Geo-Environmental Ground Investigation Report

Darwen Inks Works Redevelopment

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1.0 INTRODUCTION

Fairhurst were appointed by SITA UK (The Client) to undertake a geo-environmental investigation and interpretation for the proposed Darwen Ink Works Redevelopment in Lower Eccleshill Road, Darwen.

The purpose of the investigation was to provide a geotechnical and environmental assessment of the existing Darwen Ink Works warehouse building with specific reference to the environmental and geotechnical constraints anticipated to affect the proposed redevelopment works.

This report details and interprets the results of the ground investigation undertaken. Comments are included with respect to the ground and groundwater conditions with regard to both geotechnical and chemical conditions. Recommendations are given for remedial measures and where appropriate foundation options.

As at the time of compiling this report, two no. gas monitoring visits are outstanding and will be carried out, subsequent to which this report will be updated.

2.0 DEVELOPMENT PROPOSALS

The proposed development layout is shown for the Darwen Ink Works building on Atkins Drawing No. 5085520/C/P/_/110, Appendix 1 and includes:

- Reconfiguration of existing building into a material recycling facility including a waste reception, material recycling facility plant, conveyor trenches storage area and office area. This involves the installation of bases for new machinery.
- Staff and visitor car parking with access roads and associated infrastructure in the south.

3.0 SOURCES OF INFORMATION

The following information has been utilised throughout this interpretative report:

- Phase 1 - Desk Study Geo-Environmental Report for Eccleshill Road, Darwen, Blackburn. Report Reference r001il. Prepared by Entec UK and dated September 2010 (Ref.1).
- Factual Report on Site Investigation of Darwen Ink Works, Lower Ecclehill Blackburn. Report Ref. CCG-C-11-6459. Prepared by CC Geotechnical Limited and dated December 2011 (Ref. 2).

4.0 SITE DESCRIPTION

4.1 Site Location and Description

The site is located at approximate National Grid Reference SD 695 239, approximately 4 miles south of Blackburn city centre as indicated on Drawing No. 92064/9001, Appendix 1.

The current layout of the site is presented in Drawing No. 92064/9002, Appendix 1. The site is an existing warehouse with adjacent hardstanding and vegetated areas around the building. There is an existing electric substation building located to the north of the warehouse. Demolition works have recently being carried out within the main site with two building remaining in place, Springfield House (SITA Office) and the Darwen Ink Production facility/ warehouse.

The level around the existing warehouse building is recorded from ground investigation to be at an elevation varying approximately between 150 to 151m AOD.

Existing adjacent land uses within the immediate vicinity of to the site include:

North

- Woodland containing minor watercourse running north and the M65 embankment.

South

- Site access point off Lower Eccleshill road.

East

- Agricultural fields.

West

- Railway Line.

5.0 DESIGN OF GROUND INVESTIGATION

5.1 Investigation Design Objectives

The ground investigation was designed in accordance with BS 5930: 1999+A2:2010 Code of Practice for Site Investigations and BS 10175 (2011): Investigation of Potentially Contaminated Sites. The aim of the investigation of the site was to provide information for the design of the proposed site redevelopment and to specifically target the environmental and geotechnical issues identified by the Entec 2010 desk study.

In addition, seven boreholes were installed around the building for hydrogeological assessment of the site area. The locations of these holes were determined by others, however the information was used in the creation of the ground model.

The following environmental and geotechnical constraints to the development were identified in the Entec 2010 desk study and required intrusive investigation and interpretation.

Environmental Considerations

- Identify the chemical conditions of the existing made ground, natural superficial deposits present beneath the building and in the groundwater.
- Confirmation of the gas and vapour regime at the site

Geotechnical Considerations

- Determine the stratification and geotechnical properties of superficial natural deposits in relation to the proposed redevelopment.
- Determine the geotechnical parameters for the design of new foundations and slabs within the existing building.
- Determine the groundwater conditions beneath the site.

Chemical testing was scheduled to determine environmental risks and undertaken in an MCERTs accredited laboratory on soil and groundwater samples.

5.2 Investigation Works Undertaken

The site investigation was undertaken by CC Geotechnical Ltd (CCG) overseen by Fairhurst, between November and December 2011. The works comprised the following:

- 7 No. cable percussive boreholes (BH 01 to BH07), including Standard Penetration Tests (SPTs), to a maximum depth of 10.0 metres below ground level (140.55m AOD).

These boreholes were located the Client for hydrogeological assessment purposes but have been interpreted as part of this report.

- 4 No. dynamic windowless sampling boreholes bored within the superficial deposits to a maximum depth of 6.0 metres below ground level (144.75m AOD).
- Installation of gas and groundwater monitoring standpipes in all the cable percussive exploratory holes and all dynamic windowless sampling holes.
- 5 No. trial pits (TP 1 to TP 5) excavated to a maximum depth of 3.20 mbgl within the existing building, in the area of the proposed car park and access roads and adjacent to the building.
- 2 No. Hand excavated pits to expose existing foundations of the existing building.
- 5 No. concrete cores within the internal concrete floor slab and external areas of hardstanding.
- Monitoring of soil gas and groundwater levels.
- A programme of geotechnical and chemical testing of samples recovered.

The locations of the exploratory holes are shown on Fairhurst Drawing No. 92064/9002, Appendix 1 and the records of the ground investigation are presented in CC Geotechnical Limited, Factual Ground Investigation Report, Ref. CCG-C-11-6459 and dated January 2012 (Ref. 2).

5.3 In-Situ Testing

Standard penetration tests (SPTs) were carried out in the boreholes to provide an indication on the relative density of the granular soils encountered and the shear strength of cohesive soils. The results of the insitu testing are recorded on the borehole records which are presented in CC Geotechnical Limited Factual Report (Ref. 2).

5.4 Monitoring Works Undertaken

11 No. groundwater monitoring standpipes were installed in BH 01 to BH 07 and WS01 to WS04.

The standpipes in these exploratory boreholes were installed with response zones placed alternately in the made ground and superficial deposits to monitor groundwater levels and soil gas.

At the time of reporting, the standpipes have been monitored on four occasions between 23rd November and 3rd January 2012. At the time of compiling this report two monitoring visits are outstanding, this report will be updated when the result become available. Monitoring included the recording of the concentrations of carbon dioxide, methane, oxygen, hydrogen sulphide, volatile organic compound together with gas flow rate and atmospheric pressure.

A summary of the ground gas/ vapour monitoring is presented in Appendix 2. The results of the gas and groundwater monitoring are presented in CC Geotechnical Limited Factual Report (Ref. 2).

5.5 Laboratory Testing

5.5.1 Environmental Soil Testing

The chemical analysis of soil and water samples obtained from the site was designed to test for contaminants of concern appropriate to the preliminary conceptual site model:

- Contamination in the made ground, natural superficial deposits beneath the existing warehouse building and its immediate surroundings.
- Determination of the chemical characteristics of the groundwater beneath the proposed development area.

The following samples tested were scheduled to determine the lateral and vertical distribution of contaminants:

Contamination Source	Spatial Distribution	Soil Type	Testing		
			Exploratory Holes		Determinants
			No.	Depth range of samples taken	
Made Ground	Existing Warehouse Building and Surroundings	Made Ground	All	0.40 – 3.00m bgl	General Suite, Speciated PAH and Speciated TPH.
Natural Sand	Existing Warehouse Building	Sand	BH4	3.50m bgl	General Suite, Speciated PAH and Speciated TPH.
Electrical Substation	North of the warehouse	Made ground	TP2	0.50 – 1.50m bgl	General Suite, Speciated PAH, Speciated TPH and PCB.
Groundwater	Existing Warehouse Building and Surroundings	Groundwater	BH01 – BH06, WS1	1.68 – 4.44m bgl	General Suite, Ammonia, Speciated PAH and Speciated TPH.

N.B. General suite comprised heavy metals including arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, zinc, inorganics including boron, free and complex cyanide, thiocyanate, sulphide, total sulphate, water soluble sulphate, sulphur and pH, and organics including phenol.

5.5.2 Geotechnical Testing

A programme of geotechnical testing was designed and scheduled to address the main properties of the soil deposits. The soil testing undertaken to provide the geotechnical design information required, specific to the proposed development, is listed below:

- Natural moisture content.
- Atterberg Limits.
- Particle Size Distribution Test (PSD) – wet sieve method and hydrometer sedimentation

- Unconsolidated undrained triaxial compression tests.
- Oedometer consolidation testing.
- California Bearing Ratio Test (CBR)
- pH and sulphate testing.

6.0 QUALITY ASSURANCE AND QUALITY CONTROL

6.1 General

The quality assurance / control requirements for the ground investigation were prepared by Fairhurst.

6.2 Responsibilities

The Contractor was responsible for overall implementation and monitoring of the quality assurance during sampling, field investigations and laboratory analysis. Monitoring of the quality of the investigation was also undertaken by Fairhurst during the duration of the site works.

6.3 Laboratory Testing

The geotechnical tests undertaken on soils were required to be UKAS accredited and undertaken to BS1377: 1990. In addition, chemical testing was to be undertaken to by an MCERTS accredited laboratory.

7.0 GROUND CONDITIONS

A summary of the ground conditions encountered as part of the ground investigation is described below and presented in Drawing No. 92064/9004 & 9005, Appendix 1. The cross-section location plan is presented in Drawing No. 92064/9003, Appendix 1.

The ground condition is considered in two sections as listed below with the affected exploratory holes for each section listed.

1. Darwen Ink Works Building: BH4, WS1 – WS4, RC1 – RC3 & TP1
2. External Area: BH1 – BH3, BH5 – BH7, TP2 – TP5 & RC4 – RC5

7.1 Darwen Ink Works Building

The ground conditions determined within the footprint of the warehouse building comprised reinforced concrete slab from ground level to between 0.20m bgl and 0.35m bgl (150.55 to 150.40m AOD). Beneath the reinforced concrete slab, made ground was encountered with thickness varying between 0.80m bgl (149.93m AOD) and 2.80m bgl (147.95m AOD). Underlying the made ground beneath the building was mainly silty clay with isolated occurrences of clayey silt to a proved depth of 10.00 mbgl (140.75m AOD).

7.1.1 Reinforced Concrete Slab

Reinforced concrete slab was encountered from ground level, recorded up to 0.33m thick (generally the thickness was 0.20m). Concrete coring carried out at all the exploratory hole locations within the building proved a slab thickness of 0.20m except for one isolated location where a thickness of 0.33m was recorded. These locations are identified to be pits which have recently been infilled with concrete.

7.1.2 Made Ground

Made ground comprising of sandy gravel and gravely sand sub base and, silty gravel, gravelly sand, and silty clay were encountered underlying the reinforced concrete slab. The made ground was encountered from 0.20m bgl to depth varying between 0.80m bgl (149.93m AOD) and 2.80m bgl (147.95m AOD).

A plastic membrane was noted within the made ground at shallow depth in one of the exploratory holes (WS3) located within the central area of the warehouse building. This is likely to be a damp proof membrane laid below the slab.

A layer of gravel identified as slag was encountered in WS3 at depth of between 2.35m (148.41m AOD) and 2.60m bgl (148.16m AOD).

7.1.3 Clays and Silts

Underlying the made ground beneath the existing building, silty clay was encountered at between 2.10m bgl and 2.80m bgl (148.65 to 147.95m AOD) and proven to a depth of 10.00 mbgl (140.75m AOD) beneath majority of the area. An isolated layer of clayey silt with a thickness of 1.55m was encountered in WS2 located within the building to the west, to a depth of 3.75m bgl (147.00m AOD).

The silty clay, comprised predominantly firm and stiff (but locally soft to firm) grey brown and brown, slightly sandy and sandy, slightly gravelly and gravelly silty clay. The clayey silt was described as firm grey sandy slightly gravelly clayey silt.

7.2 External Areas

The ground conditions determined comprised topsoil and made ground from ground level to between 0.10 mbgl and 1.30 mbgl (150.56 to 149.47m AOD) underlain by a sequence of sands and gravels, silts and clays to a depth greater than 10.00m bgl (140.40m AOD).

7.2.1 Topsoil / Made Ground

Grassed topsoil was observed from ground level to between 0.10 mbgl and 0.20 mbgl (150.56m to 150.35m AOD).

Made ground comprising of concrete hardstanding (BH3 and BH7) located to the west and south east of the building and isolated occurrence of sand (BH6) at the south west of the building was also observed from ground level to depth of between 0.20m and 1.30m bgl (150.55 to 149.47m AOD)

Made ground comprising of sandy gravel sub base, silty clay and silty gravel were encountered across the external area of the proposed development area from 0.10m bgl to depth varying between 0.6m bgl and 3.9m bgl (150.16m AOD to 146.50m AOD)

7.2.2 Clays and Silts

Underlying the topsoil, concrete and isolated occurrence of made ground at ground surface, silty clay was encountered between 0.60m bgl and 3.90m bgl (150.16m to 146.50m AOD) and proven to a depth of up to 10.00m bgl (140.40m AOD) beneath majority of the external area. It was not encountered in BH5 located to the west of the site where sands and gravel was encountered to depth. The silty clay comprised predominantly firm and stiff (but locally soft) grey brown and light brown, slightly sandy and sandy, slightly gravelly and gravelly silty clay with occasional sand bands and lenses.

7.2.3 Sands and Gravels

Beneath the silty clay, a layer of sands and gravel was encountered to the east of the existing warehouse building. This layer was encountered at 4.60m bgl (146.16m AOD) and proven to the base of the hole at 10.0m bgl (140.76m AOD). The gravel is described as fine, medium and coarse subrounded to rounded and of varying lithology.

7.3 Solid Geology

No borehole taken to depth encountered solid geology which was reported to be Lower Westphalian Measures and Pennine Lower Coal Measures which are mainly productive coal measures comprising mudstone, sandstone and siltstones.

7.4 Groundwater Conditions

During the ground investigation, groundwater strikes / seepages were recorded as detailed below:

Groundwater Seepages Recorded During Drilling		
Borehole	Depth of Seepage / Strike	Strata Encountered
BH 03	Groundwater Seepage at 3.90m bgl (146.50m AOD)	Silty Clay
BH 04	Groundwater Strike at 8.20m bgl (142.45m AOD)	Silty Clay
BH 05	Groundwater Strike at 4.30m bgl (146.46 m AOD). Rising to 4.10m bgl (146.66 m AOD) after 20 mins	Silty Clay

The results of monitoring groundwater levels undertaken between 23rd November 2011 and 3rd January 2012 within the standpipes installed in all the boreholes and window sample holes are presented in Appendix 2 and can be summarised as:

Groundwater Monitoring Records				
Borehole	Response Zone	Water Level ranges	Water level Elevation	Strata
BH01	0.40 – 10.00	4.32 – 5.66	146.24 – 144.9	Silty clay
BH02	1.0 – 10.00	3.55 – 4.02	147 – 146.53	Clayey silt
BH 03	0.50 – 3.90	2.51 – 3.37	147.89 – 147.03	Made ground
BH 04	2.80 – 10.00	4.44 – 5.00	146.31 – 145.75	Silty clay
BH05	2.80 – 10.00	1.68 – 1.72	149.08 – 149.04	Made ground
BH06	0.50 – 2.60	2.38 – 2.43	148.39 – 148.34	Made ground
BH07	0.60 – 10.00	1.49 – 1.74	149.27 – 149.02	Silty Clay
WS01	2.80 – 5.0	2.31 – 2.41	148.45 – 148.35	Made ground
WS02	0.50 – 2.60	0.52 – 0.56	150.23 – 150.19	Made ground
WS03	0.50 – 2.90	DRY	-	
WS04	0.50 – 4.00	DRY	-	

The results of the groundwater monitoring (Appendix 2) and observations during the ground investigation indicate the following groundwater regime beneath the site:

- A superficial groundwater table within the silty clay made ground, with levels between 150.23m AOD and 148.35m AOD exist beneath the development area. Within the natural silty clay this was encountered in the external building area at levels between 149.27m AOD and 145.75m AOD.

- An assessment of the monitoring records show a substantial rise in the groundwater level from levels identified during drilling when compared with the levels from monitoring. It is considered that the upper silty clay strata is acting as a confining layer for a water bearing lower silty clay layer.

8.0 MATERIAL PROPERTIES

8.1 Chemical Properties

The following assessment is provided in relation to the main environmental concerns from the recent ground investigation (Section 7.1). This is based on the inspection for visual / olfactory evidence of contamination during the ground investigation, the results of chemical testing undertaken on soil samples and gas concentrations recorded during site monitoring.

8.1.1 Soils – Visual/Olfactory Evidence of Contamination

The results of the investigation indicated the following visual/olfactory evidence of contamination:

Topsoil

- No visual / olfactory evidence of contamination was observed within topsoil materials.

General Made Ground

- A thin layer of slag was encountered at depth in WS3 located within the central area of the warehouse building. This is considered to be insignificant as it occurs at depth of 2.35m bgl and will not be disturbed by the proposed development. As such it is not considered further.

Clays and Silts

- No visual / olfactory evidence of contamination was observed within the clays and silts materials.

Sands and gravels

- No visual / olfactory evidence of contamination associated with the sands and gravels deposits.

Electric Substation

- No visual / olfactory evidence of contamination was identified near the electrical substation.

8.1.2 Soils – Total Concentrations

Chemical testing to confirm the chemical characteristics of made ground and clays was undertaken on the following:

- Twenty one samples of the made ground; (nine samples within the building footprint and twelve samples in external areas)
- Two samples of the silty clay; (Two samples within the building footprint)

The results of this testing are summarised in terms of the maximum and minimum values and presented in Appendix 3.

Made Ground

The results of chemical testing undertaken on made ground materials within the nine samples from the footprint of the existing warehouse building indicated the following:

- Elevated concentrations of heavy metals, inorganics, organics and hydrocarbons were recorded above detection limits within the general made ground.

The results of chemical testing undertaken on made ground materials within the nine samples from the external area indicated the following:

- Elevated concentrations of heavy metals, inorganics, organics and hydrocarbons were recorded above detection limits within the general made ground.

Natural soils

The results of chemical testing undertaken on silty clay materials within the two samples of the natural soils within the footprint of the building indicated the following:

- Elevated concentrations of heavy metals, inorganics, organics and hydrocarbons were recorded above detection limits within the natural soils.

Electric Substation

The results of chemical testing undertaken on made ground materials within the two samples from adjacent the electric substation indicated the following:

- Elevated concentrations of heavy metals, inorganics, and organics were recorded above detection limits within the made ground.
- No elevated concentration of Poly Chlorinated Biphenyl (PCB) was recorded above detection limit within one sample tested.

8.1.3 Soils – Asbestos

Testing of one soil sample of made ground for asbestos have not identified the presence of asbestos.

8.1.4 Groundwater

Chemical testing was undertaken on water samples from the superficial waters in the silty clay deposit beneath the site. The results of the chemical testing have been assessed to determine the main contaminants recorded at concentrations significantly above the detection limits across the area. These contaminants are summarised below:

Water samples were taken from boreholes (BH1 – BH6) and window sample hole (WS1) during subsequent monitoring visits. The positions of the exploratory holes are shown on Drawing No. 92064/9002, Appendix 1. The water samples have been assessed based on the following:

1. Existing building footprint
2. External areas

Existing Building Footprint

Chemical testing of two samples (BH4 & WS1) beneath the existing building footprint identified elevated concentrations of Ammonia (4100µg/l), chromium

(33µg/l), nickel (10µg/l), copper (59.4 µg/l), zinc (17µg/l), Naphthalene (0.26µg/l), acenaphthene (0.27µg/l), TPH Aliphatic (C16-C21)(19µg/l), (C21-C35)(32µg/l), (C35-C44)(12µg/l) above detection limit.

External Areas

Chemical testing of five samples (BH1, BH2, BH3, BH5 & BH6) beneath the external areas identified elevated concentrations of Ammonia (4100µg/l), nickel (18µg/l), copper (51.5 µg/l), zinc (64µg/l), Lead (13µg/l), TPH Aliphatic (C16-C21)(19µg/l), (C21-C35)(26 µg/l), above detection limit.

8.1.5 Soil Gas and Vapours

The ground conditions at the site comprise made ground materials (0.10m – 3.9m thick), that was visually observed not to contain significant quantities of gas generating putrescible materials and no visual or olfactory evidence of vapour generating material. As such, it is considered that the existing deposits on site would present a very low gas generation potential source in accordance with CIRIA C665 (Ref. 3). Based upon this assessment and the low sensitivity of the development (commercial), 6 gas and vapour monitoring was undertaken over a period of three months at intervals in general accordance with guidance detailed in CIRIA C665 (Ref. 3) were scheduled.

At the time of writing this report gas and vapour monitoring had been undertaken on four occasions between 23rd November 2011 and 3rd January 2012 in standpipes installed in boreholes BH 01 - BH 07 & WS1 – WS4. Three of the four readings were carried out during low atmospheric pressure (<1000ppm)

The results of the monitoring carried out indicate the following:

- Methane not detected
- Maximum concentrations of 4.0% carbon dioxide.
- Oxygen concentrations typically ranging between 14.1% and 20.2%.
- No elevated concentrations of volatile vapours were recorded.
- Flow recorded was <0.1l/hr.

Two additional monitoring visits are to be undertaken and this section updated.

8.2 Geotechnical Properties

The geotechnical properties for the strata encountered across the site have been based on the results of the in situ testing and laboratory testing undertaken as part of the ground investigation.

8.2.1 Concrete

A concrete slab was encountered at ground level within the existing warehouse building. The positions of the concrete cores are shown on Drawing No. 92064/9003, Appendix 1. Visual examination of five concrete cores within the building and external areas indicate the following:

Existing Building Footprint

Three concrete cores 168mm to 330mm thick reveal the maximum nominal aggregate size to be 20mm with 2/3 No. 8mm diameter bars. The higher thickness of 330mm was located at area of pit reported to have been infilled with concrete.

In-situ compressive strength test carried out on the concrete cores indicate compressive strength of between 40kN/m^2 and 50kN/m^2 (mean 45.2kN/m^2).

External Areas

Two concrete cores 178mm to 222mm thick reveal the maximum nominal aggregate size to be 20mm with 1/2 No. 8mm diameter bars.

In-situ compressive strength test carried out on the concrete cores indicate compressive strength of 38kN/m^2 and 44kN/m^2 (mean 41kN/m^2).

8.2.2 Made Ground

Made ground was encountered across the entire development area. Visual examination of the made ground indicate that the strata comprises mainly grey/ brown silty clay beneath concrete hardstand and sandy gravel sub-base.

The geotechnical properties of the made ground are discussed below:

Moisture Content

The result of eighteen moisture content tests undertaken on the silty clay made ground from depth between 0.2m and 2.5m bgl gave moisture content results of between 9.2% and 39% (mean 21.8%).

Particle Size Distribution

Cohesive

The result of three particle size distribution tests undertaken on cohesive made ground samples from depth of between 1.2m and 1.75m bgl, indicate the strata to comprise silty clay with clay content of between 15% and 21% (mean 17%), silt content of between 25% and 47% (mean 34%), sand content of between 34% and 41% (mean 37.3%) and gravel content of between 1% and 19% (mean 11.6%). This confirms the visual description.

Granular

The result of four particle size distribution tests undertaken on granular made ground samples from depth of between 0.2m and 1.75m bgl, indicate the strata to comprise silty gravel with clay content of between 0% and 10% (mean 3.6%), silt content of between 0% and 14% (mean 7.75%), sand content of between 14% and 32% (mean 21.5%) and gravel content of between 52% and 70% (mean 61.8%). This confirms the visual description.

Plasticity Index

The results of eleven Atterberg limit tests undertaken on the silty clay samples from depth of between 1.2m and 3.0m bgl gave plastic limits of between 17% and 27% (mean 21%), liquid limits of between 29% and 43% (mean 38%) and plasticity indices of between 12% and 21% (mean 18%).

On the basis of these results the silty clays are indicated to be of low to intermediate plasticity.

Undrained Shear Strength

No laboratory undrained shear strength test was carried out on the made ground.

The result of thirteen SPTs undertaken in the made ground determined N values of between 5 and 13 with an average of 8.

Based on the correlation between SPT N values, plasticity indices and undrained shear strength and using F_1 value of between 5.4 and 6.5, shear strength of between 29kN/m^2 and 76.7kN/m^2 has been determined with an average of 47kN/m^2 indicating a soft to firm consistency.

Based upon the visual description of the silty clay and consideration of the undrained shear strengths derived from correlation between SPT N values, minimum undrained shear strength of 40kN/m^2 is considered appropriate for design purposes.

For the soft and/or wet deposits, a moderately conservative undrained shear strength of 25 kN/m^2 is considered appropriate for design purposes.

Coefficient of Volume Compressibility

No one dimensional consolidation test was carried out on the made ground.

Based on empirical correlations between plasticity indices, the coefficient of compressibility and SPT (N) values and using F_2 values of 0.58, m_v values of between 0.13 to 0.34 m^2/MN with an average of 0.23m^2/MN have been determined.

Based upon consideration of the above and consideration of published data a moderately conservative design coefficient of compressibility of 0.20m^2/MN is considered appropriate for design purposes for the silty clay.

CBR

One laboratory CBR tests were undertaken with results of 3.2 and 4.0% (top) and 3.1 and 3.8% (bottom). Based upon consideration of the visual description of the silty clay made ground as being generally soft to firm, consideration of the plasticity indices (5% and 17%, mean 11%) at shallow depth (up to 1.0m bgl) and guidance provided in Interim Advice Note 73/06 2009 (Ref. 6), a maximum drained CBR value of 3% is expected. Based on the shear strength an undrained CBR value of 3% is also expected. As such, a CBR of 3% should be considered for design purposes.

Organic Matter

The results of four organic matter content tests undertaken on the made ground materials indicated organic matter content of between 0.8% and 1.3% (mean 1.0%). On the basis of these results the made ground is classified as low organic.

pH and Sulphate

Based on the result of four chemical water soluble sulphate and pH tests, the made ground has a Characteristic Sulphate Value of between 84mg/l SO_4 and 207mg/l SO_4 (mean 136mg/l SO_4), and pH values of between 8.3 and 10.7 (mean 9.8).

8.2.3 Natural Silty Clays

Visual examination of the silty clays indicates this strata to comprise predominantly firm and stiff (but locally soft) grey brown and light brown, slightly sandy and sandy, slightly gravelly and gravelly silty clay with occasional sand bands and lenses.

The geotechnical properties of the silty clays are discussed below:

Moisture Content

The result of twenty five moisture content tests undertaken on the natural silty clay from depth between 1.0m and 6.0m bgl gave moisture content results of between 15% and 34% (mean 23.5%).

A plot of moisture content against depth (attached in Figure 3, Appendix 4), show high moisture contents of greater than 25% at depth of between 1 and 3m bgl reducing to less than 25% below 3m bgl.

Bulk Density

Based upon one result, a bulk density (γ) value of 2.12 Mg/m^3 was recorded within the natural silty clay. This value correlates with published data (BS 8002(Ref. 8)) and a design bulk density (γ) value of 21 kN/m^3 is considered appropriate for this material.

Particle Size Distribution

The result of three particle size distribution tests undertaken on the natural silty clay samples from depth of between 1.0m and 5.0m bgl, indicate the strata to comprise silty clay with clay content of between 20% and 34% (mean 25%), silt content of between 27% and 46% (mean 35%), sand content of between 20% and 42% (mean 33%) and gravel content of between 0% and 14% (mean 6.6%). This confirms the visual description.

Plasticity Index

The results of twenty two Atterberg limit tests undertaken on the silty clay samples from depth of between 1.0m and 4.0m bgl gave plastic limits of between 15% and 28% (mean 19%), liquid limits of between 26% and 44% (mean 35%) and plasticity indices of between 11% and 21% (mean 15%).

On the basis of these results the silty clays are indicated to be of low to intermediate plasticity.

Using the average values of plasticity indices and moisture content, consistency indices is calculated to be 0.75 indicating a firm consistency.

Drained Angle of Shearing Resistance

Based upon the correlation of angle of shearing resistance (φ') and plasticity index (Ref. 8) a phi peak of 28˚ can be determined for the silty clay.

Undrained Shear Strength

The result of one undrained triaxial test gave shear strength of 19kN/m^2, indicating very soft strength property. However, the test was reported to have been performed outside the calibrated range of the equipment. This result is therefore not considered further.

The result of twenty eight SPTs undertaken in the silty clay determined N values of between 9 and 18 with an average of 14.

Based on the correlation between SPT N values, plasticity indices and undrained shear strength and using an F_1 value of between 5.4 and 6.5, shear strength of between 38kN/m^2 and 117kN/m^2 has been determined with an average of 71.6kN/m^2 as presented in Figure 1, Appendix 4 indicating a firm to stiff consistency.

The results of shear strength derived from the correlation between SPT N values and plasticity indices and the results of triaxial testing show a wide range in shear strength as demonstrated in Figure 1, Appendix 4. There is a general trend for shear strength to increase with depth.

Based upon the visual description of the silty clay and consideration of the undrained shear strengths derived from correlation between SPT N values, minimum undrained shear strength of 40kN/m^2 is considered appropriate for design purposes at depth of between 2.0m and 3.0m. An undrained shear strength of 75kN/m^2 is considered appropriate for design purposes at depth greater than 3.0m bgl.

Coefficient of Volume Compressibility

One dimensional consolidation tests indicate the coefficient of volume compressibility (Mv) of 0.17 m^2/MN, for a pressure increment of 100kN/m^2 above overburden pressure at depths of 4.00m bgl.

Based on empirical correlations between plasticity indices, the coefficient of compressibility and SPT (N) values and using F_2 values of between 0.54 and 0.7, m_v values of between 0.08 to 0.21m^2/MN with an average of 0.15m^2/MN have been determined.

Based upon consideration of the above and published data, a moderately conservative design coefficient of compressibility of 0.20m^2/MN is considered appropriate for design purposes for the silty clay at depth of between 2.0m and 3.0m. A moderately conservative design coefficient of compressibility of 0.15m^2/MN is considered appropriate for design purposes at depth greater than 3.0m bgl

pH and Sulphate

Based on the result of two chemical water soluble sulphate and pH tests, the made ground has a Characteristic Sulphate Value of between 38mg/l SO_4 and 88mg/l SO_4 (mean 63mg/l SO_4), and pH values of between 7.1 and 8.5 (mean 7.8)

8.2.4 Sands and Gravel

Visual examination of the layer of sands and gravels indicates this strata comprises dense very silty sand and gravel.

Relative Density

Four SPT test was undertaken in the natural sand and gravel layer encountered in BH5. The results determined N values of between 17 and 30 with an average of 23 indicating the sand and gravel is medium dense

Angle of Shearing Resistance

Based upon the SPT results and published information (Ref. 9) the angle of shearing resistance of 34˚ is considered suitable for design.

No further geotechnical testing was carried out on the sand and gravel layer.

9.0 ENVIRONMENTAL ASSESSMENT: PRELIMINARY CONCEPTUAL MODEL AND QUALITATIVE RISK ASSESSMENT

9.1 Principles of Environmental Risk Assessment

The Environmental Protection Act 1990, Part II A Contaminated Land (Section 57 of the Environment Act 1995) and the Contaminated Land Regulations 1999 provide a basis on which to determine the risks and liabilities presented by a contaminated site. Contaminated Land is defined within Annex 3, Chapter A Part 1- Scope of Chapter and in all those Sections mentioned as:

“Any land which appears to the local authority in whose area it is situated to be in such a condition, by reason of substances in, on or under the land that-

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

(b) Pollution of controlled waters is being, or is likely to be caused.”

Section 57 of the Environment Act 1995 requires that any site identified as being "contaminated" by the Local Authority will be registered by them and remediation will be required to render the site fit for use.

The presence of contamination is not the sole factor for deciding whether a site is contaminated. Site-specific risks must be determined then cost-effective methods should be evaluated to manage the contamination in a manner which satisfies the proposed end use.

The assessment of environmental risks in this report is based on the identification of three principal elements forming a 'pollutant linkage':

- Source: the contaminant
- Pathway: the route through which the contaminant can migrate, and
- Receptor: any human, animal, plant, controlled water or property that may be adversely affected (harmed) by the contaminant

In the absence of any one of these elements, on any given site, there is no risk. Where all three elements are present, risk assessment is required to determine the significance of the harm or pollution that is being or may be caused. As outlined above, the terms of the Contaminated Land regime specify that remediation need only be implemented where a site is causing, or there is a significant possibility that it will cause, significant harm, or that pollution of controlled waters is being, or is likely to be caused.

Development of contaminated land is usually addressed through the application of planning and development legislation and guidance (i.e. Planning Guidance Note PPG23 in England). The suitability for use approach is seen as the most appropriate basis to deal with contaminated land, taking account of environmental, social and economic objectives. The assessment is made in the context of the proposed land use (e.g. for this site commercial).

9.2 Conceptual Model and Pollution Linkages

The development proposals for the site are shown on Atkins Drawing No. 5085520/C/P/_/110, Appendix 1, include the reconfiguration of existing warehouse building into a material recycling facility including a waste reception, installation of material recycling facility plant, conveyor trenches, storage and office area, with staff and visitor car parking and access road in the south.

A site conceptual model drawing No. 92064/9005 is included in Appendix 1

9.2.1 Potential Sources of Contamination

Potential onsite sources of contamination identified by the desk study and investigated by the site investigation are outlined below:

Existing Warehouse Building

- Made ground associated with the development

External Areas

- Made ground associated with the development.
- Historical landfill to the northern part of thedevelopment.
- Electrical substation

9.2.2 Receptor Characterisation

Based on the proposed development and environmental conditions the following potential environmental receptors have been identified:

Part IIA Receptors

Human Health:	End Users of the commercial development.
	Adjacent commercial properties.
Property (Build Development):	Material recycling facility and car parking areas,
	Buried concrete and services/ utilities.
Controlled Waters:	
Groundwaters	Site underlain by confined water bearing silty clay layer.
Surface Waters	Minor water course running to the northern part of the development.
Ecology:	No ecological receptors.

Non Part IIA Receptors

Human Health:	Construction and Maintenance Workers.
Ecology:	None.

9.2.3 Pathway Characterisation

The potential pathways by which potential receptors identified for the site might be exposed to contaminants (sources) at the site are dependent on the proposed land use (i.e. commercial).

Humans

For humans, the three possible routes of exposure to contaminants are:

- Inhalation of dusts and accumulated soil gas.
- Ingestion of dusts or soil by hand-to-mouth activity.
- Dermal (skin) contact with contaminated soils and waters and transfer of contaminants through the skin into the body.

Buildings, Property and Services

The main pathways by which buildings can be affected are through soil gas accumulating within confined spaces in structures, by contact with aggressive or acidic soils/groundwaters or service trenches acting as preferential migration pathways. Below ground plastic utility pipes will be affected by direct contact with hydrocarbon contaminated soils.

Controlled Waters (Groundwater)

The primary routes by which controlled waters can be affected are:

- As upper silty clay layer is confining the groundwater, no viable pathway for the leaching of contaminants from the soil migrating vertically or laterally to groundwater beneath the site.
- Movement of dissolved contaminants in soil pore water.

9.2.4 Pollution Linkages

The following potential pollution linkages have been identified with the following receptor from the results of the desk study and ground investigation and by consideration of the final proposed redevelopment layout:

End-Users

- None

Adjacent Residential Users

- There is a low likelihood of a pollution linkage between the localised, isolated soil contamination in the made ground materials as inhalation of wind blown dust during construction and adjacent commercial users.

Construction and Maintenance Workers

- Risk to Construction / Maintenance workers is not assessed. It is considered that the adoption of appropriate health and safety measures and personnel protective equipment throughout the required works, will adequately mitigate against the presence of any elevated concentrations of contaminants.

Controlled Waters

- Only minor seepages were recorded within the made ground and long term seepage from within silty clay in to the monitoring boreholes.

  In view of the above and the presence of low permeable nature of the silty clay there is no potential pollution linkage / viable pathway between minor contamination in made ground in landscaped areas and the underlying Aquifer.

- There is a potential for the minor water course running to the north of the site to be in hydraulic continuity with the shallow groundwater beneath the development.

Built Development

- The determined concentrations of contaminants within the made ground and groundwater will present a risk to the built development including in ground concrete and buried services.

Landscaping

- None

9.3 Hazard Assessment

Hazards have been assessed by comparison of the contaminant concentrations identified with site specific Assessment Criteria and consideration of the receptors identified. Determination of the Assessment Criteria and the hazards identified are addressed in the following section. In addition, a Hazard Assessment Table is presented as follows which illustrates contaminants that are elevated above the Assessment Criteria of specific receptors.

9.3.1 Assessment Criteria

A preliminary screen of the chemical analyses data (as presented in Appendix 3) using maximum concentration values has been undertaken in order to identify contamination hazards using site specific Assessment Criteria developed for the specific receptors and conditions. These criteria are presented in Appendix 5, and have been derived in accordance with the current Environment Agency/DEFRA guidance.

The table below details contaminants that are above the Assessment Criteria for that determinand in relation to a specific receptor:

Hazard Assessment Table – Soil Contamination.

Material Type	Location	Depth (m)	Receptor Specific Assessment Criteria (concentrations in mg/kg)						
			Human Health			Built Development		Ecology	Pollution to Controlled Waters
			End-User	Adjacent Users	Construction / Maintenance	Buildings	Services	Landscaping	Groundwaters
Made ground	Existing Warehouse Building	0.5-2.0	None	None	None	None	Sulphate 7942 (**2000**), pH 12.3(**8**), arsenic 33.8(**10**), cadmium 3.8(**3**), Benzo(a)pyrene 1.7(**1**)	None	None
	External Areas	0.5 – 3.0	None	None	None	None	Sulphate 2132 (**2000**), pH 11.6(**8**), arsenic 72.7(**10**), Benzo(a)pyrene 5.0(**1**), fluoranthene 14.1(**10**), pyrene 11.2(**10**)	None	None

Hazard Assessment Table – Water Contamination.

Material Type	Location	Depth (m)	Receptor Specific Assessment Criteria (concentrations in mg/kg)						
			Human Health			Built Development		Ecology	Pollution to Controlled Waters
			End-User	Adjacent Users	Construction / Maintenance	Buildings	Services	Landscaping	Groundwaters
Groundwater	Existing Warehouse Building	2.31 – 4.44	None	None	None	sulphate 876 (**400**)	None	None	pH 9.5 (**8.5**), sulphate 876 (**250**), Ammonia 4100 (**500**)
	External Areas	1.68 – 4.32	None	None	None	None	None	None	sulphate 1286 (**250**), Ammonia 4100 (**500**)

Notes: Figures in brackets are receptor specific assessment criteria (See Appendix 5), Other figures are recorded concentrations.

9.3.2 Qualitative Risk Assessment

The conceptual model for the development, as presented in Section 9.2 has been used to undertake a qualitative risk assessment for the proposed redevelopment with a view to identifying significant risks that may exist to the proposed development as a result of contamination on or within the ground and groundwaters. This model has been compiled in relation to the specific hazards identified in Sections 9.2 and 9.3 in relation to the pollution linkages and receptors identified by the desk study and ground investigation.

A qualitative risk assessment of the site has been undertaken and is presented below:

<u>Part IIA Receptors</u>

Human Health: End Users

- None

Human Health: Adjacent Land Users

- None.

Property: Built Development

- Elevated concentrations of contaminants identified in the made ground as detailed in Section 9.3.1 present a potential risk of tainting water supplies where water supply pipes are placed in these materials. As such, the mitigation measures as detailed in Section 10 should be implemented.
- Elevated concentrations of sulphates have been identified within the groundwaters underlying the existing warehouse building at shallow depth. In ground concrete should therefore be designed to be resistant to sulphates in accordance with BRE Digest No. 1

Controlled Waters:

Surface waters	There is a potential risk for the minor watercourse immediately north of the development to be impacted by groundwater recharge containing elevated concentrations of ammonia and sulphate.
Groundwaters	Elevated concentrations of ammonia have been identified within the groundwater. This can likely be attributed to the historical use of the northern area of the site for waste disposal. No risk to the proposed development has been determined.

Ecology

- None.

Non Part IIA Receptors

Human Health: Construction and Maintenance Workers

- It is assumed that the adoption of appropriate health and safety measures after appropriate risk assessment by the Contractor and which is likely to include personal protective equipment will adequately mitigate the risk to construction and maintenance workers. As such, no pollution linkage exists.

Landscaped Areas

- None

10.0 RECOMMENDATIONS ON REMEDIAL/MITIGATION MEASURES

Based on the results of the ground investigation the following remediation and mitigation measures are recommended.

10.1 Measures within Preparatory/Advance Works

The following mitigation measures should be undertaken during the general preparatory earthworks:

- As part of the ongoing monitoring to characterise groundwater contamination, it will be necessary to determine whether a pollution linkage to the minor water course to the north exists by sampling and testing existing surface water from the water course.
- Due to the site being located in an industrial area, use of dust suppression measures during the works should be adopted to minimise dust generation for the safety of construction workers and adjacent users.

10.2 Measures within the Build Development

It is recommended that the following mitigation measures are incorporated into the built development:

10.2.1 Gas Protection Measures

Based on the maximum concentration of carbon dioxide recorded to date (4.0%) and the maximum flow rate recorded (<0.1 l/h) a gas screening value of 0.004 has been calculated in accordance with CIRIA C665 (Ref. 3). This equates to Characteristic Situation 1, which details that no special precautions with regard to carbon dioxide or methane gas are required within the built development. To be confirmed at the end of monitoring.

10.2.2 In Ground Concrete

Due to elevated sulphate concentrations detected in groundwater, buried concrete should be designed to Design Sulphate Class DS-2, ACEC Class AC-2 in accordance with BRE Special Digest 1:2005, Concrete in Aggressive Ground (Ref. 4).

10.2.3 Services / Utilities

Due to elevated benzo(a)pyrene concentrations detected in the made ground, use of clean service corridors or service materials resistant to hydrocarbons will be necessary where services are proposed to be placed in made ground layers.

11.0 WASTE CATEGORISATION

11.1 Topsoil

The topsoil generated from the regrade for the car park will require disposal to landfill.

Based upon the results of the limited organic matter tests (1.0% and 1.3%) undertaken on the topsoil, these materials would classify as non hazardous waste.

11.2 Made Ground

It may be necessary to dispose of the made ground from the site as part of the new foundation excavations and the reprofiling works associated with the redevelopment of the existing warehouse and car park area.

Based upon the absence of visual and olfactory evidence of contamination and chemical testing results, these materials would likely classify as Category 17 05 04 (Soil and Stones) in accordance with the European Waste Catalogue. As such this would comply with the Landfill Directive definition of inert waste, without further WAC testing.

11.3 Concrete

It is likely that concrete will be classified as 17 01 01 (Concrete) in accordance with the European Waste Catalogue and as such, may be designated as inert waste.

Based upon the absence of visual and olfactory evidence of contamination, it is likely that the granular engineered sub-base material would likely classify as Category 17 05 04 Soil and Stones in accordance with the European Waste Catalogue and comply with the Landfill Directive definition of inert waste.

11.4 Silty Clay

It may be necessary to dispose of the Silty Clay from the site as part of the foundation excavations and the reprofiling works associated with the proposed car park and access road. Based upon the absence of visual and olfactory evidence of contamination and chemical testing results, these materials would likely classify as Category 17 05 04 (Soil and Stones) in accordance with the European Waste Catalogue. As such this would comply with the Landfill Directive definition of inert waste, without further WAC testing.

12.0 ENGINEERING ASSESSMENT

12.1 Design Elements and Requirements

The proposed development layout is shown on Atkins Drawing No. 5085520/C/P/_/110, Appendix 1. The development is to comprise the following:

12.1.1 Proposed Waste Treatment Facility

The proposed development comprises the following elements:

- The reconfiguration of existing buildingas a material recycling facility;
  - Material recycling facility plant with maximum foundation loads of 100 kN/m^2 a proportion of which is likely to be dynamic loading.
  - Maximum total settlement of 25mm and differential settlements of 1 in 500.
  - It is understood that the proposed finished floor level for the development will be as existing level.

12.1.2 Proposed Car Park and Roads

- Car parking to the south as proposed by SITA.
  - At the time of reporting proposed levels in the car park area have not been confirmed but are considered to be similar to existing levels.

12.2 Geotechnical Constraints

Based on the findings of the ground investigation the following geotechnical constraints to the proposed development have been identified:

- A superficial groundwater table within the silty clay (with sand bands) with maximum levels of 150.2m AOD below the existing warehouse building and 149.27m AOD in the external areas.
- The presence of made ground deposits across the area of the proposed development, to a depth of 3.90 mbgl (146.50m AOD).
- The presence of silty clay with relatively consistent strength, identified as very firm to stiff, locally soft in isolated areas.
- The presence of utility services which will require diversion to accommodate for the proposed development layout.

12.3 Mineral Instability

Information provided in the desk study report indicate that the site is located within an area underlain by a zone believed to contain coal close or near to the surface and the site is not within the likely zone of influence on the surface from past underground workings. The report also indicate that the site contains one mine shaft entry, located in the southern area of the site with no record of whether the mine entry has been capped or sealed in an appropriate manner.

As the proposed development is within an existing building, the influence of mineral instability has not been considered.

12.4 Earthworks

12.4.1 Volumes

Based upon the proposed development, only minor volumes of materials would be generated as part of foundation and cut excavations and required as part of the minimal filling operations required within the proposed car park area.

12.4.2 Material Reuse

Visual examination of the made ground within the proposed car park area indicates this strata to generally comprise soft to firm slightly sandy slightly gravelly silty clays. Although, the clay is recorded to be locally very soft.

Based upon visual description of the silty clay it is likely that this material would likely classify as Class 2A/B General Fill in accordance with the Specification of Highway Works.

A comparison of the recorded natural moisture contents (9.2% and 39% mean 21.8%) and the determined plastic limits (17% and 27% mean 21%) of the silty clay at shallow depth indicate the moisture contents of some of the silty clay made ground fall within the acceptable range in comparison with the plastic limits and hence would classify as Class 2A materials in accordance with the Specification of Highway Works. Where the moisture content of the made ground is outside the plastic limit range, this material would either require treatment prior to reuse or disposed off to landfill.

Based upon visual description of the silty clay as being firm and firm to stiff, but occasionally locally soft, with calculated consistency indices of 0.75, it is assumed that approximately 60% of the excavated materials (with lower moisture contents) would fall within the commonly acceptable shear strength range (HA 44/91, Ref. 5) suitable for re-use of 40 to 75 kPa.

Based upon the above assessment it is considered that 60% of the excavated silty clay would be suitable for re use as Class 2A General Fill without modification.

Based upon the current development proposals as shown on the following preliminary earthworks are required:

- Removal of topsoil (average thickness 0.20m thick) across the proposed car park and access road area to the south.
- Foundation excavation within the existing warehouse building to formation level.
- In the area of the proposed car park, minor excavation and regrade to allow placement of suitable sub-base.

Based upon the groundwater conditions identified in the underlying strata, as detailed in Section 7, it is anticipated that earthworks will not be affected by groundwater, other than moderate seepages at the interface of the made ground/ silty clay. Minor seepages within the silty clay were not recorded at shallow depth but should not be discounted.

12.5 Foundation Design Requirements

12.5.1 Ground Conditions

The ground conditions underlying the proposed development footprint comprise the following sequence and are presented on Drawing No. 92064/9004 & 9005, Appendix 1:

- Topsoil from ground level to elevations between 150.46m AOD (0.10 mbgl) and 150.96 mAOD (0.20 mbgl).
- Made ground to elevations of 146.50m AOD (3.90 mbgl).
- Silty clays to a proved elevation of 140.40m AOD (10.00m bgl).
- In BH05 sand and gravel to a proved elevation of 140.76m AOD (10.00 mbgl).

12.5.2 Groundwater Conditions

No water seepages were encountered within the topsoil but evidence of shallow groundwater has been identified within the made ground.

A superficial groundwater table within the silty clay had a maximum level of 150.2 m AOD (Drawing No. 92064/9004, Appendix 1).

12.5.3 Foundation and Bearing Capacity

The proposed development comprises installation of a material processing facilities which is understood could impose loading including floor point load of 100kN which is expected to be applied on 0.35m x 0.35m base plate and line loading from a Bailer with a maximum load of 10tonnes (100KN) including dynamic loading. By Inspection, it is considered that the floor point load is the most onerous in terms of static loading and is adopted for bearing capacity assessment.

The potential dynamic loading will be catered for by designing the foundations to damp out vibration and cyclical loading to appropriate codes of practise for machine foundations. All foundations subjected to dynamic loading should be isolated from adjacent slabs and foundations.

The soft to firm silty clay made ground identified beneath the development to the outside of the existing building is considered unsuitable as a founding material based upon a low bearing capacity and the risk of differential settlement. As such, it is considered that the firm or stiff clays will provide a suitable bearing stratum.

The natural silty clay identified beneath the existing warehouse building is of consistent strength, from firm and firm to stiff consistencies. The clay was recorded as being locally softened, possibly due to the presence of groundwater.

The following foundation options have been considered for the proposed plant and equipment to be housed within the existing warehouse building:

1. Load applied directly on Existing Slab

2. Shallow foundation

2. Deep Foundation.

<u>Load applied directly on Existing Slab</u>

Historically the existing slab has been loaded by racking bearing onto it as part of the previous use as a warehouse. Consideration has therefore been given to the founding of light static loaded columns directly on the existing slab.

Calculations indicate that for a 100kN column load spread through 0.35m square base plate placed on the existing slab, at an elevation of 150.75m AOD, assuming a load spread of 30 degrees through the reinforced concrete slab and 45 degrees through the sub base would impose a bearing pressure of 55kN/m^2. At these load intensities settlement would not exceed 25mm.

Industrial floor adequacy check based on load information provided has been carried out in accordance with Concrete Industrial Ground Floor Design Report TR34 (Ref. 7). Checks carried out for a slab located within the internal panel, remote from joints and free edges. If it is proposed to locate columns on slabs at the edge or corners of the building, an additional check would be required. These checks (attached in Appendix 6) indicate that the slab is suitable for the loading information assumed. Therefore based on these assessments for statically loaded structures with a point load of 100kN applied through a 0.35m square base plate, loading can be applied directly on existing slab.

<u>Shallow foundations</u>

Consideration has been given to the use of pad foundations at shallow depth to support the applied loading from the material processing plant.

Calculations indicate that for a 1.25m square pad founded in the firm silty clay made ground at 1.5m bgl, at an elevation of 149.25m AOD, could provide a bearing capacity of 80kN/m^2. At these load intensities settlements would not exceed 25mm.

Dynamically loaded foundations should be isolated from adjacent slabs and foundations.

Where evidence of soft silty clay is encountered at foundation level, excavation and replacement of the soft strata should be carried out until competent firm/stiff silty clay strata is encountered.

<u>Deep Foundations</u>

It is considered that the proposed material recycling plant can be supported on deep pad foundations founded onto the underlying firm silty clay at depths of approximately 3.00mbgl (147.75m AOD).

For a 1.25m square pad foundations placed at 3.00mbgl (147.75m AOD) the allowable bearing capacity would be 145kN/m^2. At these load intensities, settlements would not exceed 25mm in the long term.

Dynamically loaded foundations should be isolated from adjacent slabs and foundations.

Floor Slabs

At the time of reporting details on the ground floor slab loads, construction and thickness were not available. It is anticipated that the existing floor slab will be left in place in locations where new plants and equipment will not be required.

12.5.4 Retaining Walls and Slopes

No significant retaining walls or slopes are anticipated as required on-site as part of the proposed development.

12.5.5 Pavement Design

Based upon information provided in the material properties section (8.2.2) of this report, an undrained CBR value of 3% is considered to be suitable for the silty clay made ground. However, local soft spots should be excavated out and infilled with well compacted sub base or capping material.

In the east of the site (car park area) sand was identified. From a visual description, and after proof rolling, CBR values of 10 to 15% for the natural sands can be expected. Any cobbles and boulders near sub grade should be removed to avoid creating hard spots

12.6 SUDs Drainage by Soakaway

SUDs drainage is not required as a part of the proposed development as drainage infrastructure is already in place within the site.

12.7 Temporary Works

Based on a review of the ground investigation information, the following temporary works are anticipated as part of the proposed development:

- In the proposed area of the existing warehouse building, and based upon the results of the ground investigation, excavations for foundations and services are likely to encounter both water seepages and more significant inflow within the silty clay at elevations ranging between 150.20 and 145.75m AOD.

  It is anticipated that these should be adequately controlled by pumping from sumps or collection trenches. Where foundation excavations encounter groundwater (particularly at possible clay / sand & gravel interface) base heave and running sands may occur which would require excavation support and dewatering measures.

- General excavations/ earthworks for the car park are unlikely to encounter shallow groundwater; however, seepages or light flows should not be discounted. As such, dewatering by collector trenches and/ or sumps may be required.

- Exposed sub grade should be protected during periods of inclement weather to prevent the formation of soft spots and reduced CBR value.

13.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the ground investigation the following geotechnical abnormal works and mitigation measures have been identified:

13.1 Geotechnical Works

Foundation Design

- Allowable bearing capacity for the silty clay made ground at 1.50m bgl has been determined to be 80kN/m^2 and for the natural silty clay, the allowable bearing capacity at 3.00m bgl has been determined to be 145kN/m^2
- Total and differential settlements are within 25mm and 1 in 500 respectively.
- Lightly loaded columns carrying static loads can be founded directly onto the existing slab. Dynamically loaded plant foundations should be constructed as individual pad foundations isolated from the rest of the structure.

Pavement Material Properties

- Based upon consideration of the visual description of the silty clay as being generally soft and firm, locally soft and laboratory analysis a maximum drained CBR value of 3% is recommended. Exposed sub grade should be protected during periods of inclement weather to prevent the formation of soft spots and reduced CBR value
- Any cobbles and boulders near sub grade should be removed to avoid creating hard spots.

Groundwater Conditions

- The results of the groundwater monitoring (Appendix 2) and observations during the ground investigation (Section 7.4) indicate a superficial groundwater table within the silty clay (with sand bands).
- Seepages elsewhere within the topsoil/ made ground interface, made ground/silty clay interface and within granular layers/pockets within the silty clay should not be discounted.

Earthworks

As part of the earthworks for the proposed car park extension, the following materials will be generated, the majority of which will require disposal off site:

- Topsoil materials are likely to classify as non hazardous waste. However, it is anticipated that most of the topsoil materials could be re used within proposed landscaped areas
- Based upon the absence of visual and olfactory evidence of contamination and the chemical testing results, it is likely that the silty clay made ground would likely classify as Category 17 05 04 Soil and Stones in accordance with the European Waste Catalogue and comply with the Landfill Directive definition of inert waste, without further WAC testing necessary.
- It may be necessary to dispose of the natural silty clays from the site as part of the foundation excavations and the reprofiling works associated with the proposed car park. Based upon the absence of visual and olfactory evidence of contamination, these materials would likely classify as Category 17 05 04 Soil

and Stones in accordance with the European Waste Catalogue. As such this would comply with the Landfill Directive definition of inert waste, without further WAC testing.

13.2 Environmental Works

- The gassing regime of the site lies within Characteristic Situation 1 in accordance with CIRIA Report C665. As such, no gas protection measures with regards to carbon dioxide or methane are warranted. However, gas monitoring visits need to be completed to confirm this assessment.
- Buried concrete should be designed to Design Sulphate Class DS-2, ACEC Class AC-2 accordance with BRE Special Digest 1:2005, Concrete in Aggressive Ground.
- Use of clean service corridors or service materials resistant to hydrocarbon will be necessary.
- Elevated ammonia and sulphate concentrations recorded in the shallow groundwater have the potential to impact on water quality in the minor water course to the north of the site. As such, it is recommended that surface water samples are collected and analysed as part of the ongoing groundwater monitoring to determine if there is a pollution linkage causing adverse impact to the water course.

14.0 REFERENCES

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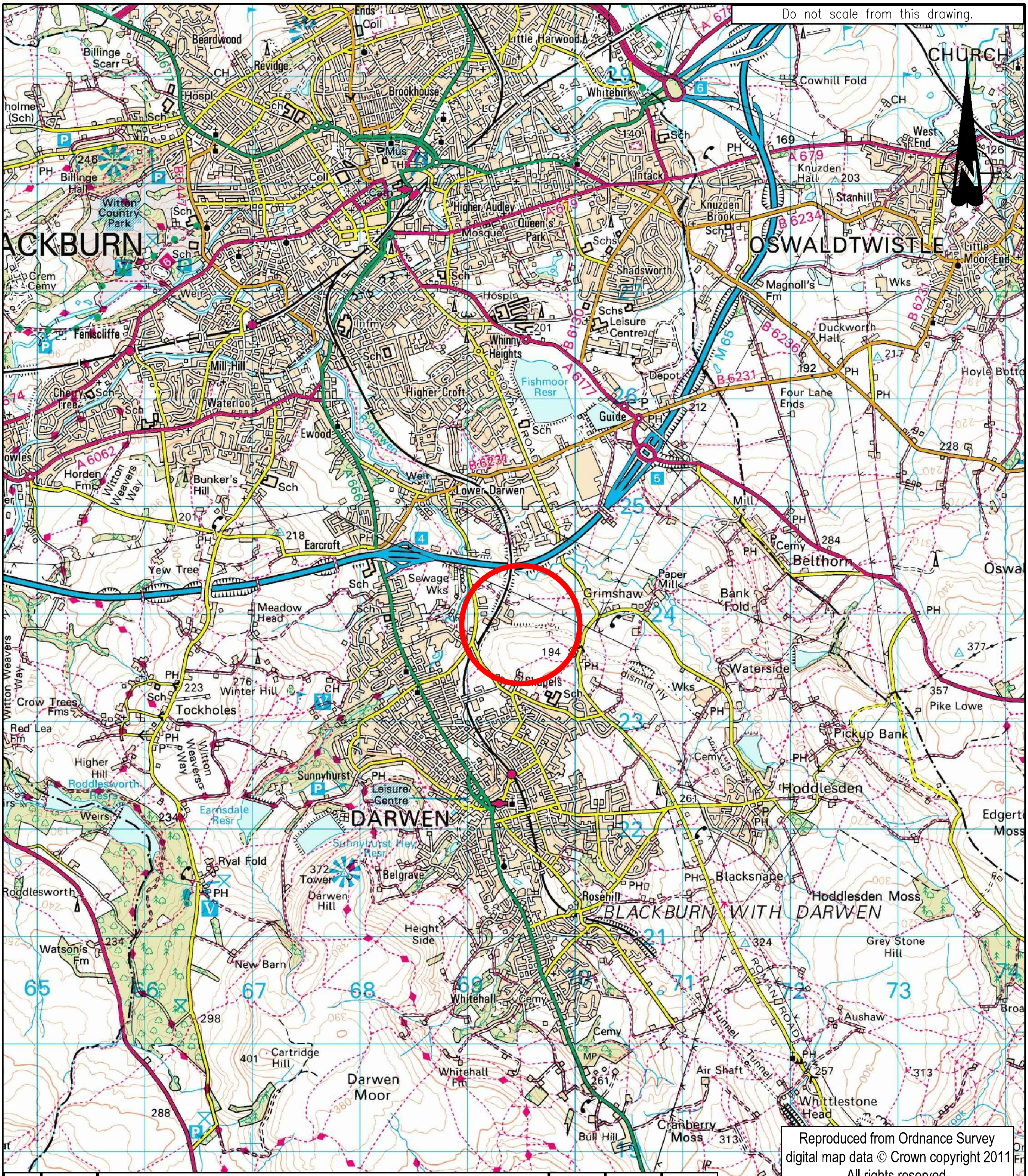
APPENDIX 1:
DRAWINGS

Drawing No.	Drawing Title
92064/9001	Regional Location Plan
92064/9002	Exploratory Hole Location Plan
92064/9003	Site Layout and Cross Section Location Plan
92064/9004	Ground Profile and Cross Section Sheet 1 of 2
92064/9005	Ground Profile and Cross Section Sheet 2 of 2
92064/9006	Site Conceptual Model
Atkins Drawings	
5085520/C/P/_/110	Proposed Development Plan

Do not scale from this drawing.



Rev.	Date	Description	Drawn	Checked	Approved

Project Title:

LOWER ECCLESHILL ROAD
DARWEN INKS WORKS
REDEVELOPMENT

Drawing Title:

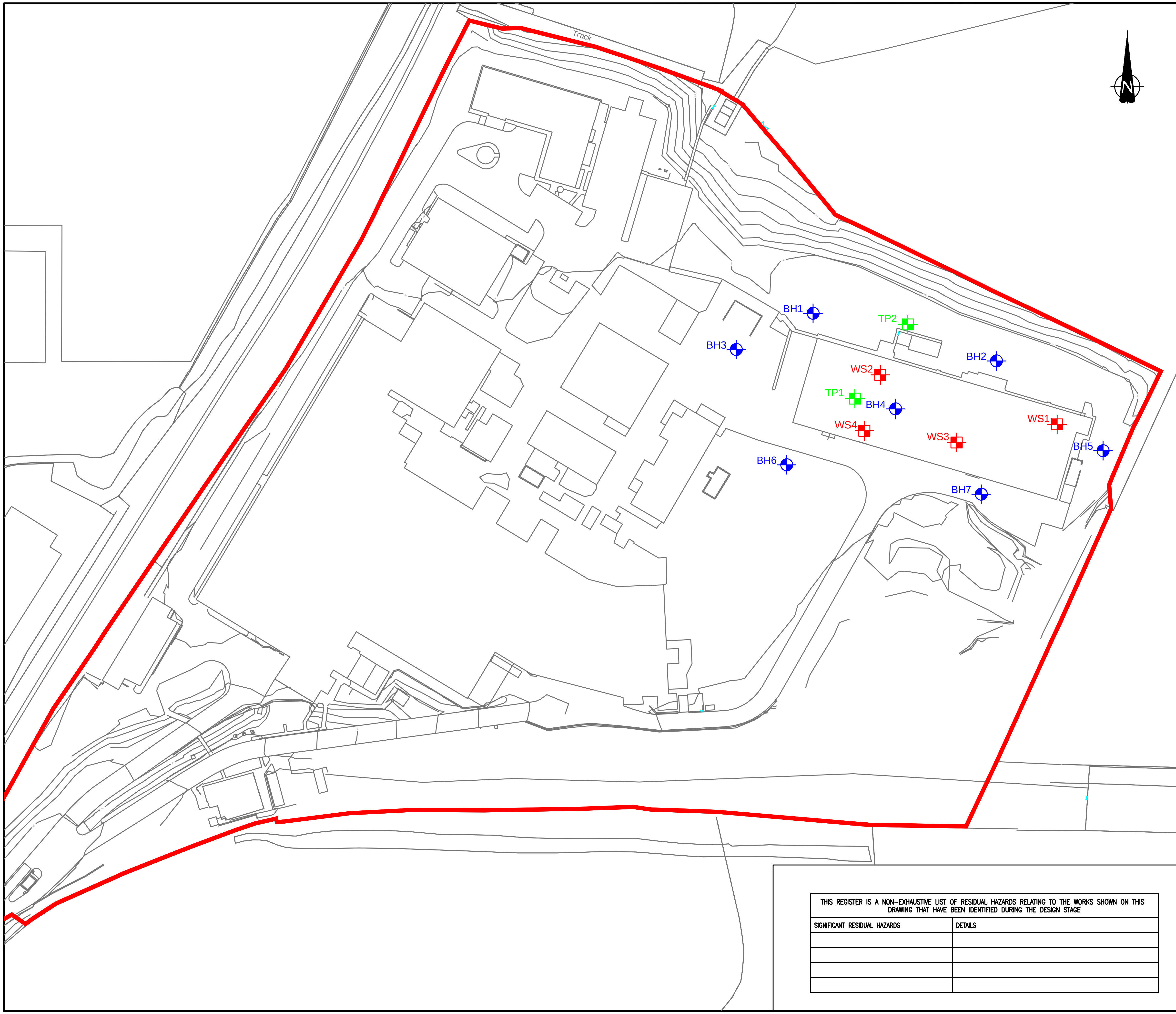
SITE LOCATION

FAIRHURST

W.A. Fairhurst & Partners
1 Arngrove Court, Barrack Road, Newcastle-upon-Tyne, NE4 6DB
Tel: 0191 221 0505 Fax: 0191 221 0949

Scale at A4:	Status:	
1:50000	Preliminary	
Drawn: SH	Checked: ME	Approved: AJL
Date: 11/10/11	Date: 19/10/11	Date: 19/10/11
Drawing No.: 92064/9001		Revision: –

Do not scale from this drawing.



KEY

- SITE BOUNDARY
- BH1 CABLE PERCUSSION BOREHOLES
- WS2 WINDOW SAMPLE (INITIAL LOCATIONS)
- TP1 TRIAL PITS (INITIAL LOCATIONS)

THIS REGISTER IS A NON-EXHAUSTIVE LIST OF RESIDUAL HAZARDS RELATING TO THE WORKS SHOWN ON THIS DRAWING THAT HAVE BEEN IDENTIFIED DURING THE DESIGN STAGE

SIGNIFICANT RESIDUAL HAZARDS	DETAILS

Rev.	Date	Description	Drwn.	Chkd.	Appd.

FAIRHURST

W.A. Fairhurst & Partners
1 Arngrove Court
Barrack Road,
Newcastle-upon-Tyne
NE4 6DB

Tel: 0191 221 0505
Fax: 0191 221 0949

Client: suez environnement SITA

Project Title:
LOWER ECCLESHILL ROAD
DARWEN INKS WORKS
REDEVELOPMENT

Drawing Title:
EXPLORATORY HOLE LOCATION PLAN

Scale at A3: 1:1250	Status: Preliminary	
Drawn: SH	Checked: ME	Approved: AJL
Date: 11/10/11	Date: 19/10/11	Date: 19/10/11
Drawing No.: 92064/9002		Revision: –

Do not scale from this drawing.

Key

Existing layout	
Proposed layout	
BH2	Boreholes
WS3	Window Samples
RC3	Rotary Core
TP1	Trial Pits
A	Section Lines

Rev.	Date	Description	Drawn	Checked	Approved

Client:

suez environnement SITA

Project Title:

LOWER ECCLESHILL ROAD
DARWEN INKS WORKS
REDEVELOPMENT

Drawing Title:

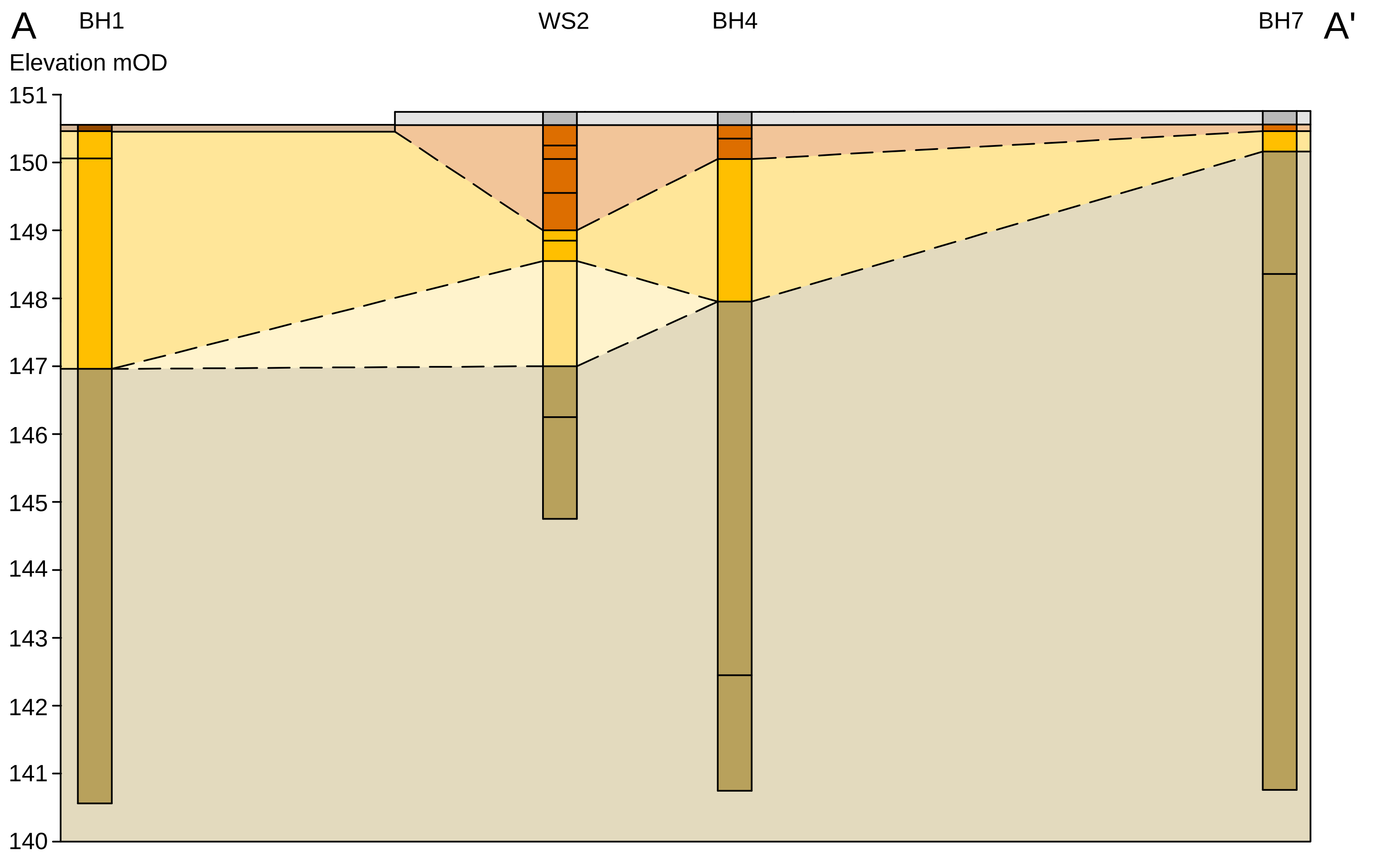
SITE LAYOUT PLAN AND CROSS SECTION LOCATION PLAN

FAIRHURST

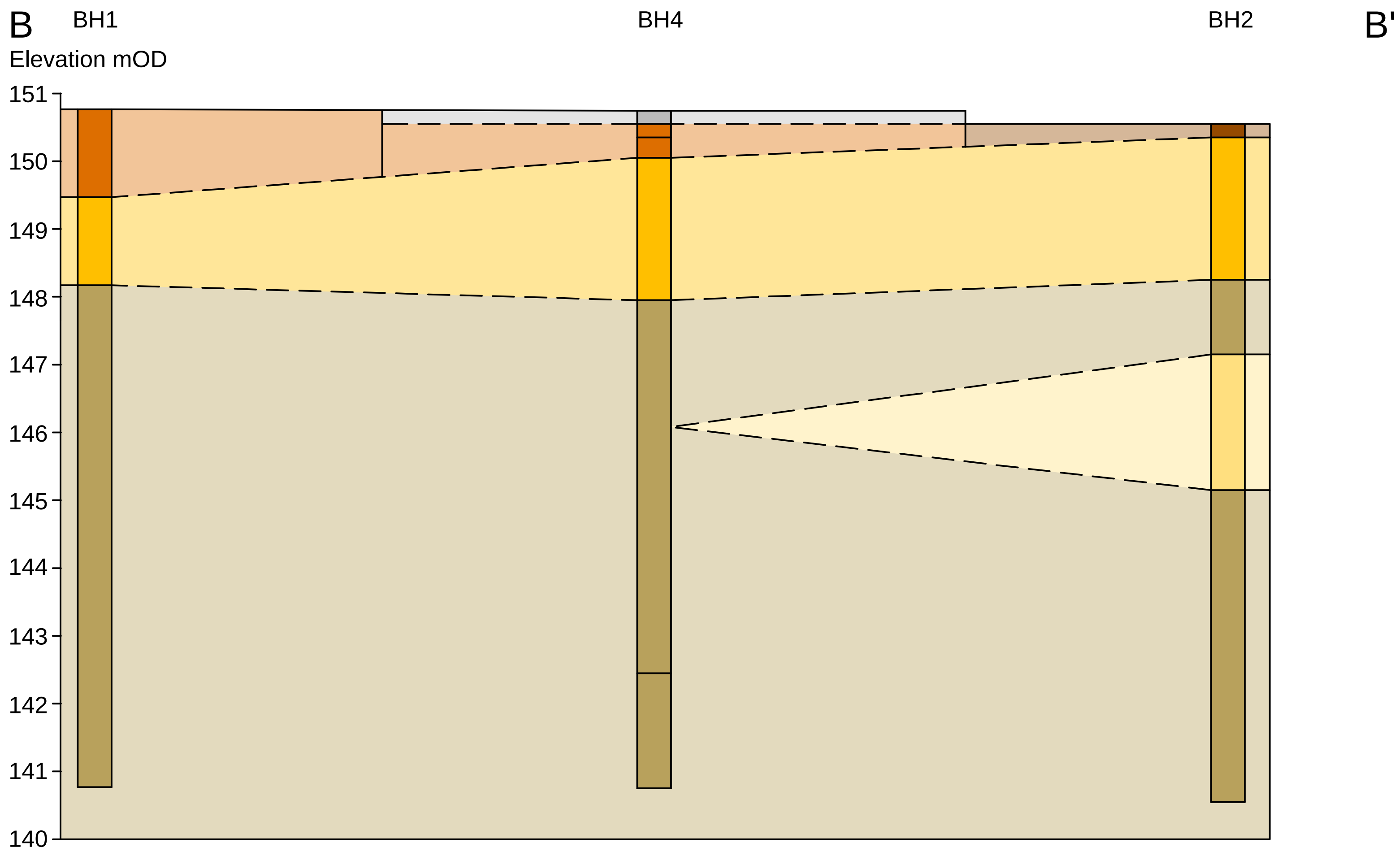
W.A. Fairhurst & Partners
1 Arngrove Court, Barrack Road, Newcastle-upon-Tyne, NE4 6DB
Tel: 0191 221 0505 Fax: 0191 221 0949

Scale at A1: 1:200	Status: For Information	
Drawn: SDR	Checked: ME	Approved: AJL
Date: 16/01/12	Date: 25/01/12	Date: 25/01/12
Drawing No.: 92064/9003	Revision: –	

Do not scale from this drawing.



CROSS SECTION A - A' SCALE - VERTICAL - 1:100 HORIZONTAL - 1:500



CROSS SECTION B - B' SCALE - VERTICAL - 1:100 HORIZONTAL - 1:500

KEY

- REINFORCED CONCRETE SLAB
- TOPSOIL
- COHESIVE MADE GROUND (SOFT / FIRM SILTY CLAY)
- CLAYEY SILT (N)
- SAND AND GRAVEL (N)
- GRANULAR MADE GROUND (SAND / GRAVEL)
- SILTY CLAY (N)

(N) - NATURAL DEPOSITS

Rev.	Date	Description	Drwn.	Chkd.	Appd.

FAIRHURST

1 Arngrove Court
Barrack Road,
Newcastle-upon-Tyne
NE4 6DB

Tel: 0191 221 0505
Fax: 0844 381 4412

Client: suez environnement SITA

Project Title:
LOWER ECCLESHILL ROAD
DARWEN INKS WORKS
REDEVELOPMENT

Drawing Title:
GROUND PROFILE AND CROSS SECTION SHEET 1 OF 2

Scale at A3: AS SHOWN	Status: For Information	
Drawn: SDR	Checked: ME	Approved: AJL
Date: 16/01/12	Date: 25/01/12	Date: 25/01/12

Drawing No.: 92064/9004

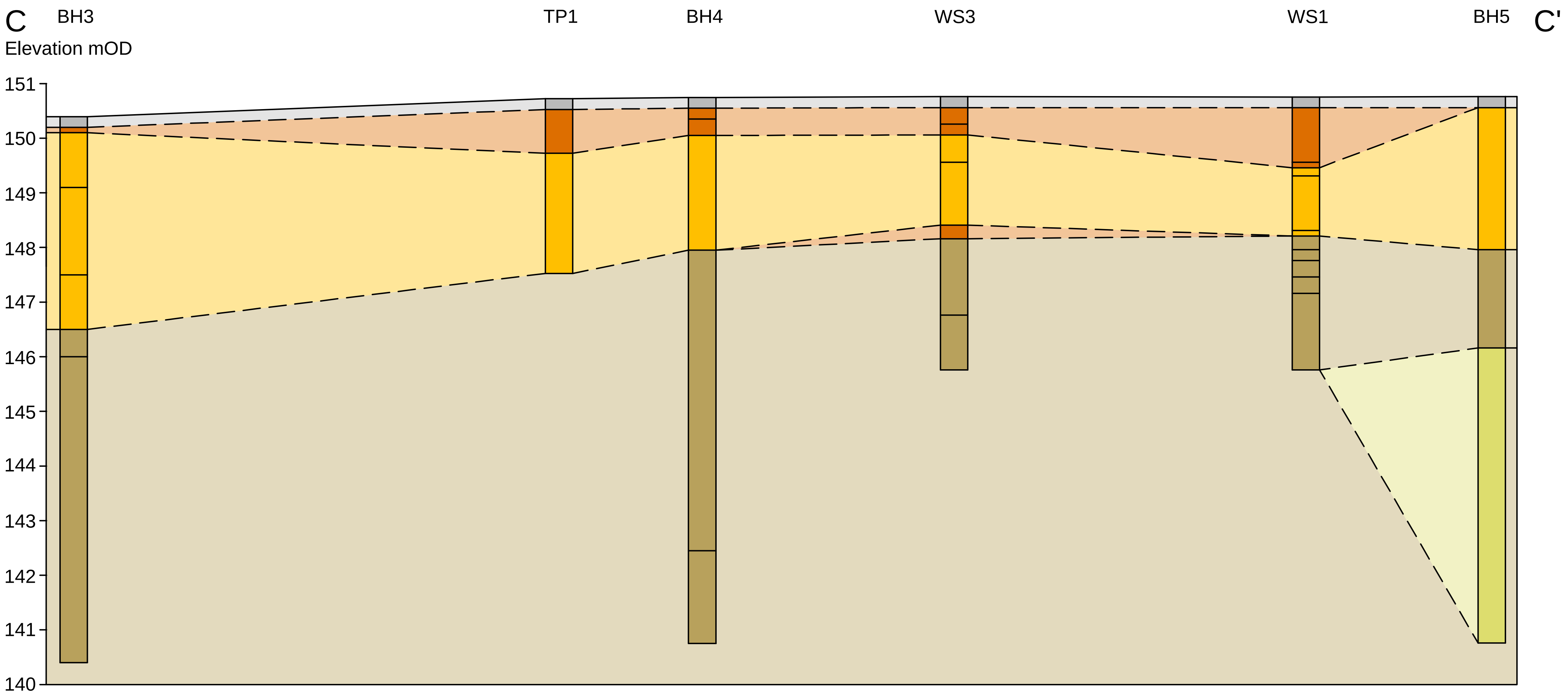
Revision: –

Do not scale from this drawing.

KEY

- REINFORCED CONCRETE SLAB
- TOPSOIL
- COHESIVE MADE GROUND (SOFT / FIRM SILTY CLAY)
- CLAYEY SILT (N)
- SAND AND GRAVEL (N)
- GRANULAR MADE GROUND (SAND / GRAVEL)
- SILTY CLAY (N)

(N) - NATURAL DEPOSITS



CROSS SECTION C - C' SCALE - VERTICAL - 1:100 HORIZONTAL - 1:500

Rev.	Date	Description	Drwn.	Chkd.	Appd.

FAIRHURST

1 Arngrove Court
Barrack Road,
Newcastle-upon-Tyne
NE4 6DB

Tel: 0191 221 0505
Fax: 0844 381 4412

Client:

Project Title:
LOWER ECCLESHILL ROAD
DARWEN INKS WORKS
REDEVELOPMENT

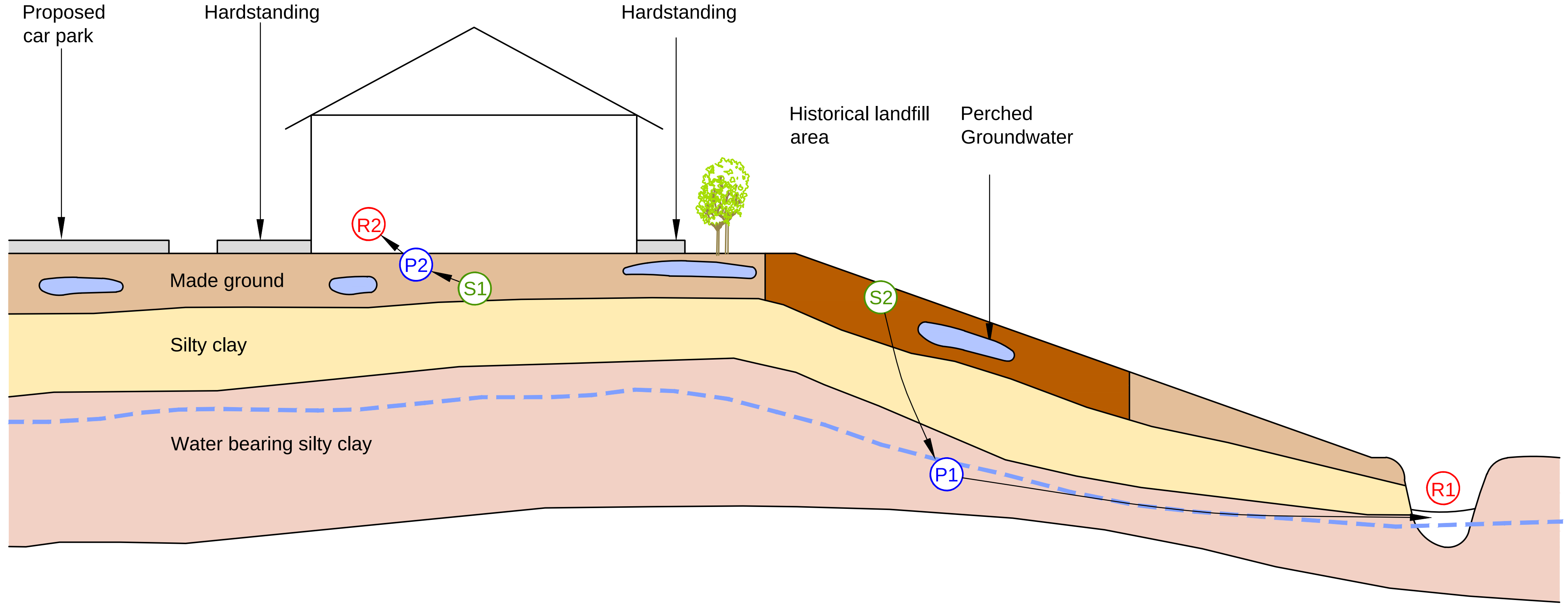
Drawing Title:
GROUND PROFILE AND CROSS
SECTION SHEET 2 OF 2

Scale at A3: AS SHOWN	Status: For Information	
Drawn: SDR	Checked: ME	Approved: AJL
Date: 16/01/12	Date: 25/01/12	Date: 25/01/12

Drawing No.: 92064/9005

Revision: –

Do not scale from this drawing.



Sources

(S1) Made ground associated with historical land use.

(S2) Historical landfill

Pathways

(P1) Leaching from soil, direct infiltration from surface run off and lateral migration from groundwater as baseflow.

(P2) Direct Contact.

Receptors

(R1) Controlled waters.

(R2) Built development (concrete / services).

Rev.	Date	Description	Drwn.	Chkd.	Appd.

FAIRHURST

1 Arngrove Court
Barrack Road,
Newcastle-upon-Tyne
NE4 6DB

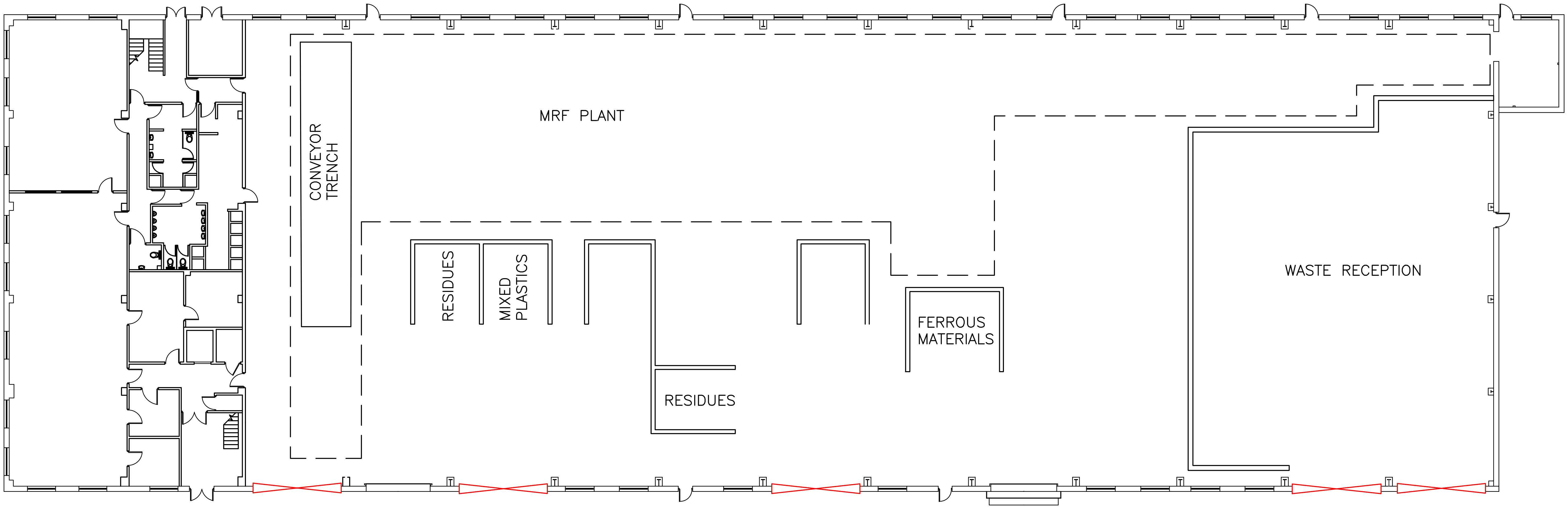
Tel: 0191 221 0505
Fax: 0844 381 4412

Client:

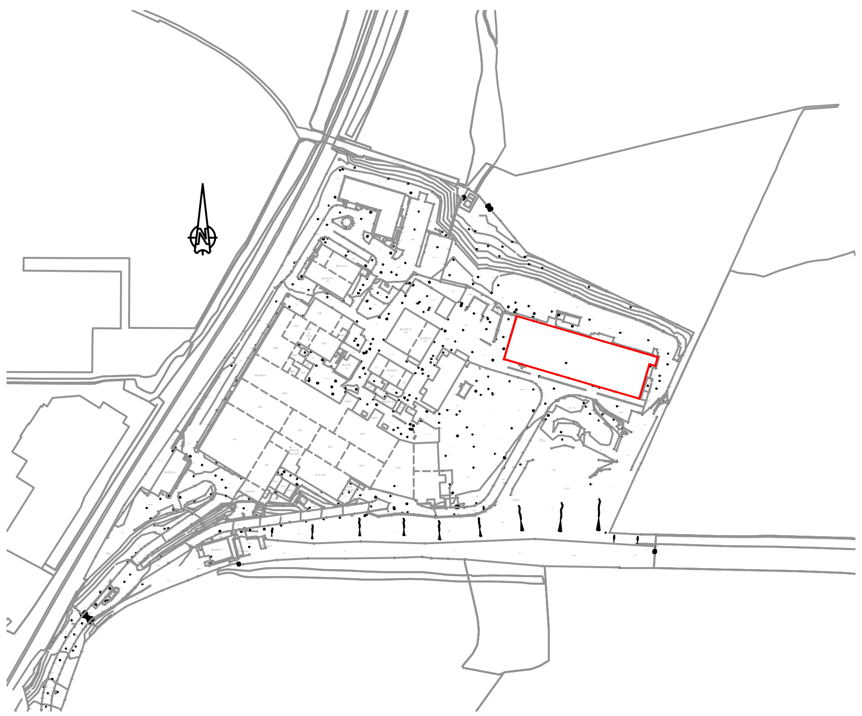
Project Title:
LOWER ECCLESHILL ROAD
DARWEN INKS WORKS
REDEVELOPMENT

Drawing Title:
SITE CONCEPTUAL MODEL

Scale at A3: NTS	Status: For Information	
Drawn: SDR	Checked: ME	Approved: AJL
Date: 25/01/12	Date: 25/01/12	Date: 25/01/12
Drawing No.: 92064/9006		Revision: –



PROPOSED BUILDING PLAN
(1:250)



BUILDING LOCATION PLAN
(1:5000)

KEY

DENOTES NEW 5.5m WIDE BY 6m HEIGHT ROLLER SHUTTER DOOR

NOTES
1. DO NOT SCALE FROM THIS DRAWING.
2. ALL MEASUREMENTS ARE IN MILLIMETRES UNLESS STATED OTHERWISE.
3. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH THE SPECIFICATION AND ALL RELEVANT ARCHITECTURAL, ELECTRICAL, MECHANICAL AND STRUCTURAL DRAWINGS.
4. DETAILS APPROXIMATE ONLY AND ARE SUBJECT TO CHANGE FOLLOWING FULL MEASURE & FINAL DESIGN.
5. BUILDING TAKEN FROM ATKINS DRAWING 5098921/WAR/101.
6. SEE DRAWING 5085520/C/X/109 FOR EXISTING BUILDING DETAILS

IN ADDITION TO THE HAZARDS/RISKS NORMALLY ASSOCIATED WITH THE TYPES OF WORK DETAILED ON THIS DRAWING, NOTE THE FOLLOWING SIGNIFICANT RESIDUAL RISKS :-

ITEM	HAZARD	RISK

REV	DESCRIPTION	BY	DATE	CHK'D	AUTH

Atkins Limited
Albany Court
Newcastle Business Park
Newcastle Upon Tyne
NE 4 7YB
England

Telephone +44(0)191 2334466

CLIENT:

PROJECT:
LOWER ECCLESHILL ROAD
DARWEN

TITLE:
INK WORKS
PROPOSED BUILDING PLAN

SCALE:	ORIGINAL SIZE:	DESIGNED:	DRAWN:	CHECKED:	AUTHORISED:
1:250	A3	SM	SM	MH	SB
	OFFICE: NCO	DATE: 23/08/11	DATE: 23/08/11	DATE: 24/08/11	DATE: 24/08/11

PROJECT NO:	DISCIPLINE:	TYPE:	CODE:	DRG NO:	REV:
5085520	C	P	_	110	00

APPENDIX 2:

GAS AND GROUNDWATER MONITORING RESULTS

FAIRHURST

Exploratory Hole Number	Date Monitored	Barometric Pressure	Total Volatile Hydrocarbons (ppm)	Methane % Volume	Carbon Dioxide % Volume	Oxygen % Volume	Flow Rate (l/ hr)
BH 01	23-11-2011	1003	0.0	0.0	1.2	18.2	<0.1
	30-11-2011	997	0.0	0.0	0.3	19.4	<0.1
	14-12-2011	968	0.0	0.0	1.3	18.4	<0.1
	03-01-2012	988	0.0	0.0	0.3	19.7	<0.1
BH 02	23-11-2011	1003	0.0	0.0	0.6	19.2	<0.1
	30-11-2011	997	0.0	0.0	4.0	14.1	<0.1
	14-12-2011	968	0.0	0.0	0.6	19.3	<0.1
	03-01-2012	988	0.0	0.0	0.2	19.9	<0.1
BH03	23-11-2011	1003	0.0	0.0	0.0	20.1	<0.1
	30-11-2011	997	0.0	0.0	0.0	19.9	<0.1
	14-12-2011	968	0.0	0.0	0.0	20.2	<0.1
	03-01-2012	988	0.0	0.0	0.0	20.1	<0.1
BH04	23-11-2011	1003	0.0	0.0	0.4	18.7	<0.1
	30-11-2011	997	0.0	0.0	0.0	20.1	<0.1
	14-12-2011	968	0.0	0.0	0.3	19.1	<0.1
	03-01-2012	988	0.0	0.0	0.2	19.6	<0.1
BH05	23-11-2011	1003	0.0	0.0	0.1	19.8	<0.1
	30-11-2011	997	0.0	0.0	0.1	19.8	<0.1
	14-12-2011	968	0.0	0.0	0.0	20.2	<0.1
	03-01-2012	988	0.0	0.0	0.0	20.1	<0.1
BH06	23-11-2011	1003	0.0	0.0	0.5	14.1	<0.1
	30-11-2011	997	0.0	0.0	0.7	14.4	<0.1
	14-12-2011	968	0.0	0.0	0.6	15.1	<0.1
	03-01-2012	988	0.0	0.0	0.3	16.8	<0.1
BH07	23-11-2011	1003	0.0	0.0	0.2	19.7	<0.1
	30-11-2011	997	0.0	0.0	0.2	19.4	<0.1
	14-12-2011	968	0.0	0.0	0.3	19.7	<0.1
	03-01-2012	988	0.0	0.0	0.1	20.1	<0.1

Exploratory Hole Number	Date Monitored	Barometric Pressure	Total Volatile Hydrocarbons (ppm)	Methane % Volume	Carbon Dioxide % Volume	Oxygen % Volume	Flow Rate (l/ hr)
WS01	23-11-2011	1003	0.0	0.0	0.0	20.1	<0.1
	30-11-2011	997	0.0	0.0	0.0	20.0	<0.1
	14-12-2011	968	0.0	0.0	0.0	20.2	<0.1
	03-01-2012	988	0.0	0.0	0.0	20.2	<0.1
WS02	23-11-2011	1003	0.0	0.0	0.0	20.0	<0.1
	30-11-2011	997	0.0	0.0	0.0	20.0	<0.1
	14-12-2011	968	0.0	0.0	0.0	20.1	<0.1
	03-01-2012	988	0.0	0.0	0.0	20.2	<0.1
WS03	23-11-2011	1003	0.0	0.0	0.0	20.1	<0.1
	30-11-2011	997	0.0	0.0	0.0	19.9	<0.1
	14-12-2011	968	0.0	0.0	0.0	20.2	<0.1
	03-01-2012	988	0.0	0.0	0.0	20.1	<0.1
WS04	23-11-2011	1003	0.0	0.0	0.6	18.4	<0.1
	30-11-2011	997	0.0	0.0	1.0	15.9	<0.1
	14-12-2011	968	0.0	0.0	0.4	18.6	<0.1
	03-01-2012	988	0.0	0.0	0.2	19.1	<0.1

ND = Not Detected

APPENDIX 3:

SUMMARY OF CHEMICAL RESULTS

Determinand	Number of samples tested	Min Conc. (mg/kg)	Max Conc. (mg/kg)	US 95 Value (mg/kg)
Heavy Metals				
Arsenic	21	2.4	72.7	20.8
Cadmium	21	<0.1	3.1	1.4
Chromium	21	8	38	25.1
Chromium (hexavalent)	21	<2	<2	2.0
Copper	21	6	462	140.0
Lead	21	7	577	158.2
Mercury	21	<0.5	<0.5	0.5
Nickel	21	6	40	29.3
Selenium	21	<0.2	1.5	0.4
Zinc	21	23	707	295.4
Inorganics				
Boron (water soluble)	21	0.2	6.5	2.1
pH	21	7.8	12.5	10.3
Sulphate (2:1 water soluble)	21	<10 mg/l	1326 mg/l	261.1Mg/l
Sulphate (total)	21	0.01%	0.79%	0.2%
Sulphur (free)	21	<10	155	52.7
Sulphide	21	<2	15.0	6.1
Free Cyanide	21	<1	<1	1.0
Complex Cyanide	21	<1	2.1	1.2
Total Cyanide	21	<1	2.1	1.2
Thiocyanate	21	<1	<2	1.2
Asbestos		None	None	NA
Organics				
Phenols (total)	21	<1	<1	1.0
Speciated PAH				
Naphthalene	10	<0.1	0.6	0.3
Acenaphthylene	10	<0.1	0.2	0.1
Acenaphthene	10	<0.1	2.1	0.8
Fluorene	10	<0.1	1.5	0.5
Phenanthrene	10	<0.1	7.5	3.6
Anthracene	10	<0.1	2.3	1.1
Fluoranthene	10	<0.1	14.1	5.7
Pyrene	10	<0.1	11.2	4.7
Benzo(a)anthracene	10	<0.1	6.0	2.5
Chrysene	10	<0.1	7.0	3.0
Benzo(b)fluoranthene	10	<0.1	4.6	2.0
Benzo(k)fluoranthene	10	<0.1	4.8	2.1
Benzo(a)pyrene	10	<0.1	5.0	2.2
Indeno(123cd)pyrene	10	<0.1	3.4	1.5
Dibenz(ah)anthracene	10	<0.1	1.0	0.5
Benzo(ghi)perylene	10	<0.1	3.1	1.4
PAH (total)	10	<0.1	71.7	31.3
Speciated TPH				
TPH Aromatic EC5-EC7	10	<0.01	<0.01	0.01
TPH Aromatic EC7-EC8	10	<0.01	<0.01	0.01
TPH Aromatic EC8-EC10	10	<0.01	1.68	0.5
TPH Aromatic EC10-EC12	10	<0.1	3.1	1.0
TPH Aromatic EC12-EC16	10	<0.1	28.5	8.5
TPH Aromatic EC16-EC21	10	<0.1	27.3	10.0
TPH Aromatic EC21-EC35	10	<0.1	92.0	38.9
TPH Aromatic EC35-EC44	10	<0.1	24.2	8.8
TPH				
TPH Aliphatic EC5-EC6	10	<0.01	<0.01	0.01
TPH Aliphatic EC6-EC8	10	<0.01	<0.01	0.01
TPH Aliphatic EC8-EC10	10	<0.01	2.70	0.8
TPH Aliphatic EC10-EC12	10	<0.1	3.0	0.9
TPH Aliphatic EC12-EC16	10	<0.1	303.8	86.1

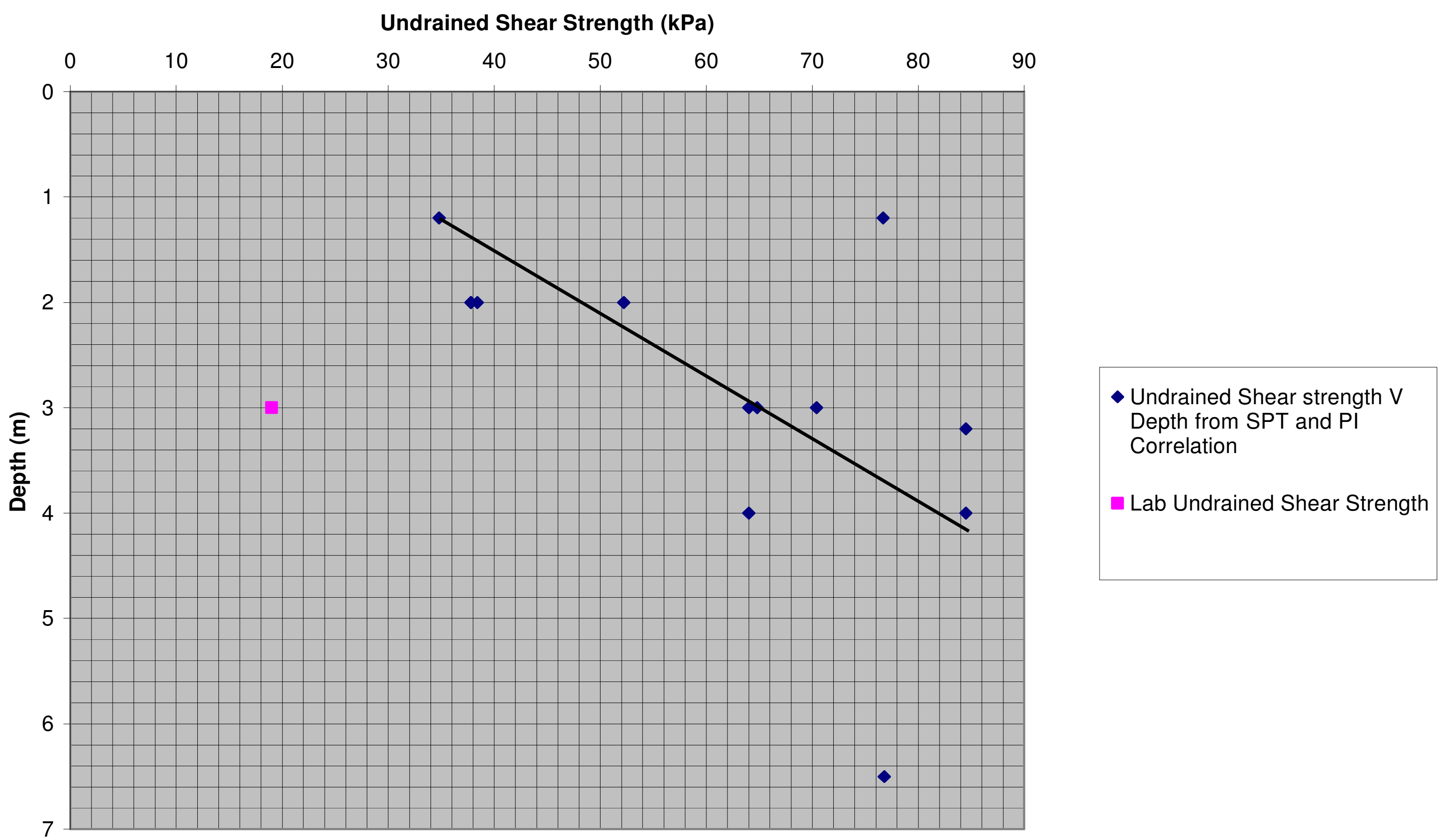
TPH Aliphatic EC16-EC21	10	<0.1	256.5	73.0
TPH Aliphatic EC21-EC35	10	<0.1	39.8	17.7
TPH Aliphatic EC35-EC44	10	<0.1	10.9	4.5
TPH C5-C35	10	0.9	619.9	213.4

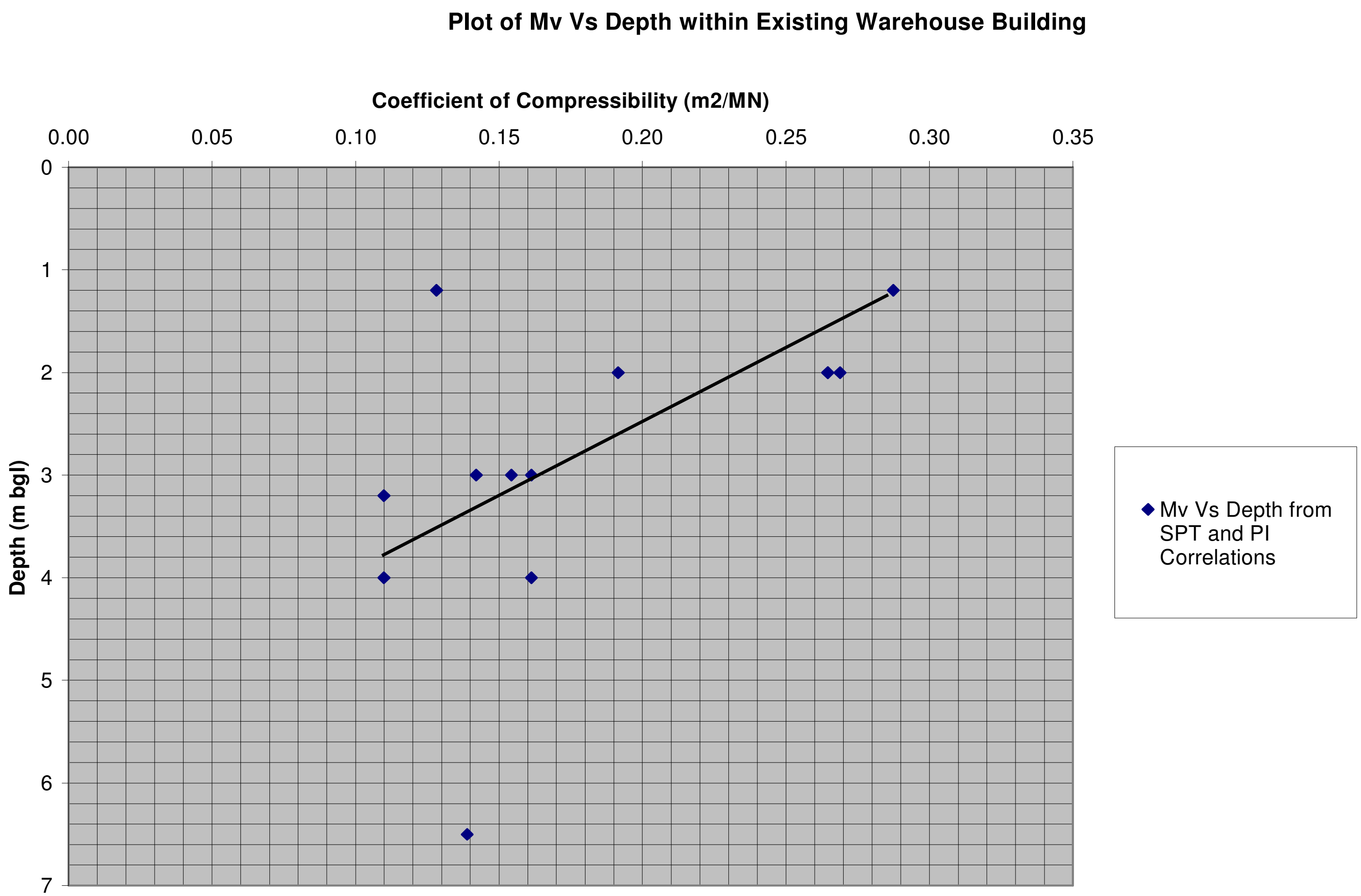
APPENDIX 4:

GEOTECHNICAL PARAMETERS

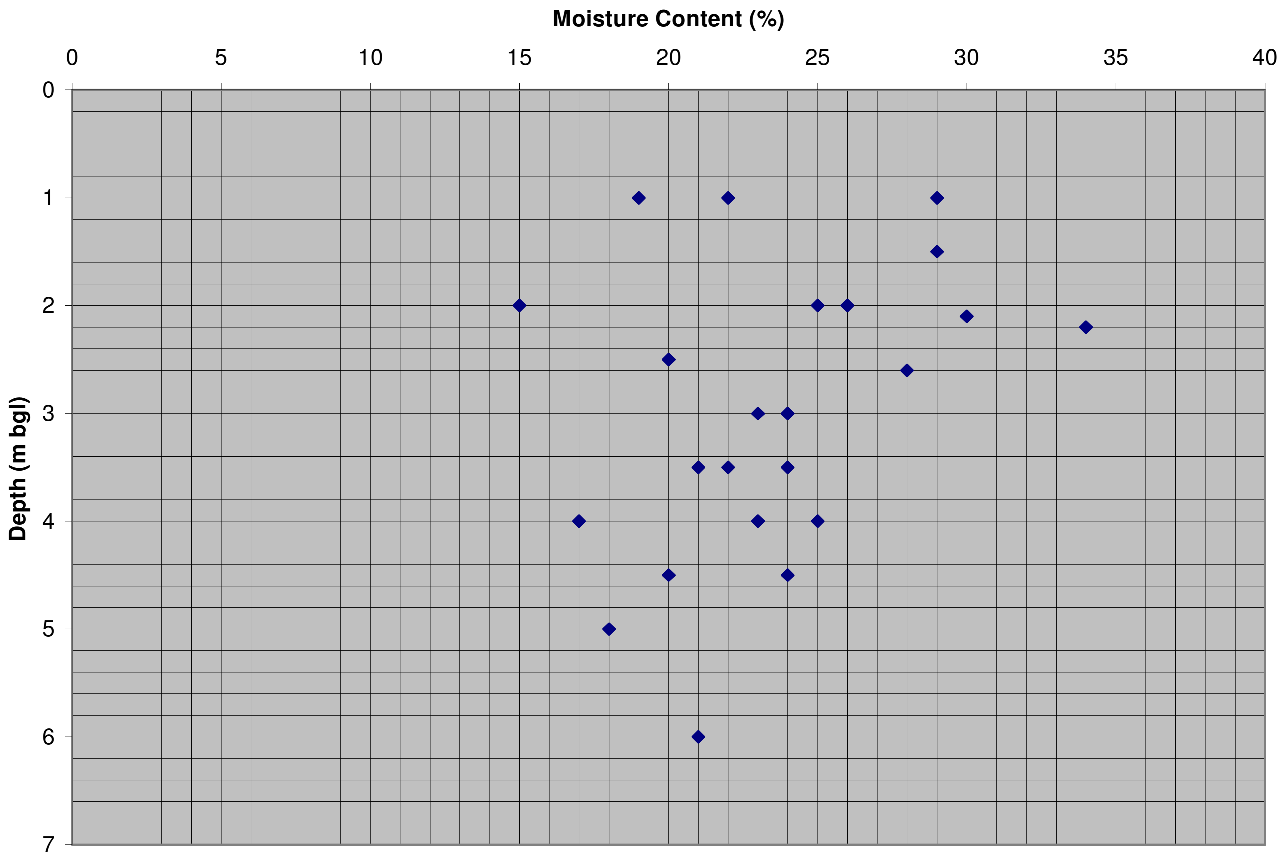
FAIRHURST

Plot of Undrained Shear strength Vs Depth within Existing Warehouse Building




Plot of Mv Vs Depth within Existing Warehouse Building
Coefficient of Compressibility (m2/MN)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
Depth (m bgl)
0
1
2
3
4
5
6
7
Mv Vs Depth from SPT and PI Correlations

Plot of Moisture Content v depth within development area



APPENDIX 5:
SITE SPECIFIC ASSESSMENT CRITERIA

Table A. **Human Health, Surface Waters and Groundwaters Assessment Criteria**

Darwen Inkworks
92064
11/01/2012
Made Ground (Reworked Natural) and Natural Ground

Assessment Criteria Substance	Human Health (Soils)				Waters					
	SITE END USE 1		SITE END USE 2							
	Commercial Development Assessment Level (mg/kg)	Source		Source	Surface Waters (mg/l) Fresh Water	Source	Surface Waters (mg/l) Marine	Source	Groundwater (mg/l)	Source
METALS										
Aluminium									0.2	UK DWS
Antimony	7500	CL:AIRE							0.005	EU DWS
Arsenic	635	CLEA 1.06			0.05	Annex G EQS	0.025	Annex G EQS	0.01	EU DWS
Barium	22000	CL:AIRE							0.7	WHO DW
Beryllium	420	LQM ed. 2							0.004	US EPA
Boron	1.92×105	LQM ed. 2			2	Annex G EQS	7	Annex G EQS	1	EU DWS
Cadmium	230	EA SGV			0.00008 - 0.00025(a)	EU standard	0.0002	EU standard	0.005	EU DWS
Chromium (III)	30400	LQM ed. 2			0.0047	proposed UKTAG	N/A		0.05 (total Cr)	EU DWS
Chromium (VI)	35	LQM ed. 2			0.0034	proposed UKTAG	0.0006	proposed UKTAG		
Copper	71700	LQM ed. 2			0.001 - 0.028(a)	Annex G EQS	0.005	Annex G EQS	2	EU DWS
Iron					1	Annex G EQS	1	Annex G EQS	0.2	EU DWS
Lead	750	SGV old			0.0072	EU standard	0.0072	EU standard	0.025	EU DWS
Manganese									0.05	UK DWS
Mercury (methyl)	397	CLEA 1.06			0.00005	EU standard	0.00005	EU standard	0.001	EU DWS
Molybdenum	17000	CL:AIRE								
Nickel	1790	CLEA 1.06			0.02	EU standard	0.02	EU standard	0.02	EU DWS
Selenium	13000	EA SGV							0.01	EU DWS
Silver					0.00005	Annex G EQS	0.00005	Annex G EQS	0.01	UK DWS
Tin					0.025	Annex G EQS	0.01	Annex G EQS		
Vanadium	3160	LQM ed. 2			0.02	Annex G EQS	0.1	Annex G EQS		
Zinc	6.65×105	LQM ed. 2			0.008 - 0.125(a)	Annex G EQS	0.04	Annex G EQS	3	WHO taste threshold
INORGANICS										
Free cyanide		SGV old			0.001 (free)	Annex G EQS	0.001 (free)	Annex G EQS	0.05(total)	EU DWS
Ammonia					0.2 - 0.6 (alkalinity dependant)	proposed UKTAG	0.021	proposed UKTAG	0.5	UK DWS
Bromate									0.01	UK DWS
Sulphate									250	UK DWS
Nitrates									50	EU DWS
Chlorine					0.002	proposed UKTAG	0.001 (short term)	proposed UKTAG	5	WHO
pH					6.0 - 9.0	Annex G EQS			6.5 - 8.5	US EPA (SDWR)
ORGANICS										
ORGANOMETALS										
Triphenyltin					0.00002	Annex G EQS	0.000008	Annex G EQS		
Tributyl tin (oxide)	130 s	CL:AIRE			0.0000002	EU standard	0.0000002	EU standard		
Hydrocarbons										
BTEX										
Benzene	106	CLEA 1.06			0.01	Annex G EQS	0.008	Annex G EQS	0.001	UK DWS
Ethylbenzene	566	CLEA 1.06			0.02	Annex G EQS	0.02	Annex G EQS	0.3	WHO DW
Toluene	1030	CLEA 1.06			0.074	proposed UKTAG	0.074	proposed UKTAG	0.7	WHO DW
P-xylene	629	CLEA 1.06			0.03 (all isomers)	Annex G EQS	0.03 (all isomers)	Annex G EQS	0.5	WHO DW
TPH										
Aliphatic 5-6	3400 (304) s	LQM ed. 2			0.02		0.02		0.3	
Aliphatic 6-8	8300 (144) s	LQM ed. 2			0.02	Ethylbenzene EQS used as surrogate	0.02	Ethylbenzene EQS used as surrogate	0.3	WHO DWS for C8-C16
Aliphatic 8-10	2100 (78) s	LQM ed. 2			0.02		0.02		0.3	
Aliphatic 10-12	10000 (48) s	LQM ed. 2			0.02		0.02		0.3	
Aliphatic 12-16	61000 (24) s	LQM ed. 2			0.02		0.02		0.3	WHO DWS
Aliphatic 16-35	1.6×106	LQM ed. 2			NV insoluble	TPHCWG	NV insoluble	TPHCWG	NV insoluble	TPHCWG
Aliphatic 35-44	1.6×106	LQM ed. 2			NV insoluble	TPHCWG	NV insoluble	TPHCWG	NV insoluble	TPHCWG
Aromatic 5-7 (waters 6-7)	n/a	LQM ed. 2			0.01	benzene EQS	0.008	benzene EQS	0.001	UK DWS for benzene
Aromatic 7-8 (waters7-8)	n/a	LQM ed. 2			0.05	toluene EQS	0.04	toluene EQS	0.7	WHO DWS for toluene
Aromatic 8-10	3700 (613) v	LQM ed. 2			0.02		0.02		0.3	WHO DWS for ethyl benzene
Aromatic 10-12	17000 (364) s	LQM ed. 2			0.02		0.02		0.1	WHO DWS
Aromatic 12-16	36000 (169) s	LQM ed. 2			0.02	ethlybenzene EQS as a surrogate	0.02	ethlybenzene EQS as a surrogate	0.1	WHO DWS
Aromatic 16-21	28000	LQM ed. 2			0.02		0.02		0.09	WHO DWS
Aromatic 21-35	28000	LQM ed. 2			0.02		0.02		0.09	WHO DWS
Aromatic 35-44	28000	LQM ed. 2			0.02		0.02		0.09	WHO DWS
PAH (US EPA-16)										
Acenaphthene	85000 (57) s	LQM ed. 2			NV		NV			
Acenaphthylene	84000 (86) s	LQM ed. 2			NV		NV			
Anthracene	5.3×105	LQM ed. 2			0.0001	EU standard	0.0001	EU standard		
Benzo(a)anthracene	90	LQM ed. 2			0.00005	B(a)P threshold	0.00005	B(a)P threshold		
Benzo(a)pyrene	14	LQM ed. 2			0.00005	EU standard	0.00005	EU standard	0.00001	EU DWS
Benzo(b)fluoranthene	100	LQM ed. 2								
Benzo(k)fluoranthene	140	LQM ed. 2			0.00003(sum)	EU standard	0.00003(sum)	EU standard	0.0001 (sum)	EU DWS
Benzo(ghi)perylene	650	LQM ed. 2								
Indeno(123-cd)pyrene	60	LQM ed. 2			0.000002(sum)	EU standard	0.000002 (sum)	EU standard		
Chrysene	140	LQM ed. 2			NV		NV			
Dibenzo(ah)anthracene	13	LQM ed. 2			0.00005	B(a)P threshold	0.00005	B(a)P threshold		
Fluoranthene	23000	LQM ed. 2			0.0001	EU standard	0.0001	EU standard		
Fluorene	64000 (31) s	LQM ed. 2			NV		NV			
Naphthalene	200 (76) s	LQM ed. 2			0.0024	EU standard	0.0012	EU standard		
Phenanthrene	22000	LQM ed. 2			NV		NV			
Pyrene	54000	LQM ed. 2								
OTHER (unchlorinated)										
Phenol	36000	CLEA 1.06			0.0077	proposed UK TAG	0.0077	proposed UK TAG		
MTBE	7900	CL:AIRE			0.015	EA report MTBE			0.015	EA report MTBE
Carbon disulphide	12	LQM ed. 2								
Styrene	3300 (626) s	CL:AIRE			0.05	Annex G EQS	0.05	Annex G EQS	0.02	WHO DW

Key	
s ( )	The assessment criterion exceeds the solubility of the hydrocarbon fraction (where the solubility limit is lower than the vapour limit). This means that the GAC cannot be correctly calculated. The fraction will not pose a significant risk. However, it is considered reasonable to use the GAC as it would be unrealistic to curtail the GAC to the solubility limit (the value in brackets). However, qualitative assessment should be done to determine if FREE-PHASE is a problem if these limits are exceeded. See Section 4.12 in the EA CLEA Software (1.05) Handbook.
v ( )	The assessment criterion exceeds the vapour limit of the hydrocarbon fraction (where the vapour limit is lower than the solubility limit). This means that the GAC cannot be correctly calculated. The fraction will not pose a significant inhalation risk. However, it is considered reasonable to use the GAC as it would be unrealistic to curtail the GAC to the volatility limit (the value in brackets). However, qualitative assessment should be done to determine if FREE-PHASE is a problem if these limits are exceeded. See Section 4.12 in the EA CLEA Software (1.05) Handbook.
**	SGV curtailed at saturation limit (conservative assumption – chemicals unlikely to pose a significant risk at any concentration).
*	Residential without Plant Uptake GACs derived by WAF by modifying the default EA model

Contaminant	Material Selection threshold Level mg/kg	Source
corrosion metal pipes		
sulphate	2000	WRAS
sulphur	5000	WRAS
sulphide	250	WRAS
pH	<5, > 8	WRAS
toxic substances		
antimony	10	WRAS
arsenic	10	WRAS
cadmium	3	WRAS
chromium (hexavalent)	25	WRAS
chromium (total)	600	WRAS
cyanide (free)	25	WRAS
cyanide (complex)	250	WRAS
lead	500	WRAS
mercury	1	WRAS
selenium	3	WRAS
thiocyanate	50	WRAS

Contaminant		Material Selection threshold Level mg/kg	Source
Chlorinated Phenols	chlorophenol	0.5	United Utilities
	dichlorophenol	0.5	United Utilities
	trichlorophenol	0.5	United Utilities
	2,4,6-trichlorophenols	0.5	United Utilities
	pentachlorophenol	0.5	United Utilities
	Total	**1**	United Utilities
Chlorinated aliphatic hydrocarbons	dichloromethane	1	United Utilities
	trichloromethane	5	United Utilities
	tetrachloromethane	0.15	United Utilities
	chloroethane	0.2	United Utilities
	dichloroethane	0.2	United Utilities
	trichloroethane (TCA)	1	United Utilities
	tetrachlorethane	0.5	United Utilities
	chloroethene	0.1	United Utilities
	dichloroethene (DCE)	1.5	United Utilities
	trichloroethene (TCE)	1.5	United Utilities
	tetrachloroethene (PCE)	0.5	United Utilities
	Total	**7**	United Utilities
Chlorinated Aromatic hydrocarbons	chlorobenzene	0.4	United Utilities
	dichlorobenzene	0.01	United Utilities
	trichlorobenzene	0.5	United Utilities
	tetrachlorobenzene	0.5	United Utilities
	pentachlorobenzene	1	United Utilities
	Total	**2**	United Utilities
PAH	Napthalene	5	United Utilities
	Anthracene	10	United Utilities
	Phenanthrene	10	United Utilities
	Fluoroanthene	10	United Utilities
	Pyrene	10	United Utilities
	benzo(a)pyrene	1	United Utilities
	Tota USEPA 16	**20**	United Utilities
Hydrocarbon (aromatic and aliphatic)	Total C6 to C21	100	United Utilities
	Total > C21	1000	United Utilities
Miscellaneous	Total Dioxins / Furans	1	United Utilities
	Styrene	5	United Utilities
	Pyridine	2	United Utilities
	cyanide (Free)	10	United Utilities
	Cyanide (Complex)	50	United Utilities
	Arsenic	20	United Utilities
	pH	between 4 and 10	United Utilities
	sulphates chlorides	7500mg/kg dry soil	United Utilities
	chlorides	7500 mg/kg dry soil	United Utilities

Planting

The following table gives the **ICRCL trigger soil concentration** thresholds for four phytotoxic determinands. These ICRCL values are for a soil pH of approximately 6.5.

Boron	3mg/kg
Copper	130mg/kg
Nickel	70mg/kg
Zinc	300mg/kg

The following table gives **BS388:2007** soil concentrations for three phytotoxic determinands at the stated pH range

pH			**< or = 6**	**6 to 7**	**> 7**
zinc (nitric acid extract) mg/kg dry sample			<200	<200	<300
copper (nitric acid extract) mg/kg dry sample			<100	<135	<200
nickel (nitric acid extract) mg/kg dry sample			<60	<75	<110

The following table gives thresholds presented in the **1998 MAFF** document for eleven phytotoxic determinands at the stated pH range

pH	**5 to 5.5**	**5.5 to 6**	**6 to 7**	**>7**	
zinc mg/kg	200	200	200	300	
copper mg/kg	80	100	135	200	
nickel mg/kg	50	60	75	110	
pH	**> 5**				
cadmium	3				
lead	300				
mercury	1				
chromium	400				
molybdenum	4				
selenium	3				
arsenic	50				
fluoride	500				

APPENDIX 6:

SLAB ADEQUACY CHECK DESIGN CALCULATIONS

CONCRETE INDUSTRIAL GROUND FLOOR DESIGN TO TR34 THIRD EDITION

TEDDS calculation version 1.0.04

Slab details

Slab description; **Slab**

Slab type; **Fabric reinforced**

Slab thickness; h = **220** mm (average)

Reinforcement details

Characteristic strength of steel; f_y = **500** N/mm^2 (based upon 2001-2006 Build)

Fabric reinforcement to bottom of slab; **A252**

Area of reinforcement in each direction; A_s = **252** mm^2/m

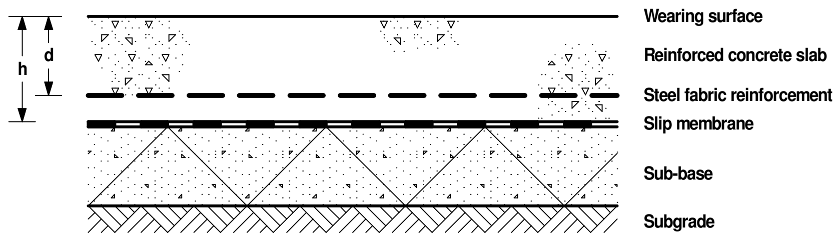
Percentage of reinforcement provided; $A_{s\_percent} = A_s / h$ = **0.115**%

Reinforcement is within recommended limits

Diameter of reinforcement; ϕ_s = **8** mm

Depth of nominal cover to reinforcement; c_{nom} = **50** mm (assumed)

Average effective depth of reinforcement; $d = h - c_{nom} - \phi_s$ = **162** mm



Strength properties for concrete from table 9.1

Characteristic compressive strength (cube); f_{cu} = **35** N/mm^2

Characteristic compressive strength (cylinder); f_{ck} = **28** N/mm^2

Mean compressive strength (cylinder); $f_{cm} = f_{ck} + 8$ N/mm^2 = **36** N/mm^2

Mean axial tensile strength; $f_{ctm} = 0.3$ N/mm$^2 \times (f_{ck} / 1$ N/mm$^2)^{2/3}$ = **2.8** N/mm^2

Characteristic axial tensile strength (5% fractile); $f_{ctk\_0.05} = 0.7 \times f_{ctm}$ = **1.9** N/mm^2

Secant modulus of elasticity; $E_{cm} = 22000$ N/mm$^2 \times (f_{cm} / 10$ N/mm$^2)^{0.3}$ = **32** kN/mm^2

Characteristic flexural strength of concrete; $f_{ctk\_fl} = \min(2, [1 + (200 \text{ mm} / h)^{1/2}]) \times f_{ctk\_0.05}$ = **3.8** N/mm^2

$k_1 = 1 + (200 \text{ mm} / d)^{1/2}$ = **2.1**

Minimum shear strength of concrete; $v_{Rd\_ct} = 0.035$ N/mm$^2 \times k_1^{3/2} \times (f_{ck} / 1$ N/mm$^2)^{1/2}$ = **0.6** N/mm^2

Subgrade construction

Modulus of subgrade reaction; k = **0.030** N/mm^3 (most onerous condition, silted clay)

Partial safety factors

Bar and fabric reinforcement; γ_s = **1.15**

Reinforced concrete; γ_c = **1.50**

Permanent actions; γ_G = **1.20**

Variable actions; γ_Q = **1.50**

Dynamic actions; γ_D = **1.60**

Properties of reinforced slabs

Allowance for restraint stresses; f_{rest} = **1.5** N/mm^2

Negative moment capacity; $M_n = (f_{ctk\_fl} - f_{rest}) \times h^2 / (6 \times \gamma_c)$ = **12.3** kNm/m

Positive moment capacity; $M_p = \min(0.95 \times A_s \times f_y \times d / \gamma_s, M_n)$ = **12.3** kNm/m

Poisson's ratio; $\nu = 0.2$

Radius of relative stiffness; $l = [E_{cm} \times h^3 / (12 \times (1 - \nu^2) \times k)]^{1/4}$ = **0.999** m

Characteristic of system; $\lambda = [3 \times k / (E_{cm} \times h^3)]^{1/4}$ = **0.715** m^{-1}

Conveyor Pt Load - Internal point load

Loading details

Number of point loads; N = **1**

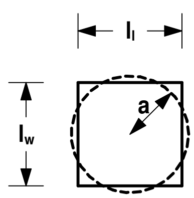
Permanent point load; G_k = **100** kN

Variable point load; Q_k = **0** kN

Dynamic point load; D_k = **0** kN

Length of loaded area; l_l = **300** mm

Width of loaded area; l_w = **300** mm



Calculate contact radius ratio

Equivalent contact radius of single load; $a = \sqrt{[(l_l \times l_w) / \pi]}$ = **169** mm

Radius ratio; a / l = **0.169**

Ultimate capacity under single internal concentrated load

For a / l = 0; $P_{u\_0} = 2 \times \pi \times (M_p + M_n)$ = **154.3** kN

For a / l = 0.2; $P_{u\_0.2} = 4 \times \pi \times (M_p + M_n) / [1 - (a / (3 \times l))]$ = **327.0** kN

Thus for a / l = 0.169; $P_u = P_{u\_0} + (P_{u\_0.2} - P_{u\_0}) \times (a / (l \times 0.2))$ = **300.6** kN

Check ultimate load capacity of slab

Loading applied to slab; $F_{uls} = F = N \times [(G_k \times \gamma_G) + (Q_k \times \gamma_Q) + (D_k \times \gamma_D)]$ = **120.0** kN

PASS - Ultimate capacity of slab is adequate for internal loads

Punching shear at the face of the loaded area

Design concrete compressive strength (cylinder); $f_{cd} = f_{ck} / \gamma_c$ = **19** N/mm^2

Shear factor; $k_2 = 0.6 \times [1 - (f_{ck} / 250\ \text{N/mm}^2)]$ = **0.53**

Length of perimeter at face of loaded area; **$u_0 = 2 \times (l_l + l_w)$ = 1200 mm**

Shear stress at face of contact area; $v_{max\_f} = 0.5 \times k_2 \times f_{cd}$ = **4.973** N/mm^2

Maximum load capacity in punching; $P_{p\_max} = v_{max\_f} \times u_0 \times d$ = **966.7** kN

PASS - Maximum load capacity in punching shear at face of loaded area is adequate for internal loads

Punching shear at the critical perimeter

Shear factor; $k_1 = \min(1 + (200\ \text{mm} / d)^{0.5}, 2)$ = **2.00**

Ratio of reinforcement by area in x-direction; $\rho_x = A_s / d =$ **0.002**

Ratio of reinforcement by area in y-direction; $\rho_y = A_s / d =$ **0.002**

Reinforcement ratio; $\rho_1 = \sqrt{(\rho_x \times \rho_y)} =$ **0.002**

Maximum shear stress at 2d from face of load; $v_{max\_2d} = 0.035 \times k_1^{3/2} \times (f_{ck} / 1\ N/mm^2)^{1/2} \times 1\ N/mm^2$

$v_{max\_2d} =$ **0.524** N/mm^2

Length of perimeter at 2d from face of load; $\mathbf{u_1 = 2 \times (l_l + l_w + 2 \times d \times \pi) = 3236\ mm}$

Maximum load capacity in punching at 2d from face; $P_p = v_{max\_2d} \times u_1 \times d =$ **274.6** kN

PASS - Maximum load capacity in punching shear at 2d from face of loaded area is adequate for internal loads

Deflection of the slab

Serviceability limit state load; $F_{sls} = N \times (G_k + Q_k + D_k) =$ **100** kN

Deflection coefficient; $\mathbf{c = 0.125}$

Deflection of the slab; $\delta = c \times [F_{sls} / (k \times l^2)] =$ **0.42** mm

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