Geo-Environmental Ground Investigation Report For A Proposed Extension To The Existing Supermarket at Hawley Road, Hinckley

REPORT PREPARED ON BEHALF OF Lidl UK GmbH

Paul Palgrave BSc (Hons) ARSM MSc C.Geol FGS
February 2010
Report QA Number 10012
QA Auditor: Mike Matthews MSc BSc(Hons) CWEM

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1. INTRODUCTION

Peak Associates Environmental Consultants Ltd (Peak Associates) was commissioned by Lidl UK GmbH (the 'Client') to undertake a geo-environmental investigation at their existing foodstore at Hawley Road, Hinckley.

Lidl UK GmbH proposes to construct an extension to the store frontage and reconfigure the car parking layout.

The site has been subject to a series of previous investigations during the 1990's, associated with the sale of the site and construction of the foodstore in the mid 1990's.

During the construction of the existing store in 1995, it is understood that the Contractor encountered potentially significant contamination beneath the site, believed to have been caused by the discharge of the contents of underground tanks by flooding with water used to damp down a fire at the previous works on the site, which was set alight by vandals sometime after closure.

The previous works on the site is reported to have been used for the production of cleaning fluids containing phenol based chemicals, and the principal concern was the high levels of phenols detected in the groundwater.

The remedial works proposed for the site following discovery of the contamination comprised the construction of a low permeability in-ground cut-off wall surrounding the site, installed to a depth of 6.0m below ground level. The cut-off wall was to comprise bentonite slurry with a vertical low permeability geo-membrane installed in the centre of the slurry filled trench to minimise further off-site migration of the contaminated groundwater.

In addition, to prevent surface infiltration and groundwater level rise, resulting in over-topping of the cut-off wall by contaminated groundwater, a horizontal low permeability geomembrane was placed across the surface of the entire site, welded to the vertical membrane at the top of the cut-off wall.

The piles and pile caps for the new foodstore building had already been installed at this time, and hence it was proposed to seal the membrane to the pile caps around the perimeter of the building.

Localised elevated methane concentrations were previously detected in some of the monitoring standpipes, hence gas protection measures were proposed for the foodstore, comprising a gas proof membrane in the floorslab, and slotted pipes in the gravel beneath the floorslab to promote venting of any potentially hazardous gases from beneath the building.

In order to prevent gas building up beneath the membrane within external areas, venting stacks were proposed in the car parking area, connected to a network of gas drainage pipes placed beneath the in-ground membrane.

The construction of the proposed new extension will need to interact in unison with these existing remedial measures, particularly with respect to the horizontal in-ground membrane. Lidl UK GmbH appointed Peak Associates Ltd to undertake a desk top study review of the existing information and undertake any necessary further intrusive investigations associated with the proposed extension.

The aims of the recent Peak Associates geo-environmental intrusive investigation are:

- To provide geotechnical information to assist with the design of the foundations for the extension.
- To establish if the level of risk from the previously encountered soil and groundwater contamination has changed significantly.
- To install gas monitoring standpipes for the purposes of undertaking further landfill gas monitoring.
- To satisfy Planning Conditions requiring a desk top study and intrusive investigation, if attached to any future approval.
- To provide the Contractors with initial soil chemical test data to use for the purpose of assisting with classifying the waste arising from future excavation works.

2. SITE DESCRIPTION

2.1 Location

The site is located south east of the junction between Hawley Road and Rugby Road (B4109), at National Grid Reference (NGR 442427, 293184), approximately 0.5km south west of Hinckley town centre, as shown on Plan 1.

2.2 Current Site Layout

The site is approximately 0.75 hectares in area, and is rectangular in shape, measuring approximately 100 metres (north-south) by 75 metres (east-west).

The existing single storey foodstore building is located in the south of the site with a tarmac surfaced car parking area to the north of the building. There are soft landscaped fringes along Hawley Road and Rugby Road, and to the rear (south) of the building.

The topographic survey shows that the majority of the site lies at a level of slightly over 98m, falling to 97.17m at the south west corner of the site, on the site boundary.

The western site boundary is defined by a post and wire fence, and the southern site boundary comprises a steel palisade fence. The other boundaries are not fenced.

There is a slope from the western site boundary to the back of the footpath along Rugby Road, which increases in height towards the south western corner of the site to a maximum of 2.0 metres.

2.3 Surrounding Land Use

A railway line on an embankment is located immediately to the south of the site. A car wash facility is located immediately east of the site, and shares the access road to the Lidl site from the north off Hawley Road, which is located immediately north of the site.

Industrial/commercial premises are located on the opposite side of Hawley Road to the north of the site. Residential areas are located to the west of the site beyond Rugby Road, and to the north west of the site.

The area to the south west of the site beyond the railway line is industrial in nature, and to the south of the site beyond the railway line there is a sports field and residential areas.

3.0 SITE HISTORY

A review of the site history has been undertaken in order to identify any previous potentially significantly contaminative uses, located either on-site, or in the surrounding area.

Potential previous on-site previous contamination sources may have contributed to any contamination identified beneath the site.

Neighbouring potentially contaminative activities may present a risk to the site through on site migration of contamination, or through the deposition of waste materials on the site.

The history of the site is recorded over selected periods by inspected maps, copies of which are presented in Appendix '1'. The account presented in this report is restricted by specific time periods represented by these maps only.

The previous uses of the site and surrounding area are summarised in Table 3.1 below, which also lists any potential contaminants associated with these uses.

Table 3.1: Summary of Uses of the Site and Surrounding Area

Date	Site Uses	Surrounding Land Use	Key Potential Contaminants Affecting the Site
1886 (1:10,560) 1889 (1:2500)	Undeveloped field with tree lined ditch along eastern boundary.	Railway embankment to the south. Fields to the east with sidings and Hinckley Station beyond. Road to the west (Rugby Road) Road to the north (New Road, now Hawley Road). Surrounding land generally undeveloped. Sketchley Brook located approximately	None anticipated.

Date	Site Uses	Surrounding Land Use	Key Potential Contaminants Affecting the Site
		100m south of the site.	
1901(1:10,560) 1903 (1:2500)	Site remains undeveloped, although ditch along the eastern boundary has been extended along the southern site boundary.	Railway embankment to the south of the site widened and sidings to the east developed further on widened embankment. Sketchley Dye Works shown to the south west beyond Sketchley Brook.	None anticipated.
1923(1:10,560) 1924 (1:2500)	No significant changes	Sketchley Dye Works has been expanded and residential development is shown to the north and north west of the site. Two Hosiery factories are shown 150m north east of the site.	None anticipated.
1938 (1:10,560)	Site remains undeveloped.	Two reservoirs shown adjacent to the south west corner of Sketchley Dye Works, with filter beds and sewage works beyond to the west.	None anticipated.
1950 (1:10,560)	Building shown in north of site, use not identified.	Development of area between Sketchley Dye Works and railway line to the north with large industrial/commercial building, with evidence of filling to the west of the new buildings.	Use of site unknown, but anticipated to be industrial. Some potential contamination anticipated.
1960-61 (1:1250 and 1:2500)	Building shown occupying the northern half of site (use not indicated) now labeled 'Works'. Drain shown along southern site boundary.	Factory shown to the east of the site, with a Coal Yard shown to the south of the factory. Further development of the area between the Sketchley Dye Works and the railway line to the north, labeled as a 'Works', and a 'garage' is also shown.	The nature of the Works on site is not indicated, but some potential contamination would be anticipated to be associated with the Works.
1968 (1:10,560)	Building in the northern half of the site is now shown to be rectangular in outline with an additional smaller building on the eastern boundary.	No significant further development of the surrounding area.	The nature of the Works on site is not indicated, but some potential contamination would be anticipated to be associated with the Works.
1975 (1:1250) 1977 (1:10,000)	The site is shown to be occupied by a Chemical Works, with expansion of the buildings along Rugby Road into the south west corner of the site.	The factories to the north are labeled as a Hosiery Works and a Hosiery Factory. Factories to the north east are labeled as a Knitwear Factory. The industrial development to the south west of the site is labeled as a Silencer Works.	The nature of the Chemical Works is not indicated, but some contamination should be anticipated.
1983 (1:10,000)	No significant changes	No significant changes	
1986-89 (1:1250)	No coverage	Development of the site between Hinckley Station and the site with two large buildings and one smaller one adjacent to Hawley Road. The buildings are labeled as warehousing.	
2002 (1:10,000)	Former Chemical Works no longer shown. Site configuration complies with current layout, with a building shown in the south of the site.	Expansion of Hinckley Station with two new large buildings shown to the east of the site.	
2009 (1:2500)	No further changes shown.	Construction of the building currently used as a car wash facility to the east of the site, and demolition of one of the large buildings adjacent to Hinckley Station.	

It is noted that the historical OS maps do not indicate the nature of the original Works and the Chemical Works on the site, and further research would usually be recommended. However, the previous site investigations and reports, and remedial works undertaken has largely superceded the need for obtaining such further information, which would have been used to scope the range of chemical testing required.

The findings of the previous site investigations and reports are summarised in Section 6.0 of this report.

4.0 ENVIRONMENTAL DATA REPORT

An updated environmental database search report ('GroundSure EnviroInsight') has been obtained and the key findings discussed below. A copy of the report is presented in Appendix 2.

4.1 Sources

An environmental database report would normally be reviewed to identify potential of sources of contamination in the area that may affect the site. However, given the presence of the peripheral bentonite cut-off wall surrounding the site, and the in-ground membrane, any off-site contamination surrounding the site is considered unlikely to impact the proposed extension on the site.

Two historic landfills are present to the south west, within 500m of the site (234m and and 260m of the site). One of these was licensed for commercial and household wastes.

The current land use map shows an office and shop equipment manufacturer and warehouses to the immediate east of the site, and two unspecified works to the north east (76m and 151m).

A pollution incident is recorded at a point 45m east of the site for an incident in 2002. Phenols and creosote are reported to have impacted the ground and water (Category 3-Minor Impact). This incident occurred after installation of the remedial measures at the site, hence is not considered to relate to the site, but may have resulted in contamination adjacent to the site.

The site is not designated as contaminated land, and no other sites within 500m are recorded as 'contaminated' by the Local Authority.

4.2 Pathways and Receptors

There is a surface water abstraction from the Sketchley Brook 83m south east of the site. The Sketchley Brook is the nearest surface water receptor to the site.

The site is not located within a groundwater source protection zone for any groundwater abstractions.

There are no designated environmentally sensitive sites within 500m of the site, and the area between the site and the Sketchley Brook are industrial in nature, or undeveloped (sports field).

5.0 GEOLOGICAL DATA REPORT

A geological data report ('GroundSure GeoInsight') has been obtained and a copy is presented in Appendix 3.

In summary, the site is shown to the underlain by the Wolston Clay, a glacial deposit. The higher ground that flanks the sides of the Sketchley Brook river valley is shown to be underlain by glacial Wolston Sand and Gravel.

The bedrock comprises mudstone belonging to the Mercia Mudstone, which is of low permeability and a non-aquifer.

The site is not affected by landslips, recorded faults, historical or current surface or underground workings, shallow or deep coal mining activities, or non coal mining cavities or other cavities. Radon protective measures are not required.

6.0 PREVIOUS REPORTS

6.1 List Of Available Report Extracts

At the time of purchase and redevelopment of the site in the mid-1990's, the Client were provided with a number of reports, commissioned by others and themselves. Some of those reports still remain in the Client's possession, as listed below:

- The Latter Ramsay Partnership. Appraisal of Site Contamination. C/6056. 26th May 1994. For Lidl (UK) Properties GmbH.
- Acer Consultants Limited. Review Of Contamination Situation And Remediation Proposals. 30 January 1995. For Lidl (UK) Properties GmbH.
- Geotechnics Limited. Factual letter report on ground investigation works. 1st June 1995. For The Latter Ramsay Partnership.
- The Latter Ramsay Partnership. Design Specification For Dealing With Known Contaminants And Possible Leachates. June/July 1995. For Lidl (UK) Properties GmbH.
- Rust Environmental. Review Of Remediation Proposals. July 1995. For Lidl UK Properties GmbH.
- Rust Environmental. Review Of Remediation Proposals. September 1995. Incorporating Attwood Testing Limited Analysis Of Soil/Water For Contaminants (21.8.1995). For Lidl UK Properties GmbH.
- Subadra Limited. Site Assessment Report. Imo01060 CL 001. May 2001. For Milburn Productions Limited. (Report on current carwash site located to the east, immediately adjacent to the Lidl site).

Copies of the extracts from the above reports are held by the Client and can be viewed by request.

A number of additional reports and drawings to those listed above were also produced, as referenced in the Acer Consultants Ltd report. Whilst it was not possible to locate copies of these reports in the Client's archives, the Acer Consultants Ltd report offers a comprehensive summary of the findings of these reports, including ground conditions, contamination levels and proposed remedial measures, including a summary of the Latter Ramsay 1994 report referenced above. The findings contained in the Acer Consultants Ltd report are discussed below.

6.2 Summary Of Acer Consultants Report Of 1995

Lidl UK GmbH purchased the site in 1993 on the basis of advice from the Clarke Bond Partnership which concluded that the levels of contamination found during the site investigations did not present any constraint to the development of the site for retail/commercial use.

However, during construction works, the Contractor, John Sisk and Son, became concerned about the nature of the ground and subsequent investigations were undertaken which revealed that contamination was far worse than would have been anticipated from the advice given by Clarke Bond Partnership.

It transpired through conversations with Local Authority that the contamination was believed to have been caused by the flushing of sumps partially filled with detergents by water used to put out a fire on the site following closure of the site which had been used for packaging of industrial detergents.

Whilst measures were taken to prevent the escape of detergent laden water into the Sketchley Brook to the south of the railway line, some seepage underground occurred, resulting in the contamination detected by John Sisk & Son during construction.

Strata Encountered

The Acer Consultants report summarises the ground conditions based on a review of a number of previous ground investigation reports which were available in 1995.

Made ground was proven to depths of between 0.7m and 3.40m, comprising loose granular material including silt, sandy silt, or coarser demolition type materials (concrete, brick and stone). The silt is described as organic and is locally clayey. Ash is also present locally and phenolic odours were reported on two trial pit logs.

The natural ground beneath the made ground comprises locally soft and soft to firm silty clay interpreted as glaciolacustrine deposits reaching a maximum proved thickness of 1.70m below ground level. Soft organic silt or sandy gravelly clay was encountered locally in a small percentage of the exploratory holes immediately beneath the made ground.

All exploratory holes encountered a firm and stiffer fissured silty clay below 4.0 metres below ground level, and this is interpreted as the Wolston Clay (a glacial deposit).

Groundwater levels are reported to lie at a depth of 0.6m to 1.80m below ground level in the made ground, which is also believed to represent the water table in the natural deposits.

Contamination Assessment: Soils

The Acer report concludes that whilst phytotoxic metals, copper, boron and zinc in the made ground may present a risk to new planting, the risk to human health in relation to the proposed development was not significant.

With respect to organic compounds in soils, the available test data revealed that 1 sample out of 30 samples showed an elevated level of phenol in relation to the guidance used at that time. In relation to current guidance, this sample would not be considered to present a risk in a commercial setting.

Mineral Oil was also assessed, and a maximum level of 0.96 mg/kg was detected in soil.

Elevated 'Coal Tar Derivatives' were also detected in some soils but there were no guide levels to assess these results against, and there remains no guidance for this screening method.

Contamination Assessment: Groundwaters

The test results available to Acer Consultants were for groundwater samples taken from trial pits, and as a result Acer Consultants concluded that this may have resulted in potential contamination of the samples by suspended sediment, which would explain the elevated results for some metals. The most notable results were for zinc (8,010) μg/l, boron (8,400 μg/l) and nickel (580 μg/l).

Total Organic Carbon and COD were notably elevated with maximum concentrations of 7,820 mg/l and 76,161 mg/l respectively, and this is also reflected in the results for phenols, mineral oil and coal tar derivatives.

With respect to phenols, 16 out of the 23 samples exceeded the 1 μg/l environmental quality standard (EQS) adopted for surface water, with a maximum value of 322 μg/l detected.

Mineral Oil screening concentrations were also elevated, with a maximum concentration of 20,896 mg/l detected. There are no available EQS for mineral oil screening tests, although a concentration of 200 μg/l is adopted by the Surface Water Abstraction Directive for dissolved or emulsified hydrocarbons, for Class A2 waters. Alternatively, the discharge standard for a class one interceptor of 5 mg/l could also be considered for streams in an urban setting.

Coal Tar Derivatives, which include a significant proportion of polycyclic aromatic hydrocarbons (PAH's), were also found to be significantly elevated with a maximum concentration of 8,332 mg/l recorded, although the actual concentration of PAH compounds is not presented.

Acer Consultants conclude that the contamination detected was consistent with the flooding of the site with detergents containing phenols and coal tars. Whilst contamination was shown to be most elevated in the vicinity of the former underground detergent tanks in the south of the site, beneath the footprint of the current Lidl foodstore, Acer concluded that groundwater contamination was generally widespread across the site.

Previous monitoring for landfill gases was also summarised by Acer. Monitoring for methane and carbon dioxide had been undertaken in 1991, and a maximum concentration of 18.5% v/v methane recorded in standpipes installed in the trial pits.

A borehole investigation in 1993 included the taking of gas samples from standpipes in boreholes on three occasions. A range of concentrations was detected ranging from 0.01%v/v to 22.35% methane, and 0.01%v/v and 6.54%v/v carbon dioxide. No measurement of gas flow rates or differential pressures was undertaken.

Remediation Proposals

The Acer Consultants report also includes an assessment of The Latter Ramsay Partnerships remediation proposals for the site, which were later subject to future amendment, possibly as a result of Acer's comments.

In summary, the remediation proposed comprised the construction of a 6 metre deep, 600mm wide, low permeability bentonite cement slurry filled trench around the perimeter of the site, including a high density polyethylene (HDPE) membrane within the centre of the trench.

The strategy included joining the vertical HDPE membrane to a horizontal HDPE membrane placed across the surface of the site beneath 650mm cover, including the car parking pavement construction. As the building was already partially constructed, the membrane would be lapped and sealed around the pile caps.

All services were to be placed within the cover material, which was to include a network of land drains to collect any infiltrating surface water ponding on the membrane. The land drains were to discharge to a surface water sewer located along the eastern site boundary, via an oil interceptor.

A peripheral land drain was proposed on the outside of the bentonite cut-off wall to intercept groundwater and prevent a rise in groundwater levels upstream of the site.

At the time of Acer's assessment, it was not proposed for the bentonite cut-off wall to completely encompass the site, and Acer drew attention to the possibility that the peripheral drain may also drain contaminated groundwater from within the site, due to the gap in the proposed wall.

The remediation strategy also included for the provision of vent stacks through the membrane to allow the escape of landfill gases from beneath the external site areas, and prevent build up of gases under pressure.

In addition, the foodstore included the installation of a low permeability membrane within the floorslab of the building, with a series of horizontal slotted pipes beneath the floorslab to vent the underside of the floorslab, and a methane gas detection and alarm system within the structure.

Whilst the Acer Consultants report concluded that the proposed remedial measures were broadly acceptable, the report identifies further issues for consideration, including principally the potential for the peripheral drain to allow the escape of contaminated groundwater, and the potential escape of contaminated groundwater beneath the barrier, as no permeability tests were available for the Wolston Clay deposits. Other issues were concerned with design responsibility, design life and construction quality assurance (CQA).

6.3 Additional Previous Reports

Geotechnics Ltd Investigation May 1995

Further to Acer Consultants' assessment of the contamination and remediation proposals, the Latter Ramsay Partnership appointed Geotechnics Limited to drill four boreholes in May 1995, to confirm the permeability of the Wolston Clay beneath the site in order to assess the potential for migration of contaminated groundwater beneath the bentonite cut-off wall.

Four boreholes were drilled in total, in the north of the site, the south, east and the west of the site. In situ and laboratory permeability testing was undertaken, and the results of the laboratory testing, which were considered by Geotechnics Ltd to be more reliable than the field tests, gave results of 10^{-10} and 10^{-11} m/sec. The constant head field tests gave results of 10^{-7} to 10^{-8} m/sec.

However, the higher results for field tests may reflect the presence of silt bands and fissuring, possibly absent from the laboratory prepared samples.

No additional chemical testing was undertaken as part of the Geotechnics Ltd investigation, although a strong phenolic odour was reported in the made ground in BH1 in the south of the site, and the made ground in BH3 (east of site) and BH4 (north of site was reported as being 'odourous'. A groundwater strike was only recorded in BH3, at 0.3m below ground level. Ground conditions were consistent with Acer's summary.

Rust Environmental Reports

Rust Environmental were commissioned by HTC Project Management on behalf of Lidl UK Properties GmbH to undertake a review of the remediation proposals put forward by The Latter Ramsay Partnership and John Sisk and Son Ltd.

Two reports were produced, one dated July 1995, and the other September 1995, which supercedes the earlier report.

It is apparent that some amendments had been made to the remediation design, and these addressed the issues raised by Acer Consultants Ltd.

In summary, the following amendments and additions were made:

- The bentonite cut-off wall was to encircle the complete site, rather than partially surround it.
- Provision of Quality Assurance (QA) documentation and third party review (by Rust) of QA procedures during the works.
- Development of a Site Operations Manual on completion of the works.
- A design life of 25 years was confirmed for the remediation measures.
- The required characteristics of the slurry wall were specified by The Latter Ramsay Partnership (Design Specification For Dealing With Known Contaminants And Possible Leachates. C/6056. June/July 1995), and this confirms a maximum permeability of 10^{-9} m/s, strains in excess of 5% without failure, a strength averaging 200 kN/m^2.

In addition, it was confirmed that a system of gas extraction pipes would be laid below the membrane, connected to vertical vents sealed to the membrane.

It is also apparent that Rust had possible access to other chemical analysis, as there report identifies the presence of chlorinated solvents in addition to the phenols, mineral oil and coal tar derivative (including PAH's), referred to by Acer Consultants. Rust refer to Attwood Testing Ltd results of 15,000 μg/l Trichloroethane, 860 μg/l Dichlorobenzene in the groundwater.

Rust concluded that the chlorinated solvents and phenols were the principal contaminants of concern, and the membrane was soak-tested by Attwood Testing Limited to establish if the membrane was resistant to such compounds at concentrations identified on site.

Rust concludes that '*the overall containment objectives of the remediation strategy should be achieved by using the techniques mentioned. Following implementation, the migration of contaminants from the encapsulated area should be controlled and future exposure of contamination to end users should be reduced to acceptable levels.*'

Subadra Limited Site Assessment Report, May 2001

The existing car wash facility immediately adjacent to the eastern boundary of the current Lidl UK GmbH foodstore was formerly in Lidl's ownership but was surplus to requirement and sold. The purchasers of the site instructed Subadra Limited to undertake a ground investigation prior to purchase.

The Subadra investigation comprised the drilling of 5 boreholes to 5.0m below ground level and the installation of standpipes.

In summary, Subadra detected chlorinated solvents and other non-chlorinated volatile solvents (ethyl benzene, toluene and xylenes) near the boundary with the Lidl site, and concluded that the contamination represented residual contamination associated with the former fire within the Chemical Works, which resulted in the spreading of industrial detergents from the underground tanks.

Whilst the soil contamination was not particularly significant with respect to these compounds, the maximum groundwater concentrations detected included 4,290 µg/l p+m xylenes, 826 µg/l o-xylene, 1020 µg/l ethyl benzene and 55 µg/l toluene. Chlorinated solvents included principally the Dichlorobenzenes 1,177 µg/l (total), with significantly lower concentrations of other chlorinated solvents, e.g. trichloroethane 6 µg/l, chorobenzene 169 µg/l. Attwood Testing had previously detected 15,000 µg/l Trichloroethane and 860 µg/l Dichlorobenzene in the groundwater beneath the site.

6.4 Observations Regarding Remediation Works

In principal, the remediation proposals were considered by Acer and Rust to provide an appropriate remedial solution to the contamination detected at the site. The principal aim was to prevent further off-site migration of phenol and chlorinated solvent contaminated groundwater, and to protect the building from methane.

The peripheral drain and sealed membrane across the surface was intended to prevent groundwater level rise up gradient of the cut-off wall, and prevent ingress of surface water and infiltration, which may have raised groundwater levels within the cut-off wall, resulting in over-topping of the wall and the escape of contaminated groundwater.

The Client is unaware of any known incidents or complaints in relation to off-site contamination migration from the site since completion of the remedial works, and no reported signs of seepages or vegetation die back along Rugby Road where groundwater would be anticipated to escape from the containment measures.

However, a third party validation report or Site Management Manual for the site has not been located by the Client.

Acer Consultants' report indicates that the National River Authority (since replaced by the Environment Agency) agreed that some leakage of contamination under the cut-off wall may occur, but appeared willing to accept this. Given the low permeability of the natural clays beneath the site, we would agree that seepage rates are unlikely to be significant.

The Client has been able to locate a copy of an as-built drawing, showing the location of the bentonite cement cut-off wall around the periphery of the site. A copy is presented in Appendix 4 of this report.

It is concluded that the remedial works undertaken appears to continue to provide protection to the surrounding area from off-site migration of contaminated groundwater, and protection of the building from landfill gases and volatile organic compound (VOC) vapours.

7. RECENT GROUND INVESTIGATION WORKS

7.1 Scope Of The Investigation

The aim of the recent investigation undertaken by Peak Associates Ltd was primarily to confirm that ground conditions were either broadly similar to those detected in the 1990's, or hopefully improved, and allow an assessment of the current level of risk presented to the users of the proposed extension along the front of the store (i.e. along the northern elevation).

In addition, information regarding the engineering properties of the soils was also obtained in order to assist with the design of the foundations for the extension. Two cable percussion holes were drilled to 10 metres below ground level for this purpose, one located at each end of the proposed extension. Standpipes were installed on completion to facilitate groundwater sampling and gas monitoring.

A further windowless sampling exploratory hole was also drilled within the car parking area to the north of the store to a depth of 8.0m below ground level to provide an additional groundwater and gas monitoring position.

The locations of the boreholes are shown on Plan 2, and the borehole logs are presented in Appendix 5.

The cable percussion boreholes CP1 and CP2 were drilled on 26th and 27th January 2010 using a Dando 150. A small tracked windowless percussion sampling rig was used to drill WS1 in the car park on 25th January 2010, using a Competitor 130 rig.

The exploratory hole drilling works were supervised full time by staff members of Peak Associates, who also logged the arisings and took sub-samples for chemical and geotechnical laboratory analysis. The samples for chemical analysis were placed in appropriate glass jars, including 1 litre, 250cc amber glass jars, and 60cc VOC jars, and

placed in cool boxes with ice-packs to await collection by the courier. The sub-samples taken for geotechnical testing were placed in plastic bags and also stored in cool boxes.

Due to the presence of the cross site HDPE membrane beneath the external pavement across the site, great care was taken to ensure that the seal was not compromised by the drilling of the boreholes and subsequent standpipe installation works.

Two options were devised to ensure that the seal was protected. Both involved excavation by hand to expose the membrane to allow a hole to be cut out slightly larger than the drill casing. The hole would then be drilled using casing through the membrane, and as deep as necessary to keep the borehole open.

In both options, on completion of drilling and standpipe installation, the casing was to be withdrawn to a metre below ground level and then bentonite granules poured into the casing with water, and the casing withdrawn in stages with further bentonite granules and water added in stages above the base of the hand dug pit. The casing would then be replaced with a sleeve comprising a length of HDPE below-ground drainage pipe of similar diameter to the casing, pushed into the bentonite seal to a depth of 1.0m below ground level, thus squeezing the bentonite tightly against the borehole wall and the sleeve, and improving the seal.

If possible, 'Option 1' comprised the use of a pre-formed 'top-hat' which was to be placed over the sleeve and sealed to the membrane using double sided tape and foil based tape over the joint. The top-hat was then to be sealed around the pipe using a jubilee clip and foil based tape over the joint.

If this was not possible due to groundwater ingress above the membrane, then 'Option 2' comprised the use of further bags of bentonite granules and water if necessary to form a plug in the base of the pit above the membrane and around the sleeve section, to improve the seal.

The excavation for CP1 and WS1 both encountered water ingress from the pavement materials above the membrane, and it was not possible to dry the membrane surface to enable the top-hat arrangement to be used, and therefore the second option was adopted, although the bentonite plug was placed first in the base of the inspection pits before driving the casing through the membrane to reduce water ingress around the casing.

CP2 was found to lack a HDPE membrane at the location drilled, and this is discussed in detail later in this report.

Standard penetration tests (SPT's) were undertaken at alternate sample intervals within the cable percussion holes, with undisturbed 100mm diameter samples taken between.

7.2 Strata Encountered

<u>Made Ground</u>

Tarmac surfacing (0.2m thick nominally) was broken out at the three locations and a hand dug pit excavated to expose the membrane. The tarmac surfacing was found to overlie a granite gravel sub-base in WS1 to a depth of 0.55m where two layer of geotextile were encountered overlying a layer of finer gravel. At 0.7m below ground level the HDPE membrane was encountered, and this rested on layer of fine gravel to 0.8m with another two layers of geotextile beneath.

Below the geotextile at 0.8m, the original made ground was encountered comprising soft wet silt sandy gravely clay overlying a basal layer of gravel and cobbles of concrete, quartzite and dolerite/basalt road stone to a depth of 2.10m.

There was a slight diesel/tarry odour associated with a black organic rich inclusion of decaying bark or tree root at the base of the made ground/upper surface of the clay beneath.

In CP1, granite gravel sub-base was found beneath the tarmac to a depth of 0.45m where a single layer of geotextile was found above a layer of red sand to approximately 0.62m where the HDPE membrane was encountered directly resting another layer of red sand to a depth of 0.9m. Below the red sand layer, the original made ground was reached, which comprises silty sandy gravely clay with brick coal, granite, glass and chert to a depth of 1.30m. A strong tarry odour was noted and the clay was stained black.

In CP2, beneath the tarmac and thick sub-base, made ground comprising silty sandy gravely soft clay was encountered and a hydrocarbon odour was also noted. At 0.9m a geotextile layer was encountered within the made ground, but no HDPE membrane was encountered above or below this layer.

Below the geotextile, further silty gravely soft clay fill was encountered to a depth of 2.80m, although below 2.0m the clay could potentially comprise natural alluvium. Hydrocarbon odours were noted throughout the fill, but becoming less strong with depth.

Natural Soils

In CP1 and CP2, between the base of the made ground and 4.60m to 4.80m below ground level, inter-bedded soft clay and loose silt was encountered, which are likely to be glacial in origin, but may not 'Wolston Clay' as shown on the published geological maps, and may represent more recent glaciofluvial or alluvial deposits. Such deposits were largely absent from WS1, with orange mottled grey firm clay with occasional fine nodules present from the base of the made ground to 3.70m below ground level, where a thin bed of silt or very silty clay was encountered to a depth of 4.10m.

In all three boreholes, firm and stiff becoming very stiff silty clay was encountered below the upper layer of clays and silts at depths of between 4.10m to 4.80m below ground level. This is interpreted to represent the Wolston Clay. In CP2 the Wolston Clay was

slightly sandy and gravely and was orange brown mottled red, whilst in WS1 and CP2 it is described as brown (WS1), and dark brown and mottled red (CP2), without any gravel.

7.3 Groundwater Observations & Standpipe Installations

Groundwater was encountered above the HDPE membrane in WS1 as a heavy seepage/inflow from below 0.45m, and the granular made ground beneath was also water bearing, indicating a high water table below the membrane and a perched water table above.

Water was also encountered above the HDPE membrane in CP1 also from approximately 0.5m below ground level, although the seepage was slower and associated with the red sand layer above the HDPE membrane.

Groundwater was not observed in CP2 at shallow depth, and as the HDPE membrane was absent, water would not have been able to pond on it.

Groundwater strikes during drilling were noted at 3.1m and 5.3m in CP1, and 3.0m in CP2.

Standpipes were installed in WS1, CP1 and CP2 on completion of the holes. In WS1 a 50mm diameter pipe was installed to 3.0m, with pea gravel surround and bentonite seal from 0.5m to 1.20m below ground level. A 100mm diameter plastic pipe (sleeve) was pushed into the hole on completion to a depth of 1.0m and a flush stopcock cover concreted in place.

In CP1 and CP2, 50mm pipes were installed to 8.0m with a slotted section and filter wrap to 5.0m, a bentonite seal to 4.0m and a plain pipe to ground level. An upper standpipe was also installed from 4.0m to ground level with 3.0m of slotted pipe having a geotextile wrap and a metre of plain pipe at the top. A bentonite seal was placed from 1.0m to above the membrane in CP1 to approximately 0.45m below ground level, and in CP2 from 1.0m up to 0.5m below ground level. A 160mm diameter sleeve (below ground drainage pipe section) was pushed into the hole to a depth of 1.0m on removal of the casing. Both holes were completed with a flush stopcock cover with concrete surround and tarmac surface finish. A rubber bung with gas tap was pushed into each standpipe on completion.

7.4 Laboratory Testing

Selected samples of soils were submitted for laboratory analysis from WS1, CP1 and CP2 for confirmatory speciated semi-volatile organic compound (SVOC) analysis (including speciated phenols) and volatile organic compound (VOC) analysis, including chlorinated solvents, benzene, toluene, ethyl benzene and xylene ('BTEX'), a s these represent the principal contaminants of concern.

Water samples were also taken for analysis from the standpipe in WS1 and both the upper and lower standpipes in CP1 and CP2 on 29th January 2010. The standpipes were purged

by pumping three times the volume of water in the column using a dedicated bailer for each installation. Each water sample comprised two 1 litre green bottles and 1 VOC vial with septum lid. The samples were sent by courier on the day of sampling in cooler boxes with ice packs. Each water sample was analysed for VOC's and SVOC's.

Four selected samples of the natural clays were also submitted for pH and water soluble sulphate analysis to establish if any special concrete protection measures are required.

Six additional samples of the natural clays were also tested to determine Plasticity Index to enable correlation of the SPT results.

Six undrained triaxial tests were undertaken on selected 100mm diameter undisturbed samples to determine undrained shear strength in order to assist with piled foundation design.

The laboratory chemical test results are presented in Appendix 6 and the geotechnical tests in Appendix 7.

7.5 Gas and Groundwater Level Monitoring

The standpipes were monitored on 02/02/2010 for %v/v methane, %v/v carbon dioxide and %v/v oxygen, parts per million hydrogen sulphide and carbon monoxide. In addition, gas flow rate, barometric pressure and groundwater level were also measured in each standpipe.

The groundwater level monitoring shows that the water level in WS1 is at, or above, the level of the underside of the in-ground membrane (0.7m below ground level). In CP1, the groundwater level is approximately 330 mm below the level of the in ground membrane (0.95m below ground level). The groundwater level in CP2 is 1.25m below groundlevel in the upper standpipe, and slightly higher in the lower standpipe (1.15m below ground level), suggesting that some drainage of the near surface soils is occurring.

Review of groundwater levels relative to site datum shows that the water levels in WS1 and CP2 are the same (97.1m), and are slightly more elevated in CP1 (97.21m), although this is based on estimated ground levels at each standpipe location using the topographic survey.

The gas and groundwater level monitoring results are presented in Appendix 8.

8. CONTAMINATION ASSESSMENT

8.1 Assessment Criteria

The contamination test data for the soils have been compared against Peak Associates' Tier 1 screening criteria for a commercial/industrial use, in relation to human health, and groundwater tests results against currently adopted Environmental Quality Standards

(EQS). A copy of the current Peak Associates Tier 1 screening values and EQS are presented in Appendix 9, with additional adopted screening values identified below where appropriate.

8.2 Soil Test Results

The soil samples submitted for chemical analysis were selected on the basis that they exhibit visual or olfactory evidence of potentially significant hydrocarbon contamination. The test results for compounds detected in one or more soil samples at concentrations above the detection limits are presented in Tables 8.1 and 8.2 below, for VOC's and SVOC's respectively. Where available, the Tier 1 screening values for commercial use has also been included in the tables.

Table 8.1: Volatile Organic Compounds Above Detection Limit In Soils

			Date Sampled	25/01/10	26/01/10	27/01/10	
			Sample Ref.	PP/LIH/4/ WS1	JH/LIH/30 1	JH/LIH/030 6	
			BH/Depth (m)	WS1/1.80 - 1.90m	CP1/1.00m	CP2/1.00m	Tier 1 Screening Value[(a)]
Determinand	Unit	MDL					µg/kg
Chloroethane	µg/kg	<5		<5	<5	47	960,000[1]
1,1-Dichloroethane	µg/kg	<5		<5	164	699	280,000[1]
cis-1,2-Dichloroethene	µg/kg	<5		<5	<5	52	22,000[1]
1,1,1-Trichloroethane	µg/kg	<5		<5	<5	746	700,000
Trichloroethene	µg/kg	<5		<5	<5	81	12,000
Toluene	µg/kg	<5		<5	442	40	870,000
Tetrachloroethene	µg/kg	<5		<5	27	811	130,000
Chlorobenzene	µg/kg	<5		<5	<5	17	59,000[2]
Ethyl Benzene	µg/kg	<2		3	5072	1760	520,000
m,p-Xylene	µg/kg	<2		7	10434	5715	1,205,000
o-Xylene	µg/kg	<2		2	6067	2343	480,000
Isopropylbenzene	µg/kg	<5		<5	4126	<5	1,400,000[1]
n-Propylbenzene	µg/kg	<5		<5	7106	88	4,100,000[1]
1,3,5-Trimethylbenzene	µg/kg	<5		<5	12755	269	
1,2,4-Trimethylbenzene	µg/kg	<5		<5	40263	630	42,000[1]
sec-Butylbenzene	µg/kg	<5		<5	4288	57	
p-Isopropyltoluene	µg/kg	<5		<5	4390	1303	
1,3-Dichlorobenzene	µg/kg	<5		<5	95	375	32,000[2]
1,4-Dichlorobenzene	µg/kg	<5		6	924	3106	4,500,000[2]
1,2-Dichlorobenzene	µg/kg	<5		18	4384	18477	2,100,000[2]

[(a)] Refer to Appendix 9, for Tier1 source, with the exception of those referenced below
[1] EIC/AGS/CL:AIRE GAC for organics with 1% SOM
[2.] LQM/CIEH 2nd Edition. GAC for Human Health Risk Assessment

Table 8.2 SVOC's Above Detection Limit In Soils

			Date Sampled	25/01/10	26/01/10	27/01/10	
			Sample Ref.	PP/LIH/4/ WS1	JH/LIH/ 0301	JH/LIH/ 0306	
			BH/Depth (m)	WS1/ 1.80 - 1.90	CP1/1.00	CP2/1.00	Tier 1 Screening Value
Determinand	Unit	MDL					mg/kg
Dibenzofuran	mg/kg	<0.1	<0.1	29	0.2		
1,2-Dichlorobenzene	mg/kg	<0.1	<0.1	1.7	19.9		2,100[2]
1,3-Dichlorobenzene	mg/kg	<0.1	<0.1	<0.1	0.7		32[2]
1,4-Dichlorobenzene	mg/kg	<0.1	<0.1	<0.1	3.6		4,500[2]
2-Methylnaphthalene	mg/kg	<0.1	<0.1	114.6	<0.1		
1,2,4-Trichlorobenzene	mg/kg	<0.1	<0.1	<0.1	0.3		230[2]

[2.] LQM/CIEH 2nd Edition. GAC for Human Health Risk Assessment

None of the test results for the soil samples exceeds the available Tier 1 (human health) screening value for a commercial land use. It should also be noted that the Tier 1 screening values are based on the contaminant being present in surface soils in soft landscaped areas and directly beneath building footprints with no vapour barrier within the floorslab to prevent indoors air inhalation.

With specific reference to the Lidl UK GmbH site, the HDPE in-ground membrane and clean cover above provides isolation from the soils beneath, and hence the risk to human health from soils is not considered significant in relation to the following exposure pathways, which are inactive: direct soil and dust ingestion, indoor and outdoor dermal uptake, indoor and outdoor dust inhalation. The future extension will provide further hard cover over the in-ground membrane hence these pathways will remain inactive.

The indoor and outdoor vapour inhalation pathways are considered the only potentially active pathways available in relation to the proposed extension. The concentration of 1,2,4 trimethlybenzene is close to the Tier 1 screening value, and the principal exposure pathway for this compound is vapour inhalation. However, the in-ground HDPE membrane and existing venting is considered sufficient to provide the appropriate level of protection required to the current site occupants and customers, and provided the integrity of the membrane is not compromised, it should also provide an appropriate level of protection for the extension from ingress of VOC's derived from the residual soil contamination.

8.3 Groundwater Contamination

The results for compounds present in groundwater above test detection limit in one or more samples are presented in Tables 8.3 and 8.4, for VOC's and SVOC's respectively.

The available Environmental Quality Standards are also presented in these Tables, where a published value is available.

Table 8.3: VOC's Above Detection Limit In Groundwater Samples

		Date Sampled	29.1.2010	29.1.2010	29.1.2010	29.1.2010	29.1.2010	
		Sample Ref	PP/LIH/4/ WS1/W	PP/LIH/4/ CP1/W	PP/LIH/4/ CP1/W	PP/LIH/4/ CP2/W	PP/LIH/4/ CP2/W	
		BH Ref	WS1	CP1/ Shallow S/P	CP1/ Deep S/P	CP2/ Shallow S/P	CP2/ Deep S/P	EQS[(a)]
Determinand	**Unit**	**MDL**						µg/l
Vinyl Chloride	µg/l	<1	26	<1	<1	<1	<1	0.5[1]-5[2]
Chloroethane	µg/l	<1	42	<1	<1	198	139	
1,1-Dichloroethene	µg/l	<1	4	<1	47	387	2	30[2]
MTBE	µg/l	<1	<1	<1	<1	17	<1	
1,1-Dichloroethane	µg/l	<1	216	53	<1	<1	454	10[2]
cis-1,2-Dichloroethene	µg/l	<1	74	<1	<1	<1	16	50[2]
1,1,1-Trichloroethane	µg/l	<1	3	<1	<1	334	417	100[3]
Benzene	µg/l	<1	3	3	2	2	2	30
Trichloroethene	µg/l	<1	10	<1	<1	5	5	10[4]
Toluene	µg/l	<1	5	10	8	10	6	50
Tetrachloroethene	µg/l	<1	<1	<1	<1	17	20	100[4]
Chlorobenzene	µg/l	<1	65	5	4	<1	3	
Ethyl Benzene	µg/l	<1	8	30	31	58	43	30
m,p-Xylene	µg/l	<1	15	65	57	929	605	30
o-Xylene	µg/l	<1	6	25	27	53	42	30
Isopropylbenzene	µg/l	<1	1	15	18	2	<1	
n-Propylbenzene	µg/l	<1	1	16	21	<1	<1	
1,3,5-Trimethylbenzene	µg/l	<1	1	34	42	5	4	
1,2,4-Trimethylbenzene	µg/l	<1	3	108	137	4	3	
sec-Butylbenzene	µg/l	<1	<1	8	10	<1	<1	
p-Isopropyltoluene	µg/l	<1	<1	10	14	2	1	
1,3-Dichlorobenzene	µg/l	<1	2	<1	<1	4	4	
1,4-Dichlorobenzene	µg/l	<1	13	6	6	26	25	300[2]
1,2-Dichlorobenzene	µg/l	<1	27	21	24	115	110	1000[2]

[(a)] Refer to Appendix 9 for EQS source, with the exception of those listed below
[1] EQS (EA. Hydrogeological Risk Assessment for Landfills)
[2] WHO (EA. Hydrogeological Risk Assessment for Landfills)
[3] EC Dangerous Substances Directive (76/464/EEC)
[4] EQS Freshwater

Table 8.4: SVOC's Above Detection Limits In Groundwater Samples

Date Sampled			29.1.2010	29.1.2010	29.1.2010	29.1.2010	29.1.2010	
Sample Ref			PP/LIH/4/ WS1/W	PP/LIH/4/ CP1/W	PP/LIH/4/ CP1/W	PP/LIH/4/ CP2/W	PP/LIH/4/ CP2/W	
BH Ref			WS1	CP1 Shallow S/P	CP1 Deep S/P	CP2 Shallow S/P	CP2 Deep S/P	EQS
Determinand	**Unit**	**MDL**						µg/l
4-Chloroaniline	µg/l	<0.1	<1	<1	16.1	<1	<1	
1,2-Dichlorobenzene	µg/l	<0.1	<1	<1	<1	5.7	5.5	1000[2]
2,4-Dimethylphenol	µg/l	<0.1	10.7	<1	4.6	153.6	126.3	
2-Methylnaphthalene	µg/l	<0.1	<1	54.7	5.2	2.1	<1	10[*]
0-Cresol	µg/l	<0.1	1.4	<1	<1	6.2	6.6	
p-Cresol	µg/l	<0.1	5.6	<1	<1	59.2	61.9	
Phenol	µg/l	<0.1	3.4	<1	<1	3.1	3.4	30[4]

[2] WHO (EA. Hydrogeological Risk Assessment for Landfills)
[4] EQS Freshwater
[*] EQS for naphthalene

The results show that a wide variety of VOC and SVOC compounds remain within the groundwater beneath the site, and are most noticeably represented by xylenes, ethyl benzene, dichloroethane, trichloroethane and dichloroethene.

The presence of vinyl chloride in WS1 in the north of the site suggests that breakdown of trichloroethene (TCE) and dichloroethene (TCE) may have occurred in this area.

Detection of the chlorinated solvents was not unexpected, given the previous investigation findings, and the local industry (dry cleaning), but benzene, toluene, ethyl benzene, xylene ('BTEX') and MTBE are typical indicators of petrol fuel contamination, which does not fit with the site history, and was not identified previously, although these chemicals may not have been tested for as part of the previous investigations.

The concentration of phenol, which was the most significant potential contaminant of concern previously identified, is notably insignificant in all the samples, although other phenolic compounds such as the cresols (methyl phenols) and dimethylphenols are more elevated in concentration than phenol, but still significantly below the total phenol concentrations detected previously within the groundwater beneath the site.

Concentrations are higher in CP1 and CP2 relative to WS1, and this would be expected on the basis that CP1 and CP2 are closer to the location of the former tanks, which were beneath the footprint of the existing Lidl store.

It is also apparent that the chlorinated solvents and 'BTEX' is present in both the upper and lower standpipes, which suggests the hydrocarbon mixture present is denser than water, and is sinking through the water column.

In absence of the remedial measures, the number and concentrations of contaminants detected in the groundwater would give cause for concern in relation to off-site migration and potential impact on off-site receptors, which are principally represented by Sketchley Brook to the south of the site. However, the bentonite cut-off wall and cross site membrane was installed to prevent the migration of contaminated groundwater off-site.

Overall, the concentrations detected appear lower than previously detected, and hence some breakdown appears to be occurring, although at a slow rate in relation to chlorinated solvents. Such compounds do not readily degrade naturally compared to other non-chlorinated hydrocarbons, and therefore tend to remain for long periods of time within groundwater plumes.

In relation to human health, there is one exposure pathway considered to be potentially active – indoor vapour inhalation of VOC vapours, derived through the process of volatilisation from groundwater. The maximum concentrations of VOC's in the groundwater detected in CP1 and CP2, none of which exceed 1 mg/l, and all of which are significantly below the solubility limit for these compounds, and this suggests that this pathway may not be significant, although this would need to be confirmed by site specific quantitative risk assessment and/or further monitoring of vapour concentrations in the ground. However, the in-ground membrane is considered to provide an appropriate level of protection against this potential pathway, and hence again it recommended that the integrity of the membrane is maintained.

8.3 Landfill Gases

The results of the recent monitoring exercise (2nd February 2010) for methane and carbon dioxide in CP1, CP2 and WS1 has not revealed any indication of any significant landfill gases or gas flow rates, and if representative of the long term concentrations of these gases beneath the site, then the risk from methane and carbon dioxide in the ground is not considered significant.

There are no landfills in the area sufficiently close that could have presented a risk to the site, and none of the descriptions of the made ground in any report suggest that there are any significant percentages of organic rich bio-degradable materials beneath the site.

The source of the elevated methane and carbon dioxide detected locally in some boreholes previously may have resulted from the breakdown of the organic chemicals released to the ground, and false triggering of gas monitoring equipment by VOC vapours in the soils may also have occurred potentially.

The water table is also very high beneath the membrane, and in WS1 the unsaturated zone between the underside of the membrane and the water table is absent, whilst in CP1 it is approximately 300mm. The presence of the elevated water table reduces landfill gas generation and migration potential.

Methane and carbon dioxide are not considered likely to present a significant risk to the proposed extension, and maintaining the integrity of the in-ground membrane will reduce this risk further. A vented void beneath the floorslab of the proposed extension will add a further level of protection.

The car parking area is to be re-configured, and hence some of the existing vent stacks will require relocation. The remediation strategy included a network of gas collection pipes beneath the in-ground membrane connected to the vent stacks to prevent methane gas building up under pressure beneath the sealed membrane. The vent stacks are not designed to draw methane out of the ground, but to allow it to escape to atmosphere and relieve pressure on the underside of the membrane.

The gas monitoring undertaken recently has not detected significant gas pressures or landfill gas concentrations, and given the nature of the made ground and the high water table, these would not be expected. However, if these vents are removed and the pipes sealed at ground level, the potential effects are difficult to predict. There may be pockets of methane generating material and these could conceivably lead to a build-up of gas in the collection pipes and unsaturated zone soils beneath the membrane, although given the anticipated slow rate of generation, this is unlikely to create any significant pressure.

In order to maintain the current balance between potential gas generation and venting, it is recommended that venting be maintained. The venting pipes that require relocation could be removed and replaced with pressure relief valves set below the ground surface in a shallow chamber that allows gas to vent to the surface, but prevent surface water ingress below the membrane. Alternatively, the vents could be relocated and re-connected to the existing penetration through the membrane with a length of pipe. It would not be possible to make a new connection to the gas drainage network through the in-ground membrane, as the pipe network beneath the membrane would be very difficult to locate without extensive investigation.

8.4 Conceptual Site Model

Based on the findings of the intrusive investigation and consideration of the risks, a conceptual site model has been produced as presented in Table 8.5 below.

Table 8.5: Revised Site Conceptual Model

Receptor	Sources	Pathways	Risk	Action
Employees and customers of the store.	Hydrocarbon contamination within the soils and groundwater	Inhalation of VOC vapours from soil and by volatilisation from groundwater.	Negligible in relation to soils. Low in relation to groundwater.	Maintain integrity of in-ground membrane.
Construction workers.	Hydrocarbon contamination within the soils and groundwater	Skin contact with contaminated soils and groundwater.	Medium, short term, but only if excavation below the in-ground membrane is required.	Adoption of appropriate PPE and hygiene practices.
Controlled water receptors (Groundwater and surface water bodies)	Hydrocarbons in the soils and groundwaters.	Thick, low permeability clay beneath the site prevents significant downward and lateral migration through these deposits.	Low, but site remains contaminated and the risk remains.	None provided existing remedial measures are not comprised.

Receptor	Sources	Pathways	Risk	Action
		Localised lateral migration of hydrocarbon contamination through near surface granular deposits	Negligible. Bentonite cut-off wall and in-ground membrane is present to prevent off-site migration.	Maintain integrity of the in-ground membrane.
Plastic based services	Hydrocarbons in the soils and groundwater	Contact with plastic based service pipes and materials. Damage to plastic and permeation through pipes into drinking water supply	Very low, provided water supply pipes and other plastic based services, remain above the in-ground membrane.	Water supply pipes to be placed above the in-ground membrane within the clean sand.

8.6 Assessment of Remedial Measures

The remedial measures in relation to the proposed extension comprise essentially ensuring that the integrity of the in-ground membrane is maintained beneath the extension.

As discussed in the following section of the report, the in-ground membrane will be breached by the installation of piles, and where this occurs, the membrane should be sealed to the pile cap, or around a larger diameter casing or sleeve through which piling works are undertaken. Grouting between the pile and the sleeve would need to be undertaken on completion of pile driving.

Maintaining the integrity of the in-ground membrane will prevent significant escape of VOC vapours and methane from beneath, and from reaching significant concentrations beneath underside of the extension floorslab. It will also reduce the infiltration of surface water through the membrane, which may otherwise occur as the fill material above the membrane supports a perched water table.

If infiltration increases, the groundwater table may potentially rise and allow contaminated groundwater to enter the surface water drains present above the membrane, or escape through other unknown breaks in the membrane.

The membrane was not encountered in CP2, which indicates that it is missing locally for some reason. The groundwater level in CP2 was lower than in CP1 and WS1, and does not appear to have resulted in a rise in the groundwater table in this locality. This may be explained by the presence of the drained tarmac cover across the car park, which also minimises and reduces infiltration potential.

During construction of the extension, it is recommended that where the in-ground membrane is missing, it is extended across the full extent of the footprint of the extension, and where located, lapped over and sealed onto the existing membrane. The tarmac surfacing should placed to a fall away from the building and sealed against the building walls or ground beams to minimise infiltration potential along the joint.

9.0 ENGINEERING CONSIDERATIONS

9.1 Foundation and Floorslab Design

The made ground deposits are considered too soft, loose and compressible to provide a suitable founding strata for shallow strip or pad footings, and extend to depths of 2.00m and 2.80m in boreholes CP1 and CP2 respectively.

Beneath the made ground, the natural clays include firm clay, loose silt and soft-very soft interlaminated clay and silt. These deposits are also considered too soft/loose, compressible and variable to provide reliable bearing strata for strip and pad foundations.

It is considered therefore that a piled foundation solution is the most appropriate. A driven pile or other type of displacement piles that do not produce arisings should be considered, as this will avoid the generation of contaminated soils.

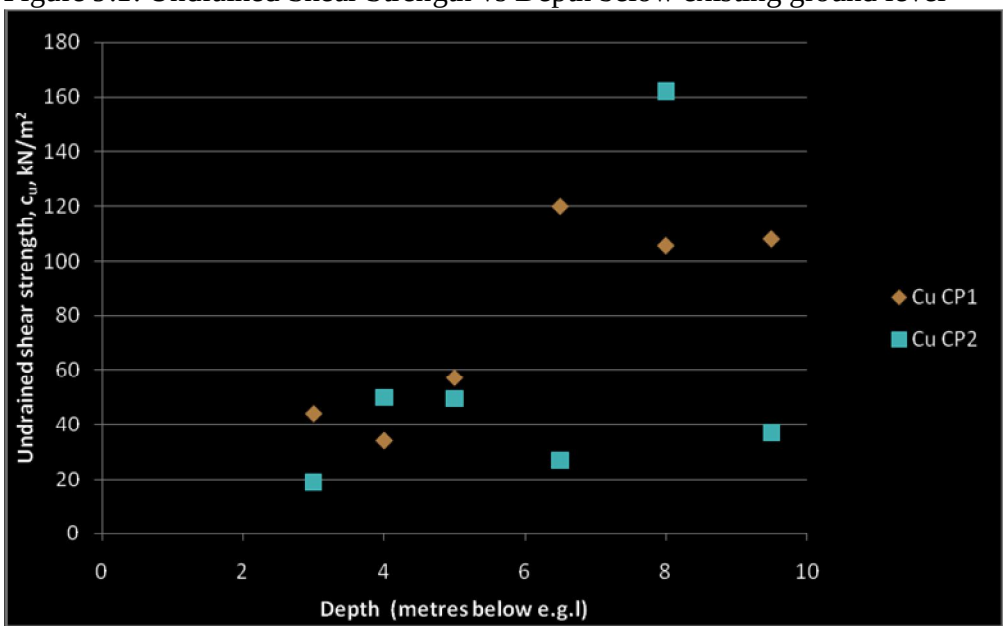
The undrained shear strengths for the natural clays have been plotted against depth, and the results presented in Figure 9.1 below:

The undrained shear strengths have been obtained using a combination of a correlation of SPT 'N' values and plasticity index, and the results of laboratory triaxial testing (undrained triaxial testing on 100mm undisturbed samples).

The SPT 'N' values and U100 triaxial test results for borehole CP1 correlate very closely, and show a steady increase in strength with depth. However, the results for the undrained triaxial results for CP2 at a depth of 6.5m and 9.5m below ground level are less than expected based on the field description of the samples and the SPT 'N' values.

Inspection of the laboratory test results shows that the mode of failure for these samples is 'plastic' and the samples are described as sandy and very sandy clays. It is considered likely that the samples included bands of silt and sand which may have resulted in the plastic failure observed.

Figure 9.1: Undrained Shear Strength vs Depth below existing ground level



In relation to pile design, an average undrained shear strength of 75 kN/m^2 is considered representative of the shear strength over the depth range 3.0m to 10.0m, as this corresponds with the field descriptions and the SPT 'N' values, and is also the average of the undrained shear strength determinations over the range 4.0-10.0 mbgl. The lower undrained shear strengths detected are considered to be related to the presence of silt and sandy bands within the sample undisturbed samples. An undrained shear strength at a depth of 10m bgl of 120kN/m^2 is considered representative.

A preliminary assessment of pile bearing capacity for a 0.5m diameter pile driven to 10m is approximately 325 to 350kN, and for a 0.3m diameter pile, this reduces to 170 - 190kN.

However, a more detailed analysis of available bearing capacity for piles should be undertaken in accordance with Eurocode 7 procedures once the anticipated loadings are known, and a specialist piling contractor approached to provide a pile design with warrantee.

With respect to floorslab design, the soft and loose made ground and upper natural clays to 4.0m below ground level are considered too compressible to support a ground bearing floorslab without significant potential settlement. Any settlement of the floorslab may create a step and/or open the construction joint between the floorslab of the extension and the floor of the existing store. In addition, settlement may overstress the in-ground membrane and tear the joints between the membrane and the existing and/or proposed pile caps.

A suspended floorslab would avoid potential problems associated with settlement, and would also provide a ventilated sub-floor void, adding further protection against vapours

and methane. Care is required to ensure a good flexible seal or waterbar is provided between the floorslab of the existing store and the floor slab of the proposed extension.

In relation to the ground beams for the extension walls, is it advised that these are designed to be constructed above the level of the in-ground membrane to avoid the need to break through the membrane and the associated problem of resealing the membrane against the ground beams. In addition, this would also avoid the need to dispose of contaminated soils and possibly groundwater.

In WS1 and CP1, groundwater was encountered within the clean fill above the in-ground membrane, perched on the membrane. This will need to be taken into consideration during piling works, particularly when attempting to seal the in-ground membrane against the pile sleeve, or pile cap.

At the location of each proposed pile, it will be necessary to excavate down to expose the in-ground membrane and cut a hole through it to allow the pile to be driven through. A sleeve may be installed through the membrane at this stage and the membrane sealed around the sleeve using a proprietary pre-formed 'top-hat' arrangement. However, in order to be able to undertake these works, the membrane must be clean and dry, and the groundwater will need to be drained from above the soils above the in-ground membrane, or the excavation sealed against groundwater ingress.

9.2 Concrete Protection Requirements

The test results show that the made ground and the natural clays fall into Design Sulphate Class 'DS-1', and the ACEC (Aggressive Chemical Environment for Concrete) classification for the location is 'AC-1'.

9.3 Waste Disposal

Provided excavations are maintained above the in-ground barrier, surplus excavation arisings are likely to be considered inert or non-hazardous.

Any soils that cannot be accommodated on site are a 'waste' under the Regulations and should only be disposed at a facility or a site licensed to accept the materials. Under the Duty of Care Regulations, the producer of the waste is obliged to ensure that all wastes are disposed of appropriately.

Any waste soils derived from the site, will require confirmation of their status for disposal via undertaking Waste Acceptance Criteria (WAC) testing, subject to the requirements of the landfill site/waste disposal site operator.

10.0 CONCLUSIONS AND RECOMMENDATIONS

In relation to contamination issues, the aim of this report is to establish the level of potential risk presented by ground conditions to the users of the proposed extension along the frontage of the existing Lidl foodstore.

After 15 years, the contamination concentrations in the groundwater do appear to have reduced and quality improved with respect to phenols, and also, at the locations sampled, with respect to chlorinated solvents. Soils were not previously considered significantly contaminated in relation to a commercial use, and this is also re-confirmed.

However, the concentrations of VOC's and SVOC's in the groundwater beneath the site are still considered sufficiently elevated to present a risk to off-site receptors and hence it is recommended that the existing remediation measures are maintained. This requires the in-ground barrier to be resealed where piled foundations penetrate the membrane, and this will ensure groundwater ingress does not increase and result in escape of contaminated groundwater to the surface water drain. In addition, and any VOC vapours and/or methane below the membrane would not be able to vent and build up beneath the underside of the extension. A passively vented void beneath the floorslab will add another level of protection from VOC vapours and possible methane.

The ground investigation has resulted in the need to break through the in-ground membrane, and proposed piling works will also require breaking through the in-ground membrane. It is recommended that the level of groundwater beneath the in-ground membrane is monitored after the works to ensure that groundwater levels are not rising due to increased infiltration.

In relation to engineering considerations, a piled foundation solution with suspended floorslab is recommended to avoid excessive settlement of the foundations and floorslab. This is of particular importance to avoid a step or gap developing between the existing floorslab and the new floorslab. A pile solution that does not generate spoil, such as a driven pile, is recommended to avoid the generation of contaminated soils. A specialist piling contractor should be approached to provide a pile design with warrantee. The joint between the proposed floorslab and existing floorslab should be provided with a flexible seal to prevent a gap developing. Ground beams should be designed to lie above the in-ground membrane to avoid the need to excavate through the membrane and the need to seal the membrane against the ground beams or foundations.

Groundwater ingress to excavations should be anticipated as the in-ground membrane supports a perched water table. This will create difficulties for sealing the membrane around pile caps, or pile sleeves, as the membrane will need to be clean and dry.

The external car parking layout requires reconfiguration and this will require the relocation of the venting stacks. Although the risk from methane gas and VOC vapours is not considered particularly significant, it is difficult to predict the effect of removing the

vents and sealing them below ground level, and it is concluded therefore that venting should be maintained to maintain the current balance.

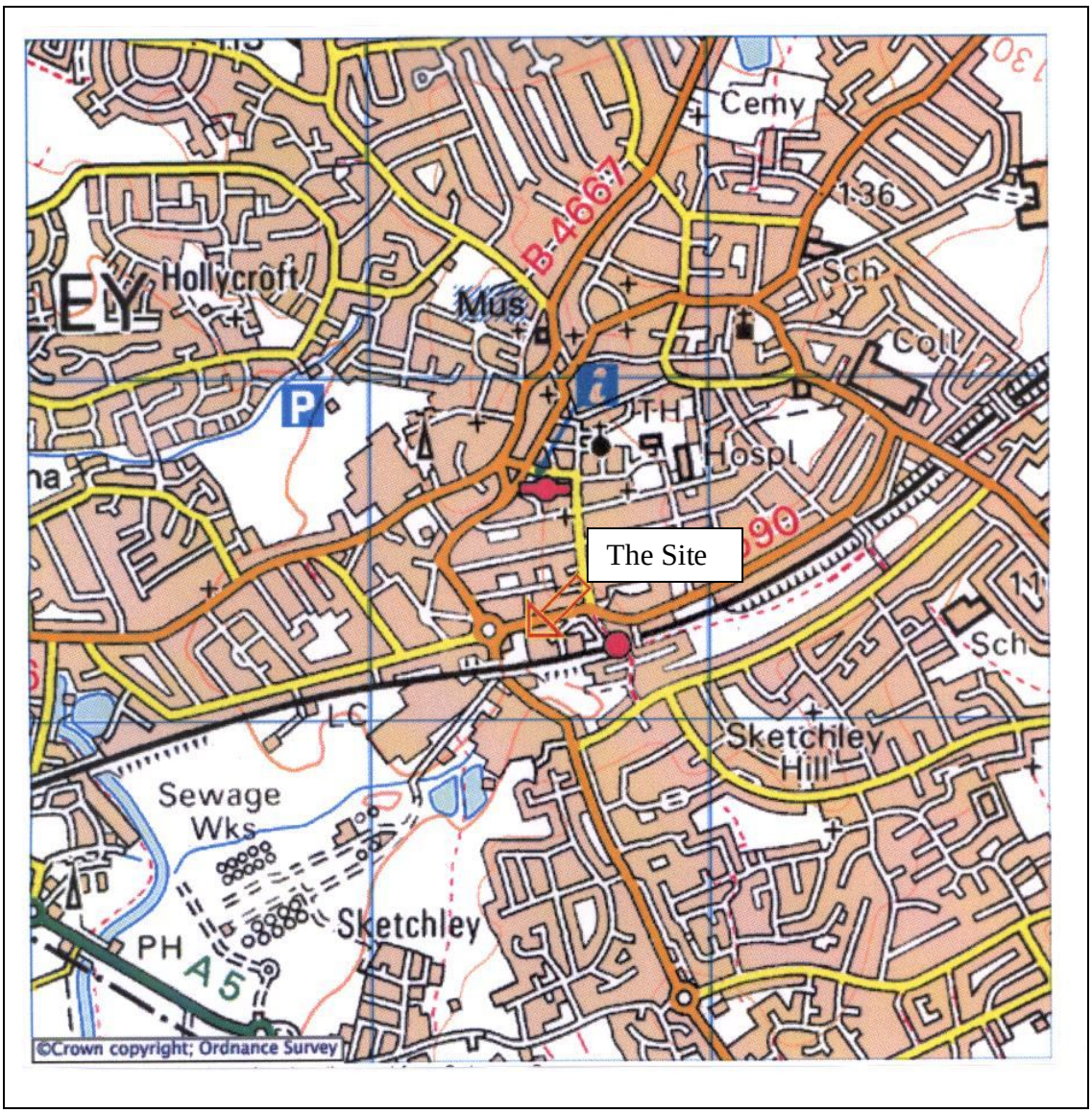
The existing vent stacks are not installed to draw gases out of the ground, but to prevent build up of gas under pressure beneath the membrane. Hence it is recommended that consideration could be given to providing below ground pressure relief valves that allow gas to vent from the network of pipes beneath the membrane, but do not allow surface water in. This would allow removal of the existing venting stacks and capping the penetration below ground level.

Provided the above precautions are taken, then it is concluded the ground conditions will not present a significant risk to the users of the proposed extension, and the surrounding land will continue to be protected by the existing remedial measures.

It is recommended that this report is submitted to the Local Authority Environmental Health Officer and the Environment Agency groundwater protection officer for comment and approval.

PLANS

Plan 1: Site Location



APPENDIX 1

Historical OS Maps.

APPENDIX 2

GroundSure EnviroInsight Environmental Data Report

APPENDIX 3

GroundSure GeoInsight Report

APPENDIX 4

As-built drawing showing the location of the bentonite cement cut-off wall

APPENDIX 5

Exploratory Hole Logs

APPENDIX 6

Chemical Laboratory Test Certificates

APPENDIX 7

Geotechnical Laboratory Test Certificates

APPENDIX 8

Gas/Groundwater Level Monitoring Results

APPENDIX 9
Peak Associates' Tier 1 Screening Values