COMBINED STAGE 1/STAGE 2

GEO-ENVIRONMENTAL REPORT

AT

QUARRY WORKS, FIELD LANE

SOUTH ELMSALL

ON BEHALF OF

WETHERBY SKIP SERVICES

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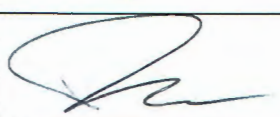
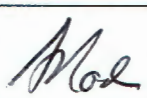
Reviewed By:	J Race BSc CGeol FGS EurGeol	
Authorised By:	A Radcliffe BEng CEng MIStructE	

ISSUE	**DATE**	**STATUS**
1	10th October 2018	V1 FINAL
2	24th January 2019	V2 FINAL

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1.0 EXECUTIVE SUMMARY

The pertinent conclusions of the report are tabulated below. However, the information below is not exhaustive, and it is recommended the report is read in its entirety.

Proposed Development	Backfilling and restoration of former quarry to generate a stable platform for future development (undetermined at this stage).
Existing Site Description	Currently occupied by a former quarry. The site comprises some hardstanding in the central quarry void, with the boundary areas populated with vegetation. There is an outbuilding located in the east of the site and access to the highway in the south.
Site History	Quarry from 1900s until the 1960s. Depot from 1960s until present.
Geology	Shown to be made ground, over dolostone of the Cadeby Formation.
Coal Mining	Site can be considered stable.
Ground Gases	Basic radon protection measures required. Carbon dioxide up to 11.2%, methane up to 4.5% and flow rate of up to 0.9l/h. CS2/ Amber 1 conditions applicable.
Ground Conditions	Up to 10.7m of made ground in the south and up to 2.9 at the base of the former quarry, overlying granular residual soils.
Contamination	Possible asbestos within buildings. Oil staining to concrete and localised hydrocarbon odour within the made ground beneath, although lab testing indicated acceptable risk.
Remediation Strategy	Asbestos survey of buildings and removal of any detected. Removal of oil stained concrete and any suspect material beneath, during site preparation.
Earthworks	Subject to confirmation of existing site levels and proposed finished earthworks levels, it is anticipated that up to 5m of fill will be required across much of the site to generate a stable development platform.

Foundations	For structures with low loads (i.e. houses) raft foundations may potentially be viable over the area of engineered fill. However, this will require excavation and re-engineering of fill material already present. Piled foundations required for structures with high loads or low settlement tolerance or for any structure placed on existing made ground in the southwestern corner of the site.
Excavations	Liable to collapse within the made ground.
Concrete	GEN1 designation for unreinforced foundations. For any reinforced concrete, other design-specific mixes will apply.
Soakaways	Due to the significant depth of fill required for the final development, soakaway drainage is not considered viable.
Consultations with regulators.	Due to the volume of imported material required, consultation with the Environment Agency and the local authority is likely to be required for licensing, permits and planning permission.
Road Pavement	If adoption is being considered, consultations with the relevant authority should be undertaken at the earliest stage.

2.0 TERMS OF REFERENCE

2.1 Wetherby Skip Services is considering developing the site at Field Lane, South Elmsall. The development of the site will be undertaken over several phases. The first phase of development is to comprise the backfilling and restoration of the former quarry using inert fill to generate a stable platform for future development. It was considered appropriate to implement a desk study and ground investigation to provide information to aid the planning process, viability assessment, and design of any subsequent development.

2.2 ARP Geotechnical Ltd was appointed by Wetherby Skip Services to carry out the investigation, which involved a desk study assessment of the geological and coal mining aspects, Ordnance Survey archive maps, radon gas, indicative flood risk, hydrogeology, landfill, and other environmental issues, primarily by assessment of a Landmark Envirocheck Report. This was supplemented by an intrusive investigation to assess the ground conditions.

2.3 The investigation was implemented generally in accordance with BS 5930 : 2015 "Code of practice for site investigations", NHBC Standard Chapter 4.1 "Land quality - managing ground conditions", Environment Agency CLR 11 "Model Procedures for the Management of Land Contamination" and BS10175 : 2011 + A2 : 2017 "Investigation of potentially contaminated sites - Code of practice". This report is limited to the data obtained as part of this investigation. It should be noted that there is a possibility of variation in ground conditions between test locations and interpretation of strata is given for guidance only. No liability is accepted for changes to site conditions, including groundwater levels, after the preparation of this report.

2.4 The initial version of the Combined Stage 1/Stage 2 report WSk/01r1 was issued in October 2018, prior to the completion of the gas monitoring program. Following completion of the gas monitoring, the report has been updated to include assessment of full data set, and this report is the result.

2.5 The general observation and assessment of the ground surface, and the identification/classification of vegetation is made in general terms only. It would be prudent for a specialist to undertake a more detailed survey, including for any invasive/harmful weeds.

2.6 The assessment of any topsoil is carried out in terms of potential chemical effects on human health only, and no account is taken of aesthetic or horticultural properties. Such considerations should be referred to a horticulturist or landscape architect.

2.7 The report has been prepared for the use and reliance of the Client only. The report shall not be relied upon or transferred to any other parties without the written agreement of ARP Geotechnical Ltd. For the avoidance of any doubt, where ARP Geotechnical Ltd enters into a letter of reliance for the benefit of a third party, that third party will be permitted to rely on the report. No responsibility will be accepted where this report is used, either in its entirety or in part, by any other party without ARP Geotechnical Ltd.'s consent.

3.0 SITE DESCRIPTION

Site Location

3.1 The site, which is centred on Ordnance Survey Grid Reference 448000, 411650 is located off Field Lane, South Elmsall near Wakefield.

3.2 A site location plan and aerial photograph are presented in Appendix A.

On - Site Features

3.3 The site is an irregular shaped piece of land extending to an area of approximately 1.5 hectares, with overall dimensions of 195m (north - south) by 100m (east - west).

3.4 The site comprises a partially infilled quarry. The southwestern corner of the site has been infilled and comprises an area of hardstanding with a dilapidated single storey building. An access ramp slopes northwards down towards the base of the quarry. The base of the quarry is partially under hardstanding of concrete, but predominantly under dense vegetative cover with numerous semi mature trees. A rectangular corrugated steel warehouse is located in the eastern end of the site. A rectangular concrete vehicle inspection pit is located adjacent to the warehouse. Visual and olfactory evidence of contamination was noted, comprising oil staining to the floor slab of the warehouse and on concrete hardstanding immediately surrounding the warehouse. Several stockpiles of quarry material or demolition material are present towards the southeastern end of the site. Numerous industrial size tyres are present across the site including a stockpile in the southeast. Site photographs are presented in Appendix B.

3.5 The southwestern corner of the site is at approximately the same level as Field Lane, with an access ramp sloping steeply down to the north towards the base of the quarry. There is an approximate 5m to 6m level difference between the base of the quarry and the area to the southwest. At the base of the quarry, the site slopes down towards the southeast. A near vertical quarry highwall is present along the western, northern, eastern and southern

boundaries of the site. Vegetation growth is present along the quarry high wall. The area surrounding the site slopes down towards the southeast.

Site Boundaries and Surrounding Land Use

3.6 The site is bounded to the north by residential properties, with a field and large commercial warehouses beyond. To the east lies a mix of residential properties, commercial buildings and an area of scrap storage, with a large warehouse beyond. Field Lane bounds the site to the south, with a former inert landfill beyond. To the west lie residential properties.

Site History

3.7 Ordnance Survey archive maps were obtained for the site. Copies of the maps are included in Appendix C, and a summary of the findings is given below.

Map Date	**On-Site**	**Off-Site**
1854	Undeveloped fields.	South Elmsall Quarry approximately 200m to the southeast.
1893	No significant changes.	Quarry to the southeast has expanded up to the southern boundary of the site, opposite Field Lane. Old quarry to the west.
1906	South Elmsall Quarry has expanded onto the southern end of the site connected by rail tracks presumably tunnelled under Field Lane.	Further expansion of South Elmsall Quarry.
1930	The quarry has extended across the whole footprint of the site.	The quarry to the southwest is no longer shown. Residential properties along the western boundary.
1962	Tunnel indicated beneath Field Lane at southern boundary of the site.	South Elmsall Quarry now disused.
1977	Depot shown on site.	Depot to the south opposite Field Lane.

1982	Two small outbuildings shown in the east of the site, as part of the depot.	South Elmsall Quarries to the south now a 'Refuse Tip'. Scrap yard and garage to the southwest.
1995	Site labelled 'Quarry Works'.	No significant changes.
2000	No significant changes.	Large warehouse of the Dale Lane Industrial Estate immediately east of the site. Much of area of the refuse tip to the south is shown as fields.
2018	No significant changes.	Tip to the south no longer shown.

3.8 In summary, quarrying has taken place on the site from at least 1906 until the 1960s. From the 1970s, the site has been used as a depot. The surrounding area has become increasingly developed with residential properties, refuse tips, and commercial warehouses.

4.0 ENVIRONMENTAL SETTING

Geology

4.1 Extracts from the British Geological Survey 1:50,000 Series Geology Maps are included within the Envirocheck Geology Report in Appendix D. The maps show the site to be covered by an area of worked ground associated with the former quarry. The bedrock comprises dolostone of the Cadeby Formation. An area of infilled ground lies across the road to the south of the site, associated with the former South Elmsall Quarries which later became a refuse tip. No superficial deposits are shown to underlie the site.

4.2 There are no faults shown to adversely affect the site.

Coal Mining

4.3 A Consultants Coal Mining Report was obtained from The Coal Authority. A copy of the report is included in Appendix F and a summary of the findings is given below.

4.3.1 There are recorded underground workings beneath the site in several seams of coal between 641m and 754m depth. The last date of working was 1972. Any associated ground movement should, by now, have ceased.

4.3.2 There are no potential unrecorded underground workings, and no future workings are proposed.

4.3.3 There are no recorded mine entries within 100m of the site, and the site is not affected by any opencast coal mining.

4.3.4 There are no notices or claims for damage or subsidence since the 1994 register commencement date.

4.4 In the light of the above, the site is considered stable with regard to coal mining.

Natural Cavities

4.5 The Envirocheck Report (presented in Appendix E) indicates that limestone caves are present 212m to the east of the site, and 897m to the southeast of the site, both within the Lower Magnesian Limestone (Cadeby Formation). However, the potential for ground dissolution stability hazards on the site is stated to be “Very Low”.

BGS Recorded Mineral Sites

4.6 A disused opencast dolomite quarry is recorded on site. A further four quarries are registered within 20m of the site, with the nearest being 55m southeast of the site. All have ceased to operate.

Hydrogeology

4.7 The Landmark Envirocheck Report, included in Appendix E, indicates the Bedrock Aquifer Designation to be "Principal Aquifer". These Aquifers comprise "layers of rock or drift deposits that have high intergranular and/or fracture permeability- meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale".

4.8 There are no groundwater abstractions within 1km of the site.

4.9 The site is not within a groundwater Source Protection Zone.

Hydrology

4.10 The general area slopes down towards the southeast. The nearest downslope surface water is an unnamed drain, approximately 213m to the east.

4.11 Any surface water run-off from the southwest corner of the site is likely to reach the surface water drainage system along Field Lane. Any surface water run-off within the base of the quarry is likely to infiltrate into the ground.

4.12 The site is not in an area at risk from river flooding. The risks of flooding from other causes such as adverse topography or insufficient surface water drainage, are not considered here, and a separate specialist Flood Risk and Drainage Report should be commissioned if such risk needs to be quantified.

4.13 There are no surface water abstractions within 1km of the site.

Other Environmental Data

4.14 The Landmark Envirocheck Report, included in Appendix E, contains information on numerous environmental aspects. A summary of the pertinent findings, not already covered, with additional comments, is given below.

4.14.1 There are no Pollution Control Authorisations within 500m of the site.

4.14.2 There are no discharge consents relating to, or adjacent to, the site.

4.14.3 There are no pollution incident to controlled waters within 250m of the site.

4.14.4 A registered waste transfer site is located on site; no longer operational. The licence holder was Earthmovers Tyres Yorkshire Ltd and the authorised waste included commercial tyres.

4.14.5 There are two historical landfills and three registered landfills within 250m of the site. All of the landfills are related to the landfilling of the adjacent South Elmsall Quarry. The nearest to the site, located 12m southeast, had a first input date of the 31st December 1980 and was licensed to receive inert waste.

4.14.6 Basic radon protective measures are stated to be necessary for new dwellings or extensions on the site, and the site is in an intermediate probability radon area.

4.14.7 There are no contemporary trade directory entries relating to any activities which could have significant impact on the site.

4.14.8 There are no fuel station entries within 500m of the site.

5.0 PRELIMINARY RISK ASSESSMENT AND CONCEPTUAL MODEL

5.1 Part II A of the Environmental Protection Act (EPA) 1990 became effective from 1st April 2000. The Regime was introduced by the Contaminated Land (England) Regulations 2000 (SI 2000, No. 227) along with the associated DEFRA Circular February 2000.

5.2 Section 78A (2) of the Act defines "Contaminated land is any land ……. in such a condition, by reason of substances in, on or under that land that -

(a) significant harm is being caused or there is a significant possibility of such harm being caused; or

(b) pollution of controlled waters is being caused, or there is a significant possibility of such pollution being caused".

From S78A (4) "Harm" : means harm to the health of living organisms or other interference with the ecological systems of which they form part and, in the case of man, includes harm to his property.

Controlled waters are defined as "..the waters in any relevant lake or pond, or of so much of any relevant river or watercourse as is above the freshwater limit, and ground waters, that is to say, any waters contained in underground strata". From the 1st October 2004, the definition of groundwater in relation to Part IIA was amended, by the Second Water Act Commencement Order SI 2004 No 2528. This makes clear that "ground waters" does not include waters above the saturation zone, i.e. does not include any soil water and pore water present in the unsaturated zone.

5.3 The objectives of the regime are to ensure that risks associated with contaminated land are reduced to an acceptable level, having regard to the costs of doing so. The costs should be proportionate, manageable and economically sustainable.

5.4 In assessing risk, it is necessary to consider the probability, or frequency, of occurrence of the hazard and the magnitude/seriousness of the consequences. Consequently, for land to be classified as contaminated, it must have, or be very likely to have, a detrimental effect on humans or the environment before it can be classified as contaminated land.

5.5 In establishing risk, the concept of the pollutant source/pathway/receptor linkage model, based on current and proposed site use, is to be considered. Therefore for a site to be deemed contaminated under the Regime, all three linkages must be in place i.e. the site must not only contain harmful substances, but the substances must have a pathway by which to leak out and cause significant harm to a receptor.

5.6 In September 2004, the Environment Agency published the Contaminated Land Report (CLR) 11, "Model Procedures for the Management of Land Contamination". The document is intended to provide the technical framework for structured decision making about land contamination, and is intended to assist all those involved in "managing" the land, in particular landowners, developers, financial service providers, planners and regulators. As the document currently provides the framework for best practice, the general principles are, therefore, followed in conducting the assessment below.

5.7 The categorisations of risk adopted in this report are adapted from CIRIA Report C552 (Contaminated Land Risk Assessment: A Guide to Good Practice, 2001). This approach assesses the potential severity of any pollution event and the probability of the event occurring, to arrive at a risk category, for the various potential source - pathway - receptor linkages. The relevant tables used, with the definitions, are presented in Appendix J.

Conceptual Site Model

5.8 The first phase of development is to comprise the backfilling and restoration of the former quarry to generate a stable platform for future development. The future phase of development has yet to be determined, but to provide a worst case assessment from a sensitivity point of view, a residential development is assumed. The site is shown to be underlain by dolostone of the Caedby Formation. The solid strata beneath the site are

designated a Principal Aquifer. There are no groundwater abstractions within 1km of the site. The nearest surface water is a drain, approximately 213m to the east. There are no surface water abstractions within 1km of the site. An historical inert landfill is located across Field Lane, to the southeast.

5.9 The site comprises a partially infilled quarry which was operational between the 1900s and 1960s. Since the 1960s, a depot has been operational on site, which is understood to have been used as storage and light industrial use. There is record of the site being used as a waste transfer station for old earthmoving tyres. There was evidence of oil staining and possible servicing of vehicles (inspection pit). The most likely contamination sources are considered to be:

5.9.1 Likely made ground associated with partial infilling of quarry: - metals inorganics, total petroleum hydrocarbons (TPH), polyaromatic hydrocarbons (PAH), phenol and asbestos.

5.9.2 Former use of the site as a depot, for servicing of vehicles and machinery, and as a waste tyre transfer station: - Possible metals, TPH, PAH, asbestos.

5.9.3 Possible asbestos within existing outbuildings.

5.9.4 Historical landfill sites 15m southeast of the site: - methane and carbon dioxide.

5.10 The conceptual model needs to consider sources of contamination, pathways along which contaminants could migrate, and the receptors which may become exposed. Guidance published by the Environment Agency has been consulted with regard to pathways and receptors. The potential sources, pathways, and receptors applicable to the initial phase of development (backfilling of quarry) and the future phase of development (final development proposal yet to be decided) are identified on the tables below. Any pathways in italics are deemed not to be viable, and the reason given.

Potential Source - Pathway - Receptor Matrix (Generation of development platform)

Contamination Sources	Pathways	Receptors	Severity of Consequence	Probability of Event	Risk
Possible made ground: - metals, inorganics, TPH, PAH, phenol Possible hydrocarbons from use of vehicles and machinery on site	• Inhalation, ingestion and dermal contact with soil and dust	**Humans:-** • Earthwork operators • Adjacent residents and general public	**Medium**	**Low Likelihood**	**Moderate/ Low**
	• Migration in surface water	• Surface water (nearest downslope is 213m to east. No abstractions)	**Medium**	**Low Likelihood**	**Moderate/ Low**
	• Migration in groundwater	• Groundwater (Principal Aquifer, no abstractions within 1km)	**Medium**	**Likely**	**Moderate**
Landfills 15m south:- methane and carbon dioxide	• Asphyxiation • Explosive risk	• Earthworks operators	**Severe**	**Low Likelihood**	**Moderate**
Possible asbestos within existing buildings and made ground	• Inhalation	• Maintenance workers • Adjacent residents and general public	**Severe**	**Unlikely**	**Moderate/ Low**

Potential Source - Pathway - Receptor Matrix (Future phase of development)

Contamination Sources	Pathways	Receptors	Severity of Consequence	Probability of Event	Risk
Possible made ground: - metals, inorganics, TPH, PAH, phenol Possible hydrocarbons from use of vehicles and machinery on site	• Inhalation, ingestion and dermal contact with soil and dust • Fruit and vegetable intake, with soil • Vapour inhalation outdoor • Vapour inhalation indoor	**Humans:-** • Future occupants • Maintenance workers • Adjacent residents and general public	**Medium**	**Unlikely**	**Low**
	• Root uptake	**Vegetation:-** • Landscape areas • Private gardens	**Mild**	**Unlikely**	**Very Low**
	• Migration	**Services/Utilities:-** • Potable water supply	**Mild**	**Unlikely**	**Very Low**
Historical landfills immediately south of the site:- methane and carbon dioxide	• Asphyxiation • Explosive risk	• Construction/de-molition workers • Future occupants • Buildings	**Severe**	**Low Likelihood**	**Moderate**
Possible asbestos within existing outbuilding and made ground	• Inhalation	• Future occupants • Maintenance workers • Adjacent residents and general public	**Severe**	**Low Likelihood**	**Moderate**

5.11 The above matrix indicates there are several potential source - pathway - receptor linkages applicable to the initial phase of the proposed development and the future development.

5.12 The assessment was used to inform the design of the subsequent ground investigation. To fully characterise the site, in accordance with BS10175 : 2011 + A2 : 2017 "Investigation of potentially contaminated sites - Code of practice", and to address the above concerns, it was decided that, in addition to geotechnical information required, the site investigation should include:

5.12.1 Trial pit excavations and windowless sample boreholes on a grid basis, preferably 25m spacing.

5.12.2 One cable percussive borehole in the area of filled ground, to establish the existing depth of infill.

5.12.3 Samples of the made ground issued for testing for a broad suite of determinands, including metals, inorganics, asbestos, phenols, speciated PAH, and TPH.

5.12.4 Landfill gas monitoring due to the presence of an historical landfill immediately south of the site.

5.12.5 Upon receipt of contamination test results, any elevated TPH would be speciated to allow further risk assessment, and leachability testing undertaken on all elevated determinands, to give indication of mobility.

6.0 SITE INVESTIGATION

6.1 The purpose of the investigation undertaken in August 2018 was to produce an assessment of the site in accordance with BS10175 : 2011 + A2 : 2017 "Investigation of potentially contaminated sites - Code of practice", and to provide geotechnical information to aid design of the development.

6.2 The site was gridded on a maximum 25m spacing and trial pits were excavated and window sample boreholes were formed and sampled on the grid, to satisfy the requirements of the British Standard, along with any targeted locations. In addition, one cable percussive borehole was formed to confirm the thickness of filled ground in the southwest corner of the site, which stands at a higher level than the rest of the site, but is known from the archive maps to have been quarried. Ten trial pits (TP1 to TP10) were excavated, to depths of between 1.5m and 2.3m using a mini excavator, seven windowless sample boreholes were formed (WS1 to WS7), to depths of between 1.3m and 6.45m. The cable percussive borehole (BH1) was formed to 10.7m depth. The exploratory holes were organised, supervised and logged by an Engineer from ARP Geotechnical Ltd. Justifications for the exploratory hole locations are given below.

LOCATION	REASON
TP1 to TP7, TP8, WS3 and WS6	Part of grid within the base of the quarry
WS4, WS5 and TP9	Targeting area of oil staining to hardstanding
WS1 and WS7	Part of a grid within the infilled higher area to the southwest
BH1	Confirm thickness of quarry infill in the higher southwestern area
WS2, WS5 and TP10	Along the edge of the access ramp into the quarry

6.3 Three gas monitoring wells were installed in WS4, WS7 and BH1, and subsequently monitored by ARP Geotechnical Ltd. The wells were installed to between 3m and 10m depth, with upper 1m to 2m comprising plain pipe with bentonite seal and lockable flush cover, and the sections beneath comprising slotted pipe with gravel surround.

6.4 The trial pit, windowless sample borehole, and cable percussive borehole logs are included in Appendix G, along with the location plan. It should be noted that the co-

ordinates on the logs have not been surveyed in, but are automatically determined by the logging software (which incorporates mapping) following approximate positioning of each location by the Engineer.

6.5 Chemical analysis of 20No. soil samples for metals, inorganics, speciated PAH, TPH, phenols, and asbestos was undertaken by the UKAS accredited Concept Life Sciences (CLS) Laboratory in Manchester. Speciated EPH testing was undertaken on selected samples which displayed visual and olfactory signs of contamination. The test certificates are included in Appendix H.

7.0 SUMMARY OF GROUND CONDITIONS

Strata and Groundwater

7.1 In the southwestern corner of the site (BH1, WS1 and WS7) a cover of concrete was encountered to between 0.18m and 0.23m depth. The concrete was underlain by made ground comprising predominantly granular, occasionally cohesive, material with fragments of brick, concrete, ceramics and occasional wood, metal and ash, to 7.1m depth in BH1. Windowless sample boreholes WS1 and WS7 terminated within the made ground at between 5.45m and 6.45m depth. The made ground was underlain by loose to medium dense orange brown slightly gravelly sand, which did not contain any man made fragments, but is considered to be reworked natural material (quarry waste). Beneath, BH1 terminated at 10.7m, which is interpreted to be intact bedrock.

7.2 Along the edge of the access ramp (TP5, TP10 and WS2), a covering of gravelly sandy topsoil (made ground) was identified to 0.2m depth at two locations (TP5 and WS2). This was underlain by granular made ground, of brick, concrete, dolostone and occasional metal and plastic. Trial pits TP5 and TP10 terminated at between 1.5m and 1.8m within the made ground, whilst in WS2, limestone quarry waste was present from 5.0m, and intact bedrock was interpreted to be present at the base of the borehole (5.26m).

7.3 Within the base of the quarry (TP1 to TP4, TP6 to TP9, WS2 to WS4 and WS6) granular made ground was encountered to between 1m to 2.3m depth, up to cobble and boulder size, including fragments of brick, concrete, ceramics, dolostone, and occasionally wood, metal and plastic. TP4 terminated in made ground at 2.1m depth. The made ground was underlain by quarry waste, proven to between 1.6m and 3m depth. Window sample boreholes WS3, WS4 and WS6 terminated at refusal; this is interpreted to be intact bedrock.

7.4 Evidence of oil staining was identified on the floor slab of warehouse in the east of the site and on the surface of the hardstanding immediately surrounding the warehouse. Visual and olfactory signs of contamination, comprising medium to strong hydrocarbon odours,

were detected within TP9 at 1.2m and WS4 at between 2.5m and 3m. These positions were located near the warehouse.

7.5 The excavations were slightly unstable within the made ground.

7.6 Water strikes during the site investigation were generally concentrated towards the southeastern end of the site (within the base of the quarry). A heavy water strike was encountered at 2m depth in TP8, with water strikes also detected in WS6 between 1.5m and 3m depth and at the base of WS5 at 1.8m depth. Moist samples were also detected within TP6 at between 1.4m and 2.3m depth and TP9 between 1.4m and 1.8m depth. During post site investigation monitoring, water was detected at the base of the installation at WS4 at 2.25m depth (base of well at 3m) and at WS7 at 4.75m (base of well at 5m).

Gas Assessment

7.7 The ground gas investigation was undertaken in accordance with BS 8576 : 2013 "Guidance on investigations for ground gas - Permanent gases and Volatile Organic Compounds (VOCs)". Ground gas risk assessment was carried out in accordance with BS 8485 : 2015 "Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings".

7.8 Gas monitoring was carried out by ARP Geotechnical Ltd on four occasions between the 20th September 2018 and 3rd December 2018, during a variety of atmospheric pressures, including one visit below 1,000mb and three other visits in periods of falling pressure. The atmospheric pressures ranged between 999mb and 1,011mb. The results revealed a maximum methane (CH_4) concentration of 4.5%, a maximum carbon dioxide (CO_2) concentration of 11.2% v/v, and a maximum flow rate of 0.9l/h. The full set of monitoring results are presented in Appendix L.

7.9 The British Standard, BS 8485 : 2015, utilises the concept of borehole hazardous gas flow rates (Q_{hg}), in litres/hour (l/hr), which are obtained by multiplying flow rate by

concentrations in the air stream of the particular gas being considered for each borehole. The Q_{hg} is used to derive a gas screening value (GSV), which is defined as the "flow rate of a specific hazardous gas representative of a site or zone, derived from assessment of borehole concentration and flow rate measurements and taking account of all other influencing factors, in accordance with a conceptual site model".

7.10 The table below allows the selection of the 'Characteristic Situation' (CS) based on the GSV, using a numbering system of 1 to 6, where 1 equates to a very low hazard potential and 6 equates to a very high hazard potential. For reference, the equivalent NHBC Traffic Light categories are also provided (from "Guidance On Evaluation Of Development Proposals On Sites Where Methane And Carbon Dioxide Are Present", NHBC Report No. 4, 2007).

Characteristic Gas Situation (CS)	**NHBC Traffic Light**	**Hazard Potential**	**Gas Screening Value - l/hr - (GSV)**	**Additional Factors**
1	Green	Very Low	<0.07	Typically <1% CH_4 and <5% CO_2, otherwise consider an increased Characteristic Gas Regime
2	Amber 1	Low	>0.07 to <0.7	Typical Measured Flow Rate <70l/hr, otherwise consider an increase to CS 3
3	Amber 2	Moderate	>0.7 to <3.5	
4	Red	Moderate to high	>3.5 to <15	
5		High	>15 to <70	
6		Very High	>70	

Based on Table 2 of BS 8485:2015

7.11 A summary of the results obtained from the ground gas monitoring investigation, together with calculated Q_{hg}s for methane and carbon dioxide, is presented in the table below.

Borehole ref.	Max Recorded Steady Flow (l/hr)	Max. CO_2 (% v/v)	Max CH_4 (% v/v)	Max BH Qhg (CO_2)	Max BH Qhg (CH_4)
BH1	0.9	8.7	1.7	0.078	0.015
WS4	0.1	11.2	4.5	0.011	0.005
WS7	0.1	9.4	0.0	0.009	0.000
Worst-credible Qhg (l/hr) *				0.078	0.015
Worst-possible Qhg (l/hr) +				0.101	0.041

* Based on maximum recorded concentration and maximum flow rate applicable to any individual borehole.

+ Based on maximum recorded concentration and maximum flow rate across the whole site (any borehole)

7.12 The worst credible gas regime identified on the site (based on the maximum recorded flow rate and concentration detected together within an individual borehole) is a Q_{hg} of 0.078 l/hr for carbon dioxide and 0.015l/hr for methane. The maximum concentration of methane is 4.5% and maximum concentration of carbon dioxide is 11.2%. This equates to a Characteristic Gas Situation of 2 (Amber 1), for both methane and carbon dioxide.

7.13 It is also a requirement of the British Standard to check the very worst case combination of the highest flow and the highest detected concentrations, of any borehole, with values not necessarily from the same borehole. If the worst case conditions indicate a higher hazard could reasonably exist, then this should be adopted as the GSV, unless further monitoring or other justification is provided for it not to be used. In this case, the worst possible Q_{hg} is 0.101 l/hr for carbon dioxide and 0.041l/hr for methane. There is no requirement to raise the classification as a result.

8.0 CONTAMINATION ASSESSMENT

Screening Values - Soils

8.1 There is presently conflicting opinion with regard to the appropriate generic assessment criteria, or screening values, for soils which should be used in contamination assessment for proposed development. In March 2014, DEFRA published Category 4 Screening Levels (C4SLs) for six contaminants: arsenic, benzene, benzo(a)pyrene, cadmium, chromium VI and lead. The values are based on the toxicological benchmark of a "low level of toxicological concern" (LLTC) rather than the previous regulatory approach of "minimal or tolerable level of risk". As the C4SLs are less protective of health than the previous approach, the Chartered Institute of Environmental Health (CIEH) has advocated an alternative approach based on minimal risk, but with some adjustment of exposure parameters to more realistic scenarios than those previously used. To this end, the CIEH has collaborated with Land Quality Management to publish "Suitable 4 Use Levels" (S4ULs) "The LQM/CIEH S4ULs for Human Health Risk Assessment", November 2014 (LQM/CIEH). However, DEFRA has reiterated its intention that the C4SLs should be used in generic risk assessment for proposed development, and there is indication that other parties will collaborate, in the near future, to extend the range of C4SL determinands beyond the six published so far.

8.2 In the absence of a final resolution to the debate, soil contamination test results in this report have been compared first against the more conservative S4UL, and where a C4SL exists for the same determinand, consideration given to the use of the C4SL for any exceedances of the S4UL, within the site specific context. Where no S4UL exists for a determinand, for example lead, the C4SL has been used. The LQM/CIEH screening values have been calculated for soil organic matter contents of 1% and 2.5%, as well as 6%, and the appropriate screening value is used for the organic matter content of the soil. All the C4SL values published are for a soil organic matter content of 6%.

8.3 A table showing the screening values utilised is included in Appendix H.

Soils Analysis

8.4 Twenty soil samples were issued to the UKAS accredited Derwentside Environmental Testing Services in Consett for a suite of testing (As, Cd, Cr (VI), Cr(III), Cu, Hg, Ni, Pb, Se, Zn, Total Sulphate, Water Soluble Sulphate, pH, Phenol-monohydric, Speciated PAH, Total TPH, Asbestos, and Organic Matter). The testing comprised:

- One sample of topsoil from TP5 (topsoil was only encountered in TP5 and WS2)
- Fifteen samples of made ground including man-made material (brick, concrete, etc.) from BH1, TP1, TP2, TP3, TP4, TP6, TP7, TP9, TP10, WS1, WS2, WS3, WS4, WS5 and WS7)
- Four samples of quarry waste comprising natural reworked material (TP8, TP9, WS4 and WS6)

8.5 For each material, determinands with exceedances of screening values were subjected to statistical analysis, to determine the 95th percentile of the results, and any outliers present. The future phase of development has yet to be determined, therefore as part of this assessment the results have been compared to screening values for residential with plant uptake to represent a worst case development proposal.

Topsoil and Quarry Waste

8.6 All determinands were below screening values for these materials, with no exceedances recorded and no asbestos present.

Made Ground

8.7 Samples with the EPH above 500mg/kg were tested further for aliphatic/aromatic split carbon weighted speciation. The results indicate the individual determinands are all below the screening values, and the EPH concentrations in the made ground are therefore, considered to be acceptable. The only determinand with any exceedances was benzo(a)pyrene, with one sample above the screening value. A results summary table is given below.

Location	Depth	B(a)P
BH1	0.3	0.1
TP1	0.3	1.9
TP2	0.2	1
TP3	0.15	1
TP4	0.5-0.6	0.2
TP6	0.05	9.7
TP7	0.6	1.9
TP9	1.2	0.1
TP10	1	2.5
WS1	0.6-0.7	0.1
WS2	1.2-1.3	0.1
WS3	0.4-0.5	0.1
WS4	1.6-1.7	0.1
WS5	1.3 -1.5	0.1
WS7	0.2-0.4	2.4
Screening Value*		**5**
95% UCL		**2.5**

Exceedance
Acceptable
* Residential with plant uptake
Values are in mg/kg unless indicated otherwise
B(a)P = Benzo(a)pyrene

8.8 It can be seen from the table that concentrations of benzo(a)pyrene are not problematic, as the 95% UCL concentration is below the screening value for residential with plant uptake. No contaminants from the made ground require any further consideration by risk assessment.

Updated Risk Assessment and Conceptual Model

8.9 Although there was olfactory evidence of hydrocarbons in TP9 and WS4, laboratory testing indicates that these localised concentrations do not present any significant risk to human health, although they are a potential odour nuisance. Laboratory testing of the various made ground on the site has not identified any other contamination. However, there is still the issue of heavy oil staining on the slabs in the east of the site.

8.10 The updated source - pathway - receptor matrices for the initial stage of development (during the generation of a development platform) and the future development (worst

case of housing with residential used) are presented below, taking into account the findings of the investigation. Any pathways in italics are deemed not to be viable, and the reason given. The finished development will be several metres above the ground levels that exist currently over the vast majority of the site. Any asbestos within existing buildings will be removed prior to any works.

Viable Source - Pathway - Receptor Matrix (Whilst Generating a Development Platform)

Contamination Sources	Pathways	Receptors	Severity of Consequence	Probability of Event	Risk
East of site - localised oil staining on hardstanding and odour nuisance in soils below	• Inhalation, ingestion and dermal contact with soil and dust	• Earthworks operatives • Adjacent residents and general public	**Medium**	**Low Likelihood**	**Moderate/ Low**
	• Migration in surface water	• Surface water (nearest downslope is 213m to east. No abstractions within 1km)	**Medium**	**Unlikely**	**Low**
	• Migration in groundwater	• Groundwater (Principal Aquifer, no abstractions within 1km)	**Medium**	**Unlikely**	**Low**
Landfill 15m southeast:- methane and carbon dioxide	• Asphyxiation • Explosive risk	• Earthworks operatives	**Severe**	**Low Likelihood**	**Moderate**
Possible asbestos within existing buildings	• Inhalation	• Earthworks operatives • Adjacent residents and general public	**Severe**	**Unlikely**	**Moderate/ Low**

Viable Source - Pathway - Receptor Matrix (Future Finished Development)

Contamination Sources	Pathways	Receptors	Severity of Consequence	Probability of Event	Risk
East of site - localised oil staining on hardstanding and odour nuisance in soils below	• *Inhalation, ingestion and dermal contact with soil and dust* • *Fruit and vegetable intake, with soil* • *Vapour inhalation outdoor* • *Vapour inhalation indoor* • *(All the above pathways not applicable - will be covered by several metres of other soils)*	***Humans:-*** • *Future occupants* • *Maintenance workers* • *Adjacent residents and general public*	**Pathways Blocked**		
	• *Migration in surface water (not applicable - will be covered by several metres of other soils)*	• *Surface water (nearest downslope is 213m to east. No abstractions within 1km)*	**Pathway Blocked**		
	• Migration in groundwater	• Groundwater (Principal Aquifer, no abstractions within 1km)	**Medium**	**Unlikely**	**Low**
	• *Root uptake (not applicable – will be covered by several metres of other soils)*	***Vegetation:-*** • *Landscape areas* • *Private gardens*	**Pathway Blocked**		
	• *Migration (not applicable – will be covered by several metres of other soils)*	***Services/Utilities:-*** • *Potable water supply*	**Pathway Blocked**		
Landfill 15m southeast:- methane and carbon dioxide	• Asphyxiation • Explosive risk	• Construction/de-molition workers • Future occupants • Buildings	**Severe**	**Low Likelihood**	**Moderate**

8.11 It can be seen from the above matrices that several pathways to receptors are operative during the works to fill the site and generate a development platform and limited pathways once the development platform is in place. Some form of remedial action is, therefore, considered necessary during the initial phase of development (generating a suitable development platform) to allow future development without excess risk. Further

remedial action will then be required during the construction works for the future development.

Risk Based Assessment of Remedial Options

Risks Whilst Generating a Development Platform

8.12 The risks from the contamination during works to fill the quarry, and the mitigation measures required, are assessed in the following matrix.

Source	Pathway	Potential risk	Risk after employing suitable Health and Safety plan.
Asbestos in existing buildings	Inhalation	High	Provided an asbestos survey is carried out, and any identified asbestos is removed from site prior to any other works commencing, the pathway is blocked and the risk is negligible.
Localised oil staining and odour nuisance on the east.	Inhalation	Moderate	Damping down of the site during dry periods and timely removal of the stained material should block this pathway and reduce the risk to negligible. If any odours are deemed excessive, work should cease until PID monitoring is carried out to determine if volatile organic compound (VOC) levels are acceptable. Material to be removed if necessary.
Localised oil staining on the east.	Ingestion	Moderate	Site fencing will exclude access to members of the public. Stained material will be removed from site at earliest opportunity. Washing facilities and a clean mess room from which work boots and overalls are excluded should be provided. These measures should block this pathway and reduce the risk to negligible.
Localised oil staining on the east.	Contact	Low	Education of workers to use adequate hygiene and PPE should block this pathway and reduce the risk to negligible.
Localised oil staining on the east.	Surface water	Low	Preventing off-site surface water run-off and early removal should block this pathway and reduce the risk to negligible.
Landfill Gases - methane and carbon dioxide	Asphyxiation and Explosion	Moderate	Any worker entering any trenches should use a personal gas alarm. Any temporary buildings or structures on the site should be raised off the ground to prevent gas ingress.

8.13 Provision of all the above measures will ensure that all the identified pathways for the contamination will be blocked during the earthworks to infill the quarry.

Finished Development - Landfill Gas

8.14 To address the potential risk from landfill 15m southeast of the site, monitoring of borehole wells has been undertaken. Based on results of the gas monitoring, gas protection measures will be required for the future development, compliant with Characteristic Gas Situation of 2 (Amber 1), for both methane and carbon dioxide.

Finished Development - Oil Staining - Groundwater Pathway

8.15 Oil staining was noted on the surface of the concrete slabs in the east of the site, and hydrocarbon odours were noted in the soils beneath - TP9 at 1.2m and WS4 between 2.5m and 3m depth. However, no elevated concentrations were identified by the laboratory testing on these soils. Although the risk to the underlying Principal Aquifer is low, in order to reduce the risk further, the oil stained hardstanding should be excavated and removed from site, along with any suspect material beneath. The risk to the underlying aquifer is further reduced by the application of several metres of inert fill material, clean cover soils, and hardcover to the final development, together with the installation of a surface water drainage system.

Finished Development - Migration to Utilities

8.16 Across much of the site, any buried water supply pipes as part of the future phase of development are likely to be laid within inert backfilled material. Therefore, protection is unlikely to be required. However, the local water company are likely to require laboratory contamination test results for imported soils, to make a judgment on any requirement for protection of buried water supply pipes from chemical attack/ingress.

Summary of Contamination Identified and Remedial Options

8.17 The site is underlain by up to 10.7m thickness of made ground in the southeast and up to 3.0m at the base of the quarry. Monitoring of ground gases, by means of borehole well installations, has been completed. Based on results of the gas monitoring, gas protection measures will be required for the future development, compliant with Characteristic Gas Situation of 2 (Amber 1), for both methane and carbon dioxide

8.18 Evidence of oil staining was identified on the floor slab of the warehouse in the east of the site and at the surface of the hardstanding immediately surrounding the warehouse. Hydrocarbon odours were detected in the underlying soils, within TP9 at 1.2m and WS4 at between 2.5m and 3m. These positions were located near the warehouse.

8.19 The contamination risk assessment, and assessment of remedial options, has indicated that, provided that the following remedial measures are adopted then the risks to the identified receptors are deemed acceptable for the proposed future development.

Remedial Measures During Generation of Development Platform

8.19.1 An asbestos survey should be carried out prior to any demolition or work on the existing buildings on the site, and any identified asbestos should be removed and disposed to a licenced facility. The work should be carried out by appropriately qualified Contractors.

8.19.2 Although the risk to the underlying Principal Aquifer is low, in order to reduce the risk further, the oil stained hardstanding in the east should be excavated and removed from site, along with any suspect material beneath.

8.19.3 If any hydrocarbon odours are deemed excessive following breaking out of the slabs, work should cease until PID (Photo Ionisation Detector) monitoring is carried out to determine if volatile organic compound (VOC) levels are

acceptable. If found to be excessively elevated, laboratory testing should be carried out on the material, and off-site removal may be required.

Remedial Measures For Proposed Future Development (Actual Measures Will Depend on Development Proposal)

8.19.4 Gas protection measures will be required for any buildings within the future phase of development, likely to include venting and application of a methane impermeable barrier. The specific design of the protection measures, and the verification required, is dependent on the proposed development, detailed foundation design, the selection of products/suppliers, the gas regime, and who installs the protection.

8.19.5 Imported fill material brought onto the site will need to be verified as suitable by inspection and testing. In particular, the soils used within the upper 0.6m zone of any gardens or landscaped areas will need to be verified as suitable in accordance with guidance supplied in the document produced by the Yorkshire and Lincolnshire Pollution Advisory Group (YALPAG): "Guidance on the Verification Requirements for Cover Systems", by a scheme of inspection and testing.

8.20 As a requirement for future development, the local water company are likely to require details of the contaminants present in the material to be brought onto site, to make a judgment on any requirement for protection of buried water supply pipes from chemical attack/ingress.

9.0 GEOTECHNICAL TESTING

9.1 Geochemical testing (water soluble sulphate and pH) was undertaken on selected samples by Concept Life Science (CLS), comprising four samples of natural strata and 15No. samples of made ground. In accordance with the BRE Special Digest 1 "Concrete in aggressive ground", the characteristic values for the two materials are given below:

Characteristic Values

Material	pH	SO_4
Made Ground	7.6	485
Natural Strata	7.8	260

SO_4 = Sulphate content in mg/l on a 2:1 water : soil extract pH = Acidity

9.2 The geochemical analyses show the natural strata and made ground to have low water soluble sulphate content and near neutral pH. The Aggressive Chemical Environment for Concrete (ACEC) class is AC-1. Therefore, the use of GEN1 designated concrete will be satisfactory for unreinforced buried concrete, in accordance with BS 8500-1:2006. For any reinforced buried concrete, other design-specific mixes will apply.

10.0 COMMENTS AND CONCLUSIONS

Site Description

10.1 At the time of the investigation, the site comprised a partially infilled quarry. The southwestern corner of the site has been infilled and comprises an area of hardstanding with a dilapidated single storey building. An access ramp slopes northwards down towards the base of the quarry. The base of the quarry is partially under hardstanding of concrete but predominantly under dense vegetative cover with numerous semi mature trees. A rectangular corrugated steel warehouse is located in the eastern end of the site. There is visual and olfactory evidence of oil staining within the warehouse and on the hardstanding immediately surrounding the warehouse. A rectangular concrete inspection pit is located adjacent to the warehouse. Several stockpiles of possible quarry material or demolition material is present towards the southeastern end of the site. Numerous industrial size tyres are present across the site, including a stockpile in the southeast.

10.2 The southwestern corner of the site is at the approximately the same level as Field Lane with an access ramp sloping down northwards towards the base of the quarry. There is an approximate 6m level difference between the base of the quarry and the area to the southwest. At the base of the quarry, the site slopes gently down towards the southeast. A near vertical quarry highwall is present along the western, northern, eastern and southern boundaries of the site. The area surrounding the site slopes down towards the southeast.

Site History

10.3 Ordnance Survey archive maps show that a quarry has been present at the southern end of the site from the 1900s expanding to cover the whole site by the 1930s. The quarry was connected to a larger quarry (South Elmsall Quarries) to the south via a tunnel under Field Lane. Partial infilling on the quarry has been undertaken in the far southwestern corner. A depot is shown to be present on site from the 1960s until the present and understood to

be used as storage /light industrial activities, including a waste transfer site for earthmoving equipment tyres.

Geology

10.4 The geological map shows the site to be underlain by an area of worked ground, from the former quarry. The bedrock comprises dolostone of the Cadeby Formation. No superficial deposits are shown to underlie the site. An area of infilled ground is shown immediately south of the site at the location of a former quarry and landfill.

Coal Mining and BGS mineral site

10.5 The site is considered stable with regard to coal mining.

10.6 An opencast dolomite quarry is recorded on site. A further four quarries are registered within 20m of the site with the nearest being 55m southeast of the site, all have ceased to operate.

10.7 A natural cavity, limestone cave, is identified 212m east of the site. However, the potential for ground dissolution stability hazards on the site is stated to be "Very Low".

Environmental Data

10.8 The strata beneath the site are classed as a Principal Aquifer. There are no groundwater abstractions within 1km of the site.

10.9 The nearest surface water is an unnamed drain, approximately 213m to the east. However, there are no surface water abstractions within 1km of the site.

10.10 Basic radon protection is required for the site. This is usually achieved by incorporating an appropriate barrier within a solid floor system, and extending the barrier through the cavity wall. However, the site is also affected by landfill gases, as discussed below.

10.11 Several landfills associated with the infilling of the former South Elmsall Quarries are recorded within 250m of the site, with the closest located 15m southeast of the site. Gas monitoring has identified maximum carbon dioxide and methane concentrations of 11.2% and 4.5% respectively. Risk assessment indicates that low level CS2 (NHBC Amber 1) gas protection, against methane and carbon dioxide, are required, if any residential properties were proposed for the site. The above measures would also provide appropriate protection against radon.

10.12 The specific design of the protection measures, and the verification required, is dependent on the future development proposal, the detailed foundation design, the selection of products/suppliers, the gas regime, and who installs the protection. Once more of these factors are known, as a minimum following foundation design and design of the protection measures, a Statement on Gas Protection should be prepared. The document should provide information for the Client and other interested parties, such as the regulatory authorities, outlining how gas protection measures for properties on the site will be implemented and the installation verified as satisfactory. The document should be agreed, prior to implementation, with the relevant Regulatory Authorities, usually the local Planning Authority and NHBC or other building control provider.

10.13 The site is not at risk from river flooding The risks of flooding from other causes such as adverse topography or insufficient surface water drainage, are not considered here, and a separate specialist Flood Risk and Drainage Report should be commissioned if such risk needs to be quantified.

Ground Conditions Encountered

10.14 In the southwestern corner of the site, a cover of concrete was encountered to between up to 0.23m thick. The concrete was underlain by made ground comprising predominantly granular, occasionally cohesive, material with fragments of brick, concrete, ceramics and occasional wood, metal and ash, to 7.1m depth in BH1. The mixed made ground was underlain by loose to medium dense reworked natural material (quarry waste). Beneath, BH1 terminated at 10.7m, which is interpreted to be intact bedrock.

10.15 Along the edge of the access ramp, granular made ground, of brick, concrete, dolostone and occasional metal and plastic, was present. In WS2, limestone quarry waste was present from 5.0m, and intact bedrock was interpreted to be present at the base of the borehole (5.26m).

10.16 Within the base of the quarry, granular made ground was encountered to between 1m to 2.3m depth, up to cobble and boulder size, including fragments of brick, concrete, ceramics, dolostone, and occasionally wood, metal and plastic. The mixed granular made ground was underlain by quarry waste, proven to between 1.6m and 3m depth. Window sample boreholes WS3, WS4 and WS6 terminated at refusal; this is interpreted to be intact bedrock.

10.17 The excavations were slightly unstable within the made ground. Water strikes during the site investigation were generally concentrated towards the southeastern end of the site (within the base of the quarry). A heavy water strike was encountered at 2m depth in TP8, with water strikes also detected in WS6 between 1.5m and 3m depth and at the base of WS5 at 1.8m depth. Moist samples were also detected within TP6 at between 1.4m and 2.3m depth and TP9 between 1.4m and 1.8m depth. During post site investigation monitoring, water was detected at the base of the installation at WS4 at 2.25m depth (base of well at 3m) and at WS7 at 4.75m (base of well at 5m).

Contamination Assessment

10.18 Evidence of oil staining was identified on the floor slab of the warehouse in the east of the site and at the surface of the hardstanding immediately surrounding the warehouse. Hydrocarbon odours were detected in the underlying soils, within TP9 at 1.2m and WS4 at between 2.5m and 3m. These positions were located near the warehouse. However, laboratory testing of soils at these locations, and of the various made ground on the site, has not identified any contamination above screening values for residential use.

10.19 The contamination risk assessment confirmed that, provided remedial measures are implemented, the materials present on the site are compatible with proposed

development, including residential use. During the initial phase of development (generating a development platform) the following remedial measures are required:

- Asbestos survey of existing building and removal by specialist contractor.
- Breakout and remove oil stained hardstanding together with any underlying suspect material.
- If any hydrocarbon odours are deemed excessive following breaking out of the slabs, PID monitoring is to be carried out to determine if VOC levels are acceptable. If found to be excessively elevated, laboratory testing should be carried out on the material, and off-site removal may be required.

The following remedial measures will be required for the future phase of development, subject to confirmation of the proposal:

- Gas protection measures will be required for any buildings within the future phase of development, likely to include venting and application of a methane impermeable barrier. The level of gas protection required will be dependent on the proposed development, to meet protection against Characteristic Gas Situation of 2 (Amber 1), conditions for both methane and carbon dioxide.

- Imported fill material brought onto the site will need to be verified as suitable by inspection and testing. In particular, the soils used within the upper 0.6m zone of any gardens or landscaped areas will need to be verified as suitable in accordance with guidance supplied in the document produced by the Yorkshire and Lincolnshire Pollution Advisory Group (YALPAG): "Guidance on the Verification Requirements for Cover Systems", by a scheme of inspection and testing.

Further detail of the remedial measures required during the initial phase of development (generating a development platform) is provided in the Earthworks Method Statement included in Appendix K. Upon completion of the initial phase of development and once the future proposed development has been finalised a Contamination Remediation Statement and a Statement on Gas Protection should be prepared.

10.20 As a requirement for future development, the local water company are likely to require details of the contaminants present in the material to be brought onto site, to make a judgment on any requirement for protection of buried water supply pipes from chemical attack/ingress.

Earthworks

10.21 Subject to confirmation of existing site levels and proposed finished earthworks levels, it is anticipated that up to 5m of fill will be required across much of the site to generate a stable development platform.

10.22 It is understood that an estimated volume of between 135,000 and 145,000 tonnes of inert recovered waste material will be required, and this is understood will comprise classified construction material/demolition waste that will be screened and crushed to a defined specification and graded for phased engineering ground works.

10.23 The following enabling works are required prior to the commencement of the filling operation;

- Remove stockpiles of tyres and other debris from base of the quarry
- Strip and remove existing vegetation and topsoil
- Remove vegetation growing along quarry highwall
- Demolition of the existing buildings, following asbestos survey
- Breakout of hardstanding and any sub surface obstructions from the base of the quarry, in order to remove obstructions for potential future piling works
- Breakout and remove oil stained hardstanding together with any underlying suspect material

10.24 It is not anticipated that significant off-site disposal of material will be required. However, the following material is likely to be generated which may require offsite disposal;

- Existing stockpiles of material from base of the quarry
- Unsuitable topsoil/made ground with many roots
- Oil stained hardstanding adjacent to the warehouse and any suspect material beneath

10.25 All disposal/waste transfer documents should be retained for any material that requires offsite disposal.

10.26 Due to the volume of imported material required, consultation with the Environment Agency and the local authority is likely to be required, with reference to licensing, permits and planning permission.

10.27 The infilling operation will be undertaken with suitable materials which have been classified and compacted in accordance with the specification, set out in the Earthworks Method Statement, to raise ground levels up to the proposed finished earthwork levels.

Foundations for future phase of development

10.28 The foundation solution for the future development will depend on the final development proposal for the site.

10.29 Following the completion of the backfilling operation, significant thickness of made ground will be present across the whole site, of up to 10.7m depth. Therefore, traditional strip/trench fill foundations are not viable.

10.30 For structures with low loads (i.e. houses) raft foundations may potentially be viable over the area of engineered fill. However, this will require excavation and re-engineering of fill material already present. Raft foundations are not considered viable for structures with high loads or low settlement tolerance or for any structure placed on existing made ground in the southwestern corner of the site (organic material identified within the fill material in the southwest) due to the risk of unacceptable settlement.

10.31 The use of vibro ground improvement techniques may potentially be viable over the area of engineered fill, but is unlikely to be acceptable in the southwestern corner of the site, due to the presence of organic material within the fill. If the imported fill to be placed is granular and is compacted too well, this can impede the installation of vibro columns.

10.32 A piled solution would be required for structures with high loads or low settlement tolerance or for any structure placed on existing made ground in the southwestern corner of the site. The piles are likely to extend into the dolostone bedrock, which was encountered at approximately 11m depth in the southwest. A specialist piling contractor should be consulted for advice on pile design. Even with a piled foundation proposed, it is still necessary to compact the fill material to a controlled specification, to support access roads, general level, and infrastructure, without excess settlement.

10.33 It is understood that the client has a preference for raft foundations for any structures with low loads on the majority of the site, and piled foundations in the southwestern area, highlighted on the foundation plan in Appendix G. However, the use of raft foundations for structures with low loads would only be viable over the area of engineered fill, provided that the fill material has been compacted to a controlled specification.

Excavations

10.34 It is likely that excavations within any made ground present on the site is likely to be unstable in the short term, requiring possible trench support, in accordance with the prevailing statutory guidance.

10.35 Water strikes during the site investigation were generally concentrated towards the southeastern end of the site (at the base of the quarry). A heavy water strike was encountered at 2m depth in TP8 with water strikes also detected in WS6 between 1.5m and 3m depth and at the base of WS5 at 1.8m depth. Moist samples were also detected within TP6 at between 1.4m and 2.3m depth and TP9 between 1.4m and 1.8m depth. During post site investigation monitoring water was detected at the base of the

installation at WS4 at 2.25m depth (base of well at 3m) and at WS7 at 4.75m (base of well at 5m). The water is likely to be perched water.

10.36 Excavations should be readily achieved using conventional hydraulic plant. However, excavations into intact bedrock, reinforced concrete hardstanding, or any buried foundations and structures, are likely to require a hydraulic breaker.

Chemical Precautions

10.37 The Aggressive Chemical Environment for Concrete (ACEC) class is AC-1 for both the natural strata and made ground. Therefore, the use of GEN1 designated concrete will be satisfactory for unreinforced buried concrete in accordance with BS 8500-1:2006. For any reinforced buried concrete, other design-specific mixes will apply.

Road Pavement Construction

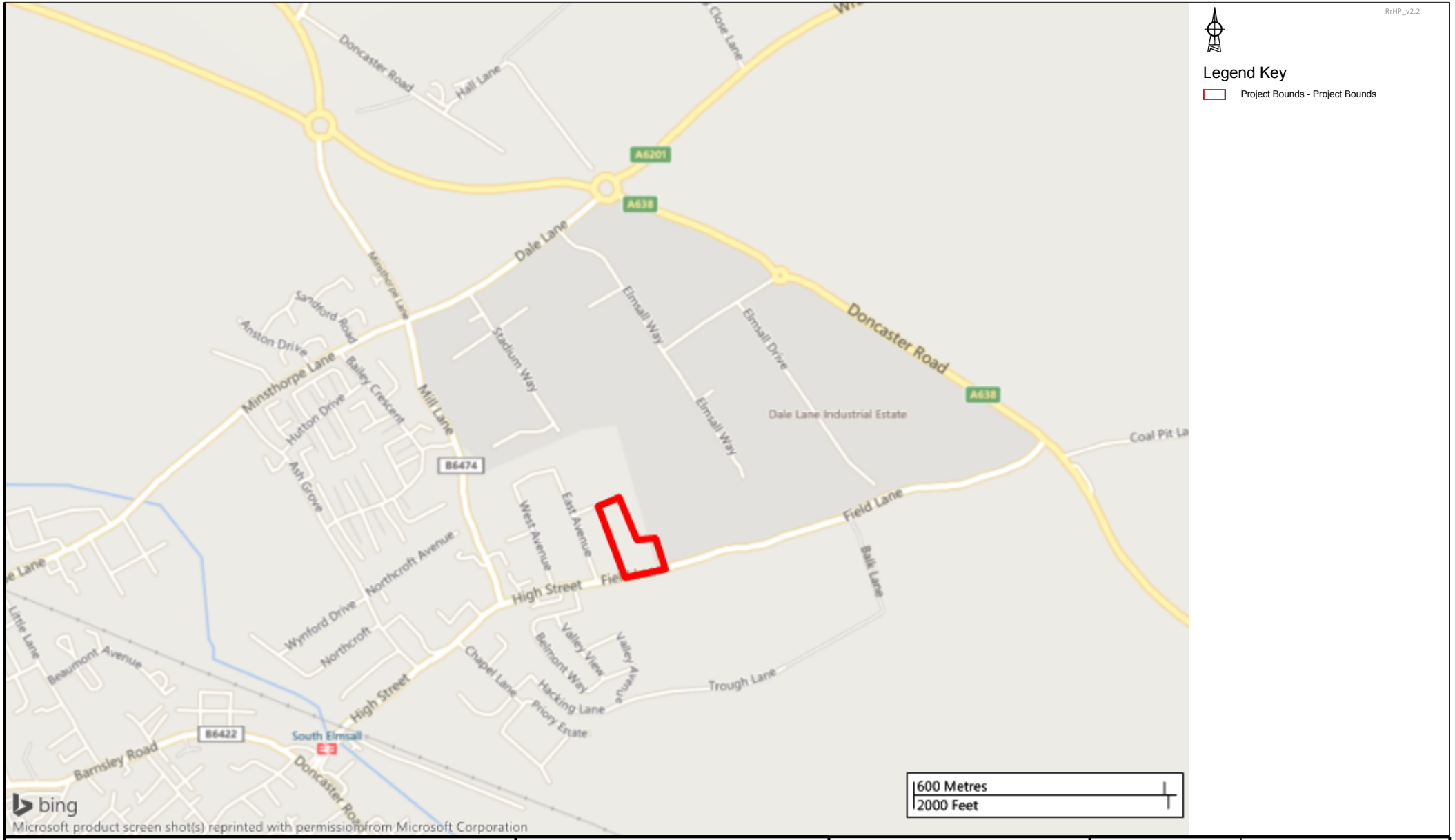
10.38 Provided the imported fill material is suitable and placed in to an accepted controlled specification with the inspection and consultation of the local authority, it should be possible to achieve an adoption, if required. However, adoption may require more onerous construction that a private access, for example it may be necessary to remove a significant depth of any existing made ground and the use of geogrid reinforced stone layers may be required. If adoption is being considered, consultations with the relevant authority should be undertaken at the earliest stage.

Soakaways

10.39 The disposal of surface water using soakaways is not practical on the site, due to the existing/proposed presence of a large thickness of fill material across the site. A drainage feasibility design should be carried out to determine the appropriate solution.

APPENDIX A

SITE LOCATION PLAN AND AERIAL PHOTOGRAPH



Project	Quarry Works, Field Lane, South Elmsall, Wakefield	Title	Site Investigation Plan	Date 0	Scale 1:12500
Client	Wetherby Skip Services			Drawn ARP	No WSK/01

RrHP_v2.2

Legend Key

Project Bounds - Project Bounds

Project: Quarry Works, Field Lane, South Elmsall, Wakefield	Title: Site Investigation Plan	ARP	Date: 0	Scale: 1:2500
Client: Wetherby Skip Services			Drawn: ARP	No: WSK/01

APPENDIX B

SITE PHOTOGRAPHS

Photograph 1: Southern boundary along Field Lane, facing northwest

Photograph 2: Site entrance off Field Lane, facing north

Photograph 3: Dilapidated building in the southwest corner of the site, facing west.

Photograph 4: Ramp sloping north down towards the base of the quarry.

Photograph 5: Half way down the ramp, facing north.

Photograph 6: Half way down the ramp, facing south towards Field Lane.