



Geopost, Sugarbrook Drive, Liverpool

Phase 2 Land Quality Assessment

Final Report for



October 2014

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Executive Summary and Conceptual Site Model

SITE INFORMATION AND SETTING	Report Purpose	Phase 2 Land Quality Assessment.
	Client	St Modwen Developments Ltd
	Site	Geopost - Sugarbrook Drive, Stonebridge Industrial Estate, Liverpool.
	Site Location	Off Sugarbrook Drive, Liverpool, L10 4UT at approximate National Grid Reference is 339014E, 395058N.
	Current Land Use and Description	The site consists of an area of open land which has been filled to create a development platform. Sugarbrook Drive is present on the northern part of the site. Drainage ditches are present along the northern and southern site boundaries and a large bund is present off-site to the north of the road.
	Development	The proposed development is to comprise a warehouse with offices and car, van and HGV parking.
PHASE 1 (DESK STUDY)	Site History	The map evidence indicates the site has been open land since the 1850s, with exception of a building and two ponds noted on the 1851 map, a tank on the northern boundary of the site from 1925 to 1955 and Sugarbrook Drive, which was constructed along the northern part of the site in approximately 2007. A sewage works was constructed north of the site in the late 1800s. Associated filter beds, settling beds and tanks have been constructed approximately 50m north of the site since.
	Unexploded Ordnance	In accordance with CIRIA C681, Chapter 5, a preliminary desk study was undertaken for the site. This indicates the site has a low UXO risk.
	Geology	The natural soils comprise Till (Glacial deposits usually of sandy, silty clay with pebbles) and Shirdley Hill Sand Formation (white or grey brown sand with peat layers in the lower part), over Wilmslow Sandstone Formation (red-brown to brick red sandstone). It is anticipated that between 0.5m and 2.0m of Made Ground will be present on site as result of filling operations to create the existing development platform.
	Hydrogeology	The Wilmslow Sandstone Formation is classified as a Principal Aquifer and the Shirdley Hill Sand Formation is classified as a Secondary A Aquifer. The site is located within a Zone 3 Source Protection Zone (SPZ) for a potable water supply over 1.5km from the site. There are no groundwater abstractions within 1km of the site.
	Hydrology	A lake is located along the southern boundary of the site and two drains run along the southern and eastern boundaries of the site into Sugar Brook. Sugar Brook flows 20m east of the site into the River Alt 500m northeast of the site. There are no surface water abstractions within 1km of the site.
	Previous Site Data	Historical ground investigations were undertaken by CC Geotechnical for JMP Consultants/Liverpool Land Development Company in April 2004 and RSK post filling of the site. The CC Geotechnical works comprised: <ul style="list-style-type: none"> • 3 cable percussive boreholes to a maximum depth of 15.0m bgl; • 10 trial pits to a maximum depth of 3.0m bgl; and • laboratory testing. The RSK works comprised: <ul style="list-style-type: none"> • 8 window sample boreholes to a maximum depth of 3.0m bgl; • 11 trial pits to a maximum depth of 3.0m bgl; and • laboratory testing. Where appropriate the data from these ground investigations are used alongside Hydrock data. However it should be noted the RSK report is a photocopied copy and the borehole location plan is not legible.



PHASE 2 – GROUND INVESTIGATION	Hydrock Site Works	<p>The Hydrock Ground investigation comprised:</p> <ul style="list-style-type: none"> • 6 window sample boreholes to a maximum depth of 4.0m bgl; • 26 trial pits to a maximum depth of 3.5m bgl; • 6 gas and groundwater installations; and • chemical testing of the soils and groundwater.
	Findings of the Ground Investigation	<p>The geology of the site (from ground level, down) comprises:</p> <ul style="list-style-type: none"> • Made Ground (fill) – to depths between 0.8 and >3.2m bgl, comprising two general types: very soft to soft grey to black sandy silt/clay with rootlets; over soft black to dark brown sandy gravelly clay/silt with gravel of brick, concrete, wood, plastic and metal. • Glacial Till – comprising brown fine sand, green grey silty sand with occasional lignite and firm to stiff (occasionally soft) red brown gravelly clay with gravel of silty sandstone. <p>Groundwater was encountered during site works and in subsequent monitoring within the Glacial Till. Groundwater levels have varied between 0.98m and 3.43m bgl during monitoring. There were occasional petroleum hydrocarbon odours within the Made Ground.</p>
ASSESSMENT AND CONCLUSIONS	Conclusions of Contamination Generic Risk Assessment	<p>Human health: The site is not considered a risk to human health.</p> <p>Plant growth: Slightly elevated copper and zinc within Made Ground soils. However, Hydrock does not consider the site poses a risk to plant life.</p> <p>Controlled Waters: Exceedances of heavy metals and ammonium were recorded within the groundwater. However, as there are no exceedances of heavy metals within soils at the site Hydrock believes the source is external of the site and does not pose a risk to Controlled Waters.</p> <p>Human health / property from ground gases:</p> <ul style="list-style-type: none"> • No radon protective measures are necessary according to current guidance. • Low to moderate risk from methane is present and CS2 conditions apply and mitigation is considered necessary.
	Outline Contamination Remediation Strategy	<p>Subject to approval, the following remedial strategy is considered necessary:</p> <ul style="list-style-type: none"> • the use of topsoil growing medium in areas of soft landscaping (300mm); • installation of ground gas protection measures to comply with Characteristic Situation 2 Classification during construction of buildings; and • verification reporting of remediation by a suitably qualified independent engineer.
	Construction Materials and Water Supply Pipework	<p>The site is brownfield and there is a presumption in the guidance that barrier pipe will be used. However, the investigation and assessment has indicated no significant Contaminants of Concern and as such standard pipework may be suitable for the site following negotiations with the supply company. However for site planning purposes and budgeting it is recommended that barrier pipe provision is assumed pending liaison with the supply company.</p>
	Flood Risk	<p>No assessment has been made regarding flood risk. See Hydrock Report R/14493/F001 for a detailed Flood Risk Assessment.</p>
FUTURE CONSIDERATIONS	Further Work	<p>The following further works will be required:</p> <ul style="list-style-type: none"> • discussions with service providers regarding the materials suitable for pipework etc.; • agreement and verification regarding the conclusions of this report with the regulatory bodies; • installation of gas mitigation measures; and • verification of the remedial works.

This Executive Summary forms part of Hydrock Consultants Limited report number R/14493/G003 (Issue 2) and should not be used as a separate document.



1.0 INTRODUCTION

1.1 Terms of Reference

In June 2014, Hydrock Consultants Limited (Hydrock) was commissioned by St Modwen Developments Ltd to undertake a ground investigation at Geopost, Sugarbrook Drive, Stonebridge Industrial Estate, Liverpool. A Phase I Desk Study for the site is reported in R/14493/G001.

The site covers approximately 2.88 ha and is currently open land.

The proposed development is to comprise a warehouse with offices and parking for cars, vans and HGVs.

A site location plan (Drawing 14493/D001), a site zonation plan (Drawing 14493/D002) and a proposed development layout (Stephen George and Partners LLP - 'Stonebridge Industrial Estate - Site Plan') are presented in Appendix A.

1.2 Objectives

The objectives of this investigation are to assess the near surface ground and groundwater conditions, with particular reference to the recently placed fill, to provide a risk assessment of potential chemical contaminants to establish 'suitability for use' under the current planning regime.

1.3 Scope

The scope of work for this commission comprises:

- a summary of the Phase I investigation and preliminary conceptual site model;
- an intrusive ground investigation including trial pitting, window sampling, TRL dynamic probing, gas and groundwater monitoring and laboratory chemical testing; and
- reporting on the findings of the desk study, ground investigation and a geo-environmental assessment of the site conditions.

See Appendix D for detailed reporting methodology.

1.4 Provided Information

The following has been provided to Hydrock by St Modwen for use in the preparation of this report:

- Stephen George and Partners LLP. 4th June 2014. 'Stonebridge Industrial Estate - Site Plan'. Drawing No. P002 Rev C.
- Greenhatch Group. 30th June 2014. 'Utility Survey'. Drawing No. 20361 OGL.
- RSK Geoconsult Limited. 1st June 2007. 'Site Investigation, Stonebridge Business Park, Fazakerley, Liverpool'. Report No. 10930-R2.



It should be noted that the information provided within this report has been designed to supplement the above and therefore the two datasets should be read in conjunction.



2.0 PRELIMINARY CONCEPTUAL SITE MODEL

A Phase I Desk Study has been produced for the site and is reported in Hydrock Report R/14493/G001.

2.1 Preliminary Ground Model

The findings of the Phase 1 investigation indicate that the site comprises an area of open land which has been filled to provide a development platform. Sugarbrook Drive runs along the northern edge of the site. Drainage ditches are present along the southern and eastern boundaries of the site, flowing into Sugar Brook, which in turn flows into the River Alt, 500m northeast of the site. A lake is present south of the site.

The natural soils comprise Glacial Till (usually of sandy, silty clay with pebbles) and the Shirdley Hill Sand Formation (white or grey brown sand with peat layers in the lower part). These overlie the Wilmslow Sandstone Formation (red-brown to brick red sandstone).

The Shirdley Hill Sand Formation is classified as a Secondary A Aquifer and the Wilmslow Sandstone Formation as a Principal Aquifer.

It is understood that up to 2.0m of fill had been placed at some point after 2007 in order to raise site levels and create a development platform. However, no information has been provided with regards to the quality or expected performance of this material.

The site is located within a Zone 3 Source Protection Zone (SPZ) for a potable water supply over 1.5km from the site. It is presumed that the abstraction is from the Wilmslow Sandstone Formation. There are no groundwater abstractions within 1km of the site.

The proposed development is to comprise a warehouse with offices and car, van and HGV parking.

The main details of the site and potential hazards are summarised on the Site Zonation Plan (Appendix A).

2.2 Preliminary Exposure Model

The preliminary exposure model is used for geo-environmental hazard identification and establishing potential contaminant linkages in line with the Statutory Guidance to Part 2A of the Environmental Protection Act 1990, also known as 'potential pollution linkages' in the Model Procedures of CLR11 (Environment Agency, 2004). This is based on the contaminant-pathway-receptor linkage approach.

2.2.1 Potential Contaminants

For the purpose of this assessment the potential contaminants have been separated according to whether they are likely to have originated from on-site or off-site sources.



Potential On-Site Sources of Contamination

- Made Ground (of unknown origin), possibly including metals, metalloids, asbestos, PAH and petroleum hydrocarbons.
- Ground gases (gases carbon dioxide and methane) from organic materials present in the Made Ground/Fill.

Potential Off-Site Sources of Contamination

The petrol filling station 100m southeast of the site and sewage works to the northeast are considered to be too distant from the site to pose a significant contamination risk. On this basis, no off-site sources are identified.

2.2.2 Potential Receptors

The following potential receptors are identified:

- Humans (site end users, neighbours).
- Development end use (buildings, utilities and landscaping).
- Groundwater: Wilmslow Sandstone (Principal aquifer) and Shirdley Hill Sand Formation (Secondary A aquifer).
- Surface water: on-site drainage ditches and lake to the south.

It should be noted that health and safety risks to Contractors have not been assessed during these works and will need to be considered separately.

2.2.3 Potential Pathways

The following potential pathways are identified:

- Humans: ingestion, skin contact, inhalation of dust and outdoor air.
- Buildings: methane ingress via permeable soils and/or construction gaps.
- Underlying groundwater: migration of contaminant via leachate dispersion through the unsaturated zone in the superficial deposits.
- Underlying groundwater: migration of contaminant into the aquifers.
- Surface water: overland flow.
- Surface water: drainage discharge.
- Surface water: base flow from groundwater.



3.0 GROUND INVESTIGATION

3.1 Investigation Rationale

The ground investigation rationale based on the findings of the preliminary risk assessment is summarised in Table 3.1.

Table 3.1: Investigation Rationale

Exploratory Holes	Purpose
WS01-06	To assess the near surface ground conditions and allow SPTs and samples for geotechnical characterisation. To allow collection of samples for contamination testing. Installation of gas and leachate wells. Generally placed within proposed building boundary.
TP 01-26	To assess shallow ground conditions. To allow collection of samples for contamination and geotechnical testing. To allow soil infiltration rate testing (TP04, 13, 16, 23, 24). No formal grid pattern.

3.2 Site Works

The position of site investigation locations are shown on the Ground Investigation Plan in Appendix B.

The site works undertaken for this investigation are summarised in Table 3.2. The logs, including details of ground conditions, soil sampling, *in-situ* testing and any installations, are presented in Appendix B.

Table 3.2: Summary of Site Works

Activity	Method	No.	Max. / Range Depth	In Situ Tests	Installations / Notes
Drilling, Pitting and Probing					
Boreholes	Dynamic Percussive Sampling (Terrier 2000)	6	4.00m	SPT	63mm HDPE wells with gas taps in 6 holes
Trial pits	Machine (JCB 3X)	26	3.50m	-	-
Other In Situ Testing or Monitoring					
CBR	TRL DCP	32		Dynamic probing	-
Soakaway	BRE Digest 365	5	2.00m	Soil infiltration rate	In TPs 04, 13, 16, 23 and 24.



3.3 Geo-Environmental Testing

3.3.1 Sampling Strategy and Protocols

The locations of the investigatory holes were determined by reference to the conditions identified in the preliminary risk assessment. No specific sampling statistics or grid were utilised in this instance.

The dataset comprises:

- 29 samples from the Made Ground at between 0.1m and 1.8m; and
- 2 samples from the natural deposits at between 2.4m and 2.6m bgl.

Samples were taken stored and transported in general accordance with BS 10175:2011+A1:2013.

3.3.2 Monitoring

Gas and groundwater monitoring boreholes were monitored on 3 occasions. The results are presented in Appendix C.

3.3.3 Laboratory Analyses

The findings of the preliminary risk assessment have been used to scope the analyses of chemicals of potential concern as follows.

The following were performed on samples of soil:

- 20 Hydrock default suite of determinands for solids comprising: As, B (water soluble), Be, Cd, Cr (III), Cr(VI), Cu, Hg (inorganic), Ni, Pb, Se, V, Zn, cyanide (free), pH, asbestos screen, speciated polycyclic aromatic hydrocarbons (PAH, by GC-MS), total phenols and fraction of organic carbon. Note: SO₄ is included within the geotechnical testing schedule. See Appendix C for details; and
- 4 total petroleum hydrocarbons by GC-FID (Hydrock Level 2 suite comprising aliphatic / aromatic split and the following carbon banding: aliphatic - EC5-EC6, >EC6-EC8, >EC8-EC10, >EC10-EC12, >EC12-EC16, >EC16-EC35, aromatic - EC5-EC7, >EC7-EC8, >EC8-EC10, >EC10-EC12, >EC12-EC16, >EC16-EC21, >EC21-EC35 plus BTEX and MTBE by GC-MS).

The following were performed on samples of water:

- 3 Hydrock default waters suite of determinands comprising: Ag, Al, As, B, Ba, Cd, Co, Cr (III), Cr(VI), Cu, Fe, Hg, Mn, Mo, Na, Ni, Pb, Sb, Se, Sn, Zn, V, cyanide (free and total), phenols (total), ammonium, bromate, chloride, fluoride, nitrate, nitrite, sulfate, PAH (speciated), pH, EC and hardness; and
- 3 total petroleum hydrocarbons by GC-FID (Hydrock Level 2 suite comprising aliphatic / aromatic split and the following carbon banding: aliphatic - EC5-EC6, >EC6-EC8, >EC8-EC10, >EC10-EC12, >EC12-EC16, >EC16-EC35, aromatic - EC5-EC7, >EC7-EC8, >EC8-EC10, >EC10-EC12, >EC12-EC16, >EC16-EC21, >EC21-EC35 plus BTEX and MTBE by GC-MS).

The chemical test results are provided in Appendix E.



4.0 GROUND INVESTIGATION DATA

4.1 Physical Ground Conditions

The ground conditions over the entire site as proven during the current works are in general accordance with the published geological literature and expectations from the desk study and previous investigation works on the site. The underlying Wilmslow Sandstone Formation was not encountered.

Details are provided in the logs in Appendix B, a summary is presented in Table 4.1 and the individual strata are described in the sections below. Relevant contour plans are presented in Appendix A.

Table 4.1: Strata Encountered

Stratum Description	Depth to Top (m bgl)	Depth to Base (m bgl)	Thickness (m)
Made Ground (fill) – comprising very soft to soft silt and clay and clayey gravelly sand.	Ground Level	0.8 - >3.2	0.8 - >3.2
Glacial Till – comprising sand or firm to stiff gravelly clay.	0.8 – 3.2	Base not proven	Base not proven

4.1.1 Made Ground (Fill)

Fill was encountered in all locations to depths of between 0.8m and >3.2m bgl. In general, there are two main types of Made Ground:

- very soft to soft grey to black sandy silt/clay with rootlets;
- soft black to dark brown sandy gravelly clay/silt with gravel of brick, concrete, wood, plastic and metal with occasional clinker; and
- brown to dark brown clayey gravelly sand with cobbles of brick and concrete and gravel of brick, wood, quartz, granodiorite, concrete, plastic and tile.

4.1.2 Glacial Till

Glacial Till was encountered in almost all locations, except where the fill or sand deposits were exceptionally deep. It comprised three types, red/orange brown fine sand, green grey silty sand with occasional lignite and firm to stiff (occasionally stiff) red brown gravelly clay with gravel of silty sandstone.

The previous investigation recorded a greater presence of sand deposits across the site. Hydrock believe that sand may have been removed off site before the fill was placed.

4.2 Visual and Olfactory Evidence of Contamination

There were a number of trial pits where, in addition to the more common man-made constituents described above, visual and olfactory evidence of contamination were encountered.



These intrusive locations are summarised in Table 4.2, with this information presented on the Site Zonation Plan in Appendix A.

Table 4.2: Visual and Olfactory Evidence of Contamination from Hydrock Investigations

Exploratory Hole	Depth	Description	Stratum
TP02	1.5m	Hydrocarbon odour.	Made Ground.
TP09	0.7m	Hydrocarbon odour.	Made Ground.
TP17	1.4m	Hydrocarbon odour.	Made Ground.
TP22	0.9m	Hydrocarbon odour.	Made Ground.

4.3 Groundwater

4.3.1 Groundwater Strikes

Groundwater strikes encountered during the investigation are summarised in Table 4.3.

Table 4.3: Groundwater Strikes

Borehole	Date	Depth to Groundwater (m bgl)	Ground Level (mOD)	Groundwater Elevation (mOD)
TP03	10/07/14	1.4	18.89	17.49
TP05		0.9	18.55	17.65
TP22	09/07/14	2.5	18.69	16.19
TP25	11/07/14	2.8	17.94	15.14
WS01	10/07/14	1.5	18.86	17.36
WS03	10/07/14	3.3	18.95	15.62
WS06	11/07/14	2.8	18.34	15.54

4.3.2 Groundwater Levels

Groundwater records from piezometers or wells obtained during subsequent monitoring visits are given in Appendix C and are summarised in Table 4.4.

Table 4.4: Groundwater Monitoring Summary

Borehole	Date Range	Depth to Groundwater (m bgl)	Ground Level (mOD)	Groundwater Elevation (mOD)	Stratum
WS01	24/07/14 – 07/08/14	0.98 – 1.13	18.86	17.73 – 17.88	Glacial Till
WS02		0.78 – 2.37	18.42	16.05 – 17.64	Glacial Till
WS03		1.75 – 1.82	18.95	17.13 – 17.20	Glacial Till
WS04		0.23 – 3.43	18.13	14.70 – 17.9	Glacial Till



Borehole	Date Range	Depth to Groundwater (m bgl)	Ground Level (mOD)	Groundwater Elevation (mOD)	Stratum
WS05		0.95 – 3.29	18.80	15.51 – 17.85	Glacial Till
WS06		2.37 – 2.39	18.34	15.95 – 15.97	Glacial Till

4.4 Geo-Environmental Results

The chemical test results for soil, leachate and groundwater are given in Appendix E, which also includes summary tables of the data.

4.5 Ground Gases (Carbon Dioxide and Methane)

Records from the gas monitoring boreholes are summarised in Appendix C.

The data indicates:

- methane concentrations of between <0.1% v/v and 6.8% v/v;
- carbon dioxide concentrations of between 0.2% v/v and 6.6% v/v;
- oxygen concentrations of between 3.2% v/v and 20.7% v/v; and
- gas flow measurements indicated emission rates of <0.1l/hr.



5.0 PRELIMINARY RISK ASSESSMENT

5.1 Updated Ground Model

The preliminary conceptual site model initially developed from the desk study and walk-over survey (Hydrock Report R/14493/G001) has been updated using the findings of the ground investigation. Contour plans marking the depth to Made Ground are presented in Hydrock Drawing 14493/D008. The main features of the site are summarised on the Site Zonation Plan (Appendix A).

Made Ground (Fill) is present across the site to depths of between 0.8m and >3.2m bgl. It comprised very soft to soft grey to black sandy silt/clay with rootlets, over soft black to dark brown sandy gravelly clay/silt with gravel of brick, concrete, wood, plastic and metal with occasional clinker.

This overlies the Shirdley Hill Sand Formation sporadically in the central and east of the site. It comprises red/orange brown fine sand and green grey silty sand with occasional lignite.

The Shirley Hill Formation, or where absent the Made Ground, overlies Glacial Till comprising red/orange brown fine sand, green grey silty sand with occasional lignite and firm to stiff red brown gravelly clay with gravel of sandstone.

The Wilmslow Sandstone Formation was not encountered during these site works. Previous works on an adjacent site have encountered the Wilmslow Sandstone Formation at between 10.60m and 21.0m OD (current site works were terminated at between 14.1m and 17.0m OD).

Groundwater was encountered during site works and in subsequent monitoring within the Glacial Till. Groundwater levels have varied between 14.70m and 17.88m OD during monitoring.

5.2 Updated Exposure Model

Following the site investigation, the plausible contaminant sources and receptors identified in Section 2.0 have been updated or confirmed.

5.2.1 Sources

No potential sources have been removed from, or added to the preliminary conceptual exposure models.

5.2.2 Receptors

No potential receptors have been removed from, or added to the preliminary conceptual exposure models.

5.2.3 Pathways

No pathways have been removed from, or added to the preliminary conceptual exposure models.



With reference to the updated ground model and updated exposure model reported above, generic risk assessment is undertaken in Section 6.0.



6.0 GENERIC QUANTITATIVE RISK ASSESSMENTS

There are plausible contaminant linkages which require further consideration, either in the form of subsequent tiers of risk assessment against generic or site-specific assessment criteria, or by proceeding directly to some form of risk management strategy (including possible remedial actions).

Generic risk assessment is a two stage process. Firstly, the measured contaminant concentrations are compared to the relevant GACs. This is the Risk Estimation stage. Where there is a suitable dataset, this is done after carrying out statistical analysis to determine the upper confidence limit on the true mean. Otherwise, maximum or specific data points are compared directly.

The second stage, Risk Evaluation, comprises an authoritative review of the findings with other pertinent information, in cases where the GACs are exceeded, in order to consider if exceedance may be acceptable in the particular circumstances.

6.1 Scope

The purpose of this risk assessment is to determine the potential contamination risks at the site for the proposed development. The aspects of risk from substances in the ground considered below are as follows:

- human health;
- plant life;
- pollution of Controlled Waters; and
- ground gases.

6.2 Human Health and Plant Life

This is a Tier 2 assessment using soil screening values and involves generic human health risk assessment for the CLEA scenario: commercial/industrial.

Priority phytotoxic chemical concentrations are screened against published values to determine the likely risk to plant growth.

In Appendix E the soil chemical analysis results have been screened against guideline soil concentrations to provide an assessment of potential risks associated with contamination at the site. Justification for the criteria adopted for this risk assessment is given in Appendix D. In the cases where all the samples tested for a given substance were below the GAC, no further consideration is necessary for that substance. However, for completeness all data is statistically assessed in the sections below. Note that the Category 4 Screening Levels (C4SL) for lead have been used in preference to the withdrawn SGV (DEFRA, March 2014) and the use of the term 'GAC' in this report includes these.

It should be noted that the term 'further assessment required' is used to denote soil concentrations that are equal to, or exceed, a GAC. This does not necessarily mean that the soil is 'contaminated'.



6.2.1 Risk Estimation (Including Statistical Testing) and Risk Evaluation

The 'averaging area' used in this report is based on the conceptual model and the proposed development and is taken to be the entire area of the site.

Initial Data Review

The data set for each chemical determinand has been assessed for the presence of potential outliers (based on the conceptual model) and to determine if the data are normally or non-normally distributed, in line with the methods described in Appendix D.

No outliers have been removed.

Statistical Testing

A suitable data set is available for statistical testing for the Hydrock default suite of determinands.

Using the methodology detailed in Appendix D and in line with the guidance provided by the CIEH (May 2008) the 95th upper confidence level on the true mean (US₉₅) has been calculated from the sample data.

Data have been assessed using the one-sample t-test or the one-sided Chebychev Theorem, as appropriate to the distribution.

Appendix E contains the detailed results of the statistical assessment for each chemical of potential concern, together with summary sheets for human health and plant life. The results are summarised below.

Human Health

With regards to human health there are no substances for which the US₉₅ exceeds the GAC and it is concluded that no further assessment is required.

Plant Life

For plant life, based on a US₉₅ exceedance of the GAC, the pervasive chemicals of potential concern which require further assessment are summarised in Table 6.1.

Table 6.1: Pervasive Chemicals of Potential Concern for Which Further Assessment is Required (Risk to Plants)

Chemical of Potential Concern	Generic Criterion (mg/kg)	Basis for Generic Criterion	No. Samples	Min. (mg/kg)	Max. (mg/kg)	No. Samples Exceeding Generic Criterion	US ₉₅ (mg/kg)
Copper	200	BS3882 2007	20	31	270	7	231
Zinc	300	BS3882 2007	20	73	540	5	335



Detriment to plant life is hard to quantify and many of the GACs are based on agricultural crop yields rather than serious harm of death of a species. As the exceedance is slight and the vegetation on site did not show any signs of physical distress, Hydrock does not believe any additional consideration is required with regards to risks to plant life.

6.2.2 Risk Estimation (Without Statistical Testing)

In this section the results are discussed for determinands for which the data set does not allow application of statistical analysis by virtue of low sample numbers and/or spatial distribution (e.g. where sampling is targeted at specific sources identified in the preliminary investigation).

Petroleum Hydrocarbons (PHC)

Laboratory testing did not detect any samples with exceedances of petroleum hydrocarbons.

Asbestos

Asbestos was detected in five samples within the Made Ground across the site. However, all five samples have been quantified at <0.001% and no further consideration is required due to the nature of the development (commercial), the use of extensive hard standing and the request for topsoil in soft landscaping areas.

6.2.3 Risk Evaluation – Human Health

There are no US₉₅ exceedances of the GAC and the site is not considered a risk to human health.

6.3 Pollution of Controlled Waters

6.3.1 Risk Estimation

The risks to groundwater and surface water from contaminants on site have been assessed according to the Environment Agency (2006) Remedial Targets Methodology (RTM). Pollutants from contaminated land sites are considered as passive inputs under the European Water Framework Directive (2000/60/EC) and as such are regulated under the Agency's 'limit' pollution objective.

Acceptable Water Quality Targets (WQT) are defined for protection of human health (based on Drinking Water Standards (DWS)) and for protection of aquatic ecosystems (Environmental Quality Standards (EQS)). For the purposes of this report, the site data are compared with the various targets as set out according to the Hydrock scenario(s) in Table 6.2 (see Appendix D for details), on the basis that the Glacial Till provides base flow to Sugar Brook and lake located south and east of the site and the site is within a Zone 3 Source Protection Zone (SPZ) related to a groundwater abstraction from the Wilmslow Sandstone Formation >1.5km northeast of the site.



Table 6.2: Summary of Water Quality Risk Assessment Protocol

Hydrock Scenario	Water Body Receptors	Secondary Receptors	Example Contaminant Linkages	RTM Level and Data Used	Water Quality Targets
D	Groundwater. Surface water.	Human health (abstraction). Aquatic ecosystem.	Contaminants from site leach or seep into groundwater body and the groundwater may be used for human consumption and the surface water is an aquatic ecosystem.	RTM Level 2 - Groundwater.	DWS EQS (inland)
<p>Notes:</p> <p>Some EQS are water hardness dependent. This is measured either in the receiving water or in groundwater (if it is part of the pathway), or is estimated from national maps.</p> <p>Inland waters EQS applicable to freshwater, other waters EQS applicable to marine or transitional waters.</p> <p>Where both DWS and EQS are applicable, it is assumed that the EQS is for inland waters.</p> <p>This table and the results of the assessment are considered as a first screening for potential risks of pollution of Controlled Waters. More specific requirements may be stipulated by the Environment Agency.</p>					

The results of the Remedial Targets Methodology assessment are presented in Appendix E and are summarised in Table 6.3.

There are no EQS or DWS for petroleum hydrocarbons in water. However, because of the sensitivity of the water environment to petroleum hydrocarbons, an initial screening exercise is also included in Table 6.3 irrespective of the assessment scenario(s) stated in Table 6.2.

It should be noted that in some instances the reporting limit (or detection limit) quoted by the laboratory may be greater than the WQT that it is being assessed against. As the current exercise is an initial screening assessment, further assessment of these elements has not been undertaken.

Table 6.3: Chemicals of Potential Concern for Which Further Assessment is Required (Controlled Waters)

Chemical of Potential Concern	Water Quality Target (ug/l)	Basis for Water Quality Target	No. Samples	Min. (ug/l)	Max. (ug/l)	No. Samples Exceeding Target
Aluminium	200	DWS	3	2	747	1
Arsenic	10	DWS	3	8.5	32.1	2
Cadmium	0.25	EQS	3	0.24	0.37	2
Cobalt	3	EQS	3	4.1	7	3
Copper	28	EQS	3	11	31	1
Iron	200	DWS	3	68	640	1
Manganese	50	DWS	3	1000	8200	3
Nickel	20	DWS & EQS	3	5.5	28	1
Lead	7.2	EQS	3	0.9	9.1	1



Chemical of Potential Concern	Water Quality Target (ug/l)	Basis for Water Quality Target	No. Samples	Min. (ug/l)	Max. (ug/l)	No. Samples Exceeding Target
Antimony	5	DWS	3	0.4	6.2	1
Zinc (total)	125	EQS	3	100	330	2
Ammonium (NH ₄ ⁺)	500	DWS	3	15	11000	2
Petroleum hydrocarbons (as TPH)*	10	Water Supply Regulations 1989 and the Private Water Supply Regulations 1991(withdrawn).	3	10	940	1
<p>Note: the maximum recorded value is compared with the water quality target.</p> <p>* The Water Supply Regulations 1989 and the Private Water Supply Regulations 1991 both contained a prescribed concentration of 10 µg/l for 'dissolved or emulsified hydrocarbons (after extraction with petroleum ether); mineral oils'. This was removed when these Regulations were updated in 2000 (consolidated 2007) and 2009, respectively. However 10 µg/l is used in this report as an initial screening assessment as it is frequently the preferred approach of the Environment Agency.</p>						

6.3.2 Risk Evaluation

Exceedance of the water quality standards for antimony, cadmium, copper, nickel and lead are minor and are not considered to represent a significant risk of pollution of Controlled Waters.

The data indicate that the DWS or EQS are exceeded for metals (aluminium, arsenic, cobalt, iron, manganese and zinc) and ammonium with the groundwater.

Whilst there are elevated concentrations of Chemicals of Potential Concern, based on the investigation works undertaken to date, Hydrock does not believe the site poses a risk to future site users. In addition, Hydrock does not believe the site poses a significant risk to Controlled Water as:

- there are no exceedances of heavy metals within soils at the site i.e. there is no significant source of the site;
- the contaminants identified in the groundwater are potentially from sewage sludge/waste water as a sewage works has been present north of the site from the 1880s; and
- the groundwater gradient is from the north to the south/southeast i.e. from the sewage works.

6.4 Ground Gases

6.4.1 Carbon Dioxide and Methane

The risks associated with the ground gases methane (CH₄) and carbon dioxide (CO₂) are assessed using BS 8485:2007 (Code of practice for the characterisation and remediation from ground gas in affected developments) and guidelines from CIRIA 665 (Wilson *et al* 2007) and the NHBC (Boyle and Witherington 2007). In the above CIRIA guidance:



- 'Situation A' covers all forms of development (residential and industrial/commercial developments), other than those in Situation B; and
- 'Situation B' is defined as the specific development of low-rise (one to three storeys in height) housing with a vented sub-floor void (min. 150 mm).

The development proposals require consideration of Situation A.

It is judged from the available evidence that the gas generation potential at the site is moderate and the sensitivity of the development is low. This is on account of deep Made Ground across the site. Consequently, an appropriate minimum monitoring regime is 3 readings over 5 weeks, provided other monitoring requirements are also met, such as prevailing atmospheric pressure conditions (for example, BS 8485:2007 suggests monitoring shall include a period of falling atmospheric pressure).

The monitoring strategy reported in Appendix C is considered suitable for assessment of ground gas risk at the site and the results are discussed below.

The guidance requires identification and use of the gas flow rate and the concentration of both carbon dioxide and methane across the whole site to calculate a Gas Screening Value (GSV). The typical worst case GSV have been calculated as 0.006 for methane and 0.006 for carbon dioxide and the site is classified as Characteristic Situation 2 in accordance with CIRIA 665.

Based on the GSV mitigation is required.

6.4.2 Radon

Reference to the *Indicative Atlas of Radon in England and Wales* (Miles *et al* 2007) and BR 211 (Scivyer 2007) indicates that the site is not in a Radon Affected Area and no radon protection measures are required.

6.5 Findings of the Generic Risk Assessments

Particular areas of the site which are of potential concern are indicated on the Site Zonation Plan in Appendix A. The source-pathway-receptor linkages given in Table 6.4 are those which, following the risk evaluation process, require further consideration and are discussed further in Section 7.0.



Table 6.4: Final Conceptual Model and Residual Risks Following Risk Evaluation

Sources	Pathways	Receptors	General Comments	Mitigation Comments
Elevated concentrations of ground gases (methane and carbon dioxide) from biodegradable matter in the Made Ground.	Migration through soils or groundwater to indoor air.	End users of new buildings (asphyxiation or explosion). New buildings (damage by explosion).	Elevated levels of methane and carbon dioxide.	Characteristic Situation 2.
Elevated concentrations of heavy metals, petroleum hydrocarbons and ammonium within groundwater.	Leaching through unsaturated zone. Base flow.	Groundwater. Surface Water.	There is no identified source on site and Hydrock believe the source is the sewage works to the north of the site. The site is within a Zone 3 SPZ and drains to Sugar Brook and a lake south of the site.	Agreement of the assessed level of risk, with the Regulators, will be required.



7.0 GEO-ENVIRONMENTAL CONCLUSIONS AND RECOMMENDATIONS

7.1 Human Health

The risk assessment indicates that Hydrock does not believe the Made Ground poses a risk to human health.

7.2 Plant Life

The risk assessment indicates that the Made Ground is a pervasive source of copper and zinc. Detriment to plant life is hard to quantify and many of the GACs are based on agricultural crop yields rather than serious harm of death of a species. The exceedances are slight and the vegetation on site did not show any signs of physical distress. Therefore Hydrock does not believe the site poses a risk to plant life.

7.3 Controlled Waters

The Level 2 risk assessment undertaken in Section 6.3 indicates that whilst there are elevated concentrations of chemicals of potential concern Hydrock does not believe the site poses a risk to future site users and a significant risk to Controlled Waters, because the site is unlikely to be the source of contamination.

7.4 Water Pipelines

The current guidance on selection of materials for water supply pipes to be laid in contaminated land is contained in UKWIR Report 10/WM/03/02 (re-issued 2010) and supplemented by guidance issued by Water UK (January 2014). The latter document sets out in Table 1 threshold values for a selection of contaminants that may have a detrimental effect on pipes and fittings. However, the document is for guidance and is not mandatory and has not been adopted universally by all water suppliers. For further details see Appendix D.

A formal water pipe risk assessment is beyond the scope of this report, however, the findings of this investigation have been compared to the threshold values in Water UK Table 1 as far as is practicable to give an indication of the possible restrictions to the use of plastic pipes for water supply to the site.

The site is brownfield and there is a presumption in the guidance that barrier pipe will be used. However, the investigation and assessment has indicated no exceedance of the threshold values and as such standard pipework may be suitable for the site. However, this investigation was not designed specifically for water pipe runs and confirmation should be sought from the water supply company at the earliest opportunity.

Until proven or agreed otherwise, it is recommended that barrier pipe provision is assumed pending liaison with the supply company.



7.5 Precautions Against Ground Gases

7.5.1 Radon

Current advice based on the BR 211 Report is that no radon protection is required for new buildings at this location.

7.5.2 Carbon Dioxide and Methane

All three of the required monitoring visits have been completed. The ground gas readings and gas regime conceptual model are considered to be sufficiently rigorous to provide an assessment of the ground gas regime and the scope of protection measures in accordance with CIRIA Report C665 (Wilson *et al* (2007)).

For Situation A, based on the gas monitoring data the site may be classified as Characteristic Situation 2.

The following mitigation measures are required.

7.5.3 Situation A: Other Residential and Industrial/Commercial Development

For CS 2 (commercial/industrial), CIRIA C665 (Wilson *et al* 2007) recommends:

1. Reinforced concrete cast *in situ* floor slab (suspended, non-suspended or raft) with at least 1200g DPM; or
2. Beam and block or pre-cast concrete and 2000g DPM / reinforced gas membrane.
3. Possibly underfloor venting or pressurisation in combination with the above depending on use.
4. All joints and penetrations sealed.

See also text following CIRIA Table 8.6 (Wilson *et al* 2007) which gives additional details.

BS 8485:2007, Table 2 indicates a score of 1 point for industrial buildings (up to a maximum of 20% methane). A combination of venting and barrier systems whose scores total at least this number of points is required from the list in Table 3 of the standard (reproduced in Appendix D). Mitigation measures will require detailed design. However, this could be achieved by the use of:

- reinforced concrete ground bearing slab;
- taped and sealed 1200g DPM membrane; and
- all joints and penetrations sealed.

Independent validation of gas protection measures will be required.

As recorded levels of both methane and carbon dioxide are elevated, consideration should be given to passive sub-floor ventilation.



7.5.4 Ground Workers

It is noted that concentrations of carbon dioxide (an asphyxiant) in the soil exceed HSE Workplace Exposure Limits for personnel in the working environment of 1.5% for short term (15 minutes) exposure or 0.5% for long term exposure. Furthermore, soil concentrations of oxygen are below the HSE recommendations of 18%.

Whilst risks to construction workers are not generally discussed in this report, and soil gas concentrations are not necessarily reflected by those in the breathing zone, all contractors and maintenance workers should be made aware of the possible presence of carbon dioxide and should take all necessary health and safety precautions when working in trenches or confined spaces.

7.6 Outline Remedial Strategy

An options appraisal and preferred remedial strategy for the site will need to be developed in consultation with the design team and the regulatory authorities. Liaison should be continued during implementation and subsequent verification.

As a conclusion to the various assessments summarised above, the following approach is suggested:

- installation of ground gas protection measures to comply with Characteristic 2 classification during construction of the warehouse; and
- the use of topsoil growing medium in areas of soft landscaping (300mm).

The methodology for the remediation should be detailed in a Remediation Method Statement which will need to be submitted to the regulatory authorities for approval.

Verification reports by a suitably qualified independent engineering geologist will be required following completion of any remedial works.

7.7 Waste Management

Any material excavated on site may be classified as waste and it is the responsibility of the holder of a material to form their own view on whether or not it is waste. This includes determining when waste that has been treated in some way can cease to be classed as waste for a particular purpose.

If material is to be removed from the site (e.g. foundation arisings) the laboratory test results in Appendix E, should be presented to the proposed receiving landfill site, prior to export, to confirm that it is suitably licensed to accept them. Some additional testing (WAC) may be necessary at the time of disposal for the receiving landfill to confirm its acceptability to receive the waste.

Based on the results of the testing it is anticipated that the natural excavated soils will be classified as inert for off-site disposal purposes. However, this will depend on the results of the WAC testing. If the soils are not proven to be inert, they may be classified as non-hazardous.



Non-hazardous soils require pre-treatment prior to disposal. Effective pre-treatment, involving separation, sorting and screening can offer cost reductions through reducing the hazardous nature and volume of soil waste. Costs for disposal of non-hazardous/hazardous soils are significant compared to disposal of inert material.

7.7.1 CATwasteSoil® Assessment

In order to inform the waste characterisation process, Hydrock has undertaken a preliminary exercise to characterise the soils encountered in the investigation. This has been undertaken using the proprietary web-based tool CATwasteSoil®.

Based on the CATwasteSoil® output, the Made Ground soils sampled between 0.2m and 1.8m bgl may be classified as non-hazardous. Further testing of the soils (WAC testing) may be required in order to satisfactorily categorise the soil for its suitability for disposal at an inert landfill site. The results of the output are included in Appendix F.

7.7.2 Waste Recommendations

Based on the CATwasteSoil® and WAC testing it would appear that if suitable segregation of different types of waste is put in place:

- the Made Ground has the potential to be classified as non-hazardous waste (and should be considered as such until proven otherwise); and
- natural soils may be able to be classified as inert (subject to appropriate WAC tests, if required).

Prior to disposal, the characteristics of any excavated soils will need final classification in consultation with landfill sites and waste disposal contractors. Further testing and analysis will be required to be carried out on the actual soil arisings which will constitute the waste. This will form the actual basis for classification of the waste.

7.7.3 Materials Management

Any material excavated on site may be classified as waste and it is the responsibility of the holder of a material to form their own view on whether or not it is waste. This includes determining when waste that has been treated in some way can cease to be classed as waste for a particular purpose.

One of the ways this can be achieved is set out in the Development Industry Code of Practice (CoP) (CL:AIRE, March 2011).

The handling, re-use or disposal of waste is regulated by the Environment Agency. The Agency will take into account the use of the CoP in deciding whether to regulate materials as waste. If materials are dealt with in accordance with the CoP, the Agency considers that those materials are unlikely to be waste at the point when they are to be used for the purpose of land development. Hydrock would recommend that a Materials Management Plan (MMP) is used for the site to allow the re-use of soils at the site.

The MMP must be signed off by a Qualified Person as defined in the CoP.



8.0 UNCERTAINTIES AND LIMITATIONS

This report details the findings of work carried out in July 2014. The report has been prepared by Hydrock on the basis of available information obtained during the study period. Although every reasonable effort has been made to gather all relevant information, all potential environmental constraints or liabilities associated with the site may not have been revealed.

The report has been prepared for the exclusive benefit of St Modwen Developments Ltd and those parties designated by them for the purpose of providing geotechnical and geo-environmental recommendations for the site. The report contents should only be used in that context. Furthermore, new information, changed practices or new legislation may necessitate revised interpretation of the report after the date of its submission.

Hydrock has used reasonable skill, care and diligence in the design of the investigation of the site. The inherent variation of ground conditions allows only definition of the actual conditions at the locations and depths of trial pits and boreholes at the time of the investigation. At intermediate locations, conditions can only be inferred.

Groundwater findings described are only representative of the dates on which they were made and levels may vary.

Information provided by third parties has been used in good faith and is taken at face value; however, Hydrock cannot guarantee its accuracy or completeness.

The work has been carried out in general accordance with recognised best practice as detailed in guidance documents such as the CLR 11 Model Procedures (Environment Agency 2004), BS 5930:1999 +A2:2010 and BS 10175:2011+A1:2013.

The rationale behind the assessments carried out for this report is given in Appendix D.

Unless otherwise stated, no assessment has been made for the presence of radioactive substances or unexploded ordnance.

Where the phrase 'suitable for use' is used in this report, it is in keeping with the terminology used in planning control and does not imply any specific warranty or guarantee offered by Hydrock.

The chemical analyses reported were scheduled for the purposes of risk assessment with respect to human health, plant life, ecosystems and controlled waters as discussed in the report. Whilst the results may be useful in applying the Hazardous Waste Assessment Methodology given in Environment Agency Technical Guidance WM2, they are not primarily intended for that purpose and additional analysis may be required should waste classification be required for consideration of off-site disposal of contaminated soils. Separate analyses will be required to meet the Waste Acceptance Criteria for specific landfill sites.

Unless otherwise stated, the chemical testing carried out for this report was not scoped to comply with the requirements of the water supply company and further work may be required.



The preliminary risk assessment process may identify potential risks to site demolition and redevelopment workers. However, consideration of occupational health and safety issues is beyond the scope of this report.

Please note that notwithstanding any site observations concerning the presence or otherwise of archaeological sites, asbestos-containing materials or invasive weeds such as Japanese knotweed, this report does not constitute a formal survey of these potential hazards.

Any site boundary line depicted on plans does not imply legal ownership of land.



9.0 RECOMMENDATIONS FOR FURTHER WORK

The following further works will be required:

- discussions with service providers regarding the materials suitable for pipework etc.;
- agreement and verification regarding the conclusions of this report with the regulatory bodies;
- installation of gas mitigation measures; and
- verification of the remedial works.



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