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CREASE DROVE, CROWLAND

REMEDIAL STRATEGY FOR PARTNER CONSTRUCTION LTD & WATERLOO HOUSING GROUP LTD

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Prepared for:

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

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1 INTRODUCTION

1.1 PREAMBLE

GRM Development Solutions Ltd (GRM) was instructed by Partner Construction Ltd and Waterloo Housing Group (Clients) to produce a Remedial Strategy for the site at Crease Drove, Crowland.

GRM standard limitations of reporting are provided in Appendix A of this report.

The Client proposes to develop the site with residential properties with associated gardens, soft landscaping, infrastructure and a balancing pond. Proposed finished floor levels have not been provided.

The following reports have been used in the preparation of this document:

- GRM Phase I Site Appraisal (Desk Study), Ref: GRM/P8723/DS.1, dated December 2018.
- GRM Gas Addendum Letter, Ref: P8723\PEL\GAL, dated March 2019.
- GRM, Phase II Site Appraisal, Ref: GRM/P8723/F.2, dated July 2019. Revision of the original Phase II report dated January 2019.
- GRM, Detailed Quantitative Risk Assessment, Ref: GRM/P8723/DQRA, dated September 2019.

A Site Location and Site Boundary Plan are included as Appendix B.

1.2 OBJECTIVES OF THIS ASSESSMENT

The principal aims of this document are as follows:

a) Assess the existing information relating to the soil and groundwater conditions within the area of the site.

b) Determine a cost and time effective remedial strategy.

c) Set out the remediation and validation processes to be followed on site to ensure the site developed does not pose a risk to human health and controlled waters.

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 SITE SETTING AND INVESTIGATION SUMMARY

2.1 SITE SETTING

The site comprises a circa 1.5Ha rectangular shaped plot which includes a warehouse and hardstanding to the west with scrub land across the central and eastern parts of the site. The surrounding area is residential to the north and east and farmland to the south and west.

Historically, the oldest maps available (1886-1887) recorded the site and the surrounding area to be farmland, which appeared to be arable in nature. The land use remained unchanged until the map of 1973-1975 which recorded the current warehouse and packing facility on-site. An additional warehouse is recorded on the map of 1995 but has since been removed; anecdotal evidence suggesting it was demolished in 2012.

The site is recorded to be underlain by Abbey Sand and Gravel and Peat deposits which in turn are underlain by the Oxford Clay Formation. The Abbey Sand and Gravel is recorded as a Secondary A Aquifer with the Peat and Oxford Clay Formation being recorded as Unproductive Aquifers.

The closest surface water features are drainage channels between parcels of land, the nearest recorded along the southern boundary. New River and River Welland are recorded 460m and 1.1km to the north west of the site respectively. It is considered that the rivers are in hydraulic continuity with the groundwater below the site encountered mostly within the Abbey Sand and Gravel which is determined to be predominantly flowing to the north west.

2.2 SUMMARY OF INTRUSIVE INVESTIGATION

GRM has undertaken two phases of ground investigation at the site in January 2019 and July 2019.

The January 2019 works comprised an initial investigation to refine the conceptual model for the site, determine potential hazards and determine cost-effective development solutions. The investigation comprised six window sample boreholes and one hand excavated trial pit and identified the following sources of contamination and ground gas:

- Made ground (potential source of ground gas).
- Peat containing organic material (source of ground gas).
- Elevated carbon dioxide (6.9%). As such, the gas regime is classified as ‘Characteristic Situation 2’ for which gas protection measures are required.
- Hydrocarbon-impacted soils identified in the south western area and dissolved phase hydrocarbon contamination within the groundwater.
- A measurable thickness of free-phase hydrocarbons were not detected within the groundwater. However, a surface sheen was present in WS06 when sampling using the low-flow pumping equipment.

The initial report identified the following:

- Localised hydrocarbon contamination within the south western area of the site at concentrations considered to pose a risk to human health and controlled waters.
- The shallow made ground in the service area (WS07) was classified as 'Hazardous' waste due to elevated pH within the soils.
- The initial site investigation was limited due to the presence of the existing warehouse in the western area. Therefore, further works were recommended beneath the building footprint to assess the underlying soils.

The second phase of investigation comprised a total of twenty-two exploratory holes (ten windowless sample boreholes, four hand-held window sample boreholes, two cable percussion boreholes, four trial trenches and two trial pits). Three groundwater monitoring wells (BH101, BH102 and WS109) were also installed to better assess the gas and groundwater regime below the site.

The further site investigation works successfully delineated the hydrocarbon-impacted materials to the south western area of the site where soils exceeded human health thresholds; however, due to the depth at which these samples were taken (WS06 at 0.9m and 1.5m begl and WS09 at 1.5m begl within the peat) they are not considered to pose a risk to end users, subject to proposed finish floor levels.

Hydrocarbon contamination was recorded within the groundwater at concentrations considered to pose a risk to controlled water receptors (underlying aquifer and nearby river) and remediation was advised. Therefore, a Detailed Quantitative Risk Assessment was recommended to derive site-specific remedial targets and to assess the risk posed to control water receptors.

Additional samples were taken of the same made ground in the service area around WS07. The samples were subject to pH analysis including a single WAC suite. The results indicated pH values were significantly lower (7.6 to 8.6) suggesting the initial pH concentration was anomalous. As such it was considered that the made ground across the area was considered suitable for disposal as non-hazardous waste.

Three holes were undertaken within the warehouse building to investigate ground conditions beneath the footprint of the building. Hydrocarbon odours were recorded below the building in HH104, although when tested, the chemical results did not record elevated hydrocarbon concentrations within these soils.

The Client also provided information that a former chemical works was located approximately 115m to the east and is currently undergoing remedial works, specifically relating to volatile organic compound (VOC) contamination in the soils.

VOCs were therefore analysed within the groundwater for baseline measurements. The results recorded on-site were found to be below the site-specific assessment criteria (SSAC) derived for the adjacent site and as such it was considered that no further work was required.

2.3 GROUND GAS AND VAPOUR ASSESSMENT

The site is not recorded in an area where radon protection measures are required.

The GRM gas addendum letter determined that carbon dioxide concentrations were found to marginally exceed 5% by volume (v/v), with no methane or gas flow recorded. As such the site was classified as 'CS2' as a conservative approach. However, the Peat strata identified underlying the site was shown to be of low organic content (<5%) and is nearly entirely submerged. It was recommended that further monitoring during the summer months when the groundwater table is most likely lower would allow a better understanding of the gas regime, which could potentially downgrade the characteristic situation to 'CS1'.

Since completing the Gas Addendum Letter, two further monitoring visits were undertaken in the summer on 18th June and 15th August 2019. Over the monitoring period locations were bailed and subsequently monitored where response zones were saturated. It should be noted that WS02 could not be found during the two additional rounds, due to overgrown vegetation in the area. The full set of results is included in Appendix C and summarised in the table below.

Well ID (No. of Readings)	Response Zone / Strata (m)	Methane (%v/v)	CO2 (%v/v)	Oxygen (%v/v)	Gas Flow (l/h)	Groundwater Level (m begl)	PID (ppm)
WS01 (8)	0.5-3.0 / Peat	0.0	0.70 – 4.60	17.50 – 20.20	0.0	0.87 – 1.10	0.0 - 0.6
WS02 (6)	0.6-1.7 / MG & PEAT	0.0	3.90 – 6.90	14.70 – 16.90	0.0	0.75 – 0.93	0.0 - 0.3
WS03 (8)	1.0-3.0 / AB	0.0	0.30 – 1.40	18.90 – 20.90	0.0	0.49 – 0.68	0.0 - 0.3
WS04 (8)	0.5-1.5 / AB	0.0	0.00 – 0.30	19.40 – 20.10	0.0	0.00 – 0.39	0.0 - 0.0
WS06 (8)	1.0-2.0 / Peat	0.0	0.00 – 0.70	19.60 – 19.80	0.0	0.75 – 1.10	0.0 - 0.3
WS109 (2)	1.3-2.5 / AB	0.0	2.20 – 4.70	6.90 – 20.20	-1.31	0.62 – 1.31	NR
BH101 (2)	4.0-15.0 / OX	0.0	0.40 – 1.80	19.70 – 20.60	0.0	0.74 – 1.27	NR
BH102 (2)	1.0-1.7 / Peat	0.0	6.30 – 30.0	6.50 – 14.10	0.0	1.12 – 1.42	NR

MG = Made Ground, AB = Abbey Sand and Gravel, OX = Oxford Clay. NR = Not recorded, Atmospheric Pressure: 1001mb to 1044mb.

2.3.1 Ground Gas

No notable difference was recorded to the groundwater level from the two additional monitoring visits across the site when compared against the previous results. Therefore it is considered that the groundwater table is relatively constant and not significantly influenced by seasonal variation.

Overall, methane was not recorded above the lower limit of detection. Carbon dioxide concentrations were found to be consistently below 5% v/v, with the exception of WS02 which recorded carbon dioxide to marginally exceed 5% v/v on three visits between 5.4% and 6.9% v/v and a maximum of 30% v/v in BH102 on a single occasion. It is considered that the elevated carbon dioxide concentrations are due to dissolved carbon dioxide concentrations present in the groundwater and are not representative of the gas regime beneath the site. Depleted oxygen concentrations were recorded broadly corresponding with the peak in carbon dioxide concentrations. No positive gas flow was recorded throughout the whole monitoring period.

Taking into account that a significant source of ground gas has not been identified, given the Peat strata has a low (<5%) organic content, ground gas concentrations are typically recorded below 5% v/v for carbon dioxide and 1% v/v for methane and no positive gas flow recorded. It is considered that the site could be characterised as 'CS1' for which no gas protection measures are required.

2.3.2 Vapours

Hydrocarbon contamination has been recorded within the natural soils which is also posing a risk to groundwater with the presence of dissolved concentrations. Therefore a potential risk via the vapour intrusion pathway has been considered. As such, all the monitoring wells were tested for the presence of volatile organic compounds (VOC) throughout the monitoring period. Very low levels of VOCs were recorded (0.0 to 0.6ppm). Furthermore, the results of the laboratory analysis of soil and water samples from WS06 recorded shorter (<C10) aliphatic and aromatic carbon bands to be below the limit of detection. Therefore, it was considered that VOC vapour protection is not required.

2.4 DETAILED QUANTITATIVE RISK ASSESSMENT (DQRA)

As discussed within the GRM Phase II report dissolved hydrocarbon contamination was considered to pose a risk to controlled waters. The DQRA identified two TPH aromatic fractions C12-C16 and C16-C21 as contaminants of concern to impact upon controlled waters. Therefore, the DQRA derived the Level 3 Remedial Target Values (RTVs) using the Environment Agency RTM model, presented in the table below;

Contaminant of Potential Concern	Soil Remedial Target Concentration (mg/kg)
TPH Aromatic >C12-C16	531
TPH Aromatic >C16-C21	284

The derived RTVs are site-specific remedial targets to be used as part of the Remedial Strategy and determine the risks posed to controlled waters receptors.

The existing results were compared against the RTVs and the concentrations of hydrocarbons in WS06 and WS109 fail the RTV for the hydrocarbon bands C16-C21 and as such remedial work was recommended.

3 REMEDIATION STRATEGY

3.1 HUMAN HEALTH

Soils with elevated hydrocarbon concentrations were recorded in WS06 and WS09 at depths from 0.9m begl. Due to the depth recorded, this is not considered to be a risk to end users unless levels onsite are reduced. Currently site levels are not planned to be reduced and this is unlikely to change due to the low lying nature of the site and surrounding area.

The existing topsoil across the eastern third of the site (WS01 to WS03) has been determined to be chemically suitable for reuse on-site and can be used as a topsoil in the growth medium within private gardens and soft landscaping. If there is insufficient topsoil to complete the proposed development, then some will need to be imported (see Section 5.2).

3.2 ASBESTOS

Asbestos was not detected in any of the soil samples screened. However, suspected asbestos containing materials are understood to be present in the warehouse located onsite. Therefore a pre-demolition asbestos survey is required followed by controlled removal by a suitably qualified contractor.

3.3 GROUNDWATER

3.3.1 Hydrocarbon Contaminated Soils

The DQRA identified that TPH soil concentrations at two locations (WS109 and WS06) pose a risk to controlled waters and are considered to be a continuing source for dissolved phase hydrocarbon contamination. As such the soils require remediation. At this stage, it is estimated that 310m^3 of contaminated soils would need to be remediated based upon the average the thickness of contaminated peat across the remedial extent as shown on the Remediation Plan (Appendix D).

The hydrocarbon-impacted materials require excavation and removal centred on WS06 and WS109 to the full depth of the impacted materials (potentially up to 2.6m begl). A watching brief of the excavation works will be required by a suitably trained engineer/geologist to segregate the grossly impacted materials for removal. Any remaining soils (i.e. non-impacted made ground) can be retained on-site for future use.

Validation of the excavation sides and base would be required to confirm the contaminated materials have been removed and will need to be compared against the soil RTV. Upon confirming the excavation is clean, the excavation can be backfilled with imported chemically and geotechnically suitable materials.

It is considered that the groundwater ingress is likely to be encountered between 1.5m and 2.6m begl and may be encountered as fast ingress during the remedial works. Therefore, consideration needs to be given to full dewatering systems (i.e. well pointing) to control ingress and allow the full depth of the contamination to be excavated.

The contaminated water associated with the excavation works will need to be disposed of off-site. Alternatively, given the anticipated water ingress, the impacted water can be treated on-site (i.e. oil/water separator) before discharge into surface water. A discharge consent will be required prior to treatment and discharge of the hydrocarbon-impacted water.

3.3.2 Dissolved Phase Hydrocarbon Contamination

Based upon the DQRA, it is considered that removal of the source of contamination will be sufficient to mitigate the risk posed to controlled waters as identified in the DQRA.

3.4 DRAINAGE TANK(S) AND PIPEWORK REMOVAL

Although there is no direct link between the hydrocarbon-impacted soil and the below ground drainage/waste tank(s), it is likely that the tanks and any associated pipes will be removed to allow the proposed development of the site. Any associated grossly contaminated materials would also require removal and validation. The impacted arisings can be remediated following one of the options above. A watching brief is required during the removal of any drainage tanks and pipes near and within the remediation area illustrated in Appendix D as part of the validation process (detailed in Section 5.1).

3.5 UNEXPECTED CONTAMINATION

Should any material suspected of being significantly contaminated be encountered during the redevelopment of the site, GRM shall be contacted to undertake additional investigation, if necessary. The local Environmental Health Officer will be contacted and informed of any additional remedial work required.

4 DISPOSAL AND CLASSIFICATION

As stated in the Phase II Site Appraisal report dated July 2019, it is considered that the natural strata impacted with hydrocarbons (WS06 at 0.9m and WS109 at 1.5) will be classed as 'Hazardous' waste.

Shallow made ground in one location from the service yard (WS07 at 0.3m begl) was also classified as 'Hazardous' in the Waste Classification Report due to elevated pH (12.2). However further testing of samples from the same made ground including a indicated pH values of between 7.8 and 8.6, suggesting the elevated pH is likely to be an anomaly. Therefore, the made ground across the site is considered suitable for disposal as 'Non-Hazardous' waste.

The unaffected natural strata underlying the site is likely to be classified as Inert for disposal purposes, however, further testing will be required to confirm this.

Early consultation with the relevant landfill sites over their particular acceptance criteria may produce cost savings. Reference should be made to the relevant notes in Appendix A (x).

Care should be taken to keep clean natural arisings separate from the made ground and free from construction materials, as natural soils mixed with made ground and construction materials may attract additional disposal costs.

Asbestos containing materials are known to be present within the existing buildings. A specialist asbestos disposal contractor should be employed and should ensure that all asbestos containing materials are suitably disposed of to a licenced facility. However, no visible asbestos containing materials (ACMs) has been detected within the existing soils.

It should be noted, following demolition of the existing buildings should ACMs be detected beneath current floors slabs or as the result of the demolition works the soils will be classified as Hazardous Waste. Visible ACMs should be removed, employing appropriate health and safety protocols and where possible should be undertaken prior to disposal.

It is recommended that any materials to be exported are stockpiled and tested to confirm disposal rates, as this may be more cost effective than using the results contained within this report.

5 POST REMEDIATION VALIDATION

Post remediation validation of both the contamination removal and placement of a growth medium will be required. It is the Client's responsibility to give GRM 10 workings days' notice in order to carry out site validation visits. Although every effort will be made to attend site when given less than 10 working days' notice, failure to do so may result in an inability to attend until a later date.

5.1 HYDROCARBON-IMPACTED MATERIALS (CONTROLLED WATERS)

Once the initial excavations are complete samples will be taken from the base and sides of the resultant void at a rate of one sample per 5m. Samples will be analysed for TPHCWG (contaminants of concern) and compared against the soil RTVs.

Contaminant of Potential Concern	Soil Remedial Target Concentration (mg/kg)
TPH Aromatic >C12-C16	531
TPH Aromatic >C16-C21	284

If the validation samples meet the remedial targets, then the excavation can be backfilled with chemically and geotechnically suitable materials. If a sample fails the targets, the excavation will require extension and re-validating.

A watching brief is required during the remediation works to provide a photographic record illustrating the removal of drainage tanks and contaminated soils will be taken and presented as part of the validation report.

5.2 VALIDATION OF IMPORTED MATERIALS

It is considered likely that a growth medium (topsoil and subsoil material) will require importing for use in gardens and soft landscaping, due to insufficient quantities of the existing chemically suitable topsoil.

For imported soils, it is advised that an existing test certificate from the proposed source is forwarded to GRM, if available, to ensure that the soils are suitable for use prior to import. The test certificate should be for the same suite of contaminants as the validation testing suite and compared against the GRM residential with plant uptake threshold values as presented in Appendix E.

Depending upon the proposed finished levels, then sufficient material should be removed to accommodate the thickness of growth medium.

The NHBC recommends chemical testing of imported topsoil and subsoil at a frequency of 1 in 4 plots for a development with >40 plots and a minimum of 3 tests per source (origin) and soil type. Based upon the origin of the soils for the growth medium, the following chemical validation regime will be followed;

Source	Imported Material Type	Chemical Validation Rate	Chemical Validation Suite		
			General Screening Suite	TPHCWG	Asbestos
Imported Greenfield [a]	Topsoil or Subsoil	1 per 250m^3	ü	û	û
Site-won		1 per 50m^3	ü	ü	ü
Imported Generated		1 per 50m^3	ü	ü	ü

[a] A site's greenfield status for imported topsoil may require agreement from the Local Authority prior to use.

One sample of both topsoil and subsoil will be taken in each soft landscaping area, assuming that the source of soils remains unchanged.

The validation chemical analysis results should be assessed against the relevant GRM residential with plant uptake threshold values (Appendix E). Any material that fails the respective threshold value will need to be exported from site.

A Materials Management Plan may be required for the import and redistribution of soils at the site.

Details of the validation testing of the soils material used in the growth medium will be required by the local Environmental Health Officer.

5.3 REPORTING

A Remediation Validation Completion Report will be required by the Local Authority to confirm that the remedial strategy has been implemented appropriately, including;

Soil Remediation

- Photographic record confirming removal of hydrocarbon contaminated soils and drainage tanks and associated pipework.
- Chemical validation of the sides and base of the resultant void.
- Confirmation that the residual soils meet targets (RTVs) set out in DQRA.
- Copies of waste transfer or consignment notes (if required).

Growth medium

- Confirmation of soil sources for imported materials to be used in growth medium (if additional quantities are required).
- Confirmation of the suitability of imported topsoil and sub-soil, if required, for use on-site including chemical analysis results / test certificates for growth medium.

APPENDIX A

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

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

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.

iii 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.

APPENDIX B

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

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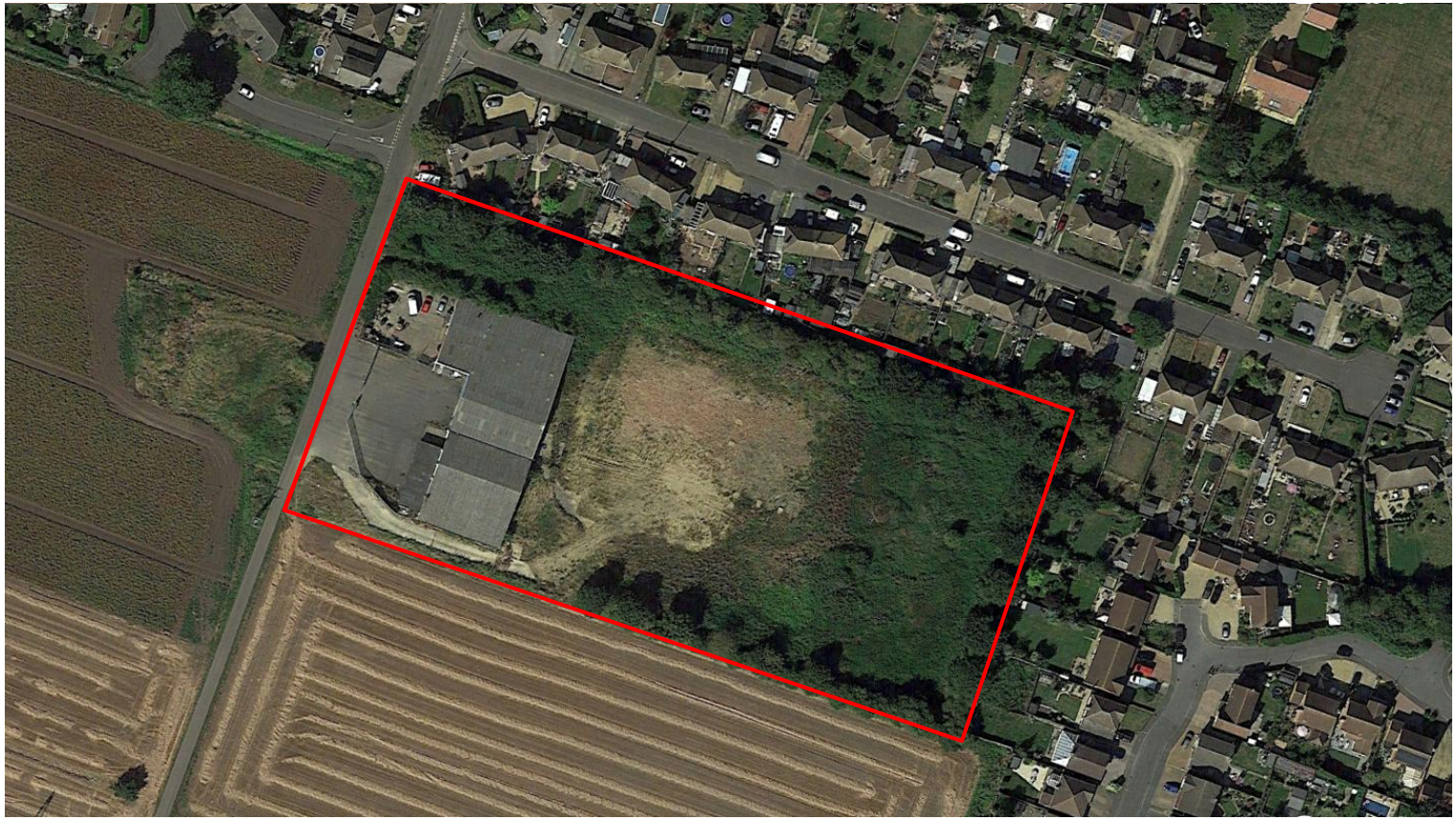

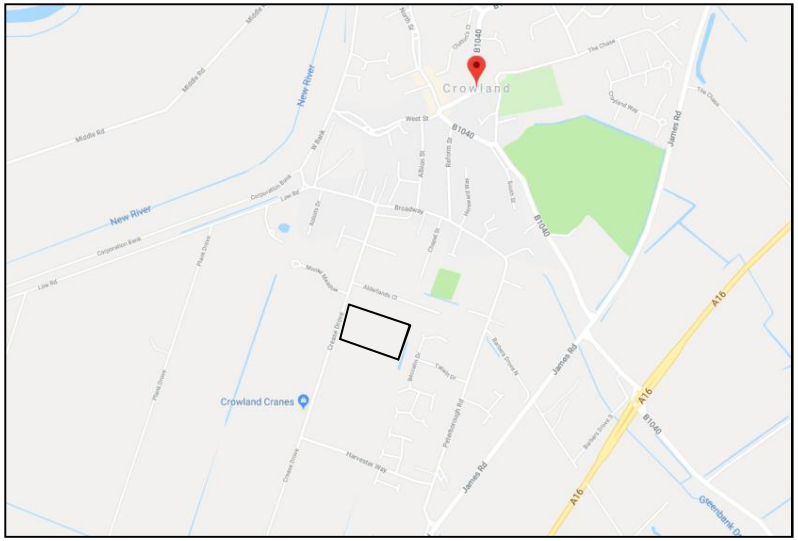

DO NOT SCALE

NOTES:

Approximate Site Boundary

GRM Development Solutions Ltd
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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 :	ISSUE:
NTS	FINAL
DESIGN/DRAWN by : DAA	DATE: June, 2019
PROJECT No: P8723	DRAWING No: 2

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APPENDIX C

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

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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														Ground Waters	
				Methane %v/v		CO2 %v/v		Oxygen %v/v		Gas Flow l/h		PID Reading ppm		Depth to Groundwater mbegl	Total Well Depth mbegl
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		1.09	2.94
WS02	0.60	1.60	NS	0.00	0.00	3.90	3.90	15.60	15.60	0.00	0.00	Not Recorded		0.75	1.65
WS03	1.00	3.00	NS	0.00	0.00	0.90	0.90	19.40	19.40	0.00	0.00	Not Recorded		0.50	3.20
WS04	0.50	1.50	NS	0.00	0.00	0.30	0.30	19.80	19.80	0.00	0.00	Not Recorded		0.39	1.43
WS06	1.00	2.00	NS	0.00	0.00	0.30	0.30	19.70	19.70	0.00	0.00	Not Recorded		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 Statra

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)	Highlighted cell for following conditions:	
N.D.	Not Detected	a	Methane =>1% v/v
N.R.	Not Recorded	b	Carbon Dioxide =>5% v/v
PID	Photo-Ionising Detector	MG	Made Ground
%	By volume	NS	Natural Strata

Ground Material Key

NS	Natural Statra

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														Ground Waters	
				Methane %v/v		CO2 %v/v		Oxygen %v/v		Gas Flow l/h		PID Reading ppm		Depth to Groundwater mbegl	Total Well Depth mbegl
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	1.10	2.90
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	0.89	1.63
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	0.68	3.20
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	0.30	1.43
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	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 =>1% v/v
b	Carbon Dioxide =>5% v/v
MG	Made Ground
NS	Natural Strata

Ground Material Key

NS	Natural Statra

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														Ground Waters	
				Methane %v/v		CO2 %v/v		Oxygen %v/v		Gas Flow l/h		PID Reading ppm		Depth to Groundwater mbegl	Total Well Depth mbegl
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	1.10	2.91
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	0.93	1.65
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	0.67	3.12
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	0.33	1.39
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	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 =>1% v/v
b	Carbon Dioxide =>5% v/v
MG	Made Ground
NS	Natural Strata

Ground Material Key

NS	Natural Statra

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														Ground Waters	
				Methane %v/v		CO2 %v/v		Oxygen %v/v		Gas Flow l/h		PID Reading ppm		Depth to Groundwater mbegl	Total Well Depth mbegl
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	0.87	2.89
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	0.75	1.63
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	0.49	3.17
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	0.00	1.40
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	0.75	1.91

Comments All holes bailed

Notes

L.E.L.	Lower Explosive Limit (100% L.E.L.= 5% Flammable Gas)	Highlighted cell for following conditions:	
N.D.	Not Detected	a	Methane =>1% v/v
N.R.	Not Recorded	b	Carbon Dioxide =>5% v/v
PID	Photo-Ionising Detector	MG	Made Ground
%	By volume	NS	Natural Strata

Ground Material Key

NS	Natural Statra

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 =>1% v/v
b	Carbon Dioxide =>5% v/v
MG	Made Ground
NS	Natural Strata

Ground Material Key

NS	Natural Statra

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														Ground Waters	
				Methane %v/v		CO2 %v/v		Oxygen %v/v		Gas Flow l/h		PID Reading ppm		Depth to Groundwater mbegl	Total Well Depth mbegl
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		0.74	15.05
CP102	1.00	1.70	NS	0.00	0.00	6.30	6.30	14.10	14.10	0.00	0.00	Not Recorded		1.12	1.82
WS01	0.50	3.00	NS	0.00	0.00	1.60	1.60	20.20	20.20	0.00	0.00	Not Recorded		0.68	2.92
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		0.00	3.10
WS04	0.50	1.50	NS	0.00	0.00	1.80	1.80	19.60	19.60	0.00	0.00	Not Recorded		0.00	1.35
WS06	1.00	2.00	NS	0.00	0.00	1.10	1.10	20.50	20.50	0.00	0.00	Not Recorded		0.60	1.87
WS109	1.30	2.50	NS	0.00	0.00	4.70	4.70	6.90	6.90	0.00	0.00	Not Recorded		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)	Highlighted cell for following conditions:	
N.D.	Not Detected	a	Methane =>1% v/v
N.R.	Not Recorded	b	Carbon Dioxide =>5% v/v
PID	Photo-Ionising Detector	MG	Made Ground
%	By volume	NS	Natural Strata

Ground Material Key

NS	Natural Statra

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														Ground Waters	
				Methane %v/v		CO2 %v/v		Oxygen %v/v		Gas Flow l/h		PID Reading ppm		Depth to Groundwater mbegl	Total Well Depth mbegl
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		1.27	15.06
CP102	1.00	1.70	NS	0.00	0.00	30.00	30.00	6.50	6.50	0.00	0.00	Not Recorded		1.42	1.84
WS01	0.50	3.00	NS	0.00	0.00	4.60	4.60	18.40	18.40	0.00	0.00	Not Recorded		1.28	2.92
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		0.77	3.06
WS04	0.50	1.50	NS	0.00	0.00	1.20	1.20	20.90	20.90	0.00	0.00	Not Recorded		0.42	1.70
WS06	1.00	2.00	NS	0.00	0.00	0.40	0.40	20.90	20.90	0.00	0.00	Not Recorded		1.10	1.87
WS109	1.30	2.50	NS	0.00	0.00	2.20	2.20	20.20	20.20	-1.31	-0.51	Not Recorded		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 Statra

APPENDIX D

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

Fax: 01283 211968

info@grm-uk.com

www.grm-uk.com

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:	DATE:	DESIGN/DRAWN:
P8723	07/2019	CM

DRAWING NUMBER:	ISSUE:
02	FINAL REV A

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APPENDIX E

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	GRM TIER 1 ASSESSMENT CRITERIA		
LAND USE	Residential with Plant Uptake		
CONTAMINANT	**1%**	**2.50%**	**6%**
[e] Arsenic	37	37	37
[e] Cadmium	26	26	26
[b] Chromium III	2590	2590	2590
[e] Chromium VI	21	21	21
[e] Lead	200	200	200
[c] Mercury	170	170	170
[a] Selenium	350	350	350
[a] Nickel	130	130	130
[b] Phenols	240	471	951
[b] Copper	2300	2300	2300
[b] Zinc	4590	4590	4590
[d] Cyanide	34	34	34
[e] Benzene	0.20	0.36	0.87
[b] Toluene	118	267	609
[b] Ethylbenzene	64	151	349
[b] *o* - xylene	43	101	235
[b] *m* - xylene	41	98	228
[b] *p* - xylene	40	93	217
Non Genotoxic PAHs			
[b] Acenaphthene	333	746	1450
[b] Acenaphthylene	170	407	906
[b] Anthracene	3770	7890	13700
[b] Fluoranthene	391	690	981
[b] Fluorene	166	939	849
[b] Napthalene	1.5	3.5	8.2
[b] Phenanthrene	149	316	558
[b] Pyrene	867	1560	2270
Genotoxic PAHs			
[e/f] Benzo(a)pyrene	5	5	5
ALIPHATIC HYDROCARBONS			
[b] C5-C6	28	51	105
[b] C6-C8	68	152	347
[b] C8-C10	18	43	102
[b] C10-C12	87	215	509
[b] C12-C16	709	1680	3400
[b] C16-35	128000	128000	128000
AROMATIC HYDROCARBONS			
[b] C5-7 (benzene)	64	128	271
[b] C7-8 (toluene)	118	267	609
[b] C8-C10	26	63	146
[b] C10-C12	69	165	364
[b] C12-C16	141	325	662
[b] C16-C21	264	547	938
[b] C21-C35	1120	1490	1720

Notes

a SGV (2009)

b LQM/CIEH values or derived using CLEAv1.06 with LQM/CIEH Data.

c SGV for inorganic Hg used (ref.2009 SGV, Pg5, Para.4)

d Atkins ATRISKsoil Value

e C4SL - SP1010 (2014)

f 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)

NB Where C4SLs/SGVs have not been produced, all TACs have been revised in line with report SP1010 (2014), however, the default consumption rates in the CLEAv1.06 model have been retained.

GRM.TAC.08.14