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PHASE I & PHASE II GEO-ENVIRONMENTAL SITE INVESTIGATION FORMER GATEACRE SCHOOL:

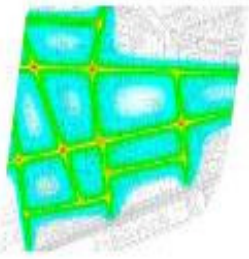
REC REFERENCE: 44808P1R3

REPORT PREPARED FOR:

LIVERPOOL CITY COUNCIL
LIVERPOOL PARTNERSHIP LLP
&
COUNTRYSIDE SIGMA LTD

JULY 2014





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QUALITY ASSURANCE

Issue/revision	Issue 1	Revision 1	Revision 2	Revision 3
Remarks	Draft	Final – inclusion of ground gas monitoring	Final – inclusion of LCC information review and C4SL update.	Final – Addition of previous testing data
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EXECUTIVE SUMMARY	
Site Address	Former Gateacre High School, Liverpool, L25 4SA
Grid Reference	N342221,E388206
Site Area	7.47ha
Current Site Use	The site is currently unoccupied; however there a number of relict foundations associated with the former school. The western sector of the site is circa 7.00m above the eastern sector and is retained in parts by a brick constructed retaining wall and a steep slope / batter (circa 1 in 1) in others. Whilst the natural topography in the area follows the same trend of a west to east slope; the site levels have been artificially raised.
Environmental Setting	The site is underlain by a Principal Aquifer. There are no ground water abstractions within 1.0km of the site boundary. The site is not within an area that is at risk from flooding.
Site History	Historical maps indicate that the site was largely undeveloped up until the construction of the school buildings in the late 1960s. Landfilling of the western sector is known to have been undertaken at some point prior to the construction of the school.
Hazardous Installations and Development Constraints	There is an active electrical substation on the eastern boundary. The deep fill associated with the historical landfill in the western sector and the unknown depth of basements associated with the school are considered to be viable development constraints, with regards to the potential for total and differential settlement and potential contamination / abnormal ground conditions.
Invasive Plant Species	A number of small stands of Japanese Knotweed were observed within the landfilled material in the central sector. The growth / maturity of these plants appeared stunted most likely due to the application of herbicide, which is currently being undertaken by Liverpool City Council's contractor.
Utility Locations	Due to the subsequent demolition of the school buildings, there are no live services on site; however drainage may still be present which could be reconnected as part of the proposed development (if required).
Landfill Sites & Ground Gas Sources	The western sector of the site has been identified as a historical landfill, which is considered to be the only significant source of hazardous ground gases which could impact receptors within the proposed development. The landfilling occurred in the mid 20th century prior to 1970. At this time the majority of wastes were incinerated before being in filled, thus the potential for organic material is significantly reduced.
Radon	Unaffected – no special precautions required.

Natural Geology, Hydrology & Hydrogeology	**Drift** – None **Bedrock** – Cheshire Pebble Bed Formation (Sandstone) **Groundwater** – Principal Aquifer **Flood Risk** – Unaffected by flooding from rivers. **Compressible Ground and Subsidence Hazards** – No risks associated with the underlying natural geology, mining or tunnelling.
Coal Mining / Land Stability	Site is unaffected by coal mining; No special precautions required.
Previous Reports	The following reports have been provided to REC for review: • Norwest Holst - Ground Investigation, dated February 2005. Project No. F13512. • Norwest Holst - Phase 2 Intrusive Land Quality Investigation, dated November 2005. Project No. F13931. • Carter Ecological Ltd - Initial Ecological Surveys, dated September 2006. • ACS Consulting – Arboricultural Survey and Constraints Plan, dated February 2007. Ref: 1516/DR.07. • Liverpool City Council – Flood Risk Assessment, dated March 2007. • Norwest Holst – Ground Investigation, dated October 2007. Project No. F14826. The exploratory hole logs, chemical analysis of the soils and the ecological findings contained within these reports have been reviewed and assessed in the following sections.
Intrusive Ground Investigation	
Ground Conditions	**Made Ground -** Made Ground was encountered in all exploratory hole locations to a maximum proven depth of 5.00m bgl (TP119) and generally comprised dark brown/black ashy gravelly sand with many inclusions of metal, textiles, clinker, glass and other household waste type materials. The Made Ground in the historical landfill appears to have been subject to partial incineration (as was common in the mid-20th Century) and as such no significant degradable organic content has been observed. **Drift** Superficial drift deposits of fine to medium SAND were encountered to a typical depth of less than 1.00m bgl in the eastern sector deepening to circa 5.00m bgl in the remainder of the site. **Solid Geology** Weathered Sandstone was encountered (presumed but unproven bedrock) at depths between 0.20m and 4.90m bgl. Generally the presumed bedrock outcrops at a shallow depth beneath the eastern sector (lower elevation) dipping to the west. **Ground Water** No groundwater was encountered during the ground investigation.

Tier 1 Contaminated Land Risk Assessment	
Human Health	The Tier I Human Health Risk Assessment has identified elevated concentrations of inorganic heavy metals, polycyclic aromatic hydrocarbons (including Naphthalene), hydrocarbon fractions C_8-C_{21} and volatile organic compounds within the landfill in the west of the site. No contaminant concentrations in the area of the former school building exceeded Tier 1 screening values, however further assessment of the soils around the electricity substation on the eastern site boundary will be required owing to the potential presence of PCBs. Further assessment is required of potential contamination associated with the former school boiler room. Further assessment of the infilled school basements is required due to the potential presence of asbestos within the demolition material. Slightly elevated concentrations of lead, benzo(b/k)fluoranthene and benzo(a)pyrene were recorded in one sample recovered from shallow Made Ground in the Northern Playing Fields area.
Controlled Waters	Potentially soluble compounds were identified within leachate samples collected from materials within the area of historic landfill. Aggressive leachate analysis suggested that the concentrations of potential constituents of concern within the Made Ground could theoretically generate a potential leaching of metals, PAHs and aromatic hydrocarbons at concentrations above the Tier 1 assessment criteria for the protection of controlled waters. The proposed bioremediation of the landfill will lead to the removal of mobile and volatile contaminants from the soil. Following the site's development, the site will be covered with housing, hardstanding and a clean cover system involving clay materials that will inhibit rainwater infiltration and the subsequent potential for contaminant mobilisation. This betterment of the site and the lack of a groundwater body will significantly reduce the risk to controlled waters posed by leachable contaminants.
Eco-toxic	Inorganic heavy metals associated with the Made Ground have been identified in concentrations likely to prove eco-toxic to plants and root vegetable if present within the upper 600mm growing medium.
Ground Gas	Elevated methane and carbon dioxide concentrations have been recorded during the ground gas monitoring; however the concentrations were associated with flow rates of less than the limit of detection and were specifically within the area of historic landfilling. When due consideration is given to the guidance outlined in CIRIA C665, the ground gas assessment indicates a moderate to high risk to future site users (albeit this is limited to the area of the former landfill). In its current configuration, the area of deep Made Ground would be classified as CS3 / Amber 2 with the remainder of the landholding being CS1 / Green.
Potable Water Infrastructure	Preliminary assessment would suggest that barrier pipe would be suitable for use within the proposed residential development.
Geotechnical Assessment	
Underground Obstructions	REC has been informed by Liverpool City Council that basements associated with the former school remain on site; however they have not disclosed the exact locations; therefore it must be assumed that for design purposes the entire school building footprint is underlain by basements. Furthermore it must be assumed that demolition has only been completed to 'slab' level and as such obstructions associated with relict infrastructure could remain beneath the sector of the site formally developed as a school.

Allowable Bearing Pressure	Allowable Bearing Pressures in excess 100kN/m² have been calculated within the underlying natural strata at depths varying from less than 1.0m bgl to >4.0m bgl. Made Ground is not considered a suitable bearing strata without specialist re-engineering to mitigate the unacceptable potential for long term total and differential settlement.
Foundation Options	Granular Made Ground was encountered in the western sector of the site, which is regarded to be geotechnically unsuitable for development due to the very low / no bearing potential (SPT N Values of 0) and the inherent variability of the material composition. As such it is recommended that the deep made Ground within the area of the historic landfill be screened sorted and replaced in a manner that will allow re-engineering through the construction of Vibro Stone Columns or Dynamic Compaction to support shallow re-enforced strip foundations in the western sector. The remainder of the site should be suitable for a combination of r-engineering through vibro stone columns (where basements / relict infrastructure has been removed) and shallow strip foundations locally deepened to mass trench fill (as required). An allowance should be made for a small number of piled plots given the potential for localised soft spots, high walls and potential areas where the Made Ground cannot be treated. The remainder of the site is suitable for a combination of shallow strip locally deepened mass trench fill foundations.
Soak-away Drainage	Infiltration testing has proven inconclusive with some good infiltration rates and some poor. It is anticipated that post remediation the underlying soils will be predominantly granular in nature and as such are likely to a provide a relatively high degree of soakage potential for drainage systems, however further assessment will be required in line with BRE special digest 365.
Sulphate Assessment	Class DS-1, (ACEC) AC-1s
CBR Design %	3%
Cut / Fill	Depending on the final site levels (yet to be disclosed) it is likely that the western sector will need to be cut to facilitate a gradual gradient rather than the steep slope at present. An indicative cut fill model is presented in Appendix III.

Revised Conceptual Site Model (CSM)

The Tier I Human Health Risk has identified locally elevated concentrations of inorganic heavy metals, various PAHs (including Naphthalene) and hydrocarbon fractions C_8 – C_{21} within the landfilled western sector. Further assessment is required of the soils surrounding the electricity substation on the eastern site boundary. Further assessment is required of the demolition material present in the infilled school basements.

Post enabling works validation testing / groundwater monitoring will be required to confirm that the site poises no unacceptable level of risk to controlled waters.

The ground gas assessment indicates that within it current configuration the area of the historic landfill is likely to be classified as Characterisation Situation 3 due to elevated methane and carbon dioxide concentrations; however on completion of the remediation / enabling works in this sector to render the land suitable for construction, the deleterious content will be removed thus negating the identified source of hazardous gasses.

The remainder of the site is likely to be classified as CS2 / Amber 1 or CS1 / Green.

Recommendations

A detailed remediation and enabling works strategy should be designed for the site to ensure that the site can be safely and legislatively compliantly redeveloped.

Due to the volume of material present, it is not considered viable to remove the landfill soils in their entirety from the site. The proposed remediation required in the landfill area will however break the pollutant linkages identified to human health for volatile pathways and lead to significant betterment at the site with regards to controlled waters.

The proposed remediation of the landfill will comprise two stages; firstly the off-site disposal of unsuitable and deleterious materials and secondly, the subsequent bioremediation of the remainder of the soils. All Made Ground within the former landfill will require excavation in its entirety and following excavation, the excavated materials will be sorted, with the unsuitable material disposed of off-site. The remainder of soils will be subject to treatment by means of bioremediation in windrows. This is considered to be an appropriate remedial technique to address the identified hydrocarbon impacts; it addresses the driving pollutant linkage by removing the volatile source. Soils will be considered to be suitably remediated as and when laboratory validation testing demonstrates that the soil concentrations are below the remediation criteria for both human health and controlled waters. The treated soils will be placed back into the void in a controlled manner.

Following the bioremediation of soils, a 600mm clean cover will be required in all garden and landscaping areas in this area to break the remaining dermal contact and ingestion pathways for the remaining contaminants.

Following the development of the site, the entire site will be covered by buildings and hardstand with landscaped areas requiring a 600mm clean cover. This clean cover should contain a clay subsoil to prevent water ingress to the material below. The proposed surface covers will significantly inhibit the potential mobilisation of any remaining leachable contamination.

The Made Ground identified in the Northern Playing Field Area and the Former School Area is considered to be physically unsuitable for retention in gardens/landscaping. This should be removed to 600mm or to natural ground (whichever is less) and made up to finished levels using topsoil and subsoil as detailed above with a minimum of 150mm topsoil.

Topsoil was encountered on site overlying both natural sands and Made Ground. Each of these topsoil sources should be segregated and stockpiled separately to allow subsequent analysis to assess their suitability in the development.

Post remediation ground gas monitoring will be required to re-classify the site as a lower Characteristic Situation.

It is recommended that a detailed Remediation Strategy and Materials Management Plan (MMP) be developed in accordance with the (EA Approved) CL:AIRE CoP. A Materials Management Plan will help to ensure that the enabling works can be undertaken in the most cost effective manner that will negate the need for off-site disposal of soil.

Further soakaway testing in line with the guidance outlined in BRE 365 is undertaken post remediation once the proposed development layout has been designed. This should not take place in the area of the former landfill.

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A CD containing all relevant environmental database information, historical & geological mapping and a complete PDF version of this report is attached to hard copy of the report.

1.0 INTRODUCTION

1.1 Background

Resource and Environmental Consultants (REC) Ltd have been commissioned by Countryside Properties to undertake a supplementary Geo-Environmental Site Investigation at the Former Gateacre High School.

The scope of work consisted of a review of all available environmentally pertinent information, historical and geological mapping in addition to an intrusive ground investigation. The scope of the supplementary intrusive Ground Investigation (GI) comprised 18 probeholes all of which were completed as environmental monitoring installations and 45 mechanically excavated trial pits, two of which were utilised for BRE365 soakaway assessments. Extensive chemical and geotechnical laboratory testing, an interpretive contaminated land assessment and geotechnical site appraisal were also undertaken as part of the scope of works.

1.2 Proposed Development

REC understands that Countryside Properties intend to redevelop the site for a proposed low rise residential end use with associated gardens, driveways, estate roads and adoptable infrastructure. A plot layout and highways design has been provided to REC and is reproduced in Appendix III as Drawing No 44808p1r0/008.

1.3 Objectives

The objectives of the geo-environmental investigation are to:

- Review historical plans, geology, hydrogeology, site sensitivity, flood-plain issues, mining records and any local authority information available in order to complete a Desk Study in line with Environment Agency (EA) document Model Procedures for the Management of Contaminated Land (Contaminated Land Report 11 (CLR11));
- Undertake a preliminary stage of sampling and analysis to provide an overview of environmental issues identified;
- Assess the implications of any potential environmental risks, liabilities and development constraints associated with the site in relation to the future use of the site and in relation to off-site receptors;
- Assess the geotechnical information and provide preliminary recommendations in relation to foundations, pavement construction and floor slabs;
- Provide an assessment of the soakage of the underlying soils to assist in the design of infiltration based SuDS; and,
- Provide recommendations regarding future works required.

1.4 Previous Reports

The following reports have been provided to REC for review:

- Norwest Holst - Ground Investigation, dated February 2005. Project No. F13512.
- Norwest Holst - Phase 2 Intrusive Land Quality Investigation, dated November 2005. Project No. F13931.
- Carter Ecological Ltd - Initial Ecological Surveys, dated September 2006.

- ACS Consulting – Arboricultural Survey and Constraints Plan, dated February 2007. Ref: 1516/DR.07.
- Liverpool City Council – Flood Risk Assessment, dated March 2007.
- Norwest Holst – Ground Investigation, dated October 2007. Project No. F14826.

The exploratory hole logs, chemical analysis of the soils and the ecological findings contained within these reports have been reviewed and assessed. These previous exploratory holes and chemical analysis have been used within the context of this report to establish a clearer understanding of the ground conditions on site. This report has been designed to supplement the previous reports and therefore, this report should be read in conjunction with the reports.

1.5 Limitations

The limitations of this report are presented in Appendix I.

At the end of March 2014, the Department for Environment and Rural Affairs (DEFRA) issued details of the outcome of a "Category 4 Screening Levels Project" which is aimed at providing a simple test for deciding when land is "suitable for use" from a human health perspective and more specifically for defining when land is definitely not contaminated land. Category 4 Screening Levels (C4SLs) were published for six substances which were selected based upon their ubiquity in contaminated land risk assessment and because they covered a range of exposure pathways and toxicological effects. C4SLs have been published for these six substances in relation to various land uses, namely residential (both with and without home-grown produce), allotments, commercial and two alternative types of Public Open Space.

The Category 4 Screening Levels (C4SLs) in effect update the current approach to the assessment of contaminated land risk in relation to Part IIa but will also influence the assessment of land affected by contamination that is dealt with through the planning process. At some stage these new levels may replace the current SGVs albeit that they prescribe different levels of risk. As the C4SLs describe a higher level of risk than the current SGVs it suggests in general that higher levels of contamination may be acceptable before remediation is required. However, the risk posed by any particular substance is specific to any given site and its environmental setting and therefore dependent upon the outcome of site specific risk assessment.

For the purpose of this report REC has based the assessment on the current SGVs and associated CLEA approach, albeit that C4SLs, where published, have also been taken into account. In situations where SGVs and/or C4SLs are exceeded and particularly where remediation measures are potentially required we recommend that the site is discussed with the Local Authority, and the Environment Agency where necessary, in order that definitive solutions can be agreed.

It should be noted that these changes do not apply to the assessment of risk to Controlled Waters.

1.6 Confidentiality

REC has prepared this report solely for the use of Liverpool City Council, Liverpool Partnership LLP, Countryside Sigma Ltd and those parties with whom a warranty agreement has been executed, or with whom an assignment has been agreed. Should any third party

wish to use or rely upon the contents of the report, written approval must be sought from REC; a charge may be levied against such approval.

2.0 SITE SETTING

2.1 Site Details

Site Address	Former Gateacre High School, Liverpool, L25 4SA
National Grid Reference	N342221,E388206
Site Area	7.47 ha

All acronyms used within this report are defined in the Glossary presented in Appendix II.

A site location map is presented in Appendix III.

2.2 Current Site Use

Site Description

The subject site currently comprises of an unoccupied parcel of land which is partly covered by historical foundations and areas of hardstanding (the former Gateacre High School), with the remainder of the site occupied by vegetation (former playing fields).

The entire western sector of the site (which is occupied by the former playing field) is circa 7m above the remainder of the site's current ground level. The features are presented on the Development Constraints drawing (44808p1r0/005) Appendix III.

Hazardous Materials Storage

No above ground storage tanks (AST) or Underground Storage Tanks (USTs) were observed at the site.

Invasive Plant Species

Japanese knotweed was observed in the vicinity of the former tennis courts in the southern sector of the site; however this is currently being treated by a third party instructed by Liverpool City Council.

Polychlorinated Biphenyls (PCBs)

An electrical substation was identified along the eastern site boundary.

Waste Storage

No potentially hazardous waste streams are routinely generated by the site.

Drainage Issues

A formal drainage survey has not been completed and as the school has now been demolished it is not expected that there are any live service connections to the former school building.

2.3 Surrounding Area

The surrounding land uses are summarised below:

Direction	Land Use
North	Residential Dwellings
East	Residential Dwellings
South	Residential Dwellings
West	Residential Dwellings

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3.0 SITE HISTORY

3.1 On-Site Historical Development

A review of historical mapping pertinent to the site is summarised in Table 3.1 below.

Table 3.1 Summary of Potentially Contaminative Historical Land Uses

Map Edition	Historical Land Use
1851 1:10,560	The site is shown as unoccupied with a footpath bisecting the northern sector of the site in an east west trend.
1893 1:2,500	The site is unchanged from the previous map edition.
1907 1:2,500	The site is unchanged from the previous map edition.
1937 1:2,500	The site is unchanged from the previous map edition.
1952 1:10,560	The site is unchanged from the previous map edition. Contours are shown on the site which indicates that the natural topography slopes from west to east with the western sector circa 9m higher than the eastern sector.
1963 1:1,250	The site is unchanged from the previous map edition.
1967 1:10,560	The site is unchanged from the previous map edition.
1968 1:1,250	The eastern sector of the site is shown as being occupied by Gateacre Comprehensive High School. The western sector is shown to undulate steeply to the eastern sector below.
2012 1:1,250	No changes from the previous map.

Following a review of the Health and Safety File for the school demolition works, the following information was gained:

- D. Morgan left site on March 12th 2013 after undertaking demolition works over a 13 week period.
- Buildings were reduced to slab level and concrete slabs left in- situ.
- All basements / culverts (though could not ascertain where culverts were located, might have been a left over sentence from a previous report) were backfilled using site won material.
- Before backfill of the basements and culverts the concrete floors were popped using a breaker.
- The building that housed the water meter was demolished and the meter left in-situ to be removed later date.
- The location of the underground boiler house was surveyed and has been plotted on the Constraints Drawing.

- In total - 26,102 ton of waste / crushed brick / metal and glass were removed from site in total.
- Asbestos was removed from the building by Asbestos Control & Treatment Ltd with APEC Environmental also involved in the Air Monitoring.
- In total 40 sealed containers of various asbestos products were removed from the school.

3.2 Off-Site Historical Development

A review of potentially contaminative uses identified on historical Ordnance Survey maps within a 250m radius of the site is summarised below in Table 3.2.

Table 3.2 Summary of Potentially Contaminative Off-Site Historical Land Uses

Surrounding Feature	Distance	Dates	Direction
Railway *Then* marked as Dismantled (cycle Route).	300m	Pre 1891 to Pre 1980 Pre 1980 to Pre 2012	East
Pond - *Then* Infilled Then marked as residential Properties.	120m	Pre 1851 to Pre 1906 Pre 1906 1974 Pre 1974 to 2012	South West

3.3 Planning History

REC has undertaken a review of on-line planning records held by Liverpool City Council; however the only environmentally pertinent information pertained to the demolition of the Former Gateacre High School which was granted planning permission on the 28th November 2011 as discussed above).

4.0 ENVIRONMENTAL SETTING

4.1 Geology & Hydrogeology

The British Geological Survey (BGS) map for the site, (Sheet 97, 1:50,000, Runcorn, Solid & Drift edition) indicates that the site is underlain by the following geological sequence:

Geological Unit	Classification	Description	Aquifer Classification
Drift	None	N/A	N/A
Solid	Chester Pebble Beds Formation (Gravelly)	Sandstone	Principal

The Groundsure report indicates there are no groundwater abstractions within 1km radius of the site.

Based on the local topography and location of surface watercourses it is considered likely that shallow groundwater, if present, will flow in an eastern direction towards Childwall Brook. However, experience gained during assessments within the surrounding areas would suggest that shallow groundwaters do not exist and that groundwater is only encountered circa 15m to 20m bgl.

4.2 Geotechnical Data

Geotechnical Data presented within the Groundsure report identifies the following ground conditions:

Hazard	Designation
Shrink-Swell Clay	Very Low.
Landslides	Very Low.
Ground Dissolution	Null – Negligible.
Compressible Ground	Negligible.
Collapsible Deposits	Very Low.
Running Sand	Very Low.

4.3 Coal Mining

The site is in an area which is not affected by coal mining and therefore further consultation with the Coal Authority Coal was not undertaken as part of this report.

4.4 Hydrology

There are no surface water features in the vicinity of the subject site and the site is not located within a currently defined flood risk zone.

4.5 Radon Risk Potential

The Groundsure Report indicates the site is situated in an area where less than 1% of

homes are above the Action Level and that the BGS reports that full radon protective measures are not necessary in the construction of new dwellings or extensions.

4.6 Industrial Land Uses

The site is situated within a predominantly residential area; however the trade directory notes 14 industrial land uses which are predominately electrical substations, the closest of which is noted at circa 1.0m from the site boundary.

The closest fuel retailing station is located circa 228m north of the subject site.

4.7 Sensitive Land Uses

The closest residential properties are located adjacent to the subject site and there is a local nature reserve noted at 196m north west of the site.

4.8 Site Sensitivity Assessment

The site is considered to be located within a low to moderate sensitivity setting due to the following reasons:

- Residential properties are located in close proximity;
- The underlying geology comprising highly permeable strata; and,
- There are no surface watercourses within influencing distance of the site.

5.0 CONSULTATIONS

5.1 Local Authority Contaminated Land Officer

The Contaminated Land Officer at the Liverpool City Council noted that the school has now been demolished and that previous reports highlighted that landfilled material was present in the western sector of the site. Copies of the previous reports were made available to REC and are discussed in more detailed within Section 6.

5.2 Landfill Sites and Waste Treatment Sites

Two historical landfill sites have been identified within influencing distance of the site. The closest of which is located on the subject site itself and is known to have accepted household waste. The operating dates have not been disclosed; however it is assumed that the landfilling occurred prior to the opening of the school in the late 1960's. No further information could be gained.

5.3 Regulatory Database

The following information has been obtained from a commercially available environmental database. The summary table only includes records not otherwise detailed in the report. A full copy of the database report is provided on the CD at the rear of this report.

Table 5.1 Summary of Groundsure Data

	0-249m	250-500m	Details
Contaminated Land Register Entries and Notices	0	0	N/A
Authorised industrial processes (IPC/IPPC/LAPPC).	0	0	N/A
Fuel Stations Entries	1	1	The closest fuel station is located 228m north of the site off Thurne Way, Liverpool.
Licensed radioactive substances	0	0	N/A
Enforcements, prohibitions or prosecutions	0	0	N/A
Discharge Consents	0	0	N/A
Pollution Incidents	0	0	N/A
Consents issued under the Planning (Hazardous Substances) Act 1990	0	0	N/A
Control of Major Accident Hazard (COMAH) sites	0	0	N/A

6.0 PREVIOUS WORK

As previously stated in Sections 1.4, the following reports have been provided to REC for review:

- Norwest Holst - Ground Investigation, dated February 2005. Project No. F13512.
- Norwest Holst - Phase 2 Intrusive Land Quality Investigation, dated November 2005. Project No. F13931.
- Carter Ecological Ltd - Initial Ecological Surveys, dated September 2006.
- ACS Consulting – Arboricultural Survey and Constraints Plan, dated February 2007. Ref: 1516/DR.07.
- Liverpool City Council – Flood Risk Assessment, dated March 2007.
- Norwest Holst – Ground Investigation, dated October 2007. Project No. F14826.

Extracts of the exploratory holes logs and chemical analysis from these reports are presented in Appendix VI and Appendix VII respectively. The locations of all exploratory hole locations are presented on Drawing No 44808p1r0-002 in Appendix III. These previous exploratory holes and chemical analysis have been used within the context of this report to establish a clearer understanding of the ground conditions on site and consequently aided the design of the REC site investigation.

6.1 Summary of Previous Reports

6.1.1 Norwest Holst – Project No. F13512

Norwest Holst conducted a ground investigation in 2004 (reported in February 2005) at the north west of the former school buildings for a proposed sports hall development. The report references a previous site investigation conducted by Sub Surface North West Limited (2003) that has not been made available to REC at this time.

The Norwest Holst investigation comprised the drilling of three cable percussive boreholes to a maximum depth of 6.00m bgl, with rotary follow-on in one borehole to 10.75m bgl; the drilling of one stand-alone rotary borehole to 11.00m bgl and the excavation of thirteen trial pits to a maximum depth of 4.50m bgl. No exploratory hole location plan was provided with the report but the location of the three cable percussive boreholes is shown on a plan in the later Norwest Holst report F13941; these locations are shown on Drawing 44808-002 in Appendix III. Although the locations of the remaining locations are not exactly known, the discussion of the ground types within the report distinguishes between the embankment locations and the remaining locations (i.e. around the northwest of the school).

Chemical testing and gas monitoring was undertaken as part of the investigation, the results of which are discussed in Sections 6.3 to 6.5 below.

6.1.2 Norwest Holst – Project No. F13931

Norwest Holst conducted a further site investigation in 2005 comprising the drilling of eight rotary boreholes to a maximum depth of 6.30m bgl around the school building to facilitate the installation of gas monitoring wells, and the excavation of seventeen trial pits to a maximum depth of 2.00m bgl to investigate the playing fields in the west of the site.

Chemical testing and gas monitoring was undertaken as part of the investigation, the results of which are discussed in Sections 6.3 to 6.5 below.

6.1.3 Carter Ecological Ltd – Initial Ecological Surveys

Carter Ecological Ltd conducted initial ecological surveys in 2006. The surveys will need to be updated but the characteristics of the site haven't changed significantly since the surveys were conducted.

The report found that areas of rough grassland on site are suitable for badger foraging but no evidence of badgers was found onsite. Areas of rough grassland are also suitable for common reptiles and nesting birds. No suitable habitat for great crested newts was found on site. Extensive stands of Japanese Knotweed were recorded on site. Any reference in the report regarding bat roosting potential is no longer applicable following the demolition of the school buildings.

6.1.4 ACS Consulting Ltd. – Arboricultural Survey

An arboricultural survey was undertaken in 2007 and a development constraints plan produced. The report found that the majority of trees onsite were considered to be mediocre or exempt from planning control. Five trees were identified that were considered desirable to be retained. Due to the time period that has elapsed since the survey was undertaken, it is considered that a new survey should be undertaken to assist with the proposed development design.

6.1.5 Liverpool City Council – Flood Risk Assessment

A flood risk assessment was undertaken to demonstrate that a proposed development of 114 homes at the site was sustainable in flood risk terms. It concluded that there was a negligible risk of fluvial flooding and the risk of flooding from groundwater was considered low with the overall permeability of the site increased following the demolition of the school building.

It is recommended that a new flood risk assessment is conducted utilising updated information to inform the planning application.

6.1.6 Norwest Holst – Project No. F14826

Norwest Holst conducted a further phase of ground investigation in April 2007 in order to extend the coverage of the former investigations and complete the human health risk assessment for the site.

This comprised the drilling of 8No. window sample boreholes and the excavation of 7No. trial pits. The window sample boreholes were positioned to form boundary monitoring wells and to install gas wells into areas of the site not previously investigated. The trial pits were positioned in the southernmost third of the playing field area which was not previously investigated. The appendices available to REC did not contain an exploratory hole location plan but a plan from email correspondence between WSP and Liverpool City Council from March 2007 shows the completed trial pit locations (erroneously labelled TP16 to TP 22 instead of TP18 to TP24, though this is discussed in the correspondence) and the proposed locations of the boundary monitoring wells BHs 9 to 13. It is considered that the borehole numbers changed between the proposal drawing and the drilling works as the log descriptions do not match the report ground conditions text. The locations shown on this plan are reproduced with the original number references on Drawing No. 44808p1r0-002 attached for indicative purposes only. It should be borne in mind that the borehole locations were only proposed at this stage and boreholes 14 to 16 not shown at all.

Chemical testing and gas monitoring was undertaken as part of the investigation, the results of which are discussed in Sections 6.3 to 6.5 below.

6.2 Ground Conditions

The topsoil at the site ranged in thickness from 0.20m to 0.50m.

Made Ground at the site was found to comprise two types. The landfill area in the west of the site contains domestic refuse comprising material including brick, glass, wood, concrete, plastic, metal, bone, rubber, pottery and newspaper. The landfill is shallowest in the west with a typical thickness of 1.50m and deepest in the east where a maximum thickness of 4.90m was encountered in Norwest Holst's 2007 investigation in the east of the embankment (BH09, location unknown).

Made Ground unconnected to the landfill was only encountered in the Norwest Holst February 2005 report in the area to the north of the school buildings. It was described as comprising clayey Sand with gravel-sized fragments of predominantly sandstone to depths ranging from 0.20m bgl to 1.30m bgl. No Made Ground was identified around the school buildings.

Drift deposits were not recorded at the site. In Norwest Holst's February 2005 investigation a Clay horizon was noted in BH6 between 0.70m bgl and 1.20m bgl and a Silt horizon was noted in TP11 between 1.40m bgl and 2.00m bgl, though these are likely to represent Made Ground horizons.

Red sandstone was recorded at shallow depths in the east of the site in the area of the school buildings, typically at 0.10m bgl to 0.50m bgl and at greater depths (1.30m bgl to 4.90m bgl) in the west due to the raised landfill. Typically, a granular weathered horizon approximately 1.00m thick was encountered overlying the bedrock.

Weak red mudstone recovered as Sand and Gravel was recorded at one location (TP24) in the 2007 investigation.

Groundwater was not noted during the site investigations but was inconsistently recorded at depths of between 3.19m and 5.98m bgl during subsequent gas monitoring in the installed boreholes around the school buildings.

6.3 Human Health Risk Assessment

The chemical data from the previous reports has been reassessed using current assessment criteria. The data is not current but provides a useful preliminary assessment to aid the formulation of an initial conceptual site model.

6.3.1 Norwest Holst Ref F13512, February 2005

Tests were undertaken on 4No. soil samples for a range of determinands including Metals, Cyanide, Phenols, TPH and Asbestos. Exceedances of current GACs were recorded with regard to Arsenic (2No), Lead (2No) and Nickel (1No).

6.3.2 Norwest Holst Ref F13931, November 2005

Testing was undertaken on 18No. soil samples for a range of determinands including Metals, PCBs, Phenols, PAHs and Asbestos.

The updated results assessment shows exceedances with regard to Arsenic (11No), Lead (12No), Mercury (2No), Nickel (1No), Zinc (1No), Benz(a)anthracene (3No), Benzo(a)pyrene (5No, although all are under the C4SL threshold), Dibenz(a,h)anthracene (1No), Naphthalene (11No), Phenanthrene (1No) and TPH Aromatic C16-C21 (1No).

6.3.3 Norwest Holst Ref F14826, October 2007

Testing was taken on 11No. soil samples for a range of determinants including Metals and TPH.

The updated results assessment shows exceedances with regard to Arsenic (3No), Lead (6No) and Hexavalent Chromium (1No, although this is under the C4SL threshold).

6.4 Groundwater Risk Assessment

Leachate testing was undertaken on 4No. soil samples following the 2007 investigation and tested on a suite of determinands similar to that of soils.

The updated results assessment shows exceedances with regards to Copper (4No EQS), Lead (2No EQS & DWS), Nickel (2No EQS & DWS), Zinc (4No EQS), Sulphate (2No EQS & DWS), Benzo(b)fluoranthene (1No EQS), Benzo(k)fluoranthene (1No EQS) and Benzo(a)pyrene (1No EQS & DWS).

6.5 Gas Assessment

3No. gas monitoring wells were installed during the initial Norwest Holst investigation (F13512). A further 8No. wells were installed in their November 2005 investigation (F13931) and an additional 8No. installations were also installed during their 2007 investigation (F14826). It should be noted that the majority of these were located outside the former landfill.

The monitoring results show a maximum methane concentration of 2.1% v/v from BH2 (F13512) and a maximum carbon dioxide concentration at of 17.6% v/v, also from BH02 (F13512). A maximum flow rate of 1.3l/h was recorded at the site. These results are only indicative due to the intervening time period but they indicate that at the time the site would have been classified as Characteristic Situation 3 if today's standards were applied to it.

7.0 INITIAL CONCEPTUAL SITE MODEL (CSM)

7.1 Initial CSM

In accordance with Environment Agency, CLR 11 (2004) and BSI 10175 (Code of Practice for Investigation of Potentially Contaminated Land), REC Ltd have developed an initial CSM to identify potential contamination sources, migration pathways and receptors within the study area.

7.2 Contaminant Sources

On-site Potential Sources

Following the review of the Desk Study information and the previous assessments, the site can be divided into three main areas dependent upon their current/historical usage; the area of the former landfill (west), the area of the former school buildings (east) and the playing fields in the north.

Landfill

The on-site landfill was known to have accepted household waste; it is assumed that the landfilling occurred prior to the opening of the school in the late 1960s. From the previous reports by Norwest Holst, the Made Ground consisted of ash deposits and the following contaminants have been proven to be present on the area:

- Metals;
- Polycyclic Aromatic Hydrocarbons (PAHs);
- Petroleum Hydrocarbons; and,
- Hazardous ground gas.

A review of the relevant Department of the Environment (DOE) Industry Profiles indicates the landfill may give rise to the following contaminants;

- Heavy Metals;
- Polycyclic Aromatic Hydrocarbons (PAH);
- Asbestos Containing Material (ACM);
- Phenols;
- Sulphates;
- Cyanide;
- Hydrocarbons;
- Semi-Volatile Organic Compounds (SVOCs); and,
- Volatile Organic Compounds (VOCs).

In addition, the presence of Made Ground may be a source of hazardous ground gases such as methane and carbon dioxide.

Former School Area

Although the demolition of the school buildings removed all asbestos from the structure, it cannot be discounted that Asbestos Containing Materials (ACMs) may be present in the infilled cellars under the footprint of the former school. Further assessment should be made given due regard to the guidance set out in CIRIA C733.

Further assessment of the soils in proximity to the electricity substation on the eastern site boundary is required to determine whether they have been impacted by PCB contamination.

Further assessment of the soils surrounding the former boiler room is required.

Made Ground that may have been historically placed could present a potential on site source of contamination. The main sources of potential Made Ground on the area are materials generated during demolition of the former site buildings and construction material in the external areas in the former school.

The presence of Made Ground may give rise to contaminants such as toxic heavy metals, sulphates, PAHs and hydrocarbons from the deposition of ash or lead pipework etc. Furthermore Made Ground has the potential for the generation of ground gases (methane and carbon dioxide) with associated explosive and asphyxiation risks.

Northern Playing Fields

The historical plans indicate that the playing fields has never been subjected any previous land-use and it is expected that there are no significant contaminant sources in that area.

Off-site Potential Sources

No viable offsite sources of contamination have been identified.

The fuel station at 196m north west of the site is not considered to be a viable source as it is located down hydraulic gradient of the site as is the electrical substation adjacent to the south eastern site boundary.

7.3 Potential Pathways

Receptors may be potentially at risk from any on site contamination via the following pathways:

- Migration of mobile contaminants on or off site via services, sewers and manmade conduits;
- Direct contact, ingestion and inhalation of contaminants on site;
- Migration of contaminated dusts during earthworks;
- Migration of mobile contaminants into groundwater and transport offsite;
- Migration of hazardous gases;
- Uptake of toxins/phytotoxins by plants/vegetables and consumption; and,
- Consumption of contaminated potable waters.

7.4 Potential Receptors

Human receptors include:

- Future users of the site and buildings; and,
- Users of adjacent areas due to off-site migration of gases, vapours or contaminated dust.

Construction workers are not considered to be a plausible receptor as exposure will be managed through the use of appropriate PPE and hygienic working practices as required under HSE / CDM regulations. Furthermore, the length of any exposure is likely to be for a short duration;

Controlled Waters

Groundwater

The site has been shown to be underlain by negligible thicknesses of superficial drift over Sandstone which is considered by the EA to be a Principal Aquifer with the nearest licensed groundwater abstractions over 1km from site. With consideration to the above points and the probability that low levels of mobile contaminants may be present in the ash deposits, it is considered that the risk of contamination to the underlying groundwater is **low/moderate**.

Surface Waters

There are no surface water features within influencing distance of the site.

Ecological Sites / Ecosystems

There is a local nature reserve at 196m north west of the site; however this is not deemed to be a viable receptor as it is located up topographic and hydraulic gradient.

Buildings, Foundations and Services

Future redevelopment of the site will include the construction of new foundations. Elevated sulphate concentrations could affect the integrity of buried concrete structures. Services may be affected by the presence of aggressive contaminants which may corrode or penetrate services. Water supply pipes can be susceptible to penetration by hydrocarbons which may then affect the quality of the water supply.

8.0 GROUND INVESTIGATION

8.1 Desk Study Information

Potential contamination sources have been identified from the desk study and former site investigations. These are listed in Table 7.1 below:

Table 8.1 Summary of Potential Contaminant Sources

Potential Source	Potential Contaminants	Potential Impact
Made Ground associated with the landfill in the west of the site	Inorganic heavy metals PAHs, TPHs, ACM and ground gas	Groundwater and human health
Made Ground associated with the demolished former school buildings and associated car park	Inorganic heavy metals PAHs, TPHs, ACM and ground gas	Groundwater and human health
Unknown Made Ground associated with the infilled former pond	Inorganic heavy metals PAHs, TPHs, ACM and ground gas	Groundwater and human health

8.2 Ground Investigation

8.2.1 General

A Ground Investigation (GI) has been designed based on the findings of the desk study with exploratory holes advanced to target specific potential contaminant sources summarised in Section 7.0. In addition, exploratory holes have also been advanced to provide information on baseline conditions across the site and to collect geotechnical information to assist in the design and construction of the development.

Exploratory fieldwork was completed on the 9th April 2013. The works are summarised in Table 8.2.

Table 8.2 Summary of Fieldwork

Potential Source/Rationale	Location Hole	Type	Maximum Depth (m bgl)	Monitoring Wells Response Zone
Made Ground associated with Landfill	WS101	Window Sample	3.00	1.00-3.00
Made Ground associated with Landfill	WS102	Window Sample	3.00	1.00-3.00
Made Ground associated with Landfill	WS103	Window Sample	5.00	1.00-4.50
Made Ground associated with Landfill	WS104	Window Sample	1.40	0.50-1.00
Made Ground associated with Landfill	WS105	Window Sample	4.90	0.50-4.60
Made Ground associated with Landfill	WS106	Window Sample	2.00	0.50-2.00
Made Ground associated with Landfill	WS107	Window Sample	1.80	0.5-1.70
Made Ground associated with Landfill	WS108	Window Sample	4.50	0.5-4.50
Baseline Conditions	WS109	Window Sample	1.00	0.5-1.00
Baseline Conditions	WS110a	Window Sample	0.50	N/A
Baseline Conditions	WS110b	Window Sample	1.00	0.5-1.0
Baseline Conditions	WS111	Window Sample	1.80	0.5-1.80
Made Ground associated with former school	WS112	Window Sample	1.00	0.50-1.00
Made Ground associated with former school	WS113	Window Sample	1.00	0.50-1.00

Potential Source/Rationale	Location Hole	Type	Maximum Depth (m bgl)	Monitoring Wells Response Zone
Made Ground associated with car park	WS114	Window Sample	1.00	0.50-1.00
Made Ground associated with infilled pond	WS115	Window Sample	1.00	0.5-1.00
Made Ground associated with car park	WS116	Window Sample	2.00	0.50-2.00
Made Ground associated with former school	WS117	Window Sample	1.00	0.50-1.00
Made Ground associated with former school	WS118	Window Sample	1.00	0.5 -1.00
Baseline Conditions	TP101	Trial Pit	1.70	N/A
Baseline Conditions	TP102	Trial Pit	2.00	N/A
Made Ground associated with Landfill	TP103	Trial Pit	3.00	N/A
Made Ground associated with Landfill	TP104	Trial Pit	5.00	N/A
Made Ground associated with Landfill	TP105	Trial Pit	4.60	N/A
Made Ground associated with Landfill	TP106	Trial Pit	3.50	N/A
Made Ground associated with Landfill	TP107	Trial Pit	3.00	N/A
Made Ground associated with Landfill	TP108	Trial Pit	3.80	N/A
Made Ground associated with Landfill	TP109	Trial Pit	4.50	N/A
Made Ground associated with Landfill	TP110	Trial Pit	2.50	N/A
Made Ground associated with Landfill	TP111	Trial Pit	2.50	N/A
Made Ground associated with Landfill	TP112	Trial Pit	2.50	N/A
Made Ground associated with Landfill	TP113	Trial Pit	5.00	N/A
Made Ground associated with Landfill	TP114	Trial Pit	4.80	N/A
Made Ground associated with Landfill	TP115	Trial Pit	4.10	N/A
Made Ground associated with Landfill	TP116	Trial Pit	2.00	N/A
Made Ground associated with Landfill	TP117	Trial Pit	2.50	N/A
Made Ground associated with Landfill	TP118	Trial Pit	4.40	N/A
Made Ground associated with Landfill	TP119	Trial Pit	5.00	N/A
Made Ground associated with Landfill	TP120	Trial Pit	4.50	N/A
Made Ground associated with Landfill	TP121	Trial Pit	3.50	N/A
Made Ground associated with Landfill	TP122	Trial Pit	2.00	N/A
Made Ground associated with Landfill	TP123	Trial Pit	2.00	N/A
Made Ground associated with Landfill	TP124	Trial Pit	2.50	N/A
Made Ground associated with Landfill	TP125	Trial Pit	3.50	N/A
Made Ground associated with Landfill	TP126	Trial Pit	4.50	N/A
Made Ground associated with Landfill	TP127	Trial Pit	2.70	N/A
Made Ground associated with Landfill	TP128	Trial Pit	4.80	N/A
Made Ground associated with Landfill	TP129	Trial Pit	4.80	N/A
Made Ground associated with Landfill	TP130	Trial Pit	2.60	N/A
Made Ground associated with Landfill	TP131	Trial Pit	1.50	N/A
Made Ground associated with former school	TP132	Trial Pit	1.00	N/A
Made Ground associated with former school	TP133	Trial Pit	3.50	N/A
Made Ground associated with former school	TP134	Trial Pit	2.00	N/A
Made Ground associated with former school	TP135	Trial Pit	1.50	N/A
Made Ground associated with former school	TP136	Trial Pit	1.50	N/A

Potential Source/Rationale	Location Hole	Type	Maximum Depth (m bgl)	Monitoring Wells Response Zone
Made Ground associated with former school	TP137	Trial Pit	2.20	N/A
Made Ground associated with car park	TP138	Trial Pit	1.50	N/A
Made Ground associated with former school	TP139	Trial Pit	1.50	N/A
Made Ground associated with car park	TP140	Trial Pit	1.20	N/A
Made Ground associated with former school	TP141	Trial Pit	2.50	N/A
Made Ground associated with former school	TP142	Trial Pit	2.50	N/A
Made Ground associated with former school	TP143	Trial Pit	2.50	N/A
Baseline Conditions	TP144	Trial Pit	1.30	N/A
Baseline Conditions	TP145	Trial Pit	1.20	N/A

The window sample probeholes were designed to provide geotechnical information and confirm the findings of the Initial Conceptual Site Model (ICSM). All of the window sample probeholes were completed with a monitoring well installation to facilitate gas and groundwater monitoring.

The trial pits were advanced to retrieve geotechnical and environmental samples in addition to investigating the presence of any below ground obstructions and to provide supplementary data of the ground conditions.

All locations were spatially distributed to offer the maximum site coverage whilst still targeting the specific potential contaminant sources. The sampling locations are illustrated in Drawing No 44808p1r0/003 (Appendix III). The ground conditions encountered and details of monitoring well response zones are indicated on the logs which are provided in Appendix VI.

Soil and groundwater samples destined for chemical analysis were collected at regular intervals in appropriate sampling containers. Samples were subsequently stored in cooled boxes prior to submission to analytical laboratory.

A detailed copy of REC Ltd sampling methodology, QA procedures and laboratory chain of custody forms can be provided upon request.

8.2.2 In-Situ Standard Penetration Testing (SPT)

In-situ geotechnical testing was conducted using the Standard Penetration Test (SPT) and where the ground was granular, a 60° cone (SPT(C)) was used instead of the sampling tube. The results are shown in the probehole logs in Appendix VI and presented in Table 8.2.

8.3 Laboratory Analysis

8.3.1 Soil Chemical Analysis

Selected soil samples were submitted for a range of chemical analysis comprising, metals, pH, total sulphate, water soluble sulphate (2:1 extract), sulphide, cyanide, phenols, total and speciated polycyclic aromatic hydrocarbons (PAHs), asbestos, organic carbon, volatile

organic compounds (VOC), semi-volatile organic compounds (SVOC) and total and speciated petroleum hydrocarbon (CWG TPH).

Scientific Analysis Laboratories (SAL) Ltd of Manchester undertook the analytical work, the results of which are included in Appendix VII and discussed in Section 10.1.

8.3.2 Water Chemical Analysis

Owing to the lack of groundwater encountered at the site, no groundwater samples could be taken as such REC has undertaken leachate analysis.

SAL Ltd of Manchester undertook the analytical work, the results of which are included in Appendix VII and discussed in Section 10.2.

8.3.3 Geotechnical Laboratory Analysis

Selected samples were submitted to Professional Soils Limited laboratory where Particle Size Distribution analysis (PSD) was undertaken. Laboratory analysis sheets are included in Appendix IX and are summarised in Section 10

8.4 Gas and Groundwater Monitoring

Following the intrusive phase of site works, gas and groundwater monitoring was undertaken from the 17th April 2013. It was initially proposed to undertake a total of twelve monitoring visits within a six month period; however, twelve monitoring visits were completed over a ten month period.

Concentrations of methane (CH_4), carbon dioxide (CO_2) and Oxygen (O_2) were measured using an infra-red gas analyser (GA2000), calibrated to a reference standard (before and after each survey) and gas flow rates were measured using an attached flow pod. Gas measurements were recorded for a minimum of sixty seconds at each location, at which point the maximum concentration of CH_4 and CO_2 together with the lowest concentration of O_2 were recorded.

Groundwater monitoring was undertaken using an electronic dip meter and interface probe to record the depth to groundwater and the thickness of any free phase hydrocarbon product, if present.

The results of the gas and groundwater monitoring are shown in Section 9.3 and discussed within Section 10.3.

9.0 GROUND AND GROUNDWATER CONDITIONS

9.1 Ground Conditions

9.1.1 Summary of Ground Conditions

The ground investigation generally confirms the published geology and identifies the strata set out in Table 9.1 below:

Table 9.1 Summary of Strata

Strata	Typical Description	Min Depth to Top of Strata (m)	Max Depth to Top of Strata (m)	Max Thickness (m)
MG Gravelly clay	Soft to firm dark brown gravelly sandy clay. Gravel is sub-angular to angular medium to course sandstone	0.00	1.00	1.00
MG Ashy sand	Black brown ashy gravelly fine to coarse sand. Gravel is fine to coarse sub-angular to angular of clinker, glass, fabric, metal, rubber and wood. Cobbles are angular of sandstone.	0.30	4.80	4.20
SAND	Reddish brown gravelly fine to medium sand. Gravel is sub-angular to angular medium to course of sandstone	0.20	5.00	1.30
SANDSTONE	Weathered red brown SANDSTONE.	0.60	4.90	2.10

9.1.2 Made Ground

Made Ground was encountered in all exploratory hole locations to a maximum proven depth of 5.00m bgl (TP119) and generally comprised dark brown/black ashy gravelly fine to medium sand with many inclusions of metal, textiles, clinker, glass and other household waste type materials. However the significant volumes of Made Ground were isolated to the western sector of the site, the Made Ground deposits typically less than 1.00m across the remainder of the site.

Topsoil

Topsoil was encountered across the landscaped areas to an average depth of 0.40m, and comprised dark brown black slightly clayey with occasional fine to medium gravel of sandstone.

Drawing 44719p1r0-004 (Appendix III) illustrates the depth of Made Ground across the site.

9.1.3 Drift Deposits

Superficial drift deposits of fine to medium SAND were encountered to a maximum depth of 5.00m bgl and typically at depths of less than 1.00m bgl in the eastern sector and 5.00m bgl in the remainder of the site.

9.1.4 Solid Geology

Sandstone

A red brown weathered Sandstone was encountered at proven depths of between 0.20m and 4.90m bgl; was recovered as a sandy gravel.

9.1.5 Soil Consistency

The density of the granular soils were derived from the Standard Penetration Tests (SPTs) completed in all window sample probehole locations. The results of which are included in Table 9.2 (overleaf).

9.1.6 Side Stability and Ease of Excavation

The sides of the exploratory trial pit excavations were predominantly stable during excavation; however there was some instability in some of the trial pits undertaken in the western sector of the site.

The presence of occasional concrete slabs and relict brick foundations in the central sector of the site, where former buildings were located, resulted in the slow and difficult excavation of Made Ground. The natural strata were excavated with ease.

No groundwater was encountered during the GI.

The presence of shallow sandstone across the site meant that a number of exploratory holes were terminated at shallow depth as it could not be penetrated.

Table 9.2 Standard Penetration Test Results

Boreholes	Depth (m bgl) (i)	Material Field Description	CPT/SPT "N" Value	Corrected "N" Value $(N_1)_{60}$	Terzaghi & Peck Relative Density (Sands)
WS101	1.00	MG ashy sand	10	10.08	Medium Dense
	2.00	MG ashy sand	11	10.05	Medium Dense
	3.00	MG ashy sand	50	43.48	Very Dense
WS102	1.00	MG ashy sand	4	4.03	Loose
	2.00	MG ashy sand	17	15.53	Medium Dense
	3.00	Brown SAND	50	43.48	Very Dense
WS103	1.00	MG ashy sand	5	5.04	Loose
	2.00	MG ashy sand	0	0.00	Very Loose
	3.00	MG ashy sand	18	15.65	Medium Dense
	4.00	MG ashy sand	15	12.67	Medium Dense
	5.00	Brown SAND	50	41.48	Very Dense
WS104	1.00	MG ashy sand	10	10.08	Medium Dense
	1.40	Brown SAND	50	47.98	Very Dense
WS105	1.00	MG ashy sand	8	8.07	Loose
	2.00	MG ashy sand	5	4.57	Loose
	3.00	MG ashy sand	7	6.09	Loose
	4.00	MG ashy sand	0	0.00	Very Loose
	5.00	Brown SAND	50	41.48	Very Dense
WS106	1.00	MG ashy sand	7	7.06	Loose
	2.00	Brown SAND	50	45.68	Very Dense
WS107	1.00	MG ashy sand	0	0.00	Very Loose
	1.80	Brown SAND	50	46.32	Dense
WS108	1.00	MG ashy sand	0	0.00	Very Loose
	2.00	MG ashy sand	0	0.00	Very Loose
	3.00	MG ashy sand	2	1.74	Very Loose
	4.00	MG ashy sand	0	0.00	Very Loose
	5.00	Brown SAND	50	41.48	Very Dense
WS109	0.90	Brown SAND	50	51.21	Very Dense
WS110A	0.50	Brown SAND	50	56.02	Very Dense
WS110B	1.00	Brown SAND	50	50.41	Very Dense
WS111	1.00	Brown SAND	50	50.41	Very Dense
	1.70	Brown SAND	50	46.69	Very Dense
WS112	1.00	Brown SAND	50	50.41	Very Dense
WS113	1.00	Brown SAND	50	50.41	Very Dense
WS114	1.00	Brown SAND	50	50.41	Very Dense
WS115	1.00	Brown SAND	50	50.41	Very Dense
WS116	1.00	MG ashy sand	1	1.01	Very Loose
	2.00	Brown SAND	50	45.68	Very Dense
WS117	1.00	Brown SAND	50	50.41	Very Dense
WS118	1.00	Brown SAND	50	50.41	Very Dense

9.1.7 Soil Infiltration

In-situ variable (falling) head permeability tests were undertaken within the monitoring well installations located in two probeholes (WS104 and WS117). The results are presented in Table 9.3.

Table 9.3 Soil Infiltration Results

Location	Depth (m)	Material	Test No.	Soil Infiltration Rate (m/s)
WS104	0.00m to 1.527m	MG Ashy gravel	Test No.1	1.62^{-4}
WS117	0.00m to 1.025m	Gravelly SAND	Test No.1	6.43^{-4}

Soakaway tests were also undertaken in trial pits TP141 and TP145 in line with the methodology outlined within the BRE Special Publication 365, the results of which are shown in Table 9.4.

Table 9.4 BRE 365 Soakaway Test Results

Location	Depth (m)	Material	Test No.	Soil Infiltration Rate (m/s)
TP141	0.25 – 1.20	MG Clayey Sand and Gravelly SAND	1	N/A
TP145	0.21 – 1.30	MG Clayey Sand and Gravelly SAND	1	N/A

Soil infiltration was taken over the wetted area from between 75% and 25% of the effective depth. Where water did not infiltrate sufficiently for the head to fall to 25% of the effective depth then the test has been considered invalid and a Not Applicable (N/A) is noted under the results column.

The application of soakaway drainage will ultimately be dependent on the specific requirements of the development. All soakaways should be designed in accordance with BRE Special Digest 365 – *Soakaway Design*.

9.1.8 pH and Sulphate

Chemical analyses for pH and soluble sulphate content contained in Appendix VII (summarised overleaf in Table 8.5), shows that the soils at the site generally meet Class DS-1, Aggressive Chemical Environment for Concrete Classification (ACEC) AC-1s in accordance with BRE Special Digest 1 (2005).

Table 9.5 Summary of pH and Sulphate Data

Location	Depth (m)	SO_4 in 2:1 water / soil (g/l)	pH Value
WS101	1.70	0.1	7.1
WS103	3.50	<0.1	7.9
WS105	2.70	0.1	7.0
WS106	0.90	0.3	7.4
WS107	1.50	0.8	6.7
WS108	3.30	0.6	7.1
WS110B	0.20	<0.1	6.4
WS111	0.40	<0.1	8.0
WS113	0.70	<0.1	7.9
WS114	0.50	<0.1	7.8
WS115	0.30	<0.1	9.2
WS117	0.60	<0.1	9.7
WS118	0.60	<0.1	7.8
TP102	0.40	<0.1	5.9
TP105	0.80	<0.1	6.7
TP110	1.20	<0.1	6.9
TP117	0.30	<0.1	6.8
TP125	2.40	<0.1	7.7
TP130	1.50	<0.1	7.7
TP134	0.80	<0.1	7.4
TP136	1.20	<0.1	8.2
TP140	0.80	<0.1	5.9
	Design Value	**0.45**	**6.2**

9.1.9 Particle Size Distribution Analysis

Particle Size Distribution (PSD) analysis was undertaken on 11 samples and the results are shown in Table 9.6.

Table 9.6 PSD Results

Sample ID	Depth (m)	Cobbles (%)	Gravel (%)	Sand (%)	Silt/Clay (%)
TP101	1.50	0	13	71	16
TP103	2.00	10	76	12	2
TP104	0.80	0	20	66	14
TP105	2.00	0	53	38	9
TP115	3.50	0	58	38	4
TP128	2.50	0	43	43	14
TP129	4.00	0	65	28	7
TP132	0.60	0	31	54	15
TP134	1.70	0	61	32	7
TP140	1.00	0	27	61	12
TP144	1.00	13	68	18	1

9.2 Groundwater Conditions

They were no groundwater strikes encountered in any of the exploratory hole locations during drilling. During the subsequent monitoring no groundwater was encountered.

9.3 Ground Gas

Gas measurements were recorded for a minimum of sixty seconds at each location, at which point the maximum concentration of CH_4 and CO_2 together with the lowest concentration of O_2 were recorded. The results of the ground gas monitoring are presented in Table 9.7 (overleaf).

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Table 9.7 Summary of Ground Gas and Groundwater Monitoring Results

Well	Date	CH_4 Initial %v/v	CH_4 Steady %v/v	CH_4 GSV l/hr	CO_2 Initial %v/v	CO_2 Steady %v/v	CO_2 GSV l/hr	O_2 %v/v	Atmos (mb)	Atmos. Dynamic	Flow (l/hr)	Response Zone (mbgl)	Depth to Base (mbgl)	Depth to Water (mbgl)
WS101	17/04/2013	11.50	11.30	0.0	8.00	7.90	0.0	3.90	1001	Steady	0.0	1.00-3.00	3.045	Dry
	03/05/2013	5.70	5.70	0.0	5.90	5.90	0.0	8.90	1014	Falling	0.0		3.035	Dry
	16/10/2013	3.70	3.70	0.0037	6.90	6.90	0.0069	11.50	1001	Falling	0.1		3.303	Dry
	21/10/2013	2.10	2.10	0.0042	7.10	7.10	0.0142	11.20	993	Falling	0.2		3.299	Dry
	05/12/2013	4.20	4.20	-0.0042	6.30	6.30	-0.0063	10.40	1011	Rising	-0.1		3.301	Dry
	17/12/2013	0.10	0.10	-0.0001	4.20	4.20	-0.0042	8.50	1017	Falling	-0.1		3.304	Dry
	27/01/2014	0.0	0.0	-0.0	5.10	5.10	-0.0051	11.20	975	Steady	-0.1		3.302	Dry
	03/02/2014	0.0	0.0	0.0	8.10	8.10	0.0081	4.10	992	Falling	0.1		3.304	Dry
	06/02/2014	0.0	0.0	0.0	4.40	4.20	0.0044	12.70	982	Steady	0.1		3.003	Dry
	12/02/2014	0.0	0.0	0.0	3.70	3.70	0.0037	14.60	973	Falling	0.1		3.000	Dry
	19/02/2014	0.0	0.0	0.0	2.50	2.50	0.0025	17.40	1001	Steady	0.1		3.006	Dry
WS102	17/04/2013	13.70	13.70	0.0137	7.80	7.80	0.0078	2.90	1001	Steady	0.1	1.00-2.50	2.551	Dry
	03/05/2013	13.40	13.40	-0.0134	9.20	9.20	-0.0092	1.30	1014	Steady	-0.1		2.538	Dry
WS103	17/04/2013	14.60	14.60	0.0	13.40	13.40	0.0	2.00	1001	Steady	0.0	1.00-3.50	4.455	Dry
	03/05/2013	2.60	2.60	0.0026	2.80	2.80	0.0028	14.60	1014	Falling	0.1		4.443	Dry
	16/10/2013	0.30	0.30	0.0003	3.50	3.50	0.0035	15.70	1001	Falling	0.1		4.446	Dry
	21/10/2013	0.20	0.20	0.0002	4.10	4.10	0.0082	14.70	993	Falling	0.2		4.447	Dry
WS104	17/04/2013	6.10	5.30	0.0	3.00	2.80	0.0	13.70	1001	Steady	0.0	0.40-1.00	1.527	Dry
	03/05/2013	2.90	2.90	-0.0058	4.40	4.40	-0.0088	10.60	1014	Falling	0.2		1.499	Dry
	16/10/2013	2.10	2.10	0.0021	5.10	5.10	0.0051	12.10	1001	Falling	0.1		1.493	Dry
	21/10/2013	1.00	1.00	0.002	4.30	4.30	0.0086	12.90	993	Falling	0.2		1.491	Dry
WS105	17/04/2013	0.50	0.50	0.0	1.60	1.60	0.0	17.80	1001	Steady	0.0	0.50-4.60	4.402	Dry
	03/05/2013	0.20	0.20	-0.0004	0.70	0.70	-0.0014	16.30	1014	Falling	-0.2		4.375	Dry
WS105	16/10/2013	0.30	0.30	0.0003	1.20	1.20	0.0012	18.20	1001	Falling	0.1	0.50-4.60	4.381	Dry
	21/10/2013	0.20	0.20	0.0002	1.20	1.20	0.0012	18.10	993	Falling	0.1		4.376	Dry
WS106	17/04/2013	0.10	0.10	-0.0001	0.40	0.40	-0.0004	20.30	1001	Steady	-0.1	0.50-2.00	4.013	Dry

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Well	Date	CH_4 Initial %v/v	CH_4 Steady %v/v	CH_4 GSV l/hr	CO_2 Initial %v/v	CO_2 Steady %v/v	CO_2 GSV l/hr	O_2 %v/v	Atmos (mb)	Atmos. Dynamic	Flow (l/hr)	Response Zone (mbgl)	Depth to Base (mbgl)	Depth to Water (mbgl)
	03/05/2013	0.20	0.20	-0.0002	1.20	1.10	-0.0012	15.90	1014	Falling	0.1		4.013	Dry
	05/12/2013	0.10	0.10	-0.0001	5.80	5.80	-0.0058	14.20	1011	Rising	-0.1		4.013	Dry
	17/12/2013	0.10	0.10	-0.0001	3.20	3.20	-0.0032	16.90	1017	Falling	-0.1		4.019	Dry
	27/01/2014	0.0	0.0	-0.0	3.50	3.50	-0.0035	17.20	975	Steady	-0.1		4.023	Dry
	03/02/2014	0.0	0.0	0.0	1.50	0.30	0.0015	19.20	992	Falling	0.1		4.021	Dry
	06/02/2014	0.0	0.0	0.0	0.50	0.50	0.0005	19.40	982	Steady	0.1		4.022	Dry
	12/02/2014	0.0	0.0	0.0	0.80	0.60	0.0008	19.20	973	Falling	0.1		4.029	Dry
WS107	17/04/2013	0.10	0.10	-0.0001	2.40	2.40	-0.0024	20.30	1001	Steady	-0.1	0.50-1.80	1.823	Dry
	03/05/2013	0.20	0.20	-0.0002	0.60	0.60	-0.0006	16.20	1014	Falling	-0.1		1.795	Dry
	16/10/2013	0.30	0.30	0.0003	1.70	1.70	0.0017	17.80	1001	Falling	0.1		1.791	Dry
	21/10/2013	0.20	0.20	0.0004	0.10	0.10	0.0002	20.40	993	Falling	0.2		1.794	Dry
	05/12/2013	0.10	0.10	-0.0001	1.10	1.10	-0.0011	19.10	1011	Rising	-0.1		1.792	Dry
	17/12/2013	0.10	0.10	-0.0001	0.40	0.40	-0.0004	19.90	1017	Falling	-0.1		1.790	Dry
	27/01/2014	0.0	0.0	0.0	0.30	0.30	-0.0003	19.80	975	Steady	-0.1		1.749	Dry
	03/02/2014	0.0	0.0	0.0	0.10	0.10	0.0001	19.30	992	Falling	0.1		1.749	Dry
	06/02/2014	0.0	0.0	0.0	0.10	0.10	0.0001	19.70	982	Steady	0.1		1.745	Dry
	12/02/2014	0.0	0.0	0.0	0.50	0.50	0.0005	19.40	973	Falling	0.1		1.745	Dry
WS108	17/04/2013	0.10	0.10	0.0	0.80	0.80	0.0	20.00	1001	Steady	0.0	0.50-4.50	4.425	Dry
	03/05/2013	0.20	0.20	-0.0002	3.20	3.20	-0.0032	14.80	1014	Falling	-0.1		4.405	Dry
	16/10/2013	0.30	0.30	0.0003	4.80	4.80	0.0048	15.10	1001	Falling	0.1		4.010	Dry
	21/10/2013	0.20	0.20	0.0002	2.50	2.50	0.0025	18.60	993	Falling	0.1		4.011	Dry
WS109	17/04/2013	0.10	0.10	0.0	2.40	2.40	0.0	18.70	1001	Steady	0.0	0.50-1.00	0.965	Dry
	03/05/2013	0.20	0.20	-0.0002	1.70	1.70	-0.0017	15.80	1014	Falling	0.1		0.935	Dry
	16/10/2013	0.30	0.30	0.0006	4.20	4.20	0.0084	17.10	1001	Falling	0.2		0.930	Dry
	21/10/2013	0.20	0.20	0.0002	5.50	5.50	0.0055	15.30	993	Falling	0.1		0.926	Dry
	05/12/2013	0.10	0.10	-0.0001	3.50	3.50	-0.0035	17.60	1011	Rising	-0.1		0.913	Dry
	17/12/2013	0.10	0.10	-0.0001	2.10	2.10	-0.0021	18.90	1017	Falling	-0.1		0.992	Dry
	27/01/2014	0.0	0.0	-0.0	3.20	2.40	-0.0032	18.70	975	Steady	-0.1		0.993	Dry

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Well	Date	CH_4 Initial %v/v	CH_4 Steady %v/v	CH_4 GSV l/hr	CO_2 Initial %v/v	CO_2 Steady %v/v	CO_2 GSV l/hr	O_2 %v/v	Atmos (mb)	Atmos. Dynamic	Flow (l/hr)	Response Zone (mbgl)	Depth to Base (mbgl)	Depth to Water (mbgl)
	03/02/2014	0.0	0.0	0.0	1.10	1.10	0.0011	16.50	992	Falling	0.1		0.995	Dry
	06/02/2014	0.0	0.0	0.0	2.10	2.10	0.0021	16.90	982	Steady	0.1		1.001	Dry
	12/02/2014	0.0	0.0	0.0	1.80	1.70	0.0018	15.20	973	Falling	0.1		0.997	Dry
	19/02/2014	0.0	0.0	0.0	0.80	0.80	0.0008	19.30	1001	Steady	0.1		0.998	Dry
WS110 (B)	17/04/2013	0.10	0.10	0.0001	0.90	0.90	0.0009	20.30	1001	Steady	0.1	0.50-1.00	1.165	Dry
	03/05/2013	0.20	0.20	0.0	0.30	0.30	0.0	16.90	1014	Falling	-0.1		1.16	Dry
	17/07/2013	0.20	0.20	-0.0002	0.20	0.20	-0.0002	17.80	1022	Falling	-0.1		1.158	Dry
	16/10/2013	0.30	0.30	0.0003	0.20	0.20	0.0002	19.80	1001	Falling	0.1		1.154	Dry
	21/10/2013	0.20	0.20	0.0002	0.40	0.40	0.0004	19.70	993	Falling	0.1		1.159	Dry
	05/12/2013	0.10	0.10	0.0001	0.10	0.10	0.0001	20.90	1011	Rising	-0.1		1.154	Dry
	17/12/2013	0.10	0.10	-0.0001	0.20	0.20	-0.0002	21.40	1017	Falling	-0.1		1.154	Dry
	27/01/2014	0.0	0.0	-0.0	0.40	0.40	-0.0004	20.10	975	Steady	-0.1		1.148	Dry
	03/02/2014	0.0	0.0	0.0	0.10	0.10	0.0001	19.40	992	Falling	0.1		1.150	Dry
	06/02/2014	0.0	0.0	0.0	0.10	0.10	0.0001	20.00	982	Steady	0.1		1.155	Dry
	12/02/2014	0.0	0.0	0.0	0.1	0.1	0.0001	19.70	973	Falling	0.1		1.155	Dry
	19/02/2014	0.0	0.0	0.0	0.0	0.0	0.0	19.90	1001	Steady	0.1		1.151	Dry
WS111	17/04/2013	0.10	0.10	0.0	5.40	5.40	0.0	15.00	1001	Steady	0.0	0.50-1.70	1.843	Dry
	03/05/2013	0.20	0.20	0.0	4.40	4.40	0.0	14.00	1014	Falling	0.0		1.816	Dry
WS112	17/04/2013	0.10	0.10	0.0001	0.00	0.00	0.0	20.40	1001	Steady	0.1	0.50-1.00	1.015	Dry
	03/05/2013	0.20	0.20	0.0	0.30	0.30	0.0	17.80	1014	Falling	0.0		1.087	Dry
	17/07/2013	0.20	0.20	-0.0002	0.0	0.0	0.0							
	16/10/2013	0.30	0.30	0.0006	0.20	0.20	0.0004	20.50	1001	Falling	0.2		1.058	Dry
	21/10/2013	0.20	0.20	0.0002	0.10	0.10	0.0001	20.60	993	Falling	0.1		1.052	Dry
	05/12/2013	0.10	0.10	-0.0001	0.20	0.20	-0.0002	21.20	1011	Rising	-0.1		1.051	Dry
	17/12/2013	0.10	0.10	0.0001	0.40	0.40	0.0004	20.60	1017	Falling	0.1		1.152	Dry
	27/01/2014	0.0	0.0	-0.0	0.50	0.50	-0.0005	19.20	975	Steady	-0.1		1.159	Dry
	03/02/2014	0.0	0.0	0.0	0.10	0.10	0.0001	19.30	992	Falling	0.1		1.156	Dry
	06/02/2014	0.0	0.0	0.0	0.10	0.10	0.0001	19.90	982	Steady	0.1		1.154	Dry

Well	Date	CH_4 Initial %v/v	CH_4 Steady %v/v	CH_4 GSV l/hr	CO_2 Initial %v/v	CO_2 Steady %v/v	CO_2 GSV l/hr	O_2 %v/v	Atmos (mb)	Atmos. Dynamic	Flow (l/hr)	Response Zone (mbgl)	Depth to Base (mbgl)	Depth to Water (mbgl)
	12/02/2014	0.0	0.0	0.0	0.10	0.10	0.0001	19.60	973	Falling	0.1		1.154	Dry
	19/02/2014	0.0	0.0	0.0	0.10	0.10	0.0001	19.80	1001	Steady	0.1		1.149	Dry
WS113	17/04/2013	0.10	0.10	0.0	0.10	0.00	0.0	20.80	1001	Steady	0.0	0.50-1.00	1.077	Dry
	03/05/2013	0.30	0.30	-0.0003	0.20	0.20	-0.0002	16.90	1014	Falling	-0.1		1.065	Dry
	17/07/2013	0.10	0.10	-0.0001	1.10	1.10	-0.0011	18.60	1022	Steady	-0.1		1.045	Dry
	16/10/2013	0.30	0.30	0.0003	2.30	2.30	0.0023	18.20	1001	Falling	0.1		1.036	Dry
	21/10/2013	0.20	0.20	0.0002	0.70	0.70	0.0007	19.40	993	Falling	0.1		1.032	Dry
	05/12/2013	0.10	0.10	0.0001	1.70	1.70	0.0017	19.40	1011	Rising	0.1		1.031	Dry
	17/12/2013	0.10	0.10	-0.0001	1.10	1.10	-0.0011	20.10	1017	Falling	-0.1		1.032	Dry
	27/01/2014	0.10	0.10	-0.0001	1.50	1.50	-0.0015	18.30	975	Steady	-0.1		1.034	Dry
	03/02/2014	0.0	0.0	0.0	1.50	1.30	0.0015	17.80	992	Falling	0.1		1.036	Dry
	06/02/2014	0.0	0.0	0.0	0.90	0.90	0.0009	19.30	982	Steady	0.1		1.035	Dry
WS113	12/02/2014	0.0	0.0	0.0	1.40	1.40	0.0014	18.60	973	Falling	0.1	0.50-1.00	1.032	Dry
	19/02/2014	0.0	0.0	0.0	0.10	0.10	0.0001	19.80	1001	Steady	0.1		1.037	Dry
WS114	17/04/2013	0.10	0.10	0.0	0.90	0.90	0.0	19.20	1001	Steady	0.0	0.50-1.00	1.000	Dry
	03/05/2013	0.20	0.20	-0.0002	1.00	1.00	-0.001	15.30	1014	Falling	0.1		0.986	Dry
	17/07/2013	0.20	0.20	-0.0002	2.40	2.40	-0.0024	16.50	1022	Steady	-0.1		0.973	Dry
	16/10/2013	0.30	0.30	0.0003	3.40	3.40	0.0034	16.60	1001	Falling	0.1		0.976	Dry
	21/10/2013	0.20	0.20	0.0002	4.60	4.60	0.0092	15.40	993	Falling	0.2		0.975	Dry
	05/12/2013	0.10	0.10	-0.0001	2.50	2.50	-0.0025	18.80	1011	Rising	-0.1		0.981	Dry
	17/12/2013	0.10	0.10	-0.0001	4.20	3.80	-0.0042	15.40	1017	Falling	-0.1		0.924	Dry
	27/01/2014	0.0	0.0	-0.0	1.60	1.60	-0.0016	18.60	975	Steady	-0.1		0.929	Dry
	03/02/2014	0.0	0.0	0.0	4.10	4.10	0.0041	9.20	992	Falling	0.1		0.935	Dry
	06/02/2014	0.10	0.10	0.0001	3.30	3.30	0.0033	11.40	982	Steady	0.1		0.938	Dry
	12/02/2014	0.10	0.10	0.0001	3.30	3.30	0.0033	11.40	973	Falling	0.1		0.938	Dry
	19/02/2014	0.0	0.0	0.0	1.90	1.90	0.0019	12.70	1001	Steady	0.1		0.944	Dry
WS115	17/04/2013	0.10	0.10	0.0003	0.50	0.50	0.0015	20.00	1001	Steady	0.3	0.50-1.00	1.103	Dry
	03/05/2013	0.20	0.20	-0.0002	0.50	0.50	-0.0005	16.40	1014	Falling	-0.1		1.091	Dry

Well	Date	CH_4 Initial %v/v	CH_4 Steady %v/v	CH_4 GSV l/hr	CO_2 Initial %v/v	CO_2 Steady %v/v	CO_2 GSV l/hr	O_2 %v/v	Atmos (mb)	Atmos. Dynamic	Flow (l/hr)	Response Zone (mbgl)	Depth to Base (mbgl)	Depth to Water (mbgl)
	17/07/2013	0.20	0.20	-0.0002	1.00	1.00	-0.001	17.70	1022	Steady	-0.1		1.083	Dry
	16/10/2013	0.30	0.30	0.0003	0.90	0.90	0.0009	19.80	1001	Falling	0.2		1.081	Dry
	21/10/2013	0.20	0.20	0.0002	1.40	1.40	0.0014	19.30	993	Falling	0.1		1.087	Dry
	05/12/2013	0.10	0.10	0.0001	0.60	0.60	0.0006	20.40	1011	Rising	0.1		1.079	Dry
	17/12/2013	0.10	0.10	-0.0001	0.10	0.10	-0.0001	21.10	1017	Falling	-0.1		1.079	Dry
	27/01/2014	0.0	0.0	-0.0	0.20	0.20	-0.0002	19.90	975	Steady	-0.1		1.074	Dry
	03/02/2014	0.0	0.0	0.0	0.10	0.10	0.0001	19.20	992	Falling	0.1		1.078	Dry
	06/02/2014	0.0	0.0	0.0	0.30	0.30	0.0003	19.90	982	Steady	0.1		1.082	Dry
WS115	12/02/2014	0.0	0.0	0.0	0.10	0.10	0.0001	19.70	973	Falling	0.1	0.50-1.00	1.082	Dry
	19/02/2014	0.0	0.0	0.0	0.10	0.10	0.0001	19.90	1001	Steady	0.1		1.075	Dry
WS116	17/04/2013	0.10	0.10	0.0	0.40	0.40	0.0	20.70	1001	Steady	0.0	0.50-1.50	1.993	Dry
	17/07/2013	0.20	0.20	-0.0002	1.90	1.90	-0.0019	15.60	1022	Steady	-0.1		1.971	Dry
	16/10/2013	0.30	0.30	0.0006	2.40	2.40	0.0048	16.9	1001	Falling	0.2		1.969	Dry
	21/10/2013	0.20	0.20	0.0002	2.70	2.60	0.0027	17.20	993	Falling	0.1		1.967	Dry
	05/12/2013	0.10	0.10	-0.0001	3.30	3.30	-0.0033	17.90	1011	Rising	-0.1		1.958	Dry
	17/12/2013	0.10	0.10	0.0001	4.90	4.90	0.0049	17.40	1017	Falling	-0.1		1.961	Dry
	27/01/2014	0.0	0.0	-0.0	2.70	2.70	-0.0027	17.60	975	Steady	-0.1		1.965	Dry
	03/02/2014	0.0	0.0	0.0	1.80	1.80	0.0018	18.20	992	Falling	0.1		1.952	Dry
	06/02/2014	0.0	0.0	0.0	1.60	1.60	0.0016	18.80	982	Steady	0.1		1.951	Dry
	12/02/2014	0.0	0.0	0.0	2.20	2.20	0.0022	18.00	973	Falling	0.1		1.950	Dry
	19/02/2014	0.0	0.0	0.0	1.00	1.00	0.001	19.20	1001	Steady	0.1		1.950	Dry
WS117	17/04/2013	0.10	0.10	0.0	0.00	0.00	0.0	20.60	1001	Steady	0.0	0.50-1.00	1.025	Dry
	03/05/2013	0.20	0.20	0.0	0.00	0.00	0.0	17.00	1014	Falling	0.0		0.903	Dry
	16/10/2013	0.30	0.30	0.0003	0.10	0.10	0.001	20.60	1001	Falling	0.2		0.926	Dry
	21/10/2013	0.20	0.20	0.0002	0.10	0.10	0.0001	20.60	993	Falling	-0.1		0.934	Dry
	05/12/2013	0.10	0.10	0.0001	0.10	0.10	0.0001	21.10	1011	Rising	0.1		0.931	Dry
	17/12/2013	0.10	0.10	0.0001	0.20	0.20	0.0002	21.20	1017	Falling	0.1		0.941	Dry
	27/01/2014	0.0	0.0	-0.0	0.10	0.10	-0.0001	19.90	975	Steady	-0.1		0.853	Dry

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Well	Date	CH_4 Initial %v/v	CH_4 Steady %v/v	CH_4 GSV l/hr	CO_2 Initial %v/v	CO_2 Steady %v/v	CO_2 GSV l/hr	O_2 %v/v	Atmos (mb)	Atmos. Dynamic	Flow (l/hr)	Response Zone (mbgl)	Depth to Base (mbgl)	Depth to Water (mbgl)
	03/02/2014	0.0	0.0	0.0	0.10	0.10	0.0001	19.50	992	Falling	0.1		0.941	Dry
	06/02/2014	0.0	0.0	0.0	0.10	0.10	0.0001	20.00	982	Steady	0.1		0.949	Dry
	12/02/2014	0.0	0.0	0.0	0.0	0.0	0.0	19.60	973	Falling	0.1		0.951	Dry
	19/02/2014	0.0	0.0	0.0	0.30	0.30	0.0003	19.90	1001	Steady	0.1		0.951	Dry
WS118	17/04/2013	0.10	0.10	0.0	1.60	1.60	0.0	19.70	1001	Steady	0.0	0.50-1.00	1.11	Dry
	03/05/2013	0.20	0.20	0.0	1.60	1.60	0.0	16.40	1014	Falling	0.0		1.102	Dry
	17/07/2013	0.20	0.20	0.0	1.60	1.60	0.0	16.40	1001	Steady	0.0		1.102	Dry
	16/10/2013	0.30	0.30	0.0003	1.40	1.40	0.0014	18.30	1001	Falling	0.1		1.109	Dry
	21/10/2013	0.30	0.30	0.0006	1.70	1.70	0.0034	18.50	993	Falling	0.2		1.111	Dry
	05/12/2013	0.10	0.10	-0.0001	1.20	1.20	-0.0012	19.70	1011	Rising	-0.1		1.107	Dry
	17/12/2013	0.10	0.10	-0.0001	2.10	2.10	-0.0021	19.10	1017	Falling	-0.1		1.104	Dry
	27/01/2014	0.0	0.0	-0.0	0.70	0.70	-0.0007	19.30	975	Steady	-0.1		1.108	Dry
	03/02/2014	0.0	0.0	0.0	3.20	3.20	0.0032	15.10	992	Falling	0.1		1.102	Dry
	06/02/2014	0.0	0.0	0.0	2.50	2.50	0.0025	16.40	982	Steady	0.1		1.114	Dry
	12/02/2014	0.0	0.0	0.0	1.70	1.70	0.0017	17.50	973	Falling	0.1		1.114	Dry
	19/02/2014	0.0	0.0	0.0	0.60	0.60	0.0006	19.50	1001	Steady	0.1		1.105	Dry

10.0 TIER 1 QUALITATIVE CONTAMINATED LAND RISK ASSESSMENT

REC has undertaken a Tier 1 qualitative risk assessment to determine if any potential contaminants within the underlying soils and groundwater pose an unacceptable level of risk to the identified receptors.

In order to provide an accurate appraisal of the site, it has been divided up into three averaging areas. These are:

- The former landfill in the west of the site;
- The area formerly occupied by the school buildings and associated hardstanding; and,
- The former playing fields in the north of the site not associated with the landfill.

In order to provide a complete analysis of each of these areas, the chemical data obtained by REC laboratory testing has been supplemented by utilising the chemical data from the previous reports discussed in Section 6.0.

10.1 Human Health Risk Assessment

At a Tier 1 stage the long term (chronic) human health toxicity of the soil has been assessed by comparing the on-site concentrations of organic and inorganic compounds with reference values published by the EA (Contaminated Land Exposure Assessment (CLEA) Soil Guideline Values (SGV)) and where absent, Generic Assessment Criteria (GACs) published by LQM/CIEH (2nd edition).

As stated above, the site has been divided into three averaging areas.

10.1.1 Former Landfill Area

The results comparison of the long term human health toxicity of the soil within the landfill area is presented in Table 10.1 below.

Table 10.1 Summary of Inorganic and Hydrocarbon Toxicity Assessment for a Residential End Use with Plant Uptake within the Landfill Area

Determinants	Units	GAC V3	C4SL	n	n of Ex	MC	Loc. of Max Ex	Pathway	Assessment
Arsenic	mg/kg	32	37	47	25	180	WS106 0.90	1	Further Action
Cadmium	mg/kg	10	26	47	0	8	N/A	1	No Further Action
Chromium (VI)	mg/kg	4.3	21	22	1	7.1	WS108 3.30	1	Further Action
Lead(ii)	mg/kg	-	200	47	30	2600	WS105 2.70	1	Further Action
Mercury	mg/kg	11		47	0	2.3	N/A	2	No Further Action
Nickel	mg/kg	130		47	4	360	WS108 3.30	1	Further Action
Selenium	mg/kg	350		47	0	2.4	N/A	1	No Further Action
Copper(ii)	mg/kg	2330		47	0	855.3	N/A	1	No Further Action
Zinc(ii)	mg/kg	3750		47	1	5336.5	TP2 1.00	1	No Further Action

Determinants	Units	GAC V3	C4SL	n	n of Ex	MC	Loc. of Max Ex	Pathway	Assessment
Cyanide - Total	mg/kg	791		22	0	259	N/A	1	No Further Action
Phenols - Total	mg/kg	210		39	0	0.5	N/A	1	No Further Action
Naphthalene	mg/kg	1.5		45	13	120	WS103 3.50	2	Further Action
Acenaphthylene	mg/kg	170		45	1	370	WS103 3.50	3	Further Action
Acenaphthene	mg/kg	210		45	1	530	WS103 3.50	1	Further Action
Fluorene	mg/kg	160		45	0	37	N/A	1	No Further Action
Phenanthrene	mg/kg	92		45	2	130	WS103 3.50	3	Further Action
Anthracene	mg/kg	2300		45	0	31	N/A	3	No Further Action
Fluoranthene	mg/kg	260		45	0	47	N/A	3	No Further Action
Pyrene	mg/kg	560		45	0	72	N/A	3	No Further Action
Benzo(a)Anthracene	mg/kg	3.1		45	3	13.2	TP8 0.50	3	Further Action
Chrysene	mg/kg	6		45	3	14.1	TP8 0.50	3	Further Action
Benzo(b/k)Fluoranthene[(i)]	mg/kg	5.6		45	2	41	WS103 3.50	3	Further Action
Benzo(a)Pyrene	mg/kg	0.83		45	9	31	WS103 3.50	3	Further Action
Indeno(123-cd)Pyrene	mg/kg	3.2		45	2	8.6	WS103 3.50	3	Further Action
Dibenzo(a,h)Anthracene	mg/kg	0.76		45	2	2.7	WS103 3.50	3	Further Action
Benzo(ghi)Perylene	mg/kg	44		45	0	11	N/A	3	No Further Action
TPH C_5-C_6 (aliphatic)*	mg/kg	30		16	0	<0.10	N/A	2	No Further Action
TPH C_6-C_8 (aliphatic)*	mg/kg	73		16	0	0.62	N/A	2	No Further Action
TPH C_8-C_{10} (aliphatic)*	mg/kg	19		16	1	140	WS103 3.50	2	Further Action
TPH C_{10}-C_{12} (aromatic)*	mg/kg	69		16	1	320	WS103 3.50	2	Further Action
TPH C_{12}-C_{16} (aromatic)*	mg/kg	140		16	1	1400	WS103 3.50	1	Further Action
TPH C_{16}-C_{21} (aromatic)*	mg/kg	250		16	1	950	WS103 3.50	1	Further Action
TPH C_{21}-C_{35} (aromatic)*	mg/kg	890		16	0	490	N/A	1	No Further Action

Notes
Main Exposure Pathways: 1 = Soil Ingestion, 2 = Vapour Inhalation (indoor), 3 = Dermal Contact & Ingestion, 4 = Dust Inhalation.
Abbreviations: GAC = General Assessment Criteria, n = number of samples, n of Ex = Number of Exceedances; MC = Maximum Concentration; Loc of Ex = Location of Exceedance.
* The Tier 1 GAC for the hydrocarbon fraction is derived from the CIEH assessment for petroleum hydrocarbons Criteria Working Group (CWG) for both aliphatic and aromatic compounds. REC has utilised the Tier 1 values for aliphatic compounds for the volatile and semi volatile fractions (C_5-C_{12}) and the Tier 1 values for aromatic compound for the non volatile fractions (C_{12}-C_{35}). The comparison of a total (aliphatic/aromatic) compounds to an individual fraction is considered to be a conservative approach and satisfactory for the protection of human health.

(i) Benzo (b) Fluoranthene (100mg/kg) Benzo (k) Fluoranthene (140mg/kg)

(ii) GAC based on human health criteria. Ecotoxicological assessment will be made using EA guidance (EPR 8.01) on soil spreading (Cu 135mg/kg, Zinc 200mg/kg, Pb 300mg/kg)

Referring to Table 10.1, the results of the direct comparison show that screening values have been exceeded for the following determinants as shown in Table 10.2.

Table 10.2 Summary of Exceedances

Non-Volatile	Volatile
Pathways	
Dermal Contact, Ingestion, Consumption of home grown produce	Inhalation of vapours
▪ Arsenic; ▪ Chromium (VI); ▪ Lead; ▪ Nickel; ▪ Zinc; ▪ Acenaphthylene; ▪ Acenaphthene; ▪ Phenanthrene; ▪ Benzo(a)Anthracene; ▪ Chrysene; ▪ Benzo(b/k)Fluoranthene; ▪ Benzo(a)Pyrene; ▪ Indeno(123-cd)Pyrene; ▪ Dibenzo(a,h)Anthracene; and, ▪ Hydrocarbon fractions aromatic C_{12}-C_{16} and C_{16}-C_{21}.	▪ Naphthalene; and, ▪ Hydrocarbon fractions aliphatic C_8-C_{10} and aromatic C_{10}-C_{12}.

The results analysis shows that the landfill area has widespread elevated levels of metals and PAHs, particularly with regard to Arsenic (25No. exceedances), Lead (30No. Exceedances), Naphthalene (13No. exceedances) and Benzo(a)pyrene (9No. exceedances).

The results are typical of contaminants of domestic landfill containing ash, clinker and coal tar products.

Elevated aliphatic and aromatic hydrocarbon results were recorded at one location out of 16No. samples tested (WS103 at 3.50m). A sample taken from below this depth within the same borehole (WS103 at 4.70m) returned testing results with all TPH fractions below the laboratory limits of detection, indicating that the hydrocarbon contamination within the landfill area is limited in nature and of low mobility.

As is shown in Table 10.2 above, the pathways for the encountered contamination are dermal contact, ingestion, consumption of home-grown produce and inhalation. In order to mitigate these risks it will be necessary to remediate the landfill. The proposed remediation of the landfill will comprise two stages; firstly the off-site disposal of unsuitable and deleterious materials and secondly, the subsequent bioremediation of the remainder of the soils. All Made Ground within the former landfill will require excavation in its entirety and following excavation, the excavated materials will be sorted, with the unsuitable material disposed of off-site. The remainder of soils will be subject to treatment by means of bioremediation in windrows. This is considered to be an appropriate remedial technique to address the identified hydrocarbon impacts; it addresses the driving pollutant linkage by removing the volatile source. Soils will be considered to be suitably remediated as and when laboratory validation testing demonstrates that the soil concentrations are below the remediation criteria for both human health and controlled waters. The treated soils will be placed back into the void in a controlled manner.

Following development, a 600mm clean cover should then be installed in this area to break the remaining dermal contact and ingestion pathways for the remaining contaminants.

10.1.2 Former School Area

The results comparison of the long term human health toxicity of the soil within the former school area is presented in Table 10.3 below

Table 10.3 Summary of Inorganic and Hydrocarbon Toxicity Assessment for a Residential End Use with Plant Uptake within the Former School Area

Determinants	Units	GAC V3	C4SL	n	n of Ex	MC	Loc. of Max Ex	Pathway	Assessment
Arsenic	mg/kg	32	37	9	0	6	N/A	1	No Further Action
Cadmium	mg/kg	10	26	9	0	<1.0	N/A	1	No Further Action
Chromium (VI)	mg/kg	4.3	21	8	0	<1.0	N/A	1	No Further Action
Lead[(ii)]	mg/kg	-	200	9	0	25	N/A	1	No Further Action
Mercury	mg/kg	11		9	0	0.1	N/A	2	No Further Action
Nickel	mg/kg	130		9	0	11	N/A	1	No Further Action
Selenium	mg/kg	350		9	0	<3.0	N/A	1	No Further Action
Copper[(ii)]	mg/kg	2330		9	0	15	N/A	1	No Further Action
Zinc[(ii)]	mg/kg	3750		9	0	47	N/A	1	No Further Action
Cyanide - Total	mg/kg	791		8	0	<1.0	N/A	1	No Further Action
Phenols - Total	mg/kg	210		9	0	<1.0	N/A	1	No Further Action
Naphthalene	mg/kg	1.5		9	0	<0.1	N/A	2	No Further Action
Acenaphthylene	mg/kg	170		9	0	<0.1	N/A	3	No Further Action
Acenaphthene	mg/kg	210		9	0	0.01	N/A	1	No Further

Determinants	Units	GAC V3	C4SL	n	n of Ex	MC	Loc. of Max Ex	Pathway	Assessment
									Action
Fluorene	mg/kg	160		9	0	<0.01	N/A	1	No Further Action
Phenanthrene	mg/kg	92		9	0	0.02	N/A	3	No Further Action
Anthracene	mg/kg	2300		9	0	0.01	N/A	3	No Further Action
Fluoranthene	mg/kg	260		9	0	0.04	N/A	3	No Further Action
Pyrene	mg/kg	560		9	0	0.05	N/A	3	No Further Action
Benzo(a)Anthracene	mg/kg	3.1		9	0	0.03	N/A	3	No Further Action
Chrysene	mg/kg	6		9	0	0.03	N/A	3	No Further Action
Benzo(b/k)Fluoranthene(i)	mg/kg	5.6		9	0	0.06	N/A	3	No Further Action
Benzo(a)Pyrene	mg/kg	0.83		9	0	0.04	N/A	3	No Further Action
Indeno(123-cd)Pyrene	mg/kg	3.2		9	0	0.03	N/A	3	No Further Action
Dibenzo(a,h)Anthracene	mg/kg	0.76		9	0	0.03	N/A	3	No Further Action
Benzo(ghi)Perylene	mg/kg	44		9	0	0.03	N/A	3	No Further Action
TPH C_5-C_6 (aliphatic)*	mg/kg	30		8	0	<0.10	N/A	2	No Further Action
TPH C_6-C_8 (aliphatic)*	mg/kg	73		8	0	<0.10	N/A	2	No Further Action
TPH C_8-C_{10} (aliphatic)*	mg/kg	19		8	0	<0.10	N/A	2	No Further Action
TPH C_{10}-C_{12} (aromatic)*	mg/kg	69		8	0	<1.0	N/A	2	No Further Action
TPH C_{12}-C_{16} (aromatic)*	mg/kg	140		8	0	<1.0	N/A	1	No Further Action
TPH C_{16}-C_{21} (aromatic)*	mg/kg	250		8	0	<1.0	N/A	1	No Further Action
TPH C_{21}-C_{35} (aromatic)*	mg/kg	890		8	0	3	N/A	1	No Further Action

Notes
Main Exposure Pathways: 1 = Soil Ingestion, 2 = Vapour Inhalation (indoor), 3 = Dermal Contact & Ingestion, 4 = Dust Inhalation.
Abbreviations: GAC = General Assessment Criteria, n = number of samples; n of Ex = Number of Exceedances; MC = Maximum Concentration; Loc of Ex = Location of Exceedance.
* The Tier 1 GAC for the hydrocarbon fraction is derived from the CIEH assessment for petroleum hydrocarbons Criteria Working Group (CWG) for both aliphatic and aromatic compounds. REC has utilised the Tier 1 values for aliphatic compounds for the volatile and semi volatile fractions (C_5-C_{12}) and the Tier 1 values for aromatic compound for the non volatile fractions (C_{12}-C_{35}). The comparison of a total (aliphatic/aromatic) compounds to an individual fraction is considered to be a conservative approach and satisfactory for the protection of human health.
(i) Benzo (b) Fluoranthene (100mg/kg) Benzo (k) Fluoranthene (140mg/kg)

(ii) GAC based on human health criteria. Ecotoxicological assessment will be made using EA guidance (EPR 8.01) on soil spreading (Cu 135mg/kg, Zinc 200mg/kg, Pb 300mg/kg)

The results assessment shows that in the area of the former school buildings, no exceedances were recorded with regard to a residential with plant uptake end-use and therefore no further action is required in this regard. It should be noted that the Made

Ground identified in the Former School Area is considered to be physically unsuitable for retention in gardens/landscaping. This should be removed to 600mm or to natural (whichever is less) and made up to finished levels using topsoil and subsoil with a minimum of 150mm topsoil.

However, further consideration should be given to the potential presence of PCBs within the soils in close proximity to the electricity substation on the eastern site boundary, to the potential for contamination associated with the former school boiler room and to the potential presence of asbestos within the demolition material within the infilled school basements.

10.1.3 Northern Playing Fields

The results comparison of the long term human health toxicity of the soil within the northern playing fields area is presented in Table 10.4 below.

Table 10.4 Summary of Inorganic and Hydrocarbon Toxicity Assessment for a Residential End Use with Plant Uptake within the Northern Playing Fields Area

Determinants	Units	GAC V3	C4SL	n	n of Ex	MC	Loc. of Max Ex	Pathway	Assessment
Arsenic	mg/kg	32	37	4	0	15	N/A	1	No Further Action
Cadmium	mg/kg	10	26	4	0	<1.0	N/A	1	No Further Action
Chromium (VI)	mg/kg	4.3	21	3	0	<1.0	N/A	1	No Further Action
Lead[(ii)]	mg/kg	-	200	4	1	230	WS111 0.40	1	Further Action
Mercury	mg/kg	11		4	0	0.1	N/A	2	No Further Action
Nickel	mg/kg	130		4	0	16	N/A	1	No Further Action
Selenium	mg/kg	350		4	0	0.2	N/A	1	No Further Action
Copper[(ii)]	mg/kg	2330		4	0	97	N/A	1	No Further Action
Zinc[(ii)]	mg/kg	3750		4	0	190	N/A	1	No Further Action
Cyanide - Total	mg/kg	791		3	0	<1.0	N/A	1	No Further Action
Phenols - Total	mg/kg	210		2	0	<1.0	N/A	1	No Further Action
Naphthalene	mg/kg	1.5		4	0	0.03	N/A	2	No Further Action
Acenaphthylene	mg/kg	170		4	0	0.03	N/A	3	No Further Action
Acenaphthene	mg/kg	210		4	0	0.07	N/A	1	No Further Action
Fluorene	mg/kg	160		4	0	0.05	N/A	1	No Further Action
Phenanthrene	mg/kg	92		4	0	1	N/A	3	No Further Action
Anthracene	mg/kg	2300		4	0	0.41	N/A	3	No Further Action
Fluoranthene	mg/kg	260		4	0	4.50	N/A	3	No Further Action
Pyrene	mg/kg	560		4	0	4.90	N/A	3	No Further Action
Benzo(a)Anthracene	mg/kg	3.1		4	0	2.50	N/A	3	No Further Action
Chrysene	mg/kg	6		4	0	2.50	N/A	3	No Further Action
Benzo(b/k)Fluoranthene[(i)]	mg/kg	5.6		4	1	5.90	WS111 0.40	3	Further Action
Benzo(a)Pyrene	mg/kg	0.83		4	1	3.40	WS111 0.40	3	Further Action
Indeno(123-cd)Pyrene	mg/kg	3.2		4	0	1.70	N/A	3	No Further Action
Dibenzo(a,h)Anthracene	mg/kg	0.76		4	0	0.47	N/A	3	No Further

Determinants	Units	GAC V3	C4SL	n	n of Ex	MC	Loc. of Max Ex	Pathway	Assessment
									Action
Benzo(ghi)Perylene	mg/kg	44		4	0	1.80	N/A	3	No Further Action
TPH C_5-C_6 (aliphatic)*	mg/kg	30		3	0	<0.10	N/A	2	No Further Action
TPH C_6-C_8 (aliphatic)*	mg/kg	73		3	0	<0.10	N/A	2	No Further Action
TPH C_8-C_{10} (aliphatic)*	mg/kg	19		3	0	<0.10	N/A	2	No Further Action
TPH C_{10}-C_{12} (aromatic)*	mg/kg	69		3	0	<1.0	N/A	2	No Further Action
TPH C_{12}-C_{16} (aromatic)*	mg/kg	140		3	0	<1.0	N/A	1	No Further Action
TPH C_{16}-C_{21} (aromatic)*	mg/kg	250		3	0	<2.0	N/A	1	No Further Action
TPH C_{21}-C_{35} (aromatic)*	mg/kg	890		3	0	21	N/A	1	No Further Action

Notes
Main Exposure Pathways: 1 = Soil Ingestion, 2 = Vapour Inhalation (indoor), 3 = Dermal Contact & Ingestion, 4 = Dust Inhalation.
Abbreviations: GAC = General Assessment Criteria, n = number of samples; n of Ex = Number of Exceedances MC = Maximum Concentration; Loc of Ex = Location of Exceedance.
* The Tier 1 GAC for the hydrocarbon fraction is derived from the CIEH assessment for petroleum hydrocarbons Criteria Working Group (CWG) for both aliphatic and aromatic compounds. REC has utilised the Tier 1 values for aliphatic compounds for the volatile and semi volatile fractions (C_5-C_{12}) and the Tier 1 values for aromatic compound for the non volatile fractions (C_{12}-C_{35}). The comparison of a total (aliphatic/aromatic) compounds to an individual fraction is considered to be a conservative approach and satisfactory for the protection of human health.
(i) Benzo (b) Fluoranthene (100mg/kg) Benzo (k) Fluoranthene (140mg/kg)

(ii) GAC based on human health criteria. Ecotoxicological assessment will be made using EA guidance (EPR 8.01) on soil spreading (Cu 135mg/kg, Zinc 200mg/kg, Pb 300mg/kg)

Referring to Table 10.4, the results of the direct comparison show that screening values have been exceeded for the following determinants as shown in Table 10.5.

Table 10.5 Summary of Exceedances

Non-Volatile	Volatile
Pathways	
Dermal Contact, Ingestion consumption of home grown produce	Inhalation of vapours
Lead; Benzo(b/k)Fluoranthene; and Benzo(a)Pyrene;	

The slightly elevated concentrations of lead, benzo(b/k)fluoranthene and benzo(pyrene) were identified in one sample location (WS111 at 0.40m bgl) at the base of the shallow Made Ground which was noted in the logs as containing ash. It is considered that the limited Made Ground in this area will not be suitable for use within landscaped areas. The Made Ground should be removed to 600mm or to natural (whichever is less) and made up to finished levels using topsoil and subsoil as detailed above with a minimum of 150mm topsoil.

10.2 Controlled Waters

The groundwater vulnerability map shows the site to be located over a Principal Aquifer (Sandstone) with a high risk of leaching. Owing to the lack of groundwater encountered at the site, no groundwater samples could be taken. REC has undertaken leachate testing on 5No. samples from the landfill area and the results collated with the leachate testing results undertaken following the 2007 Norwest Holst investigation (4No. samples, also from the landfill area).

The results of the analyses are shown in Table 10.6 below.

Table 10.6 Comparison of Groundwater Analysis with Tier 1 Screening Levels

For the purposes of the Tier 1 assessment REC have compared the laboratory test data directly to the relevant Tier 1 threshold values for the protection of controlled waters.

Determinand	Units	Hardness Banding ($CaCO_3$) mg/l	EQS Freshwater[1]	UK DWS[2]	n	MC	No of Ex	Loc of Highest Ex	Assessment
Inorganic									
Arsenic	µg/l	-	50	10	4	5.2	0	N/A	No Further Assessment
Cadmium	µg/l	-	5	5	4	0.02	0	N/A	No Further Assessment
Chromium	µg/l	0-50	2	50	4	1	0	N/A	No Further Assessment
	µg/l	50-100	10						
	µg/l	100-150	10						
	µg/l	150-200	20						
	µg/l	200-250	20						
Copper	µg/l	0-10	5	2000	4	40	2	TP102	Further Assessment
	µg/l	10-50	22						
	µg/l	50-200	40						
	µg/l	200-250	112						
Cyanide	µg/l	-	-	50	4	<0.05	0	N/A	No Further Assessment
Lead	µg/l	0-50	4	10	4	1	0	N/A	No Further Assessment
	µg/l	50-150	10						
	µg/l	150-250	20						
	µg/l	>250	20						
Mercury	µg/l	-	1	1	4	<0.05	0	N/A	No Further Assessment
Nickel	µg/l	0-50	8	20	4	9	1	TP101	Further Assessment
	µg/l	50-100	20						
	µg/l	100-150	20						
	µg/l	150-250	40						
	µg/l	>250	40						
Selenium	µg/l	-	-	10	4	0.5	1	N/A	No Further Assessment
Sulphate (SO_4)	mg/l	-	400	250	4	130	0	N/A	No Further Assessment
Zinc	µg/l	0-50	30	5000	4	37	1	TP104	Further Assessment
	µg/l	50-100	200						
	mg/l	100-250	300						
	µg/l	>250	500						
pH	µg/l	-	6-9	-	4	6.7-7.2	0	N/A	No Further Assessment
Organic									
Phenol	µg/l	-	30	0.5	4	<100	0	N/A	No Further

Determinand	Units	Hardness Banding ($CaCO_3$) mg/l	EQS Freshwater[1]	UK DWS[2]	n	MC	No of Ex	Loc of Highest Ex	Assessment
									Assessment
Aliphatic C5-C6	µg/l	-	-	10	1	<10.0	0	N/A	No Further Assessment
Aliphatic C6-C8	µg/l	-	-	10	1	<10.0	0	N/A	No Further Assessment
Aliphatic C8-C10	µg/l	-	-	10	1	<10.0	0	N/A	No Further Assessment
Aliphatic C10-C12	µg/l	-	-	10	1	20	1	WS103 3.50	Further Assessment
Aliphatic C12-C16	µg/l	-	-	10	1	70	1	WS103 3.50	Further Assessment
Aliphatic C16-C21	µg/l	-	-	10	1	<20	0	N/A	No Further Assessment
Aliphatic C21-C35	µg/l	-	-	10	1	<20	0	N/A	No Further Assessment
Aromatic C6-C7	µg/l	-	-	10	1	<10	0	N/A	No Further Assessment
Aromatic C7-C8	µg/l	-	-	10	1	<10	0	N/A	No Further Assessment
Aromatic C8-C10	µg/l	-	-	10	1	43	1	WS103 3.50	Further Assessment
Aromatic C10-C12	µg/l	-	-	10	1	150	1	WS103 3.50	Further Assessment
Aromatic C12-C16	µg/l	-	-	10	1	1100	1	WS103 3.50	Further Assessment
Aromatic C16-C21	µg/l	-	-	10	1	200	1	WS103 3.50	Further Assessment
Aromatic C21-C35	µg/l	-	-	10	1	<20	0	N/A	No Further Assessment
Benzo(a)pyrene	µg/l	-	0.05	0.03	8	0.517	2	TP18 1.30	Further Assessment
Benzo[bk]fluoranthene	µg/l	-	0.03	-	8	0.620	5	TP18 1.30	Further Assessment
Benzo(ghi)perylene	µg/l	-	0.02	-	8	0.190	4	TP18 1.30	Further Assessment
Indeno(123-cd)pyrene	µg/l	-	0.02	-	8	0.115	1	TP18 1.30	Further Assessment
Anthracene	µg/l	-	0.02	-	8	7.987	6	TP18 1.30	Further Assessment
Fluoranthene	µg/l	-	0.02	-	8	40.847	6	TP18 1.30	Further Assessment
Naphthalene	µg/l	-	10	-	8	2.9	0	N/A	No Further Assessment
PAH (Sum of Four)	µg/l	-	-	0.1	8	1.619	4	TP18 1.30	Further Assessment

Notes
Solubility <0.01µg/l

1. Council Directive of 4 May 1976 on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community (76/464/EEC). Official Journal of the European Communities 18.5.76 L129/23
2. The Surface Waters (Dangerous Substances) (Classification) Regulations 1989. SI 2286/89
3. The Surface Waters (Dangerous Substances) (Classification) Regulations 1992. SI 337/92
4. These represent non-statutory changes made in the 1990's which may be used by regulatory authorities. They are more conservative than the original 1985 values.
5. EC Dangerous Substances - List 1 parameters
6. EC Dangerous Substances - List 2 parameters as listed in Dangerous Substances Regulations of 1997 and 1998, and the DoE Circular 7/89
7. Circular from the Department of the Environment (7/89) and the Welsh Office (SI 16/89). 30 March 1989. Water and the Environment: The implementation of European Community Directives on pollution caused by certain dangerous substances discharged into the aquatic environment

Notes (Cont)

8. The Surface Waters (Dangerous Substances) (Classification) Regulations 1997. SI 2560/97
9. The Surface Waters (Dangerous Substances) (Classification) Regulations 1998. SI 389/98
10. WHO DWS for Toluene and Ethylbenzene – odour/taste/colour (Human Health Risk)
11. Specified compounds are benzo[b]fluoranthene (CAS 205-99-2), benzo[k]fluoranthene (CAS 207-08-9), benzo[g,h,i]perylene (CAS 191-24-2) and indeno[1,2,3-c,d]pyrene (CAS 193-39-5). The parametric value applies to the sum of the concentrations of the individual compounds detected and quantified in the monitoring process.

The results assessment shows widespread low level leachable metal and PAH contaminant concentrations above the Tier 1 screening values protective of controlled waters within the former landfill area.

The results also show potentially leachable aliphatic and aromatic TPH fractions. This result may however prove erroneous as it was returned by an aggressive NRA leachate test that is known to produce elevated readings. Soils testing on a deeper sample from the same borehole returned TPH results below limits of detection, indicating that vertical migration/leaching of the TPH fractions is not occurring in this case.

Though there is leachable contamination present, a pragmatic approach will need to be taken with regard to the landfill area. Due to the volume of material present, it is not considered viable to remove the landfill soils in their entirety from the site. The remediation required in the landfill area as discussed in section 10.1.1 will lead to significant betterment at the site with regard to mobile contaminants. Furthermore, the measures required to break the pollutant linkages identified with regard to human health (clean cover) will also significantly reduce the surface water infiltration rates and thus, the risks posed by leachable contaminants to controlled waters receptors. These are discussed in more detail below.

Remediation of the landfill will comprise two stages; firstly the off-site disposal of unsuitable and deleterious materials and secondly, the subsequent bioremediation of the remainder of the soils. All Made Ground within the former landfill will require excavation in its entirety and following excavation the natural surface soils will be subjected to sampling (25m grid) from the base and sides of the void and submitted to the laboratory for Speciated PAH and Banded TPH analysis to demonstrate that all soils left in-situ are suitable for use. The excavated materials will be sorted, with the unsuitable material disposed of off-site. The proposed bioremediation will lead to the removal of mobile and volatile contaminants from the soil, providing significant betterment of the site to acceptable levels.

Following the development of the site, the entire area will be covered by buildings and hardstand with landscaped areas requiring a clean cover. This clean cover should contain a clay subsoil to prevent water ingress to the material below. These elements will significantly inhibit the potential mobilisation of any leachable contamination. Furthermore, no groundwater body was noted in the previous investigations, reducing the potential for lateral mobilisation of contaminants.

It should be noted that the nature of the leachable contamination within the landfill area will preclude the use of soakaways in this part of the site.

10.3 Ground Gas

The potential impact on the development from ground gases has been assessed with reference to standards and guidelines published in CIRIA Report 665 (*Assessing risks posed by hazardous ground gases to buildings*, 2007).

During twelve monitoring visits completed over a ten month period, concentrations of methane up to 14.60%v/v (WS103) and concentrations of carbon dioxide up to 13.4%v/v (WS103) were recorded within the area of historic landfill. However, these concentrations were associated with flow rates of less than 0.1l/hr. Concentrations of methane up to 13.70%v/v and concentrations of carbon dioxide up to 9.20%v/v were also recorded in WS102 with a flow rate of 0.1l/hr. Methane and carbon dioxide are likely to originate from the decomposition of waste matter noted within the Made Ground.

In accordance with the methodology outlined within the CIRIA publication C665, REC have utilised the results of the ground gas monitoring surveys to calculate a Gas Screening Value (GSV) for the proposed development. The maximum GSV recorded for methane was 0.0146l/hr and the maximum for carbon dioxide was 0.0134l/hr in WS102.

The GSV has been compared to the criteria outlined with CIRIA C665 to determine the level of risk to the proposed development and to ensure the appropriate remedial options are incorporated into any future building design in this area. CIRIA C665 states that the maximum GSV for carbon dioxide and methane is <0.07l/hr for Characteristic Situation 1 and although the GSVs for this site fall into this bracket both methane and carbon dioxide levels have been recorded in excess of 10%. As a precaution it is therefore recommended that Characteristic Situation 3 or Amber 2 (depending on sub-floor constraints) in line with BS8485:2007 is used.

This suggests that the following measures are to be incorporated into any new structures where the landfilled material is retained on site:

- Passive sub-floor ventilation (venting layer can be a clear void or formed using gravel, geo composites, polystyrene void formers etc);
- Reinforced concrete ground bearing foundation raft or cast in-situ suspended slab, both with minimal service penetrations;
- Propriety gas membrane installed to reasonable levels of workmanship;
- Independent validation to confirm appropriate installation of membrane; and,
- All joints and service penetrations to be taped and sealed.

The above assessment is based upon the pre-remediated gas levels, it is considered remedial works comprising the processing and re-engineering of the landfilled area will be required. It is anticipated that this processing will therefore remove biodegradable content within the Made Ground and therefore, the source of the ground gas. Post remediation ground monitoring should be completed and which may show that the site could reclassified to as Characteristic Situation 1 / 2 or Green / Amber 1, dependent upon the results.

REC recommends that the final scope of any protection measures be agreed with the Local Authority prior to adoption. All protection measures, if adopted, should be validated by a suitably qualified environmental engineer.

10.4 Revised Conceptual Site Model

The initial conceptual site model has been revised in light of the ground investigation and the chemical analysis results presented the previous sections. The revised conceptual site model has been developed for the proposed future land use based upon the recommended remedial measures. This summarises the understanding of surface and sub-surface

features, the potential contaminant sources, transport pathways and receptors and is shown in Table 10.7 (overleaf) has been prepared for the site.

Table 10.7 Conceptual Model

	Source	Exposure Pathway	Potential Receptor	Probability of Exposure	Discussion of Pollutant Linkage
Landfill Area	**Human Health**				
	• Arsenic • Chromium • Lead • Nickel • Zinc • PAHs • Naphthalene • Hydrocarbon fractions aromatic C_8-C_{10}, C_{10}-C_{12}, C_{12}-C_{16}, C_{16}-C_{21}; • VOCs • Ground Gas	Soil Ingestion Dermal contact and Inhalation	Construction Workers	Likely	Any risk to construction workers will be mitigated against by use of appropriate PPE and Health and Safety measures.
			Future Site Users	Likely	Elevated concentrations are associated with the landfilled Made Ground in the western sector of the site. This material is a vapour risk and hazardous ground gas risk to human health and will require remediation to facilitate the safe development of the site.
	Controlled Water				
	Risk of leachable metals and PAHs will be mitigated by off-site disposal of unsuitable material and bioremediation of the remaining mobile contaminants. Furthermore, inhibition of infiltration by buildings, hardstand and clean cover system.				

	Source	Exposure Pathway	Potential Receptor	Probability of Exposure	Discussion of Pollutant Linkage
Former School Area	**Human Health**				
	• Unidentified Asbestos in Infilled Basements • Contaminants associated with former boiler room • Potential for PCBs Associated with Electricity Substation	Dermal contact and Inhalation	Construction Workers	Unlikely	Further assessment to be undertaken in conjunction with site clearance.
			Future Site Users	Unlikely	
	Controlled Water				
	No significant risk to controlled waters has been identified,				

	Source	Exposure Pathway	Potential Receptor	Probability of Exposure	Discussion of Pollutant Linkage
Northern Playing Fields	**Human Health**				
	▪ Lead ▪ Benzo b/k fluoranthene ▪ Benzo(a)pyrene	Soil Ingestion Dermal contact and Inhalation	Construction Workers	Unlikely	Any risk to construction workers will be mitigated against by use of appropriate PPE and Health and Safety measures.
			Future Site Users	Unlikely	Material is unsuitable for use within landscaped areas.
	Controlled Water				
	No significant risk to controlled waters has been identified				

11.0 GEOTECHNICAL ASSESSMENT

11.1 Proposed Development

It is understood that the proposed development will comprise an as yet unknown number of low rise residential properties with associated landscaping and infrastructure. Details of the proposed loadings are not known and therefore a line loading of 75kN/m has been assumed for preliminary assessment purposes only.

Given the nature of the proposed development it is considered that the structure meets the criteria of Geotechnical Category 1 of Euro Code 7 and it is considered that acceptable risk from settlement is a total settlement value of 25mm for a masonry structure.

11.2 Summary of Ground Conditions

Ground conditions identified at the site are summarised in Table 11.1 below:

Table 11.1 Summary of Ground Conditions

Strata	Typical Description	Min Depth to Top of Strata (m)	Max Depth to Top of Strata (m)	Max Thickness (m)
MG Gravelly clay	Soft to firm dark brown gravelly sandy clay. Gravel is sub-angular to angular medium to course sandstone	0.00	1.00	1.00
MG Ashy sand	Black brown ashy gravelly fine to coarse sand. Gravel is fine to coarse sub-angular to angular of clinker, glass, fabric, metal, rubber and wood. Cobbles are angular of sandstone	0.30	4.80	4.20
SAND	Reddish brown gravelly fine to medium sand. Gravel is sub-angular to angular medium to course of sandstone	0.20	5.00	1.30
SANDSTONE	Weathered red brown SANDSTONE.	0.60	4.90	2.10

11.3 Site Preparation

The site should be cleared and any vegetation below areas of proposed development stripped in accordance with Series 200 of the Specification for Highway Works. This should include:

- Roots present below the footprint of proposed structures and infrastructure should be grubbed out and the resulting void infilled with suitable compacted engineered fill;
- Old foundations have been encountered on site. These should be excavated from below the proposed development foot print with the resulting void backfilled; and,
- The Japanese Knotweed will need to be fully certified by Liverpool City Council's sub-contractor as to the eradication of the stands in the southern sector of the site.

11.4 Foundation Conditions and Bearing Capacity

General

The ground conditions across the site has been found to generally comprise a thin layer of Made Ground (<1.00m) with underlying fine to medium, medium to dense sand and sandstone bedrock. However an area of deeper Made Ground (up to 4.80m bgl) is present to the west of the site associated with the historical landfilling.

It is considered that the Made Ground is not suitable as a founding material due to the inherent variability of the material; foundation options are therefore:

- Standard strip/spread foundations onto the underlying medium dense sands or sandstone;
- Ground improvement solution to support raft or shallow spread foundations; or
- Deeper pile foundations.

Due to the contaminative nature of the Made Ground in the western sector of the site, the retention of this material is not considered viable without some form of in-situ / ex-situ treatment and therefore will require remediation likely to comprise excavation and re-engineering. Also, Liverpool City Council have noted that basement features exist below some of the former school buildings but have at this time not provided further detail on the exact locations.

Further no significant cohesive deposits were encountered during the GI, which would remove the requirement for the deepening of structural foundations to mitigate against heave.

The above foundation options are discussed below:

Strip Foundations

Shallow strip/spread foundations could be constructed at least 150mm in to the underlying medium dense sands or sandstones in the northern and eastern sectors of the site. An Allowable Bearing Pressure (ABP) of >100kN/m² has been calculated from a depth of 1.00m bgl.

Settlement in the granular material should occur relatively instantaneously upon application of load.

Ground Improvement

The use of ground improvement techniques such as vibro granular columns would allow shallow foundations to be utilised within the Made Ground. The vibro granular columns should provide a bearing capacity of around 150kN/m² but will also remove variability within the Made Ground.

Following the earthworks exercise to remove all below ground obstructions and geotechnically unsuitable material, specialist advice should be sought from a suitably experienced vibro contractor with regard to suitability for a vibro ground improvement option along with allowable bearing capacity and settlements.

If the site is to be raised in level for the proposed residential development, the material utilised should meet the geotechnical engineer's specifications.

Piled Foundations

A piled solution whilst viable is considered to be a costly option and would require detailed design.

Recommendation

A well-engineered enabling works strategy should ensure that a foundation solution comprising a mixture of shallow strip (locally deepened where basements are found) and a ground improvement solution through vibro-replacement stone columns (VSG) can be the most reliable and cost effective option for the site. For preliminary assessment purposes an allowance of 60% VSG and 40% strip foundations should be assumed.

A foundation zoning plan (44808p1r0/006) has been provided based on the existing layout in Appendix III.

11.5 Ground Floor Slabs

Due to the presence of substantial thickness' of Made Ground across the site, a suspended floor slab should be used where Made Ground exceeds 600mm in thickness. Where suspended floor slabs are employed ventilation of the under floor void will be required to address condensation issues. This would also assist in the mitigation of potential gas ingress issues.

If vibro granular columns are used for the foundations then this can be extended to the floor slab to improve formation conditions and reduce the risk of damage from settlement. However, it may be more reliable to opt for suspended floor slabs.

11.6 Pavement Construction

An assessment of the likely California Bearing Ratio (CBR) for the Made Ground has been assessed from the following sources:

- PSD results (shown in Table 9.6); and,
- Description of the materials encountered in the exploratory holes.

Based on this it is considered that a CBR of less than 3% may be required to account for variability of the Made Ground. It is, however, recommended that this be re-assessed using on site plate tests of the formation once the proposed development layout has been designed. It is possible that a higher design CBR of 5% may then be achievable.

Any material which is used for road construction, should be in accordance with Series 600 (Earthworks) of The Department of Transport (DoT) "Specification for Highway Works" 1998.

Treatment of the soils below the proposed highway should be discussed and agreed with the local highway authority in advance of any such works.

11.7 Drainage

The presence of substantial depths of Made Ground across the site may result in settlement. It is therefore recommended that drain runs are designed using steeper gradients and flexible joints to allow for some differential settlement.

Soil infiltration tests were undertaken as part of the GI; however variable results were obtained due to the presence of clay particles within the sand strata which limited infiltration during the BRE365 tests.

Falling head permeability tests were undertaken within two of the probehole locations which returned infiltration rates which would suggest that soakaways could be used. REC would recommend that once the layout design has been finalised that further BRE 365 soakaway testing is undertaken to ensure that soakaways can be incorporated.

Owing to the significant depth of Made Ground deposits in the landfill, soakaways in this area will not be allowed.

11.8 Concrete Durability

Based upon the results of the chemical analyses summarised in Table 9.5 it is considered that subsurface concrete can be designed in accordance with Design Sulphate Class DS-1, Aggressive Chemical Environment for Concrete Classification (ACEC) AC-1s in accordance with the recommendations provided in BRE Special Digest 1 (2005).

11.9 Excavations

Site observations indicated that excavations should be feasible in the near surface with normal plant, however obstructions were identified in the near surface including former foundations and building floor slabs. It is anticipated that any obstructions will be grubbed out during the reduced level dig for the sub structure works.

Due to the variability of the Made Ground it is considered that all excavations are supported or battered back in accordance with guidance contained in CIRIA RR97.

The presence of shallow Sandstone across the site meant that in certain places excavation was very slow through the Sandstone and in others the ground could not be penetrated. Consideration should be given to difficulties in excavating this hard stratum by contractors.

During the excavation of the landfilled area consideration will have to be given to the presence of mobile contaminants within the western sector to ensure that no offsite surface migration occurs.

11.10 Re-Use of Materials

Consideration has been given to the potential re-use of site won arisings from substructure works as an engineered fill. The soils have been assessed using the following:

- Physical description of the soils encountered (variability and organic content);
- Particle Size Distribution in relation to Specification for Highway Works; and,
- Guidance given in HA44/91;

It is considered that natural granular strata likely to be excavated as part of the foundation works are suitable for re-use as a general engineered fill in accordance with Class 1 and Class 2 of the Specification for Highway Works, respectively.

The granular Made Ground in the landfilled area is not considered suitable for re-use on site due to the contaminant concentrations.

11.11 Minerals

There are no minerals of economic value underlying the site at shallow depth and mining is considered to be very unlikely.

11.12 Further Works

- A detailed remediation and enabling works strategy, cut / fill and isopachyte drawing will be required to facilitate the safe and regulatory compliant redevelopment of the site;
- It is recommended that a Materials Management Plan (MMP) to be developed in accordance with the (EA Approved) CL:AIRE CoP. A Materials Management Plan will help to ensure that the enabling works can be undertaken in the most cost effective manner that will negate the need for off-site disposal of soil.

11.13 Construction Activity and Inspection

The following activities and inspections should be incorporated in to the site works:

- Due to the variability of the soils at the site it is recommended that sufficient allowance is made for the inspection of formation and sub formations to foundations and pavement construction;
- It is considered that de-watering may be required, especially following periods of heavy rainfall. Removal of surface water and water within trenches should be possible with conventional sump pumping. Discharge of any water should be agreed with the relevant regulatory body and be undertaken under a trade effluent discharge, where required. Measures to remove silt and suspended solids may be required and consideration should be given to provision of space for settling tanks or an attenuation pond;
- Excavations where access is required should be subject to a risk assessment from a competent person and where appropriate mitigation measures such as benching back the sides or use of support systems in accordance with CIRIA R97 utilised;
- Where access to confined spaces is required appropriate mitigation measures should be addressed within the Construction Stage Health and Safety Plan. Particular account should be taken of the gas results; and,
- The presence of potential contamination and mitigation measures should be addressed as part of the Construction Stage Health and Safety Plan and should include measures to design out the risks, reduce their impact and finally the use of Personnel Protective Equipment (PPE).

12.0 CONCLUSIONS & RECOMMENDATIONS

Geotechnical Assessment

Significant thicknesses of Made Ground have been identified in the western sector and basements of an unknown depth are known to exist in the central sector associated with the former school.

- It is considered that subject to removal and subsequent re-engineering / processing of all landfilled material and historical basements, ground conditions should allow for a combination of shallow strip supported by Vibro Stone Columns, mass trench fill foundations with a small number of piled foundations in the event of soft spots, high walls or groundwater.
- Infiltration testing has proven inconclusive with some good infiltration rates and some poor. It is anticipated that post remediation the underlying soils will be predominantly granular in nature and as such are likely to a provide a relatively high degree of soakage potential for drainage systems, however further assessment will be required.

Revised Conceptual Site Model

The Tier I Human Health Risk has identified locally elevated concentrations of inorganic heavy metals, various PAHs (including Naphthalene) and hydrocarbon fractions C_8 – C_{21} within the landfilled western sector. Further assessment of the soils around the electricity substation in the east of the site is required. Further assessment of the infilled school basement material is required.

The ground gas assessment indicates a likely Characterisation Situation 3 for the site due to elevated methane and carbon dioxide concentrations; however the ground gas has been identified as being limited to the area of landfill, which will be subject to some form of remediation which would remove the source. Re-assessment of the ground gas regime post remediation should confirm that the site is suitable for a Characteristic Situation 1.

Recommendations

A detailed remediation and enabling works strategy should be designed for the site to ensure that the site can be safely and legislatively compliantly redeveloped.

Due to the volume of material present, it is not considered viable to remove the landfill soils in their entirety from the site. The proposed remediation required in the landfill area will however break the pollutant linkages identified to human health for volatile pathways and lead to significant betterment at the site with regards to controlled waters.

The proposed remediation of the landfill will comprise two stages; firstly the off-site disposal of unsuitable and deleterious materials and secondly, the subsequent bioremediation of the remainder of the soils. All Made Ground within the former landfill will require excavation in its entirety and following excavation, the excavated materials will be sorted, with the unsuitable material disposed of off-site. The remainder of soils will be subject to treatment by means of bioremediation in windrows. This is considered to be an appropriate remedial technique to address the identified hydrocarbon impacts; it addresses the driving pollutant linkage by removing the volatile source. Soils will be considered to be suitably remediated as and when laboratory validation testing demonstrates that the soil concentrations are below the remediation criteria for both human health and controlled waters. The treated soils will be placed back into the void in a controlled manner.

Following the bioremediation of soils, a 600mm clean cover will be required in all garden and landscaping areas in this area to break the remaining dermal contact and ingestion pathways for the remaining contaminants.

Following the development of the site, the entire site will be covered by buildings and hardstand with landscaped areas requiring a 600mm clean cover . This clean cover should contain a clay subsoil to

prevent water ingress to the material below. The proposed surface covers will significantly inhibit the potential mobilisation of any remaining leachable contamination.

The Made Ground identified in the Northern Playing Field Area and the Former School Area is considered to be physically unsuitable for retention in gardens/landscaping. This should be removed to 600mm or to natural ground (whichever is less) and made up to finished levels using topsoil and subsoil as detailed above with a minimum of 150mm topsoil.

Topsoil was encountered on site overlying both natural sands and Made Ground. Each of these topsoil sources should be segregated and stockpiled separately to allow subsequent analysis to assess their suitability in the development.

Post remediation ground gas monitoring will be required to re-classify the site as a lower Characteristic Situation.

It is recommended that a detailed Remediation Strategy and Materials Management Plan (MMP) be developed in accordance with the (EA Approved) CL:AIRE CoP. A Materials Management Plan will help to ensure that the enabling works can be undertaken in the most cost effective manner that will negate the need for off-site disposal of soil.

Further soakaway testing in line with the guidance outlined in BRE 365 is undertaken post remediation once the proposed development layout has been designed. This should not take place in the area of the former landfill.

END OF REPORT

APPENDIX I

LIMITATIONS

1. This report and its findings should be considered in relation to the terms of reference and objectives agreed between REC Ltd and the Client as indicated in Section 1.2.

2. For the work, reliance has been placed on publicly available data obtained from the sources identified. The information is not necessarily exhaustive and further information relevant to the site may be available from other sources. When using the information it has been assumed it is correct. No attempt has been made to verify the information.

3. This report has been produced in accordance with current UK policy and legislative requirements for land and groundwater contamination which are enforced by the local authority and the Environment Agency. Liabilities associated with land contamination are complex and requires advice from legal professionals.

4. During the site walkover reasonable effort has been made to obtain an overview of the site conditions. However, during the site walkover no attempt has been made to enter areas of the site that are unsafe or present a risk to health and safety, are locked, barricaded, overgrown, or the location of the area has not be made known or accessible.

5. Access considerations, the presence of services and the activities being carried out on the site limited the locations where sampling locations could be installed and the techniques that could be used.

6. In addition to the above REC Ltd note that when investigating, or developing, potentially contaminated land it is important to recognise that sub-surface conditions may vary spatially and also with time. The absence of certain ground, ground gas, and contamination or groundwater conditions at the positions tested is not a guarantee that such conditions do not exist anywhere across the site. Due to the presence of existing buildings and structures access could not be obtained to all areas. Additional contamination may be identified following the removal of the buildings or hard standing.

7. Site sensitivity assessments have been made based on available information at the time of writing and are ultimately for the decision of the regulatory authorities.

8. Where mention has been made to the identification of Japanese Knotweed and other invasive plant species and asbestos or asbestos-containing materials this is for indicative purposes only and do not constitute or replace full and proper surveys.

9. The executive summary, conclusions and recommendations sections of the report provide an overview and guidance only and should not be specifically relied upon without considering the context of the report in full.

10. This report presents an interpretation of the geotechnical information established by excavation, observation and testing. Whilst every effort is made in interpretative reporting to assess the soil conditions over the Site it should be noted that natural strata vary from point to point and that man made deposits are subject to an even greater diversity. Groundwater conditions are dependent on seasonal and other factors. Consequently there may be conditions present not revealed by this investigation.

11. REC can not be held responsible for any use of the report or its contents for any purpose other than that for which it was prepared. The copyright in this report and other plans and documents prepared by REC is owned by them and no such plans or documents may be reproduced, published or adapted without written consent. Complete copies of this may, however, be made and distributed by the client as is expected in dealing with matters related to its commission. Should the client pass copies of the report to other parties for information, the whole report should be copied, but no professional liability or warranties shall be extended to other parties by REC in this connection without their explicit written agreement there to by REC.

12. Rather, this investigation has been undertaken to provide a preliminary characterisation of the existing sub-surface geotechnical characteristics and make up and the findings of this study are our best interpretation of the data collected, within the scope of work and agreed budget. New information, revised practices or changes in legislation may necessitate the re-interpretation of the report, in whole or in part.

13. This investigation has been undertaken to reasonably characterise existing sub-surface conditions and the findings of this study are our best interpretation of the data collected, within the scope of work and agreed budget. New information, revised practices or changes in legislation may necessitate the re-interpretation of the report, in whole or in part.

APPENDIX II

GLOSSARY

TERMS

AST	Above Ground Storage Tank
BGS	British Geological Survey
BSI	British Standards Institute
BTEX	Benzene, Toluene, Ethylbenzene, Xylenes
CIEH	Chartered Institute of Environmental Health
CIRIA	Construction Industry Research Association
CLEA	Contaminated Land Exposure Assessment
CSM	Conceptual Site Model
DNAPL	Dense Non-Aqueous Phase Liquid (chlorinated solvents, PCB)
DWS	Drinking Water Standard
EA	Environment Agency
EQS	Environmental Quality Standard
GAC	General Assessment Criteria
GL	Ground Level
GSV	Gas Screening Value
HCV	Health Criteria Value
ICSM	Initial Conceptual Site Model
LNAPL	Light Non-Aqueous Phase Liquid (petrol, diesel, kerosene)
ND	Not Detected
LMRL	Lower Method Reporting Limit
NR	Not Recorded
PAH	Poly Aromatic Hydrocarbon
PCB	Poly-Chlorinated Biphenyl
PID	Photo Ionisation Detector
QA	Quality Assurance
SGV	Soil Guideline Value
SPH	Separate Phase Hydrocarbon
Sp.TPH (CWG)	Total Petroleum Hydrocarbon (Criteria Working Group)
SPT	Standard Penetration Test
SVOC	Semi Volatile Organic Compound
UST	Underground Storage Tank
VCCs	Vibro Concrete Columns
VOC	Volatile Organic Compound
WTE	Water Table Elevation

UNITS

m	Metres
km	Kilometres
%	Percent
%v/v	Percent volume in air
mb	Milli Bars (atmospheric pressure)
l/hr	Litres per hour
µg/l	Micrograms per Litre (parts per billion)
ppb	Parts Per Billion
mg/kg	Milligrams per kilogram (parts per million)
ppm	Parts Per Million

mg/m^3	Milligram per metre cubed
m bgl	Metres Below Ground Level
m bcl	Metre Below Cover Level
mAOD	Metres Above Ordnance Datum (sea level)
kN/m^2	Kilo Newtons per metre squared
µm	Micro metre

APPENDIX III

DRAWINGS

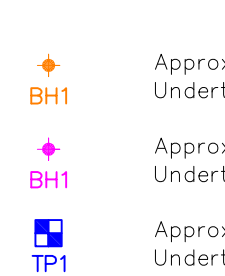
REC
Resource & Environmental Consultants

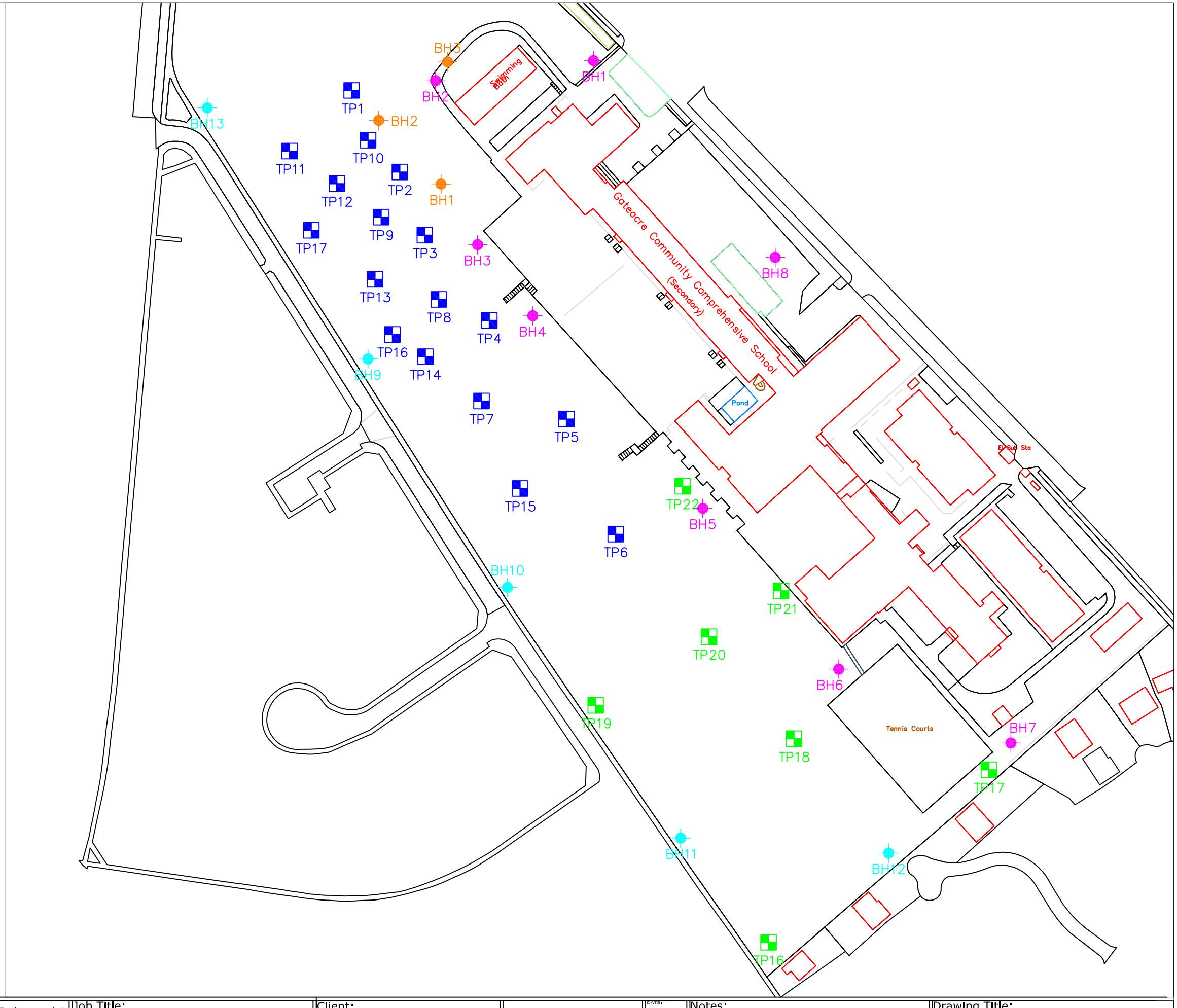
Drawing: 44808p1/001

Site Location and Aerial Photo

Key

- BH1 — Approximate Borehole Location Undertaken by Northwest Holst (2004)
- BH1 — Approximate Borehole Location Undertaken by Northwest Holst (2005)
- TP1 — Approximate Trial Pit Location Undertaken by Northwest Holst (2005)
- TP22 — Approximate Trial Pit Location Undertaken by Northwest Holst (2007)
- BH10 — Approximate Borehole Location Undertaken by Northwest Holst (2007)





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Client: Countryside Properties

Job No: 44808
Drawn by: K.Doolan
Approved by: R.Paul
Scale: 1:2000 @ A3

DATE: 15-04-14

Notes:

Drawing Title: 44808p1r0-002 Historical Exploratory Hole Location Plan

Key

WS101 — Approximate Window Sample Probehole Location

TP101 — Approximate Trial Pit Location

N

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Job No: 44808

Drawn by: R. Willoughby

Approved by: R.Paul

Scale: 1:2000 @ A3

DATE: 29-04-13

Notes:

Drawing Title: 44808p1r0-003 Exploratory Hole Location Plan

Key

- No MADE GROUND
- MADE GROUND 0.00–0.49m
- MADE GROUND 0.50–0.99m
- MADE GROUND 1.00–1.99m
- MADE GROUND 2.00m+

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DATE: 29-04-13

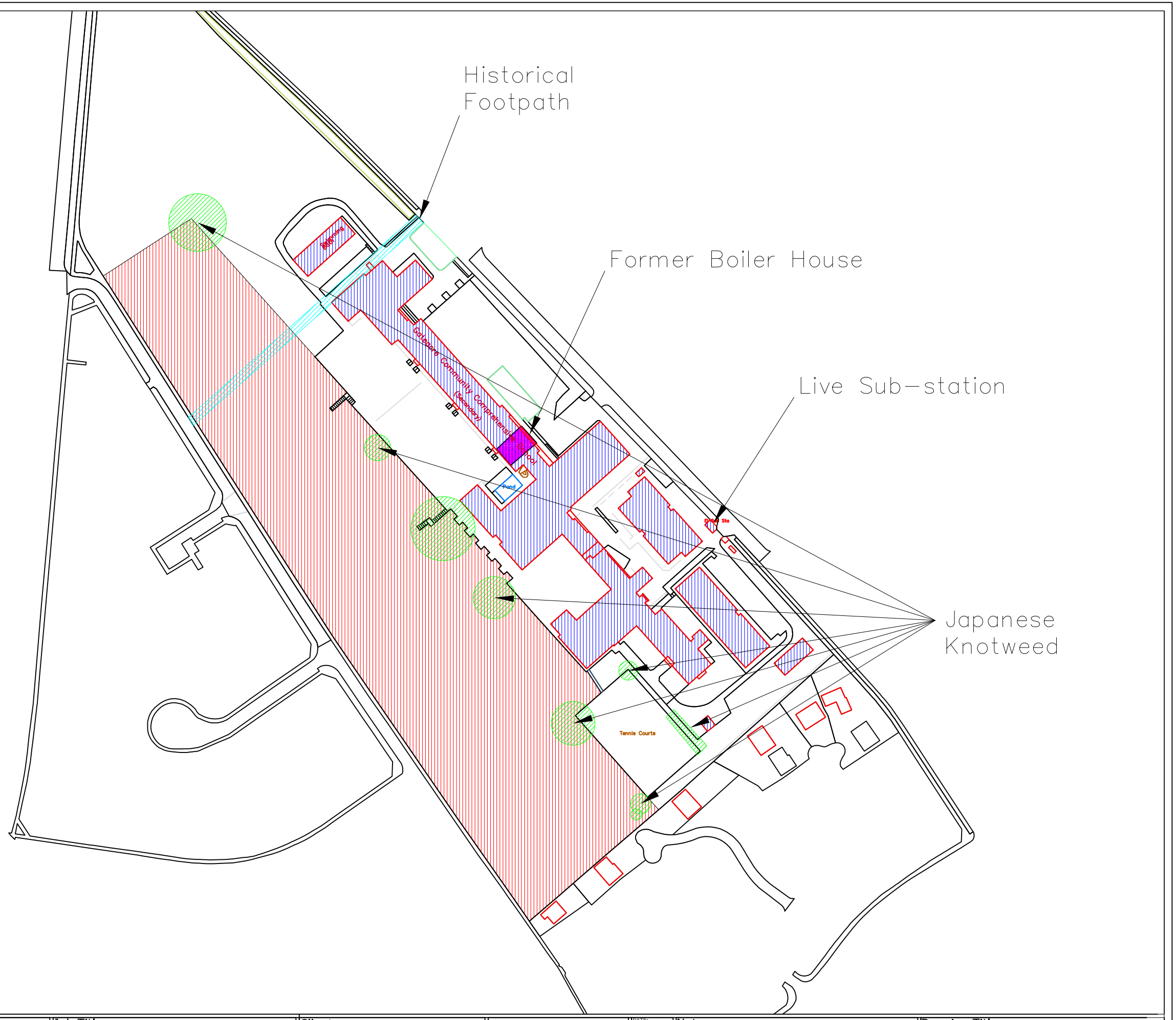
Notes:

Drawing Title: 44808p1r0-004 Depth of Made Ground Plan

Key

Area of Historic Landfill, risk of total & differential settlement, chemically impacted ground and ground gas generated risks.

Area of Gateacre High School, significant depths of Made Ground due to presence of unknown quantity of basements and infill.



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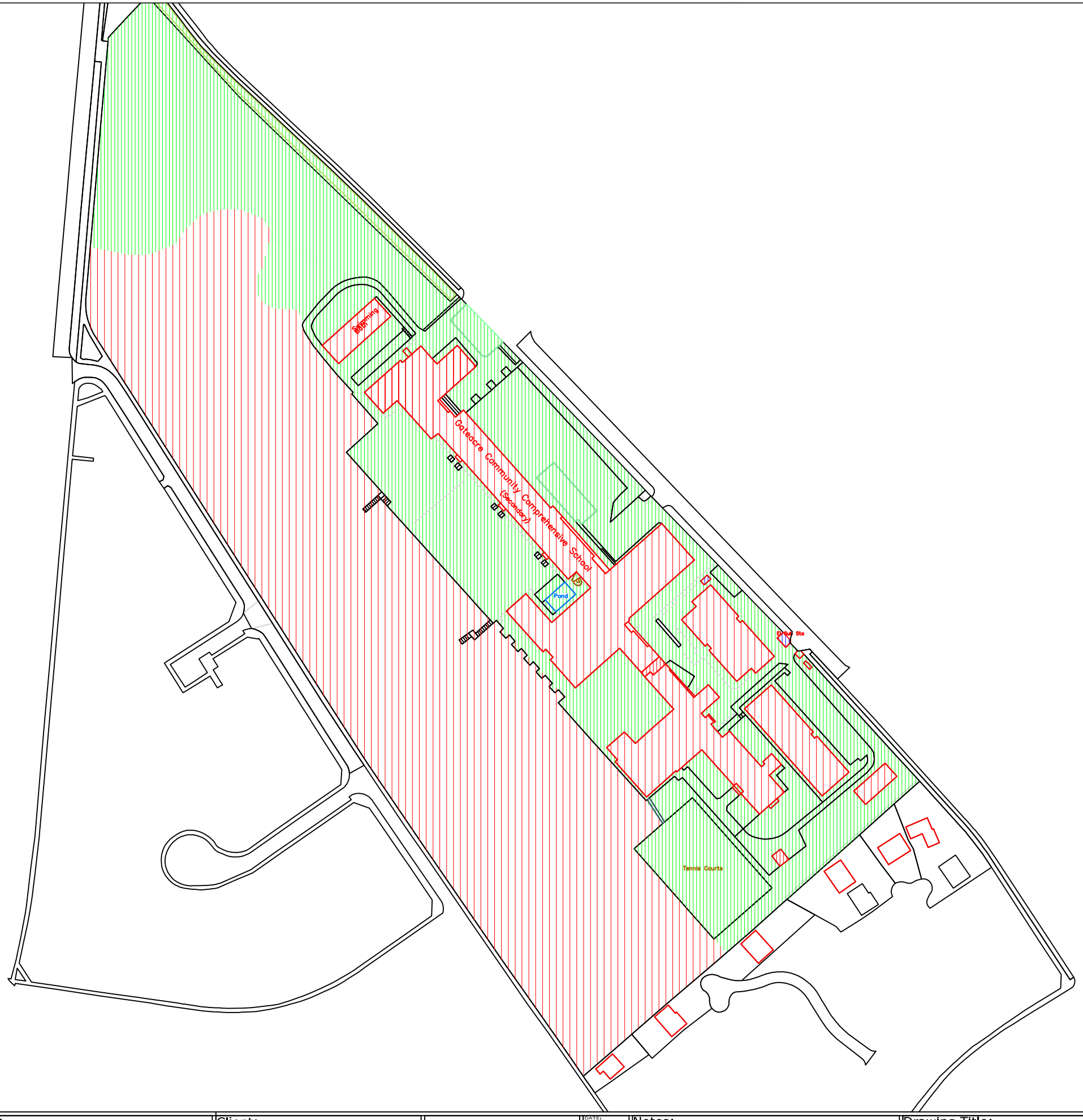
Notes:

Drawing Title: 44808p1r0-005 Development Constraints Plan

Key

Excavation & Re-engineering of ground using vibro-replacement stone columns supporting shallow strip foundations

Standard Strip footings.



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Approved by: S. Howard

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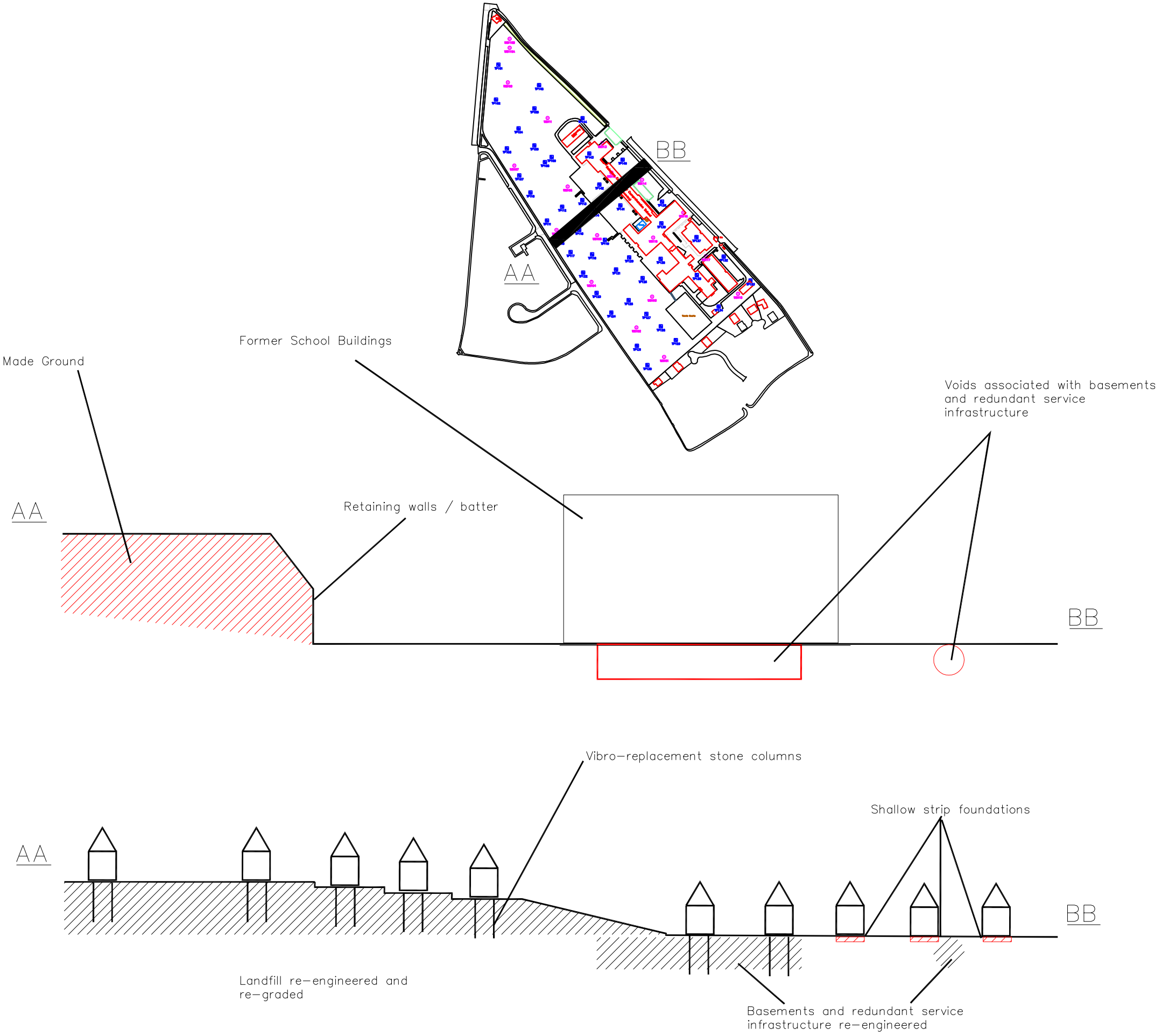
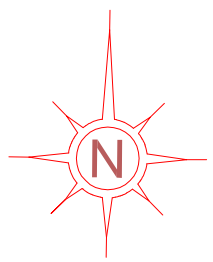
DATE: 29-04-13

Notes:

Drawing Title: 44808p1r0-006 Foundation Schedule Plan





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Client: Countryside Properties

Job No: 44808

Drawn by: R. Willoughby

Approved by: S. Howard

Scale: NTS

DATE: 29-04-13

Notes:

Drawing Title: 44808p1r0-007 Indicative Cut / Fill

Key

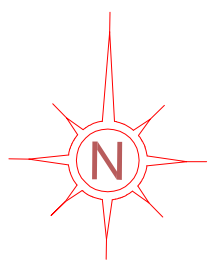
WS101 — Approximate Window Sample Probehole Location

TP101 — Approximate Trial Pit Location

Area of Historic Landfill, risk of total & differential settlement, chemically impacted ground and ground gas generated risks.

Area of Gateacre High School, significant depths of Made Ground due to presence of unknown quantity of basements and infill.

Former Boiler House



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Drawn by: R. Willoughby

Approved by: S. Howard

Scale: 1:2000 @ A3

DATE: 06-03-14

Notes:

Drawing Title: 44808p1r0-008 Historical Features/ Exploratory Hole Location Plan

Schedule

Caine	@ 710sqft	x 16
Longford	@ 893sqft	x 16
Ashop	@1075sqft	x 15
Dunham	@1169sqft	x 20
Pocklington	@1238sqft	x 25
Baybridge	@1249sqft	x 08
Cam	@1259sqft	x 10
Ribble	@1288sqft	x 10
The Glasson	@1340sqft	x 17
The Melton	@1442sqft	x 08
The Cannock	@1543sqft	x 09
The Rufford	@1623sqft	x 10
The Hatherton	@1695sqft	x 11
The Rushall	@1753sqft	x 05
New type	@2245sqft	x 03
New type	@2254sqft	x 06
New type	@2282sqft	x 02
New type	@2362sqft	x 04
New type	@2435sqft	x 02

Total	**197**
Area	19.5acres
	10.10 UPA
	14'1.87 sqft/acre

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Client:
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Job No: 44808

Drawn by: K.Doolan

Approved by: S. Howard

Scale: 1:2000 @ A3

DATE: 06-03-14

Notes:

Drawing Title:
44808p1r0-009
Proposed Development Plan

APPENDIX IV

PHOTOGRAPHS