

GRM Development Solutions
Laurus House
First Avenue
Centrum 100
Burton upon Trent
Staffordshire, DE14 2WH
www.grm-uk.com

t. 01283 551249
f. 01283 211968
e. info@grm-uk.com



CREASE DROVE, CROWLAND

CONTROLLED WATERS DETAILED QUANTITATIVE RISK
ASSESSMENT (DQRA)
FOR
PARTNER CONSTRUCTION LTD &
WATERLOO HOUSING GROUP LTD

Project Ref:
P8723

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Waterloo Housing Group Ltd
1700 Solihull Parkway
Birmingham Business Park
Solihull B37 7YD

Prepared for:
Partner Construction Ltd
19 Mallard Way
Derby
DE24 8GX

This report has been prepared in accordance with GRM's Accredited Quality Procedures

Prepared by:	Reviewed by:	Approved by:
Sonia Singh BSc (Hons) (Engineering Geologist) sonia.singh@grm-uk.com	Siobhan Jackson BSc (Hons) MEnvSc (Principal Geo-environmental Scientist) siobhan.jackson@grm-uk.com	Richard Upton BSc MSc CEnv (Director) richard.upton@grm-uk.com



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1 INTRODUCTION

1.1 PREAMBLE

GRM Development Solutions Ltd (GRM) was appointed by Partner Construction Ltd and Waterloo Housing Group Ltd to undertake a Controlled Waters Detailed Quantitative Risk Assessment (DQRA) of the hydrocarbon contamination located in the south western part of the site.

GRM Standard Limitations of reporting are provided in Appendix A of this report.

The site is located to the east of Crease Drove, approximately 350m north of the intersection with Harvester Way and comprises an area of approximately 1.5Ha. The National Grid Reference (NGR) for the approximate centre of the site is TF 237 096. The site is presently partially occupied across the western half by adjoined warehouses comprising an approximate area of 60m long by 25m wide with associated concrete and tarmac/asphalt hardstanding to the west, south and locally east.

The Client proposes to develop the site with residential properties with associated gardens, soft landscaping, infrastructure and a balancing pond. The outline development proposals provided by the Client are presented in Appendix B. A Site Location Plan and Boundary Plan is presented in Appendix C.

The aim of this report is to determine if the site poses a risk to controlled waters and provides remedial options as appropriate to the residential end-use. A separate report, under the title Remedial Strategy, has been prepared which summarises the risks towards controlled waters and human health and the recommended remedial measures.

A desk study, initial intrusive ground investigation, supplementary ground investigation and a program of gas monitoring have previously been undertaken by GRM, which have been used in preparation of this document:-

- Phase I Site Appraisal (Desk Study), Ref: GRM/P8723/DS.1, dated December, 2018.
- Phase II Site Appraisal Report, Ref: GRM/P8723/F.2, dated July, 2019.
- Gas Addendum Letter, Ref: P8723\PEL\GAL, dated March 2019.

1.2 OBJECTIVES OF THIS ASSESSMENT

The principal aims of the Detailed Quantitative Risk Assessment are as follows:

- a) Assess the existing information relating to the geological, hydrogeological and hydrological conditions within the area of the site.
- b) Assess the risks to controlled waters receptors.

- c) Determine the need for remedial action and where necessary, derive remedial target values for soil and groundwater which will not pose an unacceptable risk to the identified controlled water receptors.

Whilst every effort has been made to pre-empt the likely requirements of the Local Authority and the Environment Agency, they are likely to have specific requirements that will need to be discussed and addressed at a later date.



2 SUMMARY OF INTRUSIVE INVESTIGATIONS

Historically, the site and surrounding area comprised open agricultural land with the exception of a corn mill approximately 150m east of the development area. By 1950, several buildings were constructed approximately 70m from the site. The development of the site commenced 1973-1975 and included the construction of the existing warehouse in the western area and an approximately 100m long drainage ditch, parallel to the southern site boundary. An additional warehouse was constructed in 1995, and it remained until 2012 when it was demolished and the drainage channel was backfilled. Following this, the site remained unchanged until the present day.

GRM undertook ground investigation works in December 2018, in order to determine the existing ground conditions and contamination risk associated with the on-site developments. The works comprised a total of seven exploratory holes (six windowless sample boreholes WS01 to WS04, WS06 and WS07 and one hand-dug trial pit HD05) to depths ranging between 0.25m and 4.45m below existing ground level (begl). The ground investigation works revealed:

- Hydrocarbon contamination in the southwestern part of the site (identified in WS06) which was recorded in the soils and groundwater.
- pH impacted made ground below the service yard.
- Unknown material below the footprint of the existing warehouses (post-demolition investigation/inspection required).
- Low strength Peat strata across the southern part of the site.
- Shallow groundwater and unstable ground.

Further to the above the Client was made aware by the Local Authority that remediation of a former chemical works, located some 115m to the east, is currently being undertaken, specifically relating to volatile organic compound (VOC) contamination in soils. As such it was proposed that baseline measurements for a range of commonly occurring contaminants and specifically VOCs be taken in the groundwater below the subject site.

Following the initial investigation, the site tenant advised GRM of an underground drainage tank in the southwest corner of the site adjacent to WS06, where elevated concentrations of hydrocarbon contaminated soils were identified. Although not currently in use, it is understood that the tank is connected to the warehouse and was used for sink water and toilet drainage purposes. However, it was not possible to locate the service hatch of the tank due to overgrown vegetation at the time of the investigation in December 2018. Additional information identified a further three service hatches along the southern site boundary.

In order to assess the risk to human health and controlled waters and further investigate the ground for geotechnical purposes, supplementary ground investigation works were undertaken in June 2019. This involved 22 exploratory holes (ten windowless sample boreholes WS101-110, four hand-held window sample boreholes HH101-104, two cable percussion BH101-BH102, four trial

trenches TT101-104 and two trial pits TP101-102), spread across the site, to depths ranging from 0.6m to 15.0m begl.

Boreholes WS101, WS102, WS109 and WS110 were progressed in areas of soft landscaping along the southern boundary, where service hatches indicated the location of below ground drainage tanks. During the investigation, the service hatches were opened in order to determine the presence of hydrocarbon contamination. Two of the three were opened; the remaining hatch was not opened due to a heavy metal cover. Of the two that were opened, one was filled with water and the other contained drainage pipes that were clogged with rubbish. No visual or olfactory evidence of hydrocarbon contamination was recorded within these hatches. Multiple service hatches could indicate there may be more than one drainage tank in the south west area of the site. Further chemical testing of soils and groundwater were also undertaken to further assess the risks.

It should be noted that during both the initial and supplementary investigation, areas not accessible at the time included to the north of the existing warehouses (northwest corner of the site).

GRM concluded;

- The risk to human health was considered to be low from general soil contamination assuming a proposed residential end-use and based on current site levels.
- The gas regime was initially assessed as CS2.
- Hydrocarbon-impacted Peat is a source of contamination and poses a potential risk to controlled waters receptors.
- The Abbey Sand and Gravel (Secondary A Aquifer) and River Welland are considered to be the most sensitive receptors.
- The risk from VOCs was assessed as being very low and is therefore not considered further in this report.

The initial and supplementary exploratory hole locations and all exploratory hole logs are included in Appendix D and E, respectively.

2.1 GROUND CONDITIONS

The relevant BGS geological map and nearby borehole data (TF20NW21 located to the west of Crease Drove, immediately across from the site, at NGR 523640, 309640) indicates the site to be underlain by superficial deposits of the Abbey Sand and Gravel (comprising sand and gravel) in the northern and western area, and Peat (potentially organic-rich clay) in the south and east. These deposits are underlain by the solid strata of Oxford Clay (comprising mudstone weathered to clay at shallower depths) across the entire site.

During the investigations, topsoil was encountered in exploratory holes WS01 to WS03 and TT103 to TT104 to depths of between 0.3m and 0.6m begl.

Where topsoil was not encountered, made ground was encountered from surface to proven depths of between 0.25m (WS106) and 1.6m (BH101). The full depth of made ground was unproven in WS102 and WS108 and exceeded 4.0m. The made ground typically comprised mixed lithology with gravels of brick, concrete, quartzite, mudstone, chalk, ceramic, metal and asphalt. Within the south western areas, hydrocarbon odours, stainings and a surface sheen were noted between 2.8m and 3.0m in the made ground.

Peat was encountered below the made ground/topsoil in most exploratory holes although it was locally absent in the central and eastern area of the site. It was proven to between 0.55m and 2.8m begl with its stratum thickness increasing towards the south east and south west of the site. It typically comprised soft to firm and occasionally very soft and stiff, grey brown, dark brown and grey occasionally stained black (due to the hydrocarbon contamination in the south western area), slightly gravelly clay with occasional decomposed fibrous plant material and organic odours. The layer was locally observed to be loose to medium dense clayey sand in WS01, WS105, WS107 and HH104 with its thickness ranging from 10cm up to 40cm.

Abbey Sand and Gravel deposits were encountered below the Peat or made ground in most exploratory holes. It was proven in some locations to depths of between 1.6m and 3.2m begl. It dominantly comprised slightly clayey sandy gravel with occasional bands of gravelly sand, generally increasing in gravel content with depth. An occasional upper bed of soft to stiff sandy gravelly clay was encountered typically where Peat was depleted or absent.

Glacial Till was locally encountered in WS06, TP101 and BH101 and comprised slightly gravelly clay with gravel of chalk and rare flint.

Below the superficial strata, the solid geology of Oxford Clay was encountered in exploratory holes WS101, WS104, WS105, WS110, TP101, BH101 TT101-N, TT102, BH102, WS03, WS04 and WS06 from depths ranging between 1.6m and 3.2m begl. It typically comprised of stiff becoming very stiff, dark grey clay with occasional limestone, chalk and mudstone gravel at the upper part of the strata.

A Schematic Geological Cross-Section of the underlying geology below the site is shown in Appendix F.

2.2 GROUNDWATER MONITORING RESULTS

The initial groundwater monitoring rounds were undertaken between December 2018 and February 2019 from five boreholes (WS01 to WS04 and WS06). A further three standpipes were installed during the supplementary investigation (BH101, BH102 and WS109) and two additional rounds were undertaken in June and August 2019. Groundwater monitoring standpipe locations and groundwater level results are presented in Appendix G and H.

Data from the on-site monitoring wells installed after the supplementary investigation indicates that the depth to groundwater is typically between 0.0m (from

surface) and 1.42m begl with groundwater elevations ranging from 0.15m AOD to 1.79m AOD as indicated in Table 1 below.

Table 1: Summary of recent Water Monitoring Results

Well	Screened Lithology / Response Zone	18-Jun-19		15-Aug-19	
		Water level (m begl)	Water level (m AOD)	Water level (m begl)	Water level (m AOD)
BH101	AB	0.74	0.95	1.27	0.42
BH102	OX	1.12	0.51	1.42	0.21
WS01	PEAT	0.68	0.75	1.28	0.15
WS02	MG/PEAT	Not found in the recent monitoring rounds due to overgrown vegetation			
WS03	AB	0.00	1.54	0.77	0.77
WS04	AB	0.00	1.62	0.42	1.20
WS06	PEAT	0.60	1.79	1.10	1.29
WS109	AB	0.62	1.52	1.31	0.83

MG – Made Ground

AB – Abbey Sand and Gravel

OX – Oxford Clay

A downhole oil/water interface probe was used during the first groundwater monitoring visit (8th January 2019) and free phase hydrocarbons were not detected, although a surface sheen was observed in WS06 when sampling with the low-flow pumping equipment.

Based upon the monitoring data, groundwater is present in both the Peat and Abbey Sand and Gravel and has been found to be similar in depths across the site, therefore indicating it is the same continuous groundwater body below the site.

Based on the groundwater elevations, there is a shallow hydraulic gradient towards the north west (towards the River Welland and New River) and a minor trend to the south east where a dry land drain is present along the southern boundary of the site. The Schematic Cross Section (presented in Appendix F) illustrates the groundwater table based on fieldwork data. Groundwater contours have also been plotted which are based on monitoring data and are presented in Appendix H.

For the purposes of this assessment, using groundwater elevations data, the groundwater within the Abbey Sand and Gravel is approximated to be flowing north west towards the identified rivers and has a calculated hydraulic gradient of 0.0365.

Rising head tests were conducted on 15th August 2019 in WS03 and WS04 where installs targeted the Abbey Sand and Gravel in known areas of uncontaminated soils based on the initial and supplementary ground investigations. The data has been analysed and used to calculate the hydraulic conductivity for the Abbey Sand and Gravel (Appendix I) which is summarised below:

- WS03 – 2.34×10^{-6} m/s (0.20m/d)
- WS04 – 2.59×10^{-6} m/s (0.22m/d)

Based on the variability and the presence of fines (silt and clay) within the lithology of Abbey Sand and Gravel, the calculated hydraulic conductivity values detailed above are to be expected.

2.3 CHEMICAL ANALYSIS RESULTS

2.3.1 Soil

Assessment of the chemical analysis results suggests the made ground, topsoil and peat recorded no metal or Polycyclic Aromatic Hydrocarbons (PAHs) contaminants in excess of their respective soil threshold values (Tier 1 Acceptance Criteria for residential with plant uptake, TACs). This is fully discussed in the Phase II assessment reports.

Asbestos and pesticides were not detected in any of the soil samples screened.

Hydrocarbon analysis has identified elevated TPH concentrations of up to 2,800mg/kg within the Peat in WS06 and WS109 where most visual and olfactory evidence of hydrocarbon was identified. The majority of the TPH concentrations are present within the Aromatic and Aliphatic carbon bands C12-C16, C16-C21 and C21-C35.

A summary of the hydrocarbon chemical results are shown in Table 2.

Copies of the chemical analysis results and GRM TACs (for reference) are presented in Appendix J and K respectively.

Table 2: Summary of the 2018 and 2019 Soil Chemical Analytical Results

Contaminant	Concentration Range (mg/kg)
Aliphatic >C ₅ -C ₆	<0.003 – 0.14
Aliphatic >C ₆ -C ₈	<0.003 – 2.3
Aliphatic >C ₈ -C ₁₀	<0.003 – 18
Aliphatic >C ₁₀ -C ₁₂	<10 – 200
Aliphatic >C ₁₂ -C ₁₆	<10 – 720
Aliphatic >C ₁₆ -C ₂₁	<10 – 790
Aliphatic >C ₂₁ -C ₃₅	<10 – 180
Aromatic >C ₅ -C ₇	<0.003
Aromatic >C ₇ -C ₈	<0.003
Aromatic >C ₈ -C ₁₀	<0.003
Aromatic >C ₁₀ -C ₁₂	<10 – 93
Aromatic >C ₁₂ -C ₁₆	<10 – 470
Aromatic >C ₁₆ -C ₂₁	<10 – 490
Aromatic >C ₂₁ -C ₃₅	<10 – 140

2.3.2 Groundwater

Groundwater sampling was taken during the first monitoring, seventh and eighth monitoring rounds (January, June and August 2019).

Table 3: Summary of field data using low flow sampling techniques taken during groundwater sampling (18/06/2019).

Location	pH	Temperature °C	Conductivity $\mu\text{S/cm}$	Dissolved Oxygen mg.L^{-1}	Redox (ORP) mV
BH101	7.25	13.87	2,194.10	9.86	-93.2
WS01	5.19	13.95	77.6	8.90	126.3
WS03	6.94	12.49	1,892.30	0.08	-57.4
WS04	6.95	16.32	21.50	9.89	-22.1
WS06	6.79	14.62	940.74	0.26	-199.8
WS109	7.80	26.53	8.41	8.14	50.4

The groundwater analytical results are compared against the UK Drinking Water Standards (UKDWS) and Environmental Quality Stands (EQS) and are summarised in Table 4. Where no UK DWS or EQS is available World Health Organisation (WHO) values have been used.

Table 4 shows the hydrocarbon fractions present within the groundwater samples taken in 2018 and 2019.

Groundwater samples confirm the presence of TPH contamination in groundwater, as shown in Table 4 in samples taken from WS06 and WS109 where exceedances of aliphatic and aromatics bands C12-16, C16-C21 and C21-C35. Given that both soils and groundwater are significantly contaminated with hydrocarbons in WS06 and WS109 with the same TPH fractions recorded to be elevated, it is considered that the hydrocarbon impacted soils are acting as a continuous source of contamination to the groundwater. Chromatographs of the groundwater samples taken from WS06 and WS109 suggest that the hydrocarbon contamination is predominantly in the range of C12-C21 and is likely to be of fuel oil in origin (provided in Appendix J).

A plan showing general groundwater contamination exceedances is presented in Appendix L. Based on the recorded contamination exceedances, the Remediation Plan shows the potential extent of hydrocarbon impacted soils in the vicinity of WS06 and WS109 and is presented in Appendix M. The approximate locations of the service hatches associated with the potentially disused drainage tank(s) are also shown on the plan. It should be noted, however, that significant hydrocarbon contamination were not observed beneath the service hatches, and therefore it is not considered to be a source of hydrocarbon contamination.

The concentrations of some of the TPH fractions detected in the groundwater samples are above their respective aqueous solubility limits (see Table 5 below). The highest concentrations are likely caused by non-aqueous phase liquid (NAPL) becoming entrained in the sample due to the sampling and testing process undertaken and are not considered representative of the dissolved phase concentrations within the groundwater at the site.

Table 4: Summary of Groundwater Chemical Analysis Results

Client Sample Location			WS06	WS01	WS03	WS04	WS06	WS109	BH101	BH102	WS01	WS03	WS04	WS06	WS109
Date of Sampling			05/12/18	18/06/19	18/06/19	18/06/19	18/06/19	18/06/19	14/08/19	14/08/19	14/08/19	14/08/19	14/08/19	14/08/19	14/08/19
Sample Type			Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
Determinant	DWS ^a	EQS ^b / EAL ^c													
Arsenic (dissolved)	10	50 ^b	-	< 3	< 3	< 3	7	-	-	-	-	-	-	-	-
Cadmium (dissolved)	5	0.25 ^b	-	< 3	< 3	< 3	< 3	-	-	-	-	-	-	-	-
Chromium (dissolved)	-	3.4 ^b	-	< 3	< 3	< 3	< 3	-	-	-	-	-	-	-	-
Copper (dissolved) (mg/l)	2	1 ^b	-	< 1	< 1	< 1	< 1	-	-	-	-	-	-	-	-
Iron (dissolved)	200	100 ^{b0}	-	76	< 10	< 10	8900	-	-	-	-	-	-	-	-
Lead (dissolved)	10	1.2 ^b	-	< 5	< 5	< 5	< 5	-	-	-	-	-	-	-	-
Mercury (dissolved)	1	0.07 ^b	-	< 1	< 1	< 1	< 1	-	-	-	-	-	-	-	-
Nickel (dissolved)	20	4 ^b	-	39	< 3	< 3	9	-	-	-	-	-	-	-	-
Selenium (dissolved)	10	7.5 ^b	-	< 1	< 1	< 1	< 1	-	-	-	-	-	-	-	-
Zinc (dissolved)	5000	10.9 ^b	-	< 5	< 5	< 5	< 5	-	-	-	-	-	-	-	-
Phenol (Total)	0.5	7.7 ^b	-	< 0.80	< 0.80	< 0.80	< 0.80	-	-	-	-	-	-	-	-
Cyanide (Total)	50	1 ^b	-	< 1	< 1	< 1	< 1	-	-	-	-	-	-	-	-
Sulphate (as SO4)	250	-	-	1200	820	580	54	-	-	-	-	-	-	-	-
Benzo (a) pyrene	0.01	0.00017 ^b	-	< 0.01	0.02	< 0.01	0.02	-	-	-	-	-	-	-	-
Benzo (b) fluoranthene	0.1	-	-	< 0.01	< 0.01	0.01	0.01	-	-	-	-	-	-	-	-
Benzo (g, h, i) perylene	0.1	-	-	< 0.01	0.01	< 0.01	0.01	-	-	-	-	-	-	-	-
Benzo (k) fluoranthene	0.1	-	-	< 0.01	0.02	< 0.01	0.02	-	-	-	-	-	-	-	-

Client Sample Location			WS06	WS01	WS03	WS04	WS06	WS109	BH101	BH102	WS01	WS03	WS04	WS06	WS109
Date of Sampling			05/12/18	18/06/19	18/06/19	18/06/19	18/06/19	18/06/19	14/08/19	14/08/19	14/08/19	14/08/19	14/08/19	14/08/19	14/08/19
Sample Type			Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
Determinant	DWS ^a	EQS ^b / EAL ^c													
Indeno (1, 2, 3,-cd) pyrene	0.1	-	-	< 0.01	0.02	< 0.01	0.02	-	-	-	-	-	-	-	-
Naphthalene	-	2 ^b	-	0.07	< 0.01	< 0.01	0.04	-	-	-	-	-	-	-	-
Aliphatics >C ₅ to C ₆	-	15000 ^c	< 0.10				< 0.10	< 0.10	3.18	2.26	1.44	4.41	4.52	8.87	3.63
Aliphatics >C ₆ to C ₈	-	15000 ^c	< 0.10				< 0.10	< 0.10	8.97	11.2	9.48	11.5	13.2	21.4	14.5
Aliphatics >C ₈ to C ₁₀		300 ^c	< 0.10				< 0.10	< 0.10	3.61	3.9	1.35	4.72	2.62	5.33	2.89
Aliphatics >C ₁₀ to C ₁₂		300 ^c	105				< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00
Aliphatics >C ₁₂ to C ₁₆	-	300 ^c	1380				< 10.00	< 10.00	< 10.00	< 10.00	< 10.00	< 10.00	< 10.00	< 10.00	93.1
Aliphatics >C ₁₆ to C ₂₁	-	300 ^d	2800				< 10.00	< 10.00	< 10.00	< 10.00	< 10.00	< 10.00	< 10.00	49.4	319
Aliphatics >C ₂₁ to C ₃₅	-	300 ^d	596				< 15.00	< 15.00	< 15.00	< 15.00	< 15.00	< 15.00	< 15.00	90.5	< 15.00
Aromatics >C ₅ to C ₇	-	10 ^{e,f}	< 0.10				< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatics >C ₇ to C ₈	-	74 ^{e,g}	< 0.10				< 0.10	< 0.10	0.07	0.04	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatics >C ₈ to C ₁₀	-	30 ^{e,h}	< 0.10				1	< 0.10	0.47	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatics >C ₁₀ to C ₁₂	-	90 ^c	44.1				< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	46.5
Aromatics >C ₁₂ to C ₁₆	-	90 ^c	652				< 10.00	< 10.00	< 10.00	< 10.00	< 10.00	< 10.00	< 10.00	58.1	335
Aromatics >C ₁₆ to C ₂₁	-	90 ^c	1720				< 10.00	< 10.00	< 10.00	< 10.00	< 10.00	< 10.00	< 10.00	77.3	288
Aromatics >C ₂₁ to C ₃₅	-	90 ^c	428				112	< 15.00	< 15.00	< 15.00	< 15.00	< 15.00	< 15.00	45	124
Total >C ₅ to C ₃₅	-	-	7700				110	< 30	< 30	< 30	< 30	< 30	< 30	360	1200

All concentrations are recorded in µg/L unless stated.

^a UK Drinking Water Standard (DWS). Statutory Instruments 2016 No. 614. Water, England and Wales. The Water Supply (Water Quality) Regulations 2016.

^b UK Freshwater EQS from <https://www.gov.uk/guidance/surface-water-pollution-risk-assessment-for-your-environmental-permit>

^c EAL for TPH fractions based on WHO, 2008. Petroleum products in drinking-water. Background document for development of WHO guidelines for drinking water quality as reported in CL:AIRE, 2017.

^d No guidelines are provided for these TPH fractions therefore EAL assumed to be the same as for previous aliphatic fractions.

^e Freshwater EQS from DEFRA & EA, 2018.

^f Freshwater EQS for benzene

^g Freshwater EQS toluene

^h Freshwater EQS xylene

BOLD - denotes an exceedance of water threshold



Table 5: Petroleum Hydrocarbon (TPHCWG) concentrations in comparison to aqueous solubility limits.

Client Sample Location			WS06			WS109		BH101	BH102	WS01	WS03	WS04
Date of Sampling			05/12/2018	18/06/2019	14/08/2019	18/06/2019	14/08/2019	14/08/2019	14/08/2019			
Sample Type			Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
Determinant	EAL	Max aqueous solubility ^a										
TPH Aliphatic >C5-C6	15000 ^b	35900	< 0.10	< 0.10	8.87	< 0.10	3.63	3.18	2.26	1.44	4.41	4.52
TPH Aliphatic >C6-C8	15000 ^b	5370	< 0.10	< 0.10	21.4	< 0.10	14.5	8.97	11.2	9.48	11.5	13.2
TPH Aliphatic >C8-C10	300 ^b	427	< 0.10	< 0.10	5.33	< 0.10	2.89	3.61	3.9	1.35	4.72	2.62
TPH Aliphatic >C10-C12	300 ^b	33.9	105	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00
TPH Aliphatic >C12-C16	300 ^b	0.759	1380	< 10.00	< 10.00	< 10.00	93.1	< 10.00	< 10.00	< 10.00	< 10.00	< 10.00
TPH Aliphatic >C16-C21	300 ^c	0.00254	2800	< 10.00	49.4	< 10.00	319	< 10.00	< 10.00	< 10.00	< 10.00	< 10.00
TPH Aliphatic >C21-C35	300 ^c	0.00254	596	< 15.00	90.5	< 15.00	< 15.00	< 15.00	< 15.00	< 15.00	< 15.00	< 15.00
TPH Aromatic >C5-C7	10 ^{d,e}	1780000	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
TPH Aromatic >C7-C8	74 ^{d,f}	590000	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	0.07	0.04	< 0.10	< 0.10	< 0.10
TPH Aromatic >C8-C10	30 ^{d,g}	64600	< 0.10	1	< 0.10	< 0.10	< 0.10	0.47	< 0.10	< 0.10	< 0.10	< 0.10
TPH Aromatic >C10-C12	90 ^b	24500	44.1	< 5.00	< 5.00	< 5.00	46.5	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00
TPH Aromatic >C12-C16	90 ^b	5750	652	< 10.00	58.1	< 10.00	335	< 10.00	< 10.00	< 10.00	< 10.00	< 10.00
TPH Aromatic >C16-C21	90 ^b	653	1720	< 10.00	77.3	< 10.00	288	< 10.00	< 10.00	< 10.00	< 10.00	< 10.00
TPH Aromatic >C21-C35	90 ^b	6.61	428	112	45	< 15.00	124	< 15.00	< 15.00	< 15.00	< 15.00	< 15.00
TPH Total	5000 ^h		7700	110	360	< 30	1200	< 30	< 30	< 30	< 30	< 30

All concentrations are recorded in µg/L unless stated.

^a Water solubility from Nathanail *et al*, 2015

^b EAL for TPH fractions based on WHO, 2008. Petroleum products in drinking-water. Background document for development of WHO guidelines for drinking water quality as reported in CL:AIRE, 2017.

^c No guidelines are provided for these TPH fractions therefore EAL assumed to be the same as for previous aliphatic fractions.

^d Freshwater EQS from DEFRA & EA, 2018.

^e Freshwater EQS for benzene

^f Freshwater EQS toluene

^g Freshwater EQS xylene

^h EQS value used is based upon the lower limit for discharge quality to surface water for oil separators as set out in the Environment Agency pollution prevention guidelines document on

"Use and design of oil separators in surface water drainage systems: PPG3 (Environment Agency, April 2006)

BOLD - denotes measured concentrations that exceed with the solubility.

3 QUANTITATIVE RISK ASSESSMENT – CONTROLLED WATERS

The potential risk to controlled waters arising from contamination in soil and groundwater has been quantitatively assessed using the Environment Agency's Remedial Targets Methodology (RTM) spreadsheet model. This section describes the modelling work undertaken.

3.1.1 Conceptual Site Model for Controlled Waters

The conceptual site model encompassing the hydrological and hydrogeological elements is based on available information including the results of the intrusive investigation works undertaken at the site. This section presents the conceptual site model which has been formulated to illustrate the linkages between the contaminant sources identified on site and the potential pathways and receptors which could be impacted by the contamination.

The conceptual site model for controlled waters receptors is summarised below:

3.1.2 Sources

The primary contamination source to controlled waters has been assessed to be the hydrocarbon impacted natural peat strata below the current commercial area confined to the south western area of the site. At this stage, the drainage tank(s) in the south west area of the site are not considered to be a definite source of hydrocarbon contamination. However, the disused drainage tank(s) are likely to be present within the area of hydrocarbon impacted soils and therefore will require removal.

It should be noted that based on the site investigation, the majority of the made ground across the current commercial area is not regarded as a significant source of contamination due to its limited thickness and it does not exhibit any obvious signs of contamination.

3.1.3 Pathways

Plausible pathways linking the on-site source of contamination to the receptors are discussed below:

- **Migration of NAPL.** The occurrence of a measurable significant thickness of free-product was not indicated during the monitoring rounds including within the hydrocarbon plume area.
- **Leaching/Dissolution.** Soil sorbed contamination may partition to pore water and migrate downwards with infiltrating rainwater to groundwater (for sources above the water table) or directly to groundwater for sources below the water table. The hydrocarbon contamination in soils and groundwater is predominantly heavy end (C16-35) hydrocarbons which have a low aqueous solubility and so dissolution into pore water is expected to be minimal. Partitioning of hydrocarbon constituents sorbed to soil into the dissolved phase is also expected to be minimal given the long-chain nature of the hydrocarbon contamination. The site area where the hydrocarbon plume is

present will be partially covered in hardstanding such as roads and houses, as part of the proposed development which will likely limit leaching of contaminants from soils above the water table.

- **Dissolved phase migration in groundwater.** Groundwater monitoring (see Section 2.2) indicates that groundwater in the Abbey Sand and Gravel is flowing to the north west with a calculated hydraulic gradient of 0.0365. Dissolved phase hydrocarbon contamination will migrate with groundwater flow but will be subject to natural attenuation processes (dispersion, retardation and biodegradation) which will limit the length of the plume.

The groundwater monitoring conducted at the site provides various lines of evidence that biodegradation of dissolved phase hydrocarbons is occurring along the groundwater pathway:

- **Primary evidence: Contaminant concentrations.** The concentrations of petroleum hydrocarbons in down-hydraulic gradient well, WS109 (total TPH of between <30-1200µg/L) are on average lower than the concentrations in the borehole considered to be the nearest to the source, WS06 (total TPH of between 360-7700µg/L).
- **Secondary evidence: Geochemical indicators.** The biodegradation of hydrocarbons requires the availability of electron acceptors which become reduced during the biodegradation process. Changes in the concentrations of electron acceptors or their reduced forms can be a potential indicator that biodegradation is occurring. Typically, dissolved oxygen is the first electron acceptor to be utilised, followed by nitrate (NO_3^{-1}), iron (Fe^{3+}) and manganese (Mn^{4+}), sulphate (SO_4^{2-}) and carbon dioxide (CO_2). A reduction in oxygen, redox, nitrate and sulphate and an increase in dissolved iron (Fe^{2+}), dissolved manganese (Mn^{2+}) and methane are all indicators of biodegradation occurring (Environment Agency, 2000).

The field readings (Table 3) of dissolved oxygen (0.26mg/L) and redox (-199.8mV) are very low in WS06 compared to the down gradient well WS109 (8.14mg/L and 50.4mV) and the other wells across the site. Therefore these are indicative of anaerobic conditions¹ in WS06 (the source well). As shown in Table 4, the concentrations of sulphate are notably lower in WS06 (54µg/L) in the source area compared to the other wells across the site (580 to 1200 µg/L). Conversely, the concentrations of dissolved iron are higher in WS06 (8900 µg/L) compared with the wells across the site with concentrations between <10 and 76µg/L. The reductions in oxygen, redox and sulphate and the increase in iron in WS06 are all geochemical indicators for the biodegradation of hydrocarbons in the source area.

3.1.4 Receptors

Plausible controlled waters receptors are discussed below:

- **Groundwater.** The Abbey Sand and Gravel is a primary receptor for the site given it is classified as a Secondary A Aquifer and as such, classed as

¹ Concentrations of dissolved oxygen of less than 1 mg/L are indicative of anaerobic conditions (Environment Agency, 2000)

containing permeable layers which are capable of supporting water supplies at a local rather than strategic scale, and in some cases may form an important source of base flow to rivers (i.e. River Welland). The Peat overlying the Secondary A Aquifer and the solid Oxford Clay strata below are classified as Unproductive Aquifers and therefore are not considered viable receptors for the site given these aquifers are unlikely to contain groundwater for water supply. The limited Glacial Till identified below the Abbey Sand and Gravel is a Secondary Undifferentiated Aquifer and is not considered to be a sensitive receptor given its dominantly cohesive nature. It is considered at Crowland that the River Welland and therefore the underlying groundwater are unlikely to be tidally influenced given the EA have designated Crowland within a freshwater flooding area. As such the groundwater and Secondary A Aquifer below the site are considered to be a receptor to site-derived contamination and have been considered in this risk assessment.

- **Surface water.** The nearest surface water feature is the drainage ditch along the southern boundary of the site and a number of drainage channels are identified further east associated with the whole area being designated as a wetland and that there are low site elevations. The nearest ditch was recorded to be dry during the monitoring rounds and therefore it is not considered to be a sensitive receptor and significant migration of any contamination would only occur during periods of flooding which would significantly dilute contaminants. New River and River Welland are located approximately 460m and 1.1km respectively to the north west of the site. Both rivers flow from south to north. New River enters the River Welland at Little London approximately 11.5km north of the site. New River has been highly modified and flows in part through a culvert and is partially surrounded by embankments, therefore it is uncertain if it is in hydraulic connection with the groundwater or whether groundwater discharges directly to the River Welland beyond. For the purposes of this assessment, both the New River and River Welland are considered to be plausible surface water receptors for site-derived contamination. It is considered that the Abbey Sand and Gravel (Secondary A Aquifer) is providing base flow to the River Welland and potentially to New River.

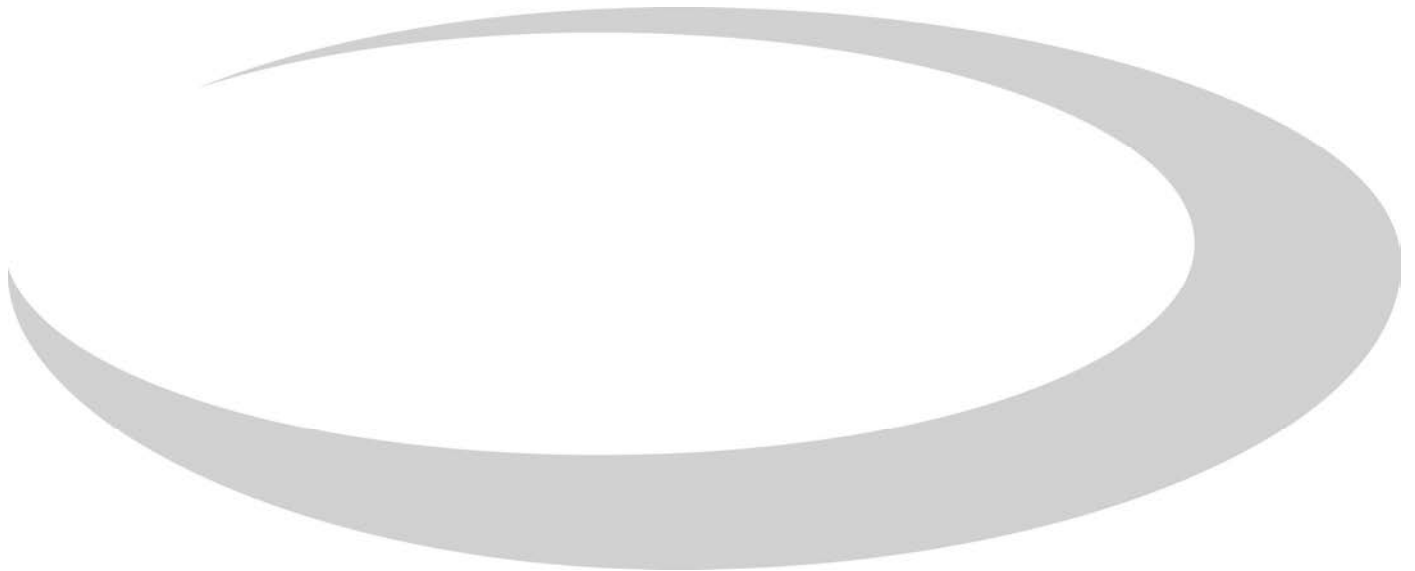
3.1.5 Plausible Contaminant Linkages

Based on the above, the following contaminant linkages (CLs) are considered plausible:

- CL1: NAPL has not been detected.
- CL2: Risk to the Abbey Sand and Gravel from dissolution/leaching of hydrocarbons from soil followed by migration of dissolved phase hydrocarbon constituents in groundwater.
- CL3: Risk to New River and River Welland from leaching/dissolution of contaminants to groundwater followed by dissolved phase migration in groundwater which then discharges to the rivers.

A schematic cross-section illustrating the conceptual site model and depicting these contaminant linkages is shown in Appendix N.

Based on the above assessment, there is an unacceptable risk from CL2 and CL3 and as such, the risk from CL2 and CL3 associated with the dissolved phase hydrocarbon migration in groundwater has been further assessed using the RTM as described below.



3.2 SELECTION OF CONSTITUENTS OF POTENTIAL CONCERN

The maximum contaminant concentrations of petroleum hydrocarbons in groundwater detected at the site (from samples obtained in 2018 and 2019) have been compared with water quality standards to make a generic assessment of the risk to controlled waters receptors (Table 4). Contaminants with maximum concentrations below the relevant water quality standards are considered unlikely to present a risk to controlled waters receptors and therefore do not need to be considered further. Contaminants with maximum concentrations above the relevant standards are considered contaminants of potential concern (COPC) and require further consideration or assessment.

It is noted that the concentrations of TPH detected in some of the groundwater samples are above aqueous solubility limits (see Table 5). This indicates that NAPL is likely to be present within the vicinity of these wells, but of very small quantities given that free phase has not been detected during the monitoring. The high concentrations recorded are likely caused by small quantities of NAPL becoming entrained in the sample and are not considered representative of dissolved phase concentrations in the groundwater at the site. Given that dissolved phase concentrations in groundwater are unlikely to exceed solubility limits, the maximum aqueous solubility has instead been compared with the water quality standards. Where the maximum measured concentration exceeds the maximum aqueous solubility but the solubility limits are lower than the EALs/EQS, these fractions have been discounted as COPC.

Table 7 below, summarises the TPH contaminants in groundwater. Given that surface water (New River and River Welland) and groundwater (Abbey Sand and Gravel) have been identified as plausible controlled waters receptors, the lowest of Environmental Quality Standards (EQS) for freshwater and Drinking Water Standards (DWS) have been used as the Environmental Assessment Limits (EALs).

Although dissolved benzo(a)pyrene in the groundwater was recorded above the EQS threshold, given that recorded concentrations were similar across the site and only slightly above laboratory limit of detection (see table 4), it is not considered to be a significant risk to controlled waters.

Table7: PAH and TPH Contaminants in Groundwater

Determinant	EAL µg/L	Max aqueous solubility ⁱ µg/L	Max Conc. in GW µg/L	COPC	Justification
Naphthalene	2 ^b	19000	0.07	No	No exceedances
Benzo(b)fluoranthene	0.1 ^c	2	<0.01	No	No exceedances
Benzo(k)fluoranthene	0.1 ^c	0.8	0.02	No	No exceedances
Benzo(a)pyrene	0.00017 ^b	3.8	0.02	Yes	Aqueous solubility exceeds EAL. Marginally above laboratory limit. Considered to be associated with the hydrocarbon impacted soils
Indeno(1,2,3-cd)pyrene	0.1 ^c	0.2	0.02	No	No exceedances
Benzo(ghi)perylene	0.1 ^c	0.26	0.01	No	No exceedances
TPH Aliphatic >C5-C6	15000 ^a	35900	8.87	No	No exceedances
TPH Aliphatic >C6-C8	15000 ^a	5370	21.4	No	No exceedances
TPH Aliphatic >C8-C10	300 ^a	427	5.33	No	No exceedances.
TPH Aliphatic >C10-C12	300 ^a	33.9	105	No	No exceedances
TPH Aliphatic >C12-C16	300 ^a	0.759	1380	No	Aqueous solubility less than EAL
TPH Aliphatic >C16-C21	300 ^d	0.00254	2800	No	Aqueous solubility less than EAL
TPH Aliphatic >C21-C35	300 ^d	0.00254	596	No	Aqueous solubility less than EAL
TPH Aromatic >C5-C7	10 ^{e, f}	1780000	<0.1	No	No exceedances
TPH Aromatic >C7-C8	74 ^{e, g}	590000	<0.1	No	No exceedances
TPH Aromatic >C8-C10	30 ^{e, h}	64600	1	No	No exceedances
TPH Aromatic >C10-C12	90 ^a	24500	46.5	No	No exceedances
TPH Aromatic >C12-C16	90 ^a	5750	652	Yes	Concentrations below the aqueous solubility Concentrations above EAL
TPH Aromatic >C16-C21	90 ^a	653	1720	Yes	Concentrations above solubility. Aqueous solubility exceeds EAL
TPH Aromatic >C21-C35	90 ^a	6.61	428	No	Aqueous solubility less than EAL

^a Unless stated otherwise EAL for TPH fractions based on WHO, 2008. Petroleum products in drinking-water.

Background document for development of WHO guidelines for drinking water quality as reported in CL:AIRE, 2017.

^b UK Freshwater EQS from <https://www.gov.uk/guidance/surface-water-pollution-risk-assessment-for-your-environmental-permit>

^c UK Drinking Water Standard (DWS). Statutory Instruments 2016 No. 614. Water, England and Wales. The Water Supply (Water Quality) Regulations 2016.

^d No guidelines are provided for these TPH fractions therefore EAL assumed to be the same as for previous aliphatic fractions.

^e Freshwater EQS from DEFRA & EA, 2018.

^f Freshwater EQS for benzene

^g Freshwater EQS toluene

^h Freshwater EQS xylene

ⁱ From Nathanail et al, 2015.

BOLD - denotes an exceedance of either DWS and / or EQS

Chemicals selected as COPC for the RTM modelling are as follows:

- TPH Aromatic >C12-C16
- TPH Aromatic >C16-C21

3.3 QUANTITATIVE CONTROLLED WATERS RISK ASSESSMENT

3.3.1 Introduction

The potential risk to the identified controlled waters receptors (Abbey Sand and Gravel and New River/ Welland River) arising from soil and groundwater contamination at the site has been quantitatively assessed using the Environment Agency's Remedial Targets Methodology (RTM) spreadsheet model (EA, 2006).

This section describes the modelling work undertaken.

3.3.2 Model Selection

The Environment Agency's RTM spreadsheet model can be used to:

- Forward predict concentrations at a compliance point from known concentrations in soil or groundwater for comparison with suitable environmental assessment levels (EALs); or
- Back-calculate remedial target values (RTVs). These are the calculated concentrations in soil or groundwater that are predicted to result in the concentration at the compliance point equal to the EALs.

For this assessment the RTM has been used to back-calculate RTVs for comparison with measured soil and groundwater concentrations at the site during remedial works.

The RTM spreadsheet model has various levels of assessment:

- Level 1 Soil - models the partitioning of contaminants between soil and pore-water (i.e. leaching). In level 1 the point of compliance is the pore-water within the soil source zone;
- Level 2 Soil - models dilution by leachate generated from contaminated soil in the unsaturated zone mixing with groundwater flowing beneath the site. In level 2 the point of compliance is groundwater within the "mixing zone" beneath the source;
- Level 3 Soil - models the migration of contaminants in groundwater (arising from leaching from soil contamination in the unsaturated zone) taking account of the natural attenuation processes of dispersion, retardation and degradation. In level 3 the point of compliance is at some distance down-hydraulic gradient of the source; and
- Level 3 Groundwater - models the migration of contaminants in groundwater from a groundwater source taking account of the natural attenuation processes of dispersion, retardation and degradation.

Given that hydrocarbon contamination is already present within the aquifer it is considered appropriate to base the RTVs on the Level 3 assessments. The distance to the compliance point down hydraulic gradient of the hydrocarbon source is assumed to be 50m. This compliance point has been chosen in accordance with Environment Agency guidance (EA, 2017a) and is considered appropriate given that the groundwater in the Abbey Sand and Gravel is already contaminated with hazardous compounds (heavy end TPH fractions). This compliance point is considered protective of both the Abbey Sand and Gravel and the New River/River Welland.

3.3.3 Assumptions and Input Parameters

The RTM model requires the utilisation of a range of input parameters that are appropriately representative of site conditions and the identified COPC. Where possible site specific input parameters have been utilised, with suitable literature source values (such as ConSim, LQM/CIEH, CL:AIRE) used where these are not available. Where literature values have been utilised these have been selected to ensure that they are appropriately conservative. The following key assumptions have been made when inputting parameters and are considered reasonable for the site:

- The source area for the petroleum hydrocarbons is assumed to be 16m long (in the direction of groundwater flow) by 11.5m wide (perpendicular to groundwater flow). This is considered a reasonable worst case estimation of the area where hydrocarbon contamination is present based on available site data from soils and groundwater.
- The infiltration rate used for the Level 2 soil analysis has been assessed using the Met Office data for effective rainfall.
- As discussed in Section 3.1.3 there are various lines of evidence that biodegradation of the COPCs is occurring in groundwater at the site. Biodegradation has been modelled using conservative high end literature values for biodegradation rates in anaerobic conditions and making a conservative assumption that biodegradation occurs in the dissolved phase only. It is considered that biodegradation would occur in all phases; however, a conservative approach has been used to generate remedial targets.
- Falling head hydraulic conductivity tests were performed on site (Appendix I). Analyses of these tests gave estimates of hydraulic conductivity of the Abbey Sand and Gravel that ranged from 0.20 to 0.22 m/d. The maximum value has been adopted for the RTM modelling.

A summary of the input parameter values and justification for these is presented in Appendix O.

3.3.4 Results

The RTM model outputs are presented in Appendix P. The calculated soil Level 3 RTVs are compared with the maximum measured concentrations in soil in Table 8.

This shows that soil concentrations values for hydrocarbon band aromatics C12-C16 are below soil RTV values.

However, the maximum concentration of the aromatic hydrocarbon fraction C16-C21 exceeds the remedial target indicating that soil remediation would be required.

Table 8: Soil Contaminants of Potential Concern compared against Remedial Targets

Contaminant of Potential Concern	Max conc. in soil on site (mg/kg)	Remedial Target Concentration (mg/kg)
TPH Aromatic >C12-C16	470	531
TPH Aromatic >C16-C21	490	284

Remedial targets rounded to 3 significant figures

Bold – denotes maximum measured concentration greater than RTV

The calculated groundwater RTVs are compared with the maximum measured concentrations in groundwater in the Table 9. The theoretical maximum aqueous solubilities are also shown for comparison. The maximum measured concentration of both aromatics TPH fractions C12 to C16 and C16 to C21 in groundwater exceeds the RTV, as shown in Table 9 below. It should be noted that the maximum concentration for the TPH fraction C16-C21 is much higher than its solubility limit suggesting it is not representative of the dissolved concentrations and is likely skewed by the presence of low level of NAPL in the sample as shown in the table below.

Table 9: Dissolved Contaminants of Concern compared against Remedial Targets

Contaminant of Concern	Remedial Target Concentration mg/L	Max conc. in groundwater on site mg/L	Maximum aqueous solubility mg/L
TPH Aromatic >C12-C16	1.95	0.650	5.75
TPH Aromatic >C16-C21	0.25	1.72	0.65

Remedial targets rounded to 3 significant figures

Bold – denotes maximum measured concentration greater than RTV

Italics – denotes maximum measured concentration greater than solubility limit

3.3.5 Uncertainty Analysis

The assumptions, procedures, and parameters used in this risk assessment are subject to various degrees of uncertainty. Uncertainty is inherent in the risk assessment process. The uncertainty analysis provides an understanding of the limitations in interpretation of the quantitative estimates of risk presented in this risk assessment.

The Conceptual Model

The CSM is based on the assumption that the principal source of contamination is hydrocarbon impacted soils within the Peat layer above the Abbey Sand and Gravel

(Secondary A Aquifer) at the site. This acts as an on-going source of groundwater contamination via leaching and dissolution. Groundwater in this aquifer is assumed to flow north-west and ultimately discharge to the New River and River Welland beyond. The CSM is based on available on and off-site data and is considered reasonably robust for the purposes of this assessment.

Measured Groundwater Concentrations

The measured concentrations of some TPH fractions in groundwater samples exceed theoretical solubility limits as discussed in Section 3.2. As discussed above, these measured concentrations are unlikely to be representative of actual dissolved phase concentrations in groundwater which are unlikely to exceed solubility.

Model Parameters

The influence of uncertainty in the model parameters on the RTM model results has been tested by varying key parameters between realistic limits and observing how this affects the groundwater RTVs for Aromatic TPH C16-C21. This COPC has been chosen because it has the lowest RTV in comparison to the solubility limited measured concentrations (i.e. the measured concentration or maximum aqueous solubility, whichever is the lower). The ranges in parameter values tested are presented in Appendix O and the results of this sensitivity analysis for soil and groundwater are presented in Figures A and B below. Note that Figures A and B show the relative change in RTV on a log scale for each input parameter. Positive values indicate an increase in RTV whilst negative values indicate a decrease.

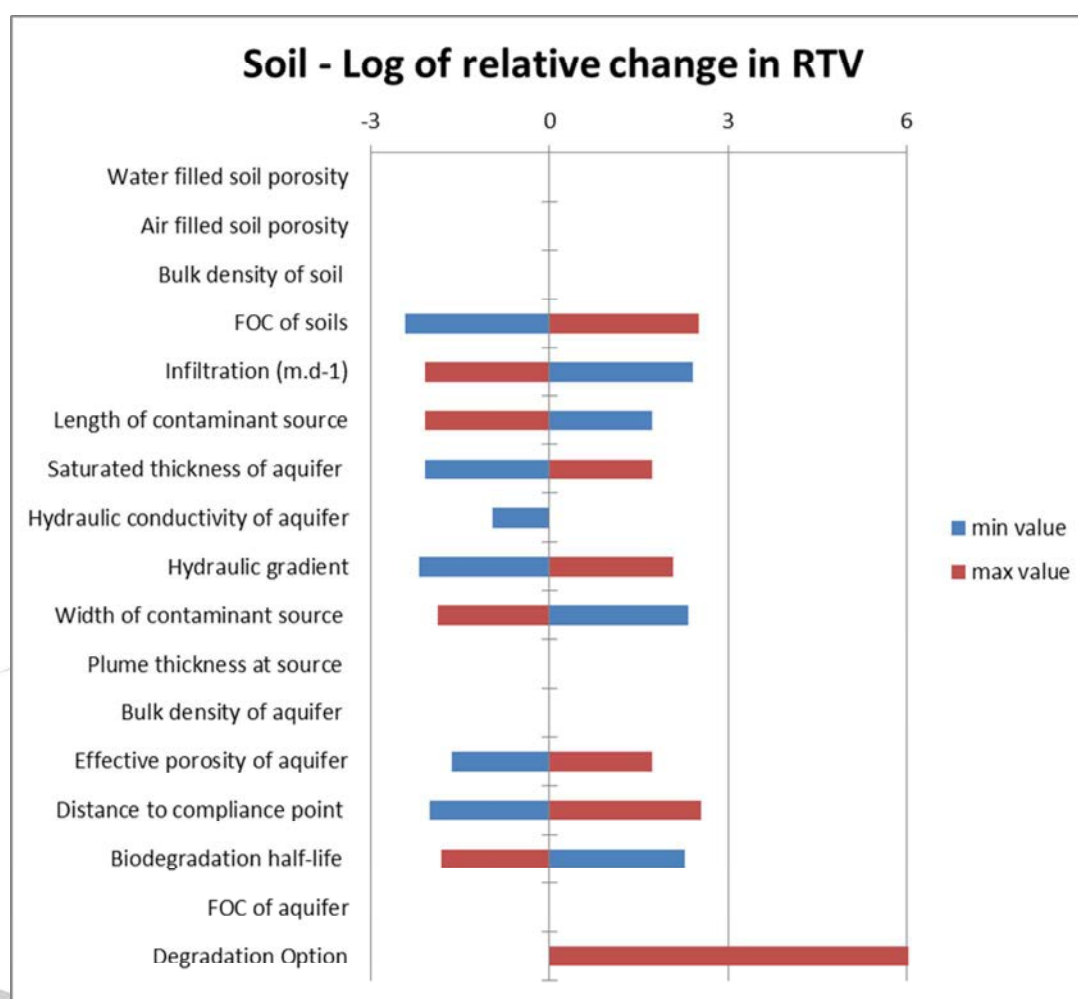


Figure A: Results of sensitivity analysis for soils - update

The sensitivity analysis for soils shows that there is sensitivity in the soil RTV to the majority of input parameter values. The parameters causing the greatest change in soil RTVs are discussed below:

- Fraction of organic carbon of soils, length of contamination, saturated thickness of aquifer, hydraulic conductivity of aquifer, hydraulic gradient of groundwater: the majority of these parameters are well established from site data, and therefore the remedial targets calculated are believed to be representative of the site-specific conditions and contaminants present.
- Infiltration rate. Effective rainfall data has been derived from the Met Office data and is considered appropriate to the site conditions.
- Effective porosity of aquifer: These are literature values but are considered to be representative of the aquifer porosity.
- Distance to compliance point. The RTVs are based on a distance to compliance point of 50m. As discussed previously, this value has been chosen in accordance with Environment Agency guidance (EA, 2017a) and is considered appropriate to the contamination present in the groundwater.

- Biodegradation half-life. The RTVs are based on upper limit biodegradation half-lives for anaerobic biodegradation and are considered to be conservative literature values.
- Degradation Option. Use of dual phase degradation results in the soil RTV increasing by several orders of magnitude. The use of single phase degradation is likely to be highly conservative.

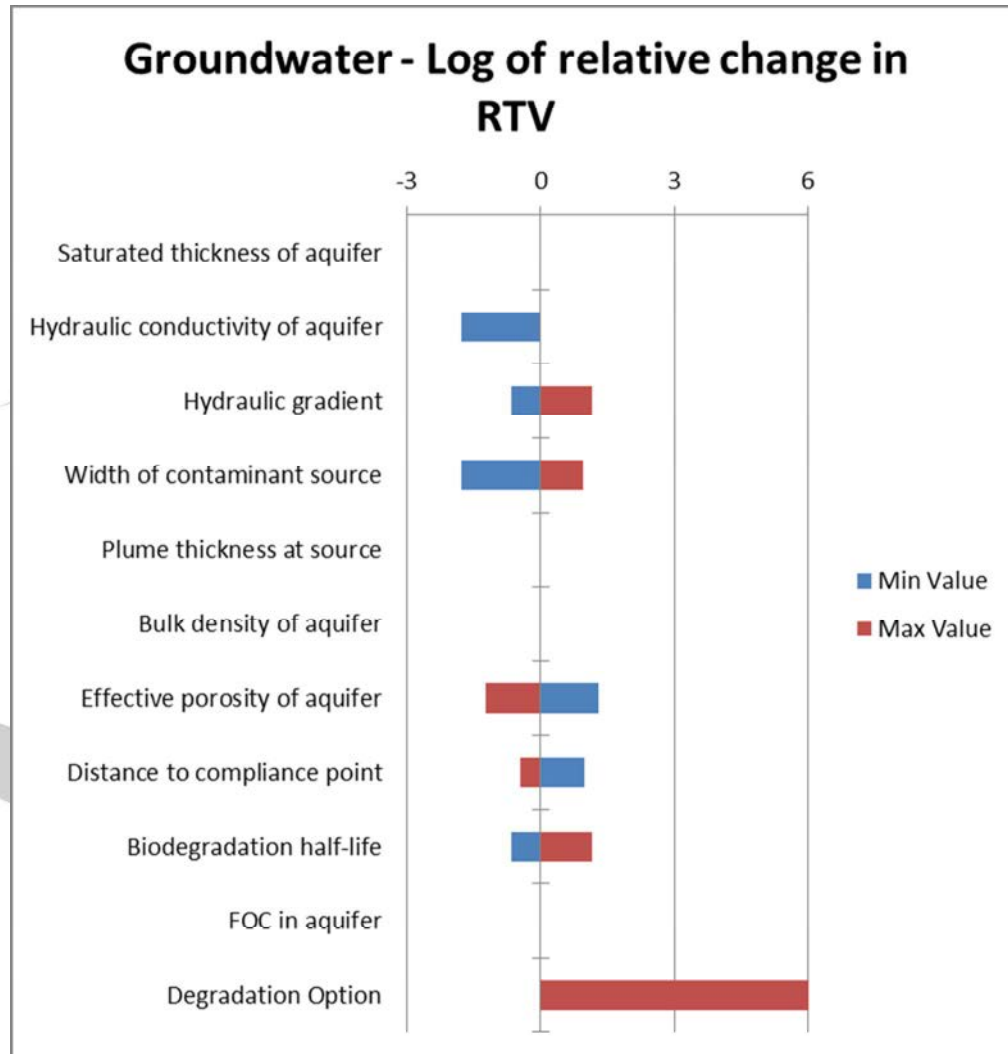


Figure B: Results of sensitivity analysis for groundwater

The sensitivity analysis for groundwater shows that there is relatively little sensitivity in the model results for groundwater to plausible changes in the majority of parameter values. The parameters causing the greatest change in RTV are discussed below:

- Width of contaminant source, hydraulic conductivity and hydraulic gradient: These have been calculated from site data and are considered to be conservative to generate RTVs for groundwater.

- Biodegradation half-life: The RTVs are based on upper limit biodegradation half-lives for anaerobic biodegradation.
- Degradation Option. Use of dual phase degradation results in the groundwater RTV increasing by several orders of magnitude. The use of single phase degradation is likely to be highly conservative.

Based on the uncertainty assessment for soil and groundwater it is considered that an overall conservative approach has been adopted for the assessment.

3.4 SUMMARY OF RISK TO CONTROLLED WATERS

RTVs have been derived for soil and groundwater using the Environment Agency's RTM spreadsheet model. Sensitivity analysis has shown that these RTVs are likely to be conservative. In particular, the assumption of single phase degradation is likely to be highly conservative because this assumes that no biodegradation occurs whilst hydrocarbons are sorbed to the aquifer matrix.

The aromatic fraction C16-C21 recorded in WS06 and WS109 at 490mg/kg and 330mg/kg respectively exceeds the RTV of 284mg/kg between depths of around 0.8m and 2.6m begl. Therefore, a risk would remain to controlled waters via dissolved phase migration and remediation would be required.

The measured concentrations in groundwater samples exceed the groundwater RTVs for both TPH fractions C12 to C16 and C16 to C21. It is therefore considered there is an unacceptable risk from CL2 and CL3, and accordingly will require remediation works.

4 CONCLUSIONS

A quantitative controlled waters risk assessment has been undertaken using the Environment Agency RTM model. The Level 3 RTVs generated will be used during remediation of hydrocarbon contamination in the south western area of the site.

It has been determined soils in WS109 and WS06 fail the RTV for C16 to C21 and as such removal of soils within these areas would be required including the removal of any contamination if present around and within the drainage tanks and associated pipes.

The area of the contaminated soils is estimated to be 216.6m² and based on the thickness of the hydrocarbon impacted soils in the south western area (as a worst case, the largest value has been used), a volume of approximately 310m³ of contaminated soils is predicted to require removal.

The details of the remedial and validation works are included in the Remedial Strategy Report.

5 REFERENCES

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GENERAL APPRAISAL COMMENTS

i INFORMATION SOURCES

Where available the following sources have been used for the identification and assessment of potential ground hazards:

- Relevant British Standards
- British Geological Survey (BGS) Geology Map Scale 1:10,000 for local area
- British Geological Survey (BGS) Geology Map Scale 1:50,000/1:63,320
- BGS Memoir
- BGS Borehole Records
- BGS online viewer: <http://www.bgs.ac.uk/data/mapViewers/home.html>
- Environment Agency Groundwater Vulnerability Maps
- Historical Ordnance Survey (OS) Maps
- Environmental Data Report
- Environment Agency Website: <http://www.environment-agency.gov.uk/>
- Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites, UKWIR, 2010.
- Coal Authority Records / Coal Mining Report
- DEFRA/Environment Agency Contaminated Land publications and DoE Industry Profiles
- BRE Guide BR211 (2015), 'Radon: Guidance on protective measures for new buildings'
- HPA-RPD-033 (2007), 'Indicative Atlas of Radon in England and Wales'
- PHE-CRCE-032 (PHE, 2017), Radon in Homes in England: 2016 Data Report
- CIRIA C665 'Assessing risks posed by hazardous ground gases to buildings'
- BS8485:2015, 'Code of Practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings'
- Other technical references used throughout this document are detailed in the text.

ii CONTAMINANTS OF CONCERN

The DoE Industry Profiles are normally used to assess likely contaminants from past land use and potential nearby industrial sources. For land uses where no profile is available, likely contaminants of concern are selected by GRM based on past experience of similar sites, a general screening suite of contaminants covered by CLEA and common contaminants from the Industry Profiles.

- | | | |
|------------|-------------------|--|
| • Arsenic | • Copper | • Water soluble sulphate |
| • Cadmium | • Nickel | • PAH (polycyclic aromatic hydrocarbons) |
| • Chromium | • Zinc | |
| • Lead | • Phenols | |
| • Mercury | • cyanide (total) | |
| • Selenium | • pH | |

Asbestos and PCBs are listed in the vast majority of profiles. PCBs are listed as the profiles expect electricity substations and switch boxes on all industrial sites. There is the potential for asbestos containing material to be mixed up with made ground, following any demolition works.

CONCEPTUAL MODEL METHODOLOGY

The consideration of contamination is based upon the principles of risk assessment, using the 'source-pathway-receptor' model in order to establish the presence, or potential presence, of a pollutant linkage.

To create a risk, contamination must have the potential to cause harm to susceptible targets or receptors such as humans, the water environment or the built environment. The potential for harm to occur requires three conditions to be satisfied to form a pollutant linkage:

- The presence of substances that may cause harm (SOURCE).
- The presence of a target which may be harmed (RECEPTOR).
- The existence of a plausible migration route between the source and the receptor (PATHWAY).

In the absence of a plausible pollutant linkage there is no risk. Where a potential linkage is identified in order for it not to pose a risk to the identified receptor it must be broken.

iv INTRUSIVE INVESTIGATION SAMPLING METHODOLOGY

The ground investigation (including fieldwork, sampling, monitoring and laboratory analyses) has been designed to identify and assess potential ground related problems and to allow cost effective solutions to be advised. It has been planned on the basis of the desk study, site inspection and the proposed development layout (where available). All fieldwork and soil descriptions were carried out in general accordance with relevant British Standards.

The exploratory holes have been positioned and advanced to depths to determine the general ground/groundwater/gas conditions below the site. A general grid pattern has been adopted, where possible, to provide sufficient information based on the current proposed layout scheme. Some holes have been targeted at particular hazards identified in the Phase I assessment. The resultant exploratory hole density is considered to be commensurate with the complexity of the site conditions and detail of information required for this phase of the investigation.

v GROUND GAS RISK ASSESSMENT METHODOLOGY

Gas monitoring programmes undertaken by GRM are designed to broadly comply with the recommendations outlined in CIRIA Report C665 'Assessing risks posed by hazardous ground gas to buildings' (2007) and BS8576 'Guidance on Investigations for ground gas – Permanent gases and Volatile Organic Compounds (VOCs) (2013).

To assess the risks posed by ground gases such as radon, carbon dioxide and methane, the relevant current guidance has been used. For radon the site has been assessed following the guidelines in 'Radon: guidance on protective measures for new dwellings (BR211: 2015)'. For methane and carbon dioxide the primary guidance document used to determine if protection measures are required is *BS8485:2015 Code of practice for the design of protective measures from methane and carbon dioxide ground gases for new buildings*. This uses hazardous gas flow rates (Q_{hg}), which are gas concentrations multiplied by borehole flow rates, to derive a Gas Flow Rate (GSV) for the site. The gas regime is then determined based on the GSV and other limiting factors such as gas concentrations.

Where flow is not recorded during the monitoring a default flow rate of 0.1l/hr will be used in the assessment to produce a positive result.

vi HUMAN HEALTH RISK ASSESSMENT METHODOLOGY

Guidance contained in the Environment Agency's CLEA Reports has been used to assess the risks posed to human health.

For residential developments that include domestic gardens the default Tier 1 Assessment Criteria (TAC) for 'residential land with plant uptake' are used, i.e. a female with a start age class of one and an end age class of six. All pathways are considered including the consumption of home-grown vegetables.

For residential developments that do not include domestic gardens the default Tier 1 Assessment Criteria (TAC) for 'residential land without plant uptake' are used, i.e. a female with a start age class of

one and an end age class of six. All pathways are considered except the consumption of home-grown vegetables.

For commercial/industrial developments the default Tier 1 Assessment Criteria (TAC) for 'commercial/industrial' are used, i.e. a female with a start age class of sixteen and an end age class of eighteen. All pathways are considered except the consumption of home-grown vegetables.

The TAC used by GRM include Category 4 Screening Levels (C4SLs) published by DEFRA, values calculated by GRM using the CLEA v1.071 risk assessment, and values and Suitable for Use Levels (S4UL) developed by LQM/CIEH. The TAC used in the assessment are selected based on the lowest site specific SOM values returned as part of the chemical analysis.

Where soil chemical analysis results are found to exceed the TAC, Site-Specific Risk Assessments may be undertaken using the CLEA v1.071 risk assessment software using the age classes and pathways described above.

vii RISK TO SITE WORKERS – GENERAL COMMENTS

The risks to site workers are similar to those posed to site end users, although likely to be less severe due to the site workers' shorter exposure to the identified contamination. However, site workers (particularly groundworkers) are more likely to come into direct contact with contaminated soils due to the nature of their work. On this basis ground and construction workers should be provided with basic Personal Protective Equipment based on the site's general health and safety risk assessment, but including as a minimum safety footwear, gloves and overalls.

A site specific risk assessment should be carried out for all hazards identified within the ground investigation in accordance with current health and safety legislation. This assessment should identify any measures required to further reduce risks i.e. providing further Personal Protective Equipment, welfare facilities and if necessary preventing access to certain areas.

Demolition and dismantling of existing structures on the site must be carried out to a safe and acceptable standard, in accordance with current UK guidance and best practice. Whilst not ground related, asbestos and hazardous substances surveys should be conducted prior to any demolition.

Any unusual colours, odours and suspicious ground should be reported immediately to site management and then GRM.

Whilst this appraisal has considered the long-term effects of contamination, GRM can also help during the formulation of Health and Safety documentation, if required.

viii CONTROLLED WATERS RISK ASSESSMENT METHODOLOGY

Where the desk study and fieldwork do not reveal a potential source of contamination no leachate or groundwater testing will be performed. Where a potential source is identified the testing will comprise leachate testing on the material considered most likely to pose a risk, groundwater testing will be undertaken if water is present at shallow depth.

The UK Drinking Water Standards (UKDWS) or Environmental Quality Standards (EQS) are usually adopted for comparison with the leachate/groundwater test results. When the most sensitive receptor is considered to be the aquifer (groundwater) UKDWS will be adopted as the Initial Tier 1 screening values. Where the most sensitive receptor is a surface water feature the EQS values will be used as Initial Tier I Screening values.

ix CONSTRUCTION MATERIALS RISK ASSESSMENT METHODOLOGY

The 'screening levels' adopted for the assessment of risk to construction materials are taken from the following documents:

- UK Water Industry Research (UKWIR) Contamination thresholds for sub-surface water pipes, for the protection of buried pipes.
- Building Research Establishment (BRE) Special Digest SD1 (2005), 'Concrete in Aggressive Ground', for the protection of buried concrete.

x WASTE DISPOSAL, SITE WASTE MANAGEMENT PLANS AND MATERIAL MANAGEMENT PLANS

Under current Waste Management Regulations, waste soil materials produced from the site will require characterisation to enable it to be disposed of correctly.

The chemical analysis results included in this report should be provided to the relevant landfill operators to establish the characterisation of the waste, confirm its suitability for landfill disposal and provide estimated costings. If material is classified as hazardous, then the site will need to be registered with the Environment Agency prior to the movement of the waste. Depending on the receiving landfill's current permit, further chemical analysis, incorporating Waste Acceptance Criteria (WAC) leachate analysis, may be required.

All materials removed from the site will be classified as 'waste' and therefore must be removed by a suitably licensed carrier of waste. This applies whether or not the waste is contaminated. All waste removed to landfill will attract Landfill Tax.

The developer/builder is likely to be classed as the waste producer and therefore, has a duty of care to ensure that all waste is disposed of appropriately. This includes ensuring the waste carrier is licensed and disposes of the waste to a suitably licensed landfill site. They are also required to keep a paper trail from 'cradle to grave' including copies of the waste disposal tickets.

Efficient materials management on site is recommended as it can lead to significant cost savings when compared to the traditional side casting or single stockpile of arisings. GRM can assist in the production of Material Management Plans under the CL:AIRE Definition of Waste: Code of Practice. The DoWCoP enables:

- The direct transfer and re-use of clean naturally occurring soil materials between sites, and
- The re-use of both contaminated and uncontaminated materials on their site of origin and between sites within defined Cluster projects.

GRM can also undertake the role of Qualified Person and submit the DoW CoP project Declaration.

Likewise making the site as volume neutral as possible will reduce the costs of development. Whilst not a statutory requirement, Site Waste Management Plans allow better waste management practices, help to reduce the amount of waste produced and identify best environmental disposal options. Implementing a Site Waste Management Plan (SWMP) can reduce costs (increasing business profits) and maximise resource efficiency.

xi GEOTECHNICAL ASSESSMENT GENERAL COMMENTS

Where finished floor levels of proposed structures have not been provided by the Client, then for the purposes of initial assessment, GRM will assume that finished levels will not vary appreciably from the existing ground levels. If the depths of any underground engineering works (i.e. sewers, pumping stations etc.) are unknown they will not be taken in to account in the assessment and it will be assumed that any such works will not compromise foundation or ground stability.

Should the development proposals or finished levels be different from these assumptions then the comments/recommendations in the Geotechnical Assessment may require revising.

It should be noted that the results of window sampling and/or cable percussive boreholes may not give a true indication of a soils actual engineering properties (i.e. stability, mass structure etc). GRM consider that that prior to development trial pitting should be undertaken to confirm the recommendations in the Geotechnical Assessment.

xii GEOTECHNICAL ASSESSMENT – ENGINEERING GROUND TREATMENT

Near surface soils have the potential to be disturbed by weathering and site traffic. Precautions should always be taken to avoid this, as excessive disturbance may leads to more onerous floor slab designs, road cap thickness and increased amounts of off-site disposal etc.

Near surface soils may need treatment or reinforcing to allow safe movement of construction plant and labour. An assessment by the contractor should be undertaken once the type of machinery/plant needed to complete the development is known.

xiii GEOTECHNICAL ASSESSMENT – EXCAVATIONS

Excavation instability (over-break) can result in damage to existing services or structures (e.g. foundations, roads or boundary walls/fences) both on and off-site, as well as increased foundation concrete costs. In order to minimise this, all excavations deeper than 1.2m deep (or any excavation within 1.5m of any existing structure or service) should be supported. Full support should be provided to the full depth of all near vertically sided excavations in made ground, soft and very soft clays and granular soils. A reduction to intermediate support should be acceptable within firm and stiffer natural clays.

Wherever possible, man entry into excavations should be prevented; however, where this is not possible, entry to, and time spent in, excavations should be kept to a minimum.

The build program should be tailored to reflect the impact that deep excavations through potentially unstable strata can have on adjacent properties, so that they are not undermined.

All excavations on site should be in accordance with HSE guidelines and stability should be practically maintained at all times. Reference should be made to HSE construction information sheet No. 8 (Revision 1) 'Safety in Excavations'.

Care should be taken to ensure that falls from excavation faces do not adversely affect the integrity of foundation concrete.

If contaminated water enters excavations it should be removed and transported to an appropriate treatment facility by a suitably licensed carrier before construction begins.

xiv GEOTECHNICAL ASSESSMENT – SUBSTRUCTURES

Where practicable, existing buried construction should be fully removed; however, if this is not practicable all new foundations should be carried down to fully penetrate it and it should be broken well away from all new structures.

There may be existing structures and/or infrastructure in close proximity to the proposed development. New build foundations may be constructed next to pavements with existing underground services beneath them, or excavations may be required near existing footings associated with adjacent properties. These potential hazards need to be taken into consideration when designing foundations and the groundworker needs to be made aware of their potential impact during the redevelopment works. Foundations close to existing underground services or buildings may require alternative foundation techniques (such as piling) to protect the integrity of these structures.

The contractor for the works should carry them out in such a fashion so as to not cause excessive overbreak, concrete usage or undermine existing buildings/roads/ services that are to be retained.

xv GEOTECHNICAL ASSESSMENT – SOAKAWAYS

Soakaway testing in trial pits by GRM is broadly carried out in accordance with BRE DG 365 (2016). The testing comprises the excavation of a test pit to a suitable depth, and the placement of water into the pit. The level of water present is then monitored over time. For borehole installations, the permeability testing (falling head/rising head) is undertaken in accordance with BS5930.

If it is decided to proceed with the use of soakaway drainage, then the following general points should be noted:

- Soakaways should not be placed so that water can be discharged through potentially contaminated made ground.
- The Environment Agency may require soakaways to be sealed systems such that only roof run off falls to soakaway.

- Interceptors are likely to be required for soakaways for highway drainage. The adopting authority for the highways should be consulted at the earliest opportunity regarding the use of soakaways for highways drainage.
- Consideration of site levels and slopes should be taken into account during the design.
- The construction of all soakaways should be in accordance with the current building regulations.
- Soakaways should not be placed within 5m of a proposed building.
- Placement of soakaways needs to be considered so as to avoid ponding of water down slope.
- The base of a soakaway should not be below the highest recorded water level.
- The Environment Agency prefer 1m of dry soil to be present between the base of a soakaway and the water table to provide attenuation for contamination.

xvi

GEOTECHNICAL ASSESSMENT – FOUNDATIONS

If soft or hard spots are encountered during foundation excavation then they should be replaced with suitably compacted material or the footings deepened to suitable strata, to avoid differential settlement.

If strata of differing bearing character (e.g. sand and clay) are encountered at foundation levels within the excavations for a single plot then the excavation depths should be altered as appropriate to ensure the foundations rest on a single stratum, or strata that will not induce differential settlement. Where this is impractical then GRM should be contacted to assess a reinforced concrete detail or an alternative foundation solution (e.g. piles or vibro-replacement).

NOTES ON LIMITATIONS**General**

GRM Development Solutions Limited has prepared this report solely for the use of the Client and those parties with whom a warranty agreement had been executed, or with whom an assignment had been agreed. Should any third party wish to use or rely upon the contents of the report, written approval must be sought from GRM Development Solutions Limited; a charge may be levied against such approval.

GRM Development Solutions Limited accepts no responsibility or liability for:

- a) the consequences of this document being used for any purpose or project other than for which it was commissioned, and
- b) the consequences of this document being used by any third party with whom an agreement has not been executed.

Phase I Environmental Audits/ Desk Studies

The work undertaken to provide the basis of this report comprised a study of available documented information from a variety of sources (including the Client), together with (where appropriate) a brief walk over inspection of the site and meetings and discussions with relevant authorities and other interested parties. The opinions given in this report have been dictated by the finite data on which they are based and are relevant only to the purpose for which the report was commissioned. The information reviewed should not be considered exhaustive and has been accepted in good faith as providing true and representative data pertaining to site conditions. Should additional information become available which may affect the opinions expressed in this report, GRM Development Solutions Limited reserves the right to review such information and as considered necessary and appropriate to modify the opinions accordingly. It should be noted that any risks identified in a Phase 1 report are perceived risks based on the information reviewed; actual risks can only be assessed following a physical investigation of the site.

Phase II Environmental Audits (Contamination Investigations)

The investigation of the site has been carried out to provide sufficient information concerning the type and degree of contamination, ground and groundwater conditions to allow a reasonable risk assessment to be made. The objectives of the investigation have been limited to establishing the risks associated with potential human targets, building materials, and controlled waters.

The amount of exploratory work and chemical testing undertaken has necessarily been restricted by the short timescale available, and the locations of exploratory holes have been restricted to the areas unoccupied by the building(s) on the site and by buried services. A more comprehensive investigation may be required if the site is to be redeveloped as, in addition to risk assessment, a number of important engineering and environmental issues need to be resolved.

For these reasons if costs have been included in relation to site remediation these must be considered as provisional only and must, in any event, be confirmed by a commercial adviser.

The exploratory holes undertaken, which investigate only a small volume of the ground in relation to the size of the site, can only provide a general indication of site conditions. Whilst exploratory testing is intended to gain an accurate representation of the site, the very nature of sampling and testing is such that it cannot ensure that all localised conditions are detected.

The risk assessment and opinions provided take in to consideration, inter alia, currently available guidance relating to acceptable contamination concentrations; no liability can be accepted for the retrospective effects of any future changes or amendments to these values.

Phase II Geo-environmental Investigations (Combined Geotechnical and Contamination Investigations)

The investigation of the site has been carried out to provide sufficient information concerning the type and degree of contamination, geotechnical characteristics, and ground and groundwater conditions to provide a reasonable assessment of the environment risks together with engineering and development implications. If costs have been included in relation to site development a commercial adviser must confirm these.

The exploratory holes undertaken, which investigate only a small volume of the ground in relation to the size of the site, can only provide a general indication of site conditions. The opinions provided and recommendations given in this report are based on the ground conditions apparent at the site for each of the exploratory holes. There may be exceptional ground conditions elsewhere on the site which have not been disclosed by this investigation and which have therefore not been taken into account in this report.

The comments made on groundwater conditions are based on observations made at the time the site work was conducted. It should be noted that groundwater levels will vary owing to seasonal, tidal and weather related effects. The scope of the investigation was selected on the basis of the specific development proposed by the Client and may be inappropriate to another form of development or scheme.

The risk assessment and opinions provided take in to consideration, inter alia, currently available guidance relating to acceptable contamination concentrations; no liability can be accepted for the retrospective effects of any future changes or amendments to these values.



A P P E N D I X B

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Tel: 01283 551249

info@grm-uk.com

Fax: 01283 211968

www.grm-uk.com



ACCOMMODATION SCHEDULE

DWELLING TYPE		GIFA	HEIGHT (STOREYS)	AMOUNT	%
1B	1B2P HOUSE	54.20m ²	2	06	12
F133	2B4P HOUSE	72.54m ²	2	24	48
F113	3B5P HOUSE	84.30m ²	2	02	40
F131	3B5P HOUSE	83.66m ²	2	18	
TOTAL				50	100

AREA = 1.54 Ha

- 1800mm brick wall
- 1800mm close boarded fence
- Proposed Knee Rail
- Paving Hatch
- Proposed trees
- Trees retained
- Trees removed
- Root Protection Area
- Bin storage
- Rent to Buy
- Shared Ownership
- Rented

Notes

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- Do not scale this drawing. Work to figured dimensions only.
- Contractors and consultants are to advise BM3 Architecture Limited of any discrepancies.

Revision	Date	By	Chkd
A MIX UPDATED	17.10.18	JJ	
B MOVED PLOTS 9M AWAY NORTHERN AND SOUTHERN BOUNDARY EDGE	26.10.18	JB	
C HOUSING MIX UPDATED BASED ON COMMENTS DRAWING UPDATED TO PLANNING. INDICATED TREES AROUND BOUNDARY EDGE REMOVED.	30.01.19	JB	JJ
D LAYOUT AMENDED BASED ON REPOSITIONING OF BALANCING POND. INCLUSION OF PUMPING STATION AND COMMENTS FROM WATERLOO.	22.02.19	JB	
E UPDATED BASED ON CHANGE IN HOUSING MIX TO SUIT REQUIRED TENURES AND COMMENTS FROM PARTNER CONSTRUCTION.	07.03.19	JB	JJ

PLANNING



Client

Partner

Project
CREASE DRIVE
CROWLANDS
PETERBOROUGH

CISb Element

Drawing
SITE LAYOUT

Drawn by JJ	Checked
Scale 1:500@A2	Dated OCT 2018
Job No. 70688	Drawing No. D01
	Revision E

Birmingham Office
28 Pickford Street, Digbeth, Birmingham, B5 5QH
T. 0121 633 0000 F. 0121 633 0300 E. design@bm3.co.uk

BM3



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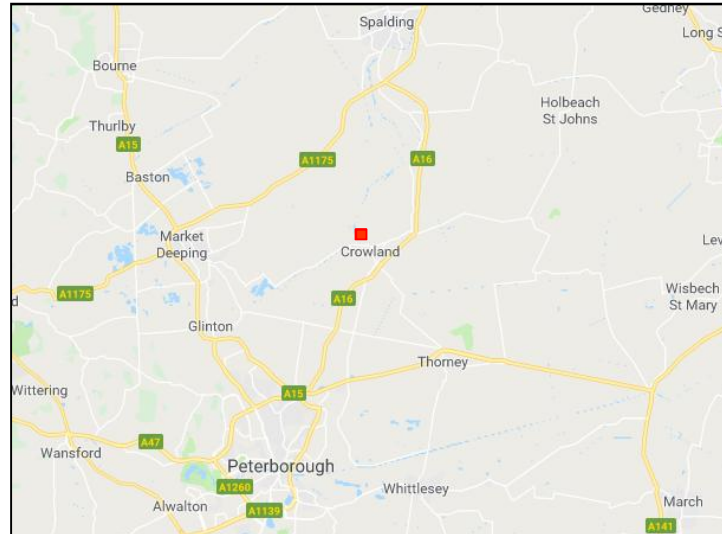
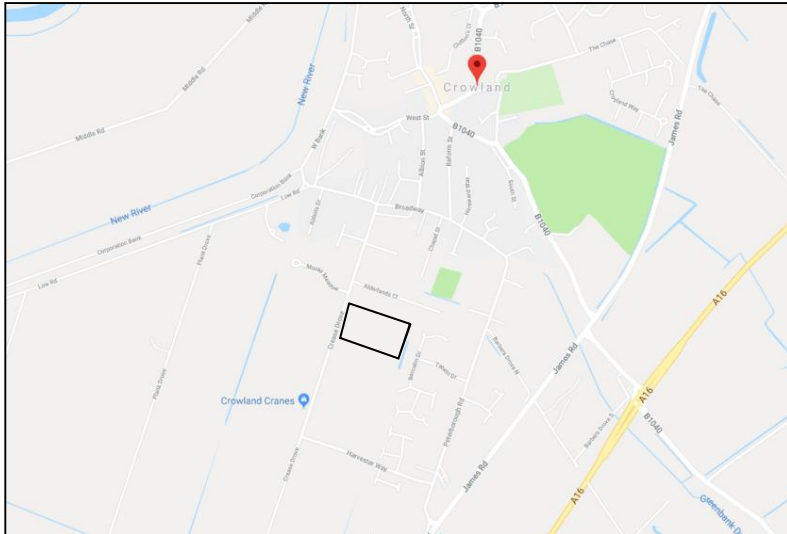
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- Civil and Infrastructure Services
- Structural Engineering Services
- Construction Management
- Site Services

Tel: 01283 551249

info@grm-uk.com

Fax: 01283 211968

www.grm-uk.com



DO NOT SCALE

NOTES:

— Approximate Site Boundary



GRM Development Solutions Ltd

Laurus House, First Ave, Centrum 100,

Burton-on-Trent, Staffordshire

Tel: 01283 551 249 Fax: 01283 211 968

mail@grm-uk.com www.grm-uk.com

CLIENT:

Partner Construction Ltd

PROJECT:

Crease Drove, Crowland

TITLE:

Site Location and Boundary Plan

SCALE@SIZE:

NTS

ISSUE:

FINAL

DESIGN/DRAWN by:

DAA

DATE:

June, 2019

PROJECT No:

P8723

DRAWING No:

1

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info@grm-uk.com

Fax: 01283 211968

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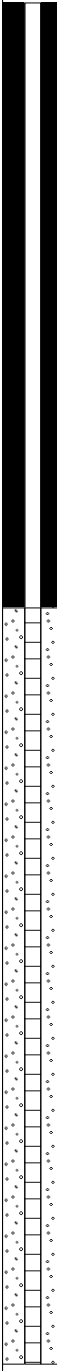
Tel: 01283 551249

info@grm-uk.com

Fax: 01283 211968

www.grm-uk.com

		GRM Development Solutions Ltd Laurus House, First Avenue, Centrum 100, Burton-on-Trent, DE14 2WH Tel (HQ): 01283 551249 Email: info@grm-uk.com		Cable-Percussion Borehole			Borehole No. BH101 Sheet 1 of 2	
Site Name: Crease Drove, Crowland							Ground Level (mAOD) 1.69	
Client: Partner Construction Ltd					GRM Project Ref: P8723		Coordinates 523766 E 309626 N	

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		0.00 - 0.60	B	N=10 (3,2/2,2,3,3)	0.60	1.09		Firm, brown, slightly sandy, gravelly CLAY. Sand is fine to coarse. Gravel is fine to coarse, angular, brick. MADE GROUND	1
		0.30	D						
		0.60 - 1.20	B						
		1.00	D						
		1.20 - 1.70	B						
		1.20	C	N=12 (3,2/1,2,3,6)	2.30	-0.61		Firm to stiff, brown to grey, gravelly CLAY. PEAT	2
		1.40	D						
		2.00	D						
		2.00 - 2.50	B	N=12 (3,2/1,2,3,6)	2.30	-0.61		Brown, slightly clayey, sandy GRAVEL. ABBEY SAND AND GRAVEL	2
		2.00	C						
		3.00 - 3.40	D	N=12 (1,1/2,3,3,4)	4.00	-2.31		Firm to stiff, grey, gravelly CLAY. OXFORD CLAY	3
		3.00	S						
		4.00	U	N=26 (3,3/4,6,7,9)	5.00			Stiff to very stiff, grey CLAY. OXFORD CLAY	4
		5.00 - 5.45	D						
		5.00	S						
	6.50	U	N=43 (5,7/9,9,11,14)	8.00			Stiff to very stiff, grey CLAY. OXFORD CLAY	5	
	8.00 - 8.45	D							
	8.00	S	N=43 (5,7/9,9,11,14)				Stiff to very stiff, grey CLAY. OXFORD CLAY	6	
									7
									8
									9

Continued on Next Sheet

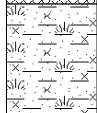
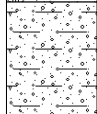
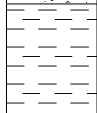
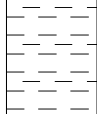
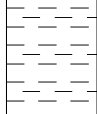
Crew: T. Beford, Site Investigation.		Logger: KD		Chiselling Details		
				Depth Top	Duration	Remarks
				1.00	00:30	
Equipment:				Casing Diameter by Depth		
Groundwater Remarks: Groundwater encountered at 1.8m begl, rising to 1.4m begl.				Depth Base	Diameter	Remarks
General Remarks:						
Hole Started: 04/06/2019		Hole Complete: 05/06/2019		Version: FINAL		Scale: 1:50

		GRM Development Solutions Ltd Laurus House, First Avenue, Centrum 100, Burton-on-Trent, DE14 2WH Tel (HQ): 01283 551249 Email: info@grm-uk.com		Cable-Percussion Borehole			Borehole No. BH101 Sheet 2 of 2	
Site Name: Crease Drove, Crowland							Ground Level (mAOD) 1.69	
Client: Partner Construction Ltd					GRM Project Ref: P8723		Coordinates 523766 E 309626 N	

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		9.50	U				Stiff to very stiff, grey CLAY. OXFORD CLAY		
		11.00 - 11.45 11.00	D S	N=46 (8,7/10,10,12,14)					
		12.50	U						
		14.50 - 14.95 14.50	D S	N=58 (13,12/12,14,15,17)					
					15.00	-13.31		End of Borehole at 15.00m	

Crew: T. Beford, Site Investigation.		Logger: KD		Chiselling Details <table border="1"> <tr> <th>Depth Top</th> <th>Duration</th> <th>Remarks</th> </tr> <tr> <td>1.00</td> <td>00:30</td> <td></td> </tr> </table>			Depth Top	Duration	Remarks	1.00	00:30	
Depth Top	Duration	Remarks										
1.00	00:30											
Equipment:				Casing Diameter by Depth <table border="1"> <tr> <th>Depth Base</th> <th>Diameter</th> <th>Remarks</th> </tr> <tr> <td></td> <td></td> <td></td> </tr> </table>			Depth Base	Diameter	Remarks			
Depth Base	Diameter	Remarks										
Groundwater Remarks: Groundwater encountered at 1.8m begl, rising to 1.4m begl.												
General Remarks:												
Hole Started: 04/06/2019		Hole Complete: 05/06/2019		Version: FINAL		Scale: 1:50						

		GRM Development Solutions Ltd Laurus House, First Avenue, Centrum 100, Burton-on-Trent, DE14 2WH Tel (HQ): 01283 551249 Email: info@grm-uk.com		Cable-Percussion Borehole			Borehole No. BH102 Sheet 1 of 2	
Site Name: Crease Drove, Crowland							Ground Level (mAOD) 1.63	
Client: Partner Construction Ltd					GRM Project Ref: P8723		Coordinates 523843 E 309619 N	

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		0.30	D				Firm, brown, gravelly CLAY. MADE GROUND		
		1.00	D	N=6 (1,1/1,2,1,2)	0.90	0.73		Firm, grey, sandy, silty organic CLAY PEAT	1
		1.20	C						
		1.50	D						
		2.00	C	N=5 (1,1/1,1,2,1)	1.70	-0.07		Loose to medium dense, brown, clayey, sandy GRAVEL. ABBEEY SAND AND GRAVEL	2
		2.50	D						
		3.00	D						
		3.00	C	N=9 (1,2/2,2,2,3)	3.20	-1.57		Firm to stiff, becoming very stiff, grey CLAY. OXFORD CLAY	3
		4.00 - 4.45	D						
		4.00	S	N=13 (2,3/3,3,3,4)					4
	5.00	U							5
	6.50 - 6.95	D	N=33 (6,6/7,8,8,10)						
	6.50	S							7
	8.00	U							8
							Continued on Next Sheet	9	

Crew: T. Bedford, Site Investigation.		Logger: KD.		Chiselling Details		
				Depth Top	Duration	Remarks
Equipment:						
Groundwater Remarks: Groundwater encountered at 4.2m begl, rising to 4.1m begl.				Casing Diameter by Depth		
General Remarks:				Depth Base	Diameter	Remarks
Hole Started: 05/06/2019		Hole Complete: 05/06/2019		Version: FINAL		Scale: 1:50

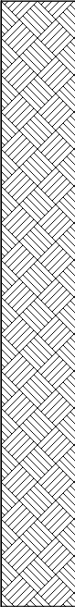
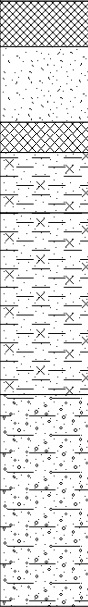
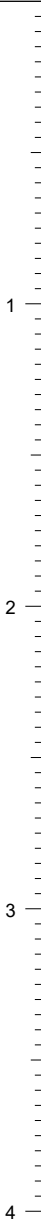
		GRM Development Solutions Ltd Laurus House, First Avenue, Centrum 100, Burton-on-Trent, DE14 2WH Tel (HQ): 01283 551249 Email: info@grm-uk.com		Cable-Percussion Borehole			Borehole No. BH102 Sheet 2 of 2	
Site Name: Crease Drove, Crowland							Ground Level (mAOD) 1.63	
Client: Partner Construction Ltd					GRM Project Ref: P8723		Coordinates 523843 E 309619 N	

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		9.50 - 9.95 9.50	D S	N=51 (8,9/10,13,13,15)			Firm to stiff, becoming very stiff, grey CLAY. OXFORD CLAY		
		11.00	U						
		12.50 - 12.95 12.50	D S	N=68 (10,12/14,16,17,21)					
		14.50	U						
					15.00	-13.37		End of Borehole at 15.00m	

Crew: T. Bedford, Site Investigation.		Logger: KD.		Chiselling Details		
Equipment:		Groundwater Remarks: Groundwater encountered at 4.2m begl, rising to 4.1m begl.		Depth Top	Duration	Remarks
				Casing Diameter by Depth		
				Depth Base	Diameter	Remarks
General Remarks:						
Hole Started: 05/06/2019		Hole Complete: 05/06/2019		Version: FINAL		Scale: 1:50

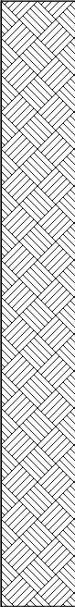
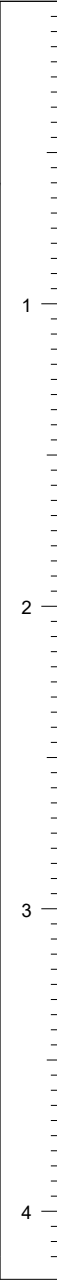
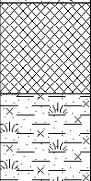
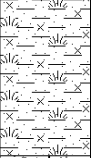
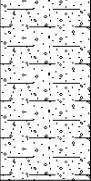
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		GRM Development Solutions Ltd Laurus House, First Avenue, Centrum 100, Burton-on-Trent, DE14 2WH Tel (HQ): 01283 551249 Email: info@grm-uk.com		Windowless Sample Borehole				Borehole No HH102 Sheet 1 of 1	
Site Name: Crease Drive, Crowland								Ground Level (mAOD) 2.50	
Client: Partner Construction Ltd						GRM Project Ref: P8723		Coordinates 523702 E 309669 N	

Installation/ Backfill	Water Strike	Samples/Tests			Dynamic Probing (Blows per 100mm)	Depth (m)	Level (m)	Legend	Stratum Description	
		Depth	Type	Result						
						0.15	2.35		Black asphalt / tarmacadam hardstanding.	
						0.40	2.10		MADE GROUND	
		0.40 - 0.50	D		0.50	2.00	Grey concrete hardstanding.			
		0.40 - 0.50	ES				Approximately loose, buff, slightly clayey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse, angular to sub-angular, limestone and quartzite. Wet.			
		0.60 - 0.70	D				MADE GROUND			
		0.70 - 0.60	ES				Firm, grey slightly sandy, silty organic CLAY. Sand is fine to coarse. Occasional fibrous plant material and natural organic odour present.			
		0.70 - 0.70					PEAT			
							Soft light grey, sandy silty organic CLAY. Sand is fine to coarse. Natural organic odour present.			
							PEAT			
							Approximately loose to medium dense, yellow brown, slightly clayey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse, angular to sub-rounded, quartzite. Wet.			
					2.00	0.50		ABBEY SAND AND GRAVEL	2	
								End of Borehole at 2.000m	3	
									4	

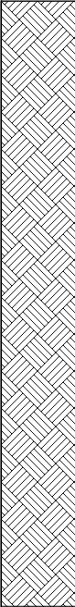
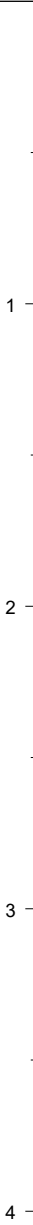
Crew: GRM.		Logger: AL.		Weather: Sunny.	
Equipment: Hand Held Windowless Sampler.					
Reason for termination of borehole: Design depth achieved.					
Groundwater Remarks: Wet material at 0.4m and 1.3m begl.					
General Remarks:					
Hole Started:	05/06/2019	Hole Complete:	05/06/2019	Version:	FINAL
				Scale:	1:25

		GRM Development Solutions Ltd Laurus House, First Avenue, Centrum 100, Burton-on-Trent, DE14 2WH Tel (HQ): 01283 551249 Email: info@grm-uk.com		Windowless Sample Borehole				Borehole No HH103 Sheet 1 of 1	
Site Name: Crease Drive, Crowland								Ground Level (mAOD) 2.50	
Client: Partner Construction Ltd						GRM Project Ref: P8723		Coordinates 523711 E 309691 N	

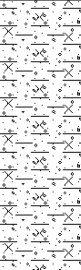
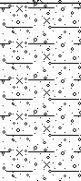
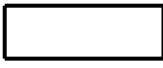
Installation/ Backfill	Water Strike	Samples/Tests			Dynamic Probing (Blows per 100mm)	Depth (m)	Level (m)	Legend	Stratum Description	
		Depth	Type	Result						
		0.30 - 0.40	D			0.30	2.20		Grey concrete Hardstanding. MADE GROUND	
		0.30 - 0.40	ES			0.60	1.90			
	0.90 - 1.00	D						Firm, dark grey stained black, slightly sandy, silty organic CLAY. Sand is fine to coarse. PEAT		
	0.90 - 1.00	ES			1.40	1.10			Approximately medium dense, light brown, slightly clayey, slightly gravelly SAND. Sand is fine to coarse. Gravel is fine to coarse, sub-rounded, mudstone. Wet. ABBEE SAND AND GRAVEL	
	1.50 - 1.60	D			2.00	0.50			End of Borehole at 2.000m	
	1.50 - 1.60	ES								

Crew: GRM.		Logger: AL.		Weather: Sunny.	
Equipment: Hand Held Windowless Sampler.					
Reason for termination of borehole: Design depth achieved.					
Groundwater Remarks: Wet material at 0.3m and 1.4m begl.					
General Remarks:					
Hole Started: 05/06/2019		Hole Complete: 05/06/2019		Version: FINAL	
				Scale: 1:25	

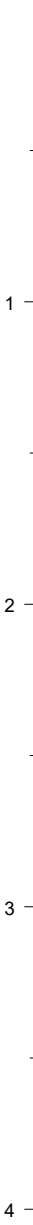
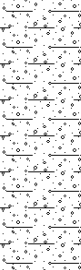
		GRM Development Solutions Ltd Laurus House, First Avenue, Centrum 100, Burton-on-Trent, DE14 2WH Tel (HQ): 01283 551249 Email: info@grm-uk.com		Windowless Sample Borehole				Borehole No HH104 Sheet 1 of 1	
Site Name: Crease Drove, Crowland								Ground Level (mAOD) 2.50	
Client: Partner Construction Ltd						GRM Project Ref: P8723		Coordinates 523732 E 309690 N	

Installation/ Backfill	Water Strike	Samples/Tests			Dynamic Probing (Blows per 100mm)	Depth (m)	Level (m)	Legend	Stratum Description	
		Depth	Type	Result						
		0.30 - 0.40	D			0.30	2.20		Grey concrete hardstanding. MADE GROUND	
		0.30 - 0.40	ES			0.60	1.90			
	0.70 - 0.80	D			0.70	1.80		MADE GROUND		
	0.70 - 0.80	ES			0.95	1.55			Solid layer of red brick. MADE GROUND	
	1.30 - 1.40	D			1.20	1.30			Soft, dark grey stained black, slightly silty organic CLAY. Sand is fine to coarse. Natural organic odour present. Wet	
	1.30 - 1.40	ES			1.80	0.70			PEAT	
					2.00	0.50			Firm, grey, slightly gravelly, slightly sandy, silty organic CLAY. Sand is fine to coarse. Gravel is fine to coarse. sub-rounded, mudstone and occasional quartzite. PEAT	
									Approximately dense, dark grey stained black, clayey SAND. Sand is fine to coarse. Strong Hydrocarbon odour present. PEAT	
								Approximately medium dense to dense, light brown, slightly clayey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse, quartzite. ABBAY SAND AND GRAVEL		
								End of Borehole at 2.000m		

Crew: GRM.		Logger: AL.		Weather: Sunny.	
Equipment: Hand Held Windowless Sampler.					
Reason for termination of borehole: Design depth achieved.					
Groundwater Remarks: Wet material at 0.3m and 0.95m begl.					
General Remarks:					
Hole Started: 05/06/2019		Hole Complete: 05/06/2019		Version: FINAL	
				Scale: 1:25	

		GRM Development Solutions Ltd Laurus House, First Avenue, Centrum 100, Burton-on-Trent, DE14 2WH Tel (HQ): 01283 551249 Email: info@grm-uk.com		Trial Pit Log		Trial Pit No TP101 Sheet 1 of 1	
Site Name: Crease Drive, Crowland						Ground Level (mAOD) 2.50	
Client: Partner Construction Ltd				GRM Project Ref: P8723		Coordinates 523716 E 309707 N	
Water Strike	Samples & In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
	Depth	Type	Results				
	0.50 - 0.60 0.50 - 0.60	B D		0.30	2.20	 Vegetation over dark brown, slightly sandy, slightly gravelly silty CLAY. Sand is fine to coarse. Gravel is fine to coarse, sub-rounded, quartzite, mudstone and occasional chalk. MADE GROUND	1
						 Soft, light brown to yellow brown, slightly gravelly, very sandy, silty CLAY. Sand is fine to coarse. Gravel is fine to coarse, quartzite and mudstone. ABBEY SAND AND GRAVEL	
	1.50 - 1.60 1.50 - 1.60	B D		1.20	1.30	 Loose to medium dense, light brown, to yellow brown, slightly clayey, slightly silty, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse, sub-angular, quartzite, mudstone and occasional chalk. Wet. ABBEY SAND AND GRAVEL	2
	1.90 - 2.00 1.90 - 2.00	B D		1.80 2.00	0.70 0.50	 Firm to stiff, grey, slightly sandy, gravelly CLAY with pockets of orange fine to coarse sand. Gravel is fine to coarse, sub-angular to rounded, chalk, limestone and occasional quartzite. OXFORD CLAY End of Pit at 2.00m	
Date Excavated: 04/06/2019				Groundwater Observations:			
Date Backfilled: 04/06/2019				Wet material at 1.2m begl.			
Shoring: None.							
Stability: Stable at full depth.							
Plant Used: JCB 3CX.				Trial Pit Dimensions (m):		Reason for termination of Trial Pit:	
Logged by: AL.				0.45  2.10		Target depth achieved.	
General Remarks:							
Relative density is approximate and determined by observation only.							
Version: FINAL				Scale: 1:25			

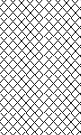
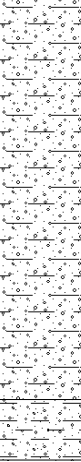
		GRM Development Solutions Ltd Laurus House, First Avenue, Centrum 100, Burton-on-Trent, DE14 2WH Tel (HQ): 01283 551249 Email: info@grm-uk.com		Trial Pit Log		Trial Pit No TP102 Sheet 1 of 1	
Site Name: Crease Drive, Crowland						Ground Level (mAOD) 1.57	
Client: Partner Construction Ltd				GRM Project Ref: P8723		Coordinates 523812 E 309666 N	

Water Strike	Samples & In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
	Depth	Type	Results					
 	0.40 - 0.50	B D		0.30	1.27		Vegetation over dark brown, slightly sandy, gravelly, silty CLAY. Sand is fine to coarse. Gravel is angular to sub-rounded, brick, concrete, sandstone and ceramics. MADE GROUND	
	0.40 - 0.50			0.50	1.07		Soft, light brown to yellow brown, slightly gravelly, very sandy, silty CLAY. Sand is fine to coarse. Gravel is fine to coarse, sub-angular to rounded, chalk, limestone and quartzite. ABBEY SAND AND GRAVEL	
				0.80	0.77		Soft, light brown to yellow brown, very sandy, silty CLAY. Sand is fine to coarse. ABBEY SAND AND GRAVEL	
	1.00 - 1.10 1.00 - 1.10	B D		1.90	-0.33		Loose to medium dense, slightly clayey, very sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse, sub-angular to rounded, chalk, quartzite and mudstone. Wet. ABBEY SAND AND GRAVEL	
							End of Pit at 1.90m	

Date Excavated: 04/06/2019		Groundwater Observations:	
Date Backfilled: 04/06/2019		Wet material at 0.8m begl. Fast water ingress at 1.2m begl.	
Shoring: None.			
Stability: Stable at full depth.			
Plant Used: JCB 3CX.		Reason for termination of Trial Pit:	
Logged by: AL.		Target depth achieved.	
General Remarks:			

Relative density is approximate and determined by observation only.	Version: FINAL	Scale: 1:25
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		GRM Development Solutions Ltd Laurus House, First Avenue, Centrum 100, Burton-on-Trent, DE14 2WH Tel (HQ): 01283 551249 Email: info@grm-uk.com		Trial Pit Log			Trial Pit No TT101-S Sheet 1 of 1	
Site Name: Crease Drive, Crowland							Ground Level (mAOD) 2.00	
Client: Partner Construction Ltd					GRM Project Ref: P8723		Coordinates 523738 E 309636 N	

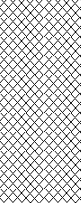
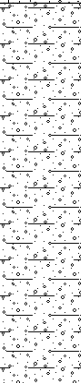
Water Strike	Samples & In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
	Depth	Type	Results					
	0.40 - 0.50 0.40 - 0.50 0.50 - 0.60 0.50 - 0.60	B D B D		0.50	1.50		Dark brown, slightly sandy, gravelly silty CLAY, with a moderate cobble content. Sand is fine to coarse. Gravel is fine to coarse. Gravel and cobbles are angular to sub-rounded, brick, concrete, plastics, sandstone and limestone. MADE GROUND <i>Boulders of angular concrete between 0.4 to 0.5m begl.</i>	
	1.00 - 1.10 1.00 - 1.10	B D		0.70	1.30		Soft, dark brown, stained black, slightly gravelly silty CLAY. Gravel is fine to medium mudstone, sub-angular to rounded, mudstone. Natural organic odour present. PEAT Loose to medium dense, light brown, slightly clayey, very sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse, sub-angular to rounded, quartzite. ABBEY SAND AND GRAVEL	1
	2.10 - 2.20 2.10 - 2.20	B D		2.10	-0.10		Firm to stiff, slightly sandy, gravelly CLAY. Sand is fine to coarse. Gravel is fine to medium, sub-rounded to rounded, chalk, limestone with occasional quartzite. OXFORD CLAY <i>End of Pit at 2.30m</i>	2
				2.30	-0.30			3
								4

Date Excavated: 04/06/2019		Groundwater Observations:	
Date Backfilled: 04/06/2019		Wet material at 1.1m. Fast water ingress at 1.8m begl.	
Shoring: None.			
Stability: Sidewall collapse at 0.7m begl.			
Plant Used: JCB 3CX.		Reason for termination of Trial Pit:	
Logged by: AL.		Target depth achieved.	
General Remarks: Combined with TT01-N.			

Relative density is approximate and determined by observation only.		Version: FINAL		Scale: 1:25	
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Scale: 1:25

		GRM Development Solutions Ltd Laurus House, First Avenue, Centrum 100, Burton-on-Trent, DE14 2WH Tel (HQ): 01283 551249 Email: info@grm-uk.com		Trial Pit Log		Trial Pit No TT102-S Sheet 1 of 1	
Site Name: Crease Drove, Crowland						Ground Level (mAOD) 1.80	
Client: Partner Construction Ltd				GRM Project Ref: P8723		Coordinates 523757 E 309636 N	

Water Strike	Samples & In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
	Depth	Type	Results					
▼	0.50 - 0.60	B D		0.70	1.10		Dark brown, slightly sandy, gravelly, silty CLAY with a moderate cobble content. Sand is fine to coarse. Gravel is fine to coarse. Gravel and cobbles are angular to sub-rounded, brick, quartzite, concrete, ceramics and limestone. MADE GROUND	1
	0.50 - 0.60						Soft, dark grey stained black, slightly gravelly, slightly sandy, organic CLAY. Sand is fine to coarse. Gravel is fine to medium, mudstone. frequent slightly decomposed plant fibrous plant material. PEAT	
	1.80 - 1.90	B D		1.20	0.60		Loose to medium dense, yellow brown, slightly clayey, very sandy GRAVEL. Sand is fine to coarse.. Gravel is fine to coarse, sub-angular to rounded, quartzite, chalk and mudstone. ABBEY SAND AND GRAVEL	2
	1.80 - 1.90						Firm to stiff, grey, slightly sandy, gravelly CLAY. Sand is fine to coarse. Gravel is fine to coarse, sub-rounded to rounded, chalk, mudstone and occasional quartzite. OXFORD CLAY	
				2.50	-0.70			3
				2.70	-0.90		End of Pit at 2.70m	
								4

Date Excavated: 04/06/2019		Groundwater Observations:	
Date Backfilled: 04/06/2019		Fast water ingress at 1.6m begl.	
Shoring: None.			
Stability: Stable at full depth.			
Plant Used: JCB 3CX.		Reason for termination of Trial Pit:	
Logged by: AL.		Target depth achieved.	

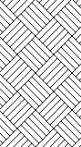
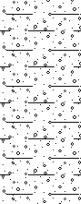
General Remarks: Combined with TT02-N.

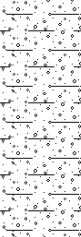
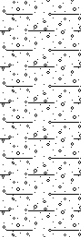
Trial Pit Dimensions (m):

0.45

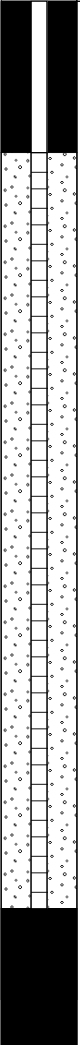
7.00

Relative density is approximate and determined by observation only.	Version: FINAL	Scale: 1:25
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		GRM Development Solutions Ltd Laurus House, First Avenue, Centrum 100, Burton-on-Trent, DE14 2WH Tel (HQ): 01283 551249 Email: info@grm-uk.com		Trial Pit Log		Trial Pit No TT103 Sheet 1 of 1	
Site Name: Crease Drove, Crowland						Ground Level (mAOD) 1.54	
Client: Partner Construction Ltd				GRM Project Ref: P8723		Coordinates 523787 E 309627 N	
Water Strike	Samples & In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
	Depth	Type	Results				
▼ ▼	0.40 0.40	B D		0.55	0.99		Vegetation over dark brown, slightly gravelly, sandy CLAY. Sand is fine to coarse. Gravel is fine to coarse, sub-angular, quartzite and mudstone. TOPSOIL
	0.60 - 0.70 0.60 - 0.70	B D					<u>Band of sandy silty clay.</u> Soft, dark grey with occasional black staining, slightly gravelly, slightly sandy silty organic CLAY. Sand is fine to coarse. Gravel is fine to coarse, sub-rounded, mudstone. Occasional decomposed fibrous plant material. Natural organic odour present. PEAT
	1.20 - 1.30 1.20 - 1.30	B D		1.50	0.04		Loose, grey, slightly clayey silty fine to coarse SAND. Wet. ABBEY SAND AND GRAVEL
	1.80 - 1.90 1.80 - 1.90	B D		1.60	-0.06		
				2.40	-0.86		Loose to medium dense, yellow brown, slightly clayey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse, sub-angular to rounded, mudstone, chalk and quartzite. ABBEY SAND AND GRAVEL
							End of Pit at 2.40m
Date Excavated: 04/06/2019			Groundwater Observations:				
Date Backfilled: 04/06/2019			Wet material at 1.5m begl. Moderate water ingress at 2.1m begl.				
Shoring: None.			Trial Pit Dimensions (m): 0.45  7.50				
Stability: Slight sidewall collapse between 1.6 and 1.9m.							
Plant Used: JCB 3CX.			Reason for termination of Trial Pit:				
Logged by: AL.			Target depth achieved.				
General Remarks:							
Relative density is approximate and determined by observation only.							
Version: FINAL				Scale: 1:25			

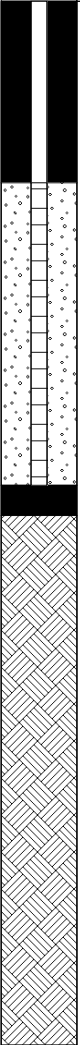
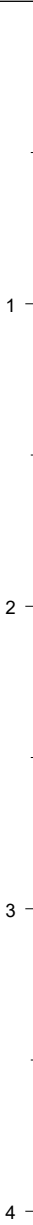
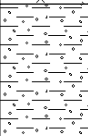
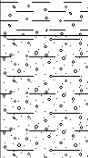
		GRM Development Solutions Ltd Laurus House, First Avenue, Centrum 100, Burton-on-Trent, DE14 2WH Tel (HQ): 01283 551249 Email: info@grm-uk.com		Trial Pit Log			Trial Pit No TT104 Sheet 1 of 1		
Site Name: Crease Drive, Crowland							Ground Level (mAOD) 1.59		
Client: Partner Construction Ltd					GRM Project Ref: P8723			Coordinates 523822 E 309632 N	
Water Strike	Samples & In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description		
	Depth	Type	Results						
▼ ▼	0.30 - 0.40	B		0.40	1.19		Vegetation over dark brown, slightly gravelly, sandy, CLAY. Sand is fine to coarse. Gravel is fine to coarse, sub-angular to sub-rounded, quartzite, mudstone and occasional chalk.		
	0.30 - 0.40	D			1.09		TOPSOIL		
	0.50 - 0.60	B					Medium dense, grey, slightly clayey silty fine to coarse SAND.		
	0.50 - 0.60	D					PEAT		
					1.70	-0.11		Soft, dark brown occasional stained black, slightly sandy, slightly gravelly silty organic CLAY. Sand is fine to coarse. Gravel is fine to medium, mudstone. Occasional decomposed plant material. Natural organic odour present. PEAT	
						Becoming sandy below 1.5m begl.			
	2.00 - 2.10	B		2.50	-0.91		Loose to medium dense, yellow brown, slightly clayey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse, sub-angular to rounded, quartzite and mudstone.		
	2.00 - 2.10	D					ABBEY SAND AND GRAVEL		
							Wet material at 1.9m begl.		
							End of Pit at 2.50m		
Date Excavated: 04/06/2019				Groundwater Observations:					
Date Backfilled: 04/06/2019				Wet material at 1.9m begl, Moderate water ingress at 2.2m begl.					
Shoring: None.									
Stability: Stable at full depth.									
Plant Used: JCB 3CX.				Trial Pit Dimensions (m):		Reason for termination of Trial Pit:			
Logged by: AL.				0.45 		Target depth achieved.			
General Remarks:									
Relative density is approximate and determined by observation only.				Version: FINAL		Scale: 1:25			

		GRM Development Solutions Ltd Laurus House, First Avenue, Centrum 100, Burton-on-Trent, DE14 2WH Tel (HQ): 01283 551249 Email: info@grm-uk.com		Windowless Sample Borehole			Borehole No WS01 Sheet 1 of 1	
Site Name: Crease Drive, Crowland							Ground Level (mAOD) 1.43	
Client: Partner Construction Ltd					GRM Project Ref: P8723		Coordinates 523827 E 309611 N	

Installation/ Backfill	Water Strike	Samples/Tests			Dynamic Probing (Blows per 100mm)	Depth (m)	Level (m)	Legend	Stratum Description	
		Depth	Type	Result						
		0.05 - 0.20	D	N=1 (0,0/0,1,0,0)				Dark brown, slightly sandy CLAY. sand is fine to medium. With a trace of rootlets. TOPSOIL <i>- with some brick and slate fragments</i>	1 2 3 4	
		0.05 - 0.20	ES							
		0.50 - 0.60	D			0.40	1.03	Firm to stiff, grey-brown, CLAY. PEAT.		
		0.50 - 0.60	ES			0.70	0.73	Soft to firm, grey-brown stained yellow-brown, slightly sandy CLAY. Sand is fine to medium. With trace of rootlets. PEAT.		
		0.80 - 1.00	D							
		0.80 - 1.00	ES			1.05	0.38	Very soft to soft, grey slightly stained red-brown, silty CLAY. With a trace of roots. PEAT.		
		1.00 - 1.45	SPTLS							
		1.00 - 1.20	S							
		1.20 - 1.40	D					<i>- grading dark brown, slightly sandy silty clay</i>		
						1.50	-0.07	Firm, grey, slightly gravelly CLAY. Gravel is fine to medium, subrounded, mudstone. PEAT.		
		1.80	D			1.70	-0.27	Soft, grey frequently stained dark grey and black, sandy CLAY. Sand is fine to medium. With some rootlets and visible wood fragments. Faint organic odour. PEAT.		
		2.00 - 2.45	SPTLS		N=6 (1,1/1,2,2,1)					
		2.00 - 2.00	S					<i>- slightly gravelly clayey sand band, wet</i>		
		2.50	D					<i>- grading stiff slightly gravelly sandy CLAY</i>		
		2.90	D			2.80	-1.37	Medium dense, brown to orange-brown, slightly clayey, slightly sandy GRAVEL. Sand is fine to coarse. Gravel is fine to medium, subangular, quartzite. ABBEY SAND AND GRAVEL.		
	3.00 - 3.45	SPTLS	N=15 (2,3/3,3,4,5)							
	3.00 - 3.00	S		3.45	-2.02	End of Borehole at 3.450m				

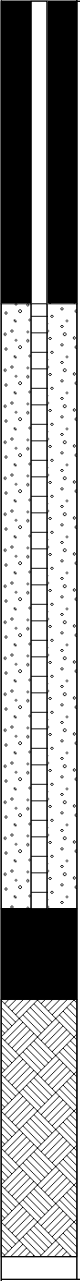
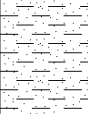
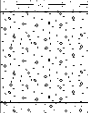
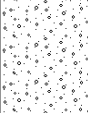
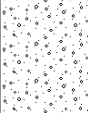
Crew: RGI	Logger: LB	Weather: Rain
Equipment: Tracked Window Sampling Rig		
Reason for termination of borehole: Target depth reached		
Groundwater Remarks: 2.0m.		
General Remarks:		
Hole Started: 05/12/2018	Hole Complete: 05/12/2018	Version: FINAL
		Scale: 1:25

		GRM Development Solutions Ltd Laurus House, First Avenue, Centrum 100, Burton-on-Trent, DE14 2WH Tel (HQ): 01283 551249 Email: info@grm-uk.com		Windowless Sample Borehole			Borehole No WS02 Sheet 1 of 1		
Site Name: Crease Drive, Crowland							Ground Level (mAOD) 1.48		
Client: Partner Construction Ltd					GRM Project Ref: P8723			Coordinates 523843 E 309660 N	

Installation/ Backfill	Water Strike	Samples/Tests			Dynamic Probing (Blows per 100mm)	Depth (m)	Level (m)	Legend	Stratum Description		
		Depth	Type	Result							
		0.20	D						Brown-grey CLAY. With some rootlets. TOPSOIL.		
		0.20	ES								
		0.60					0.88		Firm, dark brown, silty CLAY. With trace of rootlets. PEAT.		
		0.80	D				0.73				
		0.80	ES						Firm to stiff, brown and orange-brown, slightly sandy, slightly gravelly CLAY. Sand is fine to medium. Gravel is fine to medium, subangular and quartzite. Wet. ABBEY SAND AND GRAVEL.		
		1.00 - 1.45	SPTLS	N=33 (1,7/8,8,8,9)							
		1.00	S								
		1.30	D				1.30	0.18			Medium dense, brown, slightly clayey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to medium, subangular and subrounded, quartzite. ABBEY SAND AND GRAVEL.
		1.80	D								
		2.00 - 2.45	SPTLS	N=20 (3,4/5,4,6,5)							- grading orange-brown sandy GRAVEL
2.00	S										
2.70	D							- grading slightly clayey sandy GRAVEL			
3.00 - 3.45	SPTLS	N=13 (3,3/3,2,4,4)									
3.00	S										
					3.45	-1.97		End of Borehole at 3.450m			

Crew: RGI	Logger: LB	Weather: Rain
Equipment: Tracked Window Sampling Rig		
Reason for termination of borehole: Target depth reached		
Groundwater Remarks: 0.8m.		
General Remarks:		
Hole Started: 05/12/2018	Hole Complete: 05/12/2018	Version: FINAL
		Scale: 1:25

		GRM Development Solutions Ltd Laurus House, First Avenue, Centrum 100, Burton-on-Trent, DE14 2WH Tel (HQ): 01283 551249 Email: info@grm-uk.com		Windowless Sample Borehole			Borehole No WS03 Sheet 1 of 2		
Site Name: Crease Drive, Crowland							Ground Level (mAOD) 1.54		
Client: Partner Construction Ltd					GRM Project Ref: P8723			Coordinates 523785 E 309636 N	

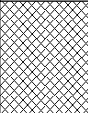
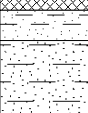
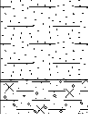
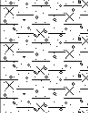
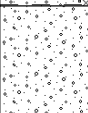
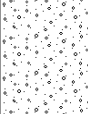
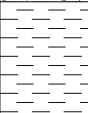
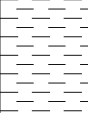
Installation/ Backfill	Water Strike	Samples/Tests			Dynamic Probing (Blows per 100mm)	Depth (m)	Level (m)	Legend	Stratum Description	
		Depth	Type	Result						
		0.20 0.20	D ES			0.30	1.24		Dark brown CLAY. With some rootlets. TOPSOIL.	
						0.55	0.99		Firm to stiff, grey, slightly gravelly, sandy CLAY. Sand is fine. Gravel is fine, subangular, mudstone and quartzite. PEAT.	
		0.70 0.70	D ES						Stiff, brown and orange-brown, slightly gravelly sandy CLAY. Sand is fine to medium. Gravels is fine, subangular, mudstone and quartzite. ABBEY SAND AND GRAVEL.	
		1.00 - 1.45	SPTLS	N=28 (1,5/5,7,8,8)		1.00	0.54		- grading firm to stiff slightly sandy CLAY Medium dense, grey-brown, slightly clayey, slightly gravelly SAND. Sand is fine to coarse. Gravel is fine to medium, subangular, quartzite. With some shells. Wet. ABBEY SAND AND GRAVEL.	1
		1.00 1.20	S D			1.30	0.24		Medium dense, brown to orange-brown, slightly clayey, sandy GRAVEL. Sand is fine to medium. Gravel is fine to medium, subangular, quartzite. ABBEY SAND AND GRAVEL.	
		1.70	D						- grading sandy GRAVEL	
		2.00 - 2.45	SPTLS	N=11 (3,3/4,3,2,2)						2
		2.00	S							
		2.60	D							
		2.95 3.00 - 3.45 3.00	D SPTLS S	N=29 (4,4/5,7,9,8)		2.95	-1.41		Stiff, grey, CLAY. OXFORD CLAY.	3
	3.90 4.00 - 4.45 4.00	D SPTLS S	N=20 (2,2/4,5,5,6)						4	

Crew: RGI		Logger: LB		Weather: Rain	
Equipment: Tracked Window Sampling Rig					
Reason for termination of borehole: Target depth reached					
Groundwater Remarks: 1.0m.					
General Remarks:					

Hole Started:	05/12/2018	Hole Complete:	05/12/2018	Version:	FINAL	Scale:	1:25
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		GRM Development Solutions Ltd Laurus House, First Avenue, Centrum 100, Burton-on-Trent, DE14 2WH Tel (HQ): 01283 551249 Email: info@grm-uk.com		Windowless Sample Borehole				Borehole No WS03 Sheet 2 of 2		
Site Name: Crease Drove, Crowland								Ground Level (mAOD) 1.54		
Client: Partner Construction Ltd					GRM Project Ref: P8723			Coordinates 523785 E 309636 N		
Installation/ Backfill	Water Strike	Samples/Tests			Dynamic Probing (Blows per 100mm)	Depth (m)	Level (m)	Legend	Stratum Description	
		Depth	Type	Result						
						4.45	-2.91		Stiff, grey, CLAY. OXFORD CLAY.	
									End of Borehole at 4.450m	
										5
										6
										7
										8
Crew: RGI					Logger: LB			Weather: Rain		
Equipment: Tracked Window Sampling Rig										
Reason for termination of borehole: Target depth reached										
Groundwater Remarks: 1.0m.										
General Remarks:										
Hole Started: 05/12/2018		Hole Complete: 05/12/2018		Version: FINAL		Scale: 1:25				

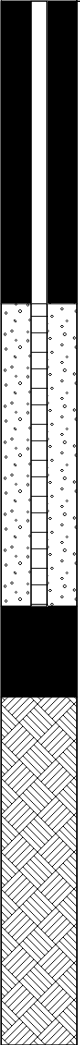
		GRM Development Solutions Ltd Laurus House, First Avenue, Centrum 100, Burton-on-Trent, DE14 2WH Tel (HQ): 01283 551249 Email: info@grm-uk.com		Windowless Sample Borehole			Borehole No WS04 Sheet 1 of 1		
Site Name: Crease Drive, Crowland							Ground Level (mAOD) 1.62		
Client: Partner Construction Ltd					GRM Project Ref: P8723			Coordinates 523775 E 309677 N	

Installation/ Backfill	Water Strike	Samples/Tests			Dynamic Probing (Blows per 100mm)	Depth (m)	Level (m)	Legend	Stratum Description		
		Depth	Type	Result							
		0.20 0.20	D ES						Brick fill, fine to coarse gravel and cobbles of brick, slightly clayey. MADE GROUND.		
						0.40 0.50	1.22 1.12			Stiff, grey mottled orange-brown, slightly gravelly, sandy CLAY. Sand is fine to medium. Gravel is fine to medium, subangular, quartzite. ABBEY SAND AND GRAVEL.	
		0.70	D							Medium dense, brown and orange-brown, slightly gravelly, clayey SAND. Sand is fine to medium. Gravel is fine to medium, subangular, quartzite. ABBEY SAND AND GRAVEL.	
		1.00 - 1.45 1.00	SPTLS S	N=24 (2,4/5,6,7,6)		1.00	0.62			Wet. ABBEY SAND AND GRAVEL. - sandy CLAY from 0.6m to 0.75m	1
		1.40	D							Stiff, grey-brown, slightly sandy, slightly gravelly CLAY. Sand is fine to medium. Gravel is fine, subangular, quartzite. ABBEY SAND AND GRAVEL.	
		1.60	D			1.50	0.12			Medium dense, orange-brown, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to medium, subangular, quartzite. Wet. ABBEY SAND AND GRAVEL. - Gravelly CLAY band from 1.7m to 1.9m	2
		2.00 - 2.45 2.00	SPTLS S	N=11 (2,1/2,2,4,3)							
		2.80	D			2.60	-0.98			Stiff, grey mottled orange-brown, CLAY OXFORD CLAY. - selenite observed from 2.6m to 2.8m	
		3.00 - 3.45 3.00	SPTLS S	N=17 (2,2/4,5,4,4)						- grey	3
						3.45	-1.83			End of Borehole at 3.450m	4

Crew: RGI		Logger: LB		Weather: Rain	
Equipment: Tracked Window Sampling Rig					
Reason for termination of borehole: Target depth reached					
Groundwater Remarks: 1.5m.					
General Remarks:					

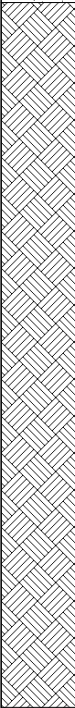
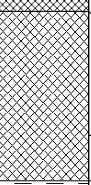
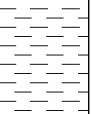
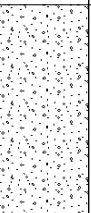
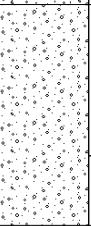
Hole Started:	05/12/2018	Hole Complete:	05/12/2018	Version:	FINAL	Scale:	1:25
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		GRM Development Solutions Ltd Laurus House, First Avenue, Centrum 100, Burton-on-Trent, DE14 2WH Tel (HQ): 01283 551249 Email: info@grm-uk.com		Windowless Sample Borehole				Borehole No WS06 Sheet 1 of 1	
Site Name: Crease Drove, Crowland								Ground Level (mAOD) 2.39	
Client: Partner Construction Ltd						GRM Project Ref: P8723		Coordinates 523682 E 309646 N	

Installation/ Backfill	Water Strike	Samples/Tests			Dynamic Probing (Blows per 100mm)	Depth (m)	Level (m)	Legend	Stratum Description		
		Depth	Type	Result							
		0.40	D	N=6 (1,1/1,2,2,1)		0.30	2.09		Dark grey and brown, gravelly SAND. Sand is fine to medium. Gravel is fine to medium, subangular, slate and quartzite. MADE GROUND.	1	
		0.40	ES			0.50	1.89				Approximately medium dense, light brown, slightly sandy, cobbly GRAVEL. sand is fine to medium. Gravel is fine to coarse, subrounded and subangular, sandstone. MADE GROUND.
		0.90	ES			0.75	1.64				Firm to stiff, grey, slightly sandy CLAY. Sand is fine to medium. POSSIBLE MADE GROUND.
		1.00	D			0.85	1.54				Firm, dark grey, slightly sandy, silty CLAY. Sand is fine. POSSIBLE MADE GROUND.
		1.00 - 1.45	SPTLS	N=19 (3,5/5,4,5,5)		2.00	0.39		Soft to firm, grey frequently stained black, slightly gravelly clay. Gravel is fine to medium, subangular. Strong hydrocarbon odour. PEAT.	2	
		1.45	S								- faint hydrocarbon odour, grading stiff, grey mottled orange-brown, wet
		1.90	D								Stiff, orange-brown, slightly sandy gravelly CLAY. Sand is fine to coarse. Gravel is fine to medium, subangular, quartzite. ABBEY SAND AND GRAVEL. Wet.
		2.00 - 2.45	SPTLS	N=21 (2,3/4,4,5,8)		2.60	-0.21		- grading medium dense, orange-brown, slightly clayey, gravelly SAND.	3	
		2.45	S								Stiff, grey, slightly gravelly CLAY. Gravel is fine to medium, subangular, chalk and rare flint. Oxford Clay.
		2.90	D								Stiff, grey, CLAY. OXFORD CLAY
3.00 - 3.45	SPTLS			3.45	-1.06		End of Borehole at 3.450m	4			
3.45	S										

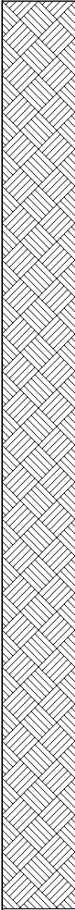
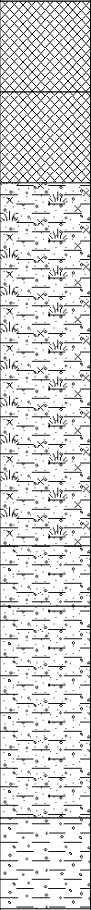
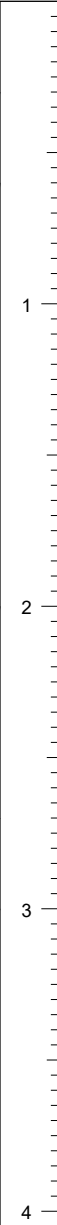
Crew: RGI		Logger: LB		Weather: Rain	
Equipment: Tracked Window Sampling Rig					
Reason for termination of borehole: Target depth reached					
Groundwater Remarks: 1.5m.					
General Remarks:					
Hole Started: 05/12/2018		Hole Complete: 05/12/2018		Version: FINAL	
				Scale: 1:25	

		GRM Development Solutions Ltd Laurus House, First Avenue, Centrum 100, Burton-on-Trent, DE14 2WH Tel (HQ): 01283 551249 Email: info@grm-uk.com		Windowless Sample Borehole				Borehole No WS07 Sheet 1 of 1	
Site Name: Crease Drove, Crowland								Ground Level (mAOD) 2.49	
Client: Partner Construction Ltd						GRM Project Ref: P8723		Coordinates 523690 E 309682 N	

Installation/ Backfill	Water Strike	Samples/Tests			Dynamic Probing (Blows per 100mm)	Depth (m)	Level (m)	Legend	Stratum Description		
		Depth	Type	Result							
		0.30	ES			0.04	2.45		ASPHALT/TARMAC Approximately medium dense, light brown, gravelly SAND. Sand is fine to medium. Gravel is fine to medium, subangular, quartzite. MADE GROUND. - sandstone cobble band (50mm)	1	
		0.70	D			0.60	1.89				Firm, dark grey, slightly sandy, slightly gravelly CLAY. Sand is fine to medium. Gravel is fine, subangular and quartzite. with rare wood fragments. PEAT.
		0.70	ES								
		0.90	D								
		0.90	ES								
		1.00	S	N=15 (2,2/3,3,4,5)		1.00	1.49		Medium dense, brown, slightly gravelly SAND. Sand is fine to coarse. Gravel is fine to medium, subangular, quartzite. Wet. ABBEY SAND AND GRAVEL.		
		1.10	D								
		1.20	ES								
		1.20	ES								
				1.80	D			1.70	0.79		
		2.00	S	N=51 (1,5/51 for 275mm)		2.43	0.06	End of Borehole at 2.430m			
										3	
										4	

Crew: RGI		Logger: LB		Weather: Rain	
Equipment: Tracked Window Sampling Rig					
Reason for termination of borehole: Refusal					
Groundwater Remarks: 0.35m.					
General Remarks:					
Hole Started: 05/12/2018		Hole Complete: 05/12/2018		Version: FINAL	
				Scale: 1:25	

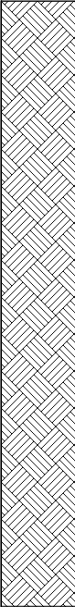
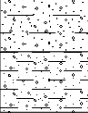
		GRM Development Solutions Ltd Laurus House, First Avenue, Centrum 100, Burton-on-Trent, DE14 2WH Tel (HQ): 01283 551249 Email: info@grm-uk.com		Windowless Sample Borehole				Borehole No WS101 Sheet 1 of 1	
Site Name: Crease Drive, Crowland								Ground Level (mAOD) 2.50	
Client: Partner Construction Ltd						GRM Project Ref: P8723		Coordinates 523672 E 309651 N	

Installation/ Backfill	Water Strike	Samples/Tests			Dynamic Probing (Blows per 100mm)	Depth (m)	Level (m)	Legend	Stratum Description	
		Depth	Type	Result						
		0.40	D			0.30	2.20		Vegetation over dark brown, slightly sandy, slightly gravelly silty CLAY. Sand is fine to coarse. Gravel is fine to medium, sub-angular to sub-rounded, quartzite, chalk, limestone with occasional brick and concrete. MADE GROUND	
		0.40	ES			0.60	1.90		Medium dense, yellow brown, slightly gravelly, slightly clayey SAND with a low cobble content. Sand is fine to coarse. Gravel is fine to coarse. Gravel and cobbles are angular to sub-rounded, brick and concrete. MADE GROUND	
		0.70 - 0.80	D						Soft, dark grey, slightly gravelly, slightly sandy, organic silty CLAY. Sand is fine to coarse. Gravel is fine to medium, sub-rounded to rounded. Frequent decomposed fibrous plant material present. Black staining and organic odour present. PEAT	
		0.70 - 0.80	ES						<i>Wet material below 1.4m begl.</i>	
		1.20 - 1.30	D			1.80	0.70		Soft, light brown, slightly sandy, gravelly CLAY. Sand is fine to coarse. Gravel is fine to coarse, sub-angular to rounded, quartzite, chalk, mudstone and limestone. ABBEY SAND AND GRAVEL	
		1.20 - 1.30	ES			2.00	0.50		<i>Band of gravelly fine to coarse sand (approx. 7cm).</i>	
		1.80 - 1.85	D						Soft, light brown, slightly sandy, gravelly CLAY. Sand is fine to coarse. Gravel is fine to medium, rounded to sub-rounded, quartzite, chalk and mudstone. ABBEY SAND AND GRAVEL	
		2.40 - 2.50	D			2.70	-0.20		<i>Band of gravelly fine to coarse sand.</i>	
		2.80 - 2.90	D			3.00	-0.50		Firm, grey, slightly gravelly CLAY. Gravel is fine to medium, sub-rounded to rounded, chalk, limestone and occasional mudstone. OXFORD CLAY	
									End of Borehole at 3.000m	

Crew: RGI.		Logger: AL.		Weather: Sunny	
Equipment: Tracked Window Sampler.					
Reason for termination of borehole: Target depth achieved.					
Groundwater Remarks: Wet material from 1.4m begl.					
General Remarks:					
Hole Started: 03/06/2019		Hole Complete: 03/06/2019		Version: FINAL	
				Scale: 1:25	

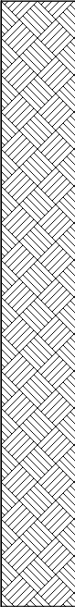
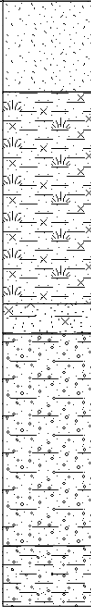
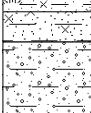
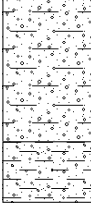
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		GRM Development Solutions Ltd Laurus House, First Avenue, Centrum 100, Burton-on-Trent, DE14 2WH Tel (HQ): 01283 551249 Email: info@grm-uk.com		Windowless Sample Borehole				Borehole No WS104 Sheet 1 of 1	
Site Name: Crease Drive, Crowland								Ground Level (mAOD) 2.56	
Client: Partner Construction Ltd						GRM Project Ref: P8723		Coordinates 523687 E 309656 N	

Installation/ Backfill	Water Strike	Samples/Tests			Dynamic Probing (Blows per 100mm)	Depth (m)	Level (m)	Legend	Stratum Description	
		Depth	Type	Result						
		0.30 - 0.45	D			0.10	2.46	 Black asphalt hardstanding. MADE GROUND  Grey concrete hardstanding. Recovered as a grey sandy GRAVEL. MADE GROUND  Loose, grey, slightly clayey, slightly sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse, sub-angular, limestone. MADE GROUND  Soft, dark grey, slightly sandy, slightly gravelly organic silty CLAY. Sand is fine to coarse. Gravel is fine to medium, sub-rounded, mudstone. Occasional slightly decomposed fibrous plant material. PEAT <i>No hydrocarbon odour or sheen below 0.9m begl.</i>  Approximately loose to medium dense, light brown, slightly gravelly, silty SAND. Sand is fine to coarse. Gravel is fine to coarse, sub-rounded, mudstone. Hydrocarbon odour and sheen. ABBEY SAND AND GRAVEL Firm, dark grey, slightly sandy, slightly gravelly CLAY. Sand is fine to medium. Gravel is fine to medium, sub-rounded, chalk, limestone and mudstone. OXFORD CLAY End of Borehole at 2.000m		
		0.45 - 0.50	ES			0.30	2.26			
		0.50 - 0.60	D			0.60	1.96			
		0.60 - 0.60	ES							
		1.50 - 1.60	D			1.60	0.96			
		1.60 - 1.60	ES			1.80	0.76			
						2.00	0.56			

Crew: RGI.		Logger: AL.		Weather: Sunny.	
Equipment: Tracked Window Sampler.					
Reason for termination of borehole: Target depth achieved.					
Groundwater Remarks: Wet material at 1.6m begl.					
General Remarks:					
Hole Started:	03/06/2019	Hole Complete:	03/06/2019	Version:	FINAL
				Scale:	1:25

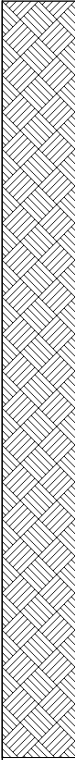
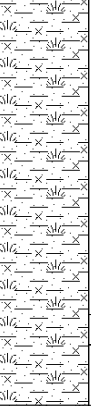
		GRM Development Solutions Ltd Laurus House, First Avenue, Centrum 100, Burton-on-Trent, DE14 2WH Tel (HQ): 01283 551249 Email: info@grm-uk.com		Windowless Sample Borehole				Borehole No WS105 Sheet 1 of 1	
Site Name: Crease Drive, Crowland								Ground Level (mAOD) 2.42	
Client: Partner Construction Ltd						GRM Project Ref: P8723		Coordinates 523691 E 309646 N	

Installation/ Backfill	Water Strike	Samples/Tests			Dynamic Probing (Blows per 100mm)	Depth (m)	Level (m)	Legend	Stratum Description				
		Depth	Type	Result									
						0.30	2.12		Grey concrete hardstanding, recovered as a grey sandy GRAVEL of concrete. MADE GROUND				
		0.70 - 0.80	D						Soft, dark grey, slightly sandy, silty organic CLAY. Sand is fine to coarse. Occasional decomposed fibrous plant material. PEAT.				
		0.70 - 0.80	ES						PEAT				
		1.10 - 1.20	D			1.00	1.42			Approximately medium dense, dark grey, slightly clayey silty SAND. Sand is fine to coarse. Organic odour present.	1		
		1.10 - 1.20	ES			1.10	1.32					PEAT	
											Approximately loose to medium dense, yellow brown, slightly clayey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse, sub-angular to rounded, quartzite and occasional mudstone. (Slight hydrocarbon odour present.	2	
									ABBEEY SAND AND GRAVEL				
									Firm to stiff, slightly sandy, slightly gravelly CLAY. Sand is fine to coarse. Gravel is fine to coarse, chalk and limestone.				
									1.80	0.62		OXFORD CLAY	
									2.00	0.42		End of Borehole at 2.000m	
										3			
										4			

Crew: RGI.		Logger: AL.		Weather: Sunny.	
Equipment: Tracked Window Sampler.					
Reason for termination of borehole: Target depth achieved.					
Groundwater Remarks: Wet material at 1.1m begl.					
General Remarks:					

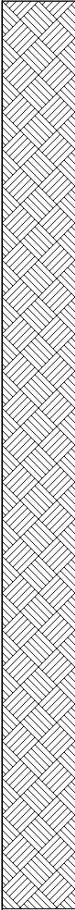
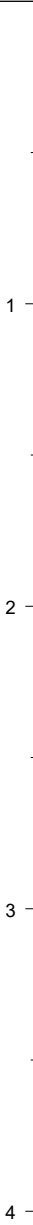
Hole Started:	03/06/2019	Hole Complete:	03/06/2019	Version:	FINAL	Scale:	1:25
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		GRM Development Solutions Ltd Laurus House, First Avenue, Centrum 100, Burton-on-Trent, DE14 2WH Tel (HQ): 01283 551249 Email: info@grm-uk.com		Windowless Sample Borehole				Borehole No WS106 Sheet 1 of 1	
Site Name: Crease Drive, Crowland								Ground Level (mAOD) 2.30	
Client: Partner Construction Ltd						GRM Project Ref: P8723		Coordinates 523699 E 309638 N	

Installation/ Backfill	Water Strike	Samples/Tests			Dynamic Probing (Blows per 100mm)	Depth (m)	Level (m)	Legend	Stratum Description		
		Depth	Type	Result							
		0.50 - 0.60	D			0.25	2.05		Grey concrete hardstanding, recovered as a grey sandy GRAVEL of concrete. MADE GROUND	1	
		0.50 - 0.60	ES						Soft, dark grey, slightly gravelly, silty organic CLAY with occasional fine to coarse sand pockets. Gravel is fine to medium, sub-rounded to rounded. Frequent decomposed plant material. Natural organic odour present. PEAT		
		<i>Band of gravelly fine to coarse sand (approx. 5cm) becoming sandy below 1.4m begl.</i>									
		1.70 - 1.80	D			1.60	0.70		Approximately loose, light brown, gravelly silty SAND. Sand is fine to coarse. Gravel is fine to coarse, sub-angular to rounded, chalk, quartzite and mudstone. ABBEEY SAND AND GRAVEL		2
		1.70 - 1.80	ES								
		2.40 - 2.50	D			2.50	-0.20		End of Borehole at 2.500m	3	
		2.40 - 2.50	ES							4	

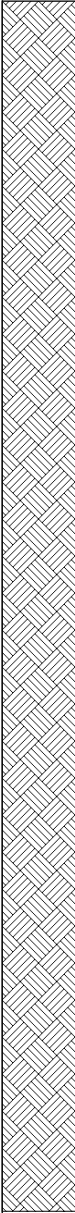
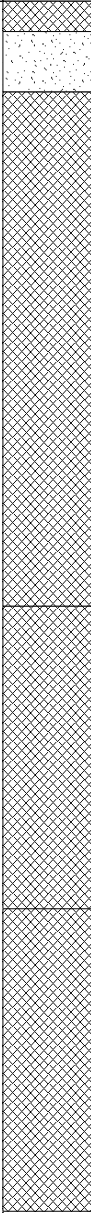
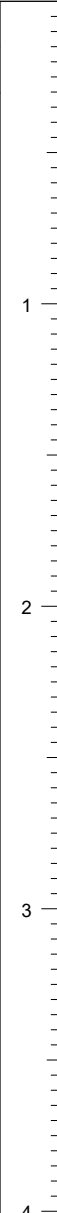
Crew: RGI.		Logger: AL.		Weather: Sunny.	
Equipment: Tracked Window Sampler.					
Reason for termination of borehole: Target depth achieved.					
Groundwater Remarks: Wet material at 1.8m begl.					
General Remarks:					
Hole Started: 03/06/2019		Hole Complete: 03/06/2019		Version: FINAL	
				Scale: 1:25	

		GRM Development Solutions Ltd Laurus House, First Avenue, Centrum 100, Burton-on-Trent, DE14 2WH Tel (HQ): 01283 551249 Email: info@grm-uk.com		Windowless Sample Borehole			Borehole No WS107 Sheet 1 of 1	
Site Name: Crease Drive, Crowland							Ground Level (mAOD) 2.60	
Client: Partner Construction Ltd					GRM Project Ref: P8723		Coordinates 523688 E 309667 N	

Installation/ Backfill	Water Strike	Samples/Tests			Dynamic Probing (Blows per 100mm)	Depth (m)	Level (m)	Legend	Stratum Description	
		Depth	Type	Result						
						0.15	2.45		Black asphalt / tarmacadam hardstanding.	
						0.25	2.35		MADE GROUND	
									Grey concrete hardstanding, recovered as a grey sandy GRAVEL of concrete.	
									MADE GROUND	
						0.70	1.90		Approximately loose to medium dense, yellow brown, slightly clayey gravelly SAND, with a low cobble content. Sand is fine to coarse. Gravel is fine to coarse. Gravel and cobbles are sub-angular, concrete and limestone.	
									MADE GROUND	
									Soft, dark brown to grey, slightly gravelly silty organic CLAY. Gravel is fine to medium, rounded to sub-rounded, mudstone and quartzite. Natural organic odour and frequent fibrous decomposed plant material present. PEAT.	
						1.60	1.00		PEAT	
						1.80	0.80		Approximately medium dense, dark grey, fine to coarse SAND. Strong Hydrocarbon odour and sheen present. PEAT	
									PEAT	
				2.20	0.40		Soft, dark brown to grey, slightly gravelly silty organic CLAY. Gravel is fine to medium, rounded to sub-rounded, mudstone and quartzite. PEAT			
							PEAT			
							Approximately loose to medium dense, yellow brown, slightly clayey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse, sub-angular to sub-rounded, quartzite and mudstone.			
							ABBEE SAND AND GRAVEL			
								End of Borehole at 3.000m	3	
						3.00	-0.40			4

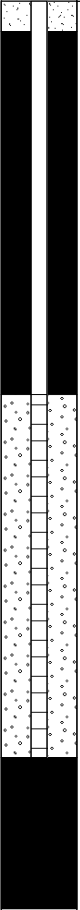
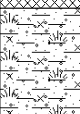
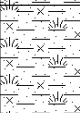
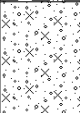
Crew: RGI.		Logger: AL.		Weather: Sunny.	
Equipment: Tracked Window Sampler.					
Reason for termination of borehole: Target depth achieved.					
Groundwater Remarks: Wet material at 1.6m to 1.7m begl, with hydrocarbon odour and sheen.					
General Remarks:					
Hole Started:	03/06/2019	Hole Complete:	03/06/2019	Version:	FINAL
				Scale:	1:25

		GRM Development Solutions Ltd Laurus House, First Avenue, Centrum 100, Burton-on-Trent, DE14 2WH Tel (HQ): 01283 551249 Email: info@grm-uk.com		Windowless Sample Borehole			Borehole No WS108 Sheet 1 of 1		
Site Name: Crease Drove, Crowland							Ground Level (mAOD) 2.50		
Client: Partner Construction Ltd					GRM Project Ref: P8723			Coordinates 523700 E 309660 N	

Installation/ Backfill	Water Strike	Samples/Tests			Dynamic Probing (Blows per 100mm)	Depth (m)	Level (m)	Legend	Stratum Description	
		Depth	Type	Result						
						0.15	2.35		Black asphalt / tarmacadam hardstanding. MADE GROUND	
						0.30	2.20		Grey concrete hardstanding, recovered as grey sandy GRAVEL of concrete. MADE GROUND	
									Poor recovery 1-2 m due to cobbles pushing material down borehole. Liner wet and stained black. MADE GROUND	
						2.00	0.50		Poor recovery 2-3m sample (approx. 20%) due to cobble pushing material down borehole. MADE GROUND	
						3.00	-0.50		Poor recovery 3-4m sample (approx. 10%). Material recovery as a firm, light brown, sandy CLAY. Material and liner was stained black. MADE GROUND	
						4.00	-1.50		End of Borehole at 4.000m	

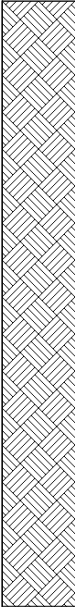
Crew: RGI.		Logger: AL.		Weather: Sunny	
Equipment: Tracked Window Sampler.					
Reason for termination of borehole:		Terminated due to poor recovery as cobble pushed material down borehole.			
Groundwater Remarks: Liners recovered wet and black stained with hydrocarbon odour.					
General Remarks:					
Hole Started:	03/06/2019	Hole Complete:	03/06/2019	Version:	FINAL
				Scale:	1:25

		GRM Development Solutions Ltd Laurus House, First Avenue, Centrum 100, Burton-on-Trent, DE14 2WH Tel (HQ): 01283 551249 Email: info@grm-uk.com		Windowless Sample Borehole			Borehole No WS109 Sheet 1 of 1		
Site Name: Crease Drive, Crowland							Ground Level (mAOD) 2.14		
Client: Partner Construction Ltd					GRM Project Ref: P8723			Coordinates 523708 E 309634 N	

Installation/ Backfill	Water Strike	Samples/Tests			Dynamic Probing (Blows per 100mm)	Depth (m)	Level (m)	Legend	Stratum Description	
		Depth	Type	Result						
									Turf over, light brown, slightly sandy, slightly gravelly CLAY. Sand is fine to coarse. Gravel is fine to coarse, angular to sub-rounded, concrete and quartzite. MADE GROUND	
						0.80	1.34		Band of grey fine to coarse sand.	1
						1.20	0.94		Soft, dark grey, slightly gravelly, organic silty CLAY. Gravel is fine to medium, sub-rounded to rounded, mudstone. Frequent decomposed fibrous plant material. PEAT	
		1.50 - 1.60	D						Soft, dark grey, sandy, silty organic CLAY. Sand is fine to coarse. Hydrocarbon odour and sheen present. Pockets of black staining. PEAT	2
		1.50 - 1.60	ES							
		2.80 - 2.90	D			2.60	-0.46		Approximately loose to medium dense, light brown, slightly clayey, sandy silty GRAVEL. Sand is fine to coarse. Gravel is fine to coarse, sub-angular to rounded, mudstone. Hydrocarbon odour and sheen present. ABBEY SAND AND GRAVEL	3
		2.80 - 2.90	ES			3.00	-0.86		End of Borehole at 3.000m	4

Crew: RGI.		Logger: AL.		Weather: Sunny.	
Equipment: Tracked Window Sampler.					
Reason for termination of borehole: Target depth achieved.					
Groundwater Remarks: Wet material at 2.6m begl.					
General Remarks:					
Hole Started: 03/06/2019		Hole Complete: 03/06/2019		Version: FINAL	
				Scale: 1:25	

		GRM Development Solutions Ltd Laurus House, First Avenue, Centrum 100, Burton-on-Trent, DE14 2WH Tel (HQ): 01283 551249 Email: info@grm-uk.com		Windowless Sample Borehole			Borehole No WS110 Sheet 1 of 1		
Site Name: Crease Drove, Crowland							Ground Level (mAOD) 2.45		
Client: Partner Construction Ltd					GRM Project Ref: P8723			Coordinates 523693 E 309649 N	

Installation/ Backfill	Water Strike	Samples/Tests			Dynamic Probing (Blows per 100mm)	Depth (m)	Level (m)	Legend	Stratum Description	
		Depth	Type	Result						
						0.30	2.15		Vegetation over dark brown slightly sandy, gravelly CLAY with a low cobble content. Sand is fine to coarse. Gravel is fine to coarse. Gravel and cobbles are sub-angular, brick and quartzite.	1
									MADE GROUND	
		0.60 - 0.70	D						Soft, dark grey slightly sandy, silty organic CLAY. Sand is fine to coarse. Occasional decomposed, fibrous plant material present. Natural organic odour present.	
		0.60 - 0.70	ES						PEAT	
		1.00	D			0.95	1.50		Approximately loose to medium dense, yellow brown, slightly clayey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse, sub-angular to rounded, quartzite and mudstone.	2
									ABBEE SAND AND GRAVEL	
		1.80 - 1.90	D			1.60	0.85		Firm to stiff, grey, slightly sandy, slightly gravelly CLAY. Sand is fine to coarse. Gravel is fine to medium, chalk and occasional limestone.	
						2.00	0.45		OXFORD CLAY	3
									End of Borehole at 2.000m	4

Crew: RGI.		Logger: AL.		Weather: Sunny.	
Equipment: Tracked Window Sampler.					
Reason for termination of borehole: Target depth achieved.					
Groundwater Remarks: Wet material at 0.95m begl.					
General Remarks:					

Hole Started:	03/06/2019	Hole Complete:	03/06/2019	Version:	FINAL	Scale:	1:25
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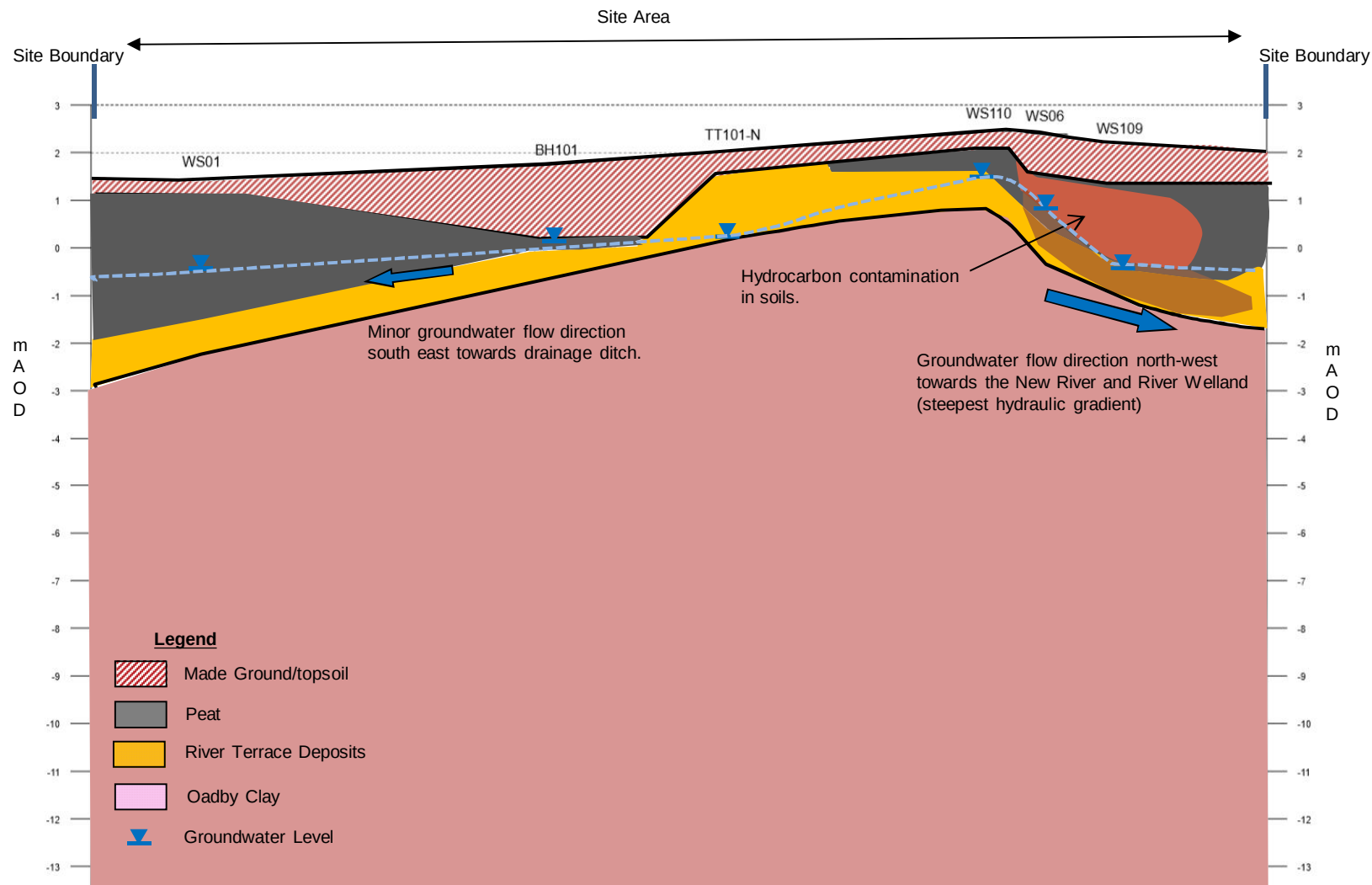
info@grm-uk.com

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South East

North West



NOTES:

Based on Fieldwork data

DO NOT SCALE

CLIENT:

Partner Construction Ltd &
Waterloo Housing Group Ltd

PROJECT:

Crease Drove, Crowland

TITLE:

Schematic Geological Cross Section

SCALE/SIZE:

NTS

DESIGN/DRAWN:

SS

PROJECT No:

P8723

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ISSUE:

FINAL

DATE:

AUG 2019

DRAWING No:

3



GRM Development Solutions Ltd
Laurus House, Centrum 100
Burton-on-Trent, Staffs, DE14 2WH
Tel: 01293 551249

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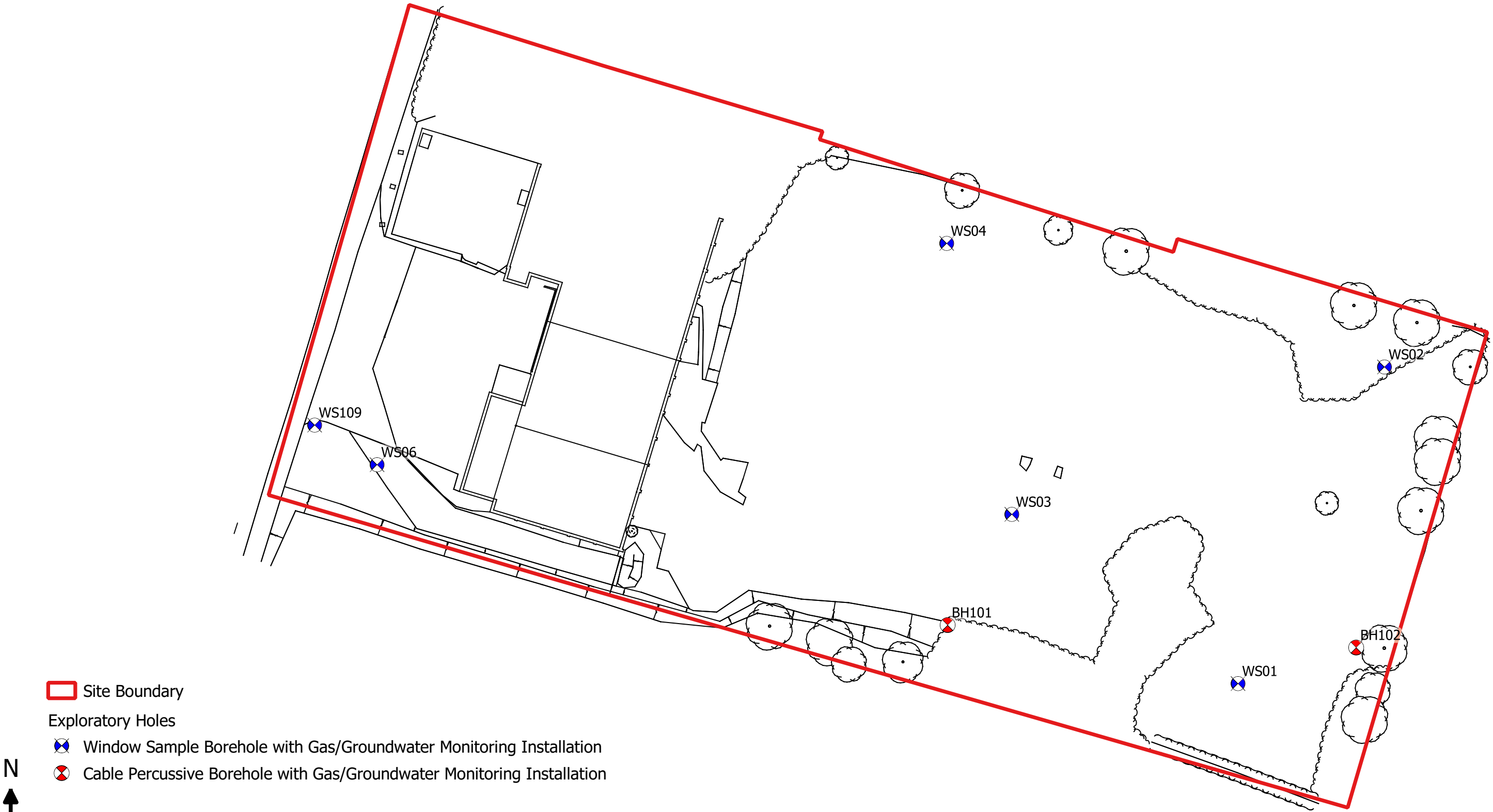
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Site Boundary

Exploratory Holes

Window Sample Borehole with Gas/Groundwater Monitoring Installation

Cable Percussive Borehole with Gas/Groundwater Monitoring Installation



NOTES:

NOTES

CLIENT: Partner Construction Ltd & Waterloo Housing Group Ltd

PROJECT: Crease Drove, Crowland

TITLE: Gas and Water Monitoring Plan

PROJECT No: P8723

DATE: 07/2019

DESIGN/DRAWN: CM

DRAWING NUMBER: 04

ISSUE: FINAL

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GRM Development Solutions Ltd
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In-Situ Gas Monitoring Results

Project Name: Crease Drove Crowland Peterborough
 Project Number: P8723
 Client: Partner Construction & Waterloo Housing Group
 Date: 20/12/2018
 Weather: Raining
 Atmospheric Pressure (mb): 1001
 Pressure Trend: Rising
 Equipment: Gas Data GFM430
 Operator: Tom Robson

Ground Gases													
				Methane %v/v		CO2 %v/v		Oxygen %v/v		Gas Flow l/h		PID Reading ppm	
ID	Top	Base	Strata	Peak	Steady	Peak	Steady	Low	Steady	Peak	Steady	Peak	Steady
WS01	0.50	3.00	NS	0.00	0.00	2.10	2.10	18.20	18.20	0.00	0.00	Not Recorded	
WS02	0.60	1.60	NS	0.00	0.00	3.90	3.90	15.60	15.60	0.00	0.00	Not Recorded	
WS03	1.00	3.00	NS	0.00	0.00	0.90	0.90	19.40	19.40	0.00	0.00	Not Recorded	
WS04	0.50	1.50	NS	0.00	0.00	0.30	0.30	19.80	19.80	0.00	0.00	Not Recorded	
WS06	1.00	2.00	NS	0.00	0.00	0.30	0.30	19.70	19.70	0.00	0.00	Not Recorded	

Ground Waters	
Depth to Groundwater mbegl	Total Well Depth mbegl
1.09	2.94
0.75	1.65
0.50	3.20
0.39	1.43
0.93	2.09

Comments: All holes bailed

Notes

L.E.L. Lower Explosive Limit (100% L.E.L.= 5% Flammable Gas)
 N.D. Not Detected
 N.R. Not Recorded
 PID Photo-Ionising Detector
 % By volume

Highlighted cell for following conditions:
 a Methane =>1% v/v
 b Carbon Dioxide =>5% v/v
 MG Made Ground
 NS Natural Strata

Ground Material Key

NS Natural Strata



In-Situ Gas Monitoring Results

Project Name: Crease Drove Crowland Peterborough
 Project Number: P8723
 Client: Partner Construction & Waterloo Housing Group
 Date: 02/01/2019
 Weather: Cloudy
 Atmospheric Pressure (mb): 1044
 Pressure Trend: Falling
 Equipment: Gas Data GFM430
 Operator: Tom Robson

Ground Gases													
				Methane %v/v		CO2 %v/v		Oxygen %v/v		Gas Flow l/h		PID Reading ppm	
ID	Top	Base	Strata	Peak	Steady	Peak	Steady	Low	Steady	Peak	Steady	Peak	Steady
WS01	0.50	3.00	NS	0.00	0.00	2.30	2.30	17.50	17.50	0.00	0.00	Not Recorded	
WS02	0.60	1.60	NS	0.00	0.00	5.80	5.80	15.00	15.00	0.00	0.00	Not Recorded	
WS03	1.00	3.00	NS	0.00	0.00	1.40	1.40	18.90	18.90	0.00	0.00	Not Recorded	
WS04	0.50	1.50	NS	0.00	0.00	0.30	0.30	19.40	19.40	0.00	0.00	Not Recorded	
WS06	1.00	2.00	NS	0.00	0.00	0.60	0.60	19.60	19.60	0.00	0.00	Not Recorded	

Ground Waters	
Depth to Groundwater mbegl	Total Well Depth mbegl
1.03	2.91
0.85	1.63
0.58	3.15
0.00	1.41
0.95	1.92

Comments: All holes bailed

Notes

L.E.L. Lower Explosive Limit (100% L.E.L. = 5% Flammable Gas)
 N.D. Not Detected
 N.R. Not Recorded
 PID Photo-Ionising Detector
 % By volume

Highlighted cell for following conditions:
 a Methane =>1% v/v
 b Carbon Dioxide =>5% v/v
 MG Made Ground
 NS Natural Strata

Ground Material Key

NS Natural Strata



In-Situ Gas Monitoring Results

Project Name: Crease Drove Crowland Peterborough
 Project Number: P8723
 Client: Partner Construction & Waterloo Housing Group
 Date: 17/01/2019
 Weather: Ice
 Atmospheric Pressure (mb): 1003
 Pressure Trend: Rising
 Equipment: Gas Data LMSXi, Ion Science Tiger Pro Photo-ionising detector (PID)
 Operator: Tom Robson

Ground Gases													
				Methane %v/v		CO2 %v/v		Oxygen %v/v		Gas Flow l/h		PID Reading ppm	
ID	Top	Base	Strata	Peak	Steady	Peak	Steady	Low	Steady	Peak	Steady	Peak	Steady
WS01	0.50	3.00	NS	0.00	0.00	0.70	0.70	19.40	19.40	0.00	0.00	0.60	0.60
WS02	0.60	1.60	NS	0.00	0.00	6.90	6.90	15.50	15.50	0.00	0.00	0.20	0.20
WS03	1.00	3.00	NS	0.00	0.00	1.30	1.30	19.20	19.20	0.00	0.00	0.00	0.00
WS04	0.50	1.50	NS	0.00	0.00	0.00	0.00	20.00	20.00	0.00	0.00	0.00	0.00
WS06	1.00	2.00	NS	0.00	0.00	0.00	0.00	19.80	19.80	0.00	0.00	0.30	0.30

Ground Waters	
Depth to Groundwater mbegl	Total Well Depth mbegl
1.10	2.90
0.89	1.63
0.68	3.20
0.30	1.43
1.10	1.90

Comments: None

Notes

L.E.L. Lower Explosive Limit (100% L.E.L. = 5% Flammable Gas)
 N.D. Not Detected
 N.R. Not Recorded
 PID Photo-Ionising Detector
 % By volume

Highlighted cell for following conditions:
 a Methane $\geq 1\%$ v/v
 b Carbon Dioxide $\geq 5\%$ v/v
 MG Made Ground
 NS Natural Strata

Ground Material Key

NS Natural Strata



In-Situ Gas Monitoring Results

Project Name: Crease Drove Crowland Peterborough
 Project Number: P8723
 Client: Partner Construction & Waterloo Housing Group
 Date: 28/01/2019
 Weather: Ice
 Atmospheric Pressure (mb): 1006
 Pressure Trend: Steady
 Equipment: Gas Data GFM430, Ion Science Tiger Pro Photo-ionising detector (PID)
 Operator: Tom Robson

Ground Gases													
				Methane %v/v		CO2 %v/v		Oxygen %v/v		Gas Flow l/h		PID Reading ppm	
ID	Top	Base	Strata	Peak	Steady	Peak	Steady	Low	Steady	Peak	Steady	Peak	Steady
WS01	0.50	3.00	NS	0.00	0.00	2.90	2.90	18.30	18.30	0.00	0.00	0.30	0.30
WS02	0.60	1.60	NS	0.00	0.00	0.90	0.90	15.10	15.10	0.00	0.00	0.30	0.30
WS03	1.00	3.00	NS	0.00	0.00	0.70	0.70	19.60	19.60	0.00	0.00	0.30	0.30
WS04	0.50	1.50	NS	0.00	0.00	0.00	0.00	19.90	19.90	0.00	0.00	0.00	0.00
WS06	1.00	2.00	NS	0.00	0.00	0.00	0.00	19.80	19.80	0.00	0.00	0.30	0.30

Ground Waters	
Depth to Groundwater mbegl	Total Well Depth mbegl
1.10	2.91
0.93	1.65
0.67	3.12
0.33	1.39
1.10	1.91

Comments: None

Notes

L.E.L. Lower Explosive Limit (100% L.E.L. = 5% Flammable Gas)
 N.D. Not Detected
 N.R. Not Recorded
 PID Photo-Ionising Detector
 % By volume

Highlighted cell for following conditions:
 a Methane $\geq 1\%$ v/v
 b Carbon Dioxide $\geq 5\%$ v/v
 MG Made Ground
 NS Natural Strata

Ground Material Key

NS Natural Strata



In-Situ Gas Monitoring Results

Project Name:	Crease Drove Crowland Peterborough
Project Number:	P8723
Client:	Partner Construction & Waterloo Housing Group
Date:	12/02/2019
Weather:	Sunny
Atmospheric Pressure (mb):	1031
Pressure Trend:	Steady
Equipment:	Gas Data GFM430, Ion Science Tiger Pro Photo-ionising detector (PID)
Operator:	Tom Robson

Ground Gases													
				Methane %v/v		CO2 %v/v		Oxygen %v/v		Gas Flow l/h		PID Reading ppm	
ID	Top	Base	Strata	Peak	Steady	Peak	Steady	Low	Steady	Peak	Steady	Peak	Steady
WS01	0.50	3.00	NS	0.00	0.00	2.60	2.60	18.30	18.30	0.00	0.00	0.00	0.00
WS02	0.60	1.60	NS	0.00	0.00	4.50	4.50	16.90	16.90	0.00	0.00	0.00	0.00
WS03	1.00	3.00	NS	0.00	0.00	0.30	0.30	20.00	20.00	0.00	0.00	0.00	0.00
WS04	0.50	1.50	NS	0.00	0.00	0.00	0.00	20.10	20.10	0.00	0.00	0.00	0.00
WS06	1.00	2.00	NS	0.00	0.00	0.70	0.70	19.60	19.60	0.00	0.00	0.00	0.00

Ground Waters	
Depth to Groundwater mbegl	Total Well Depth mbegl
0.87	2.89
0.75	1.63
0.49	3.17
0.00	1.40
0.75	1.91

Comments All holes bailed

Notes

L.E.L. Lower Explosive Limit (100% L.E.L.= 5% Flammable Gas)
 N.D. Not Detected
 N.R. Not Recorded
 PID Photo-Ionising Detector
 % By volume

Highlighted cell for following conditions:
 a Methane =>1% v/v
 b Carbon Dioxide =>5% v/v
 MG Made Ground
 NS Natural Strata

Ground Material Key

NS Natural Strata



In-Situ Gas Monitoring Results

Project Name: Crease Drove Crowland Peterborough
 Project Number: P8723
 Client: Partner Construction & Waterloo Housing Group
 Date: 25/02/2019
 Weather: Sunny
 Atmospheric Pressure (mb): 1039
 Pressure Trend: Steady
 Equipment: Gas Data GFM430
 Operator: Tom Robson

Ground Gases													
				Methane %v/v		CO2 %v/v		Oxygen %v/v		Gas Flow l/h		PID Reading ppm	
ID	Top	Base	Strata	Peak	Steady	Peak	Steady	Low	Steady	Peak	Steady	Peak	Steady
WS01	0.50	3.00	NS	0.00	0.00	2.50	2.50	17.70	17.70	0.00	0.00	Not Recorded	
WS02	0.60	1.60	NS	0.00	0.00	5.40	5.40	14.70	14.70	0.00	0.00	Not Recorded	
WS03	1.00	3.00	NS	0.00	0.00	0.60	0.60	19.80	19.80	0.00	0.00	Not Recorded	
WS04	0.50	1.50	NS	0.00	0.00	0.00	0.00	20.00	20.00	0.00	0.00	Not Recorded	
WS06	1.00	2.00	NS	0.00	0.00	0.40	0.40	19.80	19.80	0.00	0.00	Not Recorded	

Ground Waters	
Depth to Groundwater mbegl	Total Well Depth mbegl
1.05	2.93
0.88	1.63
0.63	3.14
0.29	1.39
1.06	1.91

Comments

Notes

L.E.L. Lower Explosive Limit (100% L.E.L. = 5% Flammable Gas)
 N.D. Not Detected
 N.R. Not Recorded
 PID Photo-Ionising Detector
 % By volume

Highlighted cell for following conditions:
 a Methane $\geq 1\%$ v/v
 b Carbon Dioxide $\geq 5\%$ v/v
 MG Made Ground
 NS Natural Strata

Ground Material Key

NS Natural Strata



In-Situ Gas Monitoring Results

Project Name: Crease Drove Crowland Peterborough
 Project Number: P8723
 Client: Partner Construction & Waterloo Housing Group
 Date: 18/06/2019
 Weather: Partly Sunny
 Atmospheric Pressure (mb): 1014
 Pressure Trend: Falling
 Equipment: Gas Data LMSXi
 Operator: Bryan Burgh

Ground Gases													
				Methane %v/v		CO2 %v/v		Oxygen %v/v		Gas Flow l/h		PID Reading ppm	
ID	Top	Base	Strata	Peak	Steady	Peak	Steady	Low	Steady	Peak	Steady	Peak	Steady
Cp101	4.00	15.00	NS	0.00	0.00	0.40	0.40	20.60	20.36	0.00	0.00	Not Recorded	
CP102	1.00	1.70	NS	0.00	0.00	6.30	6.30	14.10	14.10	0.00	0.00	Not Recorded	
WS01	0.50	3.00	NS	0.00	0.00	1.60	1.60	20.20	20.20	0.00	0.00	Not Recorded	
WS02	0.60	1.60	NS										
WS03	1.00	3.00	NS	0.00	0.00	1.20	1.20	20.40	20.40	0.00	0.00	Not Recorded	
WS04	0.50	1.50	NS	0.00	0.00	1.80	1.80	19.60	19.60	0.00	0.00	Not Recorded	
WS06	1.00	2.00	NS	0.00	0.00	1.10	1.10	20.50	20.50	0.00	0.00	Not Recorded	
WS109	1.30	2.50	NS	0.00	0.00	4.70	4.70	6.90	6.90	0.00	0.00	Not Recorded	

Ground Waters	
Depth to Groundwater mbegl	Total Well Depth mbegl
0.74	15.05
1.12	1.82
0.68	2.92
0.00	3.10
0.00	1.35
0.60	1.87
0.62	2.25

Comments WS02 not found due to overgrown

Notes

L.E.L. Lower Explosive Limit (100% L.E.L.= 5% Flammable Gas)
 N.D. Not Detected
 N.R. Not Recorded
 PID Photo-Ionising Detector
 % By volume

Highlighted cell for following conditions:
 a Methane =>1% v/v
 b Carbon Dioxide =>5% v/v
 MG Made Ground
 NS Natural Strata

Ground Material Key

NS Natural Strata



In-Situ Gas Monitoring Results

Project Name: Crease Drove Crowland Peterborough
 Project Number: P8723
 Client: Partner Construction & Waterloo Housing Group
 Date: 15/08/2019
 Weather: Raining
 Atmospheric Pressure (mb): 1012
 Pressure Trend: TBA
 Equipment: Gas Data LMSXi
 Operator: James Wardle

Ground Gases													
				Methane %v/v		CO2 %v/v		Oxygen %v/v		Gas Flow l/h		PID Reading ppm	
ID	Top	Base	Strata	Peak	Steady	Peak	Steady	Low	Steady	Peak	Steady	Peak	Steady
Cp101	4.00	15.00	NS	0.00	0.00	1.80	1.80	19.70	19.70	0.00	0.00	Not Recorded	
CP102	1.00	1.70	NS	0.00	0.00	30.00	30.00	6.50	6.50	0.00	0.00	Not Recorded	
WS01	0.50	3.00	NS	0.00	0.00	4.60	4.60	18.40	18.40	0.00	0.00	Not Recorded	
WS02	0.60	1.60	NS										
WS03	1.00	3.00	NS	0.00	0.00	0.30	0.30	20.90	20.90	0.00	0.00	Not Recorded	
WS04	0.50	1.50	NS	0.00	0.00	1.20	1.20	20.90	20.90	0.00	0.00	Not Recorded	
WS06	1.00	2.00	NS	0.00	0.00	0.40	0.40	20.90	20.90	0.00	0.00	Not Recorded	
WS109	1.30	2.50	NS	0.00	0.00	2.20	2.20	20.20	20.20	-1.31	-0.51	Not Recorded	

Ground Waters	
Depth to Groundwater mbegl	Total Well Depth mbegl
1.27	15.06
1.42	1.84
1.28	2.92
0.77	3.06
0.42	1.70
1.10	1.87
1.31	2.05

Comments WS02 not found due to overgrown

Notes

L.E.L. Lower Explosive Limit (100% L.E.L.= 5% Flammable Gas)
 N.D. Not Detected
 N.R. Not Recorded
 PID Photo-Ionising Detector
 % By volume

Highlighted cell for following conditions:
 a Methane =>1% v/v
 b Carbon Dioxide =>5% v/v
 MG Made Ground
 NS Natural Strata

Ground Material Key

NS Natural Strata



 New River and Welland River to the north west >400m.

- 
 Site Boundary

Exploratory Holes


 Window Sample Borehole with Gas/Groundwater Monitoring Installation


 Cable Percussive Borehole with Gas/Groundwater Monitoring Installation

Groundwater Contour lines (m AOD)

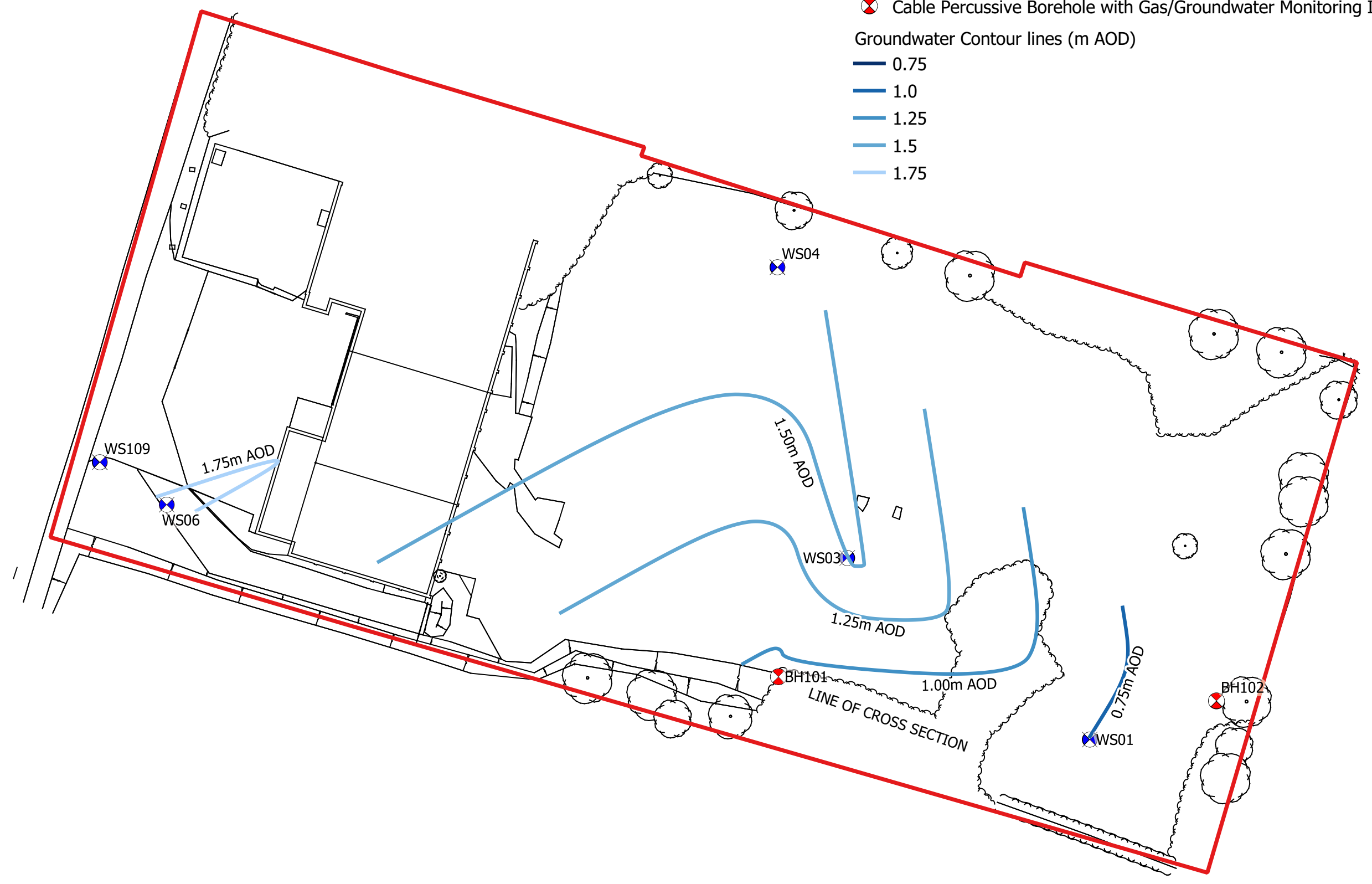

 0.75


 1.0


 1.25


 1.5


 1.75



NOTES:	CLIENT: Partner Construction Ltd & Waterloo Housing Group Ltd		PROJECT No: P8723	DATE: 07/2019	DESIGN/DRAWN: CM	 GRM Development Solutions Ltd Tel: 01283 551 249 mail@grm-uk.com www.grm-uk.com
	PROJECT: Crease Drove, Crowland		DRAWING NUMBER: 5A		ISSUE: FINAL	
	TITLE: Groundwater Contour - Monitoring data 18.06.19		© GRM Development Solutions Ltd © Crown Copyright. AL 100014100			



 New River and Welland River to the north west >400m.

- 
 Site Boundary

Exploratory Holes


 Window Sample Borehole with Gas/Groundwater Monitoring Installation


 Cable Percussive Borehole with Gas/Groundwater Monitoring Installation

Groundwater Contour lines (m AOD)

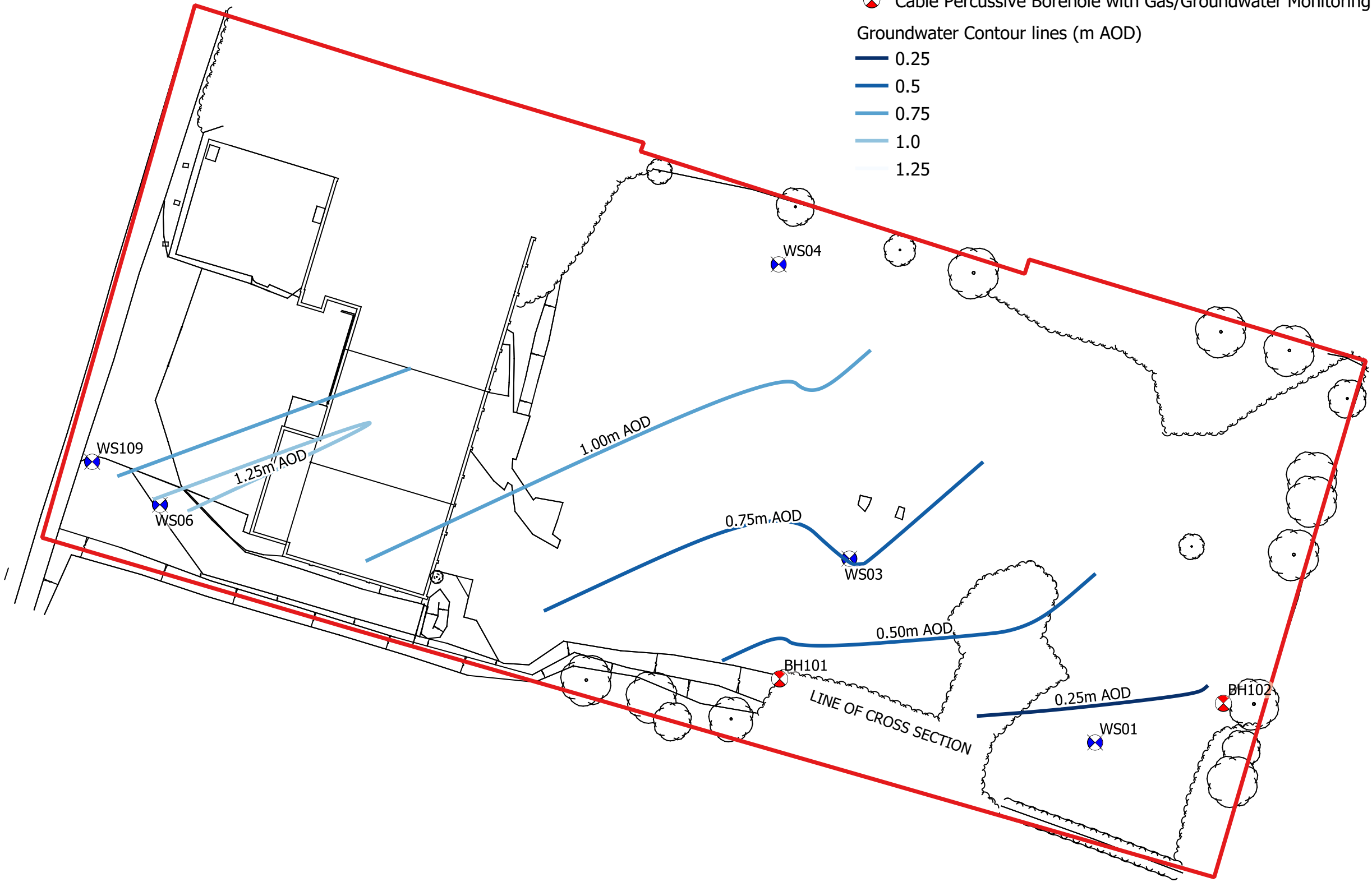

 0.25


 0.5


 0.75


 1.0


 1.25



N
 

NOTES:	CLIENT:	Partner Construction Ltd & Waterloo Housing Group Ltd	PROJECT No:	P8723	DATE:	07/2019	DESIGN/DRAWN:	CM	 GRM Development Solutions Ltd Tel: 01283 551 249 mail@grm-uk.com www.grm-uk.com
	PROJECT:	Crease Drove, Crowland	DRAWING NUMBER:	5B	ISSUE:	FINAL			
	TITLE:	Groundwater Contour - Monitoring data 15.08.19	© GRM Development Solutions Ltd © Crown Copyright. AL 100014100						



A P P E N D I X I

**GRM Development Solutions provides
multi-disciplinary consultancy services, UK-wide:**

- Geotechnical and Geo-environmental Services
- Civil and Infrastructure Services
- Structural Engineering Services
- Construction Management
- Site Services

Tel: 01283 551249

info@grm-uk.com

Fax: 01283 211968

www.grm-uk.com

r	0.175
r2	0.030625
pi * r2	0.096163

$2\pi l$	4.082
$\log(l/d) + \sqrt{1 + (l/d)^2}$	2.378106
L	0.650
L/D	1.857143

A	0.096163
F	1.716492
T = Ho = 0.37*	360

Inf (m/min)	0.000156
Inf (m/s)	2.59E-06
Inf (m/day)	0.224091



A P P E N D I X J

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Tel: 01283 551249

info@grm-uk.com

Fax: 01283 211968

www.grm-uk.com



Nicholls Colton Group
7 - 11 Harding Street
Leicester
LE1 4DH

GRM Development Solutions

Laurus House
First Avenue
Centrum 100
Burton Upon Trent
DE14 2WH

Analytical Test Report: L18/2871/GRM/001 - Amendment A

Your Project Reference:	Crease Drove, Crowland	Samples Received on:	10/12/2018
Your Order Number:	P8723	Testing Instruction Received:	10/12/2018
Report Issue Number:	2	Sample Tested:	10/12/2018 to 07/01/2019
Samples Analysed:	15 Samples	Report issued:	07/01/2019

Signed

James Gane
Commercial Manager
Nicholls Colton Group

Notes:

General

Please refer to Methodologies tab for details pertaining to the analytical methods undertaken.

Samples will be retained for 14 days after issue of this report with the exception of the asbestos test portion which is held for 6 months unless otherwise requested.

Moisture Content was determined in accordance with NC method statement MS - CL - Sample Prep, oven dried at <30°C.

Moisture Content is reported as a percentage of the dry mass of soil, this calculation is in accordance with BS1377, Part 2, 1990, Clause 3.2

Stone Content was determined in accordance with NC method statement MS - CL - Sample Prep and refers to the percentage of stones retained on a 10mm BS test sieve.

With the exception of Sulphate and Sulphur which are crushed over the 2mm test sieve, concentrations are reported as a percentage mass of the dry soil passing the 10mm BS test sieve. As received samples have been corrected for moisture content but not stone content.

Samples were supplied by customer, results are representative of the material provided

Asbestos

Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

Deviating Samples

Samples were received in suitable containers	Yes
A date and time of sampling was provided	Yes
Sample holding times were exceeded prior to analysis of determinants	No

Accreditation Key

UKAS = UKAS Accreditation, MCERTS = MCERTS Accreditation, u = Unaccredited

MCERTS Accreditation only covers the SAND, CLAY and LOAM matrices

Date of Issue 24.01.2017

Owned by Emily Blissett - Customer Services Supervisor

Authorised by James Gane - Commercial Manager

J:\Public\Projects\2018\L18\GRM - GRM Development Solutions\L18-2871-GRM P8723\L18-2871-GRM-001-Amendment A.xlsx\Cover Sheet

L18/2871/GRM/001 - Amendment A

Project Reference - Crease Drove, Crowland

Analytical Test Results - GRM Soil Suite

NC Reference			23177	23178	23179	23180	23181	23182	23183
Client Sample Reference			WS01	WS01	WS01	WS02	WS02	WS03	WS03
Client Sample Location			WS01	WS01	WS01	WS02	WS02	WS03	WS03
Depth - Top (m)			0.05	0.80	1.80	0.20	0.80	0.20	0.70
Depth - Bottom (m)			0.20	1.00	1.80	0.20	0.80	0.20	0.70
Date of Sampling			05/12/2018	05/12/2018	05/12/2018	05/12/2018	05/12/2018	05/12/2018	05/12/2018
Time of Sampling			Not Provided	Not Provided	Not Provided	Not Provided	Not Provided	Not Provided	Not Provided
Sample Matrix			Clay	Clay	Clay	Clay	Clay	Clay	Clay
Determinant	Units	Accreditation							
Arsenic	(mg/kg)	MCERTS	15	-	-	21	-	25	-
Cadmium	(mg/kg)	MCERTS	0.8	-	-	0.9	-	1.0	-
Chromium (Total)	(mg/kg)	UKAS	34	-	-	43	-	52	-
Copper	(mg/kg)	MCERTS	33	-	-	26	-	31	-
Lead	(mg/kg)	MCERTS	40	-	-	58	-	72	-
Mercury	(mg/kg)	UKAS	< 2.5	-	-	< 2.5	-	< 2.5	-
Nickel	(mg/kg)	MCERTS	41	-	-	30	-	31	-
Selenium	(mg/kg)	u	< 8.0	-	-	< 8.0	-	< 8.0	-
Zinc	(mg/kg)	MCERTS	120	-	-	100	-	90	-
Total Phenols	(mg/kg)	MCERTS	< 1.0	-	-	< 1.0	-	< 1.0	-
Cyanide (Total)	(mg/kg)	MCERTS	< 1.0	-	-	< 1.0	-	< 1.0	-
Chromium (Hexavalent)	(mg/kg)	u	< 1.0	-	-	< 1.0	-	< 1.0	-
pH	pH Units	MCERTS	6.7	5.9	-	6.7	6.8	6.0	5.3
SOM	(%)	UKAS	7.0	-	0.5	9.2	-	14	-
Sulphate	(mg/l)	u	290	450	-	< 10	77	240	390
Acenaphthene	(mg/kg)	MCERTS	< 0.02	-	-	< 0.02	-	< 0.02	-
Acenaphthylene	(mg/kg)	UKAS	< 0.02	-	-	< 0.02	-	< 0.02	-
Anthracene	(mg/kg)	UKAS	< 0.02	-	-	< 0.02	-	< 0.02	-
Benzo (a) anthracene	(mg/kg)	MCERTS	0.04	-	-	0.04	-	0.09	-
Benzo (a) pyrene	(mg/kg)	MCERTS	0.04	-	-	0.04	-	0.08	-
Benzo (b) fluoranthene	(mg/kg)	MCERTS	0.07	-	-	0.07	-	0.14	-
Benzo (g, h, i) perylene	(mg/kg)	MCERTS	0.04	-	-	0.04	-	0.06	-
Benzo (k) fluoranthene	(mg/kg)	MCERTS	< 0.02	-	-	< 0.02	-	0.05	-
Chrysene	(mg/kg)	MCERTS	0.05	-	-	0.06	-	0.11	-
Dibenzo (a,h) anthracene	(mg/kg)	MCERTS	< 0.02	-	-	< 0.02	-	< 0.02	-
Fluoranthene	(mg/kg)	MCERTS	0.07	-	-	0.09	-	0.21	-
Fluorene	(mg/kg)	MCERTS	< 0.02	-	-	< 0.02	-	< 0.02	-
Indeno (1, 2, 3-cd) pyrene	(mg/kg)	MCERTS	0.03	-	-	0.03	-	0.06	-
Naphthalene	(mg/kg)	MCERTS	< 0.02	-	-	< 0.02	-	< 0.02	-
Phenanthrene	(mg/kg)	MCERTS	0.04	-	-	0.03	-	0.09	-
Pyrene	(mg/kg)	MCERTS	0.07	-	-	0.07	-	0.18	-
Total PAH (Sum of USEPA 16)	(mg/kg)	UKAS	0.64	-	-	0.67	-	1.2	-
Asbestos	-	UKAS	-	-	-	-	-	-	-
Pesticide Screen	(mg/kg)	u	Undetected <1mg/kg	-	-	-	-	-	-
1377 Organic matter	(%)	UKAS	-	-	-	-	-	-	-

L18/2871/GRM/001 - Amendment A

Project Reference - Crease Drove, Crowland

Analytical Test Results - GRM Soil Suite

NC Reference			23185	23186	23187	23188	23189	23190	23191
Client Sample Reference			WS04	WS04	HD05	WS06	WS06	WS06	WS07
Client Sample Location			WS04	WS04	HD05	WS06	WS06	WS06	WS07
Depth - Top (m)			0.20	1.40	0.05	0.40	0.90	1.00	0.30
Depth - Bottom (m)			0.20	1.40	0.10	0.40	0.90	1.00	0.30
Date of Sampling			05/12/2018	05/12/2018	05/12/2018	05/12/2018	05/12/2018	05/12/2018	05/12/2018
Time of Sampling			Not Provided	Not Provided	Not Provided	Not Provided	Not Provided	Not Provided	Not Provided
Sample Matrix			Sand	Clay	Sand	Sand	Clay	Clay	Sand
Determinant	Units	Accreditation							
Arsenic	(mg/kg)	MCERTS	-	-	16	< 10	-	-	29
Cadmium	(mg/kg)	MCERTS	-	-	0.8	< 0.2	-	-	1.0
Chromium (Total)	(mg/kg)	UKAS	-	-	31	2.7	-	-	28
Copper	(mg/kg)	MCERTS	-	-	18	8.0	-	-	12
Lead	(mg/kg)	MCERTS	-	-	28	6.5	-	-	11
Mercury	(mg/kg)	UKAS	-	-	< 2.5	< 2.5	-	-	< 2.5
Nickel	(mg/kg)	MCERTS	-	-	21	5.1	-	-	22
Selenium	(mg/kg)	u	-	-	< 8.0	< 8.0	-	-	< 8.0
Zinc	(mg/kg)	MCERTS	-	-	380	28	-	-	70
Total Phenols	(mg/kg)	MCERTS	-	-	< 1.0	< 1.0	-	-	< 1.0
Cyanide (Total)	(mg/kg)	MCERTS	-	-	< 1.0	< 1.0	-	-	< 1.0
Chromium (Hexavalent)	(mg/kg)	u	-	-	< 1.0	< 1.0	-	-	< 1.0
pH	pH Units	MCERTS	-	8.1	7.7	8.4	-	7.3	12.2
SOM	(%)	UKAS	-	-	3.1	< 1.7	-	-	< 1.7
Sulphate	(mg/l)	u	-	200	1500	120	-	95	230
Acenaphthene	(mg/kg)	MCERTS	-	-	< 0.02	< 0.02	-	-	< 0.20
Acenaphthylene	(mg/kg)	UKAS	-	-	< 0.02	< 0.02	-	-	< 0.20
Anthracene	(mg/kg)	UKAS	-	-	< 0.02	< 0.02	-	-	< 0.20
Benzo (a) anthracene	(mg/kg)	MCERTS	-	-	< 0.02	< 0.02	-	-	< 0.20
Benzo (a) pyrene	(mg/kg)	MCERTS	-	-	< 0.02	< 0.02	-	-	< 0.20
Benzo (b) fluoranthene	(mg/kg)	MCERTS	-	-	< 0.02	< 0.02	-	-	< 0.20
Benzo (g, h, i) perylene	(mg/kg)	MCERTS	-	-	< 0.02	< 0.02	-	-	< 0.20
Benzo (k) fluoranthene	(mg/kg)	MCERTS	-	-	< 0.02	< 0.02	-	-	< 0.20
Chrysene	(mg/kg)	MCERTS	-	-	< 0.02	< 0.02	-	-	< 0.20
Dibenzo (a,h) anthracene	(mg/kg)	MCERTS	-	-	< 0.02	< 0.02	-	-	< 0.20
Fluoranthene	(mg/kg)	MCERTS	-	-	< 0.02	< 0.02	-	-	< 0.20
Fluorene	(mg/kg)	MCERTS	-	-	< 0.02	< 0.02	-	-	< 0.20
Indeno (1, 2, 3-cd) pyrene	(mg/kg)	MCERTS	-	-	< 0.02	< 0.02	-	-	< 0.20
Naphthalene	(mg/kg)	MCERTS	-	-	< 0.02	< 0.02	-	-	< 0.20
Phenanthrene	(mg/kg)	MCERTS	-	-	< 0.02	< 0.02	-	-	< 0.20
Pyrene	(mg/kg)	MCERTS	-	-	< 0.02	< 0.02	-	-	< 0.20
Total PAH (Sum of USEPA 16)	(mg/kg)	UKAS	-	-	< 0.32	< 0.32	-	-	< 3.20
Asbestos	-	UKAS	No asbestos detected	-	No asbestos detected	No asbestos detected	-	-	No asbestos detected
Pesticide Screen	(mg/kg)	u	-	-	-	Undetected <1mg/kg	-	-	-
1377 Organic matter	(%)	UKAS	-	-	-	-	1.8	-	-

L18/2871/GRM/001 - Amendment A

Project Reference - Crease Drove, Crowland

Analytical Test Results - BRE Suite

NC Reference		23184	
Client Sample Reference		WS03	
Client Sample Location		WS03	
Depth - Top (m)		3.90	
Depth - Bottom (m)		3.90	
Date of Sampling		05/12/2018	
Time of Sampling		Not Provided	
Sample Matrix		Clay	
Determinant	Units	Accreditation	
Water soluble sulphate	(mg/l)	u	450
Acid Soluble Sulphate	(%)	u	0.18
Total Sulphur	(%)	u	0.54
pH Value	pH Units	MCERTS	8.7

L18/2871/GRM/001 - Amendment A

Project Reference - Crease Drove, Crowland

Analytical Test Results - TPH CWG

NC Reference		23189	
Client Sample Reference		WS06	
Client Sample Location		WS06	
Depth - Top (m)		0.90	
Depth - Bottom (m)		0.90	
Date of Sampling		05/12/2018	
Time of Sampling		Not Provided	
Sample Matrix		Clay	
Determinant	Units	Accreditation	
Aliphatics			
>C ₅ to C ₆	(mg/kg)	u	< 0.03
>C ₆ to C ₈	(mg/kg)	u	< 0.03
>C ₈ to C ₁₀	(mg/kg)	u	1.2
>C ₁₀ to C ₁₂	(mg/kg)	u	81
>C ₁₂ to C ₁₆	(mg/kg)	u	700
>C ₁₆ to C ₂₁	(mg/kg)	u	790
>C ₂₁ to C ₃₅	(mg/kg)	u	180
Aromatics			
>C ₅ to C ₇	(mg/kg)	u	< 0.03
>C ₇ to C ₈	(mg/kg)	u	< 0.03
>C ₈ to C ₁₀	(mg/kg)	u	< 0.03
>C ₁₀ to C ₁₂	(mg/kg)	u	22
>C ₁₂ to C ₁₆	(mg/kg)	u	350
>C ₁₆ to C ₂₁	(mg/kg)	u	490
>C ₂₁ to C ₃₅	(mg/kg)	u	140
Total			
>C ₅ to C ₃₅	(mg/kg)	u	2800

L18/2871/GRM/001 - Amendment A

Project Reference - Crease Drove, Crowland

Sample Descriptions

NC Reference	Client Sample Reference	Sample Location	Description	Moisture Content (%)	Stone Content (%)	Passing 2mm test sieve (%)
23177	WS01	WS01	Dark brown slightly sandy slightly gravelly silty clay	39	2.1	-
23178	WS01	WS01	Orangish brown slightly sandy slightly gravelly silty clay	-	-	81
23179	WS01	WS01	Grey slightly sandy silty clay	26	1.1	-
23180	WS02	WS02	Dark brown slightly sandy silty clay	37	2.1	-
23181	WS02	WS02	Brown sandy silty clay	-	-	75
23182	WS03	WS03	Dark brown slightly sandy silty clay with rare rootlets	44	2.8	-
23183	WS03	WS03	Orangish brown slightly sandy silty clay	-	-	92
23184	WS03	WS03	Grey slightly sandy silty clay	-	-	100
23186	WS04	WS04	Orangish brown slightly sandy slightly gravelly silty clay	-	-	65
23187	HD05	HD05	Orangish brown gravelly sand	21	16	-
23188	WS06	WS06	Orangish brown gravelly sand	13	35	-
23189	WS06	WS06	Grey slightly sandy silty clay	22	1.2	-
23190	WS06	WS06	Orangish brown slightly sandy slightly gravelly silty clay	-	-	100
23191	WS07	WS07	Orangish brown gravelly sand	14	34	-

L18/2871/GRM/001 - Amendment A

Project Reference - Crease Drove, Crowland

Analysis Methodologies

Matrix	Determinant	Sample condition for analysis	Test Method used
Soil	Metals	Air Dried	In house method statement - MS - CL - ICP metals
Soil	PAH	As Received	In house method statement - MS - CL - PAH (As received)
Soil	Phenols	As Received	In house method statement - MS - CL - Phenols by Skalar
Soil	Chromium (hexavalent)	As Received	In house method statement - MS - CL - Hexavalent Chromium by Skalar
Soil	Cyanide	As Received	In house method statement - MS - CL - Cyanide by Skalar
Soil	pH	As Received	In house method statement - MS - CL - pH in soils (using a 1:3 soil to water extraction)
Soil	SOM	Air Dried	In house method statement - MS - CL - TOC Eltra
Soil	Sulphate (w/s)	Oven Dried	In house method statement - MS - CL - Anions by Aquakem
Soil	Acid Sulphate	Oven Dried	In house method statement - MS - CL - BRE Analysis
Soil	Total Sulphur	Oven Dried	In house method statement - MS - CL - BRE Analysis
Soil	CWG	As Received	In house method statements - MS - CL - EPH in soil and MS - CL - VPH
Soil	Asbestos	-	Fibre identification is in accordance with in house documented methods which are based on the procedure documented in the HSE Document HSG 248 "Asbestos: The analysts guide for sampling, analysis and clearance procedures"
Soil	Pesticide Screen	As Received	In house method statement - MS - CL - Pesticides 1. Sample preparation was in accordance with BS 1377 : Part 1 : 2016 2. Testing was in accordance with BS 1377: Part 3: 1990 Clause 3. 3. The reported % organic content is the average organic matter content present in the soil fraction passing the 2mm test sieve to the nearest 0.1% of the original oven dry mass of soil.
Soil	1377 Organic Matter	Air Dried	4. Some information required by BS 1377 has not been reported. This information is available on request. 5. Sulphides and chlorides were not identified in the above sample.

GRM Development Solutions

Laurus House
First Avenue
Centrum 100
Burton Upon Trent
DE14 2WH

Analytical Test Report: L19/0053/GRM/001

Your Project Reference:	Crease Drove, Crowland	Samples Received on:	08/01/2019
Your Order Number:	P8723	Testing Instruction Received:	08/01/2019
Report Issue Number:	1	Sample Tested:	08/01 to 16/01/2019
Samples Analysed:	1 water sample	Report issued:	17/01/2019

Signed



Peter Swanston
Environmental Laboratories Manager
Nicholls Colton Group

Notes:

General

Please refer to Methodologies tab for details pertaining to the analytical methods undertaken.

Samples will be retained for 14 days after issue of this report unless otherwise requested.

Samples were supplied by customer, results are representative of the material provided

Accreditation Key

UKAS = UKAS Accreditation, MCERTS = MCERTS Accreditation, u = Unaccredited

MCERTS Accreditation only covers the SAND, CLAY and LOAM matrices

Date of Issue 24.01.2017

Owned by Emily Blissett - Customer Services Supervisor

Authorised by James Gane - Commercial Manager

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L19/0053/GRM/001

Project Reference - Crease Drove, Crowland

Analytical Test Results - Water

NC Reference		24268	
Client Sample Reference		WS06	
Client Sample Location		WS06	
Depth - Top (m)		1.00	
Depth - Bottom (m)		2.00	
Date of Sampling		05/12/2018	
Time of Sampling		Not Provided	
Sample Matrix		Water	
Determinant	Units	Accreditation	
pH	pH Units	u	6.3
Sulphate	(mg/l)	u	98
Benzene	(µg/l)	u	< 6.00
Toluene	(µg/l)	u	< 6.00
Ethylbenzene	(µg/l)	u	< 6.00
m&p Xylene	(µg/l)	u	< 12.00
o-Xylene	(µg/l)	u	< 6.00
MTBE	(µg/l)	u	< 6.00

L19/0053/GRM/001

Project Reference - Crease Drove, Crowland

Analytical Test Results - TPH CWG Water Samples

NC Reference		24268	
Client Sample Reference		WS06	
Client Sample Location		WS06	
Depth - Top (m)		1.00	
Depth - Bottom (m)		2.00	
Date of Sampling		05/12/2018	
Time of Sampling		Not Provided	
Sample Matrix		Water	
Determinant	Units	Accreditation	
Aliphatics			
>C ₅ to C ₆	(µg/l)	u	< 0.10
>C ₆ to C ₈	(µg/l)	u	< 0.10
>C ₈ to C ₁₀	(µg/l)	u	< 0.10
>C ₁₀ to C ₁₂	(µg/l)	u	105
>C ₁₂ to C ₁₆	(µg/l)	u	1380
>C ₁₆ to C ₂₁	(µg/l)	u	2800
>C ₂₁ to C ₃₅	(µg/l)	u	596
Aromatics			
>C ₅ to C ₇	(µg/l)	u	< 0.10
>C ₇ to C ₈	(µg/l)	u	< 0.10
>C ₈ to C ₁₀	(µg/l)	u	< 0.10
>C ₁₀ to C ₁₂	(µg/l)	u	44.1
>C ₁₂ to C ₁₆	(µg/l)	u	652
>C ₁₆ to C ₂₁	(µg/l)	u	1720
>C ₂₁ to C ₃₅	(µg/l)	u	428
Total			
>C ₅ to C ₃₅	(µg/l)	u	7700

L19/0053/GRM/001

Project Reference - Crease Drove, Crowland

Analysis Methodologies

Matrix	Determinant	Sample condition for analysis	Test Method used
Water	pH	As Received	BS 1377, Part 3, 1990
Water	Sulphate	As Received	In house method statement - MS - CL - Anions (Aquakem)
Water	CWG	As Received	In house method statement - MS - CL - VOC and MBTEX and TPH EPH Waters
Water	BTEX	As Received	In house method statement - MS - CL - VOC and MBTEX



Nicholls Colton Group
7 - 11 Harding Street
Leicester
LE1 4DH

GRM Development Solutions

Laurus House
First Avenue
Centrum 100
Burton Upon Trent
DE14 2WH

Analytical Test Report: L19/1428/GRM/001 - Amendment B

Your Project Reference:	Crease Drove, Crowland	Samples Received on:	07/06/2019
Your Order Number:	P8723	Testing Instruction Received:	07/06/2019
Report Issue Number:	3	Sample Tested:	07/06 to 01/07/2019
Samples Analysed:	17 soil samples	Report issued:	11/07/2019

Signed

Peter Swanston

Environmental Laboratories Manager
Nicholls Colton Group

Notes:

General

Please refer to Methodologies tab for details pertaining to the analytical methods undertaken.

Samples will be retained for 14 days after issue of this report with the exception of the asbestos test portion which is held for 6 months unless otherwise requested.

Moisture Content was determined in accordance with NC method statement MS - CL - Sample Prep, oven dried at <30°C.

Moisture Content is reported as a percentage of the dry mass of soil, this calculation is in accordance with BS1377, Part 2, 1990, Clause 3.2

Stone Content was determined in accordance with NC method statement MS - CL - Sample Prep and refers to the percentage of stones retained on a 10mm BS test sieve.

With the exception of Sulphate and Lol which are crushed over the 2mm test sieve, concentrations are reported as a percentage mass of the dry soil passing the 10mm BS test sieve. As received samples have been corrected for moisture content but not stone content.

Samples were supplied by customer, results are representative of the material provided

Asbestos

Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

Deviating Samples

Samples were received in suitable containers

Yes - Except samples 39628,39629,39630,39633,39637

A date and time of sampling was provided

Yes

Sample holding times were exceeded prior to analysis of determinants

No

Where samples do not meet one or more of the above criteria they will be classed as deviating, this means data may not be representative of the sample at the time of sampling and it is possible that results provided may be compromised.

WAC Testing

Samples were leached in accordance with BS EN 12457-2: 2002.

Eluate Results are reported as L/S 10. These results have been calculated in accordance with BS EN 12457-2:2002.

Comparative values are taken from the Environment Agency document "Guidance for waste destined for disposal in landfills", Version 2, June 2006.

Accreditation Key

UKAS = UKAS Accreditation, MCERTS = MCERTS Accreditation, u = Unaccredited

MCERTS Accreditation only covers the SAND, CLAY and LOAM matrices

Date of Issue 24.01.2017

Owned by Emily Blissett - Customer Services Supervisor

Authorised by James Gane - Commercial Manager

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L19/1428/GRM/001 - Amendment B

Project Reference - Crease Drove, Crowland

Analytical Test Results - Soil

NC Reference			39622	39624	39626	39628	39629	39631	39633
Client Sample Reference			WS101	WS103	WS104	WS106	WS107	WS109	WS110
Client Sample Location			WS101	WS103	WS104	WS106	WS107	WS109	WS110
Depth - Top (m)			0.7	1.3	1.5	1.7	1.1	1.5	1.8
Depth - Bottom (m)			0.8	1.4	1.6	1.8	1.2	1.6	1.9
Date of Sampling			03/06/2019	03/06/2019	03/06/2019	03/06/2019	03/06/2019	03/06/2019	03/06/2019
Time of Sampling			Not Provided	Not Provided	Not Provided	Not Provided	Not Provided	Not Provided	Not Provided
Sample Matrix			Clay	Sand	Clay	Other	Clay	Clay	Clay
Determinant	Units	Accreditation							
Arsenic	(mg/kg)	MCERTS	-	36	-	-	-	23	-
Cadmium	(mg/kg)	MCERTS	-	0.9	-	-	-	1.0	-
Chromium (Total)	(mg/kg)	UKAS	-	24	-	-	-	40	-
Copper	(mg/kg)	MCERTS	-	16	-	-	-	26	-
Lead	(mg/kg)	MCERTS	-	20	-	-	-	53	-
Mercury	(mg/kg)	UKAS	-	< 2.5	-	-	-	< 2.5	-
Nickel	(mg/kg)	MCERTS	-	24	-	-	-	33	-
Selenium	(mg/kg)	u	-	< 8.0	-	-	-	< 8.0	-
Zinc	(mg/kg)	MCERTS	-	67	-	-	-	96	-
Total Phenols	(mg/kg)	MCERTS	-	< 1.0	-	-	-	< 1.0	-
Cyanide (Total)	(mg/kg)	MCERTS	-	< 1.0	-	-	-	< 1.0	-
Cyanide (Free)	(mg/kg)	u	-	< 1.0	-	-	-	< 1.0	-
Chromium (Hexavalent)	(mg/kg)	u	-	< 1.0	-	-	-	< 1.0	-
pH	pH Units	MCERTS	-	7.8	-	-	-	6.9	-
Sulphate (Water soluble)	(mg/l)	u	-	130	-	-	-	330	-
SOM (via TOC)	(%)	UKAS	-	< 1.7	-	< 1.7	-	7.5	-
Acenaphthene	(mg/kg)	MCERTS	-	< 0.02	-	-	-	2.4	-
Acenaphthylene	(mg/kg)	UKAS	-	< 0.02	-	-	-	0.51	-
Anthracene	(mg/kg)	UKAS	-	< 0.02	-	-	-	1.0	-
Benzo (a) anthracene	(mg/kg)	MCERTS	-	< 0.02	-	-	-	< 0.04	-
Benzo (a) pyrene	(mg/kg)	MCERTS	-	< 0.02	-	-	-	< 0.04	-
Benzo (b) fluoranthene	(mg/kg)	MCERTS	-	< 0.02	-	-	-	< 0.04	-
Benzo (g, h, i) perylene	(mg/kg)	MCERTS	-	< 0.02	-	-	-	< 0.04	-
Benzo (k) fluoranthene	(mg/kg)	MCERTS	-	< 0.02	-	-	-	< 0.04	-
Chrysene	(mg/kg)	MCERTS	-	< 0.02	-	-	-	< 0.04	-
Dibenzo (a,h) anthracene	(mg/kg)	MCERTS	-	< 0.02	-	-	-	< 0.04	-
Fluoranthene	(mg/kg)	MCERTS	-	< 0.02	-	-	-	0.10	-
Fluorene	(mg/kg)	MCERTS	-	< 0.02	-	-	-	1.9	-
Indeno (1, 2, 3,-cd) pyrene	(mg/kg)	MCERTS	-	< 0.02	-	-	-	< 0.04	-
Naphthalene	(mg/kg)	MCERTS	-	< 0.02	-	-	-	0.96	-
Phenanthrene	(mg/kg)	MCERTS	-	< 0.02	-	-	-	5.0	-
Pyrene	(mg/kg)	MCERTS	-	< 0.02	-	-	-	0.10	-
Total PAH (Sum of USEPA 16)	(mg/kg)	UKAS	-	< 0.32	-	-	-	12	-
Total TPH (>C ₈ to C ₄₀)	(mg/kg)	MCERTS	200	-	690	20	29	-	19
Asbestos	-	UKAS	-	No asbestos detected	-	-	-	No asbestos detected	-

L19/1428/GRM/001 - Amendment B

Project Reference - Crease Drove, Crowland

Analytical Test Results - Soil

NC Reference			39634	39635	39636	39637
Client Sample Reference			HH101	HH102	HH103	HH104
Client Sample Location			HH101	HH102	HH103	HH104
Depth - Top (m)			0.3	0.4	0.9	0.3
Depth - Bottom (m)			0.4	0.5	1.0	0.4
Date of Sampling			05/06/2019	05/06/2019	05/06/2019	05/06/2019
Time of Sampling			Not Provided	Not Provided	Not Provided	Not Provided
Sample Matrix			Sand	Other	Clay	Clay
Determinant	Units	Accreditation				
Arsenic	(mg/kg)	MCERTS	< 10	< 10	< 10	17
Cadmium	(mg/kg)	MCERTS	0.5	0.2	0.4	0.7
Chromium (Total)	(mg/kg)	UKAS	9.2	< 1.0	18	23
Copper	(mg/kg)	MCERTS	22	14	7.0	6.7
Lead	(mg/kg)	MCERTS	14	3.0	17	20
Mercury	(mg/kg)	UKAS	< 2.5	< 2.5	< 2.5	< 2.5
Nickel	(mg/kg)	MCERTS	14	2.9	16	23
Selenium	(mg/kg)	u	< 8.0	< 8.0	< 8.0	< 8.0
Zinc	(mg/kg)	MCERTS	35	11	43	56
Total Phenols	(mg/kg)	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0
Cyanide (Total)	(mg/kg)	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0
Cyanide (Free)	(mg/kg)	u	< 1.0	< 1.0	< 1.0	< 1.0
Chromium (Hexavalent)	(mg/kg)	u	< 1.0	< 1.0	< 1.0	< 1.0
pH	pH Units	MCERTS	8.6	8.6	7.7	7.8
Sulphate (Water soluble)	(mg/l)	u	30	27	< 10	< 10
SOM (via TOC)	(%)	UKAS	< 1.7	< 1.7	< 1.7	< 1.7
Acenaphthene	(mg/kg)	MCERTS	< 0.02	< 0.02	< 0.02	< 0.02
Acenaphthylene	(mg/kg)	UKAS	< 0.02	< 0.02	< 0.02	< 0.02
Anthracene	(mg/kg)	UKAS	< 0.02	< 0.02	< 0.02	< 0.02
Benzo (a) anthracene	(mg/kg)	MCERTS	< 0.02	< 0.02	< 0.02	< 0.02
Benzo (a) pyrene	(mg/kg)	MCERTS	< 0.02	< 0.02	< 0.02	< 0.02
Benzo (b) fluoranthene	(mg/kg)	MCERTS	0.02	< 0.02	< 0.02	< 0.02
Benzo (g, h, i) perylene	(mg/kg)	MCERTS	< 0.02	< 0.02	< 0.02	< 0.02
Benzo (k) fluoranthene	(mg/kg)	MCERTS	< 0.02	< 0.02	< 0.02	< 0.02
Chrysene	(mg/kg)	MCERTS	< 0.02	< 0.02	< 0.02	< 0.02
Dibenzo (a,h) anthracene	(mg/kg)	MCERTS	< 0.02	< 0.02	< 0.02	< 0.02
Fluoranthene	(mg/kg)	MCERTS	0.03	< 0.02	< 0.02	< 0.02
Fluorene	(mg/kg)	MCERTS	< 0.02	< 0.02	< 0.02	< 0.02
Indeno (1, 2, 3,-cd) pyrene	(mg/kg)	MCERTS	< 0.02	< 0.02	< 0.02	< 0.02
Naphthalene	(mg/kg)	MCERTS	< 0.02	< 0.02	< 0.02	< 0.02
Phenanthrene	(mg/kg)	MCERTS	0.02	< 0.02	< 0.02	0.03
Pyrene	(mg/kg)	MCERTS	0.03	< 0.02	< 0.02	< 0.02
Total PAH (Sum of USEPA 16)	(mg/kg)	UKAS	0.38	< 0.32	< 0.32	0.36
Total TPH (>C ₈ to C ₄₀)	(mg/kg)	MCERTS	-	-	-	-
Asbestos	-	UKAS	No asbestos detected	No asbestos detected	No asbestos detected	No asbestos detected

L19/1428/GRM/001 - Amendment B

Project Reference - Crease Drove, Crowland

Analytical Test Results - TPH CWG

NC Reference			39623	39624	39625	39627	39630	39631	39632
Client Sample Reference			WS102	WS103	WS104	WS105	WS107	WS109	WS109
Client Sample Location			WS102	WS103	WS104	WS105	WS107	WS109	WS109
Depth - Top (m)			2.8	1.3	0.5	1.1	1.8	1.5	2.8
Depth - Bottom (m)			3.0	1.4	0.6	1.2	1.9	1.6	2.9
Date of Sampling			03/06/2019	03/06/2019	03/06/2019	03/06/2019	03/06/2019	03/06/2019	03/06/2019
Time of Sampling			Not Provided	Not Provided	Not Provided	Not Provided	Not Provided	Not Provided	Not Provided
Sample Matrix			Clay	Sand	Clay	Clay	Clay	Clay	Sand
Determinant	Units	Accreditation							
Aliphatics									
>C ₅ to C ₆	(mg/kg)	u	0.06	< 0.03	0.14	< 0.03	< 0.03	< 0.41	0.03
>C ₆ to C ₈	(mg/kg)	u	0.23	0.21	0.20	0.24	0.21	2.3	0.24
>C ₈ to C ₁₀	(mg/kg)	u	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	18	0.04
>C ₁₀ to C ₁₂	(mg/kg)	u	< 10	< 10	44	< 10	< 10	200	< 10
>C ₁₂ to C ₁₆	(mg/kg)	u	< 10	< 10	320	< 10	< 10	720	< 10
>C ₁₆ to C ₂₁	(mg/kg)	u	< 10	< 10	340	< 10	< 10	590	< 10
>C ₂₁ to C ₃₅	(mg/kg)	u	23	< 10	160	12	14	100	17
Aromatics									
>C ₅ to C ₇	(mg/kg)	u	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.41	< 0.03
>C ₇ to C ₈	(mg/kg)	u	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.41	< 0.03
>C ₈ to C ₁₀	(mg/kg)	u	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.41	< 0.03
>C ₁₀ to C ₁₂	(mg/kg)	u	< 10	< 10	< 10	< 10	< 10	93	< 10
>C ₁₂ to C ₁₆	(mg/kg)	u	< 10	< 10	130	< 10	< 10	470	< 10
>C ₁₆ to C ₂₁	(mg/kg)	u	< 10	< 10	230	< 10	< 10	330	< 10
>C ₂₁ to C ₃₅	(mg/kg)	u	18	< 10	120	< 10	20	58	12
Total									
>C ₅ to C ₃₅	(mg/kg)	u	< 50	< 50	1300	< 50	< 50	2600	< 50

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Project Reference - Crease Drove, Crowland

Analytical Test Results - TPH CWG

NC Reference			39634	39635	39636	39637	39638
Client Sample Reference			HH101	HH102	HH103	HH104	HH104
Client Sample Location			HH101	HH102	HH103	HH104	HH104
Depth - Top (m)			0.3	0.4	0.9	0.3	1.3
Depth - Bottom (m)			0.4	0.5	1.0	0.4	1.4
Date of Sampling			05/06/2019	05/06/2019	05/06/2019	05/06/2019	05/06/2019
Time of Sampling			Not Provided	Not Provided	Not Provided	Not Provided	Not Provided
Sample Matrix			Sand	Other	Clay	Clay	Sand
Determinant	Units	Accreditation					
Aliphatics							
>C ₅ to C ₆	(mg/kg)	u	< 0.03	< 0.03	< 0.03	0.05	< 0.03
>C ₆ to C ₈	(mg/kg)	u	0.26	0.03	0.07	< 0.03	0.03
>C ₈ to C ₁₀	(mg/kg)	u	< 0.03	< 0.03	< 0.03	< 0.03	0.45
>C ₁₀ to C ₁₂	(mg/kg)	u	< 10	< 10	< 10	< 10	28
>C ₁₂ to C ₁₆	(mg/kg)	u	< 10	< 10	< 10	< 10	150
>C ₁₆ to C ₂₁	(mg/kg)	u	< 10	< 10	< 10	< 10	130
>C ₂₁ to C ₃₅	(mg/kg)	u	14	14	18	18	49
Aromatics							
>C ₅ to C ₇	(mg/kg)	u	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
>C ₇ to C ₈	(mg/kg)	u	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
>C ₈ to C ₁₀	(mg/kg)	u	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
>C ₁₀ to C ₁₂	(mg/kg)	u	< 10	< 10	< 10	< 10	13
>C ₁₂ to C ₁₆	(mg/kg)	u	< 10	< 10	< 10	< 10	83
>C ₁₆ to C ₂₁	(mg/kg)	u	< 10	< 10	< 10	< 10	84
>C ₂₁ to C ₃₅	(mg/kg)	u	16	< 10	16	19	33
Total							
>C ₅ to C ₃₅	(mg/kg)	u	< 50	< 50	< 50	< 50	570

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Project Reference - Crease Drove, Crowland

Certificate Of Analysis - WAC Suite

NC Reference	39624
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Client Sample Reference	WS103
Client Sample Location	WS103
Depth - Top (m)	1.30
Depth - Bottom (m)	1.40
Date of Sampling	03/06/2019
Time of Sampling	Not Provided
Sample Description	Orangish brown gravelly silty sand
Sample Matrix	Sand
Moisture Content (%)	14
Stone content (%)	13

Determined Result	Inert Waste Landfill	Stable non reactive hazardous waste in a non hazardous landfill	Hazardous Waste Landfill
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Solid Analysis

Total Organic Carbon	%	MCERTS	< 1.0	3.0	5.0	6.0
Loss on Ignition	%	UKAS	0.6	-	-	10.0
BTEX	mg/kg	MCERTS	< 0.22	6.00	-	-
PCB's (7 Congeners)	mg/kg	u	< 0.028	1.00	-	-
Mineral Oil (>C ₁₀ to C ₄₀)	mg/kg	u	18	500	-	-
PAH	mg/kg	u	< 0.34	100	-	-
pH	units	MCERTS	7.8	-	> 6	-

Eluate Analysis

Arsenic	mg/kg	u	< 0.03	0.50	2	25
Barium	mg/kg	u	< 0.05	20	100	300
Cadmium	mg/kg	u	< 0.03	0.04	1	5
Chromium (total)	mg/kg	u	< 0.03	0.5	10	70
Copper	mg/kg	u	0.02	2.0	50	100
Mercury	mg/kg	u	< 0.01	0.01	0.2	2
Molybdenum	mg/kg	u	< 0.03	0.5	10.0	30
Nickel	mg/kg	u	< 0.03	0.4	10.0	40
Lead	mg/kg	u	< 0.05	0.5	10.0	50
Antimony	mg/kg	u	< 0.03	0.06	0.7	5
Selenium	mg/kg	u	< 0.01	0.1	0.5	7
Zinc	mg/kg	u	< 0.05	4	50	200
Chloride	mg/kg	u	< 1	800	15000	25000
Fluoride	mg/kg	u	1	10	150	500
Sulphate (as SO ₄)	mg/kg	u	190	1000	20000	50000
Phenol Index	mg/kg	u	< 1.0	1	-	-
Dissolved Organic Carbon	mg/kg	u	94	500	800	1000

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Project Reference - Crease Drove, Crowland

Certificate Of Analysis - WAC Suite

NC Reference	39631
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Client Sample Reference	WS109
Client Sample Location	WS109
Depth - Top (m)	1.50
Depth - Bottom (m)	1.60
Date of Sampling	03/06/2019
Time of Sampling	Not Provided
Sample Description	Dark brown slightly sandy slightly gravelly silty clay with frequent hydrocarbons
Sample Matrix	Clay
Moisture Content (%)	64
Stone content (%)	1.6

	Determined Result	Inert Waste Landfill	Stable non reactive hazardous waste in a non hazardous landfill	Hazardous Waste Landfill
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Solid Analysis

Total Organic Carbon	%	MCERTS	4.4	3.0	5.0	6.0
Loss on Ignition	%	UKAS	13	-	-	10.0
BTEX	mg/kg	MCERTS	< 0.30	6.00	-	-
PCB's (7 Congeners)	mg/kg	u	< 0.056	1.00	-	-
Mineral Oil (>C ₁₀ to C ₄₀)	mg/kg	u	6500	500	-	-
PAH	mg/kg	u	13	100	-	-
pH	units	MCERTS	6.9	-	> 6	-

Eluate Analysis

Arsenic	mg/kg	u	0.03	0.50	2	25
Barium	mg/kg	u	0.30	20	100	300
Cadmium	mg/kg	u	< 0.03	0.04	1	5
Chromium (total)	mg/kg	u	< 0.03	0.5	10	70
Copper	mg/kg	u	0.02	2.0	50	100
Mercury	mg/kg	u	< 0.01	0.01	0.2	2
Molybdenum	mg/kg	u	< 0.03	0.5	10.0	30
Nickel	mg/kg	u	0.04	0.4	10.0	40
Lead	mg/kg	u	< 0.05	0.5	10.0	50
Antimony	mg/kg	u	< 0.03	0.06	0.7	5
Selenium	mg/kg	u	< 0.01	0.1	0.5	7
Zinc	mg/kg	u	< 0.05	4	50	200
Chloride	mg/kg	u	6	800	15000	25000
Fluoride	mg/kg	u	5	10	150	500
Sulphate (as SO ₄)	mg/kg	u	54	1000	20000	50000
Phenol Index	mg/kg	u	< 1.0	1	-	-
Dissolved Organic Carbon	mg/kg	u	470	500	800	1000

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Project Reference - Crease Drove, Crowland

Certificate Of Analysis - WAC Suite

NC Reference	39635
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Client Sample Reference	HH102
Client Sample Location	HH102
Depth - Top (m)	0.40
Depth - Bottom (m)	0.50
Date of Sampling	05/06/2019
Time of Sampling	Not Provided
Sample Description	Light brown crushed rock
Sample Matrix	Other
Moisture Content (%)	8.9
Stone content (%)	0

	Determined Result	Inert Waste Landfill	Stable non reactive hazardous waste in a non hazardous landfill	Hazardous Waste Landfill
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Solid Analysis

Total Organic Carbon	%	MCERTS	< 1.0	3.0	5.0	6.0
Loss on Ignition	%	UKAS	0.7	-	-	10.0
BTEX	mg/kg	MCERTS	< 0.21	6.00	-	-
PCB's (7 Congeners)	mg/kg	u	< 0.028	1.00	-	-
Mineral Oil (>C ₁₀ to C ₄₀)	mg/kg	u	45	500	-	-
PAH	mg/kg	u	< 0.34	100	-	-
pH	units	MCERTS	8.6	-	> 6	-

Eluate Analysis

Arsenic	mg/kg	u	< 0.03	0.50	2	25
Barium	mg/kg	u	< 0.05	20	100	300
Cadmium	mg/kg	u	< 0.03	0.04	1	5
Chromium (total)	mg/kg	u	< 0.03	0.5	10	70
Copper	mg/kg	u	0.02	2.0	50	100
Mercury	mg/kg	u	< 0.01	0.01	0.2	2
Molybdenum	mg/kg	u	< 0.03	0.5	10.0	30
Nickel	mg/kg	u	< 0.03	0.4	10.0	40
Lead	mg/kg	u	< 0.05	0.5	10.0	50
Antimony	mg/kg	u	< 0.03	0.06	0.7	5
Selenium	mg/kg	u	< 0.01	0.1	0.5	7
Zinc	mg/kg	u	< 0.05	4	50	200
Chloride	mg/kg	u	2	800	15000	25000
Fluoride	mg/kg	u	2	10	150	500
Sulphate (as SO ₄)	mg/kg	u	83	1000	20000	50000
Phenol Index	mg/kg	u	< 1.0	1	-	-
Dissolved Organic Carbon	mg/kg	u	100	500	800	1000



Nicholls Colton Group
7 - 11 Harding Street
Leicester
LE1 4DH

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Project Reference - Crease Drove, Crowland

Sample Descriptions

NC Reference	Client Sample Reference	Sample Location	Description	Moisture Content (%)	Stone Content (%)
39622	WS101	WS101	Dark brown slightly sandy silty clay	43	0.0
39623	WS102	WS102	Mottled greyish brown slightly sandy slightly gravelly silty clay	23	0.0
39624	WS103	WS102	Orangish brown gravelly silty sand	14	13
39625	WS104	WS104	Mottled greyish brown slightly sandy silty clay	52	2.2
39626	WS104	WS104	Mottled greyish brown sandy slightly gravelly silty clay	16	11
39627	WS105	WS105	Orangish brown slightly sandy slightly gravelly silty clay	19	12
39628	WS106	WS106	Orangish brown sandy crushed rock	8.4	31
39629	WS107	WS107	Mottled greyish brown slightly sandy silty clay	21	6.6
39630	WS107	WS107	Mottled greyish brown slightly sandy slightly gravelly silty clay	14	1.3
39631	WS109	WS109	Dark brown slightly sandy slightly gravelly silty clay with frequent hydrocarbons	64	1.6
39632	WS109	WS109	Orangish brown gravelly silty sand	11	19
39633	WS110	WS110	Mottled greyish brown slightly sandy slightly gravelly silty clay	17	8.9
39634	HH101	HH101	Brown very gravelly silty sand	13	40
39635	HH102	HH102	Light brown crushed rock	8.9	0.0
39636	HH103	HH103	Mottled brownish grey slightly sandy silty clay	14	1.3
39637	HH104	HH104	Dark brown slightly sandy slightly gravelly silty clay	13	9.7
39638	HH104	HH104	Brown slightly gravelly silty sand with rare hydrocarbons	16	0.0

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Project Reference - Crease Drove, Crowland

Sample Comments

NC Reference	Client Sample Reference	Sample Location	Comments
39622	WS101	WS101	-
39623	WS102	WS102	VPH - Sample taken from container with headspace.
39624	WS103	WS103	VOC/BTEX - Sample taken from container with headspace.
39625	WS104	WS104	-
39626	WS104	WS104	-
39627	WS105	WS105	VPH - Sample taken from container with headspace.
39628	WS106	WS106	-
39629	WS107	WS107	-
39630	WS107	WS107	VPH - Sample taken from container with headspace.
39631	WS109	WS109	VPH - Sample taken from container with headspace.
39632	WS109	WS109	-
39633	WS110	WS110	-
39634	HH101	HH101	-
39635	HH102	HH102	VOC/BTEX - Sample taken from container with headspace.
39636	HH103	HH103	-
39637	HH104	HH104	VPH - Sample taken from container with headspace.
39638	HH104	HH104	-

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Project Reference - Crease Drove, Crowland

Analysis Methodologies

Matrix	Determinant	Sample condition for analysis	Test Method used
Soil	Metals	Air Dried	In house method statement - MS - CL - ICP metals
Soil	PAH	As Received	In house method statement - MS - CL - PAH (As received)
Soil	Phenols	As Received	In house method statement - MS - CL - Phenols by Skalar
Soil	Chromium (hexavalent)	As Received	In house method statement - MS - CL - Hexavalent Chromium by Skalar
Soil	Cyanide	As Received	In house method statement - MS - CL - Cyanide by Skalar
Soil	pH	As Received	In house method statement - MS - CL - pH in soils (using a 1:3 soil to water extraction)
Soil	SOM	Air Dried	In house method statement - MS - CL - TOC Eltra
Soil	Sulphate (w/s)	Oven Dried	In house method statement - MS - CL - Anions by Aquakem
Soil	Total TPH	As Received	In house method statement - MS - CL - TPH (GC-FID)- Sample was not subject to a 'scrubbing' cleanup step prior to analysis
Soil	CWG	As Received	In house method statements - MS - CL - EPH in soil and MS - CL - VPH
Soil	Asbestos	-	Fibre identification is in accordance with in house documented methods which are based on the procedure documented in the HSE Document HSG 248 "Asbestos: The analysts guide for sampling, analysis and clearance procedures"

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Project Reference - Crease Drove, Crowland

WAC Analysis Methodologies

Matrix	Determinant	Sample condition for analysis	Test Method used
Soil	TOC	Air Dried	In house method statement - MS - CL - TOC Eltra
Soil	Lol	Oven Dried	Testing was in accordance with BS 1377: Part 3: 1990 Clause 4. Determination of the mass loss on ignition. Some information required by BS1377: 2016: Part 1 has not been reported. This information is available on request.
Soil	BTEX	As Received	In house method statement - MS - CL - VOC and MBTEX
Soil	PCB	As Received	In house method statement - MS - CL - PCB
Soil	Mineral Oil	As Received	In house method statement - MS - CL - TPH (GC-FID)
Soil	PAH	As Received	In house method statement - MS - CL - PAH (As received)
Soil	pH	As Received	In house method statement - MS - CL - pH in soils (using a 1:3 soil to water extraction)
Eluate	Metals	Leached	In house method statement - MS - CL - ICP Waters
Eluate	Anions	Leached	In house method statement - MS - CL - Anions by Aquakem
Eluate	Phenol Index	Leached	In house method statement - MS - CL - Phenols (Skalar)
Eluate	DOC	Leached	In house method statement - MS - CL - DOC

GRM Development Solutions

Laurus House
First Avenue
Centrum 100
Burton Upon Trent
DE14 2WH

Analytical Test Report: L19/1516/GRM/001

Your Project Reference:	Crease Drove Crowland	Samples Received on:	20/06/2019
Your Order Number:	P8723	Testing Instruction Received:	20/06/2019
Report Issue Number:	1	Sample Tested:	20/06 to 10/07/2019
Samples Analysed:	6 water samples	Report issued:	10/07/2019

Signed



Peter Swanston
Environmental Laboratories Manager
Nicholls Colton Group

Notes:

General

Please refer to Methodologies tab for details pertaining to the analytical methods undertaken.

Samples will be retained for 14 days after issue of this report with the exception of the asbestos test portion which is held for 6 months unless otherwise requested.

Samples were supplied by customer, results are representative of the material provided

Accreditation Key

UKAS = UKAS Accreditation, MCERTS = MCERTS Accreditation, u = Unaccredited

MCERTS Accreditation only covers the SAND, CLAY and LOAM matrices

Date of Issue 24.01.2017

Owned by Emily Blissett - Customer Services Supervisor

Authorised by James Gane - Commercial Manager

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L19/1516/GRM/001

Project Reference - Crease Drove Crowland

Analytical Test Results - GRM Water Suite

NC Reference			41002	41003	41004	41005
Client Sample Reference			WS01	WS03	WS04	WS06
Client Sample Location			WS01	WS03	WS04	WS06
Depth - Top (m)			Not provided	Not provided	Not provided	Not provided
Depth - Bottom (m)			Not provided	Not provided	Not provided	Not provided
Date of Sampling			18/06/2019	18/06/2019	18/06/2019	18/06/2019
Time of Sampling			Not provided	Not provided	Not provided	Not provided
Sample Matrix			Water	Water	Water	Water
Determinant	Units	Accreditation				
Arsenic (dissolved)	(µg/l)	u	< 3	< 3	< 3	7
Cadmium (dissolved)	(µg/l)	u	< 3	< 3	< 3	< 3
Chromium (dissolved)	(µg/l)	u	< 3	< 3	< 3	< 3
Copper (dissolved)	(µg/l)	u	< 1	< 1	< 1	< 1
Iron (dissolved)	(µg/l)	u	76	< 10	< 10	8900
Lead (dissolved)	(µg/l)	u	< 5	< 5	< 5	< 5
Mercury (dissolved)	(µg/l)	u	< 1	< 1	< 1	< 1
Nickel (dissolved)	(µg/l)	u	39	< 3	< 3	9
Selenium (dissolved)	(µg/l)	u	< 1	< 1	< 1	< 1
Zinc (dissolved)	(µg/l)	u	< 5	< 5	< 5	< 5
Phenol (Total)	(µg/l)	u	< 0.80	< 0.80	< 0.80	< 0.80
Cyanide (Total)	(mg/l)	u	< 1	< 1	< 1	< 1
pH	pH Units	u	5.0	6.8	7.2	6.9
Chloride	(mg/l)	u	28	28	58	15
Sulphate (as SO ₄)	(mg/l)	u	1200	820	580	54
Ammonical Nitrogen (as N)	(mg/l)	u	0.028	0.83	0.13	2.8
Hardness (as CaCO ₃)	(mg/l)	u	770	680	520	210
Benzo (a) pyrene	(µg/l)	u	< 0.01	0.02	< 0.01	0.02
Benzo (b) fluoranthene	(µg/l)	u	< 0.01	< 0.01	0.01	0.01
Benzo (g, h, i) perylene	(µg/l)	u	< 0.01	0.01	< 0.01	0.01
Benzo (k) fluoranthene	(µg/l)	u	< 0.01	0.02	< 0.01	0.02
Indeno (1, 2, 3-cd) pyrene	(µg/l)	u	< 0.01	0.02	< 0.01	0.02
Naphthalene	(µg/l)	u	0.07	< 0.01	< 0.01	0.04

L19/1516/GRM/001

Project Reference - Crease Drove Crowland

Analytical Test Results - TPH CWG Water Samples

NC Reference			41005	41006
Client Sample Reference			WS06	WS109
Client Sample Location			WS06	WS109
Depth - Top (m)			Not provided	Not provided
Depth - Bottom (m)			Not provided	Not provided
Date of Sampling			18/06/2019	18/06/2019
Time of Sampling			Not provided	Not provided
Sample Matrix			Water	Water
Determinant	Units	Accreditation		
Aliphatics				
>C ₅ to C ₆	(µg/l)	u	< 0.10	< 0.10
>C ₆ to C ₈	(µg/l)	u	< 0.10	< 0.10
>C ₈ to C ₁₀	(µg/l)	u	< 0.10	< 0.10
>C ₁₀ to C ₁₂	(µg/l)	u	< 5.00	< 5.00
>C ₁₂ to C ₁₆	(µg/l)	u	< 10.00	< 10.00
>C ₁₆ to C ₂₁	(µg/l)	u	< 10.00	< 10.00
>C ₂₁ to C ₃₅	(µg/l)	u	< 15.00	< 15.00
Aromatics				
>C ₅ to C ₇	(µg/l)	u	< 0.10	< 0.10
>C ₇ to C ₈	(µg/l)	u	< 0.10	< 0.10
>C ₈ to C ₁₀	(µg/l)	u	0.62	< 0.10
>C ₁₀ to C ₁₂	(µg/l)	u	< 5.00	< 5.00
>C ₁₂ to C ₁₆	(µg/l)	u	< 10.00	< 10.00
>C ₁₆ to C ₂₁	(µg/l)	u	< 10.00	< 10.00
>C ₂₁ to C ₃₅	(µg/l)	u	112	< 15.00
Total				
>C ₅ to C ₃₅	(µg/l)	u	110	< 30

L19/1516/GRM/001

Project Reference - Crease Drove Crowland

Analytical Test Results - VOC

NC Reference			41002	41003	41004	41005
Client Sample Reference			WS01	WS03	WS04	WS06
Client Sample Location			WS01	WS03	WS04	WS06
Depth - Top (m)			Not provided	Not provided	Not provided	Not provided
Depth - Bottom (m)			Not provided	Not provided	Not provided	Not provided
Date of Sampling			18/06/2019	18/06/2019	18/06/2019	18/06/2019
Time of Sampling			Not provided	Not provided	Not provided	Not provided
Sample Matrix			Water	Water	Water	Water
Determinant	Units	Accreditation				
Benzene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
Toluene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
Ethylbenzene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
m&p Xylene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
o-Xylene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
Dichlorodifluoromethane	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
Chloromethane	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
Vinyl Chloride	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
Bromomethane	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
Chloroethane	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
Trichlorofluoromethane	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
1,1-Dichloroethylene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
Dichloromethane	(µg/l)	u	21.0	22.8	23.6	21.5
MTBE	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
trans-1,2,-dichloroethylene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
1,1-Dichloroethane	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
2,2-Dichloropropane	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
cis--1,2,-dichloroethylene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
Bromochloromethane	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
Chloroform (Trichloromethane)	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
1,1,1-Trichloroethane	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
1,1-Dichloropropene	(µg/l)	u	< 6.00	< 6.00	< 6.00	20.8
Carbon Tetrachloride	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
1,2-dichloroethane	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
Trichloroethylene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
1,2-Dichloropropane	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
Dibromomethane	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
Bromodichloromethane	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
cis-1,2-dichloropropylene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
trans-1,3-dichloropropylene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
1,1,2-Trichloroethane	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
1,3-Dichloropropane	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
Tetrachloroethylene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
Chlorodibromomethane	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
1,2-Dibromoethane	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
Chlorobenzene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
1,1,1,2-tetrachloroethane	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
Styrene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
Isopropylbenzene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
Bromoform	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
1,1,2,2-Tetrachloroethane	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
1,2,3-Trichloropropane	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
n-Propylbenzene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
Bromobenzene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
1,3,5-Trimethylbenzene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
2-chlorotoluene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
4-chlorotoluene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
tert-butylbenzene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
1,2,4-trimethylbenzene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
sec-Butylbenzene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
4-Isopropyltoluene (P-Cymene)	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
1,3-Dichlorobenzene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
1,4-Dichlorobenzene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
n-Butylbenzene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
1,2-Dichlorobenzene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
1,2-Dibromo-3-chloropropane	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
1,2,4-Trichlorobenzene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
Hexachlorobutadiene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
Naphthalene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00
1,2,3-Trichlorobenzene	(µg/l)	u	< 6.00	< 6.00	< 6.00	< 6.00

L19/1516/GRM/001

Project Reference - Crease Drove Crowland

Analysis Methodologies

Matrix	Determinant	Sample condition for analysis	Test Method used
Water	Metals	As Received	In house method statement - MS - CL - ICP Waters
Water	PAH	As Received	In house method statement - MS - CL - PAH in Waters
Water	Phenols	As Received	In house method statement - MS - CL - Phenol waters by HPLC
Water	pH	As Received	BS 1377, Part 3, 1990
Water	Cyanide	As Received	In house method statement - MS - CL - Cyanide
Water	Sulphate	As Received	In house method statement - MS - CL - Anions by Aquakem
Water	Chloride	As Received	In house method statement - MS - CL - Anions by Aquakem
Water	Hardness	As Received	In house method statement - MS - CL - ICP Waters
Water	Ammonical Nitrogen	As Received	In house method statement - MS - CL - Anions by Aquakem
Water	CWG	As Received	In house method statement - MS - CL - VPH and EPH Waters
Water	VOC	As Received	In house method statement - MS - CL - VOC and MBTEX

GRM Development Solutions

Laurus House
First Avenue
Centrum 100
Burton Upon Trent
DE14 2WH

Analytical Test Report: L19/1966/GRM/001

Your Project Reference:	Crease Drove, Crowland	Samples Received on:	19/08/2019
Your Order Number:	P8723	Testing Instruction Received:	19/08/2019
Report Issue Number:	1	Sample Tested:	19/08 to 28/08/2019
Samples Analysed:	7 water samples	Report issued:	28/08/2019

Signed



Peter Swanston
Environmental Laboratories Manager
Nicholls Colton Group

Notes:

General

Please refer to Methodologies tab for details pertaining to the analytical methods undertaken.

Samples will be retained for 14 days after issue of this report unless otherwise requested.

Samples were supplied by customer, results are representative of the material provided

Accreditation Key

UKAS = UKAS Accreditation, MCERTS = MCERTS Accreditation, u = Unaccredited

MCERTS Accreditation only covers the SAND, CLAY and LOAM matrices

Date of Issue 24.01.2017

Owned by Emily Blissett - Customer Services Supervisor

Authorised by James Gane - Commercial Manager

J:\Public\Projects\2019\L19\GRM - GRM Development solutions\L19-1966-GRM P8723\L19-1966-GRM-001.xlsx\TPH CWG - Water

L19/1966/GRM/001

Project Reference - Crease Drove, Crowland

Analytical Test Results - TPH CWG Water Samples

NC Reference			48924	48925	48926	48927	48928	48929	48930
Client Sample Location			BH101	BH102	WS01	WS03	WS04	WS06	WS109
Client Sample Type			Not provided	Not provided	Not provided	Not provided	Not provided	Not provided	Not provided
Client Sample Number			Not provided	Not provided	Not provided	Not provided	Not provided	Not provided	Not provided
Depth - Top (m)			Not provided	Not provided	Not provided	Not provided	Not provided	Not provided	Not provided
Depth - Bottom (m)			Not provided	Not provided	Not provided	Not provided	Not provided	Not provided	Not provided
Date of Sampling			14/08/2019	14/08/2019	14/08/2019	14/08/2019	14/08/2019	14/08/2019	14/08/2019
Time of Sampling			11:35	12:30	13:30	12:05	14:00	11:05	Not provided
Sample Matrix			Water	Water	Water	Water	Water	Water	Water
Determinant	Units	Accreditation							
Aliphatics									
>C ₅ to C ₆	(µg/l)	u	3.18	2.26	1.44	4.41	4.52	8.87	3.63
>C ₆ to C ₈	(µg/l)	u	8.97	11.2	9.48	11.5	13.2	21.4	14.5
>C ₈ to C ₁₀	(µg/l)	u	3.61	3.90	1.35	4.72	2.62	5.33	2.89
>C ₁₀ to C ₁₂	(µg/l)	u	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00
>C ₁₂ to C ₁₆	(µg/l)	u	< 10.00	< 10.00	< 10.00	< 10.00	< 10.00	< 10.00	93.1
>C ₁₆ to C ₂₁	(µg/l)	u	< 10.00	< 10.00	< 10.00	< 10.00	< 10.00	49.4	319
>C ₂₁ to C ₃₅	(µg/l)	u	< 15.00	< 15.00	< 15.00	< 15.00	< 15.00	90.5	< 15.00
Aromatics									
>C ₅ to C ₇	(µg/l)	u	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
>C ₇ to C ₈	(µg/l)	u	0.07	0.04	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
>C ₈ to C ₁₀	(µg/l)	u	0.47	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
>C ₁₀ to C ₁₂	(µg/l)	u	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	46.5
>C ₁₂ to C ₁₆	(µg/l)	u	< 10.00	< 10.00	< 10.00	< 10.00	< 10.00	58.1	335
>C ₁₆ to C ₂₁	(µg/l)	u	< 10.00	< 10.00	< 10.00	< 10.00	< 10.00	77.3	288
>C ₂₁ to C ₃₅	(µg/l)	u	< 15.00	< 15.00	< 15.00	< 15.00	< 15.00	45.1	124
Total									
>C ₅ to C ₃₅	(µg/l)	u	< 30	< 30	< 30	< 30	< 30	360	1200

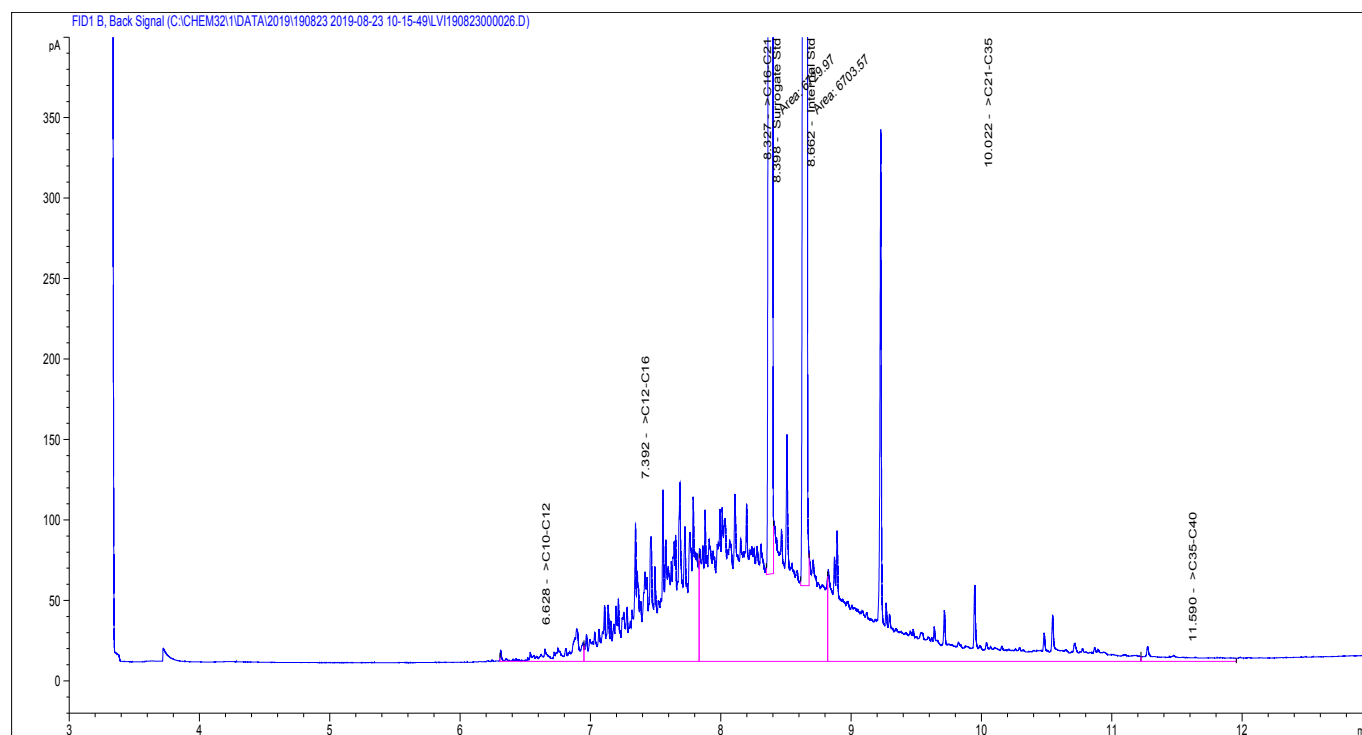
L19/1966/GRM/001

Project Reference - Crease Drove, Crowland

Analysis Methodologies

Matrix	Determinant	Sample condition for analysis	Test Method used
Water	CWG	As Received	In house method statement - MS - CL - VPH and EPH Waters

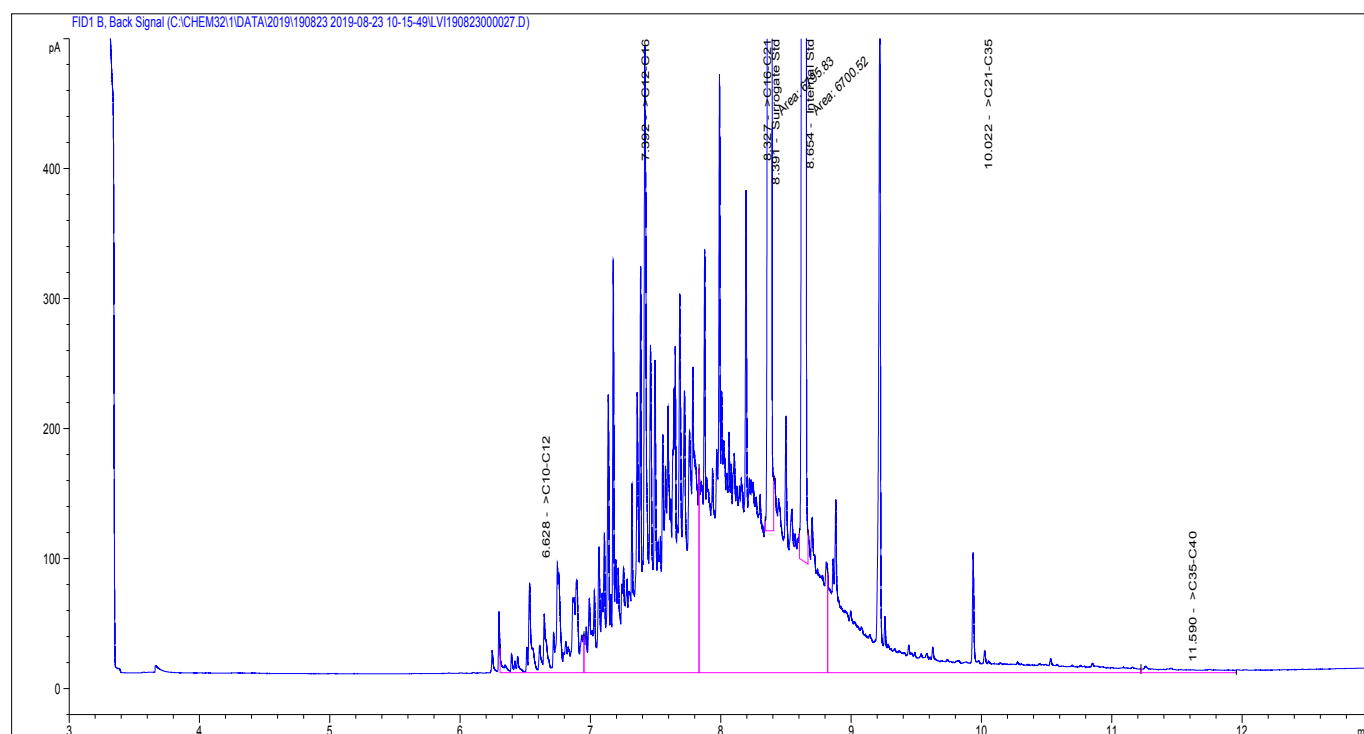
Client Ref: WS06



Page 1 of 2

Sample: 48930

Client Ref: WS109



Contamination is predominantly in the range C₁₂-C₂₁. Chromatogram is consistent with fuel oil type contamination.



A P P E N D I X K

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	GRM TIER 1 ASSESSMENT CRITERIA		
LAND USE	Residential with Plant Uptake		
CONTAMINANT	1%	2.50%	6%
^a Arsenic	37	37	37
^a Cadmium	22	22	22
^b Chromium III	910	910	910
^a Chromium VI	21	21	21
^a Lead	200	200	200
^{b/c} Mercury	40	40	40
^b Selenium	250	250	250
^b Nickel	180	180	180
^b Phenols	280	550	1100
^b Copper	2400	2400	2400
^b Zinc	3700	3700	3700
^d Cyanide	34	34	34
^a Benzene	0.20	0.33	0.87
^b Toluene	130	290	660
^b Ethylbenzene	47	110	260
^b <i>o</i> - xylene	60	140	330
^b <i>m</i> - xylene	59	140	320
^b <i>p</i> - xylene	56	130	310
Non Genotoxic PAHs			
^b Acenaphthene	210	510	1100
^b Acenaphthylene	170	420	920
^b Anthracene	2400	5400	11000
^b Fluoranthene	280	560	890
^b Fluorene	170	400	860
^b Naphthalene	2.3	5.6	13
^b Phenanthrene	95	220	440
^b Pyrene	620	1200	2000
Genotoxic PAHs			
^{a/e} Benzo(a)pyrene	5	5	5
ALIPHATIC HYDROCARBONS			
^b C5-C6	42	78	160
^b C6-C8	100	230	530
^b C8-C10	27	65	150
^b C10-C12	130	330	760
^b C12-C16	1100	2400	4300
^b C16-35	65000	92000	110000
AROMATIC HYDROCARBONS			
^b C5-7 (benzene)	70	140	300
^b C7-8 (toluene)	130	290	660
^b C8-C10	34	83	190
^b C10-C12	74	180	380
^b C12-C16	140	330	660
^b C16-C21	260	540	930
^b C21-C35	1100	1500	1700

Notes

- a C4SL - SP1010 (2014) - Benzene and Benzo(a)pyrene values for 1% and 2.5% SOM have been calculated using default C4SL parameters in CLEA v1.07
- b LQM/CIEH S4UL values (2015).
- c S4UL for inorganic Hg used.
- d Atkins ATRISKsoil Value
- e Benzo(a)pyrene is a surrogate marker for the 8 genotoxic PAHs (Benzo(a)pyrene, Benzo(a)anthracene, Benzo(b)fluoranthene, Benzo(ghi)perylene, Benzo(k)fluoranthene, Chrysene, Dibenzo(ah)anthracene, Ideno(1,2,3-cd)pyrene)

GRM TAC 11-2016

GRM Controlled Waters Tier 1 Assessment Criteria

Table 1a

UKDWS			EQS freshwater (µg/l)*	EQS other surface water (µg/l)* (Including saline waters)
Parameter	Concentration	Units		
Acrylamide	0.1	µg/l	-	
Aluminium	200	µgAl/l	-	
Ammonium	0.5	mgNH4/l	0.2 as N	0.021 unionised as N
Antimony	5	µgSb/l	-	
Arsenic	10	µgAs/l	50 (dissolved)	25 (dissolved)
Benzene	1	µg/l	10	8
Boron	1	mgB/l	750 [#]	-
Bromate	10	µgBrO3/l	-	-
Cadmium	5	µgCd/l	See Table 2b	0.2
Chromium	50	µgCr/l	-	-
Chromium (III)	-	µg/l	4.7	-
Chromium (VI)	-	µg/l	3.4	0.6
Chloride (i)	250	mgCl/l	188mg/l [#]	
Conductivity (i)	2500	µS/cm at 20°C	-	
Copper(ii)	2	mg/l	1	3.76 (where DOC <1mg/l)
Cyanide	50	µgCN/l	1	1
1, 2 dichloroethane	3	µg/l	10	
Dichloromethane	-	µg/l	20	20
Epichlorohydrin	0.1	µg/l	-	
Fluoride	1.5	mgF/l	1mg/l [#]	
Hydrogen ion	10	pH value	-	
Iron	200	µgFe/l	1000 (dissolved)	1000 (dissolved)
Lead (ii)	10	µgPb/l	1.2 (dissolved & bioavailable)	1.3
Manganese	50	µgMn/l	130 (bioavailable)	-
Mercury	1	µgHg/l	0.07 (dissolved)	0.07 (dissolved)
Mineral Oil (TPH)	10	µg/l	5000 (total) ****	5000 (total) ****
Nickel (ii)	20	µgNi/l	4 (dissolved & bioavailable)	8.6
Nitrate (iii)	50	mgNO3/l	-	-
Nitrite (iii)	0.5	mgNO2/l	-	-
Phenol	0.5	µg/l	7.7	7.7
Polycyclic Aromatic Hydrocarbons (vii) *	0.1	µg/l	-	-
Fluoranthene	-	µg/l	0.0063	0.0063
Naphthalene	-	µg/l	2	2
Benzo(a)pyrene	0.01	µg/l	0.00017	0.00017
Benzo(b)fluoranthene	-	µg/l	-	-
Benzo(k)fluoranthene	-	µg/l	-	-
Benzo(g,h,i)perylene	-	µg/l	-	-
Indeno(1,2,3-cd)pyrene	-	µg/l	-	-
Anthracene	-	µg/l	0.1	0.1
Selenium	10	µgSe/l	7.5	-
Sodium	200	mgNa/l	150mg/l [#]	-
Sulphate (i)	250	mgSO4/l	188mg/l [#]	-
Tetrachloroethene and Trichloroethene (viii)	10	µg/l	10	10
Tetrachloroethane	-	µg/l	140	-
Tetrachloromethane	3	µg/l	12	12
Toluene	700***	µg/l	74	74
Xylene	500***	µg/l	30 [†]	30 [†]
Ethylbenzene	300***	µg/l	20**	20**
1,1,1-Trichloroethane	-	µg/l	100 [†]	100 [†]
Trichlorobenzenes	-	µg/l	0.4	0.4
Trichloromethane	-	µg/l	2.5	2.5
Tributyltin	-	µg/l	0.0002	0.0002
Vinyl chloride	0.5	µg/l	-	-
Carbon Tetrachloride	-	µg/l	12	12
Zinc	5000	µg/l	10.9 (dissolved & bioavailable) + background concentration	6.8 (dissolved & bioavailable) + 1.1

Table 1b

Pesticides			EQS freshwater (µg/l)*	EQS other surface water (µg/l)* (Including saline waters)
Aldrin	0.03	µg/l	-	
Dieldrin	0.03	µg/l	-	-
Heptachlor	0.03	µg/l	-	-
Heptachlor epoxide	0.03	µg/l	-	-
other pesticides	0.1	µg/l	-	-
Cyclodiene pesticides: Sum of Aldrin, Dieldrin, Endrin & Isodrin	-	µg/l	0.01 (sum)	0.005
DDT total	-		0.025	0.025
Pesticides: Total (vi)	0.5	µg/l	-	-

Table 2

EQS for Hardness Related Substances*						
Substance	EQS Type	EQS (µg/l) for hardness classes (mg/l CaCO ₃)				
		Class 1: <40	Class 2: 40-50	Class 3: 50-100	Class 4: 100-200	Class 5: >200
Cadmium (dissolved)	Annual average	<0.08	0.08	0.09	0.15	0.25

Reference

* The Water Framework Directive (Standards and Classification) Directions (England and Wales) Directions 2015

** Provisional EQS Value

*** WHO Drinking Water Standard

**** EA PPG3

[†] The River Basin Districts Typology, Standards and Groundwater Threshold Values (Water Framework Directive) (England and Wales) Directions 2010 - Now Withdrawn

[#] Groundwater Drinking Water Protected Zones Only

Ambient Background Concentrations for dissolved zinc in freshwaters in England and Wales (to be used in conjunction with Table 1a)	
Catchment/Group of catchments ⁽ⁱⁱ⁾	ABC (µg/l)
Tyne	4.8
Tees	4.1
Ouse, Humber	2.9
Nene	4.0
Great Ouse	3.1
River Stour	3.0
Blackwater/Chelmer	3.6
Lee	3.3
Thames	2.0
Test	2.0
Avon/Hants	3.1
Exe	1.4
Dart	1.7
Clywd/Conwy	2.0
Dee	2.9
Eden	1.2
Anglesey	3.0
Tamar	2.9
Fal	5.8
Camel	7.1
Tone/Parrett	3.3
Frome, Bristol Avon	2.3
Wye	2.0
Usk	2.2
Taff	2.8
Neath	2.8
Loughar	3.9
Tywi	2.0
Teifi	2.5
Rheidol/Ystwyth	4.1
Dovey	3.2
Glaslyn	2.6
All other freshwaters not listed above	1.4



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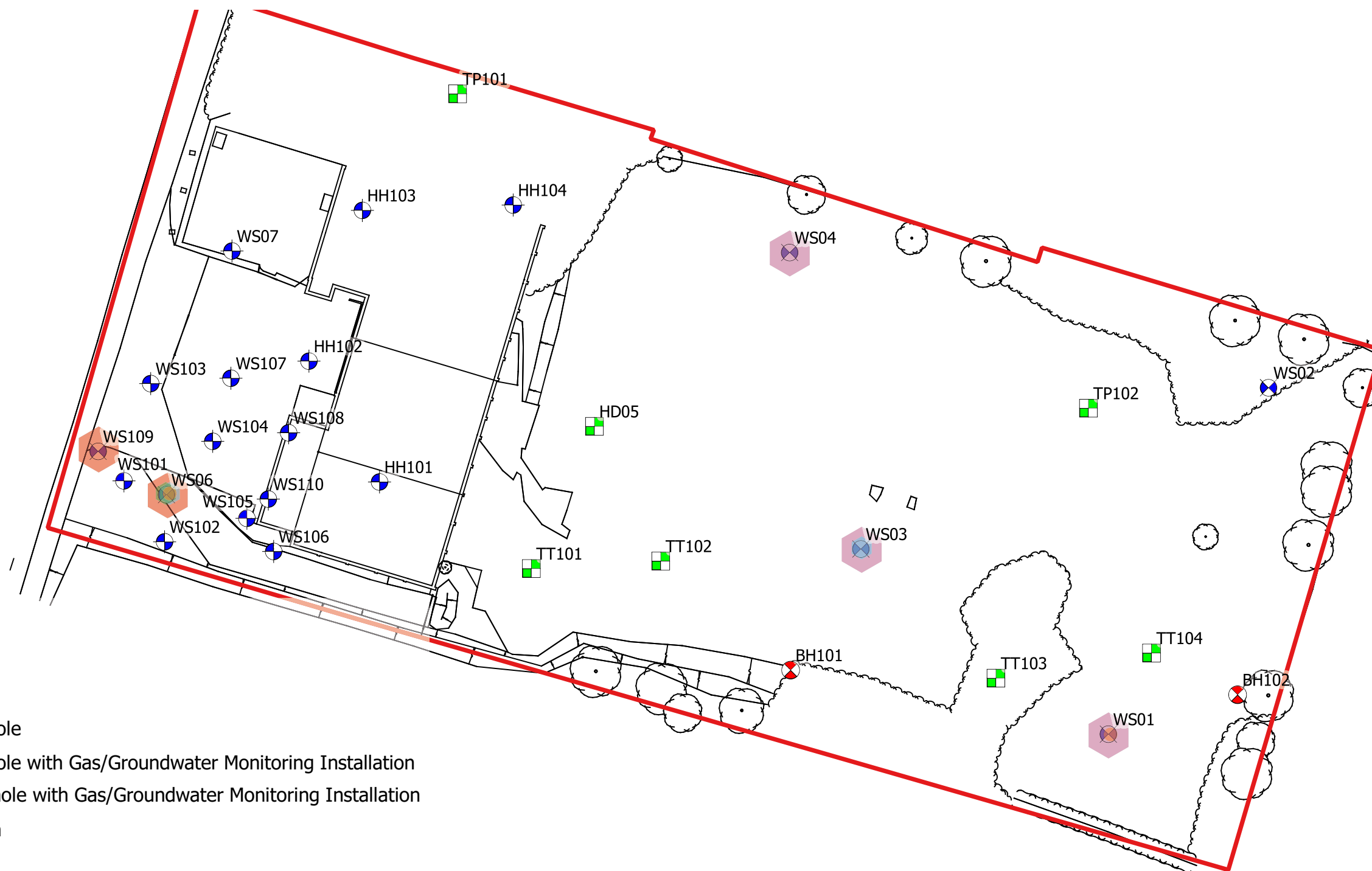
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Site Boundary

Exploratory Holes

Trial Pit

Window Sample Borehole

Window Sample Borehole with Gas/Groundwater Monitoring Installation

Cable Percussive Borehole with Gas/Groundwater Monitoring Installation

Groundwater Contamination

Hydrocarbons

Volatile Organic Compounds

Benzo(a)pyrene

Iron

Nickel



NOTES:

Chemical results compared against EQS/
UK DWS values

CLIENT:

Partner Construction Ltd &
Waterloo Housing Group Ltd

PROJECT:

Crease Drove, Crowland

TITLE:

General Groundwater Contaminant Exceedances

PROJECT No:

P8723

DATE:

07/2019

DESIGN/DRAWN:

CM

DRAWING NUMBER:

06

ISSUE:

FINAL

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N

Site Boundary

Approximate Extent of Contamination

Service Hatches

NOTES:

Remedial extent based on recorded contamination in soils.

CLIENT:	Partner Construction Ltd & Waterloo Housing Group Ltd
PROJECT:	Crease Drove, Crowland
TITLE:	Illustrative Remediation Plan

PROJECT No:	P8723	DATE:	07/2019	DESIGN/DRAWN:	CM
DRAWING NUMBER:	07	ISSUE:	FINAL REV A		
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GRM
Development Solutions
civil - structural

GRM Development Solutions Ltd

Tel: 01283 551 249
mail@grm-uk.com www.grm-uk.com



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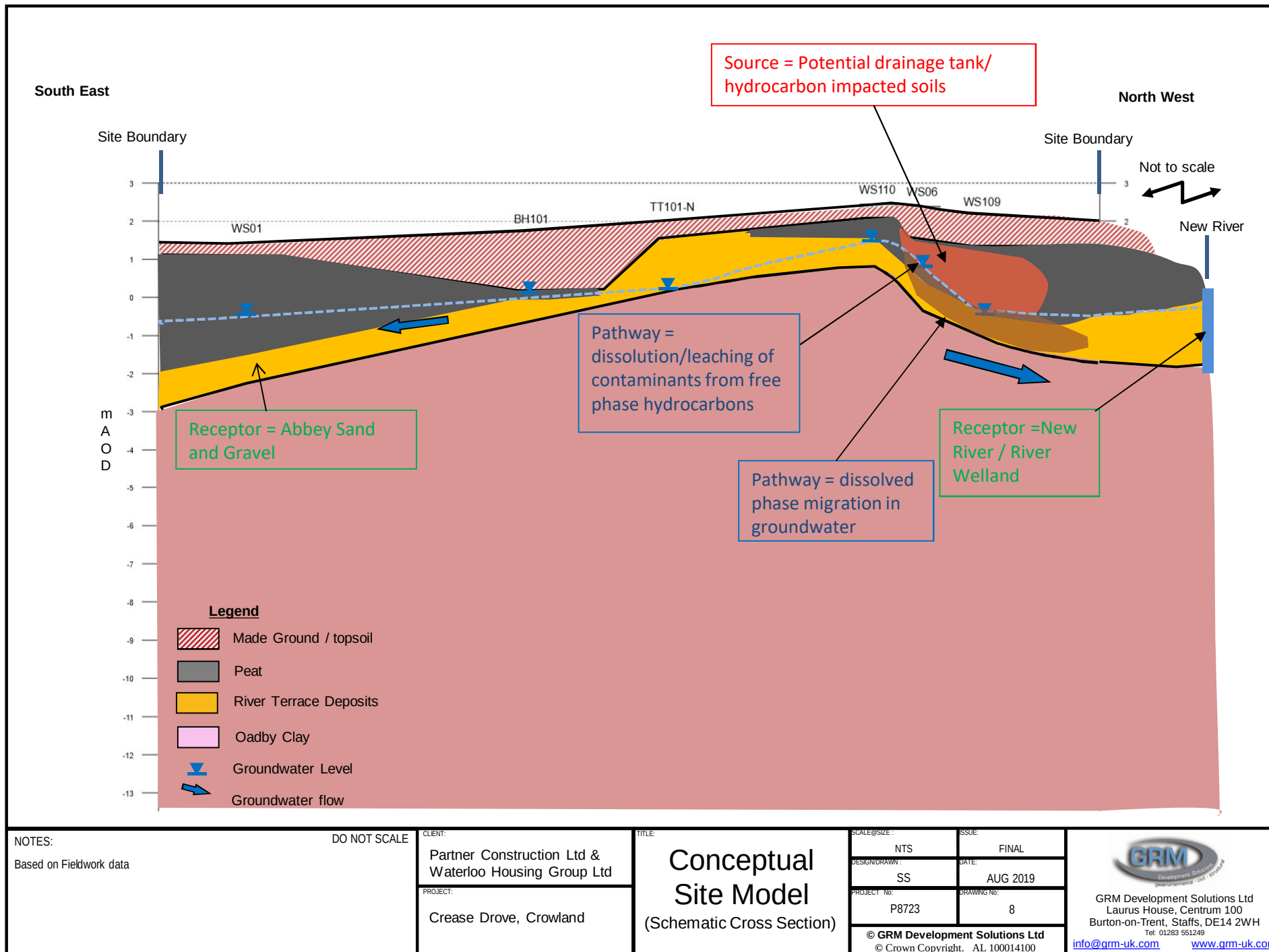
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Tel: 01283 551249

info@grm-uk.com

Fax: 01283 211968

www.grm-uk.com





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Fax: 01283 211968

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Appendix O: Input parameters

The parameter values required for the RTM model can be divided into two types, contaminant specific and non-contaminant specific. The modelled values for these parameter types are presented in Tables 1 and 2, respectively, together with a justification for choice of these values. Where possible, site specific values have been chosen.

Based on the available groundwater monitoring and analytical data the hydrocarbon source is assumed to be largely within the Peat material above the Abbey Sand and Gravel in the south western area of the site.

Table 1: Model Input Parameters

Parameter	Units	Value	Justification
Level 1			
Water filled soil porosity	-	0.226	From porosity calculator in RTM model based on average site specific moisture content of 23% for clayey peat from GRM, 2018 and 2019.
Air filled soil porosity	-	0.421	
Bulk density of soil	g.cm ⁻³	0.98	Midpoint of range given for peat in ConSim (Golder Associates, 2003). Range is from 0.91 to 1.05.
Fraction of organic carbon (in soil)	Fraction	0.0205	Average of measured values from uncontaminated soil samples above water table (i.e. <1.0 mbgl)
Level 2			
Infiltration	m.d ⁻¹	0.000255	Based on Met Office data for effective rainfall, see Table 3.
Length of contaminant source in direction of groundwater flow	m	16	Conservative assumption based on site data.
Saturated aquifer thickness	m	1.8	The aquifer thickness has been assumed from on-site and nearby BGS logs.
Hydraulic conductivity of aquifer	m.d ⁻¹	0.22	Highest value estimated from on-site falling and rising head tests data.
Hydraulic gradient	Fraction	0.0365	Based on the difference between groundwater elevation in BH105 (2.79mAOD) and WS104 (2.44 mAOD) divided by distance between locations of 75 m. Largest hydraulic gradient present on site in the direction towards the most sensitive receptor (north west), River Welland.
Width of contaminant source perpendicular to groundwater flow	m	11.5	Conservatively assumed width of the contamination plume present within the soils, perpendicular to groundwater flow.
Level 3			
Plume thickness at source	-	1.8	Assumed equal to saturated aquifer thickness.

Parameter	Units	Value	Justification
Bulk density of aquifer materials	g.cm ⁻³	1.6	Midpoint of range given for gravely sand in ConSim (Golder Associates, 2003). Range is from 1.37 to 1.81.
Effective porosity of aquifer	Fraction	0.3	Midpoint of range for total porosity for fine sand to coarse gravel in ConSim is 0.385 (Golder Associates, 2003) where the range is from 0.24 to 0.53. A value of 0.3 is considered reasonable.
Distance to compliance point	m	50	50m compliance point based on distance to the site boundary down-gradient to the contamination plume.
Fraction of organic carbon in aquifer	Fraction	0.0098	Average of measured values from samples of Abbey Sand and Gravel with no visual/olfactory evidence of contamination
Dispersivity - Longitudinal - Transverse - Vertical	m	2.98 0.298 1E-99	Calculated using Xu & Eckstein Calculated using Xu & Eckstein Vertical dispersivity assumed negligible as plume thickness assumed equal to saturated aquifer thickness.
Degradation option	-	Single Phase	The single phase option has been adopted to be conservative. The dual phase option is assessed in the sensitivity analysis.

The contaminant specific parameters required for the assessment are Henry's Law constant, biodegradation half-life, organic carbon partition coefficient (Koc) and the EAL (target concentration). These are presented in Table 2 below.

Literature values of biodegradation half-lives have been reviewed and conservative upper end estimates for anaerobic biodegradation selected. Note that there are two options for modelling biodegradation in the RTM model: single phase and dual phase. Single phase degradation makes the highly conservative assumption that biodegradation only occurs in the dissolved phase, whereas dual phase degradation makes the more realistic assumption that biodegradation occurs to both sorbed and dissolved phase contamination. For the purposes of this assessment, the highly conservative assumption of single phase degradation has been adopted. The use of the dual phase degradation option has been tested in the sensitivity analysis.

Table 2: Contaminant specific parameter values

Contaminant	Target Conc. ¹	Henry's law constant ²	Organic Carbon partition coeff (Koc) ²	Half-life for degradation of contaminant in groundwater
	ug.L ⁻¹	-	L.kg ⁻¹	Days
TPH Aromatic C12-16	90	1.26E-02	5.01E+03	408 ³
TPH Aromatic C16-21	90	6.95E-04	1.41E+04	1840 ⁴

1. Unless stated otherwise target concentration based on WHO, 2008. Petroleum products in drinking-water. Background document for development of WHO guidelines for drinking water quality as reported in CL:AIRE, 2017.
2. LQM/CIEH for S4ULs Nathanail *et al*, 2015
3. Upper limit of estimated half life for anaerobic degradation in groundwater of acenaphthene (equivalent carbon chain length of 15.5) given in Howard (1991)
4. Upper limit of estimated half life for anaerobic degradation in groundwater of anthracene (equivalent carbon chain length of 19.4) given in Howard (1991).

Table 3 - Long Term Monthly Average Rainfall, MORECS Sq. 117

MONTH	MORECS SQ.	Crop	SoilType	AvgOfEP
1	117	GRS	M	28.6
2	117	GRS	M	18.5
3	117	GRS	M	11.2
4	117	GRS	M	8.8
5	117	GRS	M	1.4
6	117	GRS	M	0.7
7	117	GRS	M	1.5
8	117	GRS	M	0.0
9	117	GRS	M	0.0
10	117	GRS	M	0.2
11	117	GRS	M	7.8
12	117	GRS	M	14.1

GRS = Grass, M = medium available water content, AvgOfEp = Effective Precipitation (mm)

Table 4: Sensitivity analysis for groundwater Remedial Target Values (RTV) for Aromatic C16-C21

Parameter	Base case	Min value	Max value	Justification
Water filled soil porosity	0.421	0.113	0.647	From porosity calculator in RTM model min based half best case moisture content for clayey peat (i.e. 11.5%). Max value is 100% water filled porosity.
Air filled soil porosity	0.226	0	0.535	
Bulk density of soil (g.cm ⁻³)	0.98	0.91	1.05	Min and max taken from range for peat in ConSim (Golder Associates, 2003)
Fraction of organic carbon (in soil)	0.0205	0.0104	0.0435	Min and Max based on range of site values
Infiltration (m.d ⁻¹)	2.55E-4	1.275E-4	5.1E-4	Min and max based 0.5x and 2x base case value
Length of contaminant source in direction of groundwater flow (m)	16	8	32	Min and max based 0.5x and 2x base case value
Saturated thickness of aquifer (m)	1.8	0.9	3.6	Min and max based 0.5x and 2x base case value
Hydraulic conductivity of aquifer (m.d ⁻¹)	0.22	0.20	0.22	Base case is max value. Lowest base on lowest value from site data.
Hydraulic gradient	0.0365	0.0182	0.0730	Min and max based 0.5x and 2x base case value
Width of contaminant source perpendicular to groundwater flow (m)	11.5	5.75	23	Min and max based 0.5x and 2x base case value
Plume thickness at source (m)	1.8	0.9	3.6	Given site observation, observations of hydrocarbon contamination across the full thickness of the Abbey Sand and Gravel. Therefore, max and min values are the same as saturated aquifer thickness.
Bulk density of aquifer (g.cm ⁻³)	1.6	1.37	1.81	Min and max taken from range for gravelly sand in ConSim (Golder Associates, 2003)
Effective porosity of aquifer	0.3	0.2	0.4	Min and max based on reasonable range for fine sand to coarse gravel
Distance to compliance point (m)	50	25	100	Min and max based on 0.5x and 2x value used
Biodegradation half-life (d)	1840	920	3680	Min and max based on 0.5x and 2x value used
Fraction of organic carbon	0.00986	0.00493	0.0197	Limited site data therefore, min and max based on 0.5x and 2x value used
Degradation Option	Single	Dual		Base case uses conservative single phase.

Blue colour: parameters affecting both soils and groundwater RTVs.



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Tel: 01283 551249

info@grm-uk.com

Fax: 01283 211968

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Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

© Environment Agency, 2006. (Produced by the Environment Agency's Science Group)

The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.
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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	Crease drove, Crowland		
Site Address:	Crease drove, Crowland		
Completed by:	SS		
Date:	01-Sep-19	Version:	v3.2
Contaminant	Aromatic C12-16		
Target Concentration (C _T)	9.00E-02	mg/l	Origin of C _T : WHO CL:AIRE 2017

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water
Partition Co-efficient by using the pull down menu
below

Calculate for non-polar organic chemicals

Contaminant
Target concentration
 C_T

Aromatic C12-16
0.09 mg/l

Input Parameters

Standard entry

Variable	Value	Unit
Water filled soil porosity θ_w	2.26E-01	fraction
Air filled soil porosity θ_a	4.21E-01	fraction
Bulk density of soil zone material ρ	9.80E-01	g/cm ³
Henry's Law constant H	1.26E-02	dimensionless

Source of parameter value

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient. The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Entry if specify partition coefficient (option)

Soil water partition coefficient K_d

l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil) f_{oc}

2.05E-02 fraction

Organic carbon partition coefficient K_{oc}

5.01E+03 l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species $K_{oc,n}$

l/kg

Sorption coefficient for ionised species $K_{oc,i}$

l/kg

pH value pH

pH units

Acid dissociation constant pK_a

Fraction of organic carbon (in soil) f_{oc}

fraction

Soil water partition coefficient used in Level Assessment K_d 1.03E+02 l/kg Calculated value

Level 1 Remedial Target

Level 1 Remedial Target	9.26E+00	mg/kg	(for comparison with soil analyses)
	or		
	0.09	mg/l	(for comparison with leachate test results)

Site being assessed: Crease drove, Crowland
Completed by: SS
Date: 01-Sep-19
Version: v3.2

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Aromatic C12-16
0.09

mg/l
from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

2.55E-04
m²

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

1.60E+01
1.80E+00
2.20E-01
3.65E-02
1.15E+01
0.00E+00

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
1.80E+00

m
m

Calculated Parameters

Dilution Factor

DF

4.54E+00

Level 2 Remedial Target

4.09E-01

mg/l

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

or

4.21E+01

mg/kg

For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)

C_c

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Crease drove, Crowland
Completed by: SS
Date: 01-Sep-19
Version: v3.2

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Aromatic C12-16		from Level 1
Target Concentration	C _T	0.09	mg/l	from Level 1
Dilution Factor	DF	4.54E+00		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks

Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration			
Enter soil concentration	470	mg/kg	
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only

Parameters values determined from options

Partition coefficient	Kd	4.91E+01	l/kg	see options
Longitudinal dispersivity	ax	2.980	m	see options
Transverse dispersivity	az	0.298	m	see options
Vertical dispersivity	ay	0.000	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Groundwater flow velocity	v	3.43E-02	m/d
Retardation factor	Rf	2.63E+02	fraction
Decay rate used	λ	6.48E-06	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	4.68E-02	fraction
Rate of contaminant flow due to retardation	u	1.31E-04	m/d
Ratio of Compliance Point to Source Concentration	C _{CP} /C ₀	7.93E-02	fraction
Attenuation factor (C _{CP} /C _{BP})	AF	1.26E+01	fraction
Calculated soil leachate concentration	Co	4.57E+00	mg/l

Remedial Targets

Level 3 Remedial Target	5.16E+00	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	5.31E+02	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	50	m	assumes Level 1 Remedial Target calculated from soil-water
Ratio of Compliance Point to Source Concentration	C _{CP} /C ₀	7.93E-02	fraction

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer foc fraction

Organic carbon partition coefficient Koc l/kg

Sorption coefficient for related species K_{oc,1} l/kgSorption coefficient for ionised species K_{oc,i} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer foc fraction

Soil water partition coefficient Kd 4.91E+01 l/kg

Define dispersivity (click brown cell and use pull down list)

User defined values for dispersivity

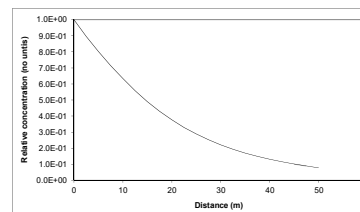
Longitudinal dispersivity	ax	2.98E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	az	2.98E-01	5.00E-01	2.98E-01	m
Vertical dispersivity	ay	1.00E-99	5.00E-99	2.98E-99	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}; az = ax/10, ay = ax/100 are assumed

Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	1.01E+00
2.5	8.96E-01	9.01E-01
5.0	8.03E-01	8.07E-01
7.5	7.15E-01	7.19E-01
10.0	6.33E-01	6.37E-01
12.5	5.58E-01	5.61E-01
15.0	4.90E-01	4.93E-01
17.5	4.30E-01	4.32E-01
20.0	3.77E-01	3.79E-01
22.5	3.30E-01	3.32E-01
25.0	2.89E-01	2.91E-01
27.5	2.53E-01	2.55E-01
30.0	2.22E-01	2.23E-01
32.5	1.95E-01	1.96E-01
35.0	1.71E-01	1.72E-01
37.5	1.50E-01	1.51E-01
40.0	1.32E-01	1.33E-01
42.5	1.16E-01	1.17E-01
45.0	1.02E-01	1.03E-01
47.5	9.00E-02	9.04E-02
50.0	7.93E-02	7.97E-02

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source. Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Crease drove, Crowland

Completed by: SS

Date: #####

Version: v3.2

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Aromatic C12-16	from Level 1
Target Concentration	9.00E-02	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	6.52E-01	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	4.08E+02	days	
Calculated decay rate	λ	1.70E-03	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.15E+01	m	
Plume thickness at source	Sy	1.80E+00	m	
Saturated aquifer thickness	da	1.80E+00	m	
Bulk density of aquifer materials	ρ	1.60E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	3.65E-02	fraction	
Hydraulic conductivity of aquifer	K	2.20E-01	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+99	days	time variant options only

Parameters values determined from options

Partition coefficient	Kd	4.94E+01	l/kg	see options
Longitudinal dispersivity	ax	2.98E+00	m	see options
Transverse dispersivity	az	2.98E-01	m	see options
Vertical dispersivity	ay	1.00E-99	m	see options

Calculated Parameters

Groundwater flow velocity	v	2.68E-02	m/d
Retardation factor	Rf	2.64E+02	fraction
Decay rate used	λ	6.42E-06	d ⁻¹
Rate of contaminant flow due to retardation	u	1.01E-04	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{ED}	3.01E-02	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	2.17E+01	

Select Method for deriving Partition Co-efficient (using pull down menu)

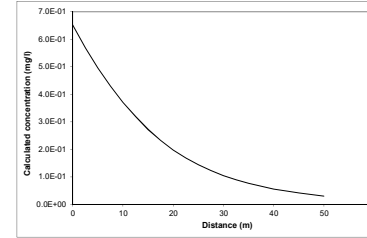
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)	Kd		l/kg
Soil water partition coefficient	K _{oc,w}		l/kg
Entry for non-polar organic chemicals (option)	foc	9.86E-03	fraction
Fraction of organic carbon in aquifer	Koc	5.01E+03	l/kg
Organic carbon partition coefficient	K _{oc,n}		l/kg
Sorption coefficient for related species	K _{oc,r}		l/kg
Sorption coefficient for ionised species	pH		
pH value	pKa		
acid dissociation constant	foc		fraction
Fraction of organic carbon in aquifer	Kd	4.94E+01	l/kg
Soil water partition coefficient			

Define dispersivity (click brown cell and use pull down list)

User defined values for dispersivity

Longitudinal dispersivity	ax	2.98E+00	2.98E+00	2.98E+00	m
Transverse dispersivity	az	2.98E-01	2.98E-01	2.98E-01	m
Vertical dispersivity	ay	1.00E-99	1.00E-99	1.00E-99	m
Note values of dispersivity must be > 0					
For calculated value, assumes ax = 0.1 * x, az = 0.01 * x, ay = 0.001 * x					
Xu & Eckstein (1995) report ax = 0.83(log ₁₀ x) ^{-0.14} ; az = ax/10, ay = ax/100 are assumed					



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed: Cressa drove, Crowland
Completed by: SS
Date: #####
Version: v3.2

Calculated concentrations for distance-concentration graph

Ogata Banks From calculation sheet

Distance	Concentration
	mg/l
0	6.5E-01
2.5	6.69E-01
5.0	4.96E-01
7.5	4.30E-01
10.0	3.71E-01
12.5	3.18E-01
15.0	2.72E-01
17.5	2.32E-01
20.0	1.98E-01
22.5	1.69E-01
25.0	1.44E-01
27.5	1.23E-01
30.0	1.05E-01
32.5	8.94E-02
35.0	7.64E-02
37.5	6.53E-02
40.0	5.59E-02
42.5	4.78E-02
45.0	4.10E-02
47.5	3.51E-02
50.0	3.01E-02

Remedial Targets

Remedial Target	1.95E+00	mg/l	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	50	m	
Concentration of contaminant at compliance point after	C _{ED} /C ₀	3.01E-02	mg/l
		1.0E+99	days

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99.



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.
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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment			
Site Name:	Crease Drove		
Site Address:	Crease Drove		
Completed by:	SS		
Date:	01-Sep-19	Version:	x.xx
Contaminant	Aromatic C16-21		
Target Concentration (C_T)	9.00E-02	mg/l	Origin of C_T: WHO CL:AIRE 2017

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil



Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant
Target concentration
 C_T

Aromatic C16-21
0.09 mg/l

Input Parameters

Standard entry

Variable	Value	Unit
Water filled soil porosity θ_w	2.26E-01	fraction
Air filled soil porosity θ_a	4.21E-01	fraction
Bulk density of soil zone material ρ	9.80E-01	g/cm ³
Henry's Law constant H	6.95E-04	dimensionless

Source of parameter value

From the porosity calculator using site data	This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient. The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.
From the porosity calculator using site data	
Midpoint for peat (Consim, 2005)	

Entry if specify partition coefficient (option)

Soil water partition coefficient K_d

l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil) f_{oc}

2.05E-02 fraction

Organic carbon partition coefficient K_{oc}

1.41E+04 l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species $K_{oc,n}$

l/kg

Sorption coefficient for ionised species $K_{oc,i}$

l/kg

pH value pH

pH units

Acid dissociation constant pK_a

Fraction of organic carbon (in soil) f_{oc}

fraction

Soil water partition coefficient used in Level Assessment K_d

2.89E+02 l/kg

Calculated value

Level 1 Remedial Target

Level 1 Remedial Target	2.60E+01	mg/kg	(for comparison with soil analyses)
	or		
	0.09	mg/l	(for comparison with leachate test results)

Site being assessed: Crease Drove
Completed by: SS
Date: 01-Sep-19
Version: x.xx

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Aromatic C16-21
0.09

from Level 1
from Level 1
mg/l

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

2.55E-04
m²

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

1.60E+01
1.80E+00
2.20E-01
3.65E-02
1.15E+01
0.00E+00

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
1.80E+00

m
m

Calculated Parameters

Dilution Factor

DF

4.54E+00

Level 2 Remedial Target

4.09E-01
or
1.18E+02

mg/l
mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)

C_c

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Crease Drove
Completed by: SS
Date: 01-Sep-19
Version: x.xx

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Aromatic C16-21		from Level 1
Target Concentration	C _T	0.09	mg/l	from Level 1
Dilution Factor	DF	4.54E+00		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration			
Enter soil concentration	490	mg/kg	
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	az	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	3.43E-02 m/d
Retardation factor	Rf	7.42E+02 fraction
Decay rate used	λ	5.07E-07 d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	4.68E-02 fraction
Rate of contaminant flow due to retardation	u	4.62E-05 m/d
Ratio of Compliance Point to Source Concentration	C _{CP} /C ₀	4.16E-01 fraction
Attenuation factor (C _{CP} /C ₀)	AF	2.40E+00 fraction
Calculated soil leachate concentration	Co	1.69E+00 mg/l

Remedial Targets

Level 3 Remedial Target	9.83E-01	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	2.84E+02	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	50	m	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C _{CP} /C ₀	4.16E-01	fraction

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer foc fraction

Organic carbon partition coefficient Koc 1.41E+04 l/kg

Sorption coefficient for related species K_{oc,1} l/kgSorption coefficient for ionised species K_{oc,i} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer foc fraction

Soil water partition coefficient Kd 1.39E+02 l/kg

Define dispersivity (click brown cell and use pull down list)

User defined values for dispersivity

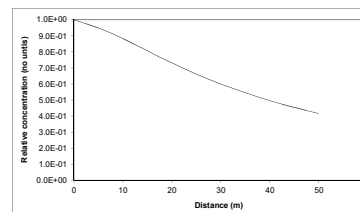
	Enter value	Calc value	Xu & Eckstein
Longitudinal dispersivity	ax	2.98E+00	5.00E+00 2.88E+00 m
Transverse dispersivity	az	2.98E-01	5.00E-01 2.88E-01 m
Vertical dispersivity	ay	1.00E-99	5.00E-99 2.88E-99 m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.414}; az = ax/10, ay = ax/100 are assumed

Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	3.73E-01
2.5	9.74E-01	3.63E-01
5.0	9.47E-01	3.53E-01
7.5	9.17E-01	3.42E-01
10.0	8.82E-01	3.29E-01
12.5	8.45E-01	3.15E-01
15.0	8.06E-01	3.01E-01
17.5	7.68E-01	2.86E-01
20.0	7.31E-01	2.73E-01
22.5	6.96E-01	2.59E-01
25.0	6.62E-01	2.47E-01
27.5	6.30E-01	2.35E-01
30.0	6.00E-01	2.24E-01
32.5	5.72E-01	2.13E-01
35.0	5.46E-01	2.03E-01
37.5	5.21E-01	1.94E-01
40.0	4.97E-01	1.85E-01
42.5	4.75E-01	1.77E-01
45.0	4.54E-01	1.69E-01
47.5	4.34E-01	1.62E-01
50.0	4.16E-01	1.55E-01

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source. Three solution methods are included, the preferred option is Ogata Banks. By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed: Crease Drove

Completed by: SS

Date: #####

Version: x.xx

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Aromatic C16-21	from Level 1
Target Concentration	9.00E-02	mg/l from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	1.74E+00	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	1.84E+03	days	
Calculated decay rate	λ	3.77E-04	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.15E+01	m	
Plume thickness at source	Sy	1.80E+00	m	
Saturated aquifer thickness	da	1.80E+00	m	
Bulk density of aquifer materials	ρ	1.60E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	3.65E-02	fraction	
Hydraulic conductivity of aquifer	K	2.20E-01	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+99	days	

Parameters values determined from options

Partition coefficient	Kd	1.39E+02	l/kg	see options
Longitudinal dispersivity	ax	2.98E+00	m	see options
Transverse dispersivity	az	2.98E-01	m	see options
Vertical dispersivity	ay	1.00E-99	m	see options

Calculated Parameters

Groundwater flow velocity	v	2.68E-02	m/d
Retardation factor	Rf	7.42E+02	fraction
Decay rate used	λ	5.07E-07	d ⁻¹
Rate of contaminant flow due to retardation	u	3.61E-05	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{ED}	6.26E-01	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	2.78E+00	

Select Method for deriving Partition Co-efficient (using pull down menu)

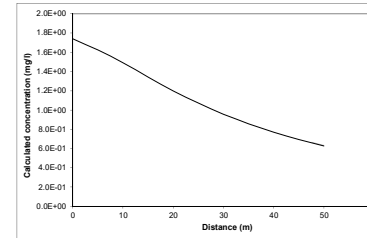
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)	Kd		l/kg
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)	foc	9.86E-03	fraction
Fraction of organic carbon in aquifer	foc	9.86E-03	fraction
Organic carbon partition coefficient	Koc	1.41E+04	l/kg
Entry for ionic organic chemicals (option)	K _{oc,ion}		l/kg
Sorption coefficient for related species	K _{oc,ion}		l/kg
Sorption coefficient for ionised species	K _{oc,ion}		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.39E+02	l/kg

Define dispersivity (click brown cell and use pull down list)

User defined values for dispersivity

Longitudinal dispersivity	ax	2.98E+00	2.98E+00	2.98E+00	m
Transverse dispersivity	az	2.98E-01	2.98E-01	2.98E-01	m
Vertical dispersivity	ay	1.00E-99	1.00E-99	1.00E-99	m
Note values of dispersivity must be > 0					
For calculated value, assumes ax = 0.1 * x, az = 0.01 * x, ay = 0.001 * x					
Xu & Eckstein (1995) report ax = 0.83(log ₁₀ x) ^{-0.14} ; az = ax/10, ay = ax/100 are assumed					



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed: Cress Drove
Completed by: SS
Date: #####
Version: x.xx

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
0	1.7E+00
2.5	1.68E+00
5.0	1.62E+00
7.5	1.56E+00
10.0	1.49E+00
12.5	1.42E+00
15.0	1.34E+00
17.5	1.27E+00
20.0	1.20E+00
22.5	1.13E+00
25.0	1.07E+00
27.5	1.01E+00
30.0	9.58E-01
32.5	9.06E-01
35.0	8.58E-01
37.5	8.13E-01
40.0	7.71E-01
42.5	7.31E-01
45.0	6.94E-01
47.5	6.59E-01
50.0	6.26E-01

Remedial Targets

Remedial Target	2.50E-01	mg/l	For comparison with measured groundwater concentration.
Ogata Banks			

Distance to compliance point 50 m

Concentration of contaminant at compliance point after 6.26E-01 mg/l Ogata Banks
1.0E+99 days

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.