ARP GEOTECHNICAL LTD
CHARTERED CONSULTING ENGINEERS

COMBINED STAGE 1 & 2
DESK STUDY AND GEO-ENVIRONMENTAL REPORT

AT

COWLERSLEY LANE, COWLERSLEY
HUDDERSFIELD

ON BEHALF OF

MARK OLIVER HOMES (YORKSHIRE) LTD

DECEMBER 2015

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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	Residential dwellings with private gardens.
Existing Site Description	Derelict land, including remains at ground level of former mill. Bounded to the north by a heavily wooded, steeply sloping embankment.
Site History	Cloth mill, including mill pond, was located on the east since before 1854. Sandstone quarries were located to the northwest and north, and encroach onto the northwest. Quarry slope later overfilled.
Geology	Huddersfield White Rock (sandstone). No drift.
Coal Mining	Site can be considered stable.
Hydrogeology	Site underlain by Secondary A Aquifer. No sensitive abstractions.
Hydrology	Nearest downslope surface water is Huddersfield Narrow Canal 150m to north, and River Colne 170m to the north. No surface water abstractions for sensitive uses within 1km of the site.
Landfill Gas & Radon	No gas protection of properties required, based on monitoring results to date. Protection may be required at WS5 due to Naphthalene, depending on remedial option selected.
Ground Conditions	Made ground topsoil up to 0.6m thick. Deeper made ground in former mill pond, proven to 1.80m, and beyond quarry face in the west, up to >10m. Sandstone bedrock is typically between 1m and 2m depth.
Contamination	Widespread contamination of topsoil and made ground. Hot spot of volatile naphthalene in made ground at WS5.
Remediation Strategy	Unsuitable topsoil requires removal. 600mm thick cohesive cover blanket with hard break layer where made ground is present in gardens/landscape. Material at WS5 requires specific attention - various options available.
Foundations	Traditional strip/trench fill onto shallow sandstone rock. Piled foundations required over backfilled quarry, although development on this area is to be avoided due to slope stability requirements.
Excavations	Liable to collapse in made ground. Groundwater unlikely.

Concrete	FND2 designation for unreinforced foundations unless made ground removed, in which case GEN 1 would be applicable.
Soakaways	Disposal of surface water via soakaways is unlikely to be feasible.

2.0 TERMS OF REFERENCE

2.1 Mark Oliver Homes (Yorkshire) Ltd is considering developing the site at Cowlersley Lane, Cowlersley, near Huddersfield, with residential properties. It was considered appropriate to implement a desk study and ground investigation to provide information to aid viability assessment and design of any subsequent development.

2.2 ARP Geotechnical Ltd were appointed by Mark Oliver Homes (Yorkshire) Ltd 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 subsoil conditions.

2.3 The investigation was implemented generally in accordance with BS 5930 : 1999 "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 + A1 : 2013 "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 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.

2.5 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.

2.6 The investigation was commenced in September 2015.

2.7 The report has been prepared for the sole use and reliance of the Client. The report shall not be relied upon or transferred to any other parties without the written agreement of ARP Geotechnical Ltd. No responsibility will be accepted where this report is used, either in its entirety or in part, by any other party.

3.0 SITE DESCRIPTION

Site Location

3.1 The site, which is centred on Ordnance Survey Grid Reference 410900, 415470, is located off Cowlersley Lane, Cowlersley, approximately 3.5km to the west of Huddersfield city centre.

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

On - Site Features

3.3 The site is an irregular shaped piece of land extending to an area of 1.23 hectares, with overall dimensions of approximately 100m (northwest - southeast) by 220m (northeast - southwest).

3.4 The site is currently a derelict piece of land. On the east of the site, the remains of a demolished waste cloth mill are evident, including concrete slabs and the bases of former walls. Land in the north is overgrown with numerous mature and immature trees. There is a significant amount of waste material, mainly building debris, scattered across the site, associated with more recent garages and sheds, which have now been demolished. It is apparent that adjacent terraced properties have historically used parts of the south of the site as gardens but their attempts at cultivation (land grabbing) have since been removed.

3.5 Ground levels on the site slope downwards to the northeast with an elevation difference of approximately 15m. The site surface is generally uneven and, in the east (lower part) of the site where the mill was previously located, there are abrupt changes in ground level where concrete slabs and fill materials are visible at the surface. In the west, the remains of a low retaining wall are evident.

Site Boundaries and Surrounding Land Use

3.6 The site is bounded to the northwest by a heavily wooded, steeply sloping embankment, which represents the side of a former sandstone quarry and slopes steeply down to Manchester Road (A62) at its base, approximately 10m below the site. To the north there is terraced housing at the base of the quarry wall. Residential properties are also present to the east and southeast, which front onto Cowlersley Lane, and to the south which front onto Yew Tree Lane. To the northwest of the site there appears to be some industrial units of unknown use.

Site History

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

Map Date	**On-Site**	**Off-Site**
1854	The square outline of a manmade pond (mill pond) is indicated in the centre and buildings shown in the northeast. A sandstone quarry encroaches into the northwest. The remainder of the site appears undeveloped.	Surrounding land is generally agricultural, with some quarries in the area, including the one on the northwest boundary.
1892	The site is annotated as a "Mungo* and Waste Mill". The mill occupies the east of the site. One tank is indicated near the eastern boundary.	Extent of quarrying can be clearly made out, with rough pastureland indicated at the bottom.
1916	The area of the former sandstone quarry in the northwest of the site has been raised back up.	Some earthworks indicated beyond northwest boundary, probably associated with raising of ground levels. Houses to southeast and east.
1938	Mill pond no longer shown (presumed to have been infilled).	Houses now shown along southwest site boundary.

1961	Several mill buildings removed from north. Many small buildings (possibly sheds/garages or containers) now shown in the centre of the site, including over the former pond.	"Works" to west, in the area of the former sandstone quarry.
2015	Mill building no longer shown.	No significant change.

* Cloth made from recycled woven or felted material.

3.8 In summary, a cloth mill was located on the east of the site since before 1854. Sandstone quarries were located to the northwest and north, and encroach onto the northwest of the site. Land in the northwest of the site was later reclaimed by overfilling the quarried slope. In the 1960s, small buildings (possibly sheds/garages or containers) were located in the centre of the site, after the millpond was infilled. In more recent years, all buildings have been removed, but remnant slabs and some low-lying walls remain.

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 C. The maps show made ground to the northeast of the site, and infilled ground to the west, both associated with the former quarry. The site itself is shown to be underlain directly by Huddersfield White Rock (sandstone) of the Carboniferous Period, with no superficial deposits present.

4.2 There are no faults shown to affect the site.

Coal Mining

4.3 The site is not within a coal mining area, and is considered stable with regard to coal mining.

Hydrogeology

4.4 The Landmark Envirocheck Report, included in Appendix D, indicates the Bedrock Aquifer Designation to be "Secondary A" Aquifer. These Aquifers comprise "permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers".

4.5 There are no groundwater abstractions for sensitive uses within 1km of the site.

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

Hydrology

4.7 The site slopes to the northeast. There are no waterbodies downslope of the site within 250m. The nearest surface waterbody is the Huddersfield Narrow Canal, approximately 150m to the north. The River Colne, a Primary River, is located approximately 170m to

the north. The Huddersfield Narrow Canal and the River Colne flow west to east along the trough of the Colne Valley. Any surface water run-off from the site is likely to drain onto adjacent properties or be intercepted by the drainage system beneath the highways.

4.8 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.

4.9 There are two active surface water abstractions within 1km down gradient of the site, at approximately 870m and 885m to the northeast. The abstractions are for non-sensitive industrial purposes.

Other Environmental Data

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

4.10.1 There are no Pollution Control Authorisations within 250m of the site.

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

4.10.3 There is one historic landfill within 250m of the site, located 84m to the north, across Manchester Road. Deposited waste included inert, industrial and liquid sludge (possibly canal dredgings). The landfill was operational from 1989 to 1993.

4.10.4 The site is not within a radon affected area, and no radon protective measures are necessary on the site.

4.10.5 There are 19 contemporary trade directory entries within 250m of the site, none of which are on the site, and many of which relate to light industrial activities

including precision engineering and car garages. None of the entries would have any significant impact on the site.

4.10.6 There are no fuel station entries within 250m 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.

Conceptual Site Model

5.7 It is known that the site is proposed for residential dwellings with private gardens. An indicative proposed site layout is included in Appendix E. The site is shown to be directly underlain by Huddersfield White Rock (sandstone). The solid strata beneath the site are designated a Secondary A Aquifer and there are no drift deposits. The nearest surface water is the Huddersfield Narrow Canal at approximately 150m to the north, and the River Colne, a Primary River, approximately 170m to the north. There are no groundwater or surface water abstractions for sensitive uses within 1km of the site.

5.8 The site has been occupied by a cloth mill since before 1854, with mill buildings and a tank in the east, and a mill pond in the centre. Sandstone quarries were located on land adjacent to the northwest and north, and encroached onto the northwest of the site. In the 1960s, small buildings (possibly sheds/garages or containers) were located in the centre

of the site after the millpond was infilled. There is the possibility that contamination may be present associated with historical uses of the textile mill, and also in any fill used on the development including within the former millpond and material used to build up site levels following quarrying. The most likely contamination sources are considered to be:

5.8.1 Possible made ground, for example ash and clinker: - metals inorganics, TPH, PAH, phenol, asbestos.

5.8.2 Possible hydrocarbons from former fuel tank(s), for example the tank noted on archive maps in the east:- TPH, PAH.

5.9 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 proposed development are identified on the table below. Any pathways in italics are deemed not to be viable (and the reason given in brackets).

Potential Source -Pathway - Receptor Matrix

Contamination Sources	Pathways	Receptors
Possible made ground - metals, inorganics, TPH, PAH, phenol, asbestos Additional possible contamination due to the historical presence of tank(s) - TPH, PAH	• Inhalation, ingestion and dermal contact with soil and dust • Fruit and vegetable intake (with soil) • Vapour inhalation outdoor • Vapour inhalation indoor	**Humans:-** • Future occupants • Construction workers • Maintenance workers • Adjacent residents and general public
	• Migration in surface water • Migration in groundwater	**Controlled waters:-** • Groundwater (Secondary A Aquifer, no abstractions within 1km) • Surface water (nearest downslope is a canal 150m to N, and there are no sensitive abstractions within 1km)
	• Root uptake	**Vegetation:-** • Landscape areas • Private gardens
	• Migration	**Services/Utilities:-** • Potable water supply
Landfill to north, made ground to northwest, and on-site mill pond - methane and carbon dioxide	• Asphyxiation • Explosive risk	• Construction/demolition workers • Future occupants • Buildings

5.10 The above matrix indicates there are several potential source - pathway - receptor linkages applicable to the proposed development.

5.11 The assessment was used to inform the design of the subsequent ground investigation. To fully characterise the site, in accordance with BS10175 : 2011 + A1 : 2013 "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:

5.11.1 Trial pit excavations and window sampling boreholes on a grid basis, preferably 25m spacing.

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

5.11.3 Landfill gas monitoring due to the presence of a landfill to the north of the site, made ground to the northwest and an on-site infilled millpond.

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

6.0 SITE INVESTIGATION

6.1 The purpose of the ground investigation undertaken in September 2015 was to produce an assessment of the site in accordance with BS10175 : 2011 "Code of practice - investigation of potentially contaminated sites", 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 and boreholes were carried out and sampled on the grid, to satisfy the requirements of the British Standard, along with any targeted locations including the former millpond. Fifteen trial pits (TP1, TP2, TP2A, TP2B, TP2C, TP3 to TP6, TP6A, TP7 to TP9, TP9A and TP9B) were excavated, to depths of between 0.20m and 3.50m, and eight window sample boreholes (WS1 to WS8) were drilled to depths of between 0.92m and 10.45m. Additional window sample holes (WS6A, PH9, PH10, PH11 and PH12) were drilled to delineate the highwall position of the former quarry and logging of soils was not necessary, only recording of the refusal depth. The trial pits and boreholes were organised, supervised and logged (with the exceptions noted above) by Engineers from ARP Geotechnical Ltd. Justifications for the trial pit and borehole locations are given below.

LOCATION	REASON
WS3, TP6 and TP6A	Former mill pond
TP7, TP8, TP11, WS5, WS8	Former mill buildings
TP9, TP9A, TP9B, TP9C, WS5, WS6, WS6A, WS7, PH9, PH10, PH11 and PH12	Highwall of former quarry
Others	Part of grid

6.3 Five gas monitoring wells were installed, in WS1, WS3, WS5, WS7 and WS8, and subsequently monitored by ARP Geotechnical Ltd. The wells in WS1, WS3, WS5 and WS8 were installed to 1m depth, with the bottom 0.5m comprising slotted pipe with gravel surround, and the upper 0.5m comprising plain pipe with bentonite seal and lockable flush cover. These boreholes all refused on shallow rock and it was not possible to install deeper wells. However, a deeper well to 3m was installed in WS7, adjacent to

the northwestern boundary, which encountered deep made ground. The well in WS7 was constructed using 2m slotted pipe with gravel surround for the lower section and plain pipe with bentonite seal for the upper 1m. The results of gas monitoring carried out to date are included in Appendix I.

6.4 The trial pit and borehole plan and logs are included in Appendix F.

6.5 Percolation tests were carried out in TP1, TP3 and TP5. The test readings, curves and calculations are included in Appendix G.

6.6 Chemical analysis of 18 soil samples, for metals, inorganics, speciated PAH, TPH, phenols and asbestos, was undertaken by the UKAS accredited DETS Laboratory in Consett. Elevated determinands were tested further for leachability to determine the potential mobility of the contaminants, and also speciated assessment (with aliphatic : aromatic split) of samples exhibiting elevated EPH was undertaken. The test certificates are included in Appendix H.

6.7 Analysis for Atterberg Limits and moisture content was undertaken by the UKAS accredited Professional Soils Laboratory (PSL) in Doncaster. The pH and water soluble sulphate testing was undertaken by DETS and also Chemtest. The test certificates are included in Appendix H.

7.0 SUMMARY OF GROUND CONDITIONS

Strata and Groundwater

7.1 Across the majority of the site, made ground varied between 0.1m and 0.6m and typically comprised reworked gravelly topsoil in which the gravel component included sandstone, brick, concrete, coal, ash, clinker, ceramic and plastic.

7.2 Made ground was encountered in the location of the former mill pond to depths of 0.80m (TP6), WS3 (0.95m) and greater than 1.80m (TP6A), indicating the made ground is deeper towards the east of the former pond, possibly due to the natural original topogrpahy. This granular made ground was found to comprise clayey sand and gravel with cobbles and boulders of sandstone with some gravel of clinker and pockets of clay.

7.3 Deeper made ground was proven beyond the buried quarry wall in the northwest, up to greater than 10m in WS7. The deep made ground consisted of sand and gravel of sandstone, brick, ash, clinker, ceramic and slate, with some cobbles of sandstone.

7.4 Below the made ground/topsoil, completely weathered sandstone rock, comprising sand, gravel and cobbles of sandstone, was present. The completely weathered zone typically extended to depths of between 0.95m and 1.80m. However, sandstone bedrock was encountered locally at very shallow depth in the centre north, where intact sandstone was proven in TP2 and TP2A immediately below the made ground topsoil. Very thin beds and small pockets of clay were also observed in the completely weathered material.

7.5 Most of the trial pits and boreholes which proved natural strata were terminated on the (at least) very weak sandstone at depths of between 1m and 2m.

7.6 The excavations generally remained stable for the short period of exposure and the pits were backfilled with the arisings on completion. Groundwater was not encountered in any of the pits or boreholes during the site works or the follow up gas monitoring visits.

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 The monitoring carried out on two occasions over a two week period, showed no methane (CH_4) to be present, a maximum carbon dioxide (CO_2) concentration of 3.0% v/v, and zero flow rate. However, a further four visits, over a two month period, are still to be carried out, and the full results will be reported by separate letter. The results of gas monitoring undertaken to date are presented in Appendix I.

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 Gas 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.

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 Peak Flow (l/hr)	Max Recorded Steady Flow (l/hr)	Max. CO2 (% v/v)	Max CH4 (% v/v)	Max BH Qhg (CO2)	Max BH Qhg (CH4)
WS01	0.1	0.1	0.7	0.0	0.001	0.000
WS03	0.1	0.1	1.3	0.0	0.001	0.000
WS05	0.1	0.1	1.2	0.0	0.001	0.000
WS07	0.1	0.1	3.0	0.0	0.003	0.000
WS08	0.1	0.1	1.4	0.0	0.002	0.000
		Worst-credible Qhg (l/hr) *			0.003	0.000
		Worst-possible Qhg (l/hr) +			0.003	0.000

* 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 Therefore, for the gas regime identified on the site, where zero CH_4 and 3.0% CO_2 were detected, along with zero borehole flow rate, a maximum Q_{hg} of 0.003 l/hr is the result. This equates to a Characteristic Gas Situation of 1**.** No specific gas protection measures are, therefore, required for proposed properties, based on the monitoring results obtained to date.

Percolation Testing

7.13 Percolation testing was implemented in TP1, TP3 and TP5 using a 1500 gallon tractor-towed water bowser to discharge water quickly into each hole. In each of the three pits, due to slow infiltration rates, it was only possible to carry out single tests.

7.14 In TP1 (in the south), the water level did not drop below 50% effective depth after almost 7 hours. Consequently a soil infiltration rate cannot be calculated. In TP3 (in the northeast), the water level fell below 50% effective depth, but not below 25% effective depth, after 4.2 hours. By extrapolating the curve, it is possible to calculate an infiltration rate of 1.37×10^{-5} m/s. In TP5 (in the centre south), the water level also fell below 50% effective depth but not below 25% effective depth, after 4.2 hours. By extrapolating the curve, it is possible to calculate an infiltration rate of 6.41×10^{-6} m/s. In each test, the response zone comprised the completely weathered sandstone rock, with the base of the test pit within intact sandstone rock.

7.15 In the light of the above, infiltration rates range from too low for soakaways, to marginal, so that any soakaway designed for the highest infiltration rate of 1.37×10^{-5} m/s likely to be so large as to be impractical. There is also the potential problem of re-emergence of water on the steep slopes to the northwest, if soakaways were to be used.

8.0 CONTAMINATION ANALYSIS

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 exceedences 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.

Screening Values - Leachability and Groundwater

8.4 In order of preference, the Environmental Quality Standards (EQS) annual averages for freshwater have been used as generic screening values for these results. Where no EQS is available, the stringent UK Drinking Water Standards (DWS) have been used, and other sources in the absence of EQS and DWS, as indicated on the groundwater screening values table in Appendix H.

Soils Analysis

8.5 18No. soil samples were issued to the UKAS accredited Derwentside Environmental Testing Services (DETS) in Consett for the suite of testing. The testing comprised:

- 11No. samples of **made ground topsoil/topsoil** from TP1, TP2, TP2B, TP3, TP4, TP5, TP8, WS1, WS6, WS7 and WS8.
- 5No. samples of **ash and clinker made ground** from TP2B (2No.), TP6, WS3 and WS5.
- 2No. samples of **granular made ground** from WS4 and WS7.

8.6 For each material, where sufficient samples allowed, any determinands with exceedences of screening values were subjected to statistical analysis in accordance with the CIEH and CL:AIRE document "Guidance on Comparing Soil Contamination Data with Critical Concentrations". The spreadsheet package from the USEPA called "Pro UCL" (Version 5.0) was used to carry out the analysis on the samples of made ground topsoil/topsoil. The dataset was tested for outliers, and after removal of the outliers, assessed for "goodness of fit" to a normal distribution. Depending on the results, Upper Confidence Level (UCL) tests were carried out by either normal, gamma, log normal, or non-parametric methods. For the other material types, statistical analysis of the results was not possible given the small number of samples obtained.

Made Ground Topsoil/Topsoil

8.7 A results summary table for determinands within the topsoil found to be above screening values is given below. It can be seen from the table that outliers are present for arsenic in the topsoil obtained from TP5, copper, lead and nickel in TP2, and several PAH determinands in WS8. When the outliers are removed from the dataset, the 95% UCL concentrations are below the relevant screening values for all determinands, with the exception of dibenzo(a,h)anthracene where the 95% UCL concentration of 1.1mg/kg above the screening level of 0.3mg/kg. With regard to dibenzo(a,h)anthracene, elevated concentrations were recorded in 8 of the 11 samples tested.

			Arsenic	Copper	Lead	Nickel	EPH (C10-C40)	Naphthalene	Phenanthrene	Fluoranthene	B(a)a	Chrysene	B(b)f	B(a)p	I (1,2,3-c,d)p	D(a,h)a
Sample Loc'n	**Depth**	**Strata Type**	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
TP01	0.10-0.20	MG Topsoil	25	57	130	14	94	< 0.1	2.1	3.8	2.2	4.6	1.3	1.7	1.7	0.4
TP02	0.10-0.20	MG Topsoil	51	6000	540	250	< 10	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TP02B	0.00-0.10	MG Topsoil	7.7	70	45	7.7	180	< 0.1	5.5	8.6	4.3	6.4	3.1	4.5	2.9	0.6
TP03	0.00-0.10	MG Topsoil	4.4	23	24	5.7	120	0.3	2.8	4.5	1.8	4.7	1.4	1.9	1.3	0.2
TP04	0.00-0.15	MG Topsoil	27	64	200	20	81	< 0.1	1.5	3.2	1.8	4.9	1	1.7	0.9	0.2
TP05	0.00-0.20	Topsoil	100	600	190	51	110	< 0.1	1.9	3.1	1.9	18	1.1	1.6	1.1	0.6
TP08	0.00-0.20	MG Topsoil	23	72	320	18	520	0.7	12	17	7.4	11	4.3	6.6	3.6	0.6
WS01	0.10-0.27	MG Topsoil	34	68	95	15	220	< 0.1	3.6	6.9	4.1	19	3.1	3.5	2.5	0.5
WS06	0.10-0.30	MG Topsoil	24	74	160	17	280	< 0.1	6.4	9.6	3.5	4.6	2.7	3.2	2.2	0.8
WS07	0.20-0.40	MG Topsoil	48	120	110	27	260	1	3.5	6.6	3.8	4.5	4.1	6.3	4.7	2
WS08	0.10-0.20	MG Topsoil	15	53	46	10	15000	310	1200	960	390	420	130	400	240	75
		Maximum	100	6000	540	250	15000	310	1200	960	390	420	130	400	240	75
		95%ile UCL^	35	355	184	26		0.7	5.9	9.1	4.3	16	3	4.4	2.9	1.1
		Screening Value	**37**	**2400**	**200**	**130**	**500**	**13***	**440***	**890***	**13***	**27***	**3.7***	**5***	**41***	**0.3***

Exceedence
Outlier (and above screening value)
Acceptable (on removal of any outliers)
* Assuming 6% organic matter
^ After removal of outliers

8.8 As EPH concentrations above 500mg/kg were recorded in samples of made ground topsoil obtained from TP8 (520mg/kg) and WS8 (15,000mg/kg), speciated analysis with aliphatic : aromatic split was undertaken on the sample with the higher concentration, and the results compared with the appropriate screening values. The further assessment

indicates that the recorded individual component concentrations are below the screening values, and therefore do not pose any risk to human health.

Granular Made Ground Including Ash & Clinker

8.9 A results summary table for determinands within the made ground found to be above screening values is given below. Statistical analysis has not been undertaken on the results due to the limited dataset and heterogeneous nature of the made ground.

			Arsenic	Lead	EPH (C10-C40)	Naphthalene	Phenanthrene	Fluoranthene	B(a)a	Chrysene	B(b)f	B(k)f	B(a)p	I(1,2,3-c,d)p	D(a,h)a
Sample Loc'n	**Depth**	**Strata Type**	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
TP02B	0.20-0.50	Ash & Clinker	16	87	270	< 0.1	1	1.4	1.2	1	0.7	1	0.7	< 0.1	< 0.1
TP02B	1.50-1.70	Ash & Clinker	17	99	89	< 0.1	0.3	0.6	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TP06	0.00-0.15	Ash & Clinker	140	170	27	< 0.1	< 0.1	0.7	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
WS03	0.20-0.40	Ash & Clinker	42	130	130	< 0.1	3.7	5.4	2.2	2.8	1.7	1.1	2.2	1.3	1.3
WS04	0.29-0.44	Granular MG	17	38	110	< 0.1	1.7	7.3	3	3.2	2.2	1.3	3	1.9	0.7
WS05	0.20-0.40	Ash & Clinker	26	390	28000	150	1600	1400	460	510	260	180	360	190	57
WS07	6.00-6.50	Granular MG	68	220	1800	1.1	16	32	39	39	24	36	67	42	16
		Maximum	140	390	28000	150	1600	1400	460	510	260	180	360	190	57
		Screening Value	**37**	**200**	**500**	**13**	**440**	**890**	**13**	**27**	**3.7**	**100**	**5**	**41**	**0.3**

Exceedence

8.10 Out of seven samples of granular made ground tested, three exhibited concentrations of arsenic greater than the screening value of 37mg/kg, with a maximum concentration of 140mg/kg recorded. Lead was found to be above the screening value in two of the seven samples, with a maximum recorded concentration of 390mg/kg. Very high PAH concentrations (including naphthalene at 150mg/kg and benzo(a)pyrene at 360mg/kg) were recorded in a sample of ash and clinker obtained from WS5 between 0.2m and 0.4m, and also high PAH concentrations were recorded in granular made ground encountered in WS7. Elevated concentrations of dibenzo(a,h)anthracene were recorded in four out of the seven samples.

8.11 As EPH concentrations above 500mg/kg were recorded in samples of made ground obtained from WS5 (28,000mg/kg) and WS7 (1,800mg/kg), speciated analysis with aliphatic : aromatic split was undertaken and the results compared with the appropriate

screening values. The further assessment indicates that the recorded TPH concentrations are below the screening values, and therefore do not pose any risk to human health.

8.12 In addition, chrysotile asbestos was detected in the sample of ash and clinker made ground obtained from WS3 between 0.2m and 0.4m. The chrysotile was present as a fibre bundle on the microscopic scale.

Water/Leachability Analysis

8.13 The laboratory test certificates for leachability analysis are presented in Appendix H. The results show that the PAH contamination within the ash and clinker, granular made ground and the made ground topsoil, has a degree of leachability, with benzo(a)pyrene recorded at a maximum of 0.13µg/l in the sample obtained from WS8, over twice the EQS of 0.05µg/l. The leachability of the identified contamination does not necessarily prevent retention of material on site, but the additional risks presented must be taken into consideration.

9.0 UPDATED RISK ASSESSMENT AND CONCEPTUAL MODEL

9.1 The conceptual model can be updated to take account of the findings of the site investigation and laboratory tests. The main refinements are given below:-

9.1.1 The majority of the site is underlain by made ground topsoil, between 0.1m and 0.6m thick. Deeper made ground (including ash and clinker) is present in the location of the former mill pond, proven to a maximum depth of 1.80m, and beyond the buried sandstone quarry face in the northwest, where greater than 10m thickness was present. Sandstone bedrock is generally present at depths of between 1m and 2m, with a completely weathered upper horizon of sand, gravel and cobbles.

9.1.2 The made ground topsoil, and topsoil where present, was found to contain elevated concentrations of arsenic, copper, lead, nickel, and individual PAHs. The highest concentrations of contaminants were recorded in a made ground topsoil sample obtained from WS8, in the area of the former mill, where respective concentrations of naphthalene and benzo(a)pyrene of 310mg/kg and 400mg/kg were recorded.

9.1.3 Elevated concentrations of contaminants (arsenic, lead and PAH) were also recorded in samples of granular made ground including ash and clinker. Very high PAH concentrations (including naphthalene at 150mg/kg and benzo(a)pyrene at 360mg/kg) were recorded in the location of WS5 in the north. Elevated concentrations of dibenzo(a,h)anthracene were recorded in four out of the seven samples tested. Chrysotile asbestos was detected in ash and clinker in the location of WS3. Of the contaminants identified, naphthalene is the only one with significant potential to migrate as a vapour.

9.2 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 sources, pathways, and receptors, applicable to the proposed development are identified on the table below. Any pathways in italics are deemed not to be viable (and the reason given in brackets).

Source - Pathway - Receptor Matrix

Contamination Sources	Pathways	Receptors
Made ground topsoil/ topsoil - arsenic, copper, lead, nickel, and PAHs Granular Made Ground (including ash and clinker) - arsenic, lead, EPH, PAH and asbestos (including high naphthalene)	• Inhalation, ingestion and dermal contact with soil and dust • Fruit and vegetable intake (with soil) • Vapour inhalation outdoor • Vapour inhalation indoor	**Humans:-** • Future occupants • Construction workers • Maintenance workers • Adjacent residents and general public
	• Migration in surface water • Migration in groundwater	**Controlled waters:-** • Groundwater (Secondary A Aquifer, no abstractions within 1km) • Surface water (nearest downslope is a canal 150m to N, and there are no sensitive abstractions within 1km)
	• Root uptake	**Vegetation:-** • Landscape areas • Private gardens
	• Migration	**Services/Utilities:-** • Potable water supply
Landfill to north - methane and carbon dioxide	• Asphyxiation • Explosive risk	• Construction/demolition workers • Future occupants • Buildings

9.3 It can be seen from the above matrix that several pathways to receptors are operative, and this may affect users of the finished development. Some form of remedial action is, therefore, considered necessary to allow residential development without excess risk.

10.0 RISK BASED ASSESSMENT OF REMEDIAL OPTIONS

10.1 The conceptual model has identified risks from the made ground topsoil from contamination by arsenic, copper, lead, nickel, and PAHs (naphthalene and benzo(a)pyrene of 310mg/kg and 400mg/kg), and also from the granular made ground including ash and clinker by arsenic, lead and PAH (including naphthalene at 150mg/kg and benzo(a)pyrene at 360mg/kg) and locally chrysotile asbestos.

10.2 There is a historic landfill located 84m to the north, but gas monitoring so far indicates no protection measures are likely to be necessary. This will be confirmed by separate letter report on completion of the monitoring.

Ingestion, Dermal Contact, and Dust Inhalation Pathways

10.3 Chemical testing indicates that much of the topsoil material present on the site is unsuitable to be retained for use in future gardens or public open space. Based on the material's high organic matter content, it will not be possible to retain the material below a cover blanket of the clean soil, or hardstanding, due to the potential for gas generation (and poor engineering qualities). Therefore, the material will require removal from site. It may be possible to reduce the quantity of the topsoil material going off site by screening to remove coarse material such as bricks, and also segregating any material that may be suitable to be retained, i.e. in the southwest where no previous industrial use has taken place.

10.4 Where made ground is present (not made ground topsoil), placement/retention below hard cover/building footprints, or provision of a cover blanket of a minimum 600mm thickness in garden landscape areas, will reduce the risk to future users of the site to acceptable levels from these pathways. This assumes a worst case double dig scenario (i.e. 2 x spade depths). As chrysotile asbestos has been identified in the made ground, the provision of a hard break layer to prevent inadvertent future exposure (due to other forms of excavation such as tree planting or construction of ponds) will also be required. However, some of the made ground will also require measures to deal with volatile content (naphthalene), and this is discussed in the sections below.

Vapour Inhalation Pathways from the Made Ground

10.5 The naphthalene concentration of 150mg/kg in WS5 at 0.2m, is well above the screening value of 13mg/kg. This material should be excluded from building footprints, and should not be within a 2m zone outside of the footprints, so that the indoor air pathway is blocked (or the relevant buildings should be provided with methane gas protection measures). The outdoor air pathway may be blocked by ensuring that any cover blanket used in garden/landscape areas is cohesive rather than granular. Under hardstanding areas, the surfacing (provided it is not porous) is likely to impede vapours sufficiently to minimal risk levels. Alternatively, the material at WS5 could be removed from site to landfill.

Surface Water and Groundwater Pathways from the Made Ground

10.6 Provision of the cover blanket noted above will block the pathway of surface water migration. Risks to groundwater are considered minimal, but can be reduced further by ensuring the cover blanket has a fines content, for example by using a gravelly clay or clayey gravel.

Risks During Construction Period

10.7 It is also necessary to consider the effects of the contamination present on the site in relation to the risks to adjacent residents, construction workers and the general public during construction. This is assessed in the following matrix.

Source	Pathway	Potential risk	Risk after employing suitable Health and Safety plan.
Contaminated fill	Inhalation	Moderate	Damping down of the site during dry periods and timely placement of contaminated fill below barriers should reduce the risk to LOW.
Contaminated fill	Ingestion	Moderate	Provision of washing facilities and a clean mess room from which work boots and overalls are excluded should reduce the risk to LOW. Site fencing will exclude access to members of the public and contaminated material will be contained within the site boundary, and placed below barriers as soon as possible.
Contaminated fill	Contact	Moderate	Education of workers to use adequate hygiene and PPE should reduce the risk to LOW.
Contaminated fill	Surface water	Moderate	Preventing surface water run off by minimising open exposure times of contaminated material and using bunds or cut off trenches as necessary will reduce the risk to LOW.

10.8 Provision of all the above measures will ensure that all the identified pathways for the contamination will be blocked.

Summary

10.9 Provided that the following remedial measures are adopted then the risks to the identified receptors are deemed acceptable for the proposed development of residential properties with private gardens.

10.9.1 Unsuitable topsoil will require removal from site. It may be possible to reduce the quantity of the topsoil material going off site by screening to remove coarse material such as bricks, for retention, and also segregating any material that may be suitable to be retained, i.e. in the southwest where no previous industrial use has taken place.

10.9.2 A 600mm thick cover blanket will be required in gardens and landscaping where made ground remains. The provision of a hard break layer below the base of the cover blanket will also be required. The cover blanket should include cohesive material (clay) to minimise downward migration of water and leachate generation.

10.9.3 Due to high naphthalene content, which can lead to volatile vapour migration, the material at WS5 should either be removed from site, or be excluded from building footprints, and should not be within a 2m zone outside of the footprints. Alternatively, the material could be left in place below buildings provided that methane gas protection measures are installed. Retention of the material below a cohesive soil cover blanket in garden/landscape areas, or below impermeable hardstanding, should also be acceptable.

10.10 The local water company are likely to require details of the contaminants present on the site, to make a judgment on any requirement for protection of buried water supply pipes from chemical attack/ingress.

10.11 A Remediation Statement is included in Appendix K. The Statement will be subject to the agreement of the Regulatory Authorities.

11.0 GEOTECHNICAL TESTING

11.1 The vast majority of materials on the site were granular. However, one sample of the clay made ground, encountered at shallow depth in TP6, was delivered to PSL in Doncaster for testing with regard to plasticity indices and moisture content. Test certificates are presented in Appendix H and a summary of the results, including Modified Plasticity Indices, is given below.

Locn.	Depth (m)	Strata	MC	LL	PL	PI	<425mm	I'p
TP6	0.15-0.30	Clay Fill	29	47	23	24	91	21.84
		No. of results	1	1	1	1		1
		Min.	29	47	23	24	91	21.84
		Max.	29	47	23	24	91	21.84

I'p	VCP
>40%	High
20% - <40%	Medium
10% - <20%	Low

MC= Moisture Content (%) LL= Liquid Limit (%) PL= Plastic Limit (%)
PI= Plasticity Index (%) I'p= Modified PI (%) VCP= NHBC Standard Chapter 4.2 Volume Change Potential

11.2 The plasticity test data shows the clay to be of intermediate plasticity, in accordance with BS 5930 (1999) "Code of Practice for Site Investigations". When the percentage retained on the 425 micron BS sieve is considered, the Modified Plasticity Index, in accordance with NHBC Standard Chapter 4.2 "Building Near Trees" is a maximum of 22%. In accordance with the Standard, this equates to Medium Volume Change Potential.

11.3 Geochemical testing (water soluble sulphate and pH) was undertaken on selected samples by DETS and Chemtest, comprising 19 samples of made ground and 7 samples of natural strata. 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	5.3	926
Natural Strata	6.1	31.5

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

11.4 The geochemical analyses show the natural strata to have low water soluble sulphate content and near neutral pH. The Aggressive Chemical Environment for Concrete (ACEC) class is AC-1. However, testing on the fill materials indicates medium water soluble sulphate content and slightly acidic pH. Based on static groundwater conditions, the (ACEC) class is therefore AC-2s. Therefore the use of FND2 designated concrete will be necessary for unreinforced buried concrete, in accordance with BS 8500-1:2006, if the existing fill materials are to be retained. If the existing made ground materials were to be removed, the use of GEN 1 designated concrete would be satisfactory for unreinforced buried concrete.

12.0 COMMENTS AND CONCLUSIONS

Site Description

12.1 At the time of the investigation, the site was a derelict piece of land, which included the remains, at ground level, of a former mill. There is a significant amount of waste material, mainly building debris, scattered across the site, associated with more recent garages and sheds, which have now been demolished.

12.2 Ground levels on the site slope downwards to the northeast with an elevation difference of approximately 15m. The site surface is generally uneven and, in the east (lower part) of the site where the mill was previously located, there are abrupt changes in ground level.

12.3 The site is bounded to the north by a heavily wooded, steeply sloping embankment, which represents the side of a former sandstone quarry. To the north of the site, terraced housing is present at the base of the quarry wall.

Site History

12.4 Ordnance Survey archive maps show that a cloth mill, including mill pond, was located on the east of the site since before 1854. Sandstone quarries were located to the northwest and north, and encroach onto the northwest of the site. Land in the northwest of the site was later reclaimed by overfilling the quarried slope. In the 1960s, small buildings (possibly sheds/garages or containers) were located in the centre of the site, after the millpond was infilled. In more recent years, all buildings have been removed, but remnant slabs and some low-lying walls remain.

Geology

12.5 The geological map shows the site to be underlain by Huddersfield White Rock (sandstone) of the Carboniferous Period, with no superficial deposits present. There are no faults shown to affect the site.

Coal Mining

12.6 The site is not within a coal mining area, and is considered stable with regard to coal mining.

Environmental Data

12.7 The strata beneath the site are classed as a Secondary A Aquifer. There are no groundwater abstractions for sensitive uses within 1km of the site.

12.8 There are no waterbodies downslope of the site within 250m. The nearest downslope surface water is the Huddersfield Narrow Canal at approximately 150m to the north, and the River Colne, a Primary River, approximately 170m to the north. There are no surface water abstractions for sensitive uses within 1km of the site.

12.9 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.

12.10 No radon protective measures are required for properties constructed on the site. However, there is one historic landfill, located 84m to the north. Gas monitoring to date has identified zero CH_4 and 3% CO_2 respectively, along with zero borehole flow rate. Risk assessment indicates that no specific gas protection of properties will be required. However, this will be confirmed by separate letter report on completion of the monitoring. Depending on the remedial solution selected for contaminated ground at WS5 (contamination is discussed in later sections below), then methane gas protection may be required for properties above the material at WS5.

Ground Conditions Encountered

12.11 The ground investigation revealed the majority of the site to be underlain by made ground topsoil, between 0.1m and 0.6m thick. Deeper made ground (including ash and clinker) is present in the location of the former millpond, proven to a maximum depth of 1.80m and beyond the buried sandstone quarry face in the northwest, where greater than 10m thickness was present. Sandstone bedrock is generally present at depths of between 1m and 2m, with a completely weathered upper horizon of sand, gravel and cobbles.

Contamination Assessment

12.12 The contamination testing revealed the made ground topsoil, and topsoil, where present, to contain elevated concentrations of arsenic, copper, lead, nickel, and PAHs. The highest concentrations of contaminants where recorded in a made ground topsoil sample obtained from WS8, in the area of the former mill, where concentrations of naphthalene and benzo(a)pyrene of 310mg/kg and 400mg/kg were recorded. Elevated arsenic, lead and PAH were also recorded in granular made ground including ash and clinker. Very high PAH concentrations (including naphthalene at 150mg/kg and benzo(a)pyrene at 360mg/kg) were recorded in the location of WS5 in the north. Chrysotile asbestos was detected in ash and clinker in the location of WS3.

12.13 The contamination risk assessment confirmed that, provided the following remedial measures are implemented, the materials present on the site are compatible with the proposed residential with gardens usage. A Remediation Statement is included in Appendix K. The Statement will be subject to the agreement of the Regulatory Authorities.

12.13.1 Unsuitable topsoil will require removal from site. It may be possible to reduce the quantity of the topsoil material going off site by screening to remove coarse material such as bricks, for retention, and also segregating any material that may be suitable to be retained, i.e. in the southwest where no previous industrial use has taken place.

12.13.2 A 600mm thick cover blanket will be required in gardens and landscaping where made ground remains. The provision of a hard break layer below the base of the cover blanket will also be required. The cover blanket should include cohesive material (clay) to minimise downward migration of water and leachate generation.

12.13.3 Due to high naphthalene content, which can lead to volatile vapour migration, the material at WS5 should either be removed from site, or be excluded from building footprints, and should not be within a 2m zone outside of the footprints. Alternatively, the material could be left in place below buildings provided that methane gas protection measures are installed. Retention of the material below a cohesive soil cover blanket in garden/landscape areas, or below impermeable hardstanding, should also be acceptable.

12.14 This report should be issued to the local water company for it to make a judgment on any requirement for protection of buried water supply pipes from chemical attack/ingress.

Foundations

12.15 The existing made ground is not considered suitable for support of foundation loads. The underlying natural sandstone rock, present on most of the site at shallow depth, is considered suitable for support of traditional strip foundations. An allowable bearing pressure of 600kN/m^2 is considered applicable. The foundation should be taken below the depth of any existing foundations or obstructions, onto natural ground. Significant slabs and substructures should be anticipated in the location of the former mill.

12.16 In the location of the former mill pond, trench fill foundations may be feasible, depending on the stability of excavation faces within the made ground. It may be possible to temporarily lower the ground levels and batter back to overcome this problem, or use piled foundations. Piles will need to be a minimum of 3m long and, therefore, may require pre-drilling on some of this area, where the made ground is less than 3m thick.

12.17 The founding strata are non plastic, and, therefore, the minimum foundation depths given in NHBC Standard Chapter 4.2 "Building Near Trees" do not apply. However, where foundations are seated on solid rock, a minimum depth of 0.45m should be adopted. If foundations are seated on natural granular material, it is recommended that a minimum foundation depth of 0.9m is adopted, to protect against fines washing subsidence in the event of a burst water supply pipe.

12.18 Construction over the edge of the former quarry should be avoided, if at all possible. For any plots constructed over the quarry, a piled foundation solution will be required. The approximate area on which this would be required is highlighted on the plan in Appendix J. Pile design will need to take into consideration the potential for lateral loading in the event of slope instability. Piles would also need to be pre-drilled/bored to ensure they were not seated on boulders or sloping faces.

Slope Stability

12.19 A detailed slope stability assessment is beyond the scope of this report. However, based on visual assessment only, it is likely that there is currently a factor of safety against failure of just over 1.0 (i.e. the slope is stable, and probably close to its natural angle of repose). However, for situations where development is taking place and there would be a danger to people or property if the slope was to fail, a factor of safety of 1.3 is usually required. The easiest way to achieve this would be to exclude any engineered structures such as roads and buildings from the top of the slope (back to a line southeast of the area which is indicated to require piling on the plan in Appendix J). Loading of the top of the slope by raising levels would also need to be avoided.

12.20 If development is intended on the hatched area, detailed stability assessment and probable engineering works to improve stability of the slope are likely to be required. There are many ways of improving stability, such as soil nailing, slope reinforcement, and retaining structures, but it should be noted that such measures may be required for the whole slope, not just the section immediately adjacent to the site.

Excavations

12.21 It is likely that excavations into the natural strata will remain stable in the short term, requiring minimal trench support, in accordance with the prevailing statutory guidance. However, instability may be anticipated within the made ground present on the site, such as in the former mill pond area.

12.22 Groundwater is not expected in typical foundation excavations. Any groundwater encountered should be controllable by pumping from an artificial sump.

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

Chemical Precautions

12.24 The Aggressive Chemical Environment for Concrete (ACEC) class is AC-2s. Therefore the use of FND2 designated concrete will be necessary for unreinforced buried concrete, in accordance with BS 8500-1:2006, if the existing fill materials are to be retained. If the existing made ground materials were to be removed, the use of GEN 1 designated concrete would be satisfactory for unreinforced buried concrete.

Road Pavement Construction

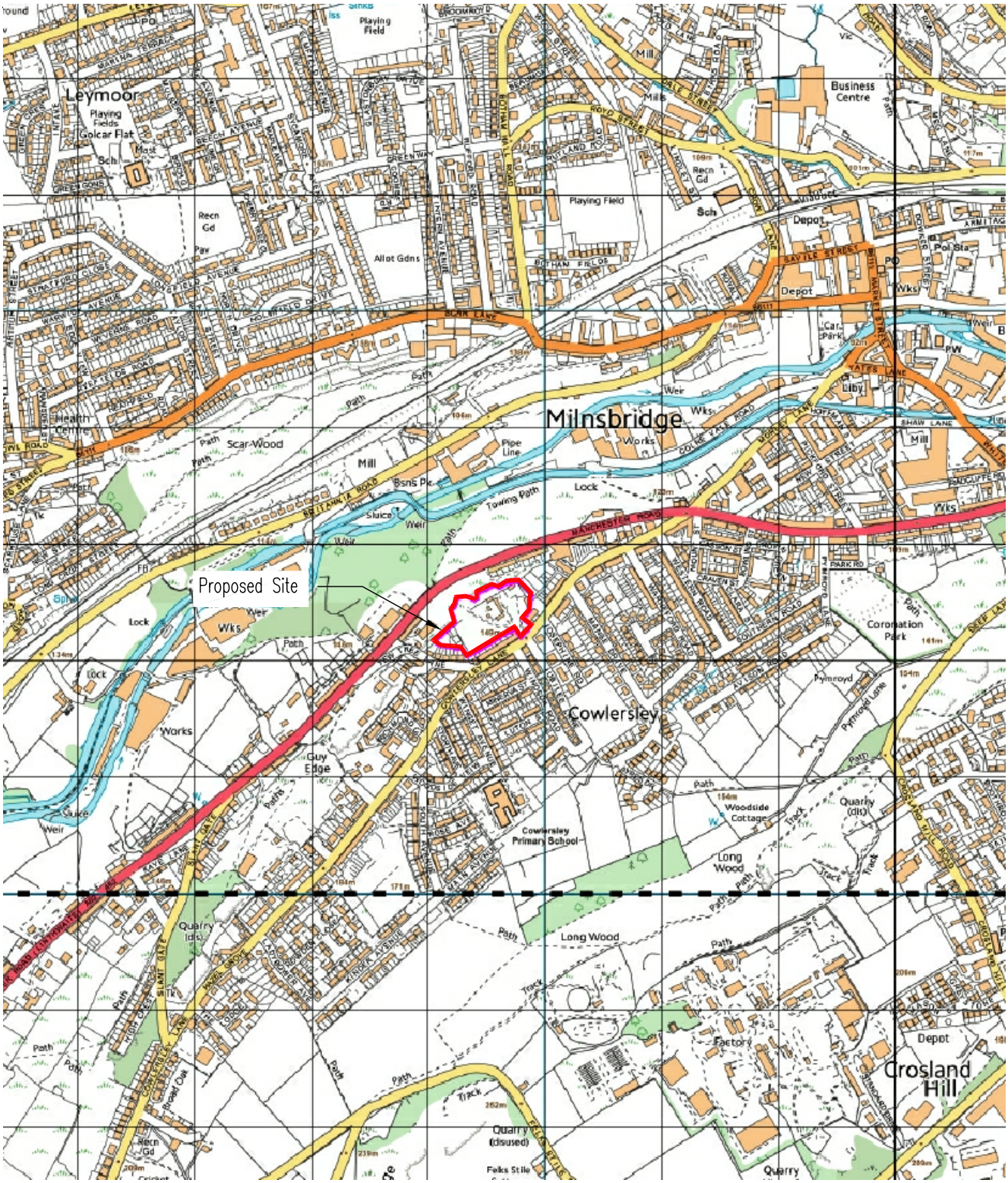
12.25 For any areas of road pavement, including parking areas, the formation is likely to comprise the completely weathered sandstone rock (sand, gravel or cobbles). Below any obvious soft/loose spots, and at equilibrium moisture content, a design California Bearing Ratio (CBR) value of 20% is considered applicable. Formation of roads on the existing made ground will not be acceptable and the use of granular capping material may be required under pavement construction, subject to levels. Where ground has been overfilled beyond the quarry face, road and car park construction should be avoided.

Soakaways

12.26 Infiltration rates range from too low for soakaways, to marginal, so that any soakaway designed for the highest infiltration rate of 1.37 x 10^{-5} m/s likely to be so large as to be impractical. There is also the potential problem of re-emergence of water on the steep slopes to the northwest, if soakaways were to be used. The use of soakaways for disposal of surface water drainage is, therefore, unlikely to be feasible on the site.

A P P E N D I X A

SITE LOCATION PLAN AND SITE PLAN



Rev	By	Date	Amendment	Chk
/	DAM	.	Issued for approval	JR

Title

SITE LOCATION PLAN

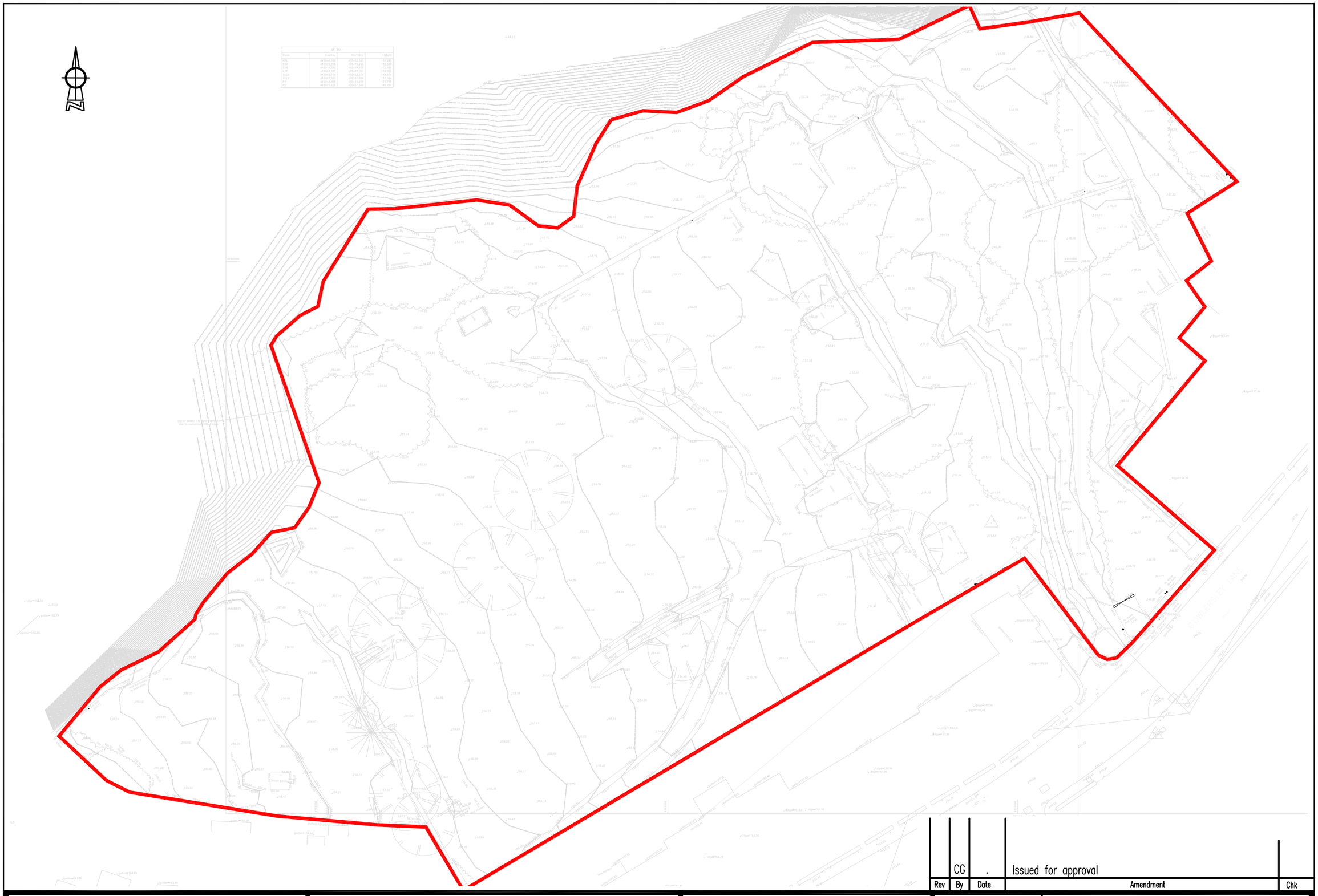
Project/Client

COWLERSLEY LANE, COWLERSLEY
MARK OLIVER HOMES (YORKSHIRE) LTD

ARP GEOTECHNICAL LTD
CHARTERED CONSULTING ENGINEERS
Northwest House • 5/6 Northwest Business Park
Servia Hill • Leeds LS6 2QH
Telephone : 0113 245 8498 • Fax : 0113 244 3864
E-Mail : leeds@arpassociates.co.uk

Scale	Drawn
NTS @ A4	DAM
Date	**Chk.**
OCT 15	JR

Drg. No.	Rev
MOY/02/SI.01	/



Rev	By	Date	Amendment	Chk
	CG	.	Issued for approval	

Project
COWLERSLEY LANE, COWLERSLEY

Client
MARK OLIVER HOMES (YORKSHIRE)

Title
SITE PLAN

ARP GEOTECHNICAL LTD
CHARTERED CONSULTING ENGINEERS
Northwest House • 5/6 Northwest Business Park • Servia Hill • Leeds LS6 2QH
Tel: 0113 2458498 • Fax: 0113 2443864 • E-Mail: Leeds@arpassociates.co.uk

Date NOV 15
Scale 1:500 @ A3
Drawn CG
Chk. JR
No MOY/02/SI.02
Rev /

A P P E N D I X B

ORDNANCE SURVEY ARCHIVE MAPS

Historical Mapping Legends

Ordnance Survey County Series 1:10,560

Gravel Pit
Sand Pit
Other Pits
Quarry
Shingle
Orchard
Osiers
Reeds
Marsh
Mixed Wood
Deciduous
Brushwood
Fir
Furze
Rough Pasture
Arrow denotes flow of water
Trigonometrical Station
Site of Antiquities
Bench Mark
Pump, Guide Post, Signal Post
Well, Spring, Boundary Post
·285 Surface Level
Sketched Contour
Instrumental Contour
Main Roads
Fenced
Un-Fenced
Minor Roads
Fenced
Un-Fenced
Sunken Road
Raised Road
Road over Railway
Railway over River
Railway over Road
Level Crossing
Road over River or Canal
Road over Stream
Road over Stream
County Boundary (Geographical)
County & Civil Parish Boundary
Administrative County & Civil Parish Boundary
Co. Boro. Bdy. County Borough Boundary (England)
Co. Burgh Bdy. County Burgh Boundary (Scotland)
R.D. Bdy. Rural District Boundary
Civil Parish Boundary

Ordnance Survey Plan 1:10,000

Chalk Pit, Clay Pit or Quarry
Gravel Pit
Sand Pit
Disused Pit or Quarry
Refuse or Slag Heap
Lake, Loch or Pond
Dunes
Boulders
Coniferous Trees
Non-Coniferous Trees
Orchard
Scrub
Coppice
Bracken
Heath
Rough Grassland
Marsh
Reeds
Saltings
Building
Direction of Flow of Water
Shingle
Sand
Glasshouse
Pylon
Pylon
Electricity Transmission Line
Sloping Masonry
Cutting
Embankment
Standard Gauge Multiple Track
Road Under
Road Over
Level Crossing
Foot Bridge
Standard Gauge Single Track
Siding, Tramway or Mineral Line
Narrow Gauge
Geographical County
Administrative County, County Borough or County of City
Municipal Borough, Urban or Rural District, Burgh or District Council
Borough, Burgh or County Constituency
Shown only when not coincident with other boundaries
Civil Parish
Shown alternately when coincidence of boundaries occurs

BP, BS	Boundary Post or Stone	Pol Sta	Police Station
Ch	Church	PO	Post Office
CH	Club House	PC	Public Convenience
F E Sta	Fire Engine Station	PH	Public House
FB	Foot Bridge	SB	Signal Box
Fn	Fountain	Spr	Spring
GP	Guide Post	TCB	Telephone Call Box
MP	Mile Post	TCP	Telephone Call Post
MS	Mile Stone	W	Well

1:10,000 Raster Mapping

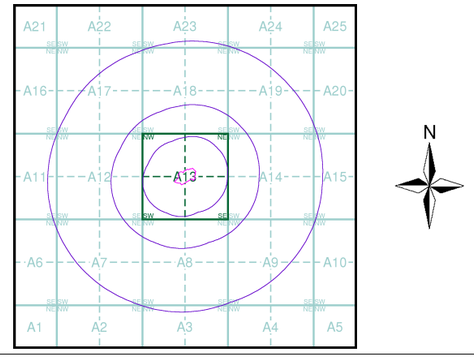
Gravel Pit
Refuse tip or slag heap
Rock
Rock (scattered)
Boulders
Boulders (scattered)
Shingle
Mud
Sand
Sand Pit
Slopes
Top of cliff
General detail
Underground detail
Overhead detail
Narrow gauge railway
Multi-track railway
Single track railway
County boundary (England only)
Civil, parish or community boundary
District, Unitary, Metropolitan, London Borough boundary
Constituency boundary
Area of wooded vegetation
Non-coniferous trees
Non-coniferous trees (scattered)
Coniferous trees
Coniferous trees (scattered)
Positioned tree
Orchard
Coppice or Osiers
Rough Grassland
Heath
Scrub
Marsh, Salt Marsh or Reeds
Water feature
Flow arrows
MHW(S) Mean high water (springs)
MLW(S) Mean low water (springs)
Telephone line (where shown)
Electricity transmission line (with poles)
BM 123.45 m Bench mark (where shown)
Triangulation station
Point feature (e.g. Guide Post or Mile Stone)
Pylon, flare stack or lighting tower
Site of (antiquity)
Glasshouse
General Building
Important Building

ARP GEOTECHNICAL LIMITED
CHARTERED CONSULTING ENGINEERS

Historical Mapping & Photography included:

Mapping Type	Scale	Date	Pg
Yorkshire	1:10,560	1854	3
Yorkshire	1:10,560	1894	4
Yorkshire	1:10,560	1908	5
Yorkshire	1:10,560	1930	6
Yorkshire	1:10,560	1938	7
Yorkshire	1:10,560	1948	8
Ordnance Survey Plan	1:10,000	1956	9
Ordnance Survey Plan	1:10,000	1966 - 1969	10
Ordnance Survey Plan	1:10,000	1978 - 1979	11
Ordnance Survey Plan	1:10,000	1980 - 1987	12
Huddersfield	1:10,000	1984	13
Ordnance Survey Plan	1:10,000	1993	14
VectorMap Local	1:10,000	2015	15

Historical Map - Slice A



Order Details

Order Number: 72526992_1_1
Customer Ref: MOY/02
National Grid Reference: 410900, 415470
Slice: A
Site Area (Ha): 1.23
Search Buffer (m): 1000

Site Details

Land at, Cowlersley Lane, Linthwaite, HUDDERSFIELD

Landmark Information Group
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk

Russian Military Mapping Legends

1:5,000 and 1:10,000 mapping

a. Not drawn to scale b. Drawn to scale

- Government and Administrative Buildings
- Military and Industrial Buildings
- Military and Communication Areas
- Subway Entrance
- Fireproof Building
- Prominent Fireproof Building
- Non-fireproof Building
- Non-fireproof Building (non-dwelling)
- Factory, mill, and flour mill, with chimneys
- Factory, mill, and flour mill, without chimneys
- Power Station, drawn to scale
- Hydroelectric Power Station
- Radio Station, drawn to scale
- Telephone Station, drawn to scale
- Abandoned Open-pit Mine or Quarry
- Open-pit Salt Mine
- Pit
- Oil Deposit or Well
- Oil Seepage
- Tailings Pile
- Fuel Storage Tanks
- Natural Gas Tank
- Bench Mark
- Drill Hole
- Burial Mound
- Triangulation Point on Burial Mound
- Single-track Railroad
- Double-track Railroad and Station Building
- Coniferous Forest
- Deciduous Forest
- Mixed Forest
- Lawns
- Citrus Orchard
- Wet Ground
- Scattered Vegetation

243,8 — Values for prominent elevations

186.0 — Numbers for spot elevations, depth soundings, contour lines, etc.

0,2 — Velocity of the current, width of river bed, depth of river

Fractional terms: length and capacity of bridges; depth of fords and condition of the river bottom; height of forest and the diameter of trees

Russian Alphabet (For reference and phonetic interpretation of map text)

А а (A)	З з (Z)	П п (P)	Ч ч (CH)
Б б (B)	И и (I)	Р р (R)	Ш ш (SH)
В в (V)	Й й (Y)	С с (S)	Щ щ (SHCH)
Г г (G)	К к (K)	Т т (T)	ъ (–)
Д д (D)	Л л (L)	У у (U)	ы (Y)
Е е (E)	М м (M)	Ф ф (F)	ь (')
Ё ё (YO)	Н н (N)	Х х (KH)	Э э (E)
Ж ж (ZH)	О о (O)	Ц ц (TS)	Ю ю (YU or IU)
			Я я (YA or IA)

1:25,000 mapping

a. Not drawn to scale b. Drawn to scale

- Government and Administrative Buildings
- Military and Industrial Buildings
- Military and Communication Areas
- Subway Entrance
- Partly Demolished Buildings
- Demolished Buildings
- Built-Up Area with Fireproof Buildings Predominant
- Built-Up Area with Non-Fireproof Buildings Predominant
- Individual Fireproof Building
- Prominent Industrial Building
- Individual Dwelling, Fireproof
- Ruins of an Individual Dwelling
- Factory or Mill Chimney
- Factory or Mill with Chimney
- Factory or Mill without Chimney
- Mine or Open Pit Mine
- Operating Shaft or Mine
- Non-Operating Shaft or Mine
- Salt Mine
- Tailings Pile
- Pit
- Stone Quarry
- Gas Pump or Service Station
- Fuel Storage or Natural Gas Tank
- Oil or Natural Gas Derrick
- Small Hydroelectric Power Station
- Power Station
- Transformer Station
- Cemetery
- Burial Mound (height in metres)
- Triangulation Point on Burial Mound
- Triangulation Point
- Bench Mark
- Bench Mark (monumented)
- Telegraph Office
- Telephone Station
- Radio Station
- Radio Tower
- Airfield or Seaplane Base
- Landing Strip
- Main Highway
- Highway under Construction
- Improved Dirt Road (former truck road)
- Double-track Railroad with First Class Station
- Dismantled Railroad
- Railroad Under Construction
- Shore Embankment
- River or Ditch with Embankment
- Direction and velocity of current
- Well
- Water Reservoir or Rain Water Pit
- Spring
- Isobath with value
- Heavy (Index) Contour Line
- Contour Line and Value
- Half Contour Line
- Spot Elevation Value
- Coniferous
- Deciduous
- Mixed
- Scrub

Key to Numbers on Mapping

SE11NW_Huddersfield

No.	Description
57	Factories (Use Unknown)

ARP GEOTECHNICAL LIMITED
CHARTERED CONSULTING ENGINEERS

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Yorkshire	1:10,560	1854	3
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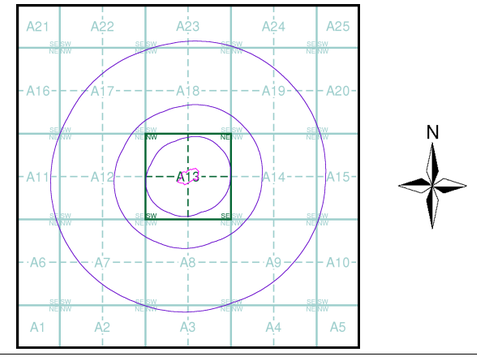
VectorMap Local	1:10,000	2015	15

Russian Map - Slice A



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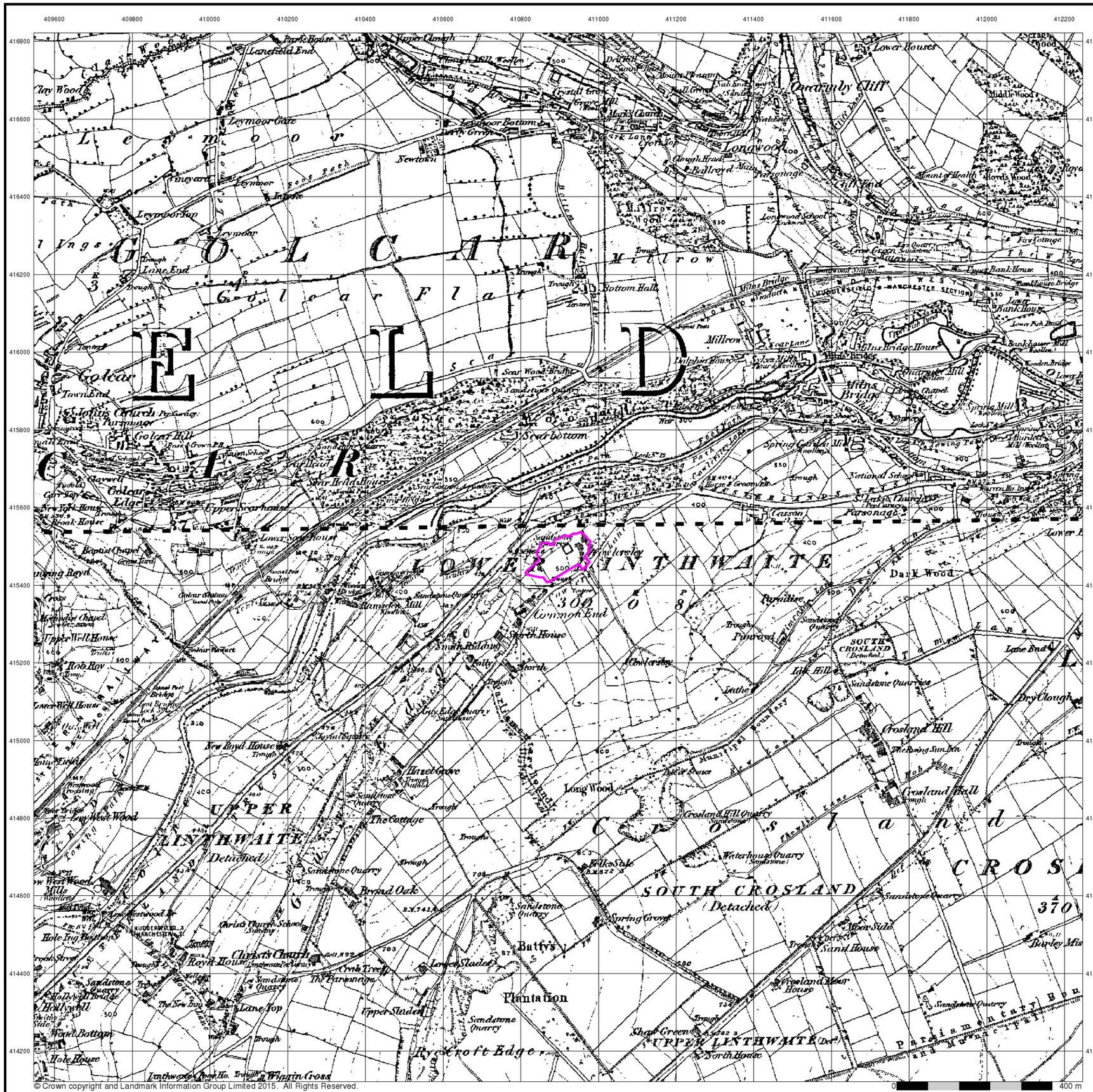
Search Buffer (m): 1000

Site Details

Land at, Cowlersley Lane, Linthwaite, HUDDERSFIELD



ARP GEOTECHNICAL LIMITED
CHARTERED CONSULTING ENGINEERS

Yorkshire

Published 1854

Source map scale - 1:10,560

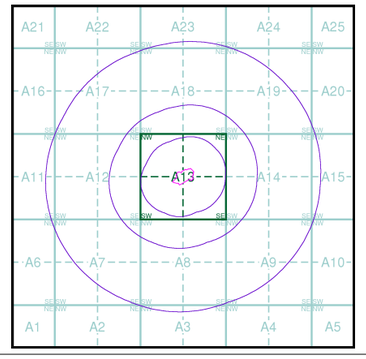
The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas; these maps were used to update the 1:10,560 maps. The published date given therefore is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas. In the late 1940`s, a Provisional Edition was produced, which updated the 1:10,560 mapping from a number of sources. The maps appear unfinished - with all military camps and other strategic sites removed. These maps were initially overprinted with the National Grid. In 1970, the first 1:10,000 maps were produced using the Transverse Mercator Projection. The revision process continued until recently, with new editions appearing every 10 years or so for urban areas.

Map Name(s) and Date(s)

24600
1854
1:10,560

26000
1854
1:10,560

Historical Map - Slice A



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