Contamination Assessment Summary Report

The Former Halls Site, Paddock Wood, Kent

for Tunbridge Wells Borough Council

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Non-Technical Summary

Government /legislation (The Environmental Protection Act 1990) requires all local authorities to inspect their areas with a view to identifying potentially contaminated land. When inspections demonstrate that land is contaminated, local authorities have a duty to ensure that any unacceptable health risks are appropriately managed and/or removed. Contaminated Land is defined in the legislation/ as land that is causing harm or has a significant possibility of causing harm to receptors. Harm is defined as harm to health or other interference with ecological systems and includes harm to property.

In fulfilling its duties under the legislation, Tunbridge Wells Borough Council (hereafter referred to as TWBC) identified the site of the former Halls Factory in Paddock Wood as a priority for investigation. The site was prioritised due to the previous factory use which could have caused contamination to be present. The site is currently a residential housing estate, with no information on file to confirm that any contamination had been properly considered when the houses were built. Because of this, there was considered to be a potential risk that the residents were being exposed to contamination. In addition to this, a number of property sales were reported to the Council as falling through due to uncertainty as to whether the site was in fact contaminated.

TWBC appointed Leap Environmental Ltd (hereafter referred to as LEAP) in a project management capacity, to assist the Council with progression of its responsibilities under the Legislation, specifically relating to the investigation and assessment of potential contamination on site. The purpose of the current report is to provide a summary of all investigation works and risk assessments completed for the former Halls site by LEAP and others. This forms the basis for the regulatory decision the Council has taken in assessing whether the Former Halls site should be formally determined as Contaminated Land.

Investigations completed by LEAP were undertaken in two phases in the summer of 2014. The investigation works included drilling boreholes across the site and testing collected soil and water samples for contamination associated with the former factory use. The numbers and locations of the tests were specifically designed to characterise the soils across the site in such a way that the findings would apply to any part of the site. That is to say that if further samples were taken from any individual garden, then the results from those samples would trend towards the results obtained for the whole site. Statistical assessment of the results of the testing and monitoring completed by LEAP concluded that with the exception of asbestos, all of the contaminants associated with the former use on site were at or below safe levels. Additional investigation and detailed risk assessment was recommended to confirm whether the asbestos contamination recorded posed a significant risk to resident health.

It is important to stress that asbestos only poses a risk to health when fibres of asbestos become airborne and are breathed in.

In late September 2014 specialists from the Institute of Occupational Medicine (IOM) visited the site and carried out tests in two gardens where asbestos had been detected. The tests included further soil sampling and activity based sampling (mimicking gardening activities) where garden soils were continuously disturbed by raking whilst air monitoring was carried out. The primary objective of the activity based sampling was to provide further data on the potential for asbestos in soils to release fibres to air and to provide more information to inform a detailed risk assessment of whether the soils posed a risk of generating asbestos fibres that could be breathed in when disturbed. In summary, IOM concluded that although asbestos is present in soils, it is unlikely to become mobilised as fibres in air and present significant risk to health under the current use as a residential garden.

URS consultants were subsequently appointed by TWBC to review all of the information available on asbestos on site, including the work undertaken by both LEAP and IOM and, to provide a detailed risk assessment of asbestos contamination on site. As part of this work URS calculated representative site concentrations of asbestos and estimated levels of exposure to fibres that might be generated when soils are disturbed.

URS concluded that the number of fibres released during soil disturbance is likely to be extremely low, and the associated health risk is expected to be low. On this basis, URS advised that the site does not pose an unacceptable risk to health and that **the site does not meet the definition of contaminated land** as defined in the Government Guidance. On completion of the above works, TWBC issued copies of all reports to Public Health England (PHE) for comment. PHE undertook a review of the information and concluded that whilst some elevated asbestos concentrations are present in soils, the findings and conclusions of assessments are reasonable.

The Council is satisfied that investigations and the risk assessments demonstrate that the levels of contaminants in the soils in the area, do not pose a significant risk to public health or the wider environment.

The Council is satisfied based upon the evidence gathered from the investigation that no further investigation (e.g. soil sampling) or remediation work is necessary.

Further guidance and advice to residents is available on the Council website at

www.tunbridgewells.gov.uk/residents/animals,-noise-and-pollution/pollution/former-halls-site-in-paddock-wood

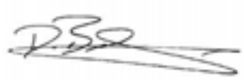
This report has been prepared by Leap Environmental Ltd on the basis of information received from a variety of sources which Leap Environmental Ltd believes to be accurate. Nevertheless, Leap Environmental Ltd cannot and does not guarantee the authenticity or reliability of the information it has obtained from others.

Leap Environmental Ltd has used all reasonable skill, care and diligence in the design and execution of this report, taking into account the manpower and resources devoted to it in agreement with the Client. Although every reasonable effort has been made to obtain all relevant information, all potential contamination, environmental constraints or liabilities associated with the site may not necessarily have been revealed.

The conclusions reached in this report are necessarily restricted to those which can be determined from the information consulted, and may be subject to amendment in the light of additional information becoming available. These conclusions may not be appropriate for alternative schemes.

This report is confidential to the Client, and Leap Environmental Ltd accepts no responsibility whatsoever to third parties to whom this report, or any part thereof, is made known, unless formally agreed by Leap Environmental Ltd beforehand. Any such party relies upon the report at their own risk.

LEAP welcomes **feedback** on the quality and content of its reports **from anyone that reads them**. Please go to http://leapenvironmental.listensnow.com/ to let us know what you think.

Signed :	 Darren Beesley MSc BSc
Countersigned :	 Richard Brinkworth BEng
Date :	10th April 2015
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A INTRODUCTION

1 Introduction and Authority

Tunbridge Wells Borough Council (hereafter referred to as TWBC) has appointed Leap Environmental Ltd (hereafter referred to as LEAP) in a project management capacity, to assist the Council with progression of its responsibilities under Part 2A of the Environmental Protection Act 1990 (hereafter referred to as Part 2A), specifically relating to the investigation and assessment of potential contamination of the former Halls site in Paddock Wood, Kent.

The site currently comprises a residential development encompassing residential properties on Waverly Place, The Shires, The Ridings, Forge Way and the northern part of Ballard Way. Properties comprise two and three storey flats, terraced, semi-detached and detached houses with private gardens, areas of communal open space, car parking and access roads. A playground is also present. The location of the site is shown below and included as Figure 1 in Appendix A.

The site forms part of the larger former Halls site that historically manufactured wooden and aluminium outdoor buildings. A number of chemicals would have been used in the historical uses of the site.

The instruction and appointment as project manager was given in an email dated 21st January 2014 from Mr Duncan Haynes (Environmental Protection Team Leader) of Tunbridge Wells Borough Council.

In addition to assistance with project management, LEAP was subsequently appointed as site investigation contractor to undertake two phases of intrusive investigations on site.

The purpose of the current report is to provide a summary of all investigation works and risk assessments completed for the former Halls site by LEAP and others, which form the basis for the regulatory decision the Council has taken in assessing whether the Former Halls site should be formally determined as Contaminated Land.

2 UK Approach to Contaminated Land Assessment

2.1 Risk Assessment Hierarchy

The UK's approach to contaminated land is outlined in the Statutory Guidance[1] (Defra 2012) and the Environment Agency's CLR11[2] guidance document (Defra & EA, 2004).

To summarise, the approach to assessing the significance of risks from contaminated land follows a hierarchical system of three tiers. After each tier of risk assessment a decision is made as to whether further action is required, such as moving to the next tier of assessment or mitigation of risks through remediation.

The three tiers of assessing the significance of risks are as follows:

2.1.1 Preliminary Risk Assessment (PRA).

The main purpose of PRA is to develop an initial understanding of the site (known as a conceptual model), via the review of available data on the history, geology, hydrogeology and historical and current land uses of the site. This information is used to identify whether any 'pollutant linkages' could potentially be present. A potential pollutant linkage is considered to be present where a potential receptor is exposed to a potential source of contamination through a potential pathway,

> *for example this might be elevated concentrations of a chemical in soil in a rear garden (contamination 'source') exposed to a resident (the 'receptor'), via direct contact with the soil (the 'pathway').*

A decision to move on to the next tier of assessment (intrusive investigations) is made based on the conceptual model and whether potential pollutant linkages have been identified.

[1] Environment Protection Act 1990: Part 2A. April 2012. Contaminated Land Statutory Guidance.

2.1.2 Generic Quantitative Risk Assessment (GQRA).

Once potential pollutant linkages have been identified and a decision to move the next phase of investigation has been made, a GQRA is undertaken to test the preliminary conceptual model of the site.

This usually involves an intrusive investigation, whereby ground conditions are confirmed, representative samples of soils and waters are collected and tested for the suspected contaminants. The results of the testing are then analysed statistically to determine representative concentrations of contamination in soil. The representative concentrations are then compared against screening values (known as generic assessment criteria) appropriate for the land use of the site. Generic assessment criteria are set as levels where no risk to health would be expected or where only low (acceptable) risks might be expected[2].

Should the GQRA confirm that representative concentrations are below the generic assessment criteria, no further action is required and the site is considered suitable for the current use.

If representative concentrations are above generic assessment criteria, consideration needs to be given to either implementing remedial actions to bring the risk to a safe level, or to expand the work to the next tier of assessment, 'Detailed Quantitative Risk Assessment' (DQRA).

2.1.3 Detailed Quantitative Risk Assessment (DQRA).

A DQRA is undertaken when either:

- contaminant levels exceed the generic assessment criteria; or
- where generic assessment criteria are not available for the identified contaminants of concern; or
- if the use of generic assessment criteria is not considered appropriate for the site.

The DQRA involves the comparison of representative contaminant concentrations on site against derived site-specific assessment criteria (SSAC). The DQRA is a final tier in the assessment regarding the significance of risk. If, following the DQRA, pollution linkages are considered to be ***significant***, then consideration of remedial options or other corrective action should take place. In the event that no ***significant*** pollutant linkages are identified, then no further action is required. The term significant is both legally and technically important in investigations under Part 2A.

[2] In contaminated land assessment acceptable risks are generally deemed to be in the range of 1 in 50,000 to 1 in 1,000,000.

2.2 Part 2A Environmental Protection Act 1990

The Statutory Guidance[1] sets out local authority duties with respect to contaminated land. The Guidance requires all local authorities to inspect their areas with a view to identifying potentially contaminated land. When investigations demonstrate that land is contaminated, local authorities have a duty to ensure that any unacceptable risks are appropriately managed and/or removed. The legislation provides local authorities with a number of enforcement powers to ensure that land contamination does not pose an unacceptable risk to human health or risks to other identified receptors. The Guidance gives a strict definition of 'contaminated land' as follows:

"Contaminated land is any land which appears to the local authority in whose area it is situated to be in such a condition, by reason of substances in, on or under the land that –

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

(b) significant pollution of controlled waters is being caused, or there is a significant possibility of such pollution being caused."

The Guidance defines harm as:

harm to the health of living organisms or other interference with the ecological systems of which they form part and, in the case of man, includes harm to his property."

It should be noted that whilst land must be shown to be causing harm, or a significant possibility of significant harm (SPOSH) to be determined as contaminated, the Guidance does not set the level at which SPOSH occurs. This is due to the inherent variability from site to site and the need for site specific information to make this assessment.

When determining land as contaminated land, local authorities have to follow the Statutory Guidance. In particular the local authorities not only need to consider whether Harm or SPOSH is occurring, but also the likely impact of any regulatory action taken (such as remediation), on residents and the wider environment e.g. potential impact on health from remediation, the economics associated with remediation, whether long term health benefits would be achieved and whether remediation works might actually result in a more hazardous situation, for example by mobilising contamination to air.

TWBC has a contaminated land strategy and summary information on Part 2A available on the Council website at:

www.tunbridgewells.gov.uk/residents/animals,-noise-and-pollution/pollution/contaminated-land

3 Background to the Former Halls Site

In accordance with the Statutory Guidance, TWBC has undertaken a review of historical land uses within the Borough, identifying those sites where historical activities have taken place that may have caused contamination.

The process followed by TWBC to inspect its area is set out in the Council's Contaminated Land Strategy a copy of which is available on the Council website.

TWBC identified the former Halls Site as a priority site for detailed inspection, as historical uses recorded on site including the manufacture of wooden and aluminium buildings, which may have caused contamination of the ground. The former Halls site was redeveloped for housing during the 1980s and 1990s.

Information available on ground conditions on site including a number of limited historical site investigation reports identified the potential for and presence of contamination on site. However, information provided to the Council by the developers responsible for providing the current housing did not include information confirming steps taken to deal with contamination at the time of redevelopment.

3.1 Rationale for Detailed Inspection Under Part 2A

It has been reported to the Council that a number of house sales in recent years have fallen through, with solicitors acting for potential house purchasers raising concerns over potential contamination. Given the identified historical uses of the site and associated potential contamination, limited information held on current conditions, the Council has been unable to advise residents and future purchasers previously that land contamination is not a significant issue for the site.

In light of the information available identifying a potential problem; the apparent lack of any information concerning remedial actions taken during the redevelopment phase, associated uncertainty over the current contamination status of the soils; and considering the number of properties and residents potentially affected, the Council concluded that the site warranted detailed inspection under Part 2A.

The aims of the works completed to date, as summarised in this report are:

- to remove uncertainty associated with the site; and
- to confirm the contamination status of the site; and
- to identify and quantify risks that may be present; and
- to inform remediation or other management actions required for the site.

The 'site' has been defined as part of the larger Former Halls Site. Previous works and information provided by the Council makes reference to the site being split into 'Zones 1-3'. The 'site' considered by the current assessment comprises Zone 1 only, as the earlier Preliminary Risk Assessment (.) of the former Halls site and review of information currently available considers this part of the site to pose the greatest contamination potential. , Based on current available information the Council considers that 'Zones 2 and 3' would only be considered for inspection under Part 2A in the event of significant contamination being identified in Zone 1. A plan showing each of the zones is included as Figure 2 in Appendix A, with Zone 1 (the site) outlined Green on the plan. An extract from Figure 2 is provided below.

The information provided herein will form an important part of the decision as to whether or not the site meets the legal definition of contaminated land. However, as set out in the Guidance any final decision related to determination of the site rests solely with the Council.

B PRELIMINARY RISK ASSESSMENT

4 Previous Reports

The site has been subject to several previous investigations and assessments including an Enhanced Desk Study (EDS) prepared by Southern Testing Laboratories Ltd (STL) to which the reader is referred. Intrusive investigations prior to site development for residential housing have also been carried out across parts of the site. The available data from these reports, has been reviewed and used to inform the following section of this report.

- Church Road, Paddock Wood. Site Assessment Report Referenced A894, dated 11th January 1990.
- Church Road Paddock Wood. Report on Site Investigation Referenced STL 3547A dated December 1990.
- The Ridings Paddock Wood. Report on Site Investigation Referenced STL 4366J, dated December 1993.
- Former Halls Site Church Road, Paddock Wood. Enhanced Desk Study Assessment. Report reference J9438 dated 7th May 2008.
- 4 Ballard Way, Paddock Wood. Contaminated Land Investigations. Report Referenced DS/BC/J11459, dated 6th June 2014.
- 14 The Ridings Contaminated Land Ground Investigations. Report Referenced DS/BC/J11821, dated 04th June 2014.
- 35 Dimmock Close Paddock Wood. Contaminated Land Ground Investigations. Report Referenced DS/BC/J11833, dated 10th June 2014.

Where possible, LEAP has confirmed information using other sources such as the British Geological Survey (BGS) and Environment Agency (EA) web sites, however LEAP cannot verify the accuracy of information contained within previous reports provided by others.

5 Description of Site

A site walkover survey was undertaken on Tuesday 24th June 2014 by Engineers from LEAP in advance of the site works.

The site is located in the north eastern part of Paddock Wood, to the south of the railway line. It is situated in a predominantly urban setting, with residential housing to the south and south west, the town to the south west, railway line with industrial units to the north and open fields to the east.

It is located on the approximate Ordnance Survey National Grid Reference. TQ 6750 4508. A site location plan is attached in Appendix A as Figure 1 together with a site layout plan as Figure 2.

The topography across the site was noted to be relatively flat and level with no significant ground levels changes noted.

It is noted that previous works (Enhanced Desk Study-prepared by STL) divided the Former Halls site into zones based largely on the historical uses identified. Broadly speaking, Zone 1(the focus of the assessment), refers to parts of the former Halls site covered by the properties of Waverly Place, The Shires, The Ridings, Forge Way and the northern part of Ballard Way. For the purposes of this report 'Zone 1' has been referred to as 'the site' in this report.

The site comprises a residential development encompassing the roads mentioned above. The housing comprises a mix of two and three storey flats, terraced, semi-detached and detached houses with private gardens, areas of communal open space, car parking and access roads. A playground is also present.

6 Geology

The geology of the site has been ascertained by reference to the British Geological Survey website and information provided by previous investigations. The site is mapped as being underlain by the following succession River Terrace Deposits overlying the Weald Clay Formation. Previous investigations have recorded the presence of alluvial soils local to some locations which are most likely associated with the River Terrace Gravels. Made ground soils associated with historical redevelopment are also expected to underlie the site.

6.1 Hydrogeology

The River Terrace Deposits beneath the site are designated as a Secondary (undifferentiated) Aquifer and the Weald Clay as a non-productive strata.

The site is not located within any source protection zone with the regards to the protection of potable water supplies.

6.2 Surface Water Resources

There are no surface water features within the site or adjoining the site boundary.

6.3 Pollution Incidents

A review of the Environment Agency Website identifies no pollution incidents on or in the immediate vicinity of the site.

6.4 Waste and Landfill Sites

There are no landfill sites reported within 250m of the site.

6.5 Unexploded Ordnance (UXO)

An inspection of the Zetica regional unexploded bomb risk maps indicates that the site is located within an area where there is a moderate risk from unexploded ordnance (UXO). Moderate risk regions are those that show a bomb density of between 11 and 50 bombs per 1000 acres and that may contain potential WWII targets.

In light of the potential risk, a UXO desk study was commissioned by TWBC to assess the potential risk of encountering UXO during the proposed ground investigation.

Fellows International Limited was appointed to undertake a comprehensive UXO desk study for the site. The assessment stated that Paddock Wood was not a strategic target for German bombing, during the Second World War, but was on the flight path to and from London. Records indicated that the Former Halls site suffered some bomb damage, with the factory canteen demolished by a direct bomb hit in November/December of 1940.

The chance of encountering UXO during the proposed ground investigation works was considered by Fellows International Ltd to be remote and recommendations were made for a munitions awareness briefing to be undertaken prior to works commencing. This was undertaken with representatives from LEAP and TWBC attending prior to works commencing on site.

6.6 Site History

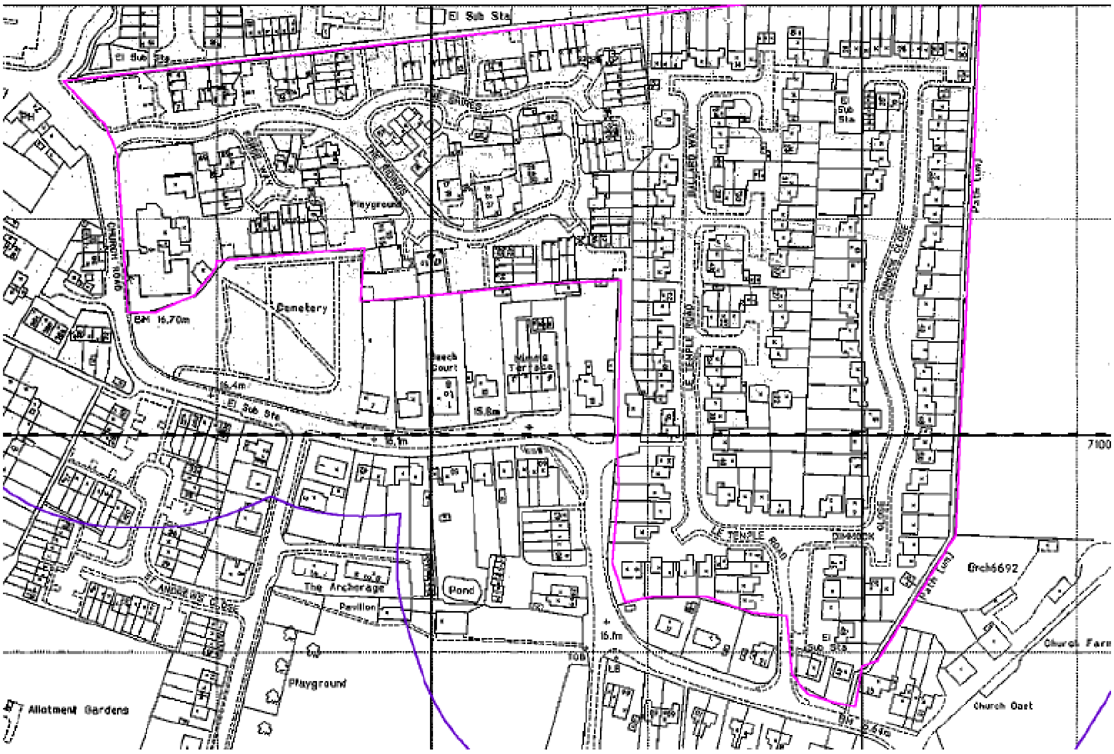
A comprehensive review of the Historical Ordnance Survey Maps, planning history and available aerial photography was included in the STL Enhanced Desk Study Report. Historical Maps of the site were also reviewed by LEAP prior to undertaking intrusive investigations. Historical maps for the site are included in Appendix B. The history of the site can be briefly summarised as follows:-

The earliest map reviewed (dated 1872) shows the site as open fields located to the north east of St Andrews Church in Paddock Wood. A school building is shown in the south western corner site of the site at that time, fronting Church Road. Sometime between 1909 and 1938 several buildings labelled as 'Portable Building Works' were constructed in the north western corner of the site. Whilst the school building remains it is not labelled as a school on the 1938 maps.

By 1947 the works had expanded to occupy most of the site (area identified as 'Zone 1' in figure 2), with the exception of the eastern most section which remains as open and tree covered land. The works buildings include numerous large industrial units.

An extract from the 1969/1976 mapping is included below.

At sometime between 1982 and 1985 the eastern part of the site is developed for residential housing along Dimmock Close and Ballard Way. Between 1989/91 the remainder of the currently existing residential development replaces the former works. An extract from the 1990s mapping is provided below.



The Enhanced Desk Study assessment by STL included a detailed history of the expansion of the Halls Site. The report states that the works started on site in 1936 and were initially small in scale, producing chicken houses. The business expanded rapidly to include the manufacture and construction of garden sheds, green houses and garages. After three years of operation, the site had expanded from 11,000 square feet to 8 acres. Operations on site included the production of timber and aluminium buildings.

Planning records were also inspected as part of the Enhanced Desk Study. These recorded numerous applications. The most pertinent approved applications were; the construction of a timber manufacturing mill in 1949; construction of a boiler house in 1959; construction of 37 houses with estate road in 1981; construction of a residential development in 1982; new timber mill storage buildings and waste burning plant in 1984.

6.7 Previous Report Summary

Three separate phases of investigation of the site were undertaken by STL during the 1990's when the former Halls buildings were still present. These investigations identified some petroleum hydrocarbon contamination, particularly within drainage runs. Recommendations for the removal of the drain runs and further investigations prior to redevelopment were made. Following the investigation the former buildings were demolished, cleared and ground level presumably changed to accommodate the existing residential development.

The chemical data from these investigation reports, whilst of interest with respect to the former uses, have not been used in the current assessment, as it is unclear as to how the levels recorded by the former works relate to current ground levels.

The STL Enhanced Desk Study Assessment provided a comprehensive conceptual model for the site which concluded that the risks to human health (current site users) and groundwater were moderate to high. The report proposed statistically based recommendations for the intrusive investigation of the site. The recommendations comprised the inspection of Zone 1, which comprised the main area of former industrial activity (current site area). It was stated that Zones 2 and 3 (less industrial parts of the Halls site) would not need to be inspected unless adverse impacts were recorded in Zone 1. The report also set out a proposed number of sample locations depending on the type of investigation coverage (light, moderate or heavy) and the percentage confidence that a hotspot of contamination would be encountered for each level of investigation. To summarise, a 'heavy' investigation coverage with 70 sample locations identified a 68% chance of encountering a hotspot of contamination for Zone 1.

The three recent reports (dated 2014) relate to small scale investigations undertaken at individual residential properties, presumably to allow house sales to proceed. None of the reports recorded significant contamination.

7 Conceptual Site Model

As stated in section 2.1.1 the purpose of the Preliminary Risk Assessment is to develop a Conceptual Site Model, to identify potential pollutant linkages, by considering in turn, the potential contamination sources, receptors and pathways.

7.1 Sources

The following potential sources of contamination have been identified associated with the historical site use for timber and aluminium product manufacture:

- Heavy Metals
- Petroleum Hydrocarbons (PHC's)
- Poly Aromatic Hydrocarbons (PAH's)
- Volatile Organic Compounds (VOC's)
- Semi Volatile Organic Compounds (SVOC's)
- Pesticides
- Asbestos
- Dioxins and Furans

7.2 Receptors

Potential receptors are those which may be impacted by any of the contaminants of concern identified above, and include the following:-

- Human Health (Residents)
- Groundwater – Secondary (undifferentiated Aquifer)

  Material construction of buildings and infrastructure

7.3 Pathways and Potential Pollutant Linkages

The current site layout includes residential housing with private gardens and communal open space areas. All potential pollutant linkages involving resident humans and soil contaminants are active i.e. direct ingestion of soil, ingestion of soil attached to plants as well as via plant uptake, inhalation of indoor and outdoor vapour and of dust tracked back into the house and finally ingestion of water carried by plastic water pipes through contaminated ground.

The site is underlain by The River Terrace Gravels a secondary (undifferentiated aquifer). Hence there is a potential pathway for leachate from soil pollutants and for mobile liquid contaminants to enter the groundwater.

7.4 Preliminary Risk Assessment Conclusions

Moderate to high risks to human health have been identified with low to moderate risks to groundwater. Further investigation of ground conditions together with laboratory testing of soils and groundwater was therefore warranted.

C GENERIC QUANTITATIVE RISK ASSESSMENT

8 Scope of Investigation

LEAP was appointed by TWBC to undertake intrusive works across the site and provide a Generic Quantitative Risk Assessment (GQRA) of the site considering the current residential use. The following scope of works was set by TWBC at time of competitive tender:

- Completion of approximately 70 No dynamic holes to 3m (maximum depth) below ground level (bgl) (with a requirement to complete a hand dug service pit at each investigation location);
- Installation of 10 No. gas and groundwater monitoring wells to 3m;
- Geo-environmental sampling and in-situ testing;
- Full time senior engineering supervision of all site works;
- 6 rounds of gas and groundwater monitoring;
- Geo-environmental laboratory testing; and
- Provision of a GQRA report.

9 Investigation Strategy

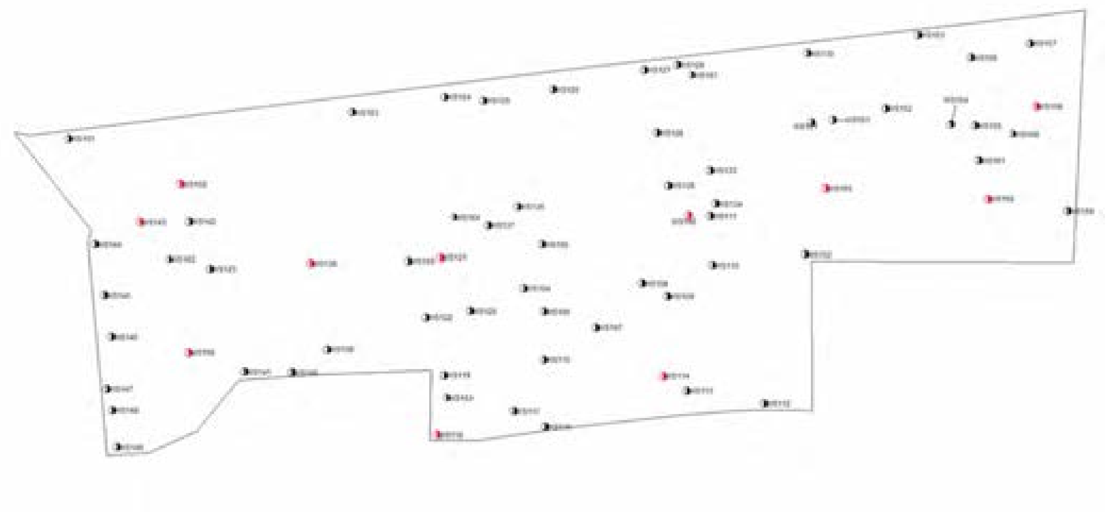
The site investigation was designed with the aim of providing sufficient information to allow an assessment of the site as whole, rather than focusing the assessment to individual property level. Boreholes labelled as WS101-WS161 inclusive and WS169, were positioned systematically across the site to provide unbiased site coverage. Investigation position locations were predetermined using the Visual Sample Plan software.

In addition to unbiased placement of investigation locations, a number of boreholes were positioned to target zones of interest identified by the historical review where contamination potential was considered to be greatest – e.g. locations of former storage tanks shown on historical plans of the site.

10 Investigation Findings

10.1 Investigation Summary

The final position of each investigation location is shown on Figure 3 included in Appendix A. An extract from Figure 3 showing spatial coverage of investigation locations across the site is provided below.



Due to refusals at shallow depth from obstructions and the need to re-drill some positions, a total of 84 holes were completed.

10.2 Fieldwork Date and Weather Conditions

The intrusive investigations were undertaken over 10 days between 25th June and 9th July 2014.

10.2.1 Hand dug service inspection pits

Given the high risk of buried services being present on site in the ground, particularly where positions were located in the front gardens of residential properties, boreholes were initiated by hand digging methods. Due to the nature of the made ground and numerous in ground obstructions encountered (such as concrete blocks and bricks) a number of hand dug starter pits were abandoned and the investigation position relocated.

10.2.2 Excavation Methods

Investigation positions were excavated by a combination of hand digging and use of a windowless sampling rig.

The windowless sampling rig consists of a tracked barrow with a sampling unit mounted on the top. When in the required position, the mast was raised to a height allowing a mechanised drop weight to fall repeatedly onto an anvil, and drive attached sample tubes or probe rods into the ground to produce reasonably intact continuous samples which were then extracted using the integrated hydraulic ram.

On completion, each trial hole was backfilled with excavated material, placed in reverse order of excavation, and the surface reinstated as found. Where monitoring standpipes were installed positions were reinstated with a metal cover concreted flush with ground surface. Where standpipes were installed, borehole arisings were removed from site.

Some locations were excavated to full depth by hand digging methods such as hand auguring, due to local access constraints preventing use of the rig.

10.2.3 Sampling

Samples from each exploratory hole were taken in plastic tubs, glass jars and vials and stored in precooled cool boxes whilst on site and transferred daily to fridges before being sent for external laboratory analysis. In order to ensure an unbiased allocation of samples within each hole, a number of sample depths from each borehole were predetermined using a random depth generator in Excel, leaving the remainder to be targeted based on the ground conditions encountered and the judgement of the engineering site staff.

10.2.4 Photoionization Detector

Each sample taken was checked for the potential presence of volatile organic compounds (for example fuel oils and solvents) with a portable photoionization detector (PID).

In general, readings from the PID are regarded as a qualitative assessment tool only. The instrument is used primarily to assist with identifying samples for laboratory testing. The instrument can also used qualitatively to highlight areas of relative volatile organic compound (VOC) contamination.

PID results are included on the exploratory hole logs provided in Appendix C.

10.2.5 Land Gas and Groundwater Monitoring Well Installations

11 no. combined groundwater and land gas monitoring wells were installed across the site and a programme of monitoring instigated to monitor the gas and groundwater regime beneath the site. The positions of the standpipes are shown on Figure 4.

10.2.6 Land gas monitoring

6 return gas monitoring visits were completed at weekly intervals (between 16/07/14 and 20/08/14), to measure concentrations of land gas and groundwater levels in each of the standpipes installed.

Each standpipe was monitored for the presence of methane, carbon dioxide, oxygen, hydrogen sulphide and carbon monoxide. Standpipes were also monitored for the presence of volatile organic compounds using a Portable Ionisation Detector (PID).

Land gas monitoring results are included in Appendix D, together with details of the monitoring equipment used.

10.2.7 Groundwater Sampling and Monitoring

During the second return gas monitoring visit completed on 23rd July 2014 a sample of groundwater was taken from each of the standpipes.

Samples were recovered using the "Waterra" pipe system which comprises of a one way foot valve attached to HDPE piping. Samples were recovered in glass amber bottles and/or clear glass vials and placed in precooled insulated boxes for transport to the laboratory for chemical analysis.

10.3 Ground Conditions

The ground conditions are described in detail in the logs attached in Appendix C. A summary of the soil conditions recorded is provided in the following table:

Table 1: Summary Ground Conditions

Depth From (m)	Depth To (m)	Soil Type	Description
GL	0.01-0.25	TOPSOIL	The majority of positions were excavated through a covering of topsoil.
GL	0.02-0.10	GRAVEL/ PEA SHINGLE	Pea shingle and or gravel (occasionally over a geotextile layer) was noted at a number of positions.
GL	0.1	ASPHALT	At investigation positions within car parking areas generally 100mm of asphalt was recorded above sub base materials.
GL-0.25	0.4-1.2	MADE GROUND	Made ground soils were recorded at all positions generally to depths of between 0.60m and 1.0m bgl. Whilst the encountered made ground soils were variable in composition it was noted that at many positions the shallower made ground (to a depth of around 0.5m-0.60m) comprised a light grey/brown sandy silty gravelly clay/ clayey gravel. At depths in excess of 600mm the made ground soils appeared to be more clay like and darker in colour. The made ground soils were noted to generally comprise gravelly clays or clayey gravels with much fine to coarse gravel and cobble of concrete, brick, tiles, plastic, clinker, ash, and flint. Suspected asbestos cement fragments and visual or

			olfactory evidence of petroleum hydrocarbons were recorded at some positions (see logs included in Appendix C). Concrete and brick obstructions prevented hand dug pits from progressing, with numerous pits terminated at various depths between 0.30m and 1.0m (due to dense ground conditions).
0.35-1.1	0.8-1.9	**ORGANIC CLAY**	At nine positions across the site the made ground soils were underlain by firm to stiff dark grey silty organic clay or brown grey silty clay with organic fragments. (WS103, WS107, WS115, WS116, WS122, WS138, WS152, WS157 and WS163). These soils are considered to present alluvial soils associated with River Terrace Deposits.
0.4-1.2	Up to 3.0*	**SILTY CLAY**	Firm to stiff orange brown and blue grey mottled silty clays were present beneath the made ground soils and/or the alluvial deposits (where encountered). The soils were noted to contain much ironstone and with some sandy horizons. These soils are considered to represent the Weald Clay deposits.

* Full depth of investigation

10.3.1 Groundwater

Groundwater was not encountered during drilling works. Groundwater levels of between 0.73m and 2.54m below ground levels were recorded in the standpipes during the return monitoring visits completed.

10.3.2 Other Observations.

Boreholes were generally stable during excavation. Where coarse made ground was encountered at shallow depths boreholes were recorded to be locally unstable.

The made ground soils at seven locations were noted to contain materials suspected as containing asbestos. The suspected Asbestos Containing Material (ACM) was generally noted within the made ground soils as fragments of cement sheeting or tile (as detailed on the exploratory hole logs). Selected samples of soils including all those where suspect ACM was noted were scheduled for laboratory testing for asbestos identification and screen and, if recorded to be present, further scheduled for asbestos quantification.

At a number of locations dark/black petroleum hydrocarbon staining and odours were noted within soils. These were often accompanied by slightly elevated PID readings (see logs included as Appendix C). Samples of soils exhibiting visual and olfactory evidence of contamination were scheduled for laboratory testing for organic (petroleum hydrocarbons, VOC's and or SVOC) contamination.

11 Laboratory Testing

Soil and groundwater samples collected were kept in cool boxes and refrigerators until they were forwarded to The Environmental Laboratory Ltd in St Leonards, East Sussex for chemical testing.

Chemical testing was undertaken at predetermined sample locations and depths in accordance with the Site Investigation Specification for the works. Results of all testing completed are included in Appendix E from the GQRA and subsequent works completed by LEAP.

Samples scheduled for chemical analysis were tested for the contaminants identified as being potentially present associated with the historical use of the site:

Arsenic, Cadmium, Chromium, Copper, Nickel, Lead, Mercury, Selenium, Zinc, Cyanide (free and complex), pH, TOC, PAH (16 speciated), Phenol (total), Asbestos screen, Hexavalent Chloride (total), Chromium Sulphide Sulphate (total).

Following receipt of the initial laboratory results recording presence of asbestos it was decided that all shallow samples collected should be subjected to asbestos screening. Where the screen for asbestos positively identified the presence of asbestos, these samples were sent for quantification. A summary of the testing undertaken is provided in the following tables:

Table 2: Laboratory Soil Tests

Test Suite	Suite A and B	TPH CWG	BTEX	VOC	SVOC	ACM Screen	ACM Qualification (IOM)	ACM Quantification (IOM)	Pesticides
No. of Soil Samples Tested	124	111	111	65	47	203	36	27	16

Table 3: Laboratory Water Tests

Test Suite	Suite A	TPH CWG	PAH Speciated	VOC	SVOC
No of Water Samples Scheduled	10	10	10	10	10

As part of the soil testing regime and to assess the quality of the data collected, duplicate tests from duplicate samples was undertaken. This is discussed in further in Section 12 'Data Uncertainty'.

12 Generic Quantitative Assessment Criteria

12.1 Assessment Criteria for Soils

As discussed previously, a GQRA involves the comparison of representative site concentrations of contaminants against Generic Assessment Criteria. The objective within a Part 2A framework is to either confirm or reject the possibility of significant harm (POSH) or significant possibility of significant harm (SPOSH). However, assessment criteria at which POSH or SPOSH would occur, have not been published.

Within this assessment both Generic Assessment Criteria (GAC), and Category 4 Screening Levels (C4SL), have been used in a staged approach. GAC have been derived for a very wide range of common contaminants and land uses and this means that they are ideal for use as the initial risk screen. If concentrations above GAC are recorded, GAC are not available, or the use of GAC is not considered applicable, C4SL are used (where available). The range of C4SL derived at the time of writing is very limited. If exceedances of C4SL are encountered, or they are not suitable or available for use, then the assessment may need to progress to Detailed Quantitative Risk Assessment where site specific assessment criteria are derived. The primary difference between the use of GAC and C4SL is the level of risk they represent. This is discussed below.

12.1.1 Generic Assessment Criteria (GAC)

The guidance states that GAC are guidelines on the level of long-term human exposure to individual chemicals in soil that, unless stated otherwise, are tolerable or **pose a minimal risk** to human health. Where used in this assessment, the GAC are based on LQM/CIEH Generic Assessment Criteria[3] (GAC) assuming a residential land use. In some cases where LQM/CIEH has not published assessment criteria, CLEA v1.06 has been used by LEAP to derive GAC. If

[3] The LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment. 2nd edition. Chartered Institute of Environmental Health and Land Quality Management Ltd. 2009.

a representative concentration of a contaminant is below the GAC then the level of risk is considered to be acceptable and no further assessment is required. It must be noted that exceedence of GAC values does not necessarily indicate SPOSH.

12.1.2 Category 4 Screening Levels (C4SL)

Revision to the Statutory Guidance in 2012 presented a four category system for considering contaminated land under the Part 2A regime. The system comprises of four levels which range from category 4 where risk levels are considered acceptable (no risk of harm or possibility of significant harm) up to category 1, where the risk of harm is unacceptably high. The decision to determine a site as contaminated land (i.e. land that is causing harm or poses a significant possibility of significant harm) under Part 2A resides between Category 2 and Category 3.

C4SL have been derived as part of a recent DEFRA sponsored research programme. They represent the upper end of Category 4 (acceptable risk). If a representative site concentration is below a C4SL the level of risk is considered to be acceptable and no further assessment is required. It is noted that no values have been published for Category 3 to Category 1 and that if recorded, an exceedance of a C4SL does not necessarily indicate SPOSH.

12.1.3 Asbestos

There are currently no assessment criteria for asbestos within soils and therefore a GQRA alone is unlikely to be sufficient to assess risks from asbestos, should any be detected. The 2012 Control of Asbestos Regulations do provide an occupational (work place) exposure control limit for asbestos in air, of 0.1 asbestos fibres per cubic centimetre of air (0.1 f/cm^3). It is noted however that the regulations state that the control limit is not a 'safe' level and exposure from work activities involving asbestos must be reduced to as far below the control limit as possible.

12.2 Assessment Criteria for Controlled Water

The groundwater and surface water test results have been compared with Water Quality Standards taken from UK Guidance where available. These are in the form of environmental quality standards (EQS) or UK drinking water standards (DWS). The most conservative screening value has been used in the current assessment where both EQS and DWS are available.

In the case of petroleum hydrocarbons there is no current UK standard, therefore the now withdrawn DWS for dissolved or emulsified hydrocarbons of 10µg/l has been used as a conservative screening value.

12.3 Assessment Criteria for Gas

Results from gas monitoring completed have been assessed following industry guidance set out in the CIRIA Report C665, 'Assessing risks from hazardous ground gases to buildings' dated 2007.

13 Data Uncertainty

The risk assessment process is inevitably fraught with uncertainty and an acknowledgement of its implications is an essential part of this study. It should be noted that where assumptions and decisions have been made in the assessment, they have been justified in the report text. It should also be noted that the uncertainties are an inherent part of assessments under Part 2A due to the absence of definitive guidance. Their identification should not be seen as a weakness of this particular assessment, nor as an indication that any further assessment would necessarily reduce or eradicate them.

This section identifies key sources of uncertainty within the GQRA and assesses their likely impact on the overall results. It adopts a predominantly qualitative approach for assessing uncertainty, consistent with the recent Food and Environmental Research Agency (FERA) study[4]. However, limited quantitative methods have been applied as well.

The above-mentioned FERA study concludes that the use of site investigation data in risk assessment could result in a small under-estimation of risk to a moderate over-estimation of risk.

Statistical approaches have been used to interpret the data in this GQRA, identifying representative site concentrations, rather than maximum concentrations, as highlighted above. This is likely to have resulted in the uncertainty from this issue being less than FERA estimates, although residual uncertainty may still exist due to the following:

Incomplete spatial coverage (considered likely to be low). To mitigate the uncertainty derived from incomplete spatial coverage the unbiased locations of the boreholes were designed using the Visual Sampling Package (VSP) software. As discussed in the STL Enhanced Desk Study Assessment Report, the site forms the part of the Former Halls Site where the main industrial/ manufacturing activity took place. The VSP tool was used to determine the number of samples required for the site area, to provide a statistically robust assessment. VSP calculated that a site investigation, with a 68 % level of confidence of hitting a hotspot of contamination, would comprise 70 sample locations (this was defined by the STL Desk Study as a 'heavy' level of

[4] Potential health effects of contaminants in soil. Food and Environmental Research Agency, 2010. Available at: http://randd.defra.gov.uk/Document.aspx?Document=SP1002_8879_SD5.pdf

inspection). Due to need for multiple holes at some locations due to obstructions, 84 sample locations were eventually completed as part of the GQRA.

Incomplete depth coverage (considered likely to be low). To reduce uncertainty associated with the depth coverage of the investigation a number of predetermined unbiased sample depths and tests were determined using MS Excel. Additional targeted samples were then collected based on site conditions, visual/olfactory inspections of soils, and the judgement of the engineering site staff.

Chemicals present but not analysed for (considered likely to be low). The site was historically used for the manufacture of timber and aluminium garden buildings and would have included the use and storage of chemical treatments, fuels, metals and asbestos containing materials. Boiler houses and incinerators would also have been present. It is not possible to test for all potential contaminants as this would not be cost effective, however if evidence gained from initial testing indicates that other contamination may be present, further testing could be undertaken. For example, Dioxins and furans associated with an incinerator have been identified by the PRA as potential contaminants. Dioxins and furans are released as by-products from waste incineration, the burning of fuels and the processing of metals. The decision was taken to exclude these contaminants from initial testing, due to the excessive cost of including them and low likelihood of positive identification. It was decided that if significant evidence for incinerated waste material or ashy materials were to be identified, then further targeted testing for these contaminants would be undertaken. Additionally specific wood treatments were not tested for. However, general SVOC and pesticide screens have been carried out – again with the intention that if any evidence to suggest contamination with wood treatments were present, further specific testing would be undertaken.

Sampling /laboratory error. Recent work conducted by Professor Mike Ramsay of the University of Sussex has suggested that the "uncertainty of measurement" (UoM) at contaminated sites can range from 50% - >150%[5]. This UoM is often overlooked, he says, and it may not necessarily be negligible just because measurements are made in an accredited laboratory. In his view, sampling methods and sample preparation are responsible for most of the UoM.

A limited quantitative assessment of empirical uncertainty was carried out as part of this review by consideration of duplicate tests from samples, and duplicate holes with matching depth samples.

A pre-determined allowance for approximately 10% duplicate testing was made in the investigation specification. Two different types of duplicate samples were tested in order to give indications of uncertainty. Duplicate samples were taken by dividing the same sample into

[5] Conference presentation available at: http://www.rsc.org/images/Uncertainty%20meeting_tcm18-171850.pdf

two sample containers and subjecting it to two tests and by drilling duplicate holes within 1m of each other. Where duplicate boreholes were excavated, holes were denoted with the suffix a or b, (e.g WS107a and WS107b) and were located within 1.0m of each other.

Typically, the repeatability of the duplicate laboratory test results was better than the range of results encountered by the study by Ramsey et al.

On the basis of the above, the overall potential impact from sources of uncertainty related to intrusive investigation data-related aspects is judged to be a small under-estimation to a small over-estimation of risk. The analysis undertaken indicates that uncertainty from sampling or laboratory error is low.

14 Statistical Assessment

This section summarises the methodology employed to compare site soil concentrations of contaminants with GAC and/or C4SL values described in the previous section.

The results of the laboratory analysis are included in Appendix E.

14.1.1 Data

For the purpose of the GQRA the soils on site were spilt into three datasets based on likely exposure; ground level (G.L) to 300mm b.gl, >300mm - 600mm b.g.l and >600mm b.g.l. The soils within the G.L-300mm and <300mm-600mm datasets comprised made ground soils whilst the soils in the >600mm set comprised some made ground soils and some natural alluvial and Weald Clay soils.

It is considered appropriate to separate the soils in to these datasets as they correlate with likely exposures in domestic gardens and communal areas, for example, most digging/ gardening activity would occur in the top 300mm, with much less if any, below 600mm. Splitting the dataset into these three categories also allows for the direct comparison of recorded concentrations in the most turned over/mixed zones with the less disturbed zones below 600mm.

By analysing a mixture of made ground soils and natural soils below 600mm there is the potential for high contaminant concentrations within made ground soils to be masked by the cleaner natural soils. To prevent this, a separate check of the statistical relevance of each dataset was also carried out, to ensure that isolated elevated concentrations if present, were not ignored.

All of the soils within each of these datasets are considered representative of the soils across the site as a whole. Ground conditions at the targeted investigation locations were similar to conditions encountered at non-targeted sample locations. Results from both the targeted and untargeted locations have therefore been treated in the same populations. The following table summarises the pH and soil organic values for each of the datasets. A median value for pH has been used as it is a log scale and therefore not appropriate to use mean values.

Table 4: Summary of pH and organic values for each dataset

Dataset	Mean Total Organic Content	Median pH Value
G.L to 300mm	1.3	8.1
>300mm to 600mm	1.4	8.6
>600mm	0.7	7.6

14.1.2 Rationale for Statistical Assessment

To provide a focussed assessment of contaminants that are suitable for and require statistical analysis, a summary of the analysis undertaken for each dataset depth was prepared. For contaminants with samples not recording concentrations above the limit of detection for the test were not taken forward for statistical analysis and not considered further by the assessment,

Some results are not suitable for statistical analysis due to the sporadic nature of occurrence of elevated values that are not considered representative of overall site conditions. Justification for or against undertaking statistical analysis is given within the tables, for each dataset and contaminant.

Table 5: Summary of tests and number of concentrations above the limit of detection GL-300mm

Contaminant Group	Number of Samples Tested	No of samples/results above Limit of Detection (LOD)	Statistical Assessment Required?
Metals	53	All samples with the exception of the following non detects; Hexavalent Chromium; 2 Cadmium; 4 Mercury and 7 Selenium.	Yes
Cyanide (free, complex and total)	53	0	No
Speciated PAH	53	48	Yes
Speciated Petroleum Hydrocarbons (PHC)	20	13	PHC represent discrete areas of contamination, i.e. not a site wide issue but representative of a particular population. Therefore statistical assessment is not appropriate.
Volatile Organic Compounds (VOC)	14	0	No
Semi-Volatile Organic Compounds (SVOC)	7 (44 individual SVOC compounds)	0	No
Pesticides	3	0	No
Asbestos	79	10	Yes

Table 6: Summary of tests and number of concentrations above the limit of detection >300-600mm

Contaminant Group	Number of Samples Tested	No of samples/results above Limit of Detection (LOD)	Statistical Assessment Required?
Metals	34	All samples with the exception of the following non detects; Hexavalent Chromium; Selenium 32 Cadmium and 3 Mercury.	Yes
Cyanide (free, complex and total)	34	1	No
Speciated PAH	34	15	Yes
Speciated Petroleum Hydrocarbons (PHC)	54	29	PHC represent discrete areas of contamination, i.e. not a site wide issue but representative of a particular population. Therefore, statistical assessment is not appropriate.
Volatile Organic Compounds (VOC)	36 (49 individual VOC compounds)	0	No
Semi-Volatile Organic Compounds (SVOC)	22 samples (44 individual SVOC compounds)	60 individual SVOC compounds above LOD	SVOC are individual compounds and are considered separately, i.e. not appropriate for statistical analysis.
Pesticides	3	0	No
Asbestos	71	17	Yes

Table 7: Summary of tests and number of concentrations above the limit of detection >600mm

Contaminant Group	Number of Samples Tested	No of samples/results above Limit of Detection (LOD)	Statistical Assessment Required?
Metals	37	All samples with the exception of the following non detects; Cadmium Hexavalent Chromium; 35 Selenium and 34 Mercury.	Yes
Cyanide (free, complex and total)	37	2	No
Speciated PAH	37	15	Yes
Speciated Petroleum Hydrocarbons (PHC)	54	29	PHC represent discrete areas of contamination, i.e. not a site wide issue but representative of a particular population. Therefore statistical analysis is not appropriate.
Volatile Organic Compounds (VOC)	65 (49 individual VOC compounds)	3 individual VOC results	No
Semi-Volatile Organic Compounds (SVOC)	18 (44 individual SVOC compounds)	30 individual SVOC results	Individual compounds and are considered separately, i.e. not appropriate for statistical analysis.
Pesticides	10	1	No
Asbestos	51	7	Yes

To summarise the above tables, individual results for petroleum hydrocarbons, VOCs, SVOCs, and pesticides are separately compared against the respective assessment criteria, whereas metals and PAH results are grouped into appropriate datasets and assessed statistically.

14.1.3 Statistical Analysis

The 2008 CIEH Guidance on Comparing Soil Contamination Data with a Critical Concentration[6] sets out a procedure for statistical assessments specifically relevant to assessing potentially contaminated sites under Part 2A.

The simple statistical tests presented in the above guidance are used to estimate the **true mean**[7] of a set of laboratory test results (a population).

With regard to assessments under Part 2A, and to establish whether land is contaminated (i.e. presents a significant possibility of significant harm), the statistical assessment is specifically designed to establish whether it is possible to :

> *"confidently say that the level of contamination on this land is high relative to some appropriate measure of risk?"*

and to do this:

> *the statistical test involves comparing the 95th Lower Confidence Limit (LCL) - a conservative estimate - of the true population mean with the critical concentration.*

More specifically, for a contaminated land determination, the 95th LCL of the true population mean must be **above** the critical concentration. That is to say that there is confidence that the results of the testing generally exceed the appropriate acceptable level.

In the case of the statistical assessments carried out at the former Halls site, this report will refer to passing or failing the statistical tests.

A **pass** is defined as an estimate of the true mean of the distribution of test results (representative concentration), which **does not exceed the GAC/C4SL** (i.e. the representative concentration is lower than the appropriate acceptable risk level) at the LCL with an evidence level of **95% or lower**.

Conversely a **fail** is defined as an estimate of the true mean of the distribution of test results (representative concentration), which **exceeds the GAC/C4SL** (higher than minimal and acceptable risk level) at the LCL with an evidence level of **95% or greater.**

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[6] CIEH and CL:AIRE, 2008. Guidance on Comparing Soil Contamination Data with a Critical Concentration.
[7] The **true mean** is not the same as the arithmetic mean or average.

The statistical assessments consider two types of distribution of test results. The first is a normal distribution where the one sample t-test is applied. Unfortunately contaminated land test data do not always conform to a normal distribution and in that case the statistical tests that are applied are based on the Chebychev Theorem.

For ease of explanation, and hereafter in this report, the calculated LCLs from the statistical analyses are referred to as the "representative concentration" for each dataset. In other words, the concentration that is used to compare with the GAC/C4SL.Heavy Metal Analysis

The samples taken from the positions shown in Figure 3 in Appendix A have been separated into the datasets discussed above based on depth.

The tables included in Appendix F provide a summary of the statistical analysis of the recorded concentrations of heavy metals in each of the datasets.

Ground Level to 300mm

The analysis shows the representative concentrations of heavy metals to be below the respective GAC and C4SL values for the samples of soils taken from GL-300mm. That is to say that the statistical tests do not demonstrate that any of the heavy metals tested for in this depth range are significantly elevated and **are considered to have passed the statistical test**. A summary table of these results is included as Table F1 in Appendix F.

Three individual samples recorded lead concentrations above the C4SL value of 200mg/kg. Whilst elevated, these are not considered to pose a significant issue given the test results of the lead testing across the site as a whole.

Site plan showing the locations of the Lead exceedances at this depth are included in Appendix A as Figure 5a.

300mm to 600mm

The analysis shows the representative concentrations of heavy metals to be below the respective GAC and C4SL values for the samples of soils taken from a depth of between 300mm and 600mm. That is to say that the statistical tests do not demonstrate that any of the heavy metals tested for in this depth range are significantly elevated and **are considered to have passed the statistical test**.

A single sample has recorded a lead concentration above the GAC; WS115 at 0.5m taken from a soft landscaping/verge area adjacent to car parking.

A summary table of these results is included as Table F2 in Appendix F. A site plan showing the locations of the Lead exceedance at this depth are included in Appendix A as Figure 5b.

Greater than 600mm

The analysis shows the representative concentrations of heavy metals to be below the respective GAC and C4SL values for the samples of soils taken at depths greater than 600mm. No individually elevated concentrations were recorded. That is to say that the statistical tests do not demonstrate that any of the heavy metals tested for in this depth range are significantly elevated and **are considered to have passed the statistical test**.

Summary

In summary, the statistical analyses indicate that the representative heavy metal concentrations across all depth ranges are below the respective GAC or C4SL, i.e. below levels of minimal and acceptable risk to human health. That is to say that they pass the statistical tests.

A summary table of these results is included as Table F3 in Appendix F.

Poly Aromatic Hydrocarbons (PAH)

PAH are widespread within made ground and the urban environment generally. They are one of the most common contaminants in made ground. Benzo(a)Pyrene is a particular problem, being very commonly found in association with tarmac, clinker and any burnt products and also being toxic to human health. Because benzo(a)Pyrene is a well understood chemical, and human health is very sensitive to it, it is often used as a marker compound for PAHs in contaminated land assessment.

As an indication of the spatial distribution of PAH, Figures 6a, 6b, 6c and 6d show the locations of elevated concentrations of the marker PAH compound benzo(a)pyrene for various depths.

Samples from GL-300mm

As discussed previously, PAH concentrations have been compared against GAC values, with the exception of benzo(a)pyrene which has been compared against the C4SL value due to concentrations above the GAC (0.8mg/kg) being present.

A number of samples reported elevated concentrations of PAH. There is no particular spatial pattern of locations recording elevated concentrations, which is fairly common for low level PAH distributions in made ground. Whilst some individual sample results exceed the GAC/C4SL, the statistical analyses indicate that the representative concentrations for each of the PAH compounds in this depth range fall below the relevant assessment criteria, i.e. below levels of minimal and acceptable risk to human health. **That is to say that they pass the statistical test.**

A summary table of these results is included as Table F4 in Appendix F.

Samples from >300mm-600mm

For the >300mm to 600mm dataset, one sample, WS130 at 0.6m has been omitted as it is not considered to be representative of the remainder of the samples tested. This borehole was located in a gravel covered verge in a car park and the made ground soil contained gravel of roadstone/asphalt. This was not recorded within made ground elsewhere on site and as such it is considered appropriate to remove it from the dataset. Elevated concentrations of a number of individual PAH compounds (Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Chrysene, Naphthalene and Phenanthrene) were recorded above the GAC/C4SL levels in this sample. However, this single sample is not considered to pose a significant risk to residents given that the result was not replicated elsewhere; the location was in a car parking area at 600mm below ground level, where exposure will be negligible; and noting that the source of the PAHs is likely to be tarmac from the roadstone.

Whilst one individual sample results exceeds the GAC/C4SL, the statistical analyses indicate that the representative concentrations for each of the PAH compounds in this depth range fall below the relevant assessment criteria, i.e. below levels of minimal and acceptable risk to human health. **That is to say that they pass the statistical test.**

A summary table of these results is included as Table F5 in Appendix F.

Greater than 600mm

The statistical analysis indicates that PAH concentrations as a whole across the site at a depth greater than 600mm are not significantly elevated. However a number of samples did record PAH concentrations above corresponding GAC/C4SL.

One sample has been omitted from the dataset; WS111 from a depth of 1.5m as it is not considered to be representative of the remainder of the soils at this depth. Elevated concentrations of a number of PAH compounds (Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Chrysene, Naphthalene and Phenanthrene) were recorded above the GAC/C4SL levels in this sample. These results appear to be associated with black staining recorded within natural soil at this location. PHC and VOC above the limit of detection of the tests were also recorded at this position.

In consideration of the findings across the site and in light of the physical evidence, the PAH recorded greater than 600mm below ground level are not considered to be present at concentrations which are significantly in excess of acceptable or minimal risk levels.

Overall soils below 600mm pass the statistical test.

A summary table of these results is included as Table F6 in Appendix F.

Summary

In summary, the analysis indicates that the representative concentrations of PAH recorded within each of the dataset depths (GL-0.3, 0.3-.0.6 and >0.6m) are below levels of minimal or unacceptable risk to human health. **That is to say that they pass the statistical tests.**

14.2 Non Statistical Assessment

Petroleum hydrocarbons (PHC), Volatile Organic Compounds (VOC), Semi Volatile Organic Compounds (SVOC), cyanides, pesticides and asbestos results have not been subjected to statistical analysis and are considered individually below.

14.2.1 PHC

One hundred and eleven samples from across the site were tested for the presence of petroleum hydrocarbons spilt into their equivalent carbon ranges and by aliphatic and aromatic compounds.

Table F6 included in Appendix F summarises the recorded PHC concentrations across all depths 0.1m to 3.0m.

With the exception of three carbon ranges in two samples, all of the recorded speciated PHC results are below their corresponding GAC for a residential use.

A very marginal exceedance of the PHC Aromatic C_{10-12} range was recorded at WS120 at a depth of 1.8m. The GAC value is 69mg/kg whilst the recorded concentration was 69.2mg/kg. Other exceedance's were recorded for aromatic ranges C_{12-16} and C_{16-21} in the sample from WS122 at a depth of 1.9m.

Both of these elevated concentrations are located within the playground area where direct comparison against GAC (tolerable risk level derived for a private residential garden) provides an overly conservative assessment. In both cases the exceedances are marginal and the samples were collected from greater than 1.5m below ground level. The actual risk from soils at the depth recorded, located in a playground are not considered to be significant.

Whilst not above the GAC, as discussed in section 13.1.5 samples from WS111 at 0.90m and 1.5m were noted to contain to contain 42mg/kg and 3mg/kg total PHC respectively. These soils were noted to have black staining and volatile odours with PID reading of 9.5ppm. These soils also recorded elevated concentrations of PAH compounds. No such visual evidence of contamination was recorded at adjacent nearby holes WS110 and WS166 at similar depths, although slight PHC were recorded at shallow depths. This would suggest that the PHC impacts recorded are localised and in any event, the recorded concentrations are below the respective GAC.

All of the recorded PHC concentrations are below or close to GAC which suggests that minimal risks are considered to be present.

14.2.2 Volatile Organic Compounds (VOCs)

Sixty five samples were subjected to VOC analysis, where 49 different volatile organic compounds were tested for. PID analysis was also undertaken on every sample collected, including those scheduled for VOC analysis. No significantly elevated PID readings indicating the presence of elevated levels of volatile compounds were recorded during investigation works completed across the site.

The majority of samples tested for VOC did not record concentrations above the detection limit of the test.

The results of the samples recording detectable concentrations are summarised in Table F7 included in Appendix F.

No detectable concentrations of VOC were recorded in any of the samples tested between ground level and 600mm b.g.l. Three samples recorded VOC concentrations above the detection limit in samples from depths greater than 600mm depth. All three samples recording detectable concentrations were from depths of between 1.5m and 2.5m below ground level. There is no GAC available for one of the VOC compounds recorded (1, 3, 5 Trimethylbenzene). To provide a conservative reference point a comparison has been made against GAC for benzene of 0.33mg/kg. The concentration present at WS111 is below the Benzene GAC and is located beneath a verge to a car park, suggesting negligible likelihood of actual exposure to residents.

WS129 was noted to have black stains and odours at 2.5m below ground level. In a sample from this depth, Cis-1, 2- Dichloroethene was recorded but was not elevated above its GAC. Trichloroethylene was recorded, in the same sample, at a concentration (0.8mg/kg) above its GAC (0.4mg/kg). The overlying soils at this position are clay or clay based made ground. Exposure to VOC will be inhibited by the overlying clay soil. Given that only a marginal exceedence of the minimal risk GAC has been recorded and noting the clayey nature of overlying soils, risk of actual exposure to elevated VOC is considered to be negligible.

14.2.3 Semi-Volatile Organic Compounds (SVOCs)

Forty seven samples from across the site were tested for the presence of 44 Semi Volatile Compounds (SVOC). The lower limit of detection for the test was 10µg/kg. Most samples did not record any detectable SVOC compounds and where detected, all results were generally very low. 11 different SVOC Compounds were identified above laboratory reporting detection limits. A summary of the positive identification of SVOC compounds is provided in Table F8 included in Appendix F.

Comparisons against GAC values, where available, show recorded concentrations to be below the respective GAC. 4-Chloroaniline was recorded at a single location (WS137a at 0.3m). Although no GAC exists for this chemical, the measured concentration is very close to the detection limit of the test and, several magnitudes lower than levels where literature review suggests ill health would be expected. It is noted that a duplicate borehole and sample (WS137b at 0.3m), located within 1m from borehole WS137a recorded no detectable levels of this SVOC, and as such the recorded concentration is not considered to pose a significant risk.

14.2.4 Pesticides

Sixteen samples were analysed for a wide range of Organo-Chlorine and Organo-Phosphorus Pesticides.

Two samples recorded pesticides above the 0.100 mg/kg detection limit of the test, WS151 at a depth of 0.70m and WS159 at a depth of 0.30m. Both samples recorded 0.105mg/kg of ppDDE. DDE is an isomer and breakdown product of DDT, but it is noted that no DDT was detected in any sample. The detected concentration is very close to the lower limit of detection. Historically the Dutch Intervention levels (now withdrawn) provided a screening value of for DDE of 2.3mg/kg. The LEAP GAC for DDT is 47.2mg/kg. Given the results recorded are only marginally elevated and that no DDT has been detected the recorded levels are not considered to be significant.

14.2.5 Cyanide

258 individual tests for complex, free and total cyanide were undertaken from samples of all depths. Only three samples recorded concentrations above the detection limit of the test: WS102 at 0.7m - 5.3mg/kg; WS125 at 0.5m - 8.1mg/kg; and WS166 at 1.0m - 13.5mg/kg. In each case the results was reported to be complex cyanides. None of the recorded concentrations exceed the GAC value of 544mg/kg for complex cyanide, nor the more conservative total cyanide GAC of 20mg/kg.

14.2.6 Asbestos in Soils

As discussed in section 11.1.1 there are no GAC for asbestos in soils. This GQRA presents a qualitative assessment considering the following:

a) the presence or absence of Asbestos Containing Material in soils (via screening);
b) the form of the asbestos i.e. bound or loose;
c) the quantification of asbestos in the sample; and
d) the depth and location (i.e. Likelihood of potential exposure and likely release of fibres to air from soil).

Initially 87 samples were subjected to an asbestos screen. Following the positive identification of asbestos at a number of locations, the decision to screen all shallow samples for asbestos was taken. In total 203 samples were screened for asbestos. Plans showing asbestos detects by depth for the GQRA and subsequent phase of works are included in Appendix A as figures 8a, 8b and 8c.

Where the screening identified the presence of asbestos, the laboratory (ELAB) provided a description of the type of asbestos identified e.g. white (chrysotile), brown (amosite) or blue (crocidolite). The sample was then sent to IOM Consulting Ltd who provided further qualification on the type of asbestos and quantification of the amount present. It is noted that in six cases, IOM did not record any asbestos in samples where ELAB recorded a positive identification. This is because as part of the initial asbestos screen identified asbestos is removed from the sample for inspection under a microscope, before the remainder of the sample is sent for quantification. In these cases it is assumed that the total amount of asbestos present in the sample will have been very small, with none subsequently recorded in the remaining sample analysed by IOM. Additionally in some cases where asbestos cement fragments have been identified as positive asbestos hits, they have not been subject to quantification since the amount of asbestos present in cement is known to be around 10-15% w/w.

Visual evidence of fibrous materials suspected to be asbestos was identified in the made ground encountered at nine positions, summarised in Table F9 included in Appendix F.

Two of the samples where suspected fibrous materials were encountered (by visual inspection) were confirmed to be free from asbestos. However, chrysotile, amosite and crocidolite forms of asbestos were confirmed elsewhere. It is noted that the majority of sample locations with visual evidence of asbestos were located in verges of car parks at depths of below 300mm, rather than in private garden areas.

The laboratory screening of samples has however identified asbestos at locations where no visual evidence was recorded – because the lab screening is done under a microscope.

Plans showing asbestos test locations and positive and negative identifications are included as Figures 7a, 7 and 7c. The plans have been separated into three depths to account for expected decreasing likelihood of exposure, i.e. GL-300mm, >300mm-600mm and >600mm. Summary tables F10, F11 and F12 showing the positive asbestos identifications are presented in Appendix F.

All three types of commonly used asbestos (Amosite Chrysotile and Crocidolite) have been recorded across the site, with chrysotile being the most common form identified. Whilst no asbestos is safe, it is generally accepted that the more dangerous forms of asbestos are Amosite and Crocidolite (part of the amphibole minerals) due to the shape of the fibres.

Figures 8a-8c and the tables appended indicate that asbestos is spread laterally across most of the site i.e. there does not appear any obvious lateral clustering / spatial pattern to the distribution. The locations of positive asbestos identification have been compared with historical locations of structures (as shown on historical maps) with no obvious positive correlation between the two. Given that some of the asbestos has been described as insulation (bound and unbound) and that the asbestos is located within made grounds soils that are fairly consistent across the site, it is suggested that the source of the asbestos could be the result of demolition of former structures at the time that the site was redeveloped for housing Ten, seventeen and seven positive identifications have been recorded for the depth ranges of G.L-300mm, 300mm to 600mm and deeper than 600mm respectively. This indicates that the made ground soils between 300mm and 600mm are the primary source of the asbestos and that some materials have been brought up to shallower depths through gardening activities. There was little evidence of asbestos at shallow depth in areas of communal landscaping, where digging and activity would be less than in say private gardens and there are positive identifications within the soils greater than 300mm in communal areas. From the testing undertaken as part of the GQRA work there was insufficient evidence to confirm this to be the case, as shallow positive identifications have been recorded in verges to car parks, which would generally be expected to be less disturbed. Further testing of soils in private gardens at near surface depths was recommended to assess this further.

Generally speaking the quantification results showed less than 0.075% asbestos within soil samples. However, higher concentrations were recorded in samples at WS109 at 0.60m (0.876%), WS116 at 0.40m (0.474%), WS125 at 0.5m (2.028%) and WS141 at 0.8m (1.236%). It is noted that these higher concentrations were recorded in the soils below 300mm. In the samples where quantification analysis have been undertaken at depths between ground level and 300mm, results of between 0.002% and 0.019% were obtained suggesting that asbestos quantifications were greatest beneath the top 300mm. Again it was recommended that further quantification analyses be undertaken on a greater number of samples taken from near surface soils to further inform this assessment.

14.3 Soils Risk Assessment

14.3.1 Metals, Cyanides, PAHs, PHCs, VOCs, SVOCs and Pesticides

Elevated concentrations of metals, cyanides, PAHs, PHCs, VOCs, SVOCs and pesticides sufficient to suggest a contaminated land determination is warranted under the Part 2A legislation **have not** been recorded by the investigations. Some individual samples have recorded concentrations above conservative minimum and acceptable risk assessment criteria (GAC/C4SL), but in each case these are not considered to be sufficiently elevated, or widespread to support a contaminated land determination decision or, the need for further investigation or assessment.

14.3.2 Asbestos

As discussed, there are no GAC for asbestos in soils, although an occupational exposure control limit for asbestos in air, of 0.1 asbestos fibres per cubic centimetre of <u>air</u> (0.1 f/cm^3) is often used. Asbestos may pose an unacceptable risk if there is a potential for respirable fibres from asbestos in soil to become airborne. There are many factors which would affect the potential release of asbestos fibres from soil to air including:

Quantity and type of asbestos

The quantity and type of asbestos have a substantial impact on the potential for fibre release from soil. It is generally accepted that the more dangerous forms of asbestos are Amosite and Crocidolite (part of the amphibole minerals) due to their fibres shape, aerodynamic diameter, length and persistence and their tendency to stay in the lungs longer. The fibres of chrysotile (serpentine minerals) are more flexible and less persistent and therefore more likely to move through the lungs. All three types of asbestos have been detected during the site investigation, with more chrysotile recorded than amosite and crocidolite. Additionally, asbestos has been found in bound forms such as cement and bound insulation as well as loose insulation and loose free fibres. Where present as loose free fibres there is a greater potential for fibre release during the disturbance of dry soil.

Moisture

Moisture is an extremely important factor when determining the extent of potential dust and hence fibre release from soils. The presence of even a small amount of moisture severely inhibits dust and fibre release. The moisture content of soil depends on a range of factors including climate, vegetation cover, soil type and organic content and depth. The samples where asbestos was identified, recorded moisture contents ranging between 4-16%. This is therefore likely to provide some mitigation to fibre release.

Soil Type

Soil type plays an important role in determining the likelihood that soils may dry out and potentially release fibres. The made ground soils were noted to generally comprise gravelly clays or clayey gravels with much fine to coarse gravel and cobble of concrete, brick, tiles, plastic, clinker, ash, and flint. Whilst clays would inhibit release of fibres, gravelly made ground may not. Additionally, the soils type at the very shallowest depths, i.e. at surface, will play an important role.

Soil disturbance

Disturbance of soil leading to the generation and release of airborne dust has an important influence on fibre release, where free fibre is present in soil. This is likely to be more significant in private garden areas where the highest level of activity/disturbance would be envisaged.

With the above in mind, and given the distribution of the asbestos recorded, which includes asbestos recorded in rear gardens (where the highest levels/likelihood of activity/disturbance would be envisaged), there is the potential for the asbestos in soil to become airborne particularly where it is present in near surface soils.

A ***potentially*** significant pollutant linkage was therefore considered to be present with respect to asbestos contamination, that being: Presence of asbestos in soil (source), agitation of soils and mobilisation of fibres to air (garden activity) followed by potential inhalation (pathway) by residents (receptors).

15 GQRA Groundwater

15.1 Water testing

Water samples taken during the second monitoring visit on the 23rd July 2014 were sent for laboratory analysis. The results are summarised in Table F14 included in Appendix F.

No metal results above the drinking water standards have been detected in any of the water samples analysed.

Benzo(a)pyrene Benzo(b)fluoranthene & Benzo(k)fluoranthene Benzo(g,h,i)perylene & Indeno(1,2,3-cd)pyrene were measured at concentrations above environmental quality standards (EQS).

No detectable petroleum hydrocarbons or VOC compounds were recorded.

The following SVOC's were detected above the 10µg/l limit of detection (LOD); Phenol- 16µg/l, 3 methyl phenol- 14µg/l, 2methyl napthalene– 26µg/l, 1-methyl napthalene– 43µg/l and Dibenzofuran 11µg/l in WS121 only. It is notable that the soil samples from this position (WS121 – within the playground) also recorded detectable concentrations of the same SVOC compounds. None of the above compounds have DWS. The EQS for phenol has been set at a highly conservative value of 7.7µg/l, which is less than the recorded value at WS121. None of the other detected SVOC have EQS. The significance of this is discussed in the following section.

15.2 Controlled Water Risk Assessment

The site is underlain by River Terrace Deposits (RTG), which are designated as a Secondary (undifferentiated) Aquifer. The RTG were encountered at nine positions across the site as grey alluvial clays. These soils were underlain by the soils of the Weald Clay a non-productive strata. The site is not located within any source protection zones with the regards to the protection of potable water supplies and there are no reported abstractions within the vicinity of the site. No significant surface water features are present on or in the immediate vicinity of the site. Overall, therefore, the groundwater is considered to be a low sensitivity receptor.

Given the above; the clay nature of the underlying soils; and the low sensitivity of the site in terms of groundwater and surface water, the recorded contaminant concentrations in the collected water samples are not considered to represent significant contamination.

16 GQRA Gas

Six gas monitoring visits were undertaken monitoring 11 standpipes installed on site between the 16th July and 20th August 2014. The results of the monitoring are included in Appendix D together with details on the equipment used. The results of the gas monitoring completed have been assessed following guidance set out in the CIRIA Report C665, 'Assessing risks from hazardous ground gases to buildings' dated 2007 and are summarised below. In summary the results were as follows:-

Methane concentrations recorded ranged between 0% and 0.4%

Carbon dioxide readings recorded ranged between 0% and 6%

Low to no flow rates were generally recorded across all of the boreholes. The flow rate of 3.9l/hr recorded in borehole WS166 on the 23rd August (considered to represent a reasonable worst case) was used in the gas risk assessment.

The gassing potential for this site has been assessed as LOW. There are no significant sources of land gas on or in the immediate vicinity on the site. The sensitivity of this development would be classified as HIGH (low rise residential) in accordance with the CIRIA Guidance.

In line with the CIRIA guidance a Gas Screening Value (GSV) has been calculated. The calculation is made by multiplying the total concentration of gas recorded by the gas flow rate. The following GSV were calculated for the site:

CO_2 Calculated GSV: 3.9 l/hr x 0.06% = 0.234l/hr.

CH_4 Calculated GSV: 3.9 l/hr x 0.001% = 0.0156l/hr.

For low rise housing the NHBC have devised a 'traffic light classification system', whereby the GSV is used to classify the site as either 'Green', 'Amber 1', 'Amber 2' or 'Red'.

Following the guidance and NHBC classification system, considering both the calculated GSV and maximum levels of recorded gas the site is classified as 'Green/Amber1'. The calculated GSV value is below the 0.78 l/h GSV value that would classify the site as amber, however the guidance also states that where typical maximum carbon dioxide concentration exceed 5% then consideration should be given to the classifying as Amber 1. The guidance goes on to state:

"Typical Maximum Concentrations can be exceeded in certain circumstances should the Site Conceptual Model indicate it is safe to do so"

Given the lack of any sources of gas and the fact that concentrations above 5% carbon dioxide were only occasionally recorded (4 readings out of 66) it is considered appropriate to classify the site as 'Green'.

A Green classification indicates that no gas protection measures are required.

17 GQRA Conclusions and Recommendations

The results of the investigation indicated that there are no significant risks to human health (residents) at the site from metal, PAH, VOC, TPH, SVOC, cyanides, pesticides or land gases. In addition no significant risks to controlled waters were identified.

The investigation did however identify ***potentially*** significant risks associated with asbestos recorded in near surface soils in gardens.

The GQRA recommended that a DQRA be undertaken to further assess the risks posed to residents from asbestos in soils. Further sampling and asbestos screening and identification from soils in rear garden areas was recommended. The GQRA recommended that shallow soils samples should be collected from near surface soils between ground level and 150mm, between 150mm and 300mm and up to a depth of 600mm. In addition, activity based air sampling was recommended to assess whether the asbestos identified in the soils could be mobilised in to air, through activities such as gardening.

B ASBESTOS INVESTIGATION

18 Additional Asbestos Sampling

Following the initial GQRA works, LEAP was appointed by Tunbridge Wells Borough Council (TWBC) to undertake a second phase of investigation works at the 'Former Halls Site', at Paddock Wood in Kent. The instruction to proceed with the investigation was given in an email dated 4th September 2014 from Mr Duncan Haynes (Environmental Protection Team Leader) of Tunbridge Wells Borough Council.

The primary objective of the second phase of works was to provide further data on the potential presence and spread of asbestos in rear garden areas, to inform a DQRA of asbestos on site.

19 Scope of Investigation

The investigation comprised the following:

- Excavation of 40 No hand auger/ hand dug boreholes to a depth of 600mm below ground level in rear gardens;
- Laboratory asbestos screening and where present, asbestos identification of 100 soil samples taken at depths of between ground level and 600mm below ground level;
- Laboratory asbestos quantification determination of samples where screening has confirmed the presence of asbestos; and
- Provision of a Factual Report on works completed.

20 Additional Investigation Summary

The intrusive investigation was undertaken over a 5 day period between 15th September and 19th September 2014. The investigation was completed during a period of clear and dry weather conditions.

Hand excavated boreholes labelled as HA201- HA240 inclusive, were positioned across the site targeting private rear gardens where activity and exposure to asbestos was considered by the previous investigation to be greatest. The location of each of the trial holes is shown in Figure 7. Plans included as figures 8a to 8c show positive asbestos detection locations across the site from both GQRA and additional investigation phases of work.

20.1.1 Excavation Methods

Investigation positions were excavated to a depth of 600mm below ground level (b.g.l) by a combination of hand digging and hand auger excavation methods.

20.1.2 Sampling

Samples from each exploratory hole were taken in plastic tubs and were sent daily for external laboratory analysis. Depending on the ground conditions encountered, samples were taken within the following depth categories:-

Surface samples – Ground Level to 0.20m;

Mid-range - 0.25m to 0.40m; and

Deeper - 0.45m to 0.60m.

20.2 Ground Conditions

The ground conditions encountered were generally consistent with those previously recorded, with a variable thickness of topsoil at most locations (0.15m to 0.5m) overlying made ground soils (gravelly clays with fine to coarse gravel and cobble of concrete, brick, tiles, plastic, clinker, ash and flint) to the full depth of excavation (0.6m) with the exception of HA214. At trial hole HA214 natural silty clay soils were encountered at 0.4m below ground level.

20.2.1 Other Observations

Visual evidence of fibrous materials suspected to contain asbestos was recorded at 11 out of 40 locations. Table F15 in Appendix F summarises the locations where suspected materials were recorded by visual inspection. The table also records the results of the subsequent laboratory testing.

21 Laboratory Testing

A further 100 No. Samples were subjected to an asbestos screen by The Environmental Laboratory (ELAB). Where the screening identified the presence of asbestos, ELAB provided a description of the type of asbestos identified e.g. white (chrysotile), brown (amosite) or blue (crocidolite). The sample was then sent to IOM Consulting Ltd who provided further qualification on the type of asbestos and quantification (UKAS accredited) on the amount of asbestos present.

It is noted that in four cases, IOM did not record any asbestos in samples where ELAB had initially recorded a positive identification. ELAB advise that this is most likely because as part of the initial asbestos screening process, identified asbestos is removed from the sample for inspection under a microscope, before the remainder of the sample is sent for quantification. In these cases it is assumed that the total amount of asbestos present initially in the sample will have been very small, with none subsequently recorded in the remaining sample analysed by IOM.

Laboratory test certificates from both laboratories are included within Appendix E. A summary of the testing undertaken by each laboratory is presented in Table 8 below.

Table 8: Laboratory Soil Tests

	Asbestos screen ELAB	Positive Identifications at ELAB	Subsequent Positive Identification at IOM	Subsequent Quantifications at IOM
No.	100	22	17	17

A summary of all positive asbestos identifications is included on Table F15 in Appendix F.

22 Air monitoring

On the 16th September 2014, subcontractors appointed by LEAP (Tersus Ltd) attended site to carry out background air monitoring during the excavation of boreholes HA209 and HA210. The aim of the monitoring was to assess whether the intrusive works (hand digging activities) were mobilising asbestos fibres that may have been present within the soil into the air.

Two air pumps with filters were set up in each garden and switched on for the course of the works (digging, sampling and backfilling boreholes), over a duration of approximately 30 minutes). The filters were then removed, prepared and examined under a microscope for the presence of asbestos fibres.

Tersus Ltd attended site again on the 18th September to carry out similar monitoring during the excavation of trial holes HA227 and HA228.

In both cases (16th and 18th September) the reported results were <0.01 f/ml. (fibres/millilitre) – the detection limit of the method used.

During the excavation of trial holes HA227 and HA228, the technician carrying out the excavation works wore a personal exposure monitor (air pump and filter) during the works. The reported results were reported as being <0.05 f/ml – the detection limit of the method used.

C ACTIVITY BASED SAMPLING

As discussed above, asbestos present in soils can only pose a risk to human health when it is disturbed, causing the release of fibres to air that become respirable.

As recommended by the initial GQRA works Tunbridge Wells Borough Council (TWBC) commissioned engineers from the Institute of Occupational Medicine (herafter referred to as IOM), to undertake activity based sampling at selected gardens within the site where previous works undertaken by LEAP had recorded the presence of asbestos in near surface soils.

The primary objective of the activity based sampling was to provide further data on the potential for asbestos recorded in soils to release respirable fibres to air during normal gardening activities, to inform a DQRA and subsequent TWBC decision as to whether further assessment or remediation was required to protect end users from recorded asbestos on site.

The work undertaken by IOM was reported under report reference 610-40610 dated October 2014.

23 Scope of Investigation

The work completed by IOM comprised the following:

- A pilot field study of activity based sampling in two gardens with known asbestos contamination in near surface soils, to provide field data as to the potential for release of asbestos fibre release during controlled activities simulated to represent normal gardening activities.
- Asbestos screening of soils for asbestos from each test area.
- Air monitoring during activity based sampling for asbestos fibre at each test area.
- Preparation of interpretative report.

24 Activity Based Sampling Methodology

The activity based sampling method comprised the following methodology:

- Selection of a 1m square test area in each garden a turf covered location where asbestos had been recorded during the works undertaken previously by LEAP.
- Removal of turf to exposing underlying soils.
- Erection of metal framed enclosed and sealed polythene pod over test area.
- The polythene pod had a slit cut in 1 side to allow a rake to be inserted to allow exposed soils to be agitated. The remaining 3 sides of the pod each had air pumps installed to facilitate asbestos fibre monitoring during raking of soils.

- Vigorous raking of soils within the pod for the first 15 minutes of each hour of sampling. With raking/air monitoring undertaken over a 1 day period in each garden.
- Laboratory screening of raked and exposed composite samples for asbestos.
- Laboratory analysis of air pump filters for asbestos fibres.

25 Activity Based Sampling Findings

The intrusive investigation was undertaken on the 29th and 30th September 2014. On both days the weather was overcast and warm, with the monitoring preceded by a generally dry period. During the afternoon of the 29th September it began to rain, as such the test area proposed for the following day was covered with polythene sheeting to keep the test area dry for the works taking place the following day.

In both test gardens, visual evidence of asbestos containing materials was noted prior to undertaking activity based sampling (asbestos cement fragments in side perimeter planting bed and beneath exposed turf).

No asbestos fibres were reported from air monitoring completed as part of the works undertaken on the first test area. A small number of asbestos fibres (amphibole) were detected in one of the air sample filters from the works completed on the second day/test area. Whilst some fibres were identified, the overall concentration of fibres recorded was very low and below the limit of detection of the test, at less than 0.0005 fibres/ ml of air.

6 soil samples were taken from the two test areas, with two samples confirming the presence of chrysotile asbestos, in both bound and unbound forms (asbestos cement and loose insulation).

26 Activity Based Sampling Conclusions

Both test gardens were noted as being impacted with asbestos materials. The presence of asbestos in soils is generally sporadic and as such quantities of asbestos would expect to be highly variable across short distances within each garden.

Test areas were selected to target areas where asbestos was known to be present. Due to the sporadic nature of asbestos contamination across the wider site, IOM report concluded that the selected test areas were considered to likely be representative of across the two test areas.

During vigorous raking of soils whilst a few individual amphibole fibres were recorded the results were below the limit of detection of the very sensitive methodology used. It is important to note that very low concentrations of airborne asbestos fibres are typically present everywhere ('background' concentrations).

The soil sampling recorded the presence of asbestos in the form of bound cement and loose insulation, neither of which contained amphibole fibres. It was concluded that whilst the amphobile fibres would have arisen from the test area soils exposed, the quantity of these fibres in the soil sample was too small to have been picked up by the soil sampling.

In summary, IOM concluded that although asbestos is present in soils, it is unlikely to become mobilised as fibres in air and present significant risk to health, based on real field data.

The IOM report advised that the level of 'activity' simulated by the activity based sampling was much greater than would be expected as a part of 'normal' gardening activity. Also, that the sampling was undertaken within an enclosed pod, removing effects of windblown dispersion of fibres that would be released. (i.e. the test represents worst case conditions) IOM also noted that the works were undertaken in dry conditions and that any rainfall would increase soil moisture and reduce potential for airborne fibre release.

IOM concluded unless works were proposed in gardens involving the disturbance of large volumes of soil and particularly during dry conditions, that they would not propose any precautionary measures, and based on the tests completed no remediation would be required to protect against asbestos recorded in soils.

D ASBESTOS DETAILED QUANTITATIVE RISK ASSESSMENT

As recommended by the initial GQRA works and following the findings of the Activity Based Sampling undertaken, Tunbridge Wells Borough Council (TWBC) commissioned URS Infrastructure & Environment UK Limited (URS), to undertake a review of all works completed and to prepare a detailed quantitative risk assessment of asbestos present in soil on site.

The work undertaken by URS was reported under report reference 47072662 dated December 2014.

27 Objectives

The primary intent of the URS report was to provide a quantitative assessment of the potential health risk posed by exposure to asbestos identified in shallow soil samples taken from locations across the Site and to put that risk estimate in the context of risk acceptability as defined in the revised statutory guidance for Part 2A of the Environmental Protection Act 1990.

The objectives were to:

- Compile the relevant available data on reported asbestos concentrations in surface and shallow soil samples.
- Estimate potential exposure levels to airborne asbestos fibres for residents and short term maintenance workers at the site.
- Estimate the potential health risk associated with the defined exposure estimates.
- Determine whether the risk estimates are acceptable, or whether they might indicate the presence of a 'significant contaminant linkage' as defined by the current (April 2012) statutory guidance for Part 2A.

The URS assessment focused on use of statistical assessments to define a reasonable estimate of average soil conditions across the site and, to define a suitably representative scenario for residential exposure.

Based on the representative soil conditions, the report considered what the possible airborne asbestos fibre exposure might be and what risk that exposure might pose.

A key assumption made by URS, based on and corroborated by the findings of previous works undertaken by LEAP is that the distribution of asbestos in soils across the site is heterogeneous (variable). That is to say that the distribution of asbestos across the site is a random scattering of small fragments of asbestos containing materials (ACMs) and associated loose fibres, such that no one sample result can be considered to be representative of a significant volume of soils, or that any spatial pattern be inferred from the spatial distribution of the individual sample results.

In this context the report states that the appropriate estimate of exposure in any one garden is an estimate based on all of the site data rather than any sub set of that data.

28 Representative Concentration of Asbestos in Soil

The assessment reviewed all soil testing undertaken previously by LEAP where samples were screened for the presence of asbestos, including those samples where no asbestos was recorded. The report states that overall the vast majority of samples did not contain quantifiable concentrations of asbestos, with 86% of samples across the site recording no quantifiable asbestos. Therefore it is reasonable to assume that if a garden were sampled repeatedly the majority of samples would report no asbestos, with a small number reporting fragments of ACMs and low concentrations of loose fibres.

URS estimated the representative asbestos site concentration (based on the 90^{th} percentile for the entire dataset) to be 0.003% wt/wt, with this value representing loose fibres in soil that are capable of being released into air following disturbance. This was considered to represent a likely overestimation of actual releasable fibres from soil (i.e. a conservative assumption).

The risk assessment assumed that the 0.003%wt/wt value related to loose chrysotile fibres whereas in reality some of those fibres are bound up in small cement fragments. Both crocidolite and amosite fibres have been detected in soil but were assumed to not contribute materially to overall risk from asbestos on site based on the very low concentrations recorded for each of these forms.

29 Exposure Estimation

URS calculated exposure estimates following current good practice (CIRIA Guidance C733 published in 2014) for two exposure scenarios, (long term residential land-use assuming a child age 0-6yrs is the critical receptor and secondly short term construction worker use , assuming a nominal work duration of two weeks with a 50 hour exposure duration).

The first step in the exposure estimation is to determine the representative soil concentration. The second step is to estimate the airborne fibre concentration that might be present in soil dust. URS state with a representative asbestos concentration in soil of 0.003% wt/wt and assuming majority of fibres will be chrysotile, that a possible fibre in air concentration might be 0.02f/ml per mg/m^3 of air borne dust.

Having estimated a possible amount of fibres in air from a representative concentration of asbestos in soil the next step in estimating residential exposure is to estimate the amount of dust that might be released from the ground during a soil disturbance activity. URS adopted the suggested value in the CIRIA guidance for dust levels in residential gardens of 0.1mg/m3 (based on dry and dusty conditions). For the construction-type activities in a garden, a higher dust concentration of 1.4mg/m^3 was adopted.

Based on dust levels of 0.1mg/m^3 and 1.4mg/m^3, the estimated airborne fibre concentrations of 0.002f/ml for regular garden use and 0.03f/ml for short term but higher disturbance construction type activities, URS noted that these theoretical estimates for air concentrations were higher than those detected by IOM during the activity-based sampling on-site. No airborne fibre concentrations were reported from IOM above the laboratory method reporting limit of 0.0005f/ml (4 times lower than the estimate for normal residential garden).

The final exposure estimation step is to calculate the cumulative exposure that occurs based on repeated exposure to soil dust over a long period of time. URS calculated the predicted cumulative exposures as follows:-

- Longer term residential exposure child on site from birth to 6 years (90 hours of exposure to soil dust per year) - 0.0005f/ml/years.
- Short term maintenance/construction work (50 hours over a single year) – 0.00075fml.years. (50% higher than the cumulative exposure for the young child).

30 Risk Estimation

URS estimated lifetime cancer risks associated with developing asbestos related lung diseases associated with cumulative exposure to soils on site.

30.1 Residential Receptor

URS calculated that the lifetime risk estimates for a cumulative exposure of 0.0005f/ml for a 0-6 year old child are likely to be less than 1 in 100,000 for exposure to chrysotile and similar for exposure to crocidolite and amosite. When exposure is added over consecutive 5 year periods up to the age of 20, the life risk estimates was calculated by URS to increase approximately to 2 in 100,000. This level of exposure would be consistent with a child growing up and living in the same house up to the age of 20.

30.2 Short Term Maintenance/Construction Work

The estimated cumulative exposure over a 2 week period for a construction worker was predicted by URS to be approximately 0.00075f/ml..

The life time estimate for a 30 year old for such an exposure is likely to be less than 1 in 100,000 and potentially as low as 1 in 1,000,000.

31 URS DQRA Conclusions

URS concluded that based on available data that it is possible that asbestos fibres may be released from soil on site when that soil is physically disturbed.

The assessment suggests that the number of fibres released during soil disturbance is likely to be extremely low, and the associated health risk is expected to be low.

An excess lifetime cancer risk of 2 in 100,000 (1 in 50,000) is the excess lifetime cancer risk threshold adopted by Defra for the derivation of the category 4 screening levels (C4SL) that have been developed to aid local authorities in deciding whether land fits the statutory definition of category 4 – i.e. land that does not pose an unacceptable risk to health.

URS concluded on this basis alone that the risk from asbestos exposure at this sites meets the definition of category 4 as defined by the Statutory Guidance for Part 2a, and hence the estimated health risk is sufficiently low for it to be reasonably concluded that the site meets the definition of category 4 under the guidance and does <u>not</u> pose an unacceptable risk to health.

E CONSULTATION WITH PUBLIC HEALTH ENGLAND

Public Health England (PHE) was established on April 1 2013 to bring together public health specialists from more than 70 organisations, including the former Health Protection Agency (HPA), into a single public health service.

PHE works with national and local government, industry, and the NHS, to protect and improve the nation's health and support healthier choices.

at each stage of the assessment of the former Halls site, to ensure that advice from public health specialists was considered as part of the Council's decision making process in determining whether the site should be classified as contaminated land and, whether any intervention or remediation measures should be taken to protect public health.

On completion of the DQRA completed by URS PHE provided a formal response. The response was set out in a letter to TWBC dated 22nd December 2014. The letter and response included a review of all works undertaken by the Council as part of the assessment of the former Halls site. PHE concluded as follows :

"In line with recent changes in Government policies on land contamination (e.g. revised Part 2A Statutory Guidance); there is a requirement to consider wider issues, such as socio-economic factors and background concentrations, when assessing whether a site represents an unacceptable level of risk to human health.

Based on our assessment of the reports provided, some areas of the site potentially contain slightly elevated asbestos soil concentrations. However exposure estimation for long term residents and for short term maintenance / construction work did not indicate that there would be an excessive exposure to asbestos. In addition on the basis of activity sampling monitoring for asbestos it does not appear that asbestos found in the soil is likely to release fibres at concentrations that could pose an inhalational risk which is the primary exposure pathway of concern.

On the basis of the cautious risk assessment methodology and exposure scenarios adopted for the investigation, the conclusions within the DQRA appear reasonable."

F PROJECT CONCLUSIONS AND ADVICE TO RESIDENTS

On the basis of information currently available and in consideration of advice and support provided by specialist environmental consultants and public health specialists, TWBC has concluded that the former halls site **does not pose a significant risk to resident health**.

The Council has therefore made the decision that the site is NOT contaminated according to the definition contained within Part 2A of the Environmental Protection Act1990.

The Council is satisfied based upon the evidence gathered from the investigation that no further investigation (e.g. soil sampling) or remediation work is necessary.

The Council has consulted with Public Health England, which reviewed the investigations undertaken and was supportive of the conclusions.

Based on the currently available evidence, the Council advise that it will make no further investigations into potential land contamination in this area.

Advice to residents is available on the TWBC website Frequently Asked Questions Page

www.tunbridgewells.gov.uk/residents/animals,-noise-and-pollution/pollution/former-halls-site-in-paddock-wood