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PHASE 2 INTRUSIVE GROUND INVESTIGATION INTERPRETATIVE REPORT
For
LAND AT WARK CRESCENT,
JARROW, NE32 4SP

This report was carried out in accordance with JPB Quality Management procedures.

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1.0 INTRODUCTION

1.1 Further to written instructions received on 18 November 2013 from South Tyneside Homes Limited (STH), Johnson Poole and Bloomer Limited (JPB) is pleased to present an Interpretative Ground Investigation Report for the site known as Land at Wark Crescent, Jarrow. The site's location and boundaries are shown on JPB Drawings NB503/05 and NB503/06 respectively.

1.2 This report has been written for STH and is required in order to determine the shallow and general ground conditions on site. This report also highlights any potential environmental risks and liabilities associated with the future redevelopment of the site, arising from its past and present uses. Information is provided relating to the on site ground conditions, together with any further issues which could lead to potential financial liabilities that may affect the land value or impact upon potential redevelopment options. At the time of writing, it is understood that STH is considering the redevelopment of the site for residential purposes.

1.3 JPB has previously prepared a Phase 1 Desk Study for STH at this site. That report is referenced NB503-14/ACJ/FT and dated 25 November 2013. Where relevant, information from this previous report has been utilised in conjunction with the information obtained from the current ground investigation.

1.4 As part of this commission, RP Drilling Limited was appointed by JPB as sub-contractor, to undertake windowless sample boreholes. The site works were undertaken on 8 January 2014 under the full time supervision of a JPB Geologist.

1.5 This report and its related documents have been prepared for the sole use of the specified client in response to an agreed brief, for a stated purpose and at a particular time and its application must be made accordingly. No duty of care extends to any other party who may make use of the information contained therein.

1.6 In reading this report, the information presented and discussed in Sections 9.0 and 10.0 (Conclusions and Recommendations and General) should be consulted and noted.

2.0 SITE DESCRIPTION AND SETTING

2.1 Site Description

General

2.1.1 The site is located within Jarrow, approximately 3km to the south of the town centre. The centre of the site is at approximate National Grid Reference 432892, 562695, and the site's general location is shown on JPB Drawing NB503/05. Occupying an area of approximately 0.12ha, the site is a general wedge shape in plan view, with its overall longest axis orientated east to west. The site comprised two areas, the main site which is a former residential garage site, and an 'additional' area which is understood to have always been unoccupied. The site and its local surroundings were generally level, at an approximate elevation of 26m above ordnance datum (AOD), with the surroundings falling slightly to the north. The site boundaries and layout are shown on JPB Drawing NB503/06.

Site Boundaries and Adjacent Site Uses

2.1.2 The site comprised a cleared piece of land which is understood to have been previously used for residential garages, situated in a generally residential area. Accessed from a service road that formed an extension to Wark Crescent and extended from each end of the Crescent, the site was surrounded by the gardens of residential properties to the north, northeast and northwest. These boundaries were marked by a combination of wide and close boarded timber fencing, double timber gates (side of rear garden of 42 Wark Crescent) and a 0.75m high red brick wall (42 Wark Crescent side boundary).

2.1.3 The eastern, southern and western boundaries were open and formed by the concrete surfaced 'service road', with further residential properties beyond to the east and west and open land to the south. The open land to the south formed a wide plain at the base of an embankment approximately 4m high associated with the Metro line, which led to Felgate Metro Station approximately 100m to the east.

Site Layout

2.1.4 The site was clear of above ground features, with the only evidence of its previous garage use being concrete bases and tarmac parking bays towards the northern boundary of the site. The ground cover of the main site area was a combination of hardcore, concrete and tarmac hardstanding, whilst the 'Additional' area to the east and the westernmost area were covered with short grass. A few shrubs and brambles were noted towards the apex of the site and generally towards the northern boundary.

Site Access

2.1.5 Vehicular access to the site could be made immediately from the concrete surfaced 'service road' which led from Wark Crescent to the east and joined it again to the west of the site.

2.2 Site Setting

General

2.2.1 For full details of the site setting, reference should be made to the previous JPB Phase 1 Desk Study Report referenced NB503-14/ACJ/FT and dated 26 November 2013. A brief summary of the pertinent findings of the JPB desk study report is presented below.

History

2.2.2 The earliest available plan for the site shows the site to be within an undeveloped field. There are no significant changes recorded on site until the publication of the 1969 plan, where a row of twelve small garages are shown on site along the northwestern boundary. Only three of the garages remain on the 1992 plan, and these are located towards the apex of the site in the north. It is apparent that the site clearance of the remaining garages, leaving the unoccupied and cleared site that currently exists, was undertaken following the publication of the latest edition.

Geology

2.2.3 Made Ground is anticipated across the site, and this is likely to comprise materials arising from the demolition and construction of roads and buildings both on and off site. The BGS published information indicates the site to be underlain by clay deposits of the superficial Pelaw Clay Member, with the Pennine Upper Coal Measures Formation (mudstones, siltstones, sandstones and coal) at depth.

Mining and Quarrying

2.2.4 The Non-Residential Coal Authority Mining Report indicates that the site is within the likely zone of influence on the surface from workings in two seams of coal at 360m to 400m depth, although any ground movement from these workings, last worked in 1930, should have now ceased. However, the site is not within the likely zone of influence on the surface from current or future underground coal workings and there are no recorded mine entries within, or within 20m of the site boundaries. The Coal Authority also indicates that the site is not located within the boundary of a former, current or proposed opencast coal extraction site.

2.2.5 Information on the Coal Authority website indicates that the site is not located within a coal mining development high risk area and therefore a coal mining risk assessment report will not be required as part of the planning process.

2.2.6 On the basis of the geological setting and information provided by the Coal Authority, GroundSure Report and that held within JPB's archives, mining and quarrying are considered to be **not significant** to the site and its future redevelopment.

Hydrogeology and Hydrology

2.2.7 The Pelaw Clay Member deposits underlying the site are classified by the EA as Unproductive Strata, whilst the Pennine Middle Coal Measures strata are classified as a Secondary A Aquifer. Groundwater is considered to be of **low to moderate sensitivity**.

2.2.8 There are no major surface water features within a 250m radius of the site, except for Calfclose Burn and Monkton Burn, 220m east and 350m west of the site respectively. Based on the information reviewed, surface waters in proximity to the site are considered to be of **low to moderate sensitivity**.

Flooding

2.2.9 The EA flood maps indicate the site to be located in Flood Zone 1, which is all land outside the flood plains shown on the Environment Agency (EA) flood maps, where the risk of fluvial flooding is considered to be **low**. The site is not located in an area where the EA issue Flood Warnings or Flood Alerts.

2.2.10 Data provided by the BGS within the GroundSure Report indicates that the site is not within a groundwater flooding susceptibility area. Flooding and flood risk are therefore considered to be **not significant** to the site and its future redevelopment.

Landfills and Waste Management Sites

2.2.11 There are no records relating to various waste management sites within 500m of the site. Waste management and treatment sites are considered to be **not significant** to the site and its future redevelopment.

Conceptual Site Model (CSM)

2.2.12 A CSM included in the JPB Phase 1 desk study report was derived on the basis of the findings of the same, Phase 1 Desk Study Ground Investigation Report, on the basis of a proposed residential end use. This model identified the sources, pathways and receptors from the existing information; and also identified the potential pollutant linkages for consideration in the investigation.

2.2.13 The JPB Phase 1 Desk Study Report concluded that there were limited source-pathway-receptor linkages on site, and that the site presented a **low risk** to the health of current and future site users and construction workers and a **low risk** to the environment, from potential chemical contamination on site. Further assessment by means of an intrusive ground investigation was recommended, in order to identify the actual pollutant linkages on site.

2.2.14 The risk from ground gases was considered to be **low** and is mainly attributable to the proximity of off site former drainage ditches.

2.2.15 This report details the findings of the proposed, and now executed, intrusive ground investigation.

3.0 GROUND INVESTIGATION SCOPE OF WORKS

3.1 Introduction

3.1.1 As previously stated, JPB was commissioned by South Tyneside Homes (STH) to undertake an intrusive ground investigation, with the proposed scope of works designed on the basis of the recommendations from the JPB Phase 1 Desk Study. This included investigations to establish the general shallow ground conditions, the contamination status and the groundwater and gas regimes on site. It is understood that information presented in this ground investigation report will be used to assist in determining the feasibility of the future redevelopment of the site, for residential use.

3.1.2 The purpose of the investigation was primarily to establish the general shallow ground conditions and determine the presence, or otherwise, any contamination beneath the site. The main objective of this investigation was to provide information sufficient for STH to determine the general ground conditions and identify any remediation or abnormal redevelopment issues associated with a potential future redevelopment of the site.

3.1.3 At the time of the ground investigation, preliminary development options had been proposed although detailed development plan had not been determined. It is possible that further assessment may be required in the future, as the detailed design becomes available.

3.2 Intrusive Investigation

3.2.1 The ground investigation fieldworks were undertaken by RP Drilling Ltd on 10 January 2014, under the full time direction and supervision of a JPB Geologist. The investigation was undertaken in accordance with BS5930:1999 (incorporating Amendment 2), with all exploratory holes logged in accordance with BSEN14688-1:2002 and BSEN1997-2:2007 by the supervising JPB Geologist.

3.2.2 The ground investigation comprised the following programme of works.

- Five windowless sample boreholes, designated WS301 to WS305 advanced to a maximum depth of 6.45mbgl using a Global Geotech mini rig. In-situ geotechnical testing was carried out in the boreholes, comprising Standard Penetration Tests (SPT) where the number of blows required to drive a barrel sampler 300mm in to the base of the borehole is recorded as the ‘N’ value. Disturbed samples of the materials encountered were retrieved for both chemical and geotechnical laboratory testing. All in-situ test results and sample details are recorded on the individual exploratory hole records presented in Appendix B;

- Standpipes for monitoring gas and groundwater, and also to undertake preliminary infiltration testing, were installed under the instruction of the JPB Geologist in three of the windowless sample boreholes. Details of the installations are shown on the individual exploratory hole records presented in Appendix B;

- Preliminary infiltration testing was undertaken during the subsequent monitoring period, in all of the installed boreholes on site.

3.2.3 The positions of the various exploratory holes are shown on JPB Drawing NB503/16.

3.3 Gas and Groundwater Monitoring

3.3.1 Upon completion of the ground investigation site works, a programme of ground gas and groundwater monitoring was undertaken in order to ascertain the on site gas and groundwater regimes. These installations, WS301, WS303 and WS304, were monitored on six separate occasions.

3.3.2 During each monitoring visit, the concentrations of methane, carbon dioxide, oxygen, hydrogen sulphide and carbon monoxide were recorded, together with atmospheric pressure, borehole pressure and gas flow at each installed position. A GA5000 infra red gas analyser was utilised to obtain these readings.

3.3.3 The gas monitoring is discussed in Section 7.0 of this report and the full gas monitoring results are presented in Appendix E.

3.3.4 The level of any groundwater encountered in the monitoring wells was recorded on each visit, in order to identify and characterise any underlying groundwater regime.

3.3.5 The water monitoring results are discussed in Section 4.0 of this report and the full monitoring results are presented in Appendix E.

3.4 Chemical Laboratory Testing

3.4.1 Soil samples were obtained from the exploratory positions at varying depths within the soil profile. Samples were selected on the basis of specific on site observations, the strata encountered, specific historic land use and the proposed redevelopment. All samples were analysed for a range of parameters to provide an indication of the overall nature, extent and severity of contamination present on site and to enable the appropriate risk assessment to be undertaken.

3.4.2 Soils from the exploratory holes were sampled by the supervising JPB Geologist and dispatched to Environmental Scientifics Group (ESG), a UKAS and ISO 17025 accredited laboratory that participates in the MCERTS scheme. The samples were transported in the supplied proprietary containers, under chilled conditions.

3.4.3 The chemical analyses were scheduled by an experienced JPB Geologist for a broad suite of determinands, specified with reference to the site's former and current use and observations made on site. The chemical laboratory analytical results are presented in Appendix F of this report.

3.4.4 In total, four soil samples obtained from the boreholes were scheduled and analysed for some, or all, of the following determinands:

- *Inorganic elements and compounds* – arsenic, barium, beryllium, boron, cadmium, chromium, hexavalent chromium, copper, lead, mercury, nickel, selenium, zinc, vanadium, sulphate (water soluble), free and total cyanide, pH, and asbestos screening;

- *Organic compounds* – USEPA 16 speciated polycyclic aromatic hydrocarbons (PAH), total petroleum hydrocarbons with aliphatic and aromatic split and carbon banding in accordance with the Criteria Working Group (CWG), including MTBE and BTEX, total phenol and total organic carbon (TOC).

3.4.5 Two groundwater samples were obtained and tested for a similar suite of analysis as the soils with the addition of total alkalinity, electrical conductivity and sulphide. Groundwater samples were obtained from boreholes WS301 and WS304 during the first monitoring visit, which was completed approximately two weeks following the installation of the boreholes, to allow ground conditions to equilibrate.

3.5 Geotechnical Laboratory Testing

3.5.1 On the basis of observations made in the field, selected disturbed and undisturbed soil samples were scheduled by JPB for geotechnical laboratory analysis. The analysis was undertaken by Professional Soils Laboratories Limited at their UKAS accredited laboratory and was carried out in accordance with BS1377:1990. The following tests were conducted:

- 5 No. Moisture Content;
- 5 No. Atterberg Limits (plastic limit, liquid limit, plasticity index);

3.5.2 The geotechnical laboratory test results are presented in Appendix C.

4.0 GROUND CONDITIONS

4.1 General

4.1.1 Ground conditions encountered during the ground investigation works were generally consistent with the published BGS information. A brief description of the materials encountered on site is included in the following sections.

4.1.2 The generalised geological sequence beneath the site determined from the ground investigation is summarised in Table 4.1 below.

Table 4.1: Generalised Geological Sequence

STRATA ENCOUNTERED AND DESCRIPTION	RANGE OF THICKNESS (m)	DEPTH TO BASE (mbgl)
A. MADE GROUND (where present)		
A1 Tarmacadam surfacing.	0.10 – 0.12	0.10 – 0.12
A2 Concrete surfacing.	0.11	0.11
A3 Soft dark brown slightly silty clay. Occasional gravel sized fragments.	0.25 – 0.70	0.25 – 0.70
A4 Reddish brown slightly clayey gravel sized fragments of brick, concrete, quartzite and mudstone.	0.18 – 0.64	0.30 – 0.75
A5 brown slightly gravelly clay.	0.25	1.00
B. NATURAL SUPERFICIAL		
B1 Firm light brown mottled light grey clay. *Pelaw Clay Member*	0.20 – 0.75	1.00 – 1.40
B2 Soft to firm chocolate brown clay. Occasional lenses of silt. *Pelaw Clay Member*	1.20 – 4.60	2.20 – 5.60
B3 Stiff to firm chocolate brown slightly gravelly clay. *Pelaw Clay Member*	Not fully penetrated	Base of strata not penetrated

4.2 Made Ground

4.2.1 Made Ground Materials were encountered in each of the exploratory positions across the site. The average thickness of Made Ground deposits across the site was between 0.25m and 1.00m with the greatest total thickness of 1.00m encountered in WS303. A minimum thickness of 0.25m was encountered in WS301.

4.2.2 Two main types of Made Ground materials were generally encountered during the course of the ground investigation comprising predominantly man-made materials such as demolition rubble or re-worked natural materials that appear to be derived from the Pelaw Clay Member. Tarmacadam and concrete surfacing was also present at three of the exploratory hole locations.

4.2.3 For a full description of the Made Ground, reference should be made to the individual exploratory hole logs presented in Appendix B.

4.3 Natural Superficial Deposits

4.3.1 Natural superficial deposits were encountered in all exploratory positions beneath the identified Made Ground materials. The majority of the materials identified during the course of the ground investigation were determined to represent Pelaw Clay Member materials. The Pelaw Clay typically comprised soft to stiff slightly gravelly clay with the gravel typically occurring from 4.2m bgl and 5.6m bgl. The granular element of the Pelaw Clay deposit was noted at shallower depths of 1.0m bgl and 2.2m bgl in WS301 and WS305 respectively.

4.3.2 The material was typically identified to be predominantly cohesive with a varying granular component comprising fine to coarse gravel of quartzite, coal, mudstone and sandstone. Thin lenses of silt were encountered in exploratory holes WS304 and WS305 within the Pelaw Clay Member.

4.3.3 For a full description of the materials encountered within the natural superficial deposits, reference should be made to the individual exploratory logs presented in Appendix B.

4.4 Groundwater

4.4.1 Groundwater was not encountered during the intrusive works on site within any of the exploratory holes as they were advanced.

4.4.2 Three exploratory holes, WS301, WS303 and WS304, were fitted with standpipe installation, primarily for gas monitoring, and also for groundwater monitoring. The response zones, standpipe depths and levels of groundwater of all installed and monitored exploratory holes are shown on the exploratory hole records in Appendix B.

4.4.3 The groundwater encountered within the monitoring wells during the monitoring period is considered to represent shallow perched water bodies within the Natural Superficial deposits. The perched water is likely to occur as discrete bodies within the discontinuous granular material within the superficial clays.

4.4.4 The recorded resting groundwater levels are noted to have risen significantly when compared to the absence of groundwater noted during the advancement of the exploratory holes. It is considered that this rise in groundwater may be indicative of sub-artesian pressures on the groundwater having been released by the penetration of the overlying materials.

4.4.5 The full groundwater monitoring results are presented in Appendix E.

5.0 ENGINEERING PROPERTIES OF MATERIALS ENCOUNTERED

5.1 Engineering Properties

5.1.1 For the purposes of determining the engineering properties of the encountered materials, reference has been made to both in-situ and laboratory geotechnical testing.

5.1.2 The results of the in-situ and laboratory geotechnical testing of the samples recovered during the recent investigation are presented in Appendix D. The soil parameters from the in-situ and laboratory testing of samples are summarised in the following sections. It should be noted that the results may not be representative of the deposits as a whole due to the variation in both material types and depositional state across the site.

5.2 Made Ground

5.2.1 Made Ground deposits were identified at all of the exploratory hole positions across the site and proved to be variable in their strength, thickness and composition.

5.2.2 A single sample of cohesive Made Ground was submitted for laboratory testing to determine the liquid limits, plastic limits and plasticity indices. The result classified the tested material as ‘intermediate’ to ‘high’. Based upon guidance contained within the NHBC Standards Chapter 4.2 ‘Building near Trees’, this result would classify the shallow cohesive Made Ground materials as ‘low’ volume change potential materials. However, it should be noted that samples recovered from the underlying Pelaw Clay were identified to comprise ‘medium’ volume change materials (discussed below), and given that the Made Ground materials derive in part from these materials it is considered possible that medium volume change potential Made Ground materials could be encountered on site.

5.2.3 Limited in-situ testing with a hand held shear vane recorded undrained shear strength values of between 39kN/m^2 and 74kN/m^2. Given the variation in the composition of the deposit, it is difficult to ascribe a suitable characteristic value to the deposit. However, based upon the limited testing it is suggested that 40kNm^{-2} be adopted as a suitably conservative value for undrained shear strength for further design purposes.

5.3 Pelaw Clay Member

5.3.1 Materials considered to represent the Pelaw Clay Member deposits were encountered in all exploratory holes across the site below the identified Made Ground deposits. The Pelaw Clay was noted to be slightly variable in composition with a variable granular content.

Table 5.1: Testing Summary Table for Pelaw Clay Member

Parameter	No. of Tests	Minimum	Maximum	Typical Result
Moisture Content (%)	4	18.6	39.5	Variable
Liquid Limit (%)	4	45	53	45-53*
Plastic Limit (%)	4	21	33	21-33*
Plasticity Index (%)	4	17	27	17-27*
Modified Plasticity Index (%)	4	17	26	17-26*
Soil type based on plasticity chart	4	Intermediate	Int-High	Int-High
Volume Change Potential	4	Low	Medium	Medium

* Variable with material type, see text.

5.3.2 Atterberg limits testing identified that the Pelaw Clay member materials were of intermediate to high plasticity with plasticity indices of between 17 and 26 and would be classified as a medium volume change potential material under the NHBC guidance.

5.3.3 Limited in-situ testing with a hand held shear vane recorded undrained shear strength values for the Pelaw Clay of between 30kN/m^2 and in excess of 85kN/m^2 with 'typical' values of between 40kN/m^2 and 60kN/m^2 recorded.

5.3.4 In-situ testing using the SPT gave N values between 7 and 21 with a general increase in N value with depth across the site. Based upon the test results it is considered appropriate to assign an N value of 7 between 1.0m bgl and 2.0m bgl and 11 between 2.0m bgl and 3.0m bgl. It is possible to derive undrained shear strengths from SPT N values with typical results in the order of 30kN/m^2 to 50kN/m^2.

5.3.5 Based upon the testing, it is suggested that 40kNm^{-2} be adopted as a suitably conservative value for undrained shear strength for further design purposes.

6.0 GEOTECHNICAL AND FOUNDATION CONSIDERATIONS

6.1 General

6.1.1 At the time of writing, it is understood that STH is considering the redevelopment of the site for residential purposes. No indicative development layout or any indicative structural loads have been supplied to JPB although it is anticipated that traditional two storey residential structures are planned.

6.1.2 Based upon the engineering properties of the shallow soils discussed in Section 5.0, the following preliminary comments are offered regarding suitable founding horizons. All depths quoted are relative to the site levels at the time of investigation.

6.1.3 The following foundation recommendations are considered to be for general guidance only and further professional geotechnical advice should be sought once the building loads and the final development proposals, including levels, are known. Depending upon the nature of the final development and of any proposed earthworks operations, further ground investigation may be required to allow detailed foundation design.

6.2 General Guidance for Foundation Design

6.2.1 The shallow Made Ground deposits were noted to be highly variable in terms of thickness, composition and strength across the site and are not generally considered appropriate for use as a founding medium.

6.2.2 The underlying Pelaw Clay derived cohesive materials are broadly considered acceptable for founding purposes. The Pelaw Clay materials would be classified as ‘medium’ volume change potential materials under the NHBC guidance using their ‘modified’ plasticity indices. As such, a minimum founding depth of 1.25m bgl will be applicable assuming restricted new planting or the presence of existing trees or vegetation within influencing distance of the future foundations.

6.2.3 Outside the zone of influence of any proposed or existing trees or vegetation the minimum founding depth will be 0.90m bgl provided that a suitable foundation stratum exists at this level (given the variability of the materials encountered on site). Given that the Made Ground and Pelaw Clay Member possess variable strength properties and can be considered shrinkable soils, it will be necessary to adopt suspended floors for all future structures.

6.2.4 Assuming a founding depth of 1.25m bgl a maximum net allowable bearing pressure of 70kNm^{-2} is considered appropriate for future foundations, so as to limit settlement to less than 25mm. Conventional strip footings are considered appropriate for use for up to two storey traditional brick built structures.

6.2.5 Should higher bearing pressures be required then it may be necessary to adopt semi-raft style foundations so as to spread the imposed structural loads over a larger area. It will be necessary to check the formation level for suitability on a per plot basis, to ensure that minimum undrained shear strength of 40kNm^{-2} is available. This should be done using a hand held shear vane with a minimum sample size of eight to ten tests per plot, spaced out across the whole building footprint.

6.3 Concrete Design

6.3.1 For the purpose of designing sub-surface concrete to BS EN 206-1/BS50, guidance has been obtained from BRE SD1:2005 “Concrete in Aggressive Ground”. The site has been classified as ‘brownfield with “static groundwater” based upon the guidance documentation.

6.3.2 Determination of the water soluble sulphate content of near surface and deep soils was undertaken from four soil samples from across the site. The highest water soluble sulphate concentration was 150mg/l while the pH values across the site were found to vary between 7.3 and 8.1. Two samples of groundwater were recovered during the monitoring programme with a highest recorded sulphate level of 160mg/l in WS304.

6.3.3 The data set used for the concrete classification assessment comprised four soil samples, and following the guidance contained within BRE SD1:2005, the highest sulphate result was taken as the characteristic value. The soil characteristic value has therefore been calculated as 200mg/l (rounded up) while the water characteristic value has been rounded up to 200mg/l. These results place the site within Design Sulphate Class DS-1 and ACEC class AC-1s as derived from Table C2 in BRE SD1:2005 for ‘static’ groundwater. This corresponds to a Design Chemical Class (DC) of DC-1, assuming a designed working life of 100 years.

6.4 Drainage and Infiltration

6.4.1 As referred to in Section 3.0, preliminary infiltration testing was undertaken in the installed boreholes on site. Based on the results of the preliminary testing undertaken, the encountered geology at this site is **not considered suitable** for the use of infiltration style drainage for the collection and disposal of run-off waters as a result of the identified presence of effectively impermeable clay strata across the majority of the site.

6.4.2 As such, it is considered that attenuation storage may need to be provided to allow any future construction to meet its obligations under PPS25. Attenuation storage could take the form of lightweight honeycombed tanks beneath areas of hard standing / car parking and would require further assessment at the design stage.

6.4.3 Careful design and diligent supervision of the installation of any attenuation storage would be required, as any leakage could cause shrinkage / heave problems within the identified shrinkable soils on the site. JPB would be pleased to assist by preparing a Flood Risk Assessment for the site, if so required.

6.5 Services

6.5.1 All services **should** be designed to be flexible and be able to accommodate potential movements of up to 50mm. Excavated trenches to depths of approximately 1.2m should be relatively stable for short durations (i.e. hours) but may need to be battered to 1v in 0.6h should they need to be kept open for longer periods. Trenches deeper than 1.2m should be shored for safety and no man entry allowed under any circumstances.

6.6 General Comments

6.6.1 During site works, should any localised softening of the soils be encountered then these materials should be removed and replaced with well compacted hardcore. In addition, it is imperative that the foundation excavations are kept dry to ensure the integrity of the cohesive deposits, as this material is potentially sensitive to wetting. All excavations should be examined to ensure that the formation level material is consistent with that used in this assessment.

7.0 GROUND GAS EMISSIONS

7.1 General

7.1.1 During the intrusive investigation, monitoring instrumentation was installed in 3 of the windowless sample boreholes, namely WS301, WS303 and WS304.

7.1.2 The assessment of ground gas as a potential constraint to development has been the subject of considerable research and published guidance. Ground gas can be a concern for several reasons; flammable gases may cause an explosion, build up of gases within poorly ventilated areas may lead to asphyxia, and toxic gases may cause harm to those exposed to them. Some physical properties of ground gases are tabulated below.

Table 7.1: Physical Properties of Ground Gases

Gas	Explosive Range	Density at 20ºC	Toxicity (% by volume in air)*
Methane (CH_4)	5-15% by volume	0.72 kg/m^3	30 (low)
Carbon dioxide (CO_2)	N/A	1.98kg/m^3	0.5 (high)
Carbon monoxide (CO)	10.5-74.2% by volume	1.25kg/m^3	0.02 (high)
Hydrogen sulphide (H_2S)	4.2-46% by volume	1.54kg/m^3	0.001 (high)

* Short term exposure limits

7.1.3 Made Ground can often contain degradable material such as wood, rags, paper and vegetation. However, the proportion of such carbon-rich materials is typically low, with major components often comprising re-worked clays, silts, sands and gravels, together with anthropogenic inclusions such as brick and concrete (CIRIA C665), as is anticipated to be the case at this site. A potential risk from ground gases was considered to be present, and further information was required to clarify this risk through intrusive ground investigation on site i.e. the composition of Made Ground, the potential for gas generation on site and the permeability of the strata.

7.1.4 Gas measurements were recorded from each monitoring borehole, on six separate occasions between 21 January and 28 February 2014. Atmospheric pressures were recorded between 978mb and 1003mb during the course of the monitoring visits. The full details of the ground gas monitoring are presented in Appendix D.

7.2 Assessment of Results

Tier 1 Ground Gas Risk Assessment

7.2.1 JPB uses the following generic screening levels to determine whether a potential risk exists: CH_4 <1% by volume in boreholes, and CO_2 <1.5% by volume in boreholes, providing borehole flow rates do not exceed 7l/h and 1.4l/h respectively.

7.2.2 H_2S was not encountered during the initial three monitoring visits. Further assessment of this gas is therefore not required.

7.2.3 CH_4 was encountered at a concentration of 0.1% v/v in boreholes WS303 and WS304 during the third visit; WS304 during the fifth visit and in all three boreholes during the sixth visit. In addition, a CH_4 concentration of 0.2% v/v was recorded in WS303 and WS304 during the fourth visit. As the screening level is not exceeded, no further assessment of this gas is required.

7.2.4 CO was encountered at a concentration of 1ppm and 3ppm in borehole WS301 and WS304 respectively during the first visit, and at 1ppm in WS303 during the third and fourth visits. There is currently little published guidance on the assessment of CO for residential land use. The EH40/2005 'workplace exposure limits' guidance indicates a maximum exposure of 30ppm CO over an eight hour reference period. The CO concentrations encountered are significantly lower than this and are therefore not considered to be significant, and require no further assessment.

7.2.5 CO_2 was encountered in each monitoring well at least once during the monitoring visits. The recorded concentrations ranged from 0.2% v/v to 1.5% v/v. The maximum concentration was recorded in WS303 on the second visit. Therefore, as the screening concentration for CO_2 was reached, a more detailed Tier 2 Assessment for this gas is required.

7.2.6 The concentrations of O_2 recorded in the boreholes during the monitoring period were at typical atmospheric conditions.

7.2.7 A potentially significant gas flow has been recorded in the boreholes, with a maximum positive flow of 7.6l/hr recorded in WS301 during the first visit. Significant negative flows were also recorded during this visit, in WS304.

Tier 2 Ground Gas Risk Assessment

7.2.8 On the basis of the redevelopment of the site for a residential use of unknown construction type, guidance provided in CIRIA C665 "Assessing Risks Posed by Hazardous Ground Gases to Buildings" has been referred to undertake the gas risk assessment. Extracts from this document are presented in Appendix D.

7.2.9 Carbon dioxide is heavier than air and tends to accumulate in confined spaces rather than flow. Sites with high gas concentrations and low flow rates are considered to be of a lower risk, when compared to sites with high flow rates and low concentrations (Wilson and Card, 1999).

7.2.10 The gas screening value (GSV) has been calculated using the maximum carbon dioxide concentration i.e. 1.5% by volume in WS303 and the worst case flow rate of 7.6l/hr from WS301. The conservative GSV is therefore calculated to be 0.114l/hr (i.e. 0.015 x 7.6), which places the site in a Characteristic Situation 2 (CS2). This is considered to be 'low risk' and as such, ground gas protection measures will be required in new buildings. The recommended measures are outlined in the CIRIA C665 extract in Appendix D.

7.2.11 Whilst the assessment has classified a low risk, the JPB CO_2 screening values have been exceeded and it should be noted that this preliminary assessment has been based on a limited number (six) of gas monitoring visits, during relatively high atmospheric pressures. Further gas monitoring visits are recommended in order to obtain ground gas data over a range of varying seasonal conditions to fully verify the ground gas regime on site.

8.0 CHEMICAL RISK ASSESSMENT

8.1 Risk Assessment Approach

Introduction

8.1.1 The UK framework for chemical risk assessment recently underwent significant change, with the Environment Agency withdrawing, in August 2008, the existing CLEA (Contaminated Land Exposure Assessment) framework. The current CLEA model, CLEA version 1.06, was released in October 2009, however; all of the withdrawn publications and supporting information have yet to be re-released.

8.1.2 On this basis, JPB's risk assessment approach is subject to alteration, to coincide with changes brought about through the release of documentation under the EA's programme of change. To this end, in the absence of certain data sets, guidance and supporting information, there is currently no single approach to assessing the risk to human health from soil contamination.

Human Health

8.1.3 The assessment of risk to human health can consider the potential for exposure based on comparison of the results from site specific ground investigation to conservative generic criteria.

8.1.4 Soil guideline values (SGVs) have been published by the EA for a limited number of determinands for a single soil type. SGVs are scientific; risk based generic assessment criteria for generic land use scenarios that can be used in the preliminary assessments of the risk to human health provided that the scenario is sufficiently representative of, or suitably conservative for, the conceptual site model. SGVs are currently published for eleven determinands; arsenic, cadmium, nickel, mercury, selenium, phenol, benzene, toluene, ethylbenzene, xylenes and dioxins, furans and dioxin-like PCBs.

8.1.5 The published SGVs are based on a sandy loam soil with 6% SOM (Environment Agency, 2009). If the soil at the site in question departs from the generic assumptions inherent in the SGV, three options are presented by the EA to the risk assessor:-

- If the soil type is likely to be less protective of receptors, the risk assessor should derive a new GAC (generic assessment criteria) by adjusting the SGV for soil type and SOM. For example, a sandier, SOM-deficient soil is likely to provide less protection against exposure to volatile sources than that used in the derivation of the SGV.
- If the soil type is likely to be more protective (for example a soil with a higher clay content and greater SOM for the same volatile source), or is sufficiently similar to the SGV assumption, the SGV can be used.
- If the soil type is likely to be more protective, a new GAC (SAC) could be derived (particularly where the representative soil concentration of a chemical on a site exceed an SGV) by adjusting the SGV, thereby providing a less overly conservative screening tool.

8.1.6 Where the SGV is considered inappropriate to represent the site conditions, or where an SGV is not yet published for a determinand, soil assessment criteria (SAC) are derived for the site using CLEA Version 1.06 (released on 5 October 2009).

8.1.7 In view of the limited applicability of the published SGVs (in terms of relevant soils types), as part of this assessment, the published SGVs have not generally been adopted and SACs have been derived for the majority of common inorganic and organic analytical determinands using toxicological data from various sources, including the revised TOX Reports (arsenic, cadmium, nickel, mercury, selenium, phenol, benzene, toluene, ethylbenzene, xylenes and dioxins, furans and dioxin-like PCBs), the previously published TOX Reports (TOX 1 to 25) and the data obtained from the LQM / CIEH publication 2nd edition (2009) and the EIC/CLAIRE publication January 2010.

8.1.8 The TOX reports are currently being replaced on a rolling programme by the EA, as and when each new SGV report is published. The EA has stated "that much of the existing information in the TOX reports will not be affected by changes and will continue to be a useful interim resource until we make our new reports available" (EA website).

8.1.9 It should be noted that in assessing cadmium and its inorganic compounds in residential and allotment land uses, lifetime exposure should be considered. Although young children are generally more likely to have higher exposures to soil contaminants, the renal toxicity of cadmium are based on considerations of the kidney burden accumulated over 50 years or so (Environment Agency, 2009e). It is therefore reasonable to consider exposure not only in childhood but averaged over a longer time period. There is a facility within CLEA v1.06 to allow cadmium SACs to be generated based on lifetime exposure.

8.1.10 In the absence of a published SGV for lead, or the availability of toxicological data / standard input parameters which have been mutually agreed or accepted across the wider professional community (which would allow risk assessment using the CLEA version 1.06 model), JPB’s current approach is to assess the risks from the recorded soil lead concentrations using the RISC4.0 model, referred to in more detail below. It is understood that Society of Brownfield Risk Assessment (SoBRA) is in the process of developing standard input parameters for use in the human health risk assessment of lead. However, these are yet to be made available.

8.1.11 Using the RISC4.0 model, risk estimates are compared with acceptability criteria at the risk evaluation stage in order to determine their significance for the dermal and ingestion pathways. It is considered that a Human Hazard Index (Quotient) in excess of 1.0, or an increased lifetime cancer risk in excess of one in one hundred thousand (10^{-5}) are considered to be significant. Risk estimates for contaminants exceeding these criteria are considered to indicate that the contaminant poses a human health risk and that remedial action may be required to prevent actual harm.

8.1.12 The RISC4.0 modelling is compliant with the Risk Based Corrective Action (RBCA) philosophy and has been the subject of a comparative bench marking study carried out by the EA. Where the model allows, the input parameters have been adjusted to reflect the currently adopted UK approach. RISC4.0 is currently used to asses lead (as indicated above) and the chronic toxicity of cyanide. The acute toxicity of cyanide has been assessed using comparison to the worst case known fatal dose.

8.1.13 The soil modelling parameters calculated using both CLEA Version 1.06 and RISC4.0 are included in Appendix G, whilst further details of JPB's approach to risk assessment included in the Methodology for Exposure Assessment presented in Appendix H.

Controlled Waters

8.1.14 As with human health, the assessment of risk to controlled waters (surface waters and groundwaters) considers the potential for exposure based on comparison of the results, from the current JPB ground investigation, to conservative generic criteria.

8.1.15 Leachability analysis has been conducted on selected soil samples, in order to determine the likely mobility of the soil contaminants, and whether a threat to controlled waters exists. Leachate concentrations have been assessed against the criteria detailed below.

8.1.16 Groundwater samples are obtained, where encountered, to determine the existing concentrations within any perched waters or the underlying aquifer, which may have originated from either on site or potentially from off site sources. Groundwater concentrations are also assessed against the criteria detailed below.

8.1.17 Various Environmental Quality Standards (EQS) have been used to assess the concentrations of individual parameters identified in the leachate samples. The annual average EQS have been selected from EU Standards derived as part of the Water Framework Directive to protect surface water quality (inland waters) or from UK Standards established under the Dangerous Substances Directive (76/464/EEC), which are currently maintained under the Water Framework Directive. Predicted No Effect Concentration (PNEC) values are referred to for phenanthrene and pyrene, as there are currently no EQS values for these determinands. In addition, reference has been made to the Water Supply (Water Quality) (England and Wales) Regulations 2001 and 1989 and World Health Organisation (WHO) guidelines for drinking water, in the absence of EQS, or related EQS guidance, for specific determinands.

8.1.18 If any of the criteria described above are exceeded, for either human health or Controlled Waters, the conclusion is that a significant risk could exist, and further assessment is warranted, in order to calculate the potential levels of risk. This process therefore focuses on the parameters of concern and can inform upon any further investigations, which may be required for more detailed examination or remedial actions.

8.1.19 Further details of JPB's approach to risk assessment are presented in Appendix H - Methodology for Exposure Assessment. The chemical analysis certificates are presented in Appendix F.

8.2 Soil Chemical Analysis – Human Health

8.2.1 In deriving the GAC, this site has been assessed for a residential end use. On the basis of the findings of the previous desk study researches, it has been considered as one averaging area. The exposure pathways considered within this assessment include;

- Direct ingestion of soil and dust;
- Direct ingestion of home grown produce;
- Direct ingestion of soil on home grown produce;
- Dermal contact with soil and dust (indoor and outdoor);
- Inhalation of indoor and outdoor dust;
- Inhalation of indoor and outdoor vapours.

8.2.2 The assessment has been based upon an end user considered to be the most conservative for a residential end use; a child female resident.

8.2.3 The soil properties have been selected as silty clay (the predominant soil texture encountered on site), with the pH and Soil Organic Matter (SOM) adjusted to reflect the actual site conditions of average pH 7.70 and a minimum SOM content of 2.58%. For the purposes of this assessment, site specific building parameters have not been entered. However, in the absence of detailed development proposals, a 'semi-detached' house type has been selected as a typical structure anticipated on site.

8.2.4 The following determinands have been reported at or below the laboratory detection limits in every sample tested, and do not require any further assessment:

- Free cyanide
- Total cyanide
- Selenium
- Hexavalent chromium
- Aliphatic TPH C_5-C_{44}
- Aromatic TPH C_5-C_{12}
- Aromatic TPH C_{35}-C_{44}
- Benzene
- Toluene
- Ethylbenzene
- Xylenes
- Phenols
- MTBE

8.2.5 The soil concentrations of all the determinands encountered above the laboratory detection limits and assessed using the CLEA v1.06 model are all reported to be below the derived GAC for the specified use, with the exception of those shown in Table 8.1 below.

8.2.6 The calculated GAC for the site are presented in Appendix G.

Table 8.1: Determinands Exceeding Tier 1 Criteria (GAC) in Soil Samples

Determinand	GAC (mg/kg)	Exceedance Concentration (mg/kg)	Location on Site
Arsenic	32.4	240	WS303 at 0.4m
Benzo[a]pyrene	0.945	1.3 - 2.8	WS303 at 0.4m and WS301 at 0.1m

8.2.7 It is considered that these exceedances represent localised ‘hotspots’ of contamination, possibly relating to the former garage use of the site, where chemicals may have been stored and other unrecorded activities undertaken.

8.2.8 In the absence of generic criteria for human health risk assessment, the maximum total lead concentrations from the analysis detailed above have been assessed using the RISC4.0 model to provide a general indication of the potential risk to human health from lead encountered on site.

8.2.9 The RISC4 modelling of the dermal and ingestion pathways has been utilised to calculate the hazard indices and cancer risks to human health. Where a determinand has a risk exceeding that of the acceptability criteria; human hazard index >1 or increased cancer risk $>10^{-5}$; it has been considered that a real risk exists. The RISC4 methodology is discussed in detail in Appendix H.

8.2.10 The assessment indicated that the cancer risk from the maximum of the general concentrations of lead found during the investigation is generally less than 1 in 100,000 and the human hazard index is less than 1.

8.2.11 Two soil samples submitted to the laboratory for chemical analysis were also subjected to an asbestos screen and identification test. Neither of these two samples was determined as containing asbestos.

8.2.12 Reference to the UK Water Industry Research (UKWIR) document, “Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites”, has been made and indicates that there may be contaminants on site which may restrict water pipe materials. In view of this, and on the basis of the UKWIR guidance, it is considered that chemical contamination present may permeate certain plastic water pipes and as such either wrapped ductile iron pipes with copper connectors or an approved PE-Al-PE barrier pipe system are recommended for potable water supplies. It should be noted that the water company may require that a PID survey of the route of water supply pipes is undertaken, extending to 15m either side of the pipe route, in order to confirm that no unexpected chemical contamination is present. Alternatively, depending on the specific water supply company, this requirement can be satisfied by upgrading pipe materials to PE-Al-PE barrier pipe, which would be protective of water supplies. The water supply company responsible for the site should be consulted at the design stage of any redevelopment to confirm this.

Summary

8.2.13 On the basis of the above, it is concluded that overall, the limited soil contamination identified on site does not present a significant risk to human health, in a residential scenario. However; concentrations of arsenic and benzo(a)pyrene were locally found to exceed the GAC and therefore, there is a limited significant risk to human health. Limited remedial works will be required during future development works on site, for the protection of human health of future site occupants and users. These works typically might include delineation of the contaminated soils followed by the import and placement of clean inert cover materials to the delineated areas.

8.2.14 It should be noted that whilst the spread and density of exploratory positions and sampling is considered appropriate for the purpose of the investigation, there may remain areas of unexpected and unknown contamination on site. Observations during future earthworks should be made for any potentially contaminated or deleterious materials, with specialist advice sought at that time to determine the most appropriate course of action.

8.2.15 Further assessment would be required should there be a change in proposed use on site to a more sensitive type, or should the proposed redevelopment encompass a greater or alternative site area than has currently been investigated.

8.2.16 A copy of the certificates of analysis for all chemical laboratory analysis scheduled by JPB at the site is presented in Appendix F.

8.3 Groundwater Chemical Analysis – Controlled Waters

8.3.1 Groundwater was present in sufficient volumes to obtain representative samples for laboratory analysis from two boreholes, WS301 and WS304. The results have been assessed against the Tier 1 criteria, as described previously, based on the site's environmental setting.

8.3.2 The following determinands have been reported at, or below, the laboratory detection limits in every sample tested, and do not require any further assessment:

- Lead
- Total cyanide
- Free cyanide
- Sulphide
- Arsenic
- Beryllium
- Cadmium
- Chromium
- Hexavalent chromium
- Nickel
- Mercury
- Phenols
- USEPA 16 PAH
- Aliphatic and Aromatic TPH C_5-C_{44}
- MTBE
- Benzene
- Toluene
- Ethyl benzene
- Xylenes
- Vanadium

8.3.3 None of the concentrations of the determinands encountered above the laboratory detection limits were in excess of the Tier 1 criteria, with the exception of selenium. Selenium was encountered in the sample from WS304 at a concentration of 20ug/l, exceeding the conservative drinking water standard of 10ug/l.

Summary

8.3.4 Based on the laboratory analysis, it is concluded that limited determinands encountered in the groundwater are most likely to be attributable to the determinands present within the soil. However, given the very low concentrations and marginal exceedances of the determinands together with the localised nature of their occurrence and that of the groundwater itself, it is considered unlikely that these contaminants present a significant risk to local controlled waters, either groundwater or surface waters. **It is concluded that the elevated determinands recorded within the groundwater do not present a significant risk to controlled waters.**

8.3.5 A copy of the certificates of analysis for all chemical laboratory analysis scheduled by JPB at the site is presented in Appendix F.

8.4 Waste Classification

8.4.1 In addition to considering the potential risk from contamination on site to human health and the environment, an assessment of the waste classification has been undertaken. The assessment has been completed using the CAT-WASTE^{SOIL} service provided by Atkins.

8.4.2 All of the soil results from the site were submitted and the resulting assessment has confirmed that soils tested in this investigation would not be classified as hazardous waste should they be removed for off site disposal. The CAT-WASTE^{SOIL} output sheet is presented in Appendix G.

9.0 CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

9.1.1 A Phase 2 Intrusive Ground Investigation has been carried out by JPB at the site known as Land at Wark Crescent and is the subject of this report. This report has been written for STH and is required in order to determine the shallow and general ground conditions on site. This report also highlights any potential environmental risks and liabilities associated with the future redevelopment of the site, arising from its past and present uses. At the time of writing, it is understood that STH is considering the redevelopment of the site for residential use, although no detailed proposals have been determined.

9.1.2 The shallow Made Ground deposits were noted to be highly variable in terms of thickness, composition and strength across the site and are not generally considered appropriate for use as a founding medium.

9.1.3 The underlying Pelaw Clay derived cohesive strata are broadly considered acceptable for founding purposes. The Pelaw Clay materials would be classified as ‘medium’ volume change potential materials under the NHBC guidance. As such, a minimum founding depth of 1.25m bgl will be applicable assuming restricted new planting or the presence of existing trees or vegetation within influencing distance of the future foundations. Outside the zone of influence of any proposed or existing trees or vegetation the minimum founding depth will be 0.90m bgl provided that a suitable foundation stratum exists at this level (based on the variability of the materials encountered on site). Given that the Made Ground and Pelaw Formation possess variable strength properties and can be considered shrinkable soils, it will be necessary to adopt suspended floors for all future structures.

9.1.4 Assuming a founding depth of 1.25m bgl, provided that a suitable foundation stratum exists at this level, a maximum net allowable bearing pressure of 70kNm^{-2} is considered appropriate for future foundations, so as to limit settlement to less than 25mm. Conventional strip footings are considered appropriate for use for up to two storey traditional brick built structures. Should higher bearing pressures be required then it may be necessary to adopt semi-raft style foundations so as to spread the imposed structural loads over a larger area.

9.1.5 For the purpose of designing sub-surface concrete to BS EN 206-1/BS50, guidance has been obtained from BRE SD1:2005 “Concrete in Aggressive Ground”. The site has been classified as ‘brownfield with static groundwater’ based upon the guidance documentation. The site classifies under the guidance as DS-1 and classifies the ACEC class of the site as AC-1s, as derived from Table C2 in BRE SD1:2005. This corresponds to a Design Chemical Class (DC) of DC-1 assuming a designed working life of 100 years.

9.1.6 The Made Ground materials across the site are noted to be highly variable in composition, strength and thickness and it is considered unlikely that they would form an acceptable medium for highly trafficked service roads.

9.1.7 The various intrusive investigations indicate that the geology at this site is not suited to the use of infiltration style drainage for the collection and disposal of run-off waters as a result of the identified presence of effectively impermeable clay strata across the majority of the site.

9.1.8 Following the gas risk assessment, the gas screening value (GSV) has been calculated using the maximum carbon dioxide concentration i.e. 1.45 by volume in WS303 and the worst case flow rate of 7.6l/hr from WS301. The conservative GSV is therefore calculated to be 0.114l/hr (i.e. 0.015 x 7.6), which places the site in a Characteristic Situation 2 (CS2). This is considered to be 'low risk' and as such, ground gas protection measures will be required in new buildings. The recommended measures are outlined in the CIRIA C665 extract in Appendix D.

9.1.9 It is concluded that overall, the limited soil contamination identified on site does not present a significant risk to human health, in a residential scenario. However; concentrations of arsenic and benzo(a)pyrene were locally found to exceed the GAC and therefore, there is a limited significant risk to human health.

9.1.10 The groundwater assessment has confirmed that limited determinands encountered in the groundwater are attributable to the determinands present within the soil. However, given the low concentrations and marginal exceedances of the determinands and also the localised nature of their occurrence within the groundwater, it is considered unlikely that these contaminants present a significant risk to local controlled waters, either groundwater or surface waters. **It is concluded that the elevated determinands recorded within the groundwater do not present a significant risk to controlled waters.**

9.1.11 An assessment has been completed using the CAT-WASTE^{SOIL} service provided by Atkins. All of the soil results from the site were submitted and the resulting assessment has confirmed that soils tested in this investigation would not be classified as hazardous waste should they be removed for off site disposal.

9.1.12 Reference to the UK Water Industry Research (UKWIR) document, "Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites", has been made and indicates that there may be contaminants on site which may restrict water pipe materials. In view of this, and on the basis of the UKWIR guidance it is considered that chemical contamination present may permeate certain plastic water pipes and as such either wrapped ductile iron pipes with copper connectors or an approved PE-Al-PE barrier pipe system are recommended for potable water supplies.

9.2 Recommendations

9.2.1 As a result of the localised exceedances of the soil GACs, limited remedial works will be required during future development works on site, for the protection of human health of future site occupants and users. These works typically might include delineation of the contaminated soils followed by the import and placement of clean inert cover materials to the delineated areas.

9.2.2 Whilst the assessment has classified a low risk, the JPB CO_2 screening values have been exceeded and it should be noted that this preliminary assessment has been based on a limited number (six) of gas monitoring visits, during relatively high atmospheric pressures. Further gas monitoring visits are **recommended** in order to obtain ground gas data over a range of varying seasonal conditions to fully verify the ground gas regime on site.

9.2.3 It is **recommended** that once a development layout is available that the proposed foundation design is considered on a ‘per plot’ basis and a Foundation Schedule prepared giving details of foundation type, type of ground improvement etc. Given the variation in terms of composition, strength and thickness of the shallow soils this may result in a more economic design than considering the site as a ‘whole’. JPB would be pleased to assist in the preparation of a Foundation Schedule once a development plan has been prepared.

9.2.4 Prior to the pouring of any concrete it is **strongly recommended** that an Engineer checks the chosen formation level for competency.

9.2.5 Intrusive investigation indicates that the geology at this site is **not likely to be suited** to the use of infiltration style drainage for the collection and disposal of run-off waters. As such, it is considered that **attenuation storage will have to be provided** to allow the proposed development to meet its obligations under PPS25. Attenuation storage could take the form of increased thicknesses of sub-base beneath hardstanding or by providing ‘crated’ attenuation cells beneath hardstanding or in garden areas. JPB would be pleased to assist by preparing a Flood Risk Assessment for the site.

9.2.6 The Made Ground materials across the site are noted to be highly variable in composition, strength and thickness and it is considered unlikely that they would form an acceptable medium for highly trafficked service roads. **It is recommended that these Made Ground materials are excavated and replaced with suitable granular engineering materials.** These should be placed and compacted in accordance with an engineering specification, such as the Highways Specification, to ensure that deformation of the pavement under trafficking is within acceptable limits. The incorporation of geotextile reinforcement in the pavement design may result in a cost saving through a reduction in the volume of material to be excavated and replaced. JPB would be pleased to assist further if required.

9.2.7 The water supply company responsible for the site **should be consulted** at the design stage of any redevelopment to confirm whether specialist materials will be required for water supply pipes.

9.2.8 The recycling and reuse of materials on site **should be promoted** wherever possible to reduce waste. Therefore, during development, validation testing should be carried out on the materials to ensure their suitability in terms of chemical and physical characteristics. Any imported materials should also be subject to chemical and physical analysis to ensure that they are fit for use on site.

9.2.9 All soils for disposal require pre-treatment, which may involve screening, sorting or chemical treatment, for example, to promote the reduction in volume of wastes being landfilled, to promote recycling and/or to render materials more chemically inert. Any materials requiring off site disposal are likely to be classified as non-hazardous / inactive wastes, although it is **recommended** that confirmation of this is sought from the local landfill operator.

10.0 GENERAL

10.1 Whilst confident in the findings of our report we are unable to give an assurance that they will be accepted by the authorities without question. We therefore advise that where appropriate our report and associated matters are submitted to approving bodies and approval obtained or sought before detailed design, site works or other irrevocable action is embarked upon.

10.2 The recommendations contained in this report do not constitute any form of specification for the undertaking of the works required.

10.3 It should be noted that soil and rock conditions are highly variable and may differ between sampling points and this may affect interpolation. Additionally features may exist buried at depth and undetected by investigation. Other information may become available on the conditions of the site not available at the date of this report and thus site assessment may be subject to amendment in the light of such additional information becoming available.

10.4 The conclusions reached in this report are necessarily restricted to those that can be determined from the information consulted and may be subject to amendment in the light of additional information becoming available.

10.5 This report and related documents have been prepared for the sole use of the specified client in response to an agreed brief, for a stated purpose and at a particular time and its application must be made accordingly. No duty of care extends to any other party who may make use of the information contained therein

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Drawings

N

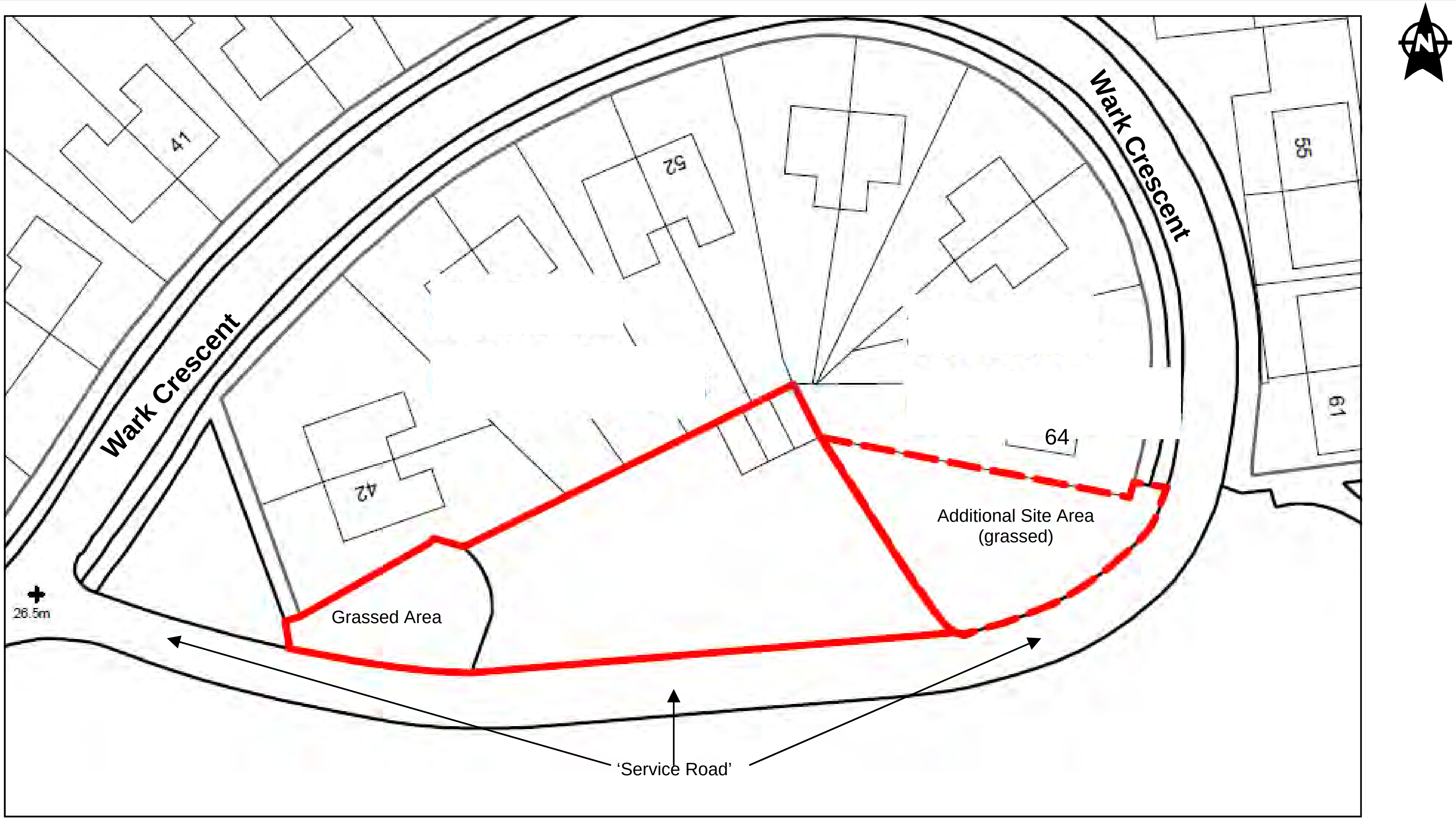
Key -

○ Site Location

JOHNSON POOLE & BLOOMER
CONSULTANTS

Engineer DM	Client	SOUTH TYNESDIE HOMES	Title	GENERAL SITE LOCATION
Checked FT	Project	LAND AT WARK CRESCENT		
Approved ACJ	Date 22-11-13	Scale As shown	Drawing	NB503/05

This Plan is based upon the Ordnance Survey Map with the sanction of the Controller of H.M. Stationery Office. Crown Copyright AL 100002652.

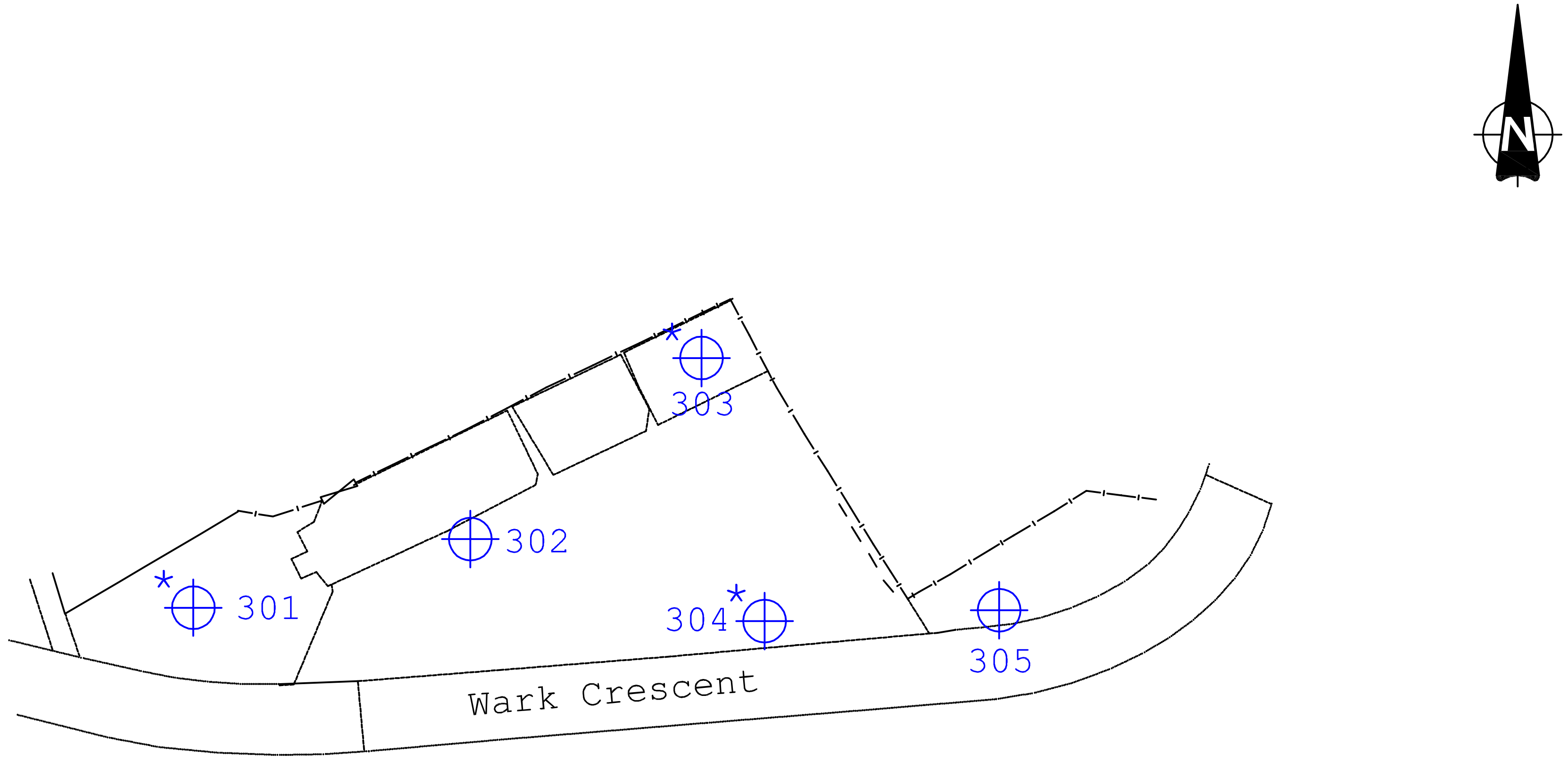


Key -

— Site Boundaries

JOHNSON POOLE & BLOOMER
CONSULTANTS

Engineer DM	Client	SOUTH TYNESIDE HOMES	Title	SITE BOUNDARIES AND LAYOUT
Checked FT	Project	LAND AT WARK CRESCENT		
Approved ACJ	Date 22-11-13	Scale N.T.S.	Drawing	NB503/06



Key

⊕ 302 Window Sample Hole

*⊕ 301 Installed Window Sample Hole

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Tel 01384 262000 www.jpb.co.uk

Engineer
DM

Checked
FT

Approved
ACJ

Client South Tyneside Homes Limited

Project Wark Crescent, Jarrow

Date 29/01/14

Scale 1:500 @ A4

Title Exploratory Hole Positions

Drawing NB503/16

Appendices

Appendix A

Information Consulted

INFORMATION CONSULTED:

In preparation of this report, the following information has been consulted:

General

- JPB Archive
- Historical Ordnance Survey Plans
- Coal Authority Gazetteer, Law Society Guidance Notes and Directory of Coal Mining Searches 2006

Environmental Setting

- British Geological Survey Sheet No SJ 90 SE, 1:10,000 scale and Sheet 153 1:50,000 scale, solid & drift edition;
- British Geological Survey website – http://www.bgs.ac.uk;
- Department of the Environment (1991) "Review of Mining Instability in Great Britain";
- GroundSure Report (EnviroInsight) dated 12 August 2013 and referenced CMAPS-CM-250108-4283-120813;
- Guide to Good Practice for the Development of Conceptual Models and the Selection and Application of Mathematical Models of Contaminant Transport Processes in the Subsurface - National Groundwater & Contaminated Land Centre report NC/99/38/2, Environment Agency 2001.
- Environment Agency Groundwater Vulnerability Map, Sheet 22, South Staffordshire and East Shropshire;
- Environment Agency website - http://www.environment-agency.gov.uk;
- Linesearch website – http://www.linesearch.org/;
- MAGIC website – http://www.magic.gov.uk/website/magic.
- Building Research Establishment 211 - 'Radon: guidance on protective measures for new dwellings'
- Indicative Atlas of Radon in England and Wales, Health Protection Agency (HPA) and British Geological Society (BGS), 2007

Environmental Risk Assessment

- CLR8: Potential Contaminants for the Assessment of Land, DEFRA 2002
- Department of the Environment Industry Profiles
- Environment Agency (March 2010) Guiding Principles for Land Contamination - GPLC1, GPLC2 and GPLC3
- Environment Agency (January 2009) Science Report SC050021/SR3 – Updated technical background to the CLEA model
- Environment Agency (January 2009) Science Report SC050021/SR4 – CLEA Software (Version 1.04) Handbook
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Appendix B

Exploratory Hole Logs

Windowless Sample Borehole Logs

JOHNSON POOLE & BLOOMER AGS

			Site Wark Crescent, Jarrow	**Number** **301**
Excavation Method Drive-in Window Sampler	**Dimensions** 101mm to 1.00m 83mm to 2.00m 77mm to 4.00m	**Ground Level (mOD)** 26.08	**Client** South Tyneside Homes Ltd	**Job Number** NB503-W
	Location See JPB drawing NB503/16	**Dates** 10/01/2014	**Engineer** Johnson Poole & Bloomer Ltd	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description
0.10	EA				(0.25)	MADE GROUND: Grass over soft dark brown slightly silty CLAY. Occasional gravel sized fragments of sub angular fine brick, quartzite, glass and tile.
				25.83	0.25	
0.50	EB					Firm light brown mottled light grey CLAY. Occasional fine rootlets.
0.60	D1				(0.75)	
0.70	V1 74 kNm2					
				25.08	1.00	Stiff chocolate brown slightly gravelly CLAY. Gravel of sub rounded fine to coarse quartzite, sandstone, mudstone and coal.
1.00-1.45	SPT N=11		2,2/2,2,3,4			
1.50	D2					
1.60	V2 85 kNm2					
1.90	V3 110 kNm2					
2.00-2.45	SPT N=19		3,3/3,4,5,7			
2.50	D3					
3.00-3.45	SPT N=14		2,2/2,3,4,5			
3.70	V4 80 kNm2				(5.45)	
4.00-4.45	SPT N=14		3,3/3,3,3,5			
4.55-5.00	U1					
5.00-5.45	SPT N=15		2,2/3,3,4,5			
5.60	V5 57 kNm2					
5.80	D4					
6.00-6.45	SPT N=21		3,3/4,5,6,6			
				19.63	6.45	
						Complete at 6.45m

Remarks
Exploratory hole checked for services prior to drilling by JPB Engineer.
Groundwater was not encountered during drilling.
Upon completion exploratory hole installed with combined gas and groundwater monitoring standpipe. GL to 0.10 metal cover set in concrete, 0.10 to 0.25m plain pipe with bentonite surround, 0.25m to 1.00m slotted pipe with gravel surround and 1.00m to 6.45m backfilled with natural arisings.
V = Hand held shear vane, E = Environmental sample, D = Disturbed sample, U = Undisturbed sample
Exploratory hole completed at 6.45m on the instruction of JPB Engineer.

Scale (approx) 1:40	**Logged By** DM
Figure No. NB503.301	

JOHNSON POOLE & BLOOMER AGS

Site	Wark Crescent, Jarrow			**Number** 302
Excavation Method Drive-in Window Sampler	**Dimensions** 101mm to 1.00m 83mm to 2.00m 77mm to 4.00m	**Ground Level (mOD)** 26.11	**Client** South Tyneside Homes Ltd	**Job Number** NB503-W
	Location See JPB drawing NB503/16	**Dates** 10/01/2014	**Engineer** Johnson Poole & Bloomer Ltd	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records
0.40	D1		
0.60	D2		
0.70	EA		
0.70	V1 48 kNm2		
0.90	D3		
0.90	V2 61 kNm2		
1.00-1.45	SPT N=9		2,2/2,2,2,3
1.60	V3 61 kNm2		
1.80	D4		
1.90	V4 91 kNm2		
2.00-2.45	SPT N=11		3,3/2,3,3,3
2.50	EB		
2.50	V5 52 kNm2		
2.55-3.00	U1		
3.00-3.45	SPT N=7		2,1/2,1,2,2
3.80	V6 30 kNm2		
3.90	D5		
4.00-4.45	SPT N=15		3,3/3,3,4,5
4.80	V7 50 kNm2		
5.00-5.45	SPT N=19		3,3/3,3,6,7
5.50	D6		
6.00-6.45	SPT N=21		4,4/4,5,5,7

Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
26.01	(0.10) 0.10	MADE GROUND: Black TARMACADAM.		
25.51	(0.50) 0.60	MADE GROUND: Maroon brown slightly clayey GRAVEL sized fragments of sub angular to angular fine to coarse brick and mudstone		
25.31	(0.20) 0.80	Firm black to dark grey slightly gravelly CLAY. Gravel of sub rounded fine and medium quartzite.		
25.11	(0.20) 1.00	Firm light brown mottled light grey CLAY. Occasional fine rootlets.		
23.11	(2.00) 3.00	Firm chocolate brown CLAY.		
21.91	(1.20) 4.20	Soft chocolate brown CLAY.		
19.66	(2.25) 6.45	Soft to firm chocolate brown slightly gravelly CLAY. Gravel of sub rounded fine quartzite and mudstone.		
		Complete at 6.45m		

Remarks
Exploratory hole checked for services prior to drilling by JPB Engineer.
Groundwater was not encountered during drilling.
Upon completion exploratory hole was backfilled with lightly compacted natural arisings.
V = Hand held shear vane, E = Environmental sample, D = Disturbed sample, U = Undisturbed sample
Exploratory hole completed at 6.45m on the instruction of JPB Engineer.

Scale (approx)	**Logged By**
1:40	DM
Figure No.	NB503.302

JOHNSON POOLE & BLOOMER AGS

Site	Wark Crescent, Jarrow			**Number** 303
Excavation Method Drive-in Window Sampler	**Dimensions** 101mm to 1.00m 83mm to 2.00m 77mm to 4.00m	**Ground Level (mOD)** 25.91	**Client** South Tyneside Homes Ltd	**Job Number** NB503-W
	Location See JPB drawing NB503/16	**Dates** 10/01/2014	**Engineer** Johnson Poole & Bloomer Ltd	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records
0.40	EA		
0.80	D1		
0.90	V1 39 kNm2		
0.90	EB		
1.00-1.45	SPT N=7		1,1/2,1,2,2
1.20	D2		
1.70	V2 79 kNm2		
1.90	D3		
2.00-2.45	SPT N=11		2,2/2,2,3,4
2.55-3.00	U1		
3.00-3.45	SPT N=10		2,2/2,2,3,3
3.50	V3 40 kNm2		
3.60	D4		
3.90	V4 40 kNm2		
4.00-4.45	SPT N=9		1,1/2,1,2,4
4.80	V5 48 kNm2		
4.80	D5		
5.00-5.45	SPT N=16		3,3/3,4,4,5
6.00-6.45	SPT N=19		3,3/4,4,5,6

Level (mOD)	Depth (m) (Thickness)	Description
25.80	(0.11) 0.11	MADE GROUND: CONCRETE. 60% clasts.
25.16	(0.64) 0.75	MADE GROUND: Brown mottled red and black slightly clayey GRAVEL sized fragments of sub angular to angular fine to coarse brick, concrete and quartzite.
24.91	(0.25) 1.00	MADE GROUND: Brown mottled light brown slightly gravelly CLAY. Gravel sized fragments of sub angular to sub rounded fine and medium brick, coal and quartzite.
24.51	(0.40) 1.40	Firm light orangey brown mottled light grey CLAY.
22.91	(1.60) 3.00	Stiff chocolate brown mottled grey CLAY. Occasional fine rootlets.
21.51	(1.40) 4.40	Soft to firm chocolate brown CLAY.
19.46	(2.05) 6.45	Firm chocolate brown slightly gravelly CLAY. Gravel of sub rounded fine sandstone, mudstone, coal and quartzite.

Complete at 6.45m

Remarks
Exploratory hole checked for services prior to drilling by JPB Engineer.
Groundwater was not encountered during drilling.
Upon completion exploratory hole installed with combined gas and groundwater monitoring standpipe. GL to 0.10 metal cover set in concrete, 0.10 to 1.00m plain pipe with bentonite surround, 1.00m to 1.40m slotted pipe with gravel surround and 1.40m to 6.45m backfilled with natural arisings.
V = Hand held shear vane, E = Environmental sample, D = Disturbed sample, U = Undisturbed sample
Exploratory hole completed at 6.45m on the instruction of JPB Engineer.

Scale (approx) 1:40	**Logged By** DM
Figure No. NB503.303	

JOHNSON POOLE & BLOOMER AGS

Site	Wark Crescent, Jarrow		**Number** **304**
Excavation Method Drive-in Window Sampler	**Dimensions** 101mm to 1.00m 83mm to 2.00m 77mm to 4.00m	**Ground Level (mOD)** 25.77	**Client** South Tyneside Homes Ltd
	Location See JPB drawing NB503/16	**Dates** 10/01/2014	**Engineer** Johnson Poole & Bloomer Ltd

Job Number NB503-W

Sheet 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
				25.65	(0.12) 0.12	MADE GROUND: Black TARMACADAM.			
				25.47	(0.18) 0.30	MADE GROUND: Reddish orange GRAVEL sized fragments of sub angular fine and medium brick.			
0.30	EA								
				25.27	(0.20) 0.50	Firm dark grey CLAY. Occasional gravel of sub angular fine coal.			
					(0.50)	Firm light brown mottled light grey CLAY.			
0.80	D1								
0.90	V1 64 kNm2								
1.00-1.45	SPT N=9		2,2/2,2,2,3	24.77	1.00	Stiff chocolate brown CLAY. Occasional lenses of silt.			
1.50	EB								
1.50	D2								
1.60	V2 80 kNm2								
1.90	D3								
2.00-2.45	SPT N=9		2,2/2,2,2,3		(2.00)				
2.70	D4								
3.00-3.45	SPT N=9		2,2/2,2,2,3	22.77	3.00	Soft chocolate brown CLAY.			
3.50	V3 50 kNm2								
3.80	D5								
4.00-4.45	SPT N=8		2,2/2,2,2,2						
					(2.60)				
4.70	V4 32 kNm2								
5.00-5.45	SPT N=16		2,2/3,4,4,5						
5.55-6.00	U1			20.17	5.60	Firm chocolate brown slightly gravelly CLAY. Gravel of sub rounded fine coal, sandstone and quartzite.			
6.00-6.45	SPT N=19		3,4/4,4,5,6		(0.85)				
				19.32	6.45				
						Complete at 6.45m			

Remarks
Exploratory hole checked for services prior to drilling by JPB Engineer.
Groundwater was not encountered during drilling.
Upon completion exploratory hole installed with combined gas and groundwater monitoring standpipe. GL to 0.10 metal cover set in concrete, 0.10 to 1.00m plain pipe with bentonite surround, 1.00m to 3.50m slotted pipe with gravel surround and 3.50m to 6.45m backfilled with natural arisings.
V = Hand held shear vane, E = Environmental sample, D = Disturbed sample, U = Undisturbed sample
Exploratory hole completed at 6.45m on the instruction of JPB Engineer.

Scale (approx)	**Logged By**
1:40	DM

Figure No.
NB503.304

JOHNSON POOLE & BLOOMER AGS

Site	Wark Crescent, Jarrow			**Number** 305
Excavation Method Drive-in Window Sampler	**Dimensions** 101mm to 1.00m 83mm to 2.00m 77mm to 4.00m	**Ground Level (mOD)** 25.54	**Client** South Tyneside Homes Ltd	**Job Number** NB503-W
	Location See JPB drawing NB503/16	**Dates** 10/01/2014	**Engineer** Johnson Poole & Bloomer Ltd	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					(0.70)	MADE GROUND: Grass over soft dark brown slightly silty CLAY. Occasional gravel sized fragments of sub angular coal and brick.		
0.50	V1 43 kNm2							
0.50	D1							
0.70	D2			24.84	0.70	Firm light brown CLAY.		
					(0.30)			
0.80	EA							
0.90	V2 55 kNm2			24.54	1.00	Firm to stiff chocolate brown CLAY. Occasional lenses of silt.		
1.00-1.45	SPT N=11		2,2/2,2,3,4					
1.50	V3 64 kNm2				(1.20)			
1.60	D3							
2.00-2.45	SPT N=17		3,2/4,4,4,5					
				23.34	2.20	Stiff chocolate brown gravelly CLAY. Gravel of sub rounded fine to coarse quartzite, coal, sandstone and mudstone.		
					(0.80)			
2.60	V4 118 kNm2							
2.90	D4							
3.00-3.45	SPT N=14		2,2/2,4,4,4	22.54	3.00	Firm chocolate brown gravelly CLAY. Gravel of sub rounded fine to coarse quartzite, coal, sandstone and mudstone.		
3.55-4.00	U1							
4.00-4.45	SPT N=17		3,3/4,4,4,5					
4.60	V5 54 kNm2				(3.45)			
4.60	D5							
5.00-5.45	SPT N=12		2,1/3,2,3,4					
6.00-6.45	SPT N=19		3,3/4,5,5,5					
				19.09	6.45	Complete at 6.45m		

Remarks
Exploratory hole checked for services prior to drilling by JPB Engineer.
Groundwater was not encountered during drilling.
Upon completion exploratory hole was backfilled with lightly compacted natural arisings.
V = Hand held shear vane, E = Environmental sample, D = Disturbed sample, U = Undisturbed sample
Exploratory hole completed at 6.45m on the instruction of JPB Engineer.

Scale (approx)	**Logged By**
1:40	DM
Figure No.	
NB503.305	

Appendix C

Geotechnical Laboratory Testing Results

2788

Laboratory
Report

GSTL
GEO Site & Testing Services Ltd

Contract Number: 22128

Client's Reference: **NB503-W PO5616**

Report Date: **07-02-2014**

Client **Johnson Poole & Bloomer (Midlands)**
Harris & Pearson Building
Brettell Lane
Brierley Hill
West Midlands
DY5 3LH

Contract Title: **Wark Crescent, Jarrow**
For the attention of: **Julian Charlesworth**

Date Received: **27-01-2014**
Date Commenced: **27-01-2014**
Date Completed: **07-02-2014**

Test Description	Qty
Moisture Content 1377 : 1990 Part 2 : 3.2 - UKAS *	5.0
4 Point Liquid & Plastic Limit (LL/PL) 1377 : 1990 Part 2 : 4.3 & 5.3 - UKAS *	5.0

Notes: **Observations and Interpretations are outside the UKAS Accreditation**
*** - denotes test included in laboratory scope of accreditation**
 # - denotes test carried out by approved contractor

Approved Signatories:
Alex Wynn (Associate Director) - Benjamin Sharp (Contracts Manager) - Emma Williams (Office Manager)
Paul Evans (Quality/Technical Manager) - Vaughan Edwards (Managing Director)

Client ref: NB503-W

Location: Wark Crescent, Jarrow

Contract Number: 22128-270114

Hole Number	Sample Number	Type	Depth (m)	Description of Sample*
301		D	0.60	Brown fine gravelly silty CLAY.
301		D	1.50	Brown fine gravelly silty CLAY.
303		D	0.80	Brown sandy clayey SILT.
303		D	1.20	Brown slightly sandy clayey SILT.
303		D	3.60	Brown clayey SILT.

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

GSTL
GEO Site & Testing Services Limited

Checked By

D P Evans
Approved By:

Date Approved: 7.2.14

Test Report: **Method of the Determination of the plastic limit and plasticity index**
BS 1377 : Part 2 : 1990 Method 5

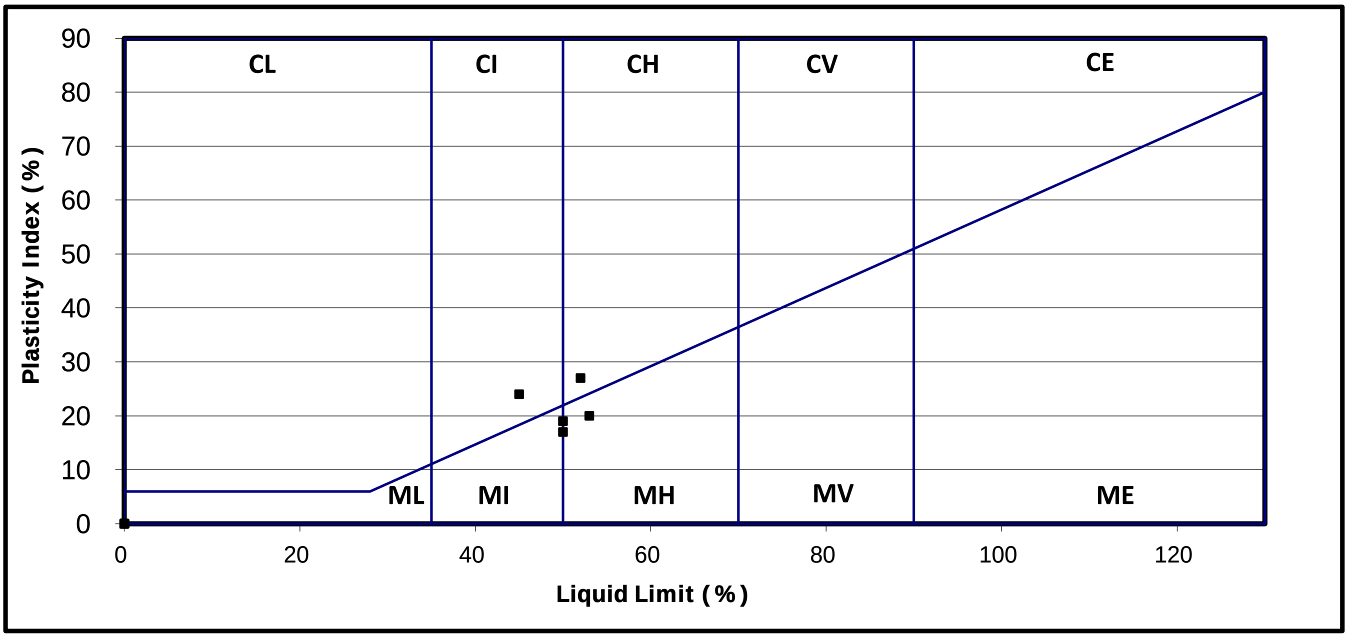
Client ref: **NB503-W**
Location: **Wark Crescent, Jarrow**
Contract Number: **22128-270114**

Hole / Sample Number	Sample Type	Depth m	Moisture Content % Cl. 3.2	Liquid Limit % Cl. 4.3/4.4	Plastic Limit % Cl. 5.	Plasticity Index % Cl. 6.	% Passing .425mm	Remarks
301	D	0.60	31.8	52	25	27	95	CH High Plasticity
301	D	1.50	18.6	45	21	24	97	CI Intermediate Plasticity
303	D	0.80	39.3	50	31	19	100	MI/H Inter/High Plasticity
303	D	1.20	35.7	50	33	17	100	MI/H Inter/High Plasticity
303	D	3.60	39.5	53	33	20	100	MH High Plasticity

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

PLASTICITY CHART FOR CASAGRANDE CLASSIFICATION.

BS 5930:1999+A2:2010



GEO Site & Testing Services Limited

Checked By

Approved By:

Date Approved: 7.2.14

UKAS TESTING 2788

Appendix D

Gas and Groundwater Monitoring Results

JPB GAS MONITORING DATA		
Site Name	Wark crescent, Jarrow	**Project Number**
Project Manager	Fiona Townley	NB503

INSTRUMENTATION

GAS CONCENTRATIONS

	VISIT 1	VISIT 2	VISIT 3	VISIT 4	VISIT 5	VISIT 6
Geotech Instruments GA5000	✓	✓	✓	✓	✓	✓
Geotech Instruments GA2000						

GAS FLOW

Geotech Instruments Inbuilt Flow Pod	✓	✓	✓	✓	✓	✓
Geotech Instruments Flow Pod						

Date	21/01/2014	**Weather**	Sunny but cold with falling pressure
Engineer	DM	**Atmospheric Pressure**	1003

Gas Readings at Borehole		**301**		**Surface level (mAOD)**		**26.08**		**Comments**				
Time	**CH_4 %vol**	**CO_2 % vol**	**O_2 % vol**	**N_2 % vol**	**H_2S ppm**	**CO ppm**	**Atmos Pressure (mb)**	**Diff Pressure (Pa)**	**Ave Flow (l/h)**	**G/water Depth (m)**	**Depth of BH (m)**	**Water Level (mAOD)**
Initial	0.0	0.2	20.8		0	0	1003	7.51	0	0.2	1.1	25.88
30s	0.0	0.7	20.0		0	1			7.6			
60s									7.1			
90s									6.7			
120s									6.3			
150s									6			
180s									5.6			
210s												
240s												
270s												
300s												

Gas Readings at Borehole		**303**		**Surface level (mAOD)**		**25.91**		**Comments**				
Time	**CH_4 %vol**	**CO_2 % vol**	**O_2 % vol**	**N_2 % vol**	**H_2S ppm**	**CO ppm**	**Atmos Pressure (mb)**	**Diff Pressure (Pa)**	**Ave Flow (l/h)**	**G/water Depth (m)**	**Depth of BH (m)**	**Water Level (mAOD)**
Initial	0.0	0.3	20.8		0	0	1003	0	0	Dry	1.46	
30s	0.0	0.2	20.9		0	0			0.1			
60s	0.0	0.2	20.9		0	0			0.1			
90s									0.1			
120s									0.1			
150s									0.1			
180s									0.1			
210s												
240s												
270s												
300s												

Gas Readings at Borehole		**304**		**Surface level (mAOD)**		**25.77**		**Comments**				
Time	**CH_4 %vol**	**CO_2 % vol**	**O_2 % vol**	**N_2 % vol**	**H_2S ppm**	**CO ppm**	**Atmos Pressure (mb)**	**Diff Pressure (Pa)**	**Ave Flow (l/h)**	**G/water Depth (m)**	**Depth of BH (m)**	**Water Level (mAOD)**
Initial	0.0	0.2	21.0		0	0	1003	-2.27	0	0.46	3.5	25.31
30s	0.0	1.4	19.3		0	3			-12.4			
60s	0.0	1.4	18.9		0	3			-11.4			
90s									-11			
120s									-8.8			
150s									-8			
180s									-7.1			
210s												
240s												
270s												
300s												

Date	27/01/2014	**Weather**	cold and cloudy with level pressure
Engineer	DM	**Atmospheric Pressure**	979

Gas Readings at Borehole		**301**		**Surface level (mAOD)**		**26.08**		**Comments**		**Submerged**		
Time	**CH_4 %vol**	**CO_2 % vol**	**O_2 % vol**	**N_2 % vol**	**H_2S ppm**	**CO ppm**	**Atmos Pressure (mb)**	**Diff Pressure (Pa)**	**Ave Flow (l/h)**	**G/water Depth (m)**	**Depth of BH (m)**	**Water Level (mAOD)**
Initial										**0**	**1.1**	**26.08**
30s												
60s												
90s												
120s												
150s												
180s												
210s												
240s												
270s												
300s												

Gas Readings at Borehole		**303**		**Surface level (mAOD)**		**25.91**		**Comments**		**Water up tube**		
Time	**CH_4 %vol**	**CO_2 % vol**	**O_2 % vol**	**N_2 % vol**	**H_2S ppm**	**CO ppm**	**Atmos Pressure (mb)**	**Diff Pressure (Pa)**	**Ave Flow (l/h)**	**G/water Depth (m)**	**Depth of BH (m)**	**Water Level (mAOD)**
Initial	**0.0**	**0.2**	**20.8**		**0**	**0**	**979**	**0.03**	**0**	**Dry**	**1.46**	
30s	**0.0**	**1.5**	**19.4**		**0**	**0**			**0.2**			
60s	**0.0**	**1.5**	**19.3**		**0**	**0**			**0.2**			
90s									**0.2**			
120s									**0.2**			
150s									**0.2**			
180s									**0.2**			
210s												
240s												
270s												
300s												

Gas Readings at Borehole		**304**		**Surface level (mAOD)**		**25.77**		**Comments**		**Water up tube**		
Time	**CH_4 %vol**	**CO_2 % vol**	**O_2 % vol**	**N_2 % vol**	**H_2S ppm**	**CO ppm**	**Atmos Pressure (mb)**	**Diff Pressure (Pa)**	**Ave Flow (l/h)**	**G/water Depth (m)**	**Depth of BH (m)**	**Water Level (mAOD)**
Initial	**0.0**	**0.2**	**20.7**		**0**	**0**	**978**	**3.69**	**0**	**0.1**	**3.49**	**25.67**
30s									**0.1**			
60s									**0.1**			
90s									**0**			
120s									**0**			
150s									**0**			
180s									**0**			
210s												
240s												
270s												
300s												

Date	04/02/2014	**Weather**	Overcast and cold with falling pressure
Engineer	DM	**Atmospheric Pressure**	992

Gas Readings at Borehole		**301**		**Surface level (mAOD)**		**26.08**		**Comments**		**Submerged**		
Time	**CH_4 %vol**	**CO_2 % vol**	**O_2 % vol**	**N_2 % vol**	**H_2S ppm**	**CO ppm**	**Atmos Pressure (mb)**	**Diff Pressure (Pa)**	**Ave Flow (l/h)**	**G/water Depth (m)**	**Depth of BH (m)**	**Water Level (mAOD)**
Initial												**26.08**
30s												
60s												
90s												
120s												
150s												
180s												
210s												
240s												
270s												
300s												

Gas Readings at Borehole		**303**		**Surface level (mAOD)**		**25.91**		**Comments**				
Time	**CH_4 %vol**	**CO_2 % vol**	**O_2 % vol**	**N_2 % vol**	**H_2S ppm**	**CO ppm**	**Atmos Pressure (mb)**	**Diff Pressure (Pa)**	**Ave Flow (l/h)**	**G/water Depth (m)**	**Depth of BH (m)**	**Water Level (mAOD)**
Initial	**0.1**	**0.2**	**21.0**		**0**	**0**	**992**	**0.12**	**0**	**0.81**	**1.46**	**25.1**
30s	**0.1**	**0.3**	**20.9**		**0**	**1**			**0.2**			
60s	**0.1**	**0.3**	**20.9**		**0**	**0**			**0.3**			
90s									**0.3**			
120s									**0.3**			
150s									**0.3**			
180s									**0.3**			
210s												
240s												
270s												
300s												

Gas Readings at Borehole		**304**		**Surface level (mAOD)**		**25.77**		**Comments**				
Time	**CH_4 %vol**	**CO_2 % vol**	**O_2 % vol**	**N_2 % vol**	**H_2S ppm**	**CO ppm**	**Atmos Pressure (mb)**	**Diff Pressure (Pa)**	**Ave Flow (l/h)**	**G/water Depth (m)**	**Depth of BH (m)**	**Water Level (mAOD)**
Initial	**0.1**	**0.2**	**20.9**		**0**	**0**	**992**	**0.02**	**0**	**1.05**	**3.5**	**24.72**
30s	**0.1**	**0.2**	**20.9**		**0**	**0**			**0.1**			
60s	**0.1**	**0.2**	**20.9**		**0**	**0**			**0.2**			
90s									**0.2**			
120s									**0.2**			
150s									**0.2**			
180s									**0.2**			
210s												
240s												
270s												
300s												

Date	11/02/2014	**Weather**	Overcast with falling pressure
Engineer	DM	**Atmospheric Pressure**	983

Gas Readings at Borehole		**301**		**Surface level (mAOD)**		**26.08**		**Comments**		**Submerged**		
Time	**CH_4 %vol**	**CO_2 % vol**	**O_2 % vol**	**N_2 % vol**	**H_2S ppm**	**CO ppm**	**Atmos Pressure (mb)**	**Diff Pressure (Pa)**	**Ave Flow (l/h)**	**G/water Depth (m)**	**Depth of BH (m)**	**Water Level (mAOD)**
Initial												**26.08**
30s												
60s												
90s												
120s												
150s												
180s												
210s												
240s												
270s												
300s												

Gas Readings at Borehole		**303**		**Surface level (mAOD)**		**25.91**		**Comments**				
Time	**CH_4 %vol**	**CO_2 % vol**	**O_2 % vol**	**N_2 % vol**	**H_2S ppm**	**CO ppm**	**Atmos Pressure (mb)**	**Diff Pressure (Pa)**	**Ave Flow (l/h)**	**G/water Depth (m)**	**Depth of BH (m)**	**Water Level (mAOD)**
Initial	**0.1**	**0.2**	**21.4**		**0**	**0**	**983**	**0.05**	**0**	**0.85**	**1.46**	**25.06**
30s	**0.2**	**0.2**	**21.4**		**0**	**1**			**0.1**			
60s	**0.2**	**0.2**	**21.4**		**0**	**1**			**0.2**			
90s									**0.2**			
120s									**0.2**			
150s									**0.2**			
180s									**0.2**			
210s												
240s												
270s												
300s												

Gas Readings at Borehole		**304**		**Surface level (mAOD)**		**25.77**		**Comments**				
Time	**CH_4 %vol**	**CO_2 % vol**	**O_2 % vol**	**N_2 % vol**	**H_2S ppm**	**CO ppm**	**Atmos Pressure (mb)**	**Diff Pressure (Pa)**	**Ave Flow (l/h)**	**G/water Depth (m)**	**Depth of BH (m)**	**Water Level (mAOD)**
Initial	**0.2**	**0.2**	**21.4**		**0**	**0**	**983**	**0.39**	**0**	**0.91**	**3.49**	**24.86**
30s	**0.2**	**0.2**	**21.3**		**0**	**0**			**0.3**			
60s	**0.2**	**0.2**	**21.3**		**0**	**0**			**0.3**			
90s									**0.3**			
120s									**0.3**			
150s									**0.3**			
180s									**0.3**			
210s												
240s												
270s												
300s												

Date	18/02/2014	**Weather**	light rain with level pressure
Engineer	DM	**Atmospheric Pressure**	1003

Gas Readings at Borehole		**301**		**Surface level (mAOD)**		**26.08**		**Comments**		**Submerged**		
Time	**CH_4 %vol**	**CO_2 % vol**	**O_2 % vol**	**N_2 % vol**	**H_2S ppm**	**CO ppm**	**Atmos Pressure (mb)**	**Diff Pressure (Pa)**	**Ave Flow (l/h)**	**G/water Depth (m)**	**Depth of BH (m)**	**Water Level (mAOD)**
Initial												**26.08**
30s												
60s												
90s												
120s												
150s												
180s												
210s												
240s												
270s												
300s												

Gas Readings at Borehole		**303**		**Surface level (mAOD)**		**25.91**		**Comments**				
Time	**CH_4 %vol**	**CO_2 % vol**	**O_2 % vol**	**N_2 % vol**	**H_2S ppm**	**CO ppm**	**Atmos Pressure (mb)**	**Diff Pressure (Pa)**	**Ave Flow (l/h)**	**G/water Depth (m)**	**Depth of BH (m)**	**Water Level (mAOD)**
Initial	**0.0**	**0.1**	**21.3**		**0**	**0**	**1003**	**0.02**	**0**	**0.85**	**1.46**	**25.06**
30s	**0.0**	**0.1**	**21.3**		**0**	**0**			**0.2**			
60s	**0.0**	**0.1**	**21.3**		**0**	**0**			**0.2**			
90s									**0.2**			
120s									**0.2**			
150s									**0.2**			
180s									**0.2**			
210s												
240s												
270s												
300s												

Gas Readings at Borehole		**304**		**Surface level (mAOD)**		**25.77**		**Comments**				
Time	**CH_4 %vol**	**CO_2 % vol**	**O_2 % vol**	**N_2 % vol**	**H_2S ppm**	**CO ppm**	**Atmos Pressure (mb)**	**Diff Pressure (Pa)**	**Ave Flow (l/h)**	**G/water Depth (m)**	**Depth of BH (m)**	**Water Level (mAOD)**
Initial	**0.1**	**0.1**	**21.4**		**0**	**0**	**1003**	**-0.34**	**0**	**0.89**	**3.5**	**24.88**
30s	**0.0**	**0.1**	**21.4**		**0**	**0**			**0.1**			
60s	**0.0**	**0.1**	**21.4**		**0**	**0**			**0.2**			
90s									**0.2**			
120s									**0.1**			
150s									**0.1**			
180s									**0.1**			
210s												
240s												
270s												
300s												

Date	26/02/2014	**Weather**	Sunny, cool, light breeze
Engineer	GP	**Atmospheric Pressure**	1001-1002

Gas Readings at Borehole		**301**		**Surface level (mAOD)**		**26.08**		**Comments**				
Time	**CH_4 %vol**	**CO_2 % vol**	**O_2 % vol**	**N_2 % vol**	**H_2S ppm**	**CO ppm**	**Atmos Pressure (mb)**	**Diff Pressure (Pa)**	**Ave Flow (l/h)**	**G/water Depth (m)**	**Depth of BH (m)**	**Water Level (mAOD)**
Initial	0.1	0.2	20.9		0	0	1002	0.22	0	0.53	1.1	25.55
30s	0.1	0.2	20.9		0	0			0			
60s	0.1	0.2	20.9		0	0			0.1			
90s									0.1			
120s									0.1			
150s									0.1			
180s									0.1			
210s												
240s												
270s												
300s												

Gas Readings at Borehole		**303**		**Surface level (mAOD)**		**25.91**		**Comments**				
Time	**CH_4 %vol**	**CO_2 % vol**	**O_2 % vol**	**N_2 % vol**	**H_2S ppm**	**CO ppm**	**Atmos Pressure (mb)**	**Diff Pressure (Pa)**	**Ave Flow (l/h)**	**G/water Depth (m)**	**Depth of BH (m)**	**Water Level (mAOD)**
Initial	0.1	0.2	20.8		0	0	1001	-0.29	0.1	0.91	1.45	25
30s	0.1	0.2	20.8		0	0			0.2			
60s	0.1	0.2	20.8		0	0			0.2			
90s									0.3			
120s									0.3			
150s									0.3			
180s									0.3			
210s												
240s												
270s												
300s												

Gas Readings at Borehole		**304**		**Surface level (mAOD)**		**25.77**		**Comments**				
Time	**CH_4 %vol**	**CO_2 % vol**	**O_2 % vol**	**N_2 % vol**	**H_2S ppm**	**CO ppm**	**Atmos Pressure (mb)**	**Diff Pressure (Pa)**	**Ave Flow (l/h)**	**G/water Depth (m)**	**Depth of BH (m)**	**Water Level (mAOD)**
Initial	0.1	0.2	20.8		0	0	1001	-0.07	0.1	1.09	3.5	24.68
30s	0.1	0.2	20.8		0	0			0.1			
60s	0.1	0.2	20.8		0	0			0.1			
90s									0.1			
120s									0.1			
150s									0.1			
180s									0.1			
210s												
240s												
270s												
300s												

Modified Wilson and Card Classification and Typical Scope of Protective Measures

Characteristic Situation (CIRIA R149)	Risk Classification	Gas Screening Value (CH_4 or CO_2) (l/hr)	Residential Building (not low rise traditional Housing)		Office / commercial / industrial Development	
			Levels of Protection	**Typical Scope of Protective Measures**	**Levels of Protection**	**Typical Scope of Protective Measures**
1	Very low	<0.07	None	No special precautions	None	No special precautions
2	Low	<0.7	2	a)Reinforced concrete cast in situ floor slab (suspended, non-suspended or raft) with at least 1200 gauge damp proof membrane and under-floor venting b)Beam and block or pre-cast concrete and 2000 gauge damp proof membrane/reinforced gas membrane and under-floor venting All joints and penetrations sealed.	1 to 2	a)Reinforced concrete cast in situ floor slab (suspended, non-suspended or raft) with at least 1200 gauge damp proof membrane and under-floor venting b)Beam and block or pre-cast concrete and 2000 gauge damp proof membrane / reinforced gas membrane and under-floor venting c)Possibly under-floor venting or pressurisation in combination with a) and b) depending on use All joints and penetrations sealed.
3	Moderate	<3.5	2	All types of floor slab as above. All joints and penetrations sealed. Proprietary gas resistant membrane and passively ventilated or positively pressurised under-floor sub-space.	1 to 2	All types of floor slab as above. All joints and penetrations sealed. Minimum 2000g reinforced gas proof membrane and passively vented under-floor sub-space or positively pressurised under-floor sub-space.
4	Moderate to High	<15	3	All types of floor slab as above. All joints and penetrations sealed. Proprietary gas resistant membrane and passively ventilated under-floor subspace or positively pressurised under-floor sub-space, over-site capping or blinding and in ground venting layer.	2 to 3	All types of floor slab as above. All joints and penetrations sealed. Proprietary gas resistant membrane and passively vented under-floor sub-space with monitoring facility.
5	High	<70	4	Reinforced concrete cast in-situ floor slab (suspended, non-suspended or raft). All joints and penetrations sealed. Proprietary gas resistant membrane and ventilated or positively pressurised under-floor sub-space, over-site capping and in ground venting layer and in ground venting wells or barriers	3 to 4	Reinforced concrete cast in-situ floor slab (suspended, non-suspended or raft). All joints and penetrations sealed. Proprietary gas resistant membrane and ventilated or positively pressurised under-floor sub-space with monitoring facility. In ground venting wells or barriers.
6	Very High	>70	5	Not suitable unless gas regime is reduced first and quantitative risk assessment carried out to assess design of protection measures in conjunction with foundation design.	4 to 5	Reinforced concrete cast in-situ floor slab (suspended, non-suspended or raft). All joints and penetrations sealed. Proprietary gas resistant membrane and ventilated or positively pressurised under-floor sub-space with monitoring facility. In ground venting wells and reduction of gas regime.

Notes:

This table has been reproduced as a combination of data tabulated in CIRIA C665, without the relevant notes and references.

Reference to the full details and guidance notes within CIRIA C665 should be made for further information or in the event of designing gas protection measures.

This table should be used for general guidance only.

Appendix E

Chemical Laboratory Results

Chemtest
The right chemistry to deliver results

Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070

Johnson Poole & Bloomer Ltd
Harris and Pearson Building
Brettell Lane
Brierly Hill, West Midlands
DY5 3LH

FAO F Townley
23 January 2014

Dear F Townley

Test Report Number **248952**
Your Project Reference **NB503 Wark Crescent**

Please find enclosed the results of analysis for the samples received 15 January 2014.

All soil samples will be retained for a period of one month and all water samples will be retained for 7 days following the date of the test report. Should you require an extended retention period then please detail your requirements in an email to customerservices@chemtest.co.uk. Please be aware that charges may be applicable for extended sample storage.

If you require any further assistance, please do not hesitate to contact the Customer Services team.

Yours sincerely

Keith Jones, Technical Manager

2183

Notes to accompany report:

- *The sign < means 'less than'*
- *Tests marked 'U' hold UKAS accreditation*
- *Tests marked 'M' hold MCertS (and UKAS) accreditation*
- *Tests marked 'N' do not currently hold UKAS accreditation*
- *Tests marked 'S' were subcontracted to an approved laboratory*
- *n/e means 'not evaluated'*
- *i/s means 'insufficient sample'*
- *u/s means 'unsuitable sample'*
- *Comments or interpretations are outside of the scope of UKAS accreditation*
- *The results relate only to the items tested*
- *Stones represent the quantity of material removed prior to analysis*
- *All results are expressed on a dry weight basis*
- *The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, phenols*
- *For all other tests the samples were dried at < 37°C prior to analysis*
- *Uncertainties of measurement for the determinands tested are available upon request*
- *Soil descriptions, including colour and texture, are beyond the scope of MCertS accreditation*
- *None of the test results included in this report have been recovery corrected*

Johnson Poole & Bloomer Ltd
Harris and Pearson Building
Brettell Lane
Brierly Hill, West Midlands
DY5 3LH

FAO F Townley

LABORATORY TEST REPORT

Results of analysis of 4 samples
received 15 January 2014

Report Date
23 January 2014

NB503 Wark Crescent

Login Batch No					**248952**			
Chemtest LIMS ID					AJ68896	AJ68899	AJ68901	AJ68904
Sample ID					301	302	303	304
Sample No								
Sampling Date					10/1/2014	10/1/2014	10/1/2014	10/1/2014
Depth					0.10m	0.70m	0.40m	1.50m
Matrix					*SOIL*	*SOIL*	*SOIL*	*SOIL*
SOP↓	Determinand↓	CAS No↓	Units↓	*				
2030	Moisture		%	M	29.6	21.6	25.8	20.9
	Stones content (>50mm)		%	M	<0.02	<0.02	<0.02	<0.02
2040	Soil colour			M	brown	brown	brown	brown
	Soil texture			M	clay	clay	clay	clay
	Other material			M	roots	none	none	none
2010	pH			M	7.3	7.5	8.1	7.9
2300	Cyanide (free)	57125	mg kg^{-1}	M	<0.50	<0.50	<0.50	<0.50
	Cyanide (total)	57125	mg kg^{-1}	M	<0.50	<0.50	<0.50	<0.50
2625	Total Organic Carbon		%	M	7.5	4.7	4.0	1.5
2120	Boron (hot water soluble)	7440428	mg kg^{-1}	M	0.5	1.2	0.9	<0.4
	Sulfate (2:1 water soluble) as SO4	14808798	g l^{-1}	M	0.02	0.05	0.15	0.06
2490	Chromium (hexavalent)	18540299	mg kg^{-1}	N	<0.5	<0.5	<0.5	<0.5
2450	Arsenic	7440382	mg kg^{-1}	M	9.0	9.2	240	13
	Barium	7440393	mg kg^{-1}	M	170	120	320	150
	Beryllium	7440417	mg kg^{-1}	M	<1.00	<1.00	1.6	1.4
	Cadmium	7440439	mg kg^{-1}	M	0.38	0.26	0.57	0.12
	Chromium	7440473	mg kg^{-1}	M	20	21	30	34
	Copper	7440508	mg kg^{-1}	M	43	31	170	28
	Mercury	7439976	mg kg^{-1}	M	0.16	0.30	1.3	<0.10
	Nickel	7440020	mg kg^{-1}	M	19	16	45	45
	Lead	7439921	mg kg^{-1}	M	120	91	460	41
	Selenium	7782492	mg kg^{-1}	M	<0.20	<0.20	<0.20	<0.20
	Vanadium	7440622	mg kg^{-1}	M	30	29	41	30
	Zinc	7440666	mg kg^{-1}	M	130	77	220	72

All tests undertaken between 16/01/2014 and 23/01/2014

* Accreditation status

This report should be interpreted in conjunction with the notes on the accompanying cover page.

Johnson Poole & Bloomer Ltd
Harris and Pearson Building
Brettell Lane
Brierly Hill, West Midlands
DY5 3LH

FAO F Townley

LABORATORY TEST REPORT

Results of analysis of 4 samples
received 15 January 2014

NB503 Wark Crescent

Report Date
23 January 2014

					248952			
					AJ68896	AJ68899	AJ68901	AJ68904
					301	302	303	304
					10/1/2014	10/1/2014	10/1/2014	10/1/2014
					0.10m	0.70m	0.40m	1.50m
					SOIL	*SOIL*	*SOIL*	*SOIL*
2675	TPH aliphatic >C5-C6		mg kg^{-1}	N	< 0.1	< 0.1	< 0.1	< 0.1
	TPH aliphatic >C6-C8		mg kg^{-1}	N	< 0.1	< 0.1	< 0.1	< 0.1
	TPH aliphatic >C8-C10		mg kg^{-1}	N	< 0.1	< 0.1	< 0.1	< 0.1
	TPH aliphatic >C10-C12		mg kg^{-1}	M	< 1	< 1	< 1	< 1
	TPH aliphatic >C12-C16		mg kg^{-1}	M	< 1	< 1	< 1	< 1
	TPH aliphatic >C16-C21		mg kg^{-1}	M	< 1	< 1	< 1	< 1
	TPH aliphatic >C21-C35		mg kg^{-1}	M	< 1	< 1	< 1	< 1
	TPH aliphatic >C35-C44		mg kg^{-1}	N	< 1	< 1	< 1	< 1
	TPH aromatic >C5-C7		mg kg^{-1}	N	< 0.1	< 0.1	< 0.1	< 0.1
	TPH aromatic >C7-C8		mg kg^{-1}	N	< 0.1	< 0.1	< 0.1	< 0.1
	TPH aromatic >C8-C10		mg kg^{-1}	N	< 0.1	< 0.1	< 0.1	< 0.1
	TPH aromatic >C10-C12		mg kg^{-1}	N	< 1	< 1	< 1	< 1
	TPH aromatic >C12-C16		mg kg^{-1}	M	5.3	< 1	1.4	< 1
	TPH aromatic >C16-C21		mg kg^{-1}	M	23	< 1	8.0	2.2
	TPH aromatic >C21-C35		mg kg^{-1}	N	27	1.6	8.9	5.3
	TPH aromatic >C35-C44		mg kg^{-1}	N	< 1	< 1	< 1	< 1
	Total Petroleum Hydrocarbons		mg kg^{-1}	N	57	< 10	18	< 10
2700	Naphthalene	91203	mg kg^{-1}	M	0.56	0.36	1	< 0.1
	Acenaphthylene	208968	mg kg^{-1}	M	0.22	0.21	0.23	< 0.1
	Acenaphthene	83329	mg kg^{-1}	M	0.57	0.29	0.29	< 0.1
	Fluorene	86737	mg kg^{-1}	M	0.54	0.27	0.32	< 0.1
	Phenanthrene	85018	mg kg^{-1}	M	4.8	2.2	2.7	< 0.1
	Anthracene	120127	mg kg^{-1}	M	1.3	0.59	0.82	< 0.1
	Fluoranthene	206440	mg kg^{-1}	M	6.9	2.6	3.7	< 0.1
	Pyrene	129000	mg kg^{-1}	M	5	1.8	2.9	< 0.1

All tests undertaken between 16/01/2014 and 23/01/2014

* Accreditation status

This report should be interpreted in conjunction with the notes on the accompanying cover page.

LIMS sample ID range AJ68896 to AJ68904

Johnson Poole & Bloomer Ltd
Harris and Pearson Building
Brettell Lane
Brierly Hill, West Midlands
DY5 3LH

FAO F Townley

LABORATORY TEST REPORT

**Results of analysis of 4 samples
received 15 January 2014**

NB503 Wark Crescent

Chemtest
The right chemistry to deliver results

**Report Date
23 January 2014**

					248952			
					AJ68896	AJ68899	AJ68901	AJ68904
					301	302	303	304
					10/1/2014	10/1/2014	10/1/2014	10/1/2014
					0.10m	0.70m	0.40m	1.50m
					SOIL	*SOIL*	*SOIL*	*SOIL*
2700	Benzo[a]anthracene	56553	mg kg^{-1}	M	4	1.3	2.2	< 0.1
	Chrysene	218019	mg kg^{-1}	M	5.1	1.7	2.4	< 0.1
	Benzo[b]fluoranthene	205992	mg kg^{-1}	N	4.1	1.6	2.1	< 0.1
	Benzo[k]fluoranthene	207089	mg kg^{-1}	N	2.9	1.1	1.2	< 0.1
	Benzo[a]pyrene	50328	mg kg^{-1}	M	2.8	0.85	1.3	< 0.1
	Dibenzo[a,h]anthracene	53703	mg kg^{-1}	M	0.65	0.31	0.2	< 0.1
	Indeno[1,2,3-cd]pyrene	193395	mg kg^{-1}	M	2.1	1.1	0.9	< 0.1
	Benzo[g,h,i]perylene	191242	mg kg^{-1}	M	2.5	1.4	1.1	< 0.1
	Total (of 16) PAHs		mg kg^{-1}	M	44	18	23	< 2
2760	Methyl tert-butylether	1634044	µg kg^{-1}	M	< 1.0	< 1.0	< 1.0	< 1.0
	Benzene	71432	µg kg^{-1}	M	< 1.0	< 1.0	< 1.0	< 1.0
	Toluene	108883	µg kg^{-1}	M	< 1.0	< 1.0	< 1.0	< 1.0
	Ethylbenzene	100414	µg kg^{-1}	M	< 1.0	< 1.0	< 1.0	< 1.0
	m- & p-Xylene	1330207	µg kg^{-1}	M	< 1.0	< 1.0	< 1.0	< 1.0
	o-Xylene	95476	µg kg^{-1}	M	< 1.0	< 1.0	< 1.0	< 1.0
2920	Phenols (total)		mg kg^{-1}	M	<0.3	<0.3	<0.3	<0.3

All tests undertaken between 16/01/2014 and 23/01/2014

* Accreditation status

This report should be interpreted in conjunction with the notes on the accompanying cover page.

Chemtest
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Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070

Johnson Poole & Bloomer Ltd
Harris and Pearson Building
Brettell Lane
Brierly Hill, West Midlands
DY5 3LH

FAO F Townley
23 January 2014

Dear F Townley

Test Report Number **248952**
Your Project Reference **NB503 Wark Crescent**

Please find enclosed the results of analysis for the samples received 15 January 2014.

If you require any further assistance, please do not hesitate to contact the Customer Services team.

Yours sincerely

KT Jones

Keith Jones, Technical Manager

UKAS TESTING
2183

Notes to accompany report:

- *The in-house procedure is employed to identify materials and fibres in soils*
- *The sample is examined by stereo-binocular and polarised light microscopy*
- *Sample size is reduced by coning and quartering to obtain a representative sub-sample if necessary*
- *The bulk identification is in accordance with the requirements of the analyst guide (HSG 248)*
- *Samples associated with asbestos are retained for six months*
- *The results relate only to the items tested as supplied by the client*
- *Comments or interpretations are beyond the scope of UKAS accreditation*

Johnson Poole & Bloomer Ltd
Harris and Pearson Building
Brettell Lane
Brierly Hill, West Midlands
DY5 3LH

FAO F Townley

LABORATORY TEST REPORT
Asbestos in Soils

Chemtest

Results of analysis of 2 samples
received 15 January 2014
NB503 Wark Crescent

Report Date
23 January 2014

Login Batch No: 248952

Qualitative Results

				SOP 2190	
				ACM Type	Asbestos Identification
Chemtest ID	Sample ID	Sample Desc	Depth (m)	UKAS Accredited	UKAS Accredited
AJ68896	301		0.10	-	No Asbestos Detected
AJ68901	303		0.40	-	No Asbestos Detected

The detection limit for this method is 0.001%

Signed

Lauren Quinn
Asbestos Analyst

All tests undertaken between 23-Jan-2014 and 23-Jan-2014 at our asbestos testing facility in Coventry

LIMS sample ID range AJ68896 to AJ68901

Chemtest
The right chemistry to deliver results

Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070

Johnson Poole & Bloomer Ltd
Harris and Pearson Building
Brettell Lane
Brierly Hill, West Midlands
DY5 3LH

FAO Fiona Townley
04 February 2014

Dear Fiona Townley

Test Report Number **250016**
Your Project Reference **NB503 - Wark Crescent**

Please find enclosed the results of analysis for the samples received 27 January 2014.

All soil samples will be retained for a period of one month and all water samples will be retained for 7 days following the date of the test report. Should you require an extended retention period then please detail your requirements in an email to customerservices@chemtest.co.uk. Please be aware that charges may be applicable for extended sample storage.

If you require any further assistance, please do not hesitate to contact the Customer Services team.

Yours sincerely

Keith Jones, Technical Manager

UKAS
TESTING
2183

Notes to accompany report:

- *The sign < means 'less than'*
- *Tests marked 'U' hold UKAS accreditation*
- *Tests marked 'M' hold MCertS (and UKAS) accreditation*
- *Tests marked 'N' do not currently hold UKAS accreditation*
- *Tests marked 'S' were subcontracted to an approved laboratory*
- *n/e means 'not evaluated'*
- *i/s means 'insufficient sample'*
- *u/s means 'unsuitable sample'*
- *Comments or interpretations are beyond the scope of UKAS accreditation*
- *The results relate only to the items tested*
- *All results are expressed on a dry weight basis*
- *The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, phenols*
- *For all other tests the samples were dried at < 37°C prior to analysis*
- *Uncertainties of measurement for the determinands tested are available upon request*
- *None of the test results included in this report have been recovery corrected*

Johnson Poole & Bloomer Ltd
Harris and Pearson Building
Brettell Lane
Brierly Hill, West Midlands
DY5 3LH

FAO Fiona Townley

LABORATORY TEST REPORT

Results of analysis of 2 samples
received 27 January 2014

NB503 - Wark Crescent

Report Date
04 February 2014

Login Batch No					**250016**	
Chemtest LIMS ID					AJ75411	AJ75412
Sample ID					301	304
Sample No						
Sampling Date					21/1/2014	21/1/2014
Depth						
Matrix					*WATER*	*WATER*
SOP↓	Determinand↓	CAS No↓	Units↓	*		
1010	pH	PH		U	8.2	7.9
1020	Electrical Conductivity	EC	µS cm^{-1}	U	830	870
1300	Cyanide (total)	57125	mg l^{-1}	U	<0.050	<0.050
	Cyanide (free)	57125	mg l^{-1}	U	<0.050	<0.050
1220	Alkalinity	ALK	mg CaCO3 l^{-1}	U	450	410
1325	Sulfide	18496258	mg l^{-1}	U	<0.050	<0.050
1610	Total Organic Carbon	TOC	mg l^{-1}	N	9.5	4.2
1220	Sulfate	14808798	mg l^{-1}	U	150	160
1450	Arsenic	7440382	µg l^{-1}	U	<1.0	<1.0
	Boron	7440428	µg l^{-1}	U	29	43
	Barium	7440393	µg l^{-1}	U	35	33
	Beryllium	7440417	µg l^{-1}	U	<1.0	<1.0
	Cadmium	7440439	µg l^{-1}	U	<0.080	<0.080
	Chromium	7440473	µg l^{-1}	U	<1.0	<1.0
	Copper	7440508	µg l^{-1}	U	6.6	1.7
	Mercury	7439976	µg l^{-1}	U	<0.50	<0.50
	Nickel	7440020	µg l^{-1}	U	<1.0	<1.0
	Lead	7439921	µg l^{-1}	U	<1.0	<1.0
	Selenium	7782492	µg l^{-1}	U	7.6	20
	Vanadium	7440622	µg l^{-1}	U	<1.0	<1.0
	Zinc	7440666	µg l^{-1}	U	4.7	5.1
1490	Chromium (hexavalent)	18540299	µg l^{-1}	U	<20	<20
1675	TPH aliphatic >C5-C6		µg l^{-1}	N	< 0.1	< 0.1
	TPH aliphatic >C6-C8		µg l^{-1}	N	< 0.1	< 0.1

All tests undertaken between 27/01/2014 and 04/02/2014

* Accreditation status

This report should be interpreted in conjunction with the notes on the accompanying cover page.

Johnson Poole & Bloomer Ltd
Harris and Pearson Building
Brettell Lane
Brierly Hill, West Midlands
DY5 3LH

FAO Fiona Townley

LABORATORY TEST REPORT

Results of analysis of 2 samples
received 27 January 2014

NB503 - Wark Crescent

Chemtest
The right chemistry to deliver results

Report Date
04 February 2014

					250016	
					AJ75411	AJ75412
					301	304
					21/1/2014	21/1/2014
					WATER	*WATER*
1675	TPH aliphatic >C8-C10		μg l^{-1}	N	< 0.1	< 0.1
	TPH aliphatic >C10-C12		μg l^{-1}	N	< 0.1	< 0.1
	TPH aliphatic >C12-C16		μg l^{-1}	N	< 0.1	< 0.1
	TPH aliphatic >C16-C21		μg l^{-1}	N	< 0.1	< 0.1
	TPH aliphatic >C21-C35		μg l^{-1}	N	< 0.1	< 0.1
	TPH aliphatic >C35-C44		μg l^{-1}	N	< 0.1	< 0.1
	TPH aromatic >C5-C7		μg l^{-1}	N	< 0.1	< 0.1
	TPH aromatic >C7-C8		μg l^{-1}	N	< 0.1	< 0.1
	TPH aromatic >C8-C10		μg l^{-1}	N	< 0.1	< 0.1
	TPH aromatic >C10-C12		μg l^{-1}	N	< 0.1	< 0.1
	TPH aromatic >C12-C16		μg l^{-1}	N	< 0.1	< 0.1
	TPH aromatic >C16-C21		μg l^{-1}	N	< 0.1	< 0.1
	TPH aromatic >C21-C35		μg l^{-1}	N	< 0.1	< 0.1
	TPH aromatic >C35-C44		μg l^{-1}	N	< 0.1	< 0.1
	Total Petroleum Hydrocarbons		μg l^{-1}	N	< 10	< 10
	Total Aliphatic Hydrocarbons		μg l^{-1}	N	< 5	< 5
	Total Aromatic Hydrocarbons		μg l^{-1}	N	< 5	< 5
1700	Naphthalene	91203	μg l^{-1}	U	<0.1	<0.1
	Acenaphthylene	208968	μg l^{-1}	U	<0.1	<0.1
	Acenaphthene	83329	μg l^{-1}	U	<0.1	<0.1
	Fluorene	86737	μg l^{-1}	U	<0.1	<0.1
	Phenanthrene	85018	μg l^{-1}	U	<0.1	<0.1
	Anthracene	120127	μg l^{-1}	U	<0.1	<0.1
	Fluoranthene	206440	μg l^{-1}	U	<0.1	<0.1
	Pyrene	129000	μg l^{-1}	U	<0.1	<0.1

All tests undertaken between 27/01/2014 and 04/02/2014

* Accreditation status

This report should be interpreted in conjunction with the notes on the accompanying cover page.

Johnson Poole & Bloomer Ltd
Harris and Pearson Building
Brettell Lane
Brierly Hill, West Midlands
DY5 3LH

FAO Fiona Townley

LABORATORY TEST REPORT

Results of analysis of 2 samples
received 27 January 2014

NB503 - Wark Crescent

Report Date
04 February 2014

					250016	
					AJ75411	AJ75412
					301	304
					21/1/2014	21/1/2014
					WATER	*WATER*
1700	Benzo[a]anthracene	56553	µg l^{-1}	U	<0.1	<0.1
	Chrysene	218019	µg l^{-1}	U	<0.1	<0.1
	Benzo[b]fluoranthene	205992	µg l^{-1}	N	<0.1	<0.1
	Benzo[k]fluoranthene	207089	µg l^{-1}	N	<0.1	<0.1
	Benzo[a]pyrene	50328	µg l^{-1}	U	<0.1	<0.1
	Dibenzo[a,h]anthracene	53703	µg l^{-1}	U	<0.1	<0.1
	Indeno[1,2,3-cd]pyrene	193395	µg l^{-1}	U	<0.1	<0.1
	Benzo[g,h,i]perylene	191242	µg l^{-1}	U	<0.1	<0.1
	Total (of 16) PAHs		µg l^{-1}	U	<2	<2
1760	Methyl tert-butylether	1634044	µg l^{-1}	N	<1.0	<1.0
	Benzene	71432	µg l^{-1}	U	<1.0	<1.0
	Toluene	108883	µg l^{-1}	U	<1.0	<1.0
	Ethylbenzene	100414	µg l^{-1}	U	<1.0	<1.0
	m- & p-Xylene	1330207	µg l^{-1}	U	<1.0	<1.0
	o-Xylene	95476	µg l^{-1}	U	<1.0	<1.0
1920	Phenols (total)		mg l^{-1}	N	< 0.03	< 0.03

All tests undertaken between 27/01/2014 and 04/02/2014

* Accreditation status

This report should be interpreted in conjunction with the notes on the accompanying cover page.

LIMS sample ID range AJ75411 to AJ75412

Appendix F

Chemical Risk Assessment

CLEA Software Version 1.06

Report generated	31-Jan-14
Report title	Wark Crescent Residential Plant with Uptake
Created by	FT at JPB

RESULTS

		Assessment Criterion (mg kg^{-1})			Ratio of ADE to HCV			Saturation Limit (mg kg^{-1})	50% rule?	
		oral	inhalation	combined	oral	inhalation	combined		Oral	Inhal
1	Boron JPB	2.91E+02	1.22E+05	2.91E+02	1.00	0.00	1.00	NR	Yes	No
2	Arsenic	3.24E+01	8.50E+01	NR	1.00	0.38	NR	NR	No	No
3	Barium	1.33E+03	NR	NR	1.00	NR	NR	NR	Yes	No
4	Beryllium JPB	1.12E+02	5.10E+01	3.84E+01	0.25	0.75	1.00	NR	Yes	No
5	Chromium (III) JPB	1.95E+04	6.37E+02	6.27E+02	0.03	0.97	1.00	NR	No	Yes
6	Copper JPB	2.66E+03	1.04E+04	2.33E+03	0.78	0.22	1.00	NR	Yes	No
7	Mercury, inorganic	1.81E+02	2.55E+03	1.69E+02	0.93	0.07	1.00	NR	No	No
8	Nickel	5.31E+02	1.27E+02	NR	0.14	1.00	NR	NR	Yes	Yes
9	Vanadium JPB	7.96E+01	6.08E+02	7.44E+01	0.93	0.07	1.00	NR	Yes	Yes
10	Zinc JPB	3.75E+03	2.55E+07	3.75E+03	1.00	0.00	1.00	NR	Yes	No
11	Aromatic >EC12 - EC16 JPB	3.22E+02	1.71E+04	3.20E+02	0.99	0.01	1.00	4.34E+02 (sol)	Yes	Yes
12	Aromatic >EC16 - EC21 JPB	4.95E+02	NR	NR	1.00	NR	NR	1.38E+02 (vap)	Yes	No
13	Aromatic >EC21 - EC35 JPB	1.11E+03	NR	NR	1.00	NR	NR	1.25E+01 (sol)	Yes	No
14	Naphthalene JPB	6.66E+01	1.23E+01	1.04E+01	0.16	0.84	1.00	1.94E+02 (sol)	No	No
15	Acenaphthylene JPB	4.31E+02	8.01E+03	4.09E+02	0.95	0.05	1.00	2.21E+02 (sol)	No	No
16	Acenaphthene JPB	5.24E+02	9.14E+03	4.96E+02	0.95	0.05	1.00	1.46E+02 (sol)	No	No
17	Fluorene JPB	4.03E+02	1.00E+04	3.88E+02	0.96	0.04	1.00	7.95E+01 (sol)	No	No
18	Phenanthrene JPB	2.10E+02	1.18E+04	2.06E+02	0.98	0.02	1.00	9.27E+01 (sol)	No	No
19	Anthracene JPB	5.16E+03	2.46E+05	5.06E+03	0.98	0.02	1.00	3.01E+00 (vap)	No	No
20	Fluoranthene JPB	4.75E+02	6.79E+04	4.71E+02	0.99	0.01	1.00	4.88E+01 (vap)	No	No

		Assessment Criterion (mg kg^{-1})			Ratio of ADE to HCV			Saturation Limit (mg kg^{-1})	50% rule?	
		oral	inhalation	combined	oral	inhalation	combined		Oral	Inhal
21	Pyrene JPB	1.07E+03	1.60E+05	1.06E+03	0.99	0.01	1.00	5.67E+00 (vap)	No	No
22	Benz[a]anthracene JPB	9.04E+00	1.09E+01	4.94E+00	0.55	0.45	1.00	4.42E+00 (sol)	No	No
23	Chrysene JPB	1.21E+01	2.55E+01	8.19E+00	0.68	0.32	1.00	1.13E+00 (vap)	No	No
24	Benzo[b]fluoranthene JPB	9.82E+00	1.98E+01	6.57E+00	0.67	0.33	1.00	3.13E+00 (sol)	No	No
25	Benzo[k]fluoranthene JPB	1.45E+01	2.83E+01	9.58E+00	0.66	0.34	1.00	1.77E+00 (sol)	No	No
26	Benzo[a]pyrene JPB	1.42E+00	2.82E+00	9.45E-01	0.66	0.34	1.00	2.35E+00 (vap)	No	No
27	Dibenz[ah]anthracene JPB	1.33E+00	2.49E+00	8.68E-01	0.65	0.35	1.00	1.01E-02 (vap)	No	No
28	Indeno[123-cd]pyrene JPB	5.77E+00	1.18E+01	3.87E+00	0.67	0.33	1.00	1.58E-01 (vap)	No	No
29	Benzo[ghi]perylene JPB	7.04E+01	1.33E+02	4.60E+01	0.65	0.35	1.00	3.97E-02 (vap)	No	No
30										

		Soil Distribution				Media Concentrations													
		Sorbed	Dissolved	Vapour	Total	Soil	Soil gas	Indoor Dust	Outdoor dust at 0.8m	Outdoor dust at 1.6m	Indoor Vapour	Outdoor vapour at 0.8m	Outdoor vapour at 1.6m	Green vegetables	Root vegetables	Tuber vegetables	Herbaceous fruit	Shrub fruit	Tree fruit
		%	%	%	%	mg kg^{-1}	mg m^{-3}	mg kg^{-1}	mg m^{-3}	mg m^{-3}	mg m^{-3}	mg m^{-3}	mg m^{-3}	mg kg^{-1} FW	mg kg^{-1} FW	mg kg^{-1} FW	mg kg^{-1} FW	mg kg^{-1} FW	mg kg^{-1} FW
1	Boron JPB	94.6	5.4	0.0	100.0	2.91E+02	NR	1.46E+02	1.24E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.16E+02	5.82E+01	5.82E+01	5.82E+01	5.82E+01	5.82E+01
2	Arsenic	99.9	0.1	0.0	100.0	3.24E+01	NR	1.62E+01	1.38E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.39E-02	1.30E-02	7.45E-03	1.07E-02	6.48E-03	3.56E-02
3	Barium	#DIV/0!	#DIV/0!	0.0	#DIV/0!	1.33E+03	NR	6.64E+02	5.66E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4	Beryllium JPB	100.0	0.0	0.0	100.0	3.84E+01	NR	1.92E+01	1.63E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.69E-01	4.61E-02	4.61E-02	4.61E-02	4.61E-02	4.61E-02
5	Chromium (III) JPB	100.0	0.0	0.0	100.0	6.27E+02	NR	3.14E+02	2.67E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.88E-02	1.88E-02	1.88E-02	1.88E-02	1.88E-02	1.88E-02
6	Copper JPB	99.5	0.5	0.0	100.0	2.33E+03	NR	1.16E+03	9.90E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.79E+01	4.79E+01	4.79E+01	5.42E+01	4.79E+01	4.79E+01
7	Mercury, inorganic	99.9	0.1	0.0	100.0	1.69E+02	NR	8.43E+01	7.18E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.41E-01	1.16E+00	7.25E-01	1.69E-01	1.86E-01	1.69E-01
8	Nickel	99.9	0.1	0.0	100.0	1.27E+02	NR	6.37E+01	5.42E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.84E-01	5.48E-01	2.42E-01	3.19E-01	3.19E-01	4.33E-01
9	Vanadium JPB	95.7	4.3	0.0	100.0	7.44E+01	NR	3.72E+01	3.17E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.67E-01	9.67E-01	9.67E-01	9.67E-01	9.67E-01	9.67E-01
10	Zinc JPB	98.6	1.4	0.0	100.0	3.75E+03	NR	1.87E+03	1.59E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.02E+02	2.02E+02	2.02E+02	5.36E+02	2.02E+02	2.02E+02
11	Aromatic >EC12 - EC16 JPB	99.3	0.7	0.0	100.0	3.20E+02	5.34E+01	1.60E+02	1.36E-07	0.00E+00	5.98E-04	2.84E-05	0.00E+00	2.69E+01	3.68E+01	1.39E+01	0.00E+00	0.00E+00	2.94E+00
12	Aromatic >EC16 - EC21 JPB	99.7	0.3	0.0	100.0	4.95E+02	1.62E+00	2.47E+02	2.11E-07	0.00E+00	8.25E-05	1.89E-05	0.00E+00	1.41E+01	2.20E+01	1.32E+01	0.00E+00	0.00E+00	6.93E-01
13	Aromatic >EC21 - EC35 JPB	100.0	0.0	0.0	100.0	1.11E+03	1.47E-02	5.57E+02	4.74E-07	0.00E+00	1.25E-06	1.39E-05	0.00E+00	1.50E+00	5.86E+00	8.73E+00	0.00E+00	0.00E+00	1.34E-02
14	Naphthalene JPB	94.7	5.3	0.0	100.0	1.04E+01	6.73E+00	5.18E+00	4.41E-09	0.00E+00	6.30E-04	1.64E-06	0.00E+00	4.14E+00	5.91E+00	1.47E+00	0.00E+00	0.00E+00	1.87E+00
15	Acenaphthylene JPB	98.0	2.0	0.0	100.0	4.09E+02	8.37E+00	2.05E+02	1.74E-07	0.00E+00	3.30E-03	3.01E-05	0.00E+00	8.47E+01	1.15E+02	2.92E+01	0.00E+00	0.00E+00	1.64E+01
16	Acenaphthene JPB	98.5	1.5	0.0	100.0	4.96E+02	1.06E+01	2.48E+02	2.11E-07	0.00E+00	3.50E-03	3.20E-05	0.00E+00	8.35E+01	1.13E+02	3.18E+01	0.00E+00	0.00E+00	1.35E+01
17	Fluorene JPB	98.7	1.3	0.0	100.0	3.88E+02	3.74E+00	1.94E+02	1.65E-07	0.00E+00	1.66E-03	2.19E-05	0.00E+00	5.60E+01	7.58E+01	2.21E+01	0.00E+00	0.00E+00	7.80E+00
18	Phenanthrene JPB	99.3	0.7	0.0	100.0	2.06E+02	3.56E-01	1.03E+02	8.77E-08	0.00E+00	2.29E-04	8.13E-06	0.00E+00	1.59E+01	2.26E+01	8.05E+00	0.00E+00	0.00E+00	1.27E+00
19	Anthracene JPB	99.4	0.6	0.0	100.0	5.06E+03	1.08E+01	2.53E+03	2.15E-06	0.00E+00	6.53E-03	1.98E-04	0.00E+00	3.81E+02	5.41E+02	1.94E+02	0.00E+00	0.00E+00	3.04E+01
20	Fluoranthene JPB	99.8	0.2	0.0	100.0	4.71E+02	1.09E-01	2.36E+02	2.01E-07	0.00E+00	8.13E-05	9.95E-06	0.00E+00	9.11E+00	1.67E+01	8.84E+00	0.00E+00	0.00E+00	2.81E-01

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		Soil Distribution				Media Concentrations													
		Sorbed	Dissolved	Vapour	Total	Soil	Soil gas	Indoor Dust	Outdoor dust at 0.8m	Outdoor dust at 1.6m	Indoor Vapour	Outdoor vapour at 0.8m	Outdoor vapour at 1.6m	Green vegetables	Root vegetables	Tuber vegetables	Herbaceous fruit	Shrub fruit	Tree fruit
		%	%	%	%	mg kg^{-1}	mg m^{-3}	mg kg^{-1}	mg m^{-3}	mg m^{-3}	mg m^{-3}	mg m^{-3}	mg m^{-3}	mg kg^{-1} FW	mg kg^{-1} FW	mg kg^{-1} FW	mg kg^{-1} FW	mg kg^{-1} FW	mg kg^{-1} FW
21	Pyrene JPB	99.8	0.2	0.0	100.0	1.06E+03	2.46E-01	5.30E+02	4.52E-07	0.00E+00	1.87E-04	2.38E-05	0.00E+00	2.36E+01	4.20E+01	2.17E+01	0.00E+00	0.00E+00	7.86E-01
22	Benz[a]anthracene JPB	100.0	0.0	0.0	100.0	4.94E+00	1.34E-04	2.47E+00	2.10E-09	0.00E+00	1.07E-07	4.85E-08	0.00E+00	1.13E-02	4.21E-02	2.92E-02	0.00E+00	0.00E+00	1.07E-04
23	Chrysene JPB	99.9	0.1	0.0	100.0	8.19E+00	3.17E-05	4.10E+00	3.49E-09	0.00E+00	3.05E-08	9.51E-08	0.00E+00	3.24E-02	9.84E-02	6.43E-02	0.00E+00	0.00E+00	4.04E-04
24	Benzo[b]fluoranthene JPB	100.0	0.0	0.0	100.0	6.57E+00	8.59E-06	3.28E+00	2.80E-09	0.00E+00	9.53E-09	5.41E-08	0.00E+00	8.99E-03	4.16E-02	2.87E-02	0.00E+00	0.00E+00	6.56E-05
25	Benzo[k]fluoranthene JPB	100.0	0.0	0.0	100.0	9.58E+00	7.53E-06	4.79E+00	4.08E-09	0.00E+00	9.01E-09	6.64E-08	0.00E+00	7.20E-03	4.31E-02	3.05E-02	0.00E+00	0.00E+00	3.98E-05
26	Benzo[a]pyrene JPB	100.0	0.0	0.0	100.0	9.45E-01	8.63E-07	4.73E-01	4.02E-10	0.00E+00	1.03E-09	7.07E-09	0.00E+00	9.17E-04	4.88E-03	3.46E-03	0.00E+00	0.00E+00	5.73E-06
27	Dibenz[ah]anthracene JPB	100.0	0.0	0.0	100.0	8.68E-01	1.68E-06	4.34E-01	3.69E-10	0.00E+00	1.46E-09	5.20E-09	0.00E+00	4.31E-04	3.10E-03	2.11E-03	0.00E+00	0.00E+00	1.97E-06
28	Indeno[123-cd]pyrene JPB	100.0	0.0	0.0	100.0	3.87E+00	6.09E-06	1.94E+00	1.65E-09	0.00E+00	6.67E-09	3.44E-08	0.00E+00	7.34E-03	2.95E-02	1.93E-02	0.00E+00	0.00E+00	6.35E-05
29	Benzo[ghi]perylene JPB	100.0	0.0	0.0	100.0	4.60E+01	2.11E-05	2.30E+01	1.96E-08	0.00E+00	2.06E-08	1.88E-07	0.00E+00	4.80E-03	7.36E-02	5.41E-02	0.00E+00	0.00E+00	1.10E-05
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		Average Daily Exposure (mg kg^{-1} bw day^{-1})							Distribution by Pathway (%)							
		Direct soil ingestion	Consumption of homegrown produce and attached soil	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour	Background (oral)	Background (inhalation)	Direct soil ingestion	Consumption of homegrown produce and attached soil	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour (indoor)	Inhalation of vapour (outdoor)	Background (oral)	Background (inhalation)
1	Boron JPB	2.16E-03	7.78E-02	0.00E+00	6.85E-06	0.00E+00	2.08E-01	2.41E-05	1.35	48.65	0.00	0.00	0.00	0.00	50.00	0.00
2	Arsenic	2.40E-04	2.27E-05	3.70E-05	7.62E-07	0.00E+00	0.00E+00	0.00E+00	79.89	7.54	12.31	0.25	0.00	0.00	0.00	0.00
3	Barium	9.86E-03	1.13E-04	0.00E+00	3.13E-05	0.00E+00	4.77E-02	6.06E-02	49.28	0.57	0.00	0.16	0.00	0.00	50.00	0.00
4	Beryllium JPB	2.85E-04	1.11E-04	0.00E+00	9.04E-07	0.00E+00	8.44E-04	0.00E+00	35.92	14.03	0.00	0.11	0.00	0.00	49.94	0.00
5	Chromium (III) JPB	4.65E-03	7.37E-05	0.00E+00	1.48E-05	0.00E+00	3.39E-03	1.64E-05	57.13	0.91	0.00	0.18	0.00	0.00	41.60	0.18
6	Copper JPB	1.73E-02	5.26E-02	0.00E+00	5.48E-05	0.00E+00	3.94E-01	4.12E-05	12.34	37.63	0.00	0.04	0.00	0.00	49.97	0.03
7	Mercury, inorganic	1.25E-03	5.64E-04	0.00E+00	3.97E-06	0.00E+00	5.63E-05	0.00E+00	66.71	30.08	0.00	0.21	0.00	0.00	3.00	0.00
8	Nickel	9.45E-04	4.66E-04	2.43E-05	3.00E-06	0.00E+00	7.31E-03	3.64E-06	32.77	16.18	0.84	0.10	0.00	0.00	49.90	0.10
9	Vanadium JPB	5.52E-04	1.04E-03	0.00E+00	1.75E-06	0.00E+00	1.29E-03	3.88E-05	19.07	36.07	0.00	0.06	0.00	0.00	44.74	0.06
10	Zinc JPB	2.78E-02	2.72E-01	0.00E+00	8.81E-05	0.00E+00	1.52E+00	1.45E-04	4.63	45.36	0.00	0.01	0.00	0.00	49.99	0.01
11	Aromatic >EC12 - EC16 JPB	2.37E-03	1.63E-02	1.22E-03	7.53E-06	5.55E-04	5.62E+95	6.06E+95	5.80	39.85	2.98	0.02	1.35	0.00	48.63	1.37
12	Aromatic >EC16 - EC21 JPB	3.67E-03	9.44E-03	1.89E-03	1.16E-05	7.71E-05	5.62E+95	0.00E+00	12.23	31.48	6.28	0.00	0.00	0.00	50.00	0.00
13	Aromatic >EC21 - EC35 JPB	8.26E-03	2.49E-03	4.24E-03	2.62E-05	1.74E-06	5.62E+95	0.00E+00	27.54	8.31	14.15	0.00	0.00	0.00	50.00	0.00
14	Naphthalene JPB	7.69E-05	2.92E-03	5.14E-05	2.44E-07	5.83E-04	3.94E-04	1.70E-04	1.83	69.65	1.22	0.01	13.87	0.00	9.38	4.04
15	Acenaphthylene JPB	3.04E-03	5.19E-02	2.03E-03	9.63E-06	3.06E-03	7.88E-06	6.67E-07	5.06	86.44	3.38	0.02	5.09	0.00	0.01	0.00
16	Acenaphthene JPB	3.68E-03	5.06E-02	2.46E-03	1.17E-05	3.24E-03	5.51E-05	1.52E-06	6.13	84.27	4.09	0.02	5.40	0.00	0.09	0.00
17	Fluorene JPB	2.87E-03	3.36E-02	1.92E-03	9.12E-06	1.54E-03	3.32E-05	5.82E-06	7.19	84.05	4.80	0.02	3.84	0.00	0.08	0.01
18	Phenanthrene JPB	1.53E-03	9.65E-03	1.02E-03	4.85E-06	2.12E-04	8.66E-05	3.14E-05	12.20	76.97	8.15	0.04	1.69	0.00	0.69	0.25
19	Anthracene JPB	3.75E-02	2.31E-01	2.50E-02	1.19E-04	6.05E-03	4.50E-06	2.49E-06	12.50	77.09	8.35	0.04	2.01	0.00	0.00	0.00
20	Fluoranthene JPB	3.50E-03	6.56E-03	2.34E-03	1.11E-05	7.56E-05	1.97E-05	5.09E-06	27.96	52.48	18.67	0.09	0.60	0.00	0.16	0.04

		Average Daily Exposure (mg kg^{-1} bw day^{-1})							Distribution by Pathway (%)							
		Direct soil ingestion	Consumption of homegrown produce and attached soil	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour	Background (oral)	Background (inhalation)	Direct soil ingestion	Consumption of homegrown produce	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour (indoor)	Inhalation of vapour (outdoor)	Background (oral)	Background (inhalation)
21	Pyrene JPB	7.87E-03	1.67E-02	5.26E-03	2.50E-05	1.74E-04	1.97E-05	3.94E-06	26.23	55.52	17.52	0.08	0.58	0.00	0.07	0.01
22	Benz[a]anthracene JPB	3.66E-05	1.43E-05	2.45E-05	1.16E-07	1.01E-07	3.38E-06	6.67E-07	48.43	18.94	32.34	0.15	0.13	0.00	0.00	0.00
23	Chrysene JPB	6.07E-05	3.44E-05	4.06E-05	1.93E-07	3.22E-08	6.19E-06	1.03E-06	44.68	25.31	29.84	0.14	0.02	0.00	0.00	0.00
24	Benzo[b]fluoranthene JPB	4.87E-05	1.37E-05	3.25E-05	1.55E-07	1.11E-08	6.19E-06	7.88E-07	51.22	14.40	34.21	0.16	0.01	0.00	0.00	0.00
25	Benzo[k]fluoranthene JPB	7.10E-05	1.39E-05	4.74E-05	2.25E-07	1.11E-08	5.06E-06	4.24E-07	53.55	10.51	35.76	0.17	0.01	0.00	0.00	0.00
26	Benzo[a]pyrene JPB	7.01E-06	1.59E-06	4.68E-06	2.22E-08	1.25E-09	6.19E-06	3.64E-07	52.67	11.97	35.18	0.17	0.01	0.00	0.00	0.00
27	Dibenz[ah]anthracene JPB	6.43E-06	9.86E-07	4.30E-06	2.04E-08	1.57E-09	2.25E-06	2.00E-06	54.81	8.40	36.60	0.17	0.01	0.00	0.00	0.00
28	Indeno[123-cd]pyrene JPB	2.87E-05	9.79E-06	1.92E-05	9.11E-08	7.61E-09	5.63E-06	5.46E-07	49.69	16.95	33.19	0.16	0.01	0.00	0.00	0.00
29	Benzo[ghi]perylene JPB	3.41E-04	2.46E-05	2.28E-04	1.08E-06	2.70E-08	3.38E-06	6.06E-07	57.37	4.13	38.31	0.18	0.00	0.00	0.00	0.00
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		Oral Health Criteria Value (µg kg^{-1} BW day^{-1})		Inhalation Health Criteria Value (µg kg^{-1} BW day^{-1})		Oral Mean Daily Intake (µg day^{-1})	Inhalation Mean Daily Intake (µg day^{-1})	Air-water partition coefficient (K_{aw}) (cm^3 cm^{-3})	Coefficient of Diffusion in Air (m^2 s^{-1})	Coefficient of Diffusion in Water (m^2 s^{-1})	log K_{oc} (cm^3 g^{-1})	log K_{ow} (dimensionless)	Dermal Absorption Fraction (dimensionless)	Soil-to-dust transport factor (g g^{-1} DW)	Sub-surface soil to indoor air correction factor (dimensionless)	Relative bioavailability via soil ingestion (unitless)	Relative bioavailability via dust inhalation (unitless)
1	Boron JPB	TDI	160	TDI	2.9	3700	0.398	NR	NR	NR	NR	NR	0	0.5	1	1	1
2	Arsenic	ID	0.3	ID	0.002	NR	NR	NR	NR	NR	NR	NR	0.03	0.5	1	1	1
3	Barium	TDI	20	NR	0	847	1000	NR	NR	NR	NR	NR	0	0.5	1	1	1
4	Beryllium JPB	TDI	2	ID	0.0012	15	NR	NR	NR	NR	NR	NR	0	0.5	1	1	1
5	Chromium (III) JPB	TDI	150	TDI	0.03	60.2	0.27	NR	NR	NR	NR	NR	0	0.5	1	1	1
6	Copper JPB	TDI	160	TDI	0.286	7000	0.68	NR	NR	NR	NR	NR	0	0.5	1	1	1
7	Mercury, inorganic	TDI	2	TDI	0.06	1	0	NR	NR	NR	NR	NR	0	0.5	1	1	1
8	Nickel	TDI	12	TDI	0.006	130	0.06	NR	NR	NR	NR	NR	0.005	0.5	1	1	1
9	Vanadium JPB	TDI	3	TDI	0.0286	23	0.64	NR	NR	NR	NR	NR	0	0.5	1	1	1
10	Zinc JPB	TDI	600	TDI	600	27000	2.4	NR	NR	NR	NR	NR	0	0.5	1	1	1
11	Aromatic >EC12 - EC16 JPB	TDI	40	TDI	60	9.99E+99	9.99E+99	1.26E-02	1.00E-05	1.00E-09	3.7	4.29	0.1	0.5	10	1	1
12	Aromatic >EC16 - EC21 JPB	TDI	30	NR	0	9.99E+99	NR	6.95E-04	1.00E-05	1.00E-09	4.15	4.82	0.1	0.5	10	1	1
13	Aromatic >EC21 - EC35 JPB	TDI	30	NR	0	9.99E+99	NR	2.48E-05	1.00E-05	1.00E-09	5.1	5.95	0.1	0.5	10	1	1
14	Naphthalene JPB	TDI	20	TDI	0.86	7	2.8	6.62E-03	6.52E-06	5.16E-10	2.81	3.34	0.13	0.5	1	1	1
15	Acenaphthylene JPB	TDI	60	TDI	60	0.14	0.011	5.68E-04	5.97E-06	4.82E-10	3.26	3.91	0.13	0.5	1	1	1
16	Acenaphthene JPB	TDI	60	TDI	60	0.98	0.025	7.59E-04	5.85E-06	4.70E-10	3.37	4.03	0.13	0.5	1	1	1
17	Fluorene JPB	TDI	40	TDI	40	0.59	0.096	4.12E-04	5.58E-06	4.47E-10	3.45	4.13	0.13	0.5	1	1	1
18	Phenanthrene JPB	TDI	12.5	TDI	12.5	1.54	0.518	1.43E-04	5.34E-06	4.32E-10	3.74	4.5	0.13	0.5	1	1	1
19	Anthracene JPB	TDI	300	TDI	300	0.08	0.041	1.81E-04	5.36E-06	4.36E-10	3.75	4.5	0.13	0.5	1	1	1
20	Fluoranthene JPB	TDI	12.5	TDI	12.5	0.35	0.084	6.29E-05	5.01E-06	4.11E-10	4.26	5.13	0.13	0.5	1	1	1

			Oral Health Criteria Value (µg kg^{-1} BW day^{-1})		Inhalation Health Criteria Value (µg kg^{-1} BW day^{-1})	Oral Mean Daily Intake (µg day^{-1})	Inhalation Mean Daily Intake (µg day^{-1})	Air-water partition coefficient (K_{aw}) (cm^3 cm^{-3})	Coefficient of Diffusion in Air (m^2 s^{-1})	Coefficient of Diffusion in Water (m^2 s^{-1})	log K_{oc} (cm^3 g^{-1})	log K_{ow} (dimensionless)	Dermal Absorption Fraction (dimensionless)	Soil-to-dust transport factor (g g^{-1} DW)	Sub-surface soil to indoor air correction factor (dimensionless)	Relative bioavailability via soil ingestion (unitless)	Relative bioavailability via dust inhalation (unitless)
21	Pyrene JPB	TDI	30	TDI	30	0.35	0.065	5.64E-05	5.01E-06	4.15E-10	4.21	5.08	0.13	0.5	1	1	1
22	Benz[a]anthracene JPB	ID	0.138	ID	0.00048	0.06	0.011	3.16E-05	4.60E-06	3.80E-10	4.89	5.91	0.13	0.5	1	1	1
23	Chrysene JPB	ID	0.2	ID	0.0007	0.11	0.017	3.18E-06	4.57E-06	3.77E-10	4.74	5.73	0.13	0.5	1	1	1
24	Benzo[b]fluoranthene JPB	ID	0.142	ID	0.0005	0.11	0.013	2.05E-06	4.38E-06	3.62E-10	5.02	6.08	0.13	0.5	1	1	1
25	Benzo[k]fluoranthene JPB	ID	0.2	ID	0.0007	0.09	0.007	1.74E-06	4.36E-06	3.62E-10	5.17	6.26	0.13	0.5	1	1	1
26	Benzo[a]pyrene JPB	ID	0.02	ID	0.00007	0.11	0.006	1.76E-06	4.38E-06	3.67E-10	5.11	6.18	0.13	0.5	1	1	1
27	Dibenz[ah]anthracene JPB	ID	0.018	ID	0.000063	0.04	0.033	5.40E-06	4.08E-06	3.40E-10	5.27	6.38	0.13	0.5	1	1	1
28	Indeno[123-cd]pyrene JPB	ID	0.086	ID	0.0003	0.1	0.009	2.05E-06	4.17E-06	3.51E-10	4.94	5.97	0.13	0.5	1	1	1
29	Benzo[ghi]perylene JPB	ID	0.909	ID	0.0032	0.06	0.01	2.86E-06	4.22E-06	3.56E-10	5.62	6.81	0.13	0.5	1	1	1
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		Soil-to-water partition coefficient (cm^3 g^{-1})	Vapour pressure (Pa)	Water solubility (mg L^{-1})	Soil-to-plant concentration factor for green vegetables (mg g^{-1} plant DW or FW basis over mg g^{-1} DW soil)	Soil-to-plant concentration factor for root vegetables (mg g^{-1} plant DW or FW basis over mg g^{-1} DW soil)	Soil-to-plant concentration factor for tuber vegetables (mg g^{-1} plant DW or FW basis over mg g^{-1} DW soil)	Soil-to-plant concentration factor for herbaceous fruit (mg g^{-1} plant DW or FW basis over mg g^{-1} DW soil)	Soil-to-plant concentration factor for shrub fruit (mg g^{-1} plant DW or FW basis over mg g^{-1} DW soil)	Soil-to-plant concentration factor for tree fruit (mg g^{-1} plant DW or FW basis over mg g^{-1} DW soil)
1	Boron JPB	1.00E+01	NR	6.35E+04	0.4 fw	0.2 fw	0.2 fw	0.2 fw	0.2 fw	0.2 fw
2	Arsenic	5.00E+02	NR	1.25E+06	0.00043 fw	0.0004 fw	0.00023 fw	0.00033 fw	0.0002 fw	0.0011 fw
3	Barium	0.00E+00	NR	8.00E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4	Beryllium JPB	1.70E+03	NR	1.66E+06	0.007 fw	0.0012 fw	0.0012 fw	0.0012 fw	0.0012 fw	0.0012 fw
5	Chromium (III) JPB	4.80E+03	NR	5.85E+05	0.00003 fw	0.00003 fw	0.00003 fw	0.00003 fw	0.00003 fw	0.00003 fw
6	Copper JPB	1.00E+02	NR	1.38E+06	0.0206 fw	0.0206 fw	0.0206 fw	0.0233 fw	0.0206 fw	0.0206 fw
7	Mercury, inorganic	5.00E+02	NR	7.40E+04	0.0038 fw	0.0069 fw	0.0043 fw	0.001 fw	0.0011 fw	0.001 fw
8	Nickel	5.00E+02	NR	2.50E+06	0.0038 fw	0.0043 fw	0.0019 fw	0.0025 fw	0.0025 fw	0.0034 fw
9	Vanadium JPB	1.26E+01	NR	2.11E+05	0.013 fw	0.013 fw	0.013 fw	0.013 fw	0.013 fw	0.013 fw
10	Zinc JPB	3.80E+01	NR	4.32E+06	0.054 fw	0.054 fw	0.054 fw	0.143 fw	0.054 fw	0.054 fw
11	Aromatic >EC12 - EC16 JPB	7.50E+01	1.14E+00	5.75E+00	model	model	model	model	model	model
12	Aromatic >EC16 - EC21 JPB	2.11E+02	5.62E-03	6.53E-01	model	model	model	model	model	model
13	Aromatic >EC21 - EC35 JPB	1.88E+03	1.61E-06	6.61E-03	model	model	model	model	model	model
14	Naphthalene JPB	9.66E+00	2.31E+00	1.90E+01	model	model	model	model	model	model
15	Acenaphthylene JPB	2.72E+01	7.08E-02	7.95E+00	model	model	model	model	model	model
16	Acenaphthene JPB	3.51E+01	7.37E-02	4.11E+00	model	model	model	model	model	model
17	Fluorene JPB	4.22E+01	1.56E-02	1.86E+00	model	model	model	model	model	model
18	Phenanthrene JPB	8.22E+01	2.82E-03	1.12E+00	model	model	model	model	model	model
19	Anthracene JPB	8.41E+01	8.49E-05	5.60E-02	model	model	model	model	model	model
20	Fluoranthene JPB	2.72E+02	1.31E-04	2.30E-01	model	model	model	model	model	model

		Soil-to-water partition coefficient (cm^3 g^{-1})	Vapour pressure (Pa)	Water solubility (mg L^{-1})	Soil-to-plant concentration factor for green vegetables (mg g^{-1} plant DW or FW basis over mg g^{-1} DW soil)	Soil-to-plant concentration factor for root vegetables (mg g^{-1} plant DW or FW basis over mg g^{-1} DW soil)	Soil-to-plant concentration factor for tuber vegetables (mg g^{-1} plant DW or FW basis over mg g^{-1} DW soil)	Soil-to-plant concentration factor for herbaceous fruit (mg g^{-1} plant DW or FW basis over mg g^{-1} DW soil)	Soil-to-plant concentration factor for shrub fruit (mg g^{-1} plant DW or FW basis over mg g^{-1} DW soil)	Soil-to-plant concentration factor for tree fruit (mg g^{-1} plant DW or FW basis over mg g^{-1} DW soil)
21	Pyrene JPB	2.43E+02	1.53E-05	1.30E-01	model	model	model	model	model	model
22	Benz[a]anthracene JPB	1.16E+03	1.24E-06	3.80E-03	model	model	model	model	model	model
23	Chrysene JPB	8.22E+02	4.52E-08	2.00E-03	model	model	model	model	model	model
24	Benzo[b]fluoranthene JPB	1.57E+03	6.34E-08	2.00E-03	model	model	model	model	model	model
25	Benzo[k]fluoranthene JPB	2.21E+03	1.64E-08	8.00E-04	model	model	model	model	model	model
26	Benzo[a]pyrene JPB	1.93E+03	2.00E-08	3.80E-03	model	model	model	model	model	model
27	Dibenz[ah]anthracene JPB	2.79E+03	1.66E-10	6.00E-04	model	model	model	model	model	model
28	Indeno[123-cd]pyrene JPB	1.30E+03	2.12E-09	2.00E-04	model	model	model	model	model	model
29	Benzo[ghi]perylene JPB	6.24E+03	1.55E-10	2.64E-04	model	model	model	model	model	model
30										

CLEA Software Version 1.06

Report generated 31-Jan-14

Report title Wark Crescent Residential Plant with Uptake

Created by FT at JPB

RESULTS

		Assessment Criterion (mg kg^{-1})			Ratio of ADE to HCV			Saturation Limit (mg kg^{-1})	50% rule?	
		oral	inhalation	combined	oral	inhalation	combined		Oral	Inhal
1	Cadmium	1.12E+01	1.85E+02	1.10E+01	0.95	0.05	1.00	NR	Yes	Yes
2										
3										
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		Soil Distribution				Media Concentrations													
		Sorbed	Dissolved	Vapour	Total	Soil	Soil gas	Indoor Dust	Outdoor dust at 0.8m	Outdoor dust at 1.6m	Indoor Vapour	Outdoor vapour at 0.8m	Outdoor vapour at 1.6m	Green vegetables	Root vegetables	Tuber vegetables	Herbaceous fruit	Shrub fruit	Tree fruit
		%	%	%	%	mg kg^{-1}	mg m^{-3}	mg kg^{-1}	mg m^{-3}	mg m^{-3}	mg m^{-3}	mg m^{-3}	mg m^{-3}	mg kg^{-1} FW	mg kg^{-1} FW	mg kg^{-1} FW	mg kg^{-1} FW	mg kg^{-1} FW	mg kg^{-1} FW
1	Cadmium	99.5	0.5	0.0	100.0	1.10E+01	NR	5.48E+00	4.67E-09	5.90E-10	0.00E+00	0.00E+00	0.00E+00	5.70E-01	3.18E-01	3.40E-01	1.76E-01	3.40E-02	1.54E-02
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4																			
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		Average Daily Exposure (mg kg^{-1} bw day^{-1})							Distribution by Pathway (%)							
		Direct soil ingestion	Consumption of homegrown produce and attached soil	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour	Background (oral)	Background (inhalation)	Direct soil ingestion	Consumption of homegrown produce and attached soil	Dermal contact with soil and dust	Inhalation of dust	Inhalation of vapour (indoor)	Inhalation of vapour (outdoor)	Background (oral)	Background (inhalation)
1	Cadmium	1.62E-05	1.60E-04	1.19E-07	6.05E-08	0.00E+00	2.51E-04	3.81E-07	4.61	45.34	0.03	0.02	0.00	0.00	49.98	0.02
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		Oral Health Criteria Value (µg kg^{-1} BW day^{-1})		Inhalation Health Criteria Value (µg kg^{-1} BW day^{-1})		Oral Mean Daily Intake (µg day^{-1})	Inhalation Mean Daily Intake (µg day^{-1})	Air-water partition coefficient (K_{aw}) (cm^3 cm^{-3})	Coefficient of Diffusion in Air (m^2 s^{-1})	Coefficient of Diffusion in Water (m^2 s^{-1})	log K_{oc} (cm^3 g^{-1})	log K_{ow} (dimensionless)	Dermal Absorption Fraction (dimensionless)	Soil-to-dust transport factor (g g^{-1} DW)	Sub-surface soil to indoor air correction factor (dimensionless)	Relative bioavailability via soil ingestion (unitless)	Relative bioavailability via dust inhalation (unitless)
1	Cadmium	TDI	0.36	TDI	0.0014	13.4	0.02	NR	NR	NR	NR	NR	0.001	0.5	1	1	1
2																	
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Environment Agency

		Soil-to-water partition coefficient (cm^3 g^{-1})	Vapour pressure (Pa)	Water solubility (mg L^{-1})	Soil-to-plant concentration factor for green vegetables (mg g^{-1} plant DW or FW basis over mg g^{-1} DW soil)	Soil-to-plant concentration factor for root vegetables (mg g^{-1} plant DW or FW basis over mg g^{-1} DW soil)	Soil-to-plant concentration factor for tuber vegetables (mg g^{-1} plant DW or FW basis over mg g^{-1} DW soil)	Soil-to-plant concentration factor for herbaceous fruit (mg g^{-1} plant DW or FW basis over mg g^{-1} DW soil)	Soil-to-plant concentration factor for shrub fruit (mg g^{-1} plant DW or FW basis over mg g^{-1} DW soil)	Soil-to-plant concentration factor for tree fruit (mg g^{-1} plant DW or FW basis over mg g^{-1} DW soil)
1	Cadmium	1.00E+02	NR	1.62E+06	0.052 fw	0.029 fw	0.031 fw	0.016 fw	0.0031 fw	0.0014 fw
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NB503-3 Wark Crescent

Scenarios:
Child Resident - Typical
Adult Resident - Typical

Routes:
INGESTION OF SOIL
DERMAL CONTACT WITH SOIL
INGESTION OF ROOT VEGETABLES
INGESTION OF ABOVE GROUND VEGETABLES

Chemicals:
   Lead

                                                     SCENARIO:
SUMMARY OF INPUT PARAMETERS                         1         2
---------------------------------------------------------------------

LIFETIME AND BODY WEIGHT
   Body Weight (kg)                              15.        70.
   Lifetime (years)                              6.0        43.

INGESTION OF SOIL
   Soil Ingestion Rate (mg/day)                 1.00E+02    60.
   Exp. Frequency Soil (events/year)            3.65E+02   3.65E+02
   Exp. Duration Soil (years)                    6.0        43.
   Absorption Adjustment Factor for
      Ingestion of Soil (-)
              Lead                                 1.0       1.0

   Soil Bioavailability (-)
              Lead                                 1.0       1.0

DERMAL CONTACT WITH SOIL
   Total Skin Surface Area (cm^2)               6.70E+03   1.76E+04
   Fraction Skin Exposed to Soil (-)            0.28       5.00E-02
   Adherence Factor for Soil (mg/cm^2)           1.0       0.30
   Exposure Freq. Soil   (events/year)          3.65E+02   3.65E+02
   Exposure Duration Soil (years)                6.0        43.
   Absorption Adjustment Factor for
      Dermal Exposure to Soil (-)
              Lead                                1.00E-02  1.00E-02

   Soil Bioavailability (-)
              Lead                                 1.0       1.0

INGESTION OF ROOT VEGETABLES
INGESTION OF ABOVE GROUND VEGETABLES
   Root Veg. Ingestion Rate (g/day)              51.       1.25E+02
   Above Ground Veg. Ing. Rate(g/day)            14.        12.
   Fraction Organic Carbon in Soil g/g          1.20E-02   1.20E-02
   Exp. Frequency Veg. (events/year)            3.65E+02   3.65E+02
   Exp. Duration Veg. Intake (years)             6.0        43.
   Fraction grown in home garden (-)            0.39       0.39
   Koc [(mg/l)/mg/l)]
              Lead                                  ND        ND

   log Kow
              Lead                                  ND        ND

   Vegetable Uptake Factor [-] (from chemical database)
              Lead                                  ND        ND

   Kd [(mg/L)/(mg/kg)] (from chemical database)
              Lead                                 9.9       9.9
```

```
MEDIA CONCENTRATIONS
--------------------
Concentration in Surficial Soil (mg/kg)
     Used in calculating carcinogenic risk and hazard index
              Lead                                4.60E+02  4.60E+02

Conc. in Garden Soil (mg/kg)
This will be the same as surficial soil conc.
     Used in calculating carcinogenic risk and hazard index
              Lead                                4.60E+02  4.60E+02

SLOPE FACTORS AND REFERENCE DOSES
---------------------------------

Ingestion Slope Factor [1/(mg/kg-day)]
              Lead                                 ND        ND

Ingestion Reference Dose (mg/kg-day)
              Lead                                3.60E-03  3.60E-03

Dermal Slope Factor [1/(mg/kg-day)]
              Lead                                 ND        ND

Dermal Reference Dose (mg/kg-day)
              Lead                                3.60E-03  3.60E-03


                                         SCENARIO:
SUMMARY OF RESULTS                    1             2
---------------------------------------------------------

INGESTION OF SOIL


   Daily Doses and Risk for : Lead
     CADD (mg/kg-day)               3.07E-03     3.94E-04
     LADD (mg/kg-day)               3.07E-03     3.94E-04
     Cancer Risk (-)                0.00E+00     0.00E+00
     Hazard Index (-)               8.52E-01     1.10E-01

DERMAL CONTACT WITH SOIL


   Daily Doses and Risk for : Lead
     CADD (mg/kg-day)               5.75E-04     1.73E-05
     LADD (mg/kg-day)               5.75E-04     1.73E-05
     Cancer Risk (-)                0.00E+00     0.00E+00
     Hazard Index (-)               1.60E-01     4.82E-03

INGESTION OF ROOT VEGETABLES

   Soil-to-root Concentration Factor, Bvr (mg/mg)
              Lead                                 0.0       0.0

   Daily Doses and Risk for : Lead
     CADD (mg/kg-day)               0.00E+00     0.00E+00
     LADD (mg/kg-day)               0.00E+00     0.00E+00
     Cancer Risk (-)                0.00E+00     0.00E+00
     Hazard Index (-)               0.00E+00     0.00E+00

INGESTION OF ABOVE GROUND VEGETABLES

   Soil-to-above-ground Concentration Factor, Bva (mg/mg)
              Lead                                 0.0       0.0

   Daily Doses and Risk for : Lead
     CADD (mg/kg-day)               0.00E+00     0.00E+00
     LADD (mg/kg-day)               0.00E+00     0.00E+00
     Cancer Risk (-)                0.00E+00     0.00E+00
     Hazard Index (-)               0.00E+00     0.00E+00
```

CAT-WASTE SOIL

Classification Assessment Tool of Soil Wastes - Hazard Summary Sheet

McArdle ATKINS

Site Name	Wark Crescent
Location	Jarrow
Site ID	F1
Job Number	NB503-3
Date	1/31/2014 11:52:35 AM
User Name	Lafferty@jpb.co.uk
Company Name	Johnson Poole & Bloomer

Hole ID	Sample Depth	Hazardous Waste Y/N	H1	H2	H3A	H3B	H4	H5	H6	H7	H8	H9	H10	H11	H12	H13	H14	H15
_301	0.1m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
_302	0.7m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
_303	0.4m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
_304	1.5m	N	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No

This output data has been generated by the CAT-Waste Soil waste classification tool provided by Atkins Consultants Ltd and J.McArdle Contracts and should be read in conjuntion with the standard Terms and Conditions

11:56 31/01/2014

Classification Assessment Tool of Soil Wastes - Individual Compound Information

Site Name	Wark Crescent
Location	Jarrow
Site ID	F1
Job Number	NB503-3
Date	1/31/2014 11:52:35 AM
User Name	Lafferty@jpb.co.uk
Company Name	Johnson Poole & Bloomer

Hole ID	Sample Depth	Contaminant	Contaminant Concentration (%)	Hazardous Waste Y/N	Hazard Class	Risk Phrases Exceeded	Additive Risk Phrases Exceeded	H14 Risk Phrases Exceeded	Additional Risk Phrases (see notes section)
_301	0.1m	Benzene	0.0001	N					R11 test
_301	0.1m	Toluene	0.0001	N					R67 (this risk phrase alone will not constitute a waste as being hazardous), R11 test
_301	0.1m	Ethylbenzene	0.0001	N					R11 test
_301	0.1m	m,p-xylene	0.0001	N					R10 test flash point
_301	0.1m	o-xylene	0.0001	N					R10 test flash point
_301	0.1m	Boron	0.001157407	N					R14 (this risk phrase alone will not constitute a waste as being hazardous)
_301	0.1m	Vanadium	0.005356187	N					R55 see comment
_301	0.1m	Free Cyanide	5E-05	N					R12 test
_302	0.7m	Benzene	0.0001	N					R11 test
_302	0.7m	Toluene	0.0001	N					R67 (this risk phrase alone will not constitute a waste as being hazardous), R11 test
_302	0.7m	Ethylbenzene	0.0001	N					R11 test
_302	0.7m	m,p-xylene	0.0001	N					R10 test flash point
_302	0.7m	o-xylene	0.0001	N					R10 test flash point
_302	0.7m	Boron	0.002777778	N					R14 (this risk phrase alone will not constitute a waste as being hazardous)
_302	0.7m	Vanadium	0.005177647	N					R55 see comment
_302	0.7m	Free Cyanide	5E-05	N					R12 test
_303	0.4m	Benzene	0.0001	N					R11 test
_303	0.4m	Toluene	0.0001	N					R67 (this risk phrase alone will not constitute a waste as being hazardous), R11 test
_303	0.4m	Ethylbenzene	0.0001	N					R11 test
_303	0.4m	m,p-xylene	0.0001	N					R10 test flash point
_303	0.4m	o-xylene	0.0001	N					R10 test flash point
_303	0.4m	Boron	0.002083333	N					R14 (this risk phrase alone will not constitute a waste as being hazardous)
_303	0.4m	Vanadium	0.007320121	N					R55 see comment
_303	0.4m	Free Cyanide	5E-05	N					R12 test
_304	1.5m	Benzene	0.0001	N					R11 test
_304	1.5m	Toluene	0.0001	N					R67 (this risk phrase alone will not constitute a waste as being hazardous), R11 test
_304	1.5m	Ethylbenzene	0.0001	N					R11 test
_304	1.5m	m,p-xylene	0.0001	N					R10 test flash point
_304	1.5m	o-xylene	0.0001	N					R10 test flash point
_304	1.5m	Boron	0.0009259259	N					R14 (this risk phrase alone will not constitute a waste as being hazardous)
_304	1.5m	Vanadium	0.005356187	N					R55 see comment
_304	1.5m	Free Cyanide	5E-05	N					R12 test

Notes - Additional Information on Risk Phrases

R1 to R6	Explosive - See comment	Associated with H15, where the hazard (H15) will apply if the waste contains substances that degrade to form, or react with, other wastes or substances (or produce on combustion) other substances with any of the properties H1 to H14, at or above the appropriate threshold.
R7, R8 and R9	Test/calculation for oxides	Applicable to solid compounds that are not explosive, highly flammable, organic peroxides or combustible. A test for the compounds oxidising properties as described in Directive 92/69/EEC, Test Method A17. For organic peroxides calculate the available oxygen content (%). For liquids and oxidising materials not covered by those previously listed no testing available.
R10	R10 test flash point	Flashpoint test as per Directive 92/62/EEC, Test Method A9
R11	R11 test flash point	For liquid substances, undertake the flashpoint test as per Directive 92/62/EEC, Test Method A9. For solid substances undertake flammability test as per directive 92/62/EEC, Test Method A10
R12	R12 test flammability	Flammability of gasses test as per Directive 92/62/EEC Test Method A11.
R15	R15 test flammability	To test the flammability of a substance when in contact with water test as per Directive 92/62/EEC, Test Method A12.
R16	R16 test for explosives	See comment above
R17	R17 pyrophoric test	To test the pyrophoric properties of solids and liquids test as per Directive 92/62/EEC, Test Method A13.
R18	R18 test for flammable explosive vapour air mixture	See comment above
R19	R19 test for flammable explosive peroxides	See comment above
R29	R29 test or calculation	Undertake test as per Directive 92/62/EEC, Test Method A12.
R31	R31 test or calculation	Undertake testing as per Directive 92/62/EEC, Test Method A12 modified to replace water with an acid which will not cause a displacement reaction to occur. Method to measure SO2 evolved when a waste is in contact with an acid (see Environment Agency SWEN 068).
R32	R32 test or calculation	Undertake testing as per Directive 92/62/EEC, Test Method A12 modified to replace water with an acid which will not cause a displacement reaction to occur).
R44	R44 test for explosives	See comment above
R54 to R58	see comment	Classification of waste as ecotoxic (on the basis of terrestrial non-aquatic toxicity) is not applicable due to the lack of detailed information. Until more data becomes available R54 to R58 should not be considered when assessing the ecotoxic hazard of wastes and classifications should be based upon aquatic toxicity data. Where there is reason to believe that a waste contains substances that only have effects on the terrestrial environment, guidance on the approapriate test method should be obtained from the Environment Agency.

Notes:

Testing of compounds which would be classified under H14 should only be undertaken where the hazards cannot be adequately identified. (i.e. where the waste contains a substance/s for which there is no aquatic toxicity data and/or where the waste is an uncharacterised mixture and/or there is the potential that the waste may contain unknown substances or breakdown products.
Aquatic toxicity testing should be undertaken in accordance with the Environmental Health and Safety Publication, series on Testing and Assessment No. 23 ENV/JM/MONO(2000) 6 June 2000

Appendix G

JPB Methodology for Exposure Assessment

JPB Methodology for Exposure Assessment

Regulatory Framework

The assessment of potentially contaminated sites and the associated risk to the proposed development is dependent on a number of factors namely, the intended site end use, distribution and level of contamination, characteristics of the soil (i.e. pH, permeability) the groundwater regime and the sensitivity of the surrounding area. An analysis of the interaction between these various factors allows a decision to be made with regard to the extent of any remedial measures required for the development.

The contaminated land provision of the Environment Protection Act 1990, inserted by Section 57 of the Environment Act 1995, came into force in July 2000. This guidance has been revised and came into force on 6 April 2012. Within this "Contaminated Land" is defined as

> *"any land .... in such a condition by reason of substances in, on or under the land, that*
>
> *a) significant harm is being caused or there is a significant possibility of such harm being caused; or*
> *b) pollution of the water environment is being, or is likely to be caused;"*
>
> In addition *"the questions*
>
> *a) what harm or pollutant of the water environment is likely to be regarded as significant*
> *b) whether the possibility of the significant harm or significant pollution of all the water environment being considered significant"*

In addition, the National Planning Policy Framework, issued March 2012, sets out the Government's planning policies for England. This framework also requires a "suitable for use approach" which requires remediation only where there are unacceptable risks to health and the environment depends on the current and proposed end use.

In addition, the guidance requires a significant pollutant linkage to be present which includes;

- A source (pollutant)
- A pathway
- A receptor

JPB has therefore developed a risk assessment approach based on this philosophy, the methodology used is represented diagrammatically in the attached flow chart.

Stage 1 - Preliminary Risk Assessment-

Desk Study
The methodology utilised for desk studies follows the specifications outlined in CLR2 "Guidance on Preliminary Site Inspection of Contaminated Land", CLR6 "Prioritisation and Categorisation Procedure for Sites which May be Contaminated" and BS 10175: 2001 "Investigation of Potentially Contaminated Sites – Code of Practice", BSI 2001.

During the study, documentary research will include an examination of the Ordnance Survey maps for details regarding previous site and adjacent land uses. Similarly the available geological maps will be examined to determine the geological/hydrogeological conditions beneath and adjacent to the site. In addition, regional memoirs will be consulted together with mine abandonment plan data and any available borehole records, in order to assess the mining conditions. A walkover survey will be carried out to determine the existing site conditions and operations. In addition, a photographic record of the site is taken during the walkover survey. Information will also be obtained from the EA website and a review of in-house information. A Report of environmental database information may also be obtained.

Conceptual Site Model
A Conceptual Site Model (CSM), which describes how potential chemical sources at the site could contribute to increased levels of risk to potentially sensitive receptors, is developed at an early stage and constantly reassessed in light of investigative findings. CSMs are generated in accordance with Guide to Good Practice for the Development of Conceptual Models and the Selection and Application of Mathematical Models of Contaminant Transport Processes in the Subsurface - National Groundwater & Contaminated Land Centre report NC/99/38/2 – Environment Agency 2001.
The first step in developing such a model is to identify whether there are potential hazards which may pose a risk on the site through desk top research and professional judgement. In addition, information regarding the site-specific environmental setting including geology, hydrogeology, hydrology etc, is gathered in order to assess the potential exposure pathways which are likely to exist and the location of humans and environmental resources which could be impacted by the site.

Following this desk based study and the development of a CSM a site investigation is designed in order to determine whether any potentially significant pollutant linkages actually exist on the site. The information gathered during the investigation is then used to revise the CSM and as the basis of the risk assessment process. While any investigation strategy will be specific to each site the following general comments can be made.

Design of Site Investigations
JPB designs and implements site investigations in accordance with BS10175. Care is taken to target investigations at potentially contaminated locations identified in the CSM from researches and from site visits or other available information. In addition, during the performance of investigations locations are refocused in the light of known site conditions. Further investigations are also undertaken at randomly selected locations resulting in a mixture of random and targeted investigation locations.

The requirement for adequate site coverage is a key consideration at the design stage and the number and type of investigation locations is determined by the available information, the brief and the requirements of the guidance given in CLR4 and R & D Publication Report P5-066/TR Secondary Model Procedure for the development of Appropriate Soil Sampling Strategies for Land Contamination. BS10175 indicates that in order to provide adequate site coverage a sampling grid of between 20m and 25m should normally be applied where residential development is considered. Where the CSM indicates there to be no potential source of contamination on the site, or other land uses are envisaged, a 50m spacing may be adopted.

Investigations are designed such that, in statistical terms, the number of sampling points investigated would identify a “hot spot” zone of contamination covering 5% or greater of the site area. On small sites where this is impractical, the design of investigations is such as to determine that a hotspot of a certain area does not go undetected.
Site-Specific Risk Assessment

Site Zoning
Some sites may need to be divided into geographical sectors where, for example, historical land uses differ or the type of development varies across the site in accordance with R & D Technical Report P5-066/TR. Good practice guidance describes averaging areas as “areas of soil to which a receptor is exposed or which otherwise contributes to the creation of hazardous conditions”. Where made ground material is contaminated at variable concentrations, but within a single geological unit JPB considers that this unit can be adopted as an averaging area for the purposes of making an assessment of human health risks. However, where measured contamination concentrations include statistical outliers of high concentration, where different historical land uses have resulted in different patterns of contamination or where there is a clear distribution of higher contaminant concentrations in one sector of the site, averaging areas are chosen to reflect this contaminant distribution. Single high contaminant concentrations may indicate the presence of “hotspots” which may merit closer scrutiny or additional investigation.

Investigation locations such as trial pits and boreholes are positioned to provide adequate site coverage, where access is available and avoiding existing services. Boreholes are situated at a mixture of targeted and random locations at the site where access is possible. During the investigation the sampling strategy in CLR 4 “Sampling strategies for contaminated land” together with the guidance given in R & D Publication Report P5-066/TR is followed. The rationale behind the sampling strategy given in the R & D publication is:

Depth of sample	**Rationale**
0-0.5	To assess ▪ Human/animal intake arising from ingestion and dermal contact ▪ Potential for wind entrainment leading to inhalation (of contaminated soils and dusts) or deposition onto neighbouring land ▪ Surface water run-off (e.g. due to flash flooding) ▪ Uptake by shallow rooting plants (e.g. crops, ornamental and wild species) ▪ Surface leaching to groundwater.
0.5m in made or natural ground	To assess ▪ Intake via ingestion/inhalation/dermal contact from “abnormal”)or unpredicted) excavation (e.g. children digging dens) or for other purposes such as swimming pools, ponds house extensions) ▪ Uptake by deep rooting shrubs and trees ▪ Intake by, or arising from, the activities of burrowing animals ▪ Intake arsing from construction / maintenance of buildings and services for example. o Foundations (usually within 2m of formation level o Water supply pipes, telecommunications, gas & power (0.5-1m of final formation level) o Sewers (from 0.5 > 1m of final formation level) To locate perched water or groundwater To confirm depth of made ground To locate possible lateral pathways for gas or vapour migration in made ground To establish extent of any leaching of soluble constituents from superficial soils To detect “deep” contaminants (e.g. gas generating materials, leachable materials, dense solvents located on top of an impermeable stratum) To obtain information of “background” soil properties To locate “natural” lateral migration pathways.

Samples are generally taken at shallow depth, then at relevant changes in material with depth. Where any made ground is thick and relatively uniform samples are taken every 0.5m to 1.0m. A sample of natural soils is generally taken from beneath each made ground horizon where the base is proven. Samples are recovered from each trial pit Samples are recovered at these regular intervals with additional samples of any atypical horizons also taken. It should be noted that there will always be the possibility of additional unrecorded conditions outwith the sampling points. Samples obtained are stored within appropriate containers and dispatched for analysis within 24 hours of sampling.

Attempts are made to recover water samples from all of the boreholes at which standpipes are installed. Each borehole is extensively purged to a volume in excess of three times the well volume using a submersible mini-whale pump. Purging before sampling allows a more representative water sample of groundwater to be obtained and ensures that any water initially present in the boreholes is removed as this may have been chemically altered due to reaction with air or with installation materials. Water samples are transferred to appropriate containers before being transported to the testing laboratory in cooled conditions.

Testing parameters scheduled on soil and water samples are based on historical and current operations information and their importance in relation to health risks, phytotoxicity, impact on the water environment, protection of building materials, services and structures from chemical attack and potential impact on the quality of potable water supplies. Where possible chemical testing is targeted at locations at the site where particular contaminants are anticipated. Selection of test parameters is performed on a site specific basis as described in the text of each investigation report.

Stage 2 Generic Quantitative Risk Assessment

The next stage of the site-specific assessment is to perform a Stage 2 risk assessment using the information gathered during the site investigation to determine the actual nature and extent of contamination, evaluating the data using conservative generic criteria to determine whether any recorded levels of contaminants could be potentially of concern.

Stage 2 Criteria

The Stage 2 generic quantitative assessment of risk to human health, property, ecology, surface water and ground water considers the potential for exposure based on comparison of the results to conservative generic criteria.

In terms of human health the results of the soil testing are assessed with reference to the guidance published by DEFRA and the Environment Agency including; Soil Guideline Values (SGVs) derived using the CLEA model and the methodology described in EA Science Report SC050021/SR3, EA CLEA science reports and the associated TOX and SGV series of reports. Based on this guidance JPB has calculated a series of generic assessment criteria (GAC) for different land use scenarios. Where no data are available from these sources, an automatic Stage 3 assessment is carried out if the parameter is present above laboratory reporting limits. The guideline concentrations appropriate to the proposed end use of the site is used in the interpretation of the results. At Stage 2 all soil contaminant concentrations are compared with GACs. If necessary, at Stage 3 representative soil contaminant concentrations are calculated and used for comparison with assessment criteria.

To assess the site’s potential for phytotoxicity JPB refers to the MAFF/DoE document “Review of the Rules for Sewage Sludge Application to Agricultural Land – Soil Fertility Aspects of Potentially Toxic Elements” in the absence of other definitive phytotoxic screening levels. This document is authoritative and scientifically based, it sets out total concentrations of various metallic elements which shouldn’t be exceeded in order to maintain soil fertility and avoid toxicity. Therefore it is considered that these limits can be applied to contaminated land and other situations, e.g. they have been adopted by DEFRA in its “Soil Code” and by the Forestry Commission. It should be noted that plant growth can also be significantly affected by many other factors including: pH, nutrient availability, soil texture and structure, temperature, moisture content and aeration. In addition reference has been made to “Soil Code” (MAFF 1998), and CLR2, “Guidance on Preliminary Site Inspection of Contaminated Land”.

Structures and Services

Where structures or services are considered to be viable targets, risks are assessed using contemporary best practice guidance given in documents published by the Building Research Establishment (BRE), CIRIA, Water Research Council (WRc), WRAS the HSE and other relevant organisations.

Risks posed to buildings and services due to aggressive soil sulphate, chloride and pH conditions are assessed using the guidance given in BRE Special Digest 1 (2005), Concrete in aggressive ground.

Water Supply Pipes

Risks posed by soil and groundwater contaminant concentrations to water supply pipes are assessed in accordance with the UK Water Industry Research (UKWIR) document, “Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites”, UKWIR report reference 10/WM/03/21, 2010. This guidance identifies the chemicals present in soils which can either permeate pipes or impact on their integrity by causing swelling, cracking and degradation or corrosion. The main focus is, therefore, on organic contaminants and on the soil’s conductivity, pH and redox potential.

Where a site has been greenfield and no chemicals have been historically or currently stored or used on it (or part of the site meets these criteria), no restriction is made on the type of water pipes which can be used on the site (or part of the site as appropriate). In these circumstances the water company may require that a PID survey of the route of water supply pipes is undertaken, extending to 15m either side of the pipe route, in order to confirm that no unexpected chemical contamination is present. Alternatively this requirement can be satisfied by upgrading pipe materials to PE-Al-PE barrier pipe, which would be protective of water supplies.

It should also be noted that where the site is within close range of a petrol station or other fuel storage facility, the water company may require that the water supply pipes installed take account of future contamination risks from these adjacent sources.

Where the site is brownfield or where chemicals have been stored or used, samples are obtained from locations on site as identified in the site CSM. Where the route of water supply pipes is known, sample locations during investigations would include locations on or within 15m either side of the route, otherwise investigation coverage for the whole site is as described previously in this methodology and as recommended in section 2.5.5 of the UKWIR report.

Selected soil samples are tested for the parameters recommended in the UKWIR guidance; VOCs (including TIC), SVOCs (including TIC), petroleum hydrocarbons (including "mineral oils"), conductivity, pH value and redox potential. Results of analyses are collated and compound group concentrations summed as described in section 2.7.9 of the UKWIR guidance, these sums are adopted as Representative Contaminant Concentrations (RCCs). The maximum concentration recorded at the site (or if appropriate within a particular site zone) for each substance is used for summing and tabulation, this is a conservative assumption.

The RCCs are compared with the UKWIR threshold values for polyethylene (PE) and polyvinylchloride (PVC pipes) detailed in Table 3.1 of the UKWIR, which have been adopted as JPB GACs. Exceedance of a single GAC indicates PE or PVC pipework is not appropriate and other pipe materials should be selected. Consideration of the corrosive properties of soils is also required where PE, PVC or barrier pipes are not selected as appropriate. The comparison of RCCs with GACs and the other criteria in Table 3.1 of the UKWIR guidance results in a list of pipe materials which would be suitable in terms of chemical properties, a preferred selection can then be made on the basis of cost, appropriateness etc. or the choice of specific materials to be used made by the engineer/developer. Further recommendations on standards and specifications for water supply pipes and fittings for various pipe materials are given in Part 4 of the UKWIR guidance.

Combustibility

Where potentially combustible materials are encountered the following assessment methodology is adopted. Despite the potential for combustion in many sites characterised by carbonaceous materials, the number of recorded instances of actual combustion are very few and there has been no definitive study of the phenomena. Consequently, there are no commonly accepted criteria for comprehensively assessing and dealing with the risk of spontaneous combustion. The ICRCL Guidance Note 61/84 "notes on fire hazards of contaminated land" suggests that there is an unacceptable risk of combustion if the material has a Calorific Value in excess of 10 MJ/kg or perhaps only 7 MJ/kg.

However a paper presented at the Fourth Mineral Waste Utilisation Symposium related to the Utilisation of Coal Refuse for Highway Base or Sub-base Material. In this paper it states that "low permeability values are desirable in order to reduce air circulation and the potential for spontaneous combustion". It then goes on to suggest that "proper compaction of coal refuse reduces air voids to less than 10% and the potential for spontaneous combustion is substantially reduced".

There is an imprecise relationship between Loss on Ignition and Calorific Value but previous comparisons by JPB has indicated 10 MJ/kg to be roughly equivalent to 30% Loss on Ignition and 7 MJ/kg to be roughly equivalent to 23% Loss on Ignition.

JPB adopts the following guidelines:

i) combustion may be induced and supported only if the Loss on Ignition value exceeds about 20% and the Calorific Value exceeds 7 MJ/kg.

ii) carbonaceous material needs to be of some bulk ie thicker than 1 metre and greater than 10 m^3 in volume.

iii) spontaneous combustion should not occur in thoroughly compacted material to which air is excluded.

Water Environment

Current SEPA guidance described in document WAT-PS-10-01: Assigning Groundwater Assessment Criteria for Pollutant Inputs (March 2010) notes that for land contamination four receptors were to be assessed, if identified as being present, namely surface water; groundwater abstraction; groundwater resource; and groundwater dependant terrestrial ecosystem (GWDTE or wetland). Routine leachability testing is carried out for water soluble contaminants in order to determine if there is a threat from soil borne contaminants to ground and surface waters.

For the protection of surface waters and groundwater resources the concentration of each contaminant in soil leachates, groundwaters and surface waters are compared against relevant assessment limits. The assessment limits may be a UK Drinking Water Standard (UKDWS), Resource Protection Value (RPV) or EQS depending on the nature of the receptor which is being considered to potentially be at risk.

Where no assessment limit has been provided other limits may be adopted such as WHO Drinking Water Guidelines, US EPA National Primary Drinking Water Regulations or the laboratory's minimum reporting limit (MRL).

Stage 2 Risk Evaluation

Stage 2 risk based guidance levels are conservative generic values against which measured contaminant concentrations can be compared. Where measured concentrations are found to be below these screening criteria then the contamination identified is not considered to pose a significant risk. The guidance used to evaluate investigation data is chosen to be relevant for the particular risk and receptor being assessed as well as being applicable to the legislative issues of concern. Where measured concentrations of contaminants exceed generic criteria the risks posed by the contaminants of concern are considered more fully in a Stage 3 risk assessment. Where no generic criteria are available or a substance, an automatic Stage 3 assessment is carried out if the contaminant is present above laboratory reporting limits.

Stage 2 criteria adopted by JPB for risk assessments are appended. If any of the appropriate criteria contained in these documents are exceeded, the conclusion is that significant risk could exist and that a further assessment (Stage 3) is warranted in order to calculate the potential levels of risk. This process therefore focuses on the contaminants of concern and can, if necessary, inform any further investigations which may be required for more detailed examination.

Stage 3 Detailed Quantitative Risk Assessment

Assessment of risks to human health
Each contaminant exceeding Stage 2 criteria is examined for its potential to cause harm. Consideration is then given to the significant pollutant linkages which are plausible for the identified hazards, i.e. whether a contaminant can conceivably come into contact with a specified target group. It is possible that a contaminant may be deemed a hazard due to its presence above screening criteria but ultimately not constitute a risk as no viable pathway exists between the source and the receptor. The relative sensitivity of all potential receptors identified is quantitatively assessed using the data obtained during the desk study and site investigation phases.

The risk to human health is determined using an exposure assessment, an estimate of potential doses of the chemicals in exposed individuals via the pathways identified in the Conceptual Site Model. This focuses on a hypothetical individual within each exposed population and involves the use of models which incorporate assumptions regarding human behaviour and physiological attributes. The assumptions are made in a “worst case” or “reasonable worst case” manner to provide estimates of dose which are unlikely to be exceeded by receptors at or in the vicinity of the site. The main focus of the exposure assessment is the estimation of long-term (chronic) dose levels from repeated exposure to chemicals in the soil and groundwater. Exposure to each chemical is estimated for each viable pathway and for any potential sensitive receptors.

The purpose of the human health assessment is to identify the levels of exposure to contaminants which, if not exceeded, do not cause adverse health effects. The subject of human health assessments is covered in depth in the DEFRA/EA Science reports to which the reader is referred for further background information, but a short review is given below.

Health Criteria Values
Human health assessment criteria are derived by comparing the estimated exposure of critical receptors to the contaminants with Health Criteria Values (HCVs) that represent a tolerable or minimal risk to health from chronic exposure to these contaminants (acute health risks must be assessed separately). Health Criteria Values are derived through the collation and review of toxicological data and its subsequent use in the derivation of soil contaminant intakes that are considered to be protective of human health. These intakes are guidelines to a risk assessor on the level of long-term human exposure to individual chemicals in soil that are tolerable or pose a minimal risk. HCVs are established from a review of the evidence from occupational and environmental epidemiological studies, animal studies, and from scientific understanding of the mechanisms of absorption, transport, metabolism and toxicity of chemicals within the human body. The derivation of HCVs is described in detail within EA Science report-SC050021/SR2.

Contaminants generally exhibit two possible types of toxicity, threshold toxicity and non-threshold toxicity. For contaminants which exhibit threshold toxicity there is some, non-zero, measurable amount of exposure (dose) that is required before a biological threshold is breached and an adverse health effect is produced. However, in some cases the toxicological mechanism responsible for producing the adverse effect is such that there is no basis to assume a threshold exists. This is most notably the case for genotoxic carcinogens. The biological mechanisms by which these types of chemicals cause damage to DNA and genetic material means, that any exposure to these chemicals, no matter how small, will carry some level of risk. The theoretical basis for this is that one ‘hit’ on DNA can produce a mutation that may eventually lead to a tumour. It is therefore not possible to identify the threshold with any confidence. Hence, the prudent assumption is made that such compounds do not have a threshold. It should be noted that not all carcinogens are genotoxic, some may exhibit a threshold, and whether a contaminant is a threshold or non-threshold substance should be determined by a review of the available toxicological evidence.

HCVs for threshold substances are referred to in the UK as Tolerable Daily Intakes (TDIs), some other authorities or organisations derive similar criteria such as Reference Doses (RfDs) or Provisional Tolerable Weekly Intakes (PTWIs). These values are in principle similar and can be thought of as “safe” levels of exposure at which adverse effects are not likely to occur, although some conversion or further consideration may be required before adoption in the UK context. These health criteria are typically derived by applying “safety” or “uncertainty” factors to intake levels observed to have little or no effects in humans or animals.

Exposure to receptors will occur not just from soil-borne contamination but also due to intakes from food, water and air. Where a contaminant is a threshold substance these background intakes of a contaminant must therefore be calculated and subtracted from the TDI, to calculate the intake of the contaminant which could be tolerated from exposure to soil contamination alone (this quantity is the TDSI – Tolerable Daily Soil Intake), in addition to normal background exposure. This background intake is the Mean Daily Intake (MDI). Where information is not available on intake levels of contaminants or where the MDI exceeds the TDI, the Science report-SC050021/SR3 states that the TDSI should be set in the model to be 50% of the TDI.

DEFRA/EA has adopted the Index Dose (ID) as the HCV for non-threshold substances, which can be considered to present a minimal human health risk from exposure to soil contaminants. For non-threshold contaminants background intake is not considered as there is no “safe level”. In addition, application of the ALARP (As Low As Reasonably Practicable) principle for these substances means that intake should be reduced to as low a level as practicable, that this principle is being adopted by the competent authorities for intakes from food, water and air and that actions are being taken to reduce these other intakes.

There are a number of sources of toxicity criteria and background exposure levels which include Department of the Environment, Food and Rural Affairs (DEFRA); World Health Organisation (WHO); the US Environmental Protection Agency (US EPA) IRIS (Integrated Risk Information System) and other published scientific literature. Where available the definitive UK toxicological and background exposure levels published in the DEFRA/EA/SEPA CLEA TOX reports, under the advice of the Department of Health and The Food Standards Agency, are used as the primary source. However, as authoritative UK based information is available for only a limited number of substances, health criteria and other model input data has been sourced from non-UK published information. The methodology outlined in Science report-SC050021/SR2 has been used to derive HCVs where an authoritative UK HCV has not been published.

General Approach to Risk Estimation

At Stage 3 where concentrations of contaminants have exceeded Stage 2 generic criteria or in the absence of generic criteria, JPB has used the CLEA 1.06 model to derive SSACs (Site-Specific Assessment Criteria), where sufficiently reliable UK authoritative or peer-reviewed input data (including HCVs) is available. The model input values published by DEFRA/EA, derived by Land Quality Management (LQM) in association with the Chartered Institute of Environmental Health (CIEH) and data published in Environment Industry Commission (EIC)/CL:AIRE Report: Soil Generic Assessment Criteria for Human Health Risk Assessment have been used for this purpose. The CLEA 1.06 model derives SSACs for use when considering the risk to human health from chronic exposure to toxic metals, metalloids and organic substances in soil. The assessment criteria represent contaminant concentrations in soils, which if exceeded on site may be indicative of unacceptable risks to human health. It is envisaged that this methodology can be used as a tool during either the detailed quantitative risk assessment or the risk management process.

The model adopts the risk-based source-pathway-receptor pollutant linkage framework and a deterministic methodology. The exposure pathways considered are direct ingestion of soil and dust, direct dermal contact with contaminated soil, consumption of home grown or allotment vegetables, ingestion of soil attached to such vegetables, inhalation of soil vapours outdoors and inhalation of soil vapours indoors. The model is intended to reflect and be compliant with the guidance in DEFRA/EA Science Reports.

Where input data from the above sources is not available, data published by other organisations has been used. It should be noted that the toxicological data available for particular substances in many cases is very limited and incomplete. In order to adopt a relatively consistent approach, where authoritative or peer reviewed UK data is not available, data has been obtained primarily from USEPA and Dutch RIVM report sources as these sources offer a wide range of expert reviewed parameter values such as health criteria values, physical and chemical property data for commonly encountered soil contaminants.

Risks posed by Lead in soil

DEFRA guidance to date has advocated assessing risks posed to human health by lead in soils using an HCV set at a blood lead level of 10µg/dL and deriving an SGV using the Society for Environmental Geochemistry and Health (SEGH) model. EA are currently working on revised TOX and SGV reports for lead and have stated that when they update the HCV and SGV for lead, they will consider setting the HCV as an intake dose. This will allow the use of the CLEA model to calculate the SGV and its use for site-specific risk assessments. These documents have not been published to date, therefore, the previous SGVs published in DEFRA/EA R&D Publication SGV 10 have been adopted in the interim.

Risks posed by Polychlorinated biphenyls (PCBs) in soil

For risk assessment purposes PCB congeners are divided into two groups; (1) dioxin-like PCBs and (2) non-dioxin like PCBs. Dioxin-like PCBs have similar structures and toxic mechanisms to dioxins and furans and so are assessed together with dioxin and furans. Non-dioxin like PCBs have a different toxic end point to dioxin-like PCBs and must therefore be assessed separately.

If the criteria set out in the SGV report are fulfilled, the PCB test results can be directly compared with the SGV given in the report. However, SGVs relate to background PCB levels where a site source is absent, and this limits the applicability of the SGV.

Where the assumptions required for the use of the SGV are not met, dioxin-like PCBs are assessed using the SGV worksheets for the standard land uses. Where site specific dioxin and furan data is not available, the median urban or rural dioxin and furan values given in the SGV report are used to account for “background” concentrations of these substances. A hazard index (HI) is calculated using the worksheet and if the HI is >1, then dioxin-like PCBs may pose a risk to human health receptors in the scenario being considered.

A specific methodology to assess risks posed by non-dioxin like PCBs has not yet been published by EA/DEFRA, however, JPB has adopted the current UK methodology used to assess other organic compounds. This involves selecting a list of target compounds, a TDI and other input data and using the CLEA model to derive GACs. PCBs are typically present as mixtures. The most persistent and toxic non-dioxin-like PCBs are present at their highest concentrations in PCB mixture aroclor 1254. The 7 ICES list indicator PCBs make up about 50% of aroclor 1254. JPB therefore compares the sum of these indicator PCBs with the assessment criteria. The criteria are derived using a TDI for aroclor 1254 and other input data using the CLEA model. The TDI is adjusted to account for the percentage of the 7 ICES compounds present in aroclor 1254. If the sum of the soil concentrations of the 7 ICES exceeds the GAC, then non-dioxin-like PCBs may pose a risk to human health receptors in the scenario being considered.

Therefore, if either the dioxin-like PCB or non-dioxin-like PCB assessment indicates the presence of a risk, remediation may be required or a further assessment may be proposed.

Risks posed by Cyanides in soil

Cyanide compounds exhibit both acute and chronic toxicity, although it should be recognised that complex cyanides are much less toxic than free cyanides. There is currently no UK SGV available to assess chronic cyanide toxicity, although a review of the toxicology of cyanide has been published (DEFRA CLR TOX 5 report).

Criteria derived to be protective of chronic cyanide exposure exceed those derived to be protective of acute exposure to both types of cyanide. Therefore, the criteria derived for acute exposure to free and complex cyanides have been conservatively adopted to be protective to receptors. The Environment Agency has not published guidance on the assessment of risks due to acute exposure to cyanide compounds. However, HPA publications indicate that hydrogen cyanide and its solutions may be fatal following acute exposure via all intake routes (ingestion, inhalation and dermal). The Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT) published a nominal acute reference dose (ARfD) of 5µg CN per kilogram bodyweight (µg/kg bw-^{1}) based on the lowest reported acute lethal dose (range of 0.5 – 3.5 mg/kg bw-^{1}) multiplied by a 100 fold uncertainty factor: 10 to account for inter-individual variability; and, taking into account the steep dose-response relationship for cyanide, 10 to extrapolate from an effect level to a no effect level.

To derive an assessment criteria for free cyanides from the above ARfD, a 2g bolus dose of soil is assumed to represent a reasonable worse case acute ingestion intake for a sensitive receptor: for residential scenarios this is a female child with a body weight of 9.8kg (default value for Age Class 2), for a commercial/industrial scenario it is a female adult worker with a body weight of 70kg (default value for Age Class 17). An SSAC for free cyanides is then calculated for the sensitive receptor based on the mass of cyanide it would be necessary for the receptor to consume via soil ingestion in order to reach the ARfD for their body weight.

Cyanide contamination in soil has been reviewed by the Dutch RIVM organisation who have derived HCVs for chronic exposure to cyanides of 50 and 800µg for free and complex cyanides respectively, a ratio of 1:16 between the two forms of cyanide. The ratio of free cyanides to complex cyanides is based on evidence reviewed by RIVM indicating that inter-conversion between complex cyanides and free cyanides occurs at a relatively low rate. RIVM also provide evidence that complex cyanides are poorly absorbed from the gut with only limited dissociation of absorbed complex cyanides to toxic HCN or CN^-. Therefore, although the Dutch HCVs are higher than the UK values, the ratio of free cyanides to complex cyanides is considered to be applicable as it is based on bio-accessibility considerations. Adjusting the UK free cyanides ARfD by a factor of 16, results in a calculated complex cyanides ARfD, of 80µg CN/kg bw. An SSAC for complex cyanides is then calculated for the sensitive receptor based on the mass of cyanide it would be necessary for the receptor to consume via soil ingestion in order to reach the adjusted ARfD for their body weight.

Representative Contaminant Concentrations and Site Specific Assessment Criteria

At this stage the chemical dose to potentially exposed human receptors are calculated, incorporating site specific data together with conservative health assumptions where necessary to derive Site Specific Assessment Criteria (SSACs). Data evaluation and statistical procedures are used to derive representative contaminant concentrations (RCC) for contaminants of concern in the relevant averaging areas of sites. RCCs are compared with SSACs at the risk evaluation stage in order to determine their significance. This process effectively reduces the conservatism of the Stage 2 assessment and provides a site specific assessment at Stage 3.

At Stage 2 all soil contaminant concentrations are compared with GACs. At Stage 3 RCCs are calculated and used for comparison with assessment criteria. Depending on the nature of the data the RCC may consist of either the maximum concentration recorded or a 95% Upper Confidence Limit (UCL95). Where small data sets are available, or where point source contamination such as hydrocarbon spillages are present, statistical analysis is not appropriate and the maximum contaminant concentration recorded is adopted as the RCC. Where larger data sets are available statistical analysis may be performed to derive an RCC where appropriate. Where RCCs exceed assessment criteria this indicates that the contaminant poses a human health risk and that remedial actions may be required to prevent actual harm.

Statistical analysis is carried out in accordance with the methodology outlined in guidance given in CL:AIRE/CIEH Publication, "Guidance on Comparing Soil Contamination Data with a Critical Concentration". A number of statistical tools may be used for deriving UCL95 values, JPB principally uses ProUCL, a software package developed by the US EPA for this purpose. In general RCC values are selected as follows;

- Determine if there is sufficient data for statistical analysis, if not the maximum concentration is selected as the RCC;
- If data is sufficient the data set for each contaminant is tested for distribution type (normal distribution, lognormal etc.);
- The data set for each contaminant is tested for the presence of outliers, and these are considered for removal or inclusion in further calculations;
- An appropriate UCL95 is calculated, based on the distribution type and revised data set, and this is used as the RCC.

Consideration of whether outliers represent potential contaminant hotpots is also undertaken.

As previously indicated, lead risks are assessed using an SGV derived using the SEGH model, which uses the geometric mean of blood lead levels as one of its input parameters. For this reason the log transformation of soil lead concentrations across a site is required prior to deriving the RCC.

Stage 3 JPB Risk Estimation Practice

JPB's Stage 3 assessment practice is to calculate SSACs, incorporating site specific data together with conservative health assumptions where necessary. This effectively reduces the conservatism of the Stage 2 assessment and provides a site specific assessment. Depending on the pollutant linkages identified in the conceptual site model and on the nature of contamination identified during site investigations, particular risk assessment tools are selected which are considered to be appropriate to assess risks to human health under the existing site conditions. In general JPB most frequently uses the CLEA 1.06 model, or the RISC4 risk assessment tool.

The CLEA 1.06 model has been designed to comply with current UK DEFRA guidance on the assessment of contaminants on land and where possible this is JPB's risk assessment tool of choice. Health criteria, toxicological, physical and chemical data are input for each contaminant for the land use envisaged. The model derives a Site-Specific Assessment Criteria (SSAC) for the contaminant which, if exceeded, would represent a human health risk to the sensitive receptor. The basis of the CLEA 1.06 model is more fully discussed in the CLEA software manual.

The RISC4 model compares risk estimates with acceptability criteria at the risk evaluation stage in order to determine their significance. It is considered that a **Human Hazard Index in excess of 1.0** is significant and an **increased lifetime cancer risk in excess of one in hundred thousand (10^{-5})** is considered to be significant, subject to the guidance in Science report-SC050021/SR2. Risk estimates for contaminants exceeding these criteria are considered to indicate that the contaminant poses a human health risk and that remedial actions may be required to prevent actual harm. JPB may chose the RISC4 risk assessment tool to carry out assessments as RISC4 allows the modelling of a wide range of exposure pathways, is compliant with the Risk Based Corrective Action (RBCA) philosophy and has been the subject of a comparative bench marking study carried out by the Environment Agency. The basis of the RISC4 model is discussed further in the RISC4 software manual. Where the model allows, the RISC4 input parameters are amended by JPB to reflect the guidance and inputs of the CLEA reports.

The CLEA 1.06 model used to derive SGVs, GACs and SSACs includes inhalation of outdoor and indoor dust pathways where appropriate. Inhalation pathways are most important in driving risk assessments where inhalation HCVs are low or where inhalation exposure is high. Where a Stage 3 assessment is required, the inhalation SSACs are presented in JPB's reports to allow further consideration of these pathways and any remedial actions which may be required.

On completion of contemporary developments the amount of bare soil exposed is generally limited to localised landscaping. This is considered to be minimal as a proportion of the site area and given that clean topsoil will generally be placed to provide a suitable rooting horizon during development, this pathway will be usually be broken by this cover for most inorganic contaminants and therefore JPB does not assess this further. An additional degree of conservatism is build into the assessment here as the overall SSACs still have these pathways included. However, where volatile organic contaminants are present, such as BTEX or naphthalene, these substances may potentially migrate through clean cover and, if present at sufficiently high concentrations, may require the introduction of protective measures such as the installation of membranes in solums of buildings etc. to prevent unacceptable exposure to receptors via vapour migration and inhalation. The generation of dust during site works may also expose site operatives or the occupiers of adjacent properties to health risks and should be managed by the provision of appropriate PPE and adoption of appropriate site practices as described in CIRIA document 132 "A guide for safe working on contaminated sites".

Stage 3 Assessment of Risk to Other Receptors

The ecological risk assessment is carried out with respect to both on-site and off-site ecologically sensitive receptors. A review of information can indicate whether any nearby ecologically sensitive areas are likely to be impacted by on-site derived contamination; a comparison of contaminant levels found in the on-site ecologically sensitive areas can also be made with the UK Environmental Quality Standards for the protection of wildlife.

Contaminants which are at concentrations in excess of the Stage 2 screening criteria are determined to present a risk to the water environment and these contaminants therefore require assessment at a Stage 3 level. The purpose is to ascertain if the concentrations create a risk. It is important to consider factors such as the background groundwater quality, the sporadic nature of the perched groundwater and the separation of the site from the regional groundwater by an aquiclude.

The most significant receptor in the water environment assessment is considered to be the local shallow and deep groundwater. In addition there is the potential for contaminants detected on-site to detrimentally affect off-site waters. In addition deep (bedrock) groundwater resources may be important in some areas, or where groundwater may be abstracted for use. The significance of the risk to these receptors is assessed by considering, using groundwater models, the potential effects contaminants may have to groundwater and surface water receptors.

Stage 3 Evaluation of Risks to Groundwater and Surface Waters

Each receptor is considered in turn at the initial CSM stage, and investigations scoped to examine these linkages where necessary.

At Stage 2 recorded soil leachate, groundwater and surface water contaminant results are compared with GACs selected as described above, dependant on the receptor being considered (e.g. UKDWS would be used where a water abstraction was the receptor). Where exceedences of GACs occur a Stage 3 assessment is undertaken.

In the Stage 3 Risk Assessment - Water Environment a re-examination of the CSM is undertaken with respect to water environment receptors on the basis of site investigation data. Where a potential linkage remains, a back calculation is undertaken for the recorded soil leachate and/or groundwater concentration exceedences in accordance with the guidance in document WAT-PS-10-01 using the EA's Remedial Targets Methodology (RTM) and the associated Remedial Targets Worksheet hydrogeological modelling tool. After applying a dilution factor and where appropriate, degradation, the theoretical concentration of each contaminant at an assessment point is compared against the relevant assessment limit at that assessment point.

The assessment limit may be a UK Drinking Water Standard (UKDWS), Resource Protection Value (RPV) or EQS depending on the nature of the receptor which is being considered to be potentially at risk. The assessment point is the point at which assessment limit must be met. For the purposes of risk assessment the assessment point is selected to be the nearest surface water course for surface water receptors, the site boundary (or 50m downgradient of the site boundary or 250m in a sewered urban environment) for the future groundwater resource receptors or in the raw water prior to any treatment this might receive for current abstractions. It should be noted that in contrast the SEPA guidance defines a compliance point as a "real" sampling point to demonstrate that inputs are acceptable. A compliance point may be the same location as the assessment point or between the source and receptor.

In addition, where required the Remedial Targets Worksheet can be used to calculate soil remedial targets which can be used to determine whether soil contaminant levels on site require remedial actions to prevent impact to water environment receptors.

For the above calculations it is assumed that leachate is theoretically produced by water infiltration from rainfall into site groundwater which can then migrate off site. In this case the leachate migrates through permeable strata until it hits a theoretical deeper groundwater. The remedial target which is calculated represents the maximum concentration of that particular contaminant which can be allowed at the assessment point or at its location on the site in the case of soil remedial targets. If concentrations are recorded above remedial targets then theoretically by the time impacted groundwater has migrated to the assessment point it will be above the relevant assessment limit for that contaminant and remedial measures would be necessary.

Other analytical, numerical and probabilistic groundwater models are available to aid in the quantitative assessment of contaminated waters, the suitability of each which can be determined upon completion of site assessment and project requirements.

RISK-BASED CONCLUSIONS

The comparison of the estimated risks with the appropriate criteria indicates whether:-

1) the site presents an insignificant risk based on the analysis; or

2) there is a potential risk to health or the environment.

Where a risk has been identified remedial strategies can then be developed in order to break any source-pathway-receptor linkage. Strategies may include; source removal, breaking the pathway from the source to the receptor or choosing developments in which sensitive receptors are not included in areas where the risk exists.

As described above a number of remedial strategies can be adopted for a site and JPB selects the most appropriate strategy for remediation on a site specific basis. One commonly adopted practice is to break the pollutant linkages by the introduction of clean capping materials. JPB has adopted, where appropriate, the BRE/DTI/NHBC/AGS document as a decision making tool to aid the design of remedial actions.

Whilst the authors of the document acknowledge that the methodology is not sufficiently advanced to provide a basis of regulatory policy, in the absence of other authoritative guidance this document provides a research based approach to designing cover systems rather than the alternative qualitative use of professional judgement. It is, however, emphasised this document is used by JPB in the context of professional judgement and experience and a knowledge of site conditions.

As at the time of investigations the concentrations of contaminants present in material to be imported for capping may not be known, a conservative approach in which the imported material is assumed to have a contaminant concentration of 75% of the target guideline value is adopted. The spreadsheet which accompanies the document contains a viability check graph which indicates whether the capping layer calculated is acceptable or whether further consideration is required as to the effectiveness of the cover system proposed. JPB's procedure is to ensure that the effectiveness of the cover system is adequate for the site conditions encountered. Where these are exceeded more stringent remedial actions are recommended. JPB considers that this methodology provides a consistent, scientifically based rationale for designing cover systems in the vast majority of sites we encounter. Where more extreme conditions are encountered, or where there are specific site requirements, these issues will be considered on a site specific basis in order to be protective of receptors at the proposed development.

Remediation Strategy

Before any works can be carried out on site a Remediation Strategy must be prepared in accordance with the "Model Procedures for the Management of Land Contamination" (CLR11) and the draft document "Verification of Remediation of Land Contamination".

Ground Gas Assessment Methodology

Introduction

The assessment of ground gas as a potential constraint to development has been the subject of a great deal of research and published guidance. Broadly speaking ground gas can be a concern for several reasons; flammable gases may cause an explosion, build up of gases within poorly ventilated areas may lead to asphyxia or toxic gases may cause harm to those exposed to them. In general we consider principally methane and carbon dioxide levels, however the presence of other gases such as carbon monoxide, hydrogen sulphide, petroleum vapours etc may also be considered where appropriate. Some physical properties of ground gases are tabulated below.

Gas	Explosive Range	Density of 20ºC	Toxicity % by volume in air*
Methane	5-15% by vol	0.72 kg/m^3	30 (low)
Carbon dioxide	N/A	1.98kg/m^3	0.5 (high)
Carbon monoxide	12.5-74.2% by vol	1.25kg/m^3	0.02 (high)
Hydrogen sulphide	4.2-46% by vol	1.54kg/m^3	0.001 (high)

* short term exposure limits

These ground gases may originate from many sources including; mine workings, organic sediments, landfilling, biodegradable materials in made ground on brownfield sites, petroleum hydrocarbons or other site specific sources. The gas concentrations measured are the result of volatile emissions and the microbial degradation of organic materials. The processes by which materials degrade to form ground gases are discussed more fully in Waste Management Paper 27 (2nd Ed, 1999) and Waste Management Paper 26A (1993).

JPB's overall methodology for ground gas assessments is summarised in the attached flow chart. In order to assess the degree of risk to receptors we must first develop a conceptual site model (CSM) of the site which can identify the various sources and receptors and any potential pathways by which they may be linked. This process can be undertaken as part of the development of a CSM for the site for contaminants other than gases. If a potential pollutant linkage is identified for ground gas, site investigations to confirm the nature and extent of ground gases will be required. Guidance on how these site investigations should be undertaken is given in B5930 (1999) - Code of Practice for Site Investigations, BS10175:2001 - Investigation of Potentially Contaminated Sites, CIRIA Reports 103 (Vol II) and 150 (Methane Investigation Strategies), CIRIA C665 (2007) and BS8485: 2007 and other published guidance.

Investigation methodologies which have been used to measure gas concentrations include spike probe surveys, sinking of boreholes with monitoring standpipes installed and flux boxes. Spike probe surveys are considered to be unreliable for the following reasons: limited depth, spikes into an aerobic layer in an open hole underestimate methane levels and spike probes may not intercept the gas source.

In preference JPB therefore generally commissions the sinking of boreholes with standpipes to characterise the gas regimes at sites. Where access is restricted, a window sampler is used to install standpipes. The number and position of bores and well response zones are carefully chosen in order to maximise the information to be obtained to fully characterise the site. Table 4.2 in CIRIA C665, reproduced below, gives some guidance on the spacing of wells, which should be interpreted in conjunction with the associated text of that paper.

Gas Hazard	Typical examples	Sensitivity of end use	Initial nominal spacing of gas monitoring wells[1,2]
High	Domestic landfill sites	High[3]	Very close (<25m)
		Moderate	Close (25-50m)
		Low	Close (25-50m)
Moderate	Older domestic landfills disused shallow mine workings[4]	High	Close/very close (<25m -50m)
		Moderate	Close (25-50m)
		Low	Close/wide (25-75m)
Low	Made ground with limited degradable material, organic clays of limited thickness	High	Close (25-50m)
		Moderate	Wide (50-75m)
		Low	Wide/very wide (50->75m)

[1] The initial spacing may need to be reduced if anomalous results indicate this is necessary to give a robust indication of the gas regime below a site. To prove the absence of gas, closer spacings may be required.

[2] The spacing assumes relatively uniform ground conditions and the gas source present below a site. The spacing will need to be reduced if ground conditions are varied or if the investigation is trying to assess migration patterns from off site.

[3] Placing high-sensitivity end use on a high gas hazard site is not normally acceptable unless the source is removed or treated to reduce gassing potential.

[4] Petrol stations and other sources of vapours are most likely to be classified as gas hazard “Moderate” however site specific assessment would be required.

Three bores with standpipes and four sets of readings should be considered an absolute minimum for even the smallest of sites.

Flux boxes can be used to measure surface gas emission rates but do not take into account a deeper source of gas generation. Flux boxes can be used to confirm that a capping layer above a source and the surface has been effective. It should be noted that methane levels at the surface may underestimate ground gas levels as aerobic conditions at the near surface will deplete methane concentrations.

Guidance on the measurement of gas levels at bores is given in the above documents, however in general a peak gas reading is taken followed by readings at 30 second intervals until a steady state is reached. This allows the assessor to determine how quickly the ground gas is replenished. Flow rate is generally measured first followed by methane/carbon dioxide levels. In addition atmospheric pressure, weather, date and any other relevant information is recorded.

Flow rates can be positive or negative, they are generally negative where ambient atmospheric pressure is high or where falling groundwater levels reduce pressures in bores. Flow rates between -0.4 and 0.4 L/h indicate that there is probably no overall flow. The length of the monitoring period and frequency of monitoring will vary from site to site depending on the sensitivity of development, geology of the site, the level of risk and other factors. Typical minimum periods and monitoring frequencies are given in Table 5.5 of CIRIA C665. Generally JPB performs a minimum of four visits over the course of a 4-6 week period.

The degree of monitoring required must enable the assessor to measure or predict the worst case gas regime.

Risk Assessment

Having obtained factual data from the investigation the ground gas regime can be assessed in a tiered approach. In the past guidance such as Waste Management Paper 27 recommended a highly conservative precautionary principle, i.e. no development within 250m of a landfill site. This approach was seen as anti-development and does not take into account the site conditions, whether a risk exists at the site for the development proposed, the level of risk and whether if can be mitigated by design. More recent approaches characterise the site and the risk and base recommendations on this assessment. Various reports and standards have recently been published to update the guidance on ground gas assessment and this JPB methodology uses the philosophy outlined in these. These include CIRIA C665 “Assessing risks posed by hazardous ground gases to buildings” (2007), NHBC Report No. 10627-R01(04) “Guidance on evaluation of development proposals on sites where methane and carbon dioxide are present” (2007) and British Standard BS8485 (2007) “Code of practice for the characterisation and remediation from ground gas in affected developments”.

Tier 1 assessment

Following the completion of investigations the assessor reviews the CSM in the light of site investigation data and identifies any intact pollutant linkages. If intact pollutant linkages exist a Tier 1 risk assessment is performed using generic screening criteria to determine whether a risk exists. JPB uses the following screening levels: **Methane <1% by volume in boreholes and Carbon dioxide <5% by volume in boreholes.**

These values are derived from Waste Management Paper 27, 1% methane by volume represents 20% of methane’s lower explosive limit of 5% by volume, 5% carbon dioxide relates to the known health effects of exposure to this gas. Both screening concentrations are detailed in the Building Regulations Approved Document C (2004) and BRE Report “Construction of New Buildings as Gas Contaminated Land” (BR 212).

A limit to gas flow rates for the above trigger values is inferred by the table given below where the limiting borehole gas volume flows for CH_4 and CO_2 are <0.07L/hr for characteristic situation 1. These are equivalent to a limiting borehole flow rate of 7L/h for CH_4 at 1% by volume and 1.4L/h for CO_2 at 5% by volume. The above Tier 1 trigger values are only valid, therefore, if these volume flows are not exceeded. Where these volume flows are exceeded a Tier 2 assessment should be undertaken.

It is understood that new guidelines on screening levels for hydrogen sulphide and other trace gases will be issued in CIRIA RP711. Other information on VOCs is available in EA Technical Guidance on Management of Landfill Gas (2004) and in the vapour models used in the CLEA model for contamination land assessments.

If these screening concentrations are not exceeded then no significant risk exists and no further action is required. Where screening concentrations are exceeded a Tier 2 assessment is performed.

Tier 2 assessment
Where Tier 1 generic screening concentrations are exceeded a Tier 2 assessment is performed using the Wilson and Card (1999) approach as outlined in CIRIA C665. Each site is classified into a “characteristic situation” based on the maximum methane and carbon dioxide concentrations measured. These measurements combined with the maximum borehole flow rate are used to calculate the gas screening value.

Gas screening value (L/hr) = gas concentration (% by volume) x borehole flow rate (L/hr).

(N.B. gas screening value is also known as “site characteristic hazardous gas flow rate (Q_{hgs}) in BS8485)

For example for a borehole flow rate of 1.5 L/h and a methane concentration of 20% the gas screening value = 1.5 x 20/100 = 0.3 L/h.

Gas screening value rates for methane and carbon dioxide can be compared with Table 8.5 of CIRIA C665 “Assessing risks posed by hazardous ground gases to buildings” (2007) or Tables 14.1 of NHBC Report No. 10627-R01(04) “Guidance on evaluation of development proposals on sites where methane and carbon dioxide are present” (2007), reproduced below, to determine a characteristic situation for the site.

Table 8.5 Modified Wilson & Card Classification (CIRIA Report C665)
NB Use for most scenarios other than low rise housing with a ventilated underfloor void (min 150mm)

Characteristic Situation (CIRIA R149)	Comparable classification in DETR et al (1999)	Risk classification	Gas Screening Value (GSV) CH_4 or CO_2 (L/hr)[1]	Additional Limiting Factors	Typical Source of generation.
1	A	Very low risk	<0.07	Typically methane <1% by volume and/or carbon dioxide < 5%. Otherwise consider increase to Situation 2.	Natural soils with low organic content. “Typical” made ground
2	B	Low risk	<0.7	Borehole air flow rate not to exceed 70L/hr. Otherwise increase to characteristic situation 3	Natural soil, high peat/organic content. “Typical” made ground
3	C	Moderate risk	<3.5		Old landfill, inert waste, mineworking flooded
4	D	Moderate to high risk	<15	Quantitative risk assessment required to evaluate scope of protection measures	Mineworking – susceptible to flooding, completed landfill, inert waste (WMP 26B criteria)
5	E	High risk	<70		Mineworkings unflooded inactive
6	F	Very high risk	>70		Recent landfill site

Table 14.1 Gas Risk Assessment (Traffic Lights) NHBC Report No. 10627-R01(04)

NB To be used for low rise housing with a ventilated underfloor void (min 150mm)

Traffic Light	**Methane[1]**		**Carbon Dioxide[1]**	
	Typical max conc.[5] (% by vol)	**Gas screening value [2,4,6] (L/hr)**	**Typical max conc. [5] (% by vol)**	**Gas screening value [2,3,4,5] (L/hr)**
Green	1	0.13	5	0.78
Amber 1	5	0.63	10	1.60
Amber 2	20	1.60	30	3.10
Red				

Radon

Radon is a naturally occurring radioactive gas that is formed from the decay of uranium and radium present in some types of rocks. It can migrate through cracks and fissures into the soil and by this route into buildings.

Radon can accumulate inside structures over the long term posing a risk to health. Long term exposure increases the risk of developing lung cancer, in a building with high levels of radon, long-term exposure can increase the risk to the point where preventative action is necessary.

BRE 211 provides guidance on how the risks posed by radon should be assessed. JPB's methodology for assessing risks posed by radon follows that guidance and this methodology is outlined below.

The location of the site is pinpointed on maps within the "Indicative Atlas of Radon in England and Wales", published in July 2007. This document was the result of a joint project between The Health Protection Agency (HPA) and the British Geological Society who prepared detailed maps of radon potential by testing radon levels in houses. Where tests on existing houses show that 1% of the houses in a particular area are likely to have a radon concentration above 200 Bq/m³ (the action level) the area is designated as a 'radon affected area'.

Where the site is indicated to be within a radon affected area, a more detailed risk report giving the estimated radon potential for the specific site is obtained through the HPA radon website www.UKradon.org. If this report indicates that the site is located on ground designated as a 'radon affected area', or on ground where radon is known to exist, protective measures are recommended. Radon protective measures are recommended in accordance with the guidance contained in BRE publication BR 211 – 'Radon: guidance on protective measures for new buildings'.

It should be noted that this approach has been adopted as monitoring radon concentrations in the ground prior to construction is not considered to be a valid methodology for assessing risks posed by radon in buildings. This is because it is difficult to equate the concentrations of radon measured in boreholes with levels inside houses, as many factors can influence the actual indoor air radon concentration experienced, including; radon generation rates, geology, construction details, ventilation rates, seasonal factors, occupant behaviour etc. Similarly, for newly constructed buildings it is impractical to determine indoor air radon concentrations over the recommended three month monitoring period and the results measured in unoccupied properties would not, in any case, be a valid assessment of conditions in occupied houses.