Pathways
Human Beings	Accidental ingestion of contaminants within soil and dust. Indoor and outdoor inhalation of vapours and ground gases Dermal contact with contaminants within soil and dust.
Controlled Waters	Vertical migration of soluble contaminants through the unsaturated zone into groundwater beneath the site. Horizontal and down-slope migration of contaminated groundwater into the local surface water environment. Leaching of contaminants into surface waters Direct Discharge to surface water via spills and leaks on site
Buildings	Direct contact of building services with contaminants in the soil.

9.4 Potential Contaminant Sources

An assessment of the potential sources of contamination at the site has been compiled based upon the information taken from the Envirocheck Report, Environment Agency and other available sources of information as detailed above.

Potential contaminative sources identified as relevant to the site are discussed in Section 2.4 and 4.4 of the desk study report and are identified as follows:

- Existing off-site waste-water treatment works;
- Existing off-site Biffa landfill
- Former on-site railway,
- Former on site RAF depot
- Former on site lorry park
- Current use as access to waste water treatment works

The main potential contaminants are therefore considered to be metals, hydrocarbons (Total Petroleum Hydrocarbons, Polycyclic Aromatic Hydrocarbons, BTEX), asbestos and PCBs.

10 RESULT OF CONTAMINANT ANALYSIS

10.1 Risk to Human Health – Soil Assessment

Soil samples (comprising 11 Made Ground and 4 natural soils) were collected from across the site area and analysed for a suite of contaminants in order to assess the degree to which contamination is present and to determine the potential risk to site end users and the water environment. The laboratory sheets are included in the Appendices of the factual report and the results are discussed below in Section 10.2.

10.1.1 Soil Screening Value (SSV)

The proposed use of the site is as a Energy from Waste plant. As there is no standard land use for such a development, the CLEA Commercial land use exposure model has been used as Tier 1 screening values.

In recent months, the Environment Agency has published several new Soil Guideline Values (SGVs) under the CLEA regime. These values will be used where appropriate. Where no published values are available, the CLEA model will be used to derive values. The toxicological data will be taken from authoritative sources and physchem input data used will be from authoritative sources such as the EA report *Compilation of Data for Priority Organic Pollutants for Derivation of Soil Guidelines Values (SC050021/SR7).*

For organic contaminants SSVs for a 1 % Soil Organic Matter (SOM) have been used as Tier 1 screening values. This is considered to be a precautionary approach.

10.1.2 Averaging Areas

On the basis of the site wide historic uses, the EnviRecover site has been considered as one averaging area. The chemical results have been separated into different soil strata such as Made Ground and natural soils and assessed separately.

10.2 Soil Results – Tier 1 Screening

10.2.1 Made Ground – Commercial End Use

Eleven soil samples were analysed from the Made Ground. Below is a summary of the findings with the site maximum compared to the appropriate SSV.

Table 10.1 Tier 1 screening of inorganic contaminants for a commercial end use

Contaminant	Concentration Range (mg/kg)	SSV (mg/kg)	Exceedance (Yes/No)
Arsenic	5.8 – 28.9	640 (1)	No
Cadmium	0.11 – 45.09	230(1)	No
Chromium	29.4 – 183.2	6250(3)	No
Copper	18.4 – 34,500	45,800(3)	No
Lead	12.6 – 4,839	750(4)	Yes (BH20 - 0.75m)
Mercury	0.1 – 0.22	3,600(1)	No
Nickel	28.5 – 216.6	1,800(1)	No
Selenium	0.5 – 3.6	13,000(1)	No
Zinc	74.5 – 14,950	667,000(3)	No
pH Value	7.7 – 9	6 – 9	No

1 EA published Soil Guideline Values
2 LQM/CIEH published value
3 Hyder Derived Value (HyGAC)
4 Previous Soil Guideline Value (Currently withdrawn)

All the contaminant concentrations are below the relevant SSVs except for Lead which will require further consideration.

Table 10.2 Tier 1 Screening for PAH contaminants in Made Ground

Contaminant	Concentration Range (mg/kg)	SSV (mg/kg)	Exceedence (Yes/No)
Naphthalene	<0.08 – 0.13	76.4(1)	No
Acenaphthylene	<0.08	91500(1)	No
Acenaphthene	<0.08	157(1)	No
Fluorene	<0.08	153(1)	No
Phenanthrene	<0.08 – 0.55	73100(1)	No
Anthracene	<0.08 – 0.23	54900(1)	No
Fluoranthene	<0.08 – 0.68	73200(1)	No
Pyrene	<0.08 – 0.62	54900(1)	No
Benz(a)anthracene	<0.08 – 0.45	130(1)	No
Chrysene	<0.08 – 0.44	1370(1)	No
Benzo(b)fluoranthene	<0.08 – 0.84	140(1)	No
Benzo(k)fluoranthene	<0.08 – 0.3	141(1)	No
Benzo(a)pyrene	<0.08 – 0.61	14.1(1)	No
Indeno(123cd)pyrene	<0.08 – 0.48	140(1)	No

Table 10.2 Tier 1 Screening for PAH contaminants in Made Ground (continued)

Contaminant	Concentration Range (mg/kg)	SSV (mg/kg)	Exceedence (Yes/No)
Dibenzo(ah)anthracene	<0.08 – 0.14	14.1[(1)]	No
Benzo(ghi)perylene	<0.08 – 0.49	54900[(1)]	No
PAH 16 Total	<1.28 – 5.63	NA	

Values in blue are soil saturation limits.

1 Hyder Derived Value (HyGAC)

Table 10.3 Tier 1 Screening for TPH contaminants in Made Ground

Contaminant	Concentration Range (mg/kg)	SSV (mg/kg)	Exceedance (Yes/No)
TPH >C8 – C10	<2	84.7[(1)]	No
TPH >C10 – C12	<2	37.2[(1)]	No
TPH >C12 – C16	<2 – 4.35	22.2[(1)]	No
TPH >C16 – C21	2.11 – 23.6	28600[(1)]	No
TPH >C21 - C35	4.88 – 359	28600[(1)]	No

Values in blue are soil saturation limits.

1 Hyder Derived Criteria (HyGAC)

All the contaminants concentrations are below the relevant SSV. Therefore PAH and TPH compounds are not considered to be contaminants of concern.

BTEX

Two soil samples from the Made Ground were analysed for BTEX (Benzene, Toluene, Ethylbenzene and Xylene). Concentrations were recorded below the laboratory limit of detection in both the soil samples.

PCBs

Two soil samples from the Made Ground were analysed for 7 PCB (Polychlorinated Biphenyls) congeners. Concentrations were recorded below the laboratory limit of detection in one soil sample, whilst the other soil sample (TP20 at 0.5m) recorded low concentrations for PCB 101 (6.4ug/kg) and PCB138 (7.3ug/kg). As a guide, the published SGV for Dioxin- like PCBs, Dioxins and Furans is 240ug/kg for a commercial end use. These values are significantly lower and therefore are not considered to pose a risk to site end users. No further consideration is required.

Asbestos

Five soil samples were analysed for asbestos and no fibres were detected. However, during the excavation of one trial pit TP24 (0.0 and 0.5m bgl), potential asbestos containing material was found. This will require further consideration.

10.2.2 Statistics Analysis

From the above Tier 1 screening, Lead is elevated in one sample from BH20. Lead concentrations have therefore been assessed statistically using current UK guidance published by CIEH and CL:AIRE *Guidance on Comparing Soil Contamination Data with a Critical Concentration.*

In this guidance the chemical data is assessed using a hypothesis approach depending on whether the site is to be redeveloped for planning or is to be considered under the Part 2a regime. The EnviRecover site will be assessed under the planning scenario. The CL:AIRE guidance uses a null and alternative hypothesis approach in order to assess the data. Depending on which scenario is being assessed, the null and alternative hypothesis can mean different things.

Under the planning scenario the key question that needs to be addressed is therefore

Is there sufficient evidence that the true mean concentration of the contaminant (x) is less than the critical concentration (Cc)?

The hypotheses are therefore

Null Hypothesis (Ho) the true mean concentration is equal to or greater than the critical concentration ($x \geq Cc$)

Alternative Hypothesis (H1) the true mean concentration is less than the critical concentration ($x < Cc$)

If the Null Hypothesis (Ho) cannot be rejected then assessment of risk at higher tiers (DQRA) or remediation of the site may be required prior to development of the site. If Ho can be rejected then the Alternative Hypothesis (H1) must be true and no further consideration is required.

For the lead concentrations encountered on site the following table illustrates the statistical analysis

Table 10.4 Statistical analysis for lead

Contaminant	SSV	Average	ko	UCL	Reject Ho	P1 (level against Ho)
Lead	750mg/kg	519mg/kg	-0.532	2406.4mg/kg	No	51%

The above analysis indicates that the null hypothesis cannot be rejected and therefore the elevated Lead concentrations are considered a contaminant of concern.

10.2.3 Natural Soils – Commercial End Use

Four soil samples were analysed from the natural soils during the ground investigation on the EnviRecover site. Below is a summary of the findings compared to the appropriate SSVs.

Table 10.5 Tier 1 screening of inorganic contaminants

Contaminant	Concentration Range (mg/kg)	SSV (mg/kg)	Exceedance (Yes/No)
Arsenic	4.9 – 7.1	640(1)	No
Cadmium	0.1 – 0.19	230(1)	No
Chromium	47.9 – 70.9	6250(3)	No
Copper	13.4 – 43.5	45,800(3)	No
Lead	7 – 12.7	750(4)	No
Mercury	0.1	3,600(1)	No
Nickel	44.2 – 64.4	1,800(1)	No
Selenium	0.5	13,000(1)	No
Zinc	80.2 – 91.4	667,000(3)	No
pH Value	8.2 – 8.9	6 – 9	No

1 EA published Soil Guideline Values
2 LQM/CIEH published value
3 Hyder Derived Value (HyGAC)
4 Previous Soil Guideline Value (currently withdrawn)

Table 10.6 Tier 1 screening for TPH Contaminants in natural soils

Contaminant	Concentration Range (mg/kg)	SSV (mg/kg)	Exceendance (Yes/No)
TPH C8 – C10	<2	84.7(1)	No
TPH >C10 – C12	<2	37.2(1)	No
TPH >C12 – C16	<2 – 2.28	22.2(1)	No
TPH >C16 – C21	<2 – 3.9	28600(1)	No
TPH >C21 – C35	4.38 – 13	28600(1)	No

Values in blue are soil saturation limits
1 Hyder Derived Criteria (HyGAC)

All the samples were analysed for PAH compounds and all the results were below the limit of laboratory detection (0.08mg/kg).

All the inorganic and organic contaminant concentrations in the natural soils are below the SSVs for a commercial land use. No further consideration is warranted with regards to the natural soils.

11 RISK TO CONTROLLED WATERS – LEACHATE AND GROUNDWATER ASSESSMENT

Five groundwater and eleven leachate samples were analysed across the EnviRecover site. The samples were analysed for a range of contaminants to determine the potential risk to Controlled Waters. The laboratory sheets are included in the Appendices of the factual report.

11.1 Water Quality Standards

To assess the leachate analysis and the groundwater in terms of its potential as a source of contamination, each contaminant concentration has been compared against appropriate Water Quality Standards (WQS), such as Environmental Quality Standards (EQS) for freshwater and UK Drinking Water Standards (DWS). EQS are considered protective of surface water and DWS are protective of groundwater which may be used as a potable supply.

For a number of contaminants, the hardness of the receiving water must be considered to determine the EQS. In the Kidderminster area the groundwater is considered to be moderately hard (150-200mg/l). Therefore the EQS values for this banding have been used in the assessment below.

The site is not within a Source Protection Zone and there are no water abstractions within 500m of the site. Therefore EQS values are considered as appropriate for the assessment.

Please note that for PAH compounds there is only an EQS value published for Naphthalene. There is a guideline value for Total PAH within the Surface Water Abstraction regulations. These values have been used as an initial screen to determine if there is a risk to water environment from PAH compounds in the leachate or groundwater. Other WQS values in the table (in grey) are values derived using toxic equivalent factors derived for Benzo(a)pyrene which has a drinking water standard of 10ng/l.

11.2 Leachate Results

11.2.1 Tier 1 Screening – Made Ground

Eleven soil samples from the Made Ground were subject to leachate analysis (CEN BS12457 2:1 ratio). A summary of the results and comparison to appropriate WQS is detailed below.

Table 11.1 Inorganic Leachate Results

Contaminant	Concentration Range (mg/l)	WQS (mg/l)	Exceedance (Yes/No)
Arsenic	<0.001-0.012	0.05[1]	No
Cadmium	<0.0001-0.0015	0.05[1]	No
Chromium	0.003-0.101	0.2[1]	No
Copper	0.003-0.098	0.01[1]	YES
Mercury	0.0003-0.001	0.001[1]	No
Nickel	0.002-0.043	0.15[1]	No
Lead	<0.001-0.06	0.25[1]	No
Selenium	<0.001-0.007	0.01[2]	No
Zinc	0.019-0.241	0.25[1]	No
Chloride (mg/l)	1-20	250[1]	No
Ammonical Nitrogen	<0.01-1.1	0.015[1]	YES

1 Environmental Quality Standard (EQS) for freshwater

2 Drinking Water Standards (DWS)

All the contaminant concentrations are below the relevant WQS except for Copper and Ammoniacal Nitrogen. The Copper leachate is exceeded in 9 of the 11 samples analysed, whilst the Ammoniacal Nitrogen is exceeded in 4 of the 11 samples.

Leachate results are available for organic compounds. Whilst many of the compounds were below the limit of laboratory detection, a number were above and are detailed in the table below with the appropriate guideline values.

Table 11.2 Organic Leachate Results above limit of laboratory detection

Contaminant	Concentration Range (mg/l)	WQS (mg/l)	Exceedance (Yes/No)
Naphthalene	<0.01-0.047	0.01	Yes
Acenaphthylene	<0.010-0.017	0.001	Yes
Acenaphthene	<0.01-0.061	0.01	Yes
Fluorene	<0.01-0.369	0.01	Yes
Phenanthrene	<0.01-0.982	0.01	Yes
Anthracene	<0.01-0.04	0.01	Yes

Table 11.2 Organic Leachate Results above limit of laboratory detection (continued)

Contaminant	Concentration Range (mg/l)	WQS (mg/l)	Exceedance (Yes/No)
Fluoranthene	0.011-0.101	0.001	Yes
Pyrene	0.01-0.134	0.01	Yes
Benzo(a)anthracene	<0.01-0.024	0.0001	Yes
Chrysene	<0.01-0.013	0.001	Yes
Benzo(b)fluoranthene	<0.01-0.013	0.0001	Yes
TPH Aliphatics C12-16	<0.01-0.013	0.01	Yes
TPH Aliphatics C16-21	<0.01-0.079	0.01	Yes
TPH Aromatics C16-21	<0.01-0.034	0.01	Yes
TPH Aliphatics C21-35	<0.01-0.047	0.01	Yes
TPH Aromatics C21-35	<0.01-0.025	0.01	Yes

Due to the stringent WQS used for organic contaminants, several concentrations are found to be above the guideline values and may warrant further consideration.

11.3 Groundwater Results

11.3.1 Tier 1 Screening

Five groundwater samples obtained from wells screened into the Mercia Mudstone were analysed during the ground investigation by Hyder. Samples were taken from BH22, BH23, BH24, BH25 and BH26. All the results are summarised below in Tables 11.3 and 11.4.

Table 11.3 Summary of inorganic groundwater results

Contaminant	Concentration Range (mg/l)	WQS (mg/l)	Exceedance (Yes/No)
Chloride	29-120	250(1)	No
Nickel	0.003-0.007	0.150(1)	No
Chromium	0.006-0.011	0.2(1)	No
Cadmium	<0.0001-0.0002	0.05(1)	No
Copper	0.001-0.004	0.01(1)	No
Lead	<0.001	0.25(1)	No
Zinc	<0.002-0.011	0.25(1)	No
Arsenic	<0.001-0.004	0.05(1)	No
Mercury	<0.0001	0.001(1)	No

Table 11.3 Summary of inorganic groundwater results (continued)

Contaminant	Concentration Range (mg/l)	WQS (mg/l)	Exceedance (Yes/No)
Selenium	<0.001 – 0.033	0.010[2]	YES
Ammoniacal Nitrogen as N	<0.1 – 1.1	0.015[1]	YES

1 Environmental Quality Standard (EQS) for freshwater

2 Drinking Water Standards (DWS)

All the contaminants are below the WQS except for Ammoniacal Nitrogen and Selenium. The Ammoniacal Nitrogen is above the WQS in 4 of the 5 groundwater samples, whilst Selenium is only elevated in 1 sample.

Both the WQS for Ammoniacal Nitrogen and Selenium are DWS and are therefore considered to be conservative for the water environment on site. The levels of Ammoniacal Nitrogen recorded are considered not to be indicative of landfill leachate which would typical be concentrations experienced are in the order of 20 to 30 mg/l.

Given the environmental setting and the conservative WQS, Ammoniacal Nitrogen and Selenium are not considered to be contaminants of concern and do not warrant further consideration.

The groundwater samples were analysed for PAH compounds and all were below the limit of laboratory detection except Benzo(a)anthracene in BH26 which had a concentration of 0.012ug/l. This concentration is below the WQS of 0.1ug/l and therefore is not considered to be of concern.

The groundwater samples were analysed for TPH using the TPHCWG method. All the results including those of BTEX compounds were found to be below the laboratory detection limit except for the Aromatic fraction C21-35 which had concentrations of 0.011mg/l in BH22 and BH24. This concentration is only very slightly above the DWS of 0.01mg/l for oils and hydrocarbons and therefore is not considered to pose a significant risk and does not warrant further consideration.

It should be noted that groundwater concentrations of Copper and several organic compounds were below the WQS but were found to be elevated in leachate analysis. The leachate analysis is a method of testing undertaken in a laboratory to determine if a risk is posed from contaminants in the soil, but it may not demonstrate what is actually occurring on site. As the groundwater is not significantly impacted by these contaminants it would indicate that leaching is not readily occurring on site. The elevated leachate results are therefore not considered to pose a significant risk to the water environment. For completeness they are however considered in the risk assessment that follows in Section 13.

11.4 Summary of Contamination

From the above sections, the following are considered to be contaminant sources and need consideration in the risk assessment which follows:

- Lead in the Made Ground
- Potential Asbestos containing material in the Made Ground.
- PAH, Copper and Ammoniacal Nitrogen in the leachate

12 GROUND GAS MONITORING

12.1 Gas Assessment

Due to the proximity of the site to a landfill, gas monitoring is necessary. Subsequently Hyder is in the process of an ongoing monitoring phase using the seven installed boreholes on-site. At present 2 monitoring rounds have been undertaken over the course of 1 month.

It should be noted that this is part of an ongoing phase of monitoring occurring twice every month for 3 months. The full ground gas assessment will therefore be provided as an addendum to this report.

To date no methane has been detected on site and the maximum readings are below:

- Methane 0%
- Carbon dioxide 10.5% (BH22)
- Oxygen 0.3% (BH22) (minimum)
- Flow rate 0.2l/hr (BH26)

The atmospheric pressure during the monitoring visit was between 900mb and 1018mb.

The results indicate that carbon dioxide gas is present on site and therefore is a potential risk that should be considered further and assessed again after monitoring process is complete.

Gas Characterisation Situation

CIRIA guidance (*Assessing risk posed by hazardous ground gases to buildings, CIRIA C659, 2006 now revised as CIRIA C665*) has been released which sets out the latest way of undertaking gas risk assessments.

As part of the CIRIA report **Situation A** covers *all development types except low rise housing with gardens,* which adopts the method proposed by Wilson and Card (1995).

The GSV are calculated using the formula:

GSV = borehole flow rate (l/hr) x gas concentration (v/v %)

This calculation is carried out for both the maximum methane, carbon dioxide and flow rates which would illustrate the measured worst-case-scenario on site over the monitoring period. The GSV is then compared with the Characteristic Situation (Modified Wilson and Card classification) detailed in the CIRIA guidance and from this an assessment of the risk can be established.

Due to the likely presence of a landfill adjacent to the site, there is the potential for migration of carbon dioxide and methane towards the surface.

The ground investigation identified a maximum carbon dioxide concentration of 10.5% and a worst case flow rate of 0.2 l/hr. The GSV for carbon dioxide (to date) is therefore calculated as 0.021l/hr.

No concentrations of methane were found. Based on these results the site could be characterised as Characteristic situation 1, Very low risk. This will be reviewed once all the gas monitoring data is available.

13 RISK ASSESSMENT

13.1 Methodology

Risk assessment is the process of collating known information on a hazard or set of hazards (to determine the potential severity of any impact) along with details on the likelihood of impact on detailed receptors. Risks are generally managed by isolating the sensitive receptor or by intercepting or interrupting the exposure pathway, thus no pollutant linkages are formed and there is no risk. The following risk assessment focuses on the potential contaminants identified on the site and the proposed development of the site.

CIRIA guidance (C552) states that the designation of risk is based upon a consideration of both:

- The likelihood of an event (probability); (takes into account both the presence of the hazard and the receptor and the integrity of the pathway).
- The severity of the potential consequence (takes into account both the potential severity of the hazard and the sensitivity of the receptor).

Under such a classification system the following categorisation of risk has been developed and the terminology adopted as follows:

Table 13.1 **Summary of risk classification categories**

Term	**Description**
Very High Risk	There is a high probability that significant harm could arise to a designated receptor from an identified hazard at the site with appropriate remedial action.
High Risk	Significant Harm is likely to arise to a designated receptor from an identified hazard at the site without appropriate remedial action.
Moderate Risk	It is possible that without appropriate remedial action, harm could arise to a designated receptor but it is relatively unlikely that any such harm would be severe and if any harm were to occur, it is likely that such harm would be relatively mild.
Low Risk	It is possible that significant harm could arise to a designated receptor from an identified hazard but it is likely that at worst this harm if realised would normally be mild.
Very Low Risk	There is a low possibility that harm could arise to a receptor. In the event of such harm being realised, it is not likely to be severe.

Further risk assessment definitions are located in Appendix D.

13.2 Pollutant Linkages

Based on the potential contaminant source and the potential receptors and pathways identified above, Table 13.2 provides an assessment of each identified pollutant linkage to establish the potential risk to the sensitive receptors. The proposed development has been taken into consideration and the risk assessment has been developed based on the site being developed as a Energy to Waste site.

Table 13.2: Pollutant Linkages

Pollutant Linkage	Contaminant Source	Sensitive Receptor	Pathway	Hazard (Severity)	Likelihood	Potential Risk	Further Assessment/ Remediation Required
1	Lead in the Made Ground	Human Health – site end users, site workers and maintenance workers.	Direct contact / accidental ingestion of contamination within soil or inhalation of dust.	Long term health effects to humans – blood poisoning. (Severe)	Unlikely. Elevated Lead above the relevant SSV was only encountered in one location at shallow depth. Site construction workers by the nature of the work are unlikely to come into long term contact with the contamination and any exposure is likely to be short term.	Moderate/low risk.	Yes, subject to regulatory approval (Section 14.2).
2		Controlled Waters (unnamed stream onsite and groundwater beneath the site)	Leaching from contaminants within the made ground and subsequent percolation through the underlying weathered Mercia Mudstone.	Reduction in Water Quality (Medium)	Unlikely. Groundwater was encountered during the ground investigation and 5 groundwater samples were taken for analysis. Concentrations of Lead were not recorded to be elevated in the groundwater beneath the site.	Low Risk	No, subject to regulatory approval.
3	Copper, Ammoniacal Nitrogen and PAH in leachate	Controlled Waters (unnamed stream on site and groundwater beneath the site)	Leaching of contaminants within the made ground and percolation through the unsaturated strata into the groundwater /surface water	Reduction in Water Quality (Medium)	Unlikely. Whilst leachate analysis of the Made Ground indicated exceedances, the concentrations in the groundwater were generally shown to be below the appropriate guidelines. It is therefore considered that leaching is not readily occurring and therefore these concentrations are not considered to pose a risk to the water environment.	Low Risk	No, subject to regulatory approval.
4	Possible Asbestos containing material in the Made Ground	Human health (construction workers, site end users and, maintenance workers)	Accidental ingestion and/or inhalation of soil dust	Potential Carcinogenic health risks (Severe).	Low Likelihood. A piece of potential asbestos board was encountered in the Made Ground at shallow depth. Asbestos testing was carried out on samples of Made Ground but no asbestos fibres were positively identified, therefore there is a limited occurrence of potential asbestos containing materials which can be visually identified.	Moderate Risk	Yes, subject to regulatory approval (Section 14.3)

Pollutant Linkage	Contaminant Source	Sensitive Receptor	Pathway	Hazard (Severity)	Likelihood	Potential Risk	Further Assessment/ Remediation Required
5	Ground Gas (Carbon Dioxide and Methane)	Human Health /Buildings	Migration of ground gases and via ground voids and build up in confined spaces	Explosion, asphyxiation and build up of gases in confined spaces (Severe)	Low Risk. Carbon dioxide readings have been recorded to date but at a relatively low concentration and flow rate.	Moderate Risk	Further Monitoring is being undertaken and a full assessment will be in an addendum report.

14 CONTAMINATION CONSIDERATIONS

14.1 Protection of Workers

Contamination from materials brought on to site (e.g. fuel and lubricating oils for plant) during the construction phase must be considered harmful to human health, the environment and controlled waters. The risks posed from all imported substances must be adequately addressed within a comprehensive site management plan.

Additionally, in accordance with good practice procedures, it is advisable to utilise the document HSG 66: *"Protection of Workers and the General Public During Development of Contaminated Land"* published by the HSE (Ref. 8) to ensure that all construction workers are adequately protected (using appropriate Personal Protective Equipment) and that a suitable health and safety scheme is adopted during any construction activities.

14.2 Elevated Lead Concentrations

Whilst the risk from the Lead concentrations is considered to be low, it would be prudent to remove the elevated Lead concentration from BH20 at 0.75m. The concentration at this location is significantly higher than the other Lead concentrations recorded on site. From the borehole log the contamination is within the Made Ground strata which contains coal fragments and is to a depth of 1.2m.

Validation work should be undertaken of the area after excavation to ensure that all the Lead contamination has been removed from site. The contaminated material should be removed to a suitably licensed landfill facility

14.3 Watching Brief / Discovery Strategy

During the site enabling works, a watching brief should be maintained with regards to the potential presence of currently unknown contaminant sources. If visually contaminated material is encountered analysis should be undertaken by an experienced Geo Environmental Engineer to confirm if the soil meets the required criteria to be protective of human health and controlled waters. Work in the affected area should cease until the analysis results are received and a solution is approved.

Across the site in areas of Made Ground the work force should remain aware of the possibility of encountering asbestos containing material. If any asbestos containing materials are discovered, disposal to a suitably licensed or permitted waste facility should be undertaken. Appropriate health and safety measures should also be adopted.

15 WASTE MANAGEMENT

As part of any development or construction works, it must be noted that should any material require off-site disposal to an appropriately licensed landfill (for example, material generated due to excavation works associated with any development/construction) due consideration should be given to the UK Landfill Directive. Furthermore, any materials without a defined re-use on-site can be considered as waste. If material is to be re-used on site, then the principles included in the draft CL:AIRE document "Definition of Waste: Development Industry Code of Practice" (Ref. 9) should be followed.

Due to the introduction of the Landfill Directive in July 2004, waste must be characterised prior to being sent to an appropriately licensed landfill site. Landfills are categorised into one of three types; inert, non-hazardous and hazardous and can only accept waste they are licensed for. The characterisation is therefore to ensure that the landfill is suitably licensed to accept the excavated soil (i.e. the waste) from the site.

Waste producers have a duty to classify and describe their waste correctly; this includes selecting the most appropriate six-digit code from the European Waste Catalogue (EWC). Appropriate hauliers with waste handling licences must be sought for removal of material off-site.

15.1.1 Waste Disposal CATWASTE^{soil}

The results from the Made Ground of the investigation have been input into CATWASTE^{soil} which determines from the total concentrations if the material is non-hazardous or hazardous. The results indicated that of the 11 made ground samples 2 were found to be HAZARDOUS and the others were non-hazardous. The output spreadsheet is included in Appendix E.

The 2 samples (BH20 at 0.75m and TP26 at 0.5m) which are hazardous due to elevated lead, copper and zinc results.

Please note that CATWASTE does not consider the Total Organic Carbon (TOC) content of the soil samples. This will need to be taken account of before disposal in a landfill can take place. This will need to be taken account of before disposal in a landfill can take place. The maximum value allowed in a hazardous landfill is 6% TOC.

15.2 Waste Acceptance Criteria (WAC)

15.2.1 Waste Acceptance Criteria Testing

Two samples (TP20 at 0.5m and TP25 at 1.2m) were analysed for WAC, with the full results included within the Factual Report. Using the CATWASTE results, both these samples are considered to be non-hazardous. The WAC results are therefore compared to the Inert leaching criteria to determine if this material would be considered to be Inert.

The soil sample from TP20 at 0.50m bgl exceeded the Total Organic Matter criteria and Antimony for inert material and therefore is likely to be considered as non-hazardous.

The WAC results from the soil sample from TP25 at 1.2m bgl were all below the inert leaching criteria and therefore is likely to be considered as inert.

It is recommended that material that is excavated which requires disposal off site to an appropriate landfill site, should be re-tested from the stockpile to determine the correct disposal route. When stockpiling Made Ground/Natural Soils and contaminated/non contaminated material should be kept separate whenever possible as the material may have different waste classifications and therefore could be disposed at different landfill sites. This will ensure minimum cost for disposal for the project.

The duty of care for waste disposal falls with the waste producer. Above is an indication of the likely classification.

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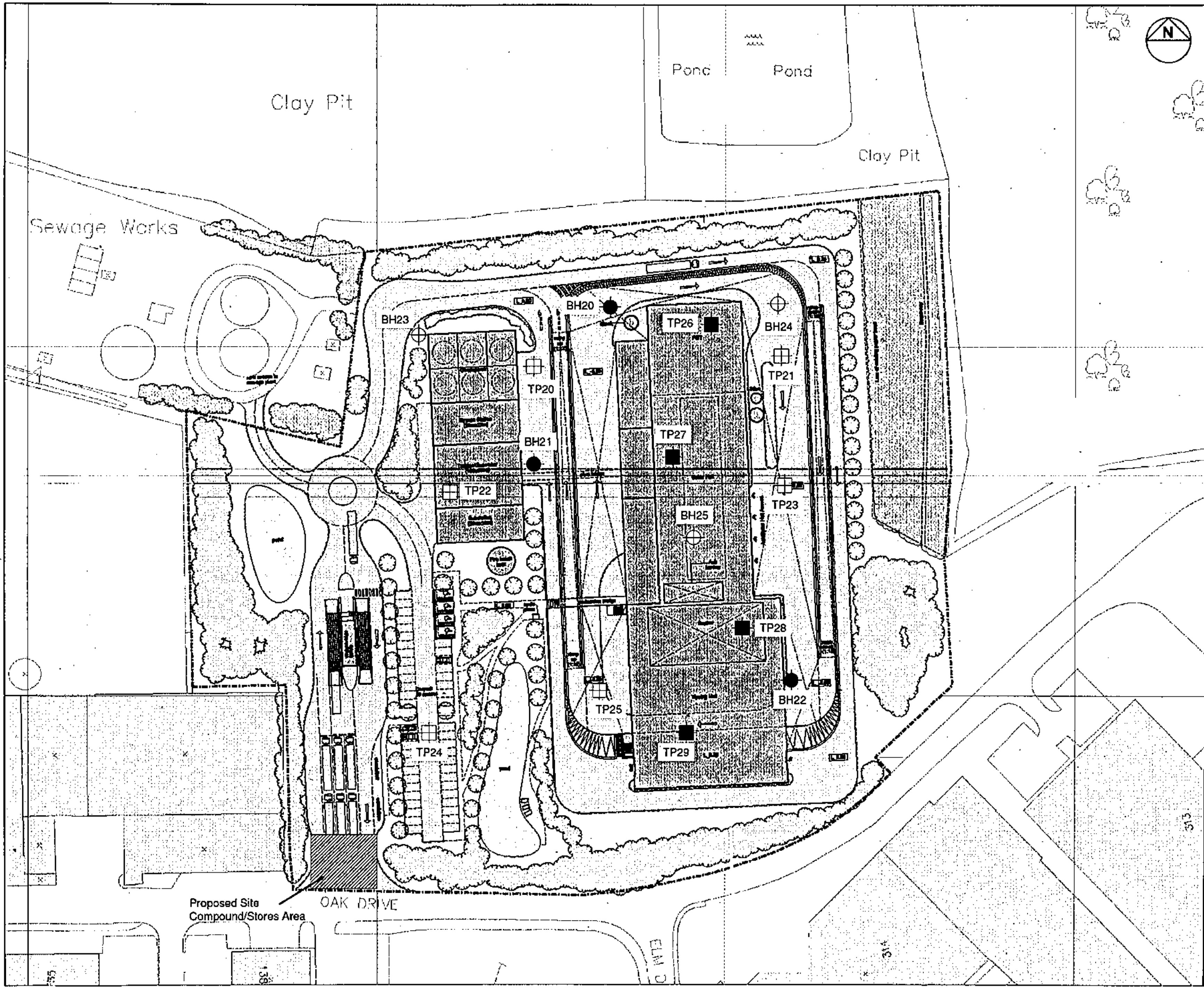
22. CIRIA Report 140, Water-resisting Basements (Summary Report) (1995)

Appendix A

Site Location Plan



THE CONTRACTOR MUST NOT SCALE FROM THE DRAWING ALL DIMENSIONS TO BE TAKEN FROM DIMENSION STRINGS.

WHERE ANY DISCREPANCIES ARE FOUND BETWEEN DIMENSIONS THESE MUST BE BROUGHT TO THE ATTENTION OF THE ARCHITECTS FOR RESOLUTION.

WHERE DISCREPANCIES EXIST BETWEEN REFERENCE OR ASSEMBLY DRAWINGS & DETAIL DRAWINGS, THE LATTER TAKE PREFERENCE.

KEY

- ● BH20-BH22 Rotary Cored to 20m Depth
- ⊕ BH23-BH25 Cable Percussive to 10m Depth
- ⊞ TP20-TP25 Trial Pit to 2m Depth
- ■ TP26-TP29 Trial Pit to 5m Depth

PROPOSED EXPLORATORY HOLE LOCATIONS ARE SUBJECT TO CONFIRMATION OF SERVICES LOCATIONS

FOR INFORMATION

Hyder

MERCIA WASTE MANAGEMENT

CLIENT

PROPOSED GROUND INVESTIGATION AT HARTLEBURY INDUSTRIAL ESTATE

DRAWING

1:500@A1
1:1000@A3

APPROXIMATE SCALE

JANUARY 2010

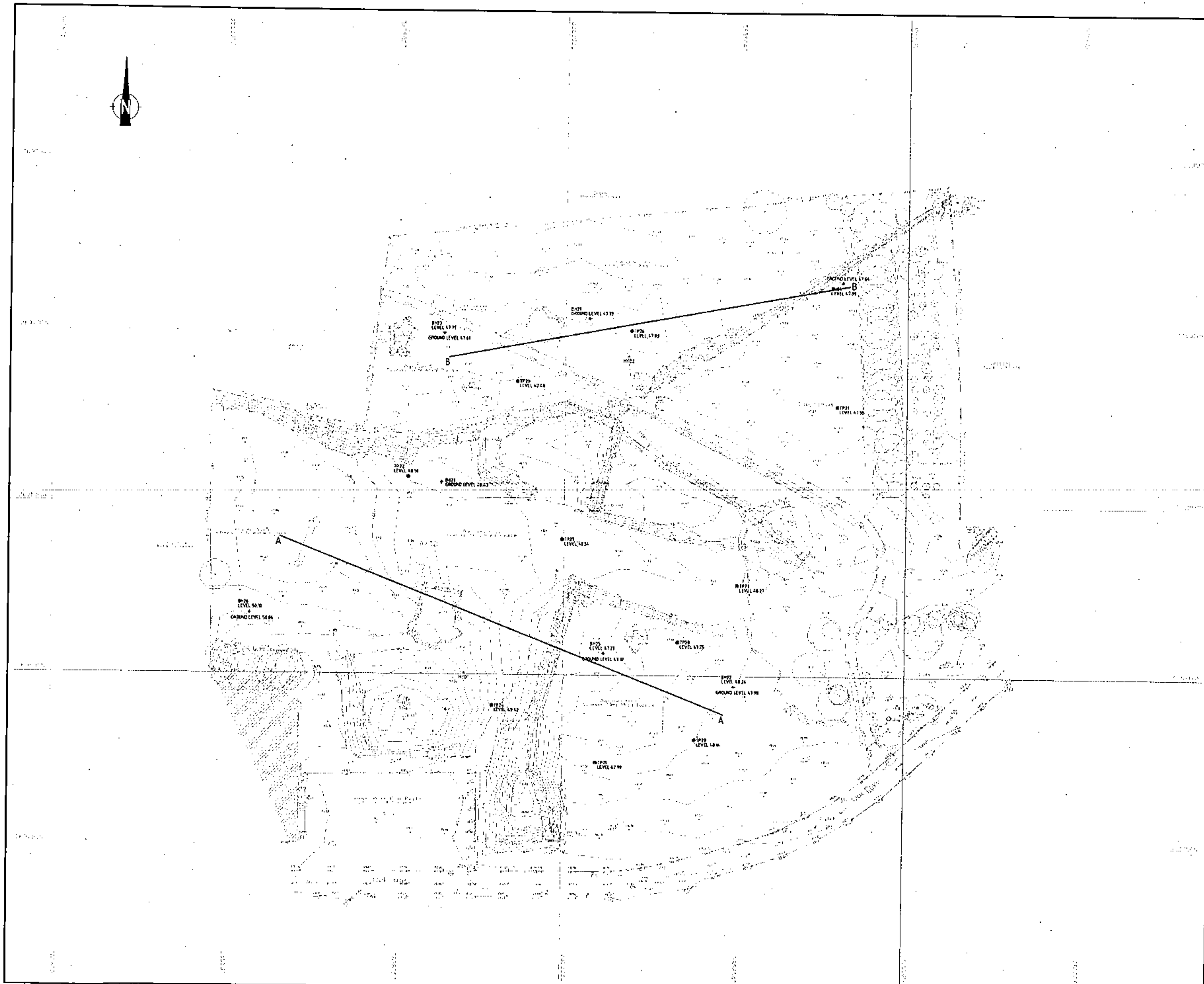
DATE

-

DWG. NO. | REVISION | CHECKED

Appendix B

Exploratory Hole Location Plan



Notes

1. The Survey is based on Ordnance Survey coordinates & levels related to WGS84 & OSTN02.
2. Fences shown are not necessarily legal boundaries.
3. Dimensions should not be scaled. All dimensions should be checked on site before any fabrication / construction.
4. All drainage connections shown are sounded only. They have not been water tested.
5. Copyright of all data produced by Hyder shall remain with Hyder unless otherwise specifically agreed.
6. Information provided should not be altered or modified in any way. It should not be used for any purpose other than for which it was intended and should not be issued to other parties without prior agreement of Hyder.
7. Hyder cannot accept responsibility for any damage to computer systems which may result from viruses which may be contained in the data provided.
8. Preliminary data is generally unchecked therefore it is not guaranteed.
9. If the AutoCAD drawing is being read by any system other than AutoCAD it should be checked against a hard copy. Hyder cannot accept liability for omissions.
10. All tree species are judged by the surveyor at the time of site visit and should act as a guide only.
11. All tree heights are estimates only.

Key

Stations Schedule

Station	Easting	Northing	Level	Notes
HY01	[illegible]	[illegible]	[illegible]	PEG
HY02	[illegible]	[illegible]	[illegible]	PEG

Borehole Schedule

Point	Easting	Northing	Level
[illegible]	[illegible]	[illegible]	[illegible]

Issue	Description	Amc	Apr	Date

Status: **FINAL**

Scales	1:500	Current Issue Signatures
		Author COLLETT 12/02/10
Original Size	A1	Checker A WHITE 12/02/10
Height Datum	OS	Approver A WHITE 12/02/10
Grid	OS	© Copyright reserved

Filename

Client

SEVERN WASTE SERVICES

Hyder Consulting Ltd

Project

HARTLEBURY,
LAND OFF OAK DRIVE
HARTLEBURY TRADING ESTATE

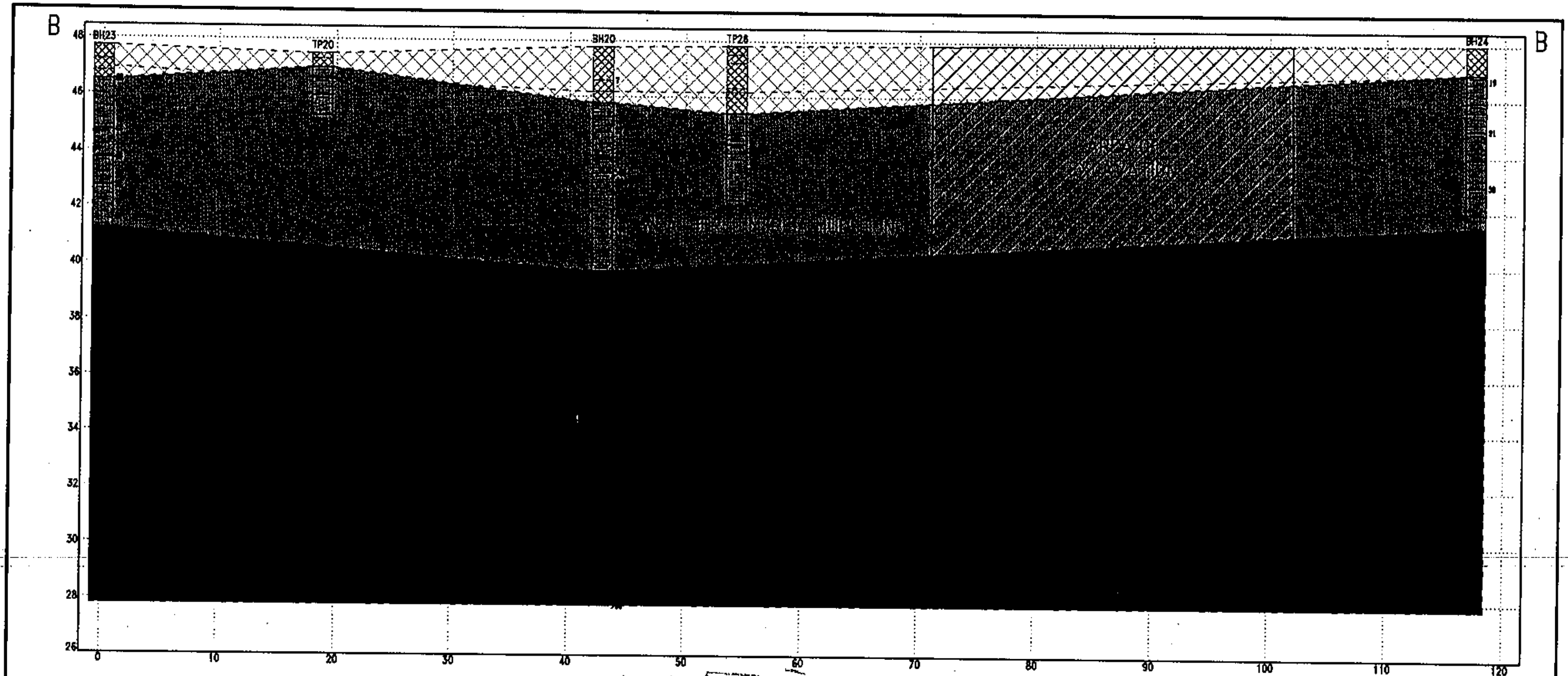
Title

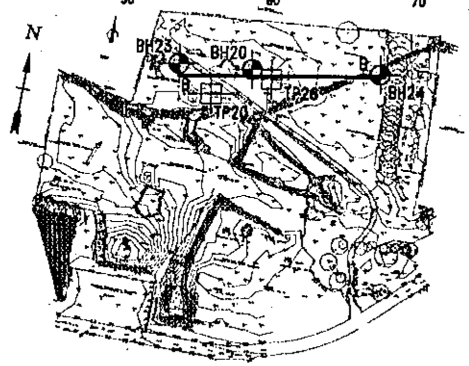
EXPLORATORY HOLE
LOCATION PLAN

Drawing No.	Project No.	Issue
G010	LN01323	01

Appendix C

Geological Cross Sections





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KEY

- CLAY
- MADE GROUND
- AREA OF EXCAVATION
- MUDSTONE

N.B. SUPERFICIAL DEPOSITS HAVE BEEN INCLUDED IN THE MADE GROUND HORIZON

Issue	Description	Date
01	FIRST ISSUE	26/03/10

50mm on Original

Client: MERCIA WASTE MANAGEMENT

Status: **PRELIMINARY**
NOT TO BE USED FOR CONSTRUCTION

		Current Issue Signatures
Scales	1:1000	Author R.JORDAN
Original Size	A3	Checker C.GILLET
Height Datum	DATUM	Approver M.LUNDIE
Grid	GRID	© Copyright reserved
Filename:	G002-LN01323-WXO-01B'B.DWG	

Project: ENVIRECOVER

Title: CROSS SECTION "B-B"

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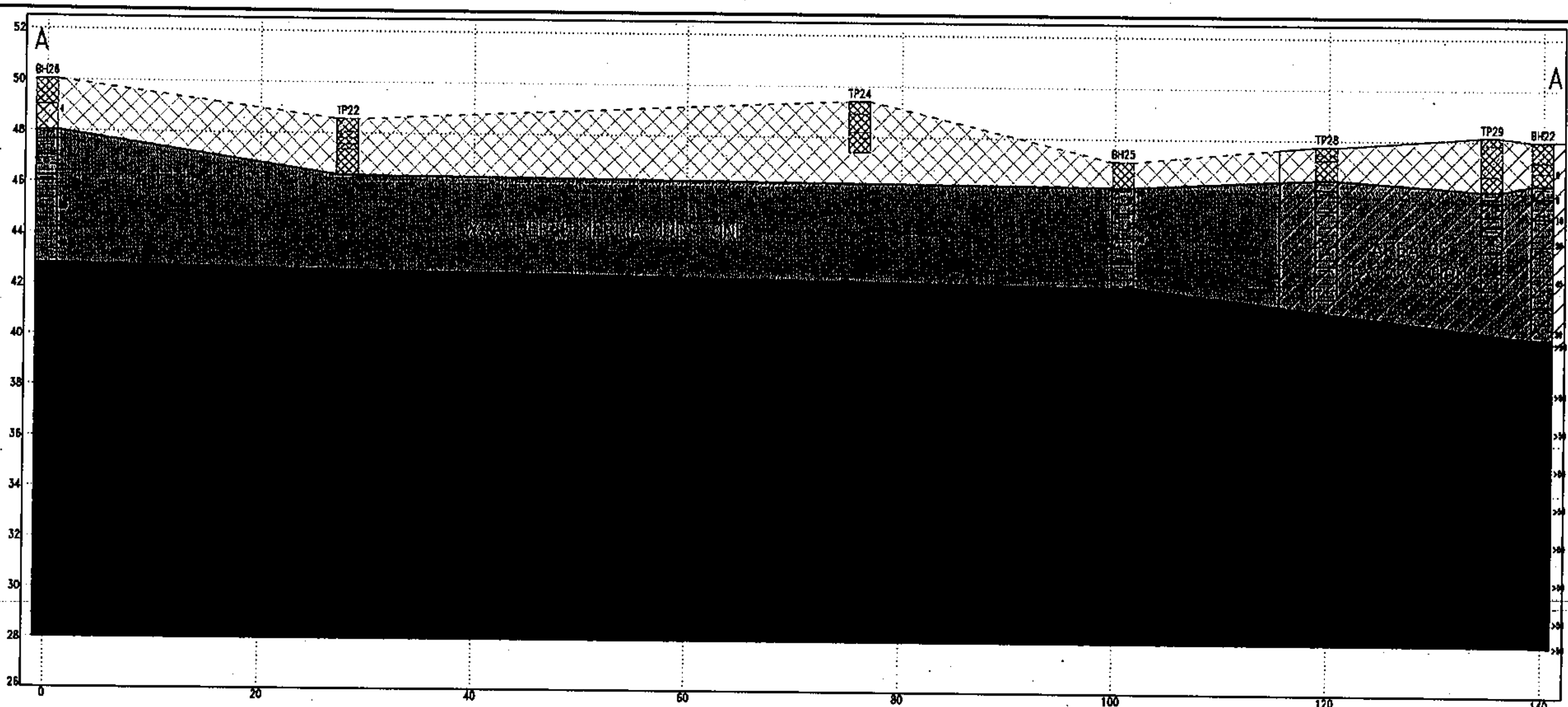
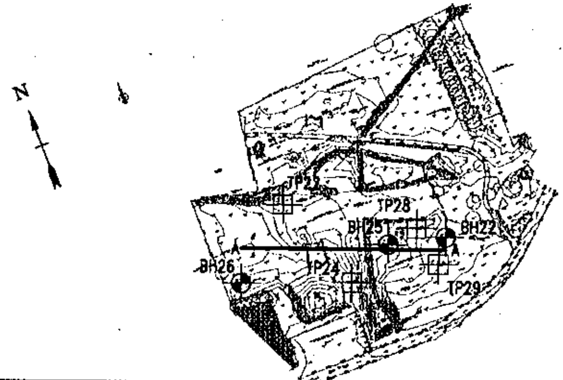
Drawing No.	Project No.	Issue
G002	LN01323	01

Plot Date: 08/Apr/2010 2:53:00 PM File Location K:\PROJECTS\LN01323 - ENVIRECOVER\E-OURDRAWINGS\CURRENT\G002-LN01323-WXO-01B'B.DWG V1





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1:1000

KEY
CLAY
MADE GROUND
AREA OF EXCAVATION
MUDSTONE

N.B. SUPERFICIAL DEPOSITS HAVE BEEN INCLUDED IN THE MADE GROUND HORIZON

Issue	Description	Date
01	FIRST ISSUE	26/03/10

50mm on Original

Client: MERCIA WASTE MANAGEMENT

Status: **PRELIMINARY** NOT TO BE USED FOR CONSTRUCTION

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		Author R.JORDAN	
Original Size	A3	Checker C.GILLET	
Height Datum	DATUM	Approver M.LUNDIE	
Grid	GRID	© Copyright reserved	
Filename:	G001-LN01323-WXD-01 A'A.DWG		

Project: ENVIRECOVER

Title: CROSS SECTION "A-A"

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Drawing No.	Project No.	Issue
G001	LN01323	01

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Appendix D

Risk Assessment Definitions

Risk assessment considers the identified sources, the potential receptors and the pathways linking them together.

In the pollutant linkage table of this report, the column designated as 'Hazard (severity)' gives an indication of the sensitivity of a given receptor to a particular source being considered. It is a worst case classification and is based on full exposure via the particular linkage being examined. The derivation of the classes used to rank this particular aspect are given in the table below

Classification of Potential Consequence (Severity)

Classification	Human Health	Controlled Water	Built Environment	Ecosystems
Severe	Irreversible damage to human health. Short term (acute) risk to human health likely to result in "significant harm" as defined by Part 2a.	Substantial pollution of sensitive water resources	Catastrophic damage to buildings, structures or the environment	A short-term risk to a particular ecosystem or organism forming part of such ecosystem.
Medium	Chronic damage to human health. Non-permanent health effects to humans	Pollution of sensitive water resources or small scale pollution of sensitive water resources	Damage to buildings, structures or the environment	A significant change in a particular ecosystem or forming part of such ecosystem
Mild	Slight short term health effects to humans	Pollution to non-sensitive water resources	Damage to sensitive buildings, structures services or the environment.	Significant damage to crops
Minor	Non permanent health effects to human health (easily prevented by means such as personal protective clothing etc)	Insubstantial pollution to non-sensitive water resources	Easily repairable effects of damage to buildings or structures	Harm (although not necessarily significant harm which may result in financial loss or expenditure to resolve. eg loss of plants in a landscape scheme.

Subsequently, in the column entitled 'Likelihood of Occurrence", in the Pollutant Linkage table, an assessment is made of the probability of the selected source and receptor being linked by the identified pathway. This assessment is ranked based on site specific conditions as detailed in the table that follows

Appendix E

CATWASTE

Classification of probability

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

In the Pollutant Linkage table of this report, the 'Potential Risk' column is an overall assessment of the actual risk, which considers the likely consequence of a given risk being realised and the likelihood of that risk being realised. The risk classifications are assigned using the following consequence/likelihood matrix:

Potential Consequence				
Severe	Moderate/Low	Moderate	High	**Very High**
Medium	Low	Moderate/Low	Moderate	High
Mild	Very Low	Low	Moderate/Low	Moderate
Minor	Very Low	Very Low	Low	Moderate/Low
Likelihood	**Unlikely**	**Low**	**Likely**	**High**

Table below describes the risk classifications

Risk Term	**Description**
Very High Risk	There is a high probability that significant harm could arise to a designated receptor from an identified hazard at the site without appropriate remedial action.
High Risk	Harm is likely to arise to a designated receptor from an identified hazard at the site without appropriate remedial action.
Moderate Risk	It is possible that without appropriate remedial action harm could arise to a designated receptor from an identified hazard. However it is either relatively unlikely that any such harm would be severe or if any harm were to occur it is more likely that such harm would be relatively mild.
Low Risk	It is possible that harm could arise to a designated receptor from an identified hazard but it is likely that this harm if realised would at worst normally be mild.
Very Low Risk	There is a low possibility that harm could arise to a receptor. In the event of such harm being realised it is not likely to be severe.

Appendix G – Hyder Desktop Study Report for Ground Investigation

mercia
waste management

Hyder

Mercia EnviRecover Renewable Energy Facility

Desk Study Report

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Report No 5001-LN01323-NER-01

Date February 2010

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1 INTRODUCTION

1.1 Terms of Reference

Hyder Consulting (UK) Limited (HCL) has been instructed by Mercia Waste Management (Mercia) to undertake a Geotechnical and Geo-Environmental desk study for a proposed 15.5MW renewable energy facility located at the Hartlebury Trading Estate in Worcestershire.

The interpretation of the data collected during the desk study and site walkover survey is presented within this report.

1.2 Background to the Proposed Development

The Joint Municipal Waste Management Strategy (JMWMS) for Herefordshire and Worcestershire, 2004-2034, has highlighted the need for dealing more effectively with the waste left over after recycling (referred to as 'residual waste').

In a review of the JMWMS undertaken by the Joint Members Waste Forum, a number of scenarios for managing residual waste were examined using a computer model called WRATE. Following this assessment, the option of a single site Energy-from-Waste plant with combined heat and power (CHP) capabilities was identified as the optimum solution, resulting in the Mercia EnviRecover 15.5MW renewable energy facility.

As such, a planning application is required plus a ground and groundwater assessment for inclusion in a chapter of an EIA submission document. This chapter will pick up salient points of the contamination conceptual model and achievability of the current construction development based on the recovered technical information obtained from an intrusive ground investigation.

1.3 Report Objectives

The principal objectives of this report are to identify factors that could influence construction works. These broadly include:

- The likely ground conditions beneath the site;
- The potential presence of contaminants in soil and groundwater;
- The potential health and safety issues arising as a result of ground contamination; and
- Materials management and waste issues.

In order to meet these objectives, a review of published geological and hydrogeological information has been undertaken. Historical land uses and any potential past and present sources of contamination have been identified using various sources including historical maps and the records of regulatory and statutory bodies procured through the Landmark Information Group Ltd., Envirocheck Report.

We have undertaken every effort to ensure that the information in this desk study is, at the time of writing, both accurate and current. HCL does not warrant, nor does it accept any responsibility or liability for, the accuracy or completeness of the content or for any loss, which may arise from reliance on information provided by the Landmark Information Group Ltd., and any other third party on which this desk study report is based upon.

2 SITE SETTING

2.1 Site Location

The site is located approximately 9km south-south-east of Kidderminster, within the Hartlebury Trading Estate, Worcestershire.

The site comprises a small parcel of land with an estimated surface area of 3.3 hectares. The Ordnance Survey National Grid Reference at the centre of the site is 385950,269850.

A site location plan is shown in Figure 1.

2.2 Site Description

The site comprises an unoccupied area of disused land with open access from the south via Oak Drive. To the east, the site is immediately bordered by a wooded area, to the north by a square pond and Biffa landfill site, and to the west by a small waste-water treatment works and large warehouse. The site is covered mainly by rough grass, bramble and low shrubs.

The waste-water treatment works in the west is accessed by a track that runs north-west to south-east through the centre of the site. A stream flows from the waste-water treatment works, through the centre of the site and then off-site to the south. The stream lies in a ditch, which is culverted in the centre of the site, and again off-site to the south.

2.3 Public Register Information

Public register information relating to the site and the surrounding area was obtained from the Landmark Information Group Ltd. Envirocheck Report. A complete copy of the Envirocheck Report is included within Appendices B and C of this report.

2.3.1 Waste Activities

The Envirocheck Report includes a review of records held by the Environment Agency and the Local Authorities, along with details of historical landfill sites held by the British Geological Survey.

Registered Landfill Sites and Waste Management Facilities

The southern boundary of Waresley landfill and waste management facility is located immediately to the north of the site. The landfill is operated by Biffa Waste Services Ltd. and is authorised to accept domestic waste.

A historical landfill site (Hartlebury Landfill) is recorded approximately 800m to 1km north-north-west at a clay pit associated with the Hartlebury Brickworks. The landfill was licensed to Hereford and Worcester County Council and was operational from 1980 until 1992. The site was authorised to accept inert, industrial, commercial, household, special waste and liquid sludge.

A licensed waste management facility is recorded on Plot H600, Oak Drive, which is registered to Estech Europe Ltd. However, this appears to be on the same (undeveloped) plot of land that the Mercia EnviRecover 15.5MW renewable energy facility will be located.

2.3.2 Trade Directory Entries

Contemporary Trade Directory Entries

Utilising data contained within the Envirocheck Report and from internet searches, the active trade entries located within 250m of the site are shown in Table 2.1. Those entries located further than 250m of the site are detailed within the datasheets in Appendix B of this report.

Table 2.1 Summary of Contemporary Trade Directories within 250m of the Site

Company Name	Activities	Approx. Distance (direction)
Active Trade Entries		
Rentokil Pest Control	Pest and vermin control	100m (SW)
Alo UK Ltd	Agricultural machinery – sales and service	115m (SE)
Styles Precision Ltd	Precision engineers	22m (W)
Smile Orange	Printers - textile	240m (E)
Garden Leisure Furniture Ltd	Soft furnishings - manufacturers	250m (SW)

Fuel Station Entries

There are no fuel station entries recorded within 1km of the site.

2.3.3 Pollution Controls

There is one registered Integrated Pollution Prevention and Control (IPPC) within 1km of the site, which is issued to Biffa Waste Services Ltd. for waste landfilling purposes.

A Local Authority Integrated Pollution Prevention and Control (LAIPPC) consent is issued to Wienerberger Ltd. for the manufacture of heavy clay goods and refractory goods, located 520m north-west of the site.

A registered Local Authority Pollution Prevention and Control (LAPPC) consent is recorded for TPL Printers (UK) Ltd. located 100m west of the site, however, this business is listed as inactive in the Envirocheck Trade Directory. Beyond 250m of the site, further LAPPCs are detailed within the datasheets in Appendix B of this report.

2.3.4 Industrial Processes with Hazardous Substances

There are no current activities supplied under Control of Major Accident Hazards (COMAH) or Notification of Installations Handling Hazardous Substances (NIHHS) regulations located within 1km of the site.

2.4 Potential Contamination Sources (Current)

An assessment of sources of potential contamination at the site, and in the vicinity of the site, as obtained from the Envirocheck Report, is presented in Table 2.2.

Table 2.2 Summary of potential contaminative land uses on site and in surrounding areas (Current)

Potentially Contaminative Use	Potential Contaminative Source	Potential Contaminants	Ability to Impact Site?
On Site			
Current site use is an empty area of land with a gravel track used as an access road to the waste water treatment works	Leaks and overflows from vehicles servicing waste water treatment works	Metals, hydrocarbons, inorganic chemicals, organic contaminants, faecal coliforms & other pathogens	Yes
Surrounding Area			
Biffa Waresley Landfill Site (located immediately north of the site)	Leachate leaks, landfill material migration and or overflow, accidental discharge, presence of unknown materials	Heavy metals, arsenic, sulphates, asbestos, pH, hydrocarbons, PAHs, chlorinated aliphatic and aromatic hydrocarbons, PCBs dioxins and furans	Yes – The landfill is located immediately to the north of the site, therefore any leachate that enters groundwater may migrate to site, depending on hydraulic gradient. However, the very low permeability of the landfill liner and local geology (see Sections 5.1 and 5.2 of this report) may allow for significant natural attenuation of contaminants prior to reaching site.
Waste Water Treatment Works (Located immediately west of the site)	Leaks and overflows	Metals, hydrocarbons, inorganic chemicals, organic contaminants, faecal coliforms & other pathogens	Yes – If historical spills of mobile contaminants and chemicals stored on site have occurred in the past, these may potentially migrate towards the site, dependant on groundwater flow direction. However, the very low permeability of the local geology (see Sections 5.1 and 5.2 of this report) would significantly hinder the migration of contaminants

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3 ARCHAEOLOGICAL INTEREST

The potential for archaeological interest at the site has been taken from a report produced by Enviros in 2004 (Ref. 1), as supplied by Peter Durrans of Worcestershire County Council. The report states that while the site is in proximity to a Medieval Village and a Grade II Listed Building (St. Michael's Church), it is believed that the development of the site will not have a direct effect on the church or the Medieval Village (or their importance as historical sites), as they do not encroach on the site boundaries.

Additionally, the site comprises a substantial upper stratum of Made Ground and it is considered that there is a low probability that there significant archaeological material will be present in the upper sub-surface deposits.

4 HISTORICAL LAND USE

4.1 General

The historical land use of the site has been traced with reference to currently available historical maps originally published between 1883 and 2009. The historical maps were obtained with the Envirocheck Report and are included in Appendix C of this Desk Study Report. The following text summarises significant observations relating to any potentially contaminative former land uses on and adjacent to the subject site.

4.2 The Site

The 1884 map shows the site to be undeveloped (potentially agricultural) land, with a roughly north-west to south-east trending footpath running through its centre.

There is no change to the site area until 1970, when the footpath has been widened into a track and five rail tracks are shown running parallel with it. A drain is now shown trending north-north-east to south-south-west from the centre of the site, heading off-site and culverted beneath the tracks. The drain is fed by a stream originating on the western boundary of the site at a new waste-water treatment works.

By 1987, the tracks have been removed, though the culverted drain and stream remain. By 1992, the culverted drain is no longer shown as a contiguous feature, remaining intact only up to the southern site boundary, as Oak Drive has now been constructed. The Environment Agency Detailed River Network Map (included in Appendix B) shows that the stream is culverted again beneath Oak Drive.

There are no further significant changes shown on the historical maps to the present day.

4.3 Surrounding Area

On the earliest available map of 1884, the area surrounding the site is clearly rural, with the only sign of any development being Bellington Farm, 300m south-east; Newhouse Farm, 500m north-east; the village of Elmley Lovett, 1km south-east; the north-north-west to south-south-east trending Great Western Railway line, some 550m west and the (Hartlebury) Brick Works located 1.1km north-west of the site.

The area remains essentially unchanged until 1970, when the Hartlebury Trading Estate has been constructed and a new waste-water treatment works is shown on the western site boundary.

By 1991, a clay pit is shown immediately off-site to the north (the present-day Biffa Waresley Landfill Site).

Some remodelling of the trading estate occurred in 1992, with the construction of Oak Drive along the site's southern boundary. The site layout then remained unchanged until sometime between 2000 and 2006, when new industrial units were constructed to the south-east of the site.

There are no further significant changes to the immediate site area to the present day.

4.4 Potential Contamination Sources (Historic)

An assessment of sources of potential contamination at the site and in the vicinity of the site is presented in Table 4.1.

Table 4.1 Summary of potential contaminative land uses on site and in surrounding areas (Historic)

Potentially Contaminative Use	Potential Contaminative Source	Potential Contaminants	Ability to Impact Site?
On Site			
Former Railway running through the centre of the site	Spillages from carriages/wagons, including waste materials from surrounding industrial activities	Heavy metals, hydrocarbons, inorganic chemicals, organic chemicals, asbestos	Yes – While the tracks have been removed, potentially contaminated soil beneath the former tracks may remain on site. However, organic contaminants may have mostly naturally attenuated given timescale since dismantling of railway. Metals likely to be bound to clay minerals and organic matter in soil and will not migrate far from the source. Asbestos will not migrate in the soil and will cause localised contamination only
Surrounding Area			
No historic sources identified as all potential contaminative sources remain current and are therefore addressed in Table 2.2			

5 SITE SENSITIVITY

The following sections detail the site's environmental and geotechnical sensitivity with regards to geology, mining, hydrogeology, hydrology and ecology.

5.1 Geology

Published Geology

The 1:50,000 scale British Geological Survey (BGS) Digital Geological Maps for the area, as provided within the Envirocheck Report (Appendix B), have been used to identify the likely underlying geological conditions at the site.

Superficial deposits are not shown on the geological map, as there is an insignificant thickness. The solid geology beneath the topsoil and subsoil is shown to comprise mudstone of the Mercia Mudstone Group (MMG).

Further details on the ground conditions on site and in the vicinity of the site (1km to the NW), have been obtained from an on-site ground investigation (undertaken in 2006, Ref. 3) and from a BGS report on the Hartlebury Landfill site located 800m to 1km north-west (Ref. 4). These sources confirm that the site is underlain by between 5m and 7m of superficial deposits (average of 6.2m), comprising an uppermost stratum of Made Ground, overlying firm to stiff clay. Bedrock is initially comprised of weak, red-brown mudstone (as part of the Mercia Mudstone Group). More detailed geological classification for the area is obtained from the BGS report, which confirms the solid geology of the MMG in the area as comprising an uppermost stratum of the Sidmouth Mudstone Formation (~up to 30m thick) and a lowermost stratum of the Tarporley Siltstone Formation (~up to 20m thick). The MMG is underlain by the Bromsgrove Sandstone Formation at depths ranging from 30m to 60m below ground level (bgl).

The National Soil Resources Institute Soils Site Report (Appendix D) states that the soils on site comprise reddish, loamy or fine, silty over clayey soils with slowly permeable subsoils and slight seasonal waterlogging.

5.2 Hydrogeology

5.2.1 Groundwater Vulnerability

The National Soil Resources Institute Soils Site Report classifies the soil on site as having an intermediate leaching potential. These are soils, which have a moderate ability to attenuate a wide range of diffuse source pollutants but in which it is possible that some non-adsorbed diffuse source pollutants and liquid discharges could penetrate the soil layer.

The Envirocheck Report classes the underlying Geology as a Non-Aquifer (Negligibly permeable), which would correspond with the identified geology. Non-aquifers are formations, which are generally regarded as containing insignificant quantities of groundwater. However, groundwater flow through such rocks, although imperceptible, does take place and needs to be considered in assessing the risk associated with persistent pollutants.

5.2.2 Groundwater Abstractions

There are no licensed groundwater abstractions recorded within a 500m radius of the site and the site does not lie within a Groundwater Source Protection Zone.

5.3 Hydrology

5.3.1 Nearby Surface Water Features

A stream/drainage ditch is shown to issue at the western site boundary, which then heads eastward to the centre of the site, before turning southward (the culverted drain) and flowing off-site southward through a culvert.

The nearest primary river feature is located approximately 800m south-east, and is named the Elmley Brook. There are no water quality sampling points recorded for the brook.

5.3.2 Surface Water Abstractions

There are no licensed surface water abstractions recorded within 1km of the site.

5.3.3 Discharge Consents

There is an active discharge consent for the waste-water treatment works bordering the west of the site, for the discharge of final/treated effluent to the Little Acton Brook.

There are four more discharge consents for processes located within 1km of the site. These are listed in the Envirocheck Report datasheets, contained within Appendix B of this report.

5.3.4 Pollution Incidents to Controlled Waters

There have been a total of 11 recorded pollution incidents to controlled waters within 1km of the site. All were regarded as Category 3 (Minor Incidents) and related mainly to the release of oils, solvents and detergents.

A full list of the incidents is located within the datasheets of the Envirocheck Report contained within Appendix B of this report.

5.3.5 Flooding

Information contained within the Envirocheck Report shows that the site does not lie within the zone of potential flooding from rivers. There are no recorded flood defences or floodwater storage areas shown within 1km of the site.

5.4 Sensitive Land Use

There are no ecologically sensitive areas recorded within 1km of the site. However, the site is located in an area of Adopted Green Belt and within a Nitrate Vulnerable Zone.

5.5 Environmental Sensitivity summary

Groundwater sensitivity: low

The site overlies a non-aquifer, there are no groundwater abstractions within a 500m radius of the site and the site is not located within a groundwater source protection zone.

Surface Water Sensitivity: High

A stream/drainage ditch is located in the centre of the site, which discharges to a watercourse via a series of culverts, approximately 600m south-west of the site.

Ecological Sensitivity: Low

The site itself is not designated for its ecological importance and an ecological assessment undertaken on the site in 2004 (Refs. 1 & 2) states the following:

- No evidence of Water Vole activity in or adjacent to the north to south running ditch in the centre of the site;
- Holes and crevices that were accessible within the study area did not demonstrate any evidence of being used by bat species, though bat roosts are anticipated in the woodland to the east of the site;
- There are no waterbodies on site suitable for great crested newt; a partly culverted ditch running through the site does not constitute suitable habitat;
- A careful search of the site produced no evidence of use by any other protected species;
- No species with special protection under Schedule 1 of the 1981 Wildlife and Countryside Act, or Annex I of the EU Birds Directive were recorded on or in the vicinity of the site;
- The field surveys work did not identify the presence of any plant species or habitats protected by law, or considered rare in the UK;
- There is a small stand of Japanese knotweed on site, which will impose some constraints on the timing and methods of site clearance.

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6 ENVIRONMENTAL RESTRICTIONS & EXISTING ON-SITE HAZARDS

6.1 Storage of Hazardous Materials

The historical maps show that railway lines were once present running through the centre of the site. As such, it is possible that hazardous materials were stored in rolling stock, and may have leaked into the underlying soil.

6.2 Ground Conditions

While there has been little development on the site historically, the ground levels have been artificially raised, particularly in the south-west of the site, where approximately 3m of Made Ground was encountered (see Ref. 3). Adjacent to this area is a mound, approximately 3m high, from which in excess of 4.3m of Made Ground was encountered in a trial pit excavated on top of the mound. Elsewhere on the site, the thickness of Made Ground is significantly reduced, to the order 1m to 2m.

The site is therefore not level in places, with a mounded area in the south-west and a ditch up to 2m deep in the centre.

6.3 Contaminated Land

As part of the ground investigation undertaken on site in 2006 (see Ref. 3), contamination testing was undertaken on selected samples, however the location of these sampling points is not known (the ground investigation was not undertaken by HCL). Nevertheless, laboratory analysis on the recovered samples has confirmed that the results were below the relevant soil guideline values for hydrocarbons and most metals. The only exceptions were elevated copper and zinc values, however these metals are not normally considered harmful to human health (though they are recognised phytotoxins).

During the excavation of one trial pit, asbestos cement board was found, however this was an isolated occurrence.

Groundwater samples were also analysed, with the all substances tested falling below the relevant threshold values or below the laboratory detection limit. The only exception was a single sulphate result.

As the locations of the above contamination soil sampling points are unknown at present, the conceptual site model in Section 7 will assume that no contamination testing has taken place on site.

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7 CONCEPTUAL MODEL & QUALITATIVE RISK ASSESSMENT

7.1 Introduction

Irrespective of the degree of contamination, current guidelines require a systematic approach to the assessment of contamination. This is achieved by developing a conceptual model.

The conceptual model identifies the pollutant linkages that may exist by highlighting the relationships between the contaminants, pathways and receptors and how these are linked together.

A **contaminant** may be defined as

A substance which is in, on or under the land and which appears to be causing significant harm or may cause significant harm to receptors, or pollution of controlled waters is being caused or is likely to be caused.

A **receptor** may be defined as either:

(a) *Human Health*

(b) *A living organism, a group of organisms or an ecological system.*

(c) *A piece of property which is being, or could be, harmed, by a contaminant;* or

(d) *Controlled waters, which are being, or could be polluted by a contaminant.*

A **pathway** may be defined as

One or more routes or means by, or through, which a receptor:

(a) Is being exposed to, or affected by a contaminant, or

(b) Could be so exposed or affected.

Where a pathway can expose an identified receptor to an identified contaminant, a pollution linkage is formed. All three elements must be present for a pollutant linkage to exist.

The following sections detail the method of assessment and the conceptual model assessing the potential contaminative sources, the potential pathways and the identified receptors.

7.2 Qualitative Risk Assessment

Risk assessment is the process of collating known information on a hazard or set of hazards (to determine the potential severity of any impact) along with details on the likelihood of impact on detailed receptors. Risks are generally managed by isolating the receptor or by intercepting or interrupting the exposure pathway, so no pollutant linkages are formed and there can be no risk. The following section focuses on the potential hazards or contaminants identified on site and indicates whether they may be able to impact a nearby receptor.

The assessment of risk presented is based upon the procedure outlined in the Department for Environment, Food and Rural Affairs (DEFRA), Statutory Guidance on Contaminated Land (Ref. 5).

The guidance states that the designation of risk is based upon a consideration of both:

- The likelihood of an event (probability); [takes into account both the presence of the hazard and the receptor and the integrity of the pathway], and
- The severity of the potential consequence [takes into account both the potential severity of the hazard and the sensitivity of the receptor].

Under such a classification system, the following categorisation of risk has been developed and the terminology adopted as follows:

Table 7.1 Summary of Risk Classification Categories

Term	Description
Very High Risk	There is a high probability that severe harm could arise to a designated receptor from an identified hazard at the site without appropriate remedial action.
High Risk	Harm is likely to arise to a designated receptor from an identified hazard at the site without appropriate remedial action.
Moderate Risk	It is possible that without appropriate remedial action, harm could arise to a designated receptor but it is relatively unlikely that any such harm would be severe and if any harm were to occur it is likely that such harm would be relatively mild.
Low Risk	It is possible that harm could arise to a designated receptor from an identified hazard but it is likely that at worst this harm, if realised, would normally be mild.
Negligible Risk	The presence of an identified hazard does not give rise to the potential to cause significant harm to a designated receptor.

The risk assessment has been undertaken to determine the likely levels of environmental risk associated with development of the site. More general environmental risks arising from the land associated with current use are outside the scope of this work.