**DOCUMENT STATUS**

<table>
<thead>
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<th>Site Reference</th>
<th>Broadway, Fleetwood</th>
</tr>
</thead>
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<tr>
<td><strong>Title</strong></td>
<td>Geo-environmental Investigation Report</td>
</tr>
<tr>
<td><strong>Client</strong></td>
<td>Lancashire County Council</td>
</tr>
<tr>
<td><strong>Project No.</strong></td>
<td>42315</td>
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<tr>
<td><strong>Report Version</strong></td>
<td>V1</td>
</tr>
<tr>
<td><strong>Date Issued</strong></td>
<td>14/06/2019</td>
</tr>
<tr>
<td><strong>Issue Notes</strong></td>
<td></td>
</tr>
</tbody>
</table>
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# EXECUTIVE SUMMARY

<table>
<thead>
<tr>
<th>Site</th>
<th>The site is roughly square in shape and extends to an area of approximately 1.50 hectares. It is located upon the western side of Broadway Road, just east of Fleetwood town centre.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NGR</td>
<td>SD322473</td>
</tr>
<tr>
<td>Site History</td>
<td>In summary, the site appeared to be initially agricultural land from 1892 to 1932 when it became an undeveloped area within the boundary of a school. By 1959 it was labelled, and several structures were built on the south of the site. The site remained the same until 2019 when the structures to the south are no longer present. The site was surrounded by agricultural land with several farm since the earliest map (1847-1848). It was not until 1930 that vast development of residential and commercial structures surrounded the site to the west and south after 1973.</td>
</tr>
</tbody>
</table>
| Investigations | The investigations have extended to:  
• Walkover survey  
• Desk study  
• Extensive intrusive investigations by cable percussive and window sample boreholes  
• Geotechnical & chemical analyses of soil samples |
| Ground Conditions | The investigation has indicated a thin veneer of topsoil/made ground encountered across the site. Superficial deposits comprised of cohesive material (clay, silt) and sand and gravel. This may represent Tidal Flat Deposits. The base of the cohesive material was encountered at depths in range of 3.20m to 5.00m. The base of the sand was proven within BH03 at depth of 6.00m. Gravel was encountered at depths greater than 4.50m. |
| Environmental | The intrusive investigation identified all the contaminant concentrations are below their respective guidance levels. No asbestos was detected. |
| Foundations | Based upon the results of this ground investigation it is recommended that a piled foundation solution is utilised to transfer structural loads to dense gravel at depth greater than 4.50m to 6.00m. Alternatively ground improvement may be considered. |
| Remediation | In the absence of a soil contamination source and pollutant linkage a remediation strategy would not be appropriate for this site. In the absence of a site remediation strategy no validation would be required with respect to soil contamination. |

This brief summary should not be assumed to represent a complete account of all the potential geo-environmental issues that may exist at the site. As such it is strongly recommended that the report be read in its entirety.
1 INTRODUCTION

1.1 Instructions

1.1.1 We are instructed by Lancashire County Council (LCC), PO Box 78, County Hall, Fishergate, Preston, Lancashire, PR1 8XJ, to undertake a programme of ground investigation works at a site located at Broadway, Fleetwood.

1.2 Object

1.2.1 The object of this investigation was as follows:

- To determine the engineering properties of the strata beneath the site to form a basis upon which foundation and general infrastructure recommendations and design may be based;
- To enable sufficient information regarding ground conditions to be obtained from which contamination risks to end users and the environment can be assessed;
- To utilise the information obtained from the investigations to provide recommendations for contamination remediation measures where required.

1.3 Scope

1.3.1 The investigations considered within this report comprise the following elements:

- An initial environmental and engineering desk study based upon existing reports, services location information, geological, hydrogeology and hydrological information, a commercially available database and readily available old Ordnance Survey maps;
- An initial walkover survey of the site, prior to any intrusive investigations being commenced, to determine the presence of any visible hazards or features which may affect the design of the ground investigation works;
- Ground investigation works by combination of cable percussion and window sampling;
- Sampling and analysis to assess the presence, nature and extent of any soil and groundwater contamination at the site;
- Sampling, analysis and in-situ tests to assess the engineering properties of the soils present within the site to form a basis upon which recommendations for foundations and infrastructure construction may be based;
- Consideration of results to determine potential requirements for any remedial action.
1.4 Development Proposals

1.4.1 Development proposals are for a number of residential properties with associated garden areas and road access. No proposed layout has been prepared for this development.

1.4.2 It is recognised that any development proposals will be subject to planning approval. Where development proposals vary from the assumptions made within this report, then any subsequent recommendations may become inappropriate and require reassessment.

1.5 Services

1.5.1 Information regarding the possible presence of live public services within the site area has been provided by LCC.

- Electricity records indicate no electrical services on site.
- United Utilities records indicate no foul sewer or surface water drainage on site.
- Water supply??
- Telecoms information indicate no overhead or subsurface cables that cut across the site.
- Gas records from Cadent indicate no services on site.

1.5.2 It is likely that private services may be still present prior to investigation.

1.5.3 A cable avoidance tool (CAT) was utilised to identify any potential live services. Prior to any further intrusive works being carried out on the site it will be necessary to locate and isolate all existing services routes.
2.1 Location

2.1.1 The site is roughly rectangular and extends to an area of approximately 1.50 hectares and located upon the western edge of Broadway Road, just east of Fleetwood town centre, situated at National Grid Reference SD322473. The site location is shown in figure A1.1 below.

Figure A1.1 Site Location Plan
2.2 **Boundaries**

2.2.1 The northern boundary was formed the St Wulstan’s & St Edmunds Catholic Primary School & Nursery. The eastern boundary was formed by Broadway Road with residential properties beyond. The southern and western boundaries were formed by residential properties.

2.3 **Access**

2.3.1 Access to the site was gained via a gate directly from Broadway (A587) Road.

2.4 **Topography**

2.4.1 Ground levels were generally flat across the site with an approximate elevation of 5mAOD.

2.5 **Walkover Survey**

2.5.1 Prior to commencing the ground investigation works an initial walkover survey of the site was undertaken to identify any areas which may impact upon the proposed site redevelopment works.

2.5.2 The site walkover was conducted on the 30th April 2019. Weather conditions were overcast and wet.

2.5.3 The site comprised of enclosed grassed area and no buildings were located on site. Metal fencing lined the northern and eastern perimeter of the site, with a brick wall to the west and wooden residential fencing to the south. Within the southeastern corner of the site was an area of hard standing possibly used to allow access of vehicles onto the site.

2.5.4 The site contained semi mature and overgrown vegetation to the northern and southern boundaries of the site.

2.5.5 The walkover survey has not identified any visual signs of contamination such as fuel or chemical spillage.

2.5.6 Aa single storey block building with associated tarmacadam playground and car parking was located to the west. The centre was surrounded by 2m high palisade fencing.
3 DESK STUDY

3.1.1 As part of the environmental desk studies, Lancashire County Council (LCC) supplied to Ian Farmer Associates (IFA) an Envirocheck Report by Landmark.

3.1.2 The Envirocheck Report provides details of recorded environmental context and historical mapping relating to the site and the surrounding area.

3.2 Historical Industrial Sites

3.2.1 The Envirocheck report has identified one (1 No.) record of dry cleaners, however this is in excess of 250m from the site boundary.

3.3 Environmental Permits, Incidents & Registers

3.3.1 The Envirocheck Report has identified two records of pollution incidents to controlled waters within 500m of the site and three in-between 501m and 1000m.

3.3.2 The closest record is located 285m north and relates to a minor category 3 incident whereby unknown oils entered unknown receiving water within Irish Sea Coastal catchment. This occurred on 11th August 1993.

3.3.3 The Envirocheck Report has identified one record of substantiated Pollution Incident Registers within 500m and three in-between 501m and 1000m.

3.3.4 The closest record is located 320m south and relates to a no impact category 4 incident for water and air, however classified as significant incident category 2 whereby inert construction/demolition material pollutants were known. This occurred on 19th August 2008.

3.4 Landfill Sites

3.4.1 The Envirocheck Report has not identified any historical or current landfill site or licenced waste sites within 600m of the site area, although landfill records do exist beyond this distance. The site is not considered to be at risk from migrating explosive or toxic gases from off-site landfill sources.

3.4.2 There is no Licensed Waste Treatment or disposal site and Licensed Waste Management Facility within 500m of the site.

3.4.3 There is two Local Authority Landfill Coverage thought to be on site, however there is no landfill data supplied.

3.4.4 There are one Potentially Infilled Land (Non Water) and six Potentially Infilled Land (Water) within 250m of the site, with closest 6m to the southeast.
3.5 **Current Land Uses**

3.5.1 The Envirocheck Report has identified seventeen contemporary trade entries located within 500m of the site. The closest relates to Garage Services 84m northwest of the site. Identified as active.

3.5.2 The Envirocheck report has identified two petrol/fuel sites within 500m of the site. The closest is situated 121 southwest with the brand and status being obsolete.

3.5.3 There is sixteen Points of Interest within 500m of the site, with eight of these being Commercial Services, six Public Infrastructure and two Recreational and Environmental, with the closest at 84m to the northwest categorised as Repair and Servicing.

3.6 **Hydrogeology & Hydrology**

3.6.1 The hydrogeological records, outlined in the Envirocheck Report, indicate that the site is situated on a Unproductive Strata, relating to Tidal Flat Deposits, 1, which is underlain by a Secondary B Aquifer, relating to the Kirkham Mudstone Formation.

3.6.2 The Environment Agency has assigned the term Secondary Undifferentiated to aquifers where it has not been possible to attribute category A or B due to variable characteristics of the rock type.

3.6.3 The Environment Agency defines Secondary A aquifers as 'permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers'.

3.6.4 The Envirocheck groundwater vulnerability map indicates the site Low Vulnerability, Secondary Aquifer.

3.6.5 The Envirocheck vulnerability map indicates the soil to be of high leaching potential.

3.6.6 The site is classified as being within an urban setting as designated by the Environment Agency, which therefore means that the soils are default classified as having a high leaching potential unless proved otherwise.

3.6.7 The site is not located within a groundwater source protection zone.

3.6.8 There are one groundwater abstraction wells within 1km of the site, which is 541m to the southwest used for Pipeline Testing, within 12000m³ used daily, however the license status has now expired.

3.6.9 A water feature is identified 418m to the east of the site however, feature in unknown.

3.7 **Flooding**

3.7.1 The Envirocheck report has identified that the site is not located within a groundwater source protection zone. There is no requirement for a flood risk assessment for this site.

3.7.2 The site is at risk of flooding from rivers or seas without defences and classified as Zone 3.
3.8 Environmentally Sensitive Areas

3.8.1 The Envirocheck Report has identified that the site is not located within a nitrate vulnerable zone.

3.8.2 There are a Marine Nature Reserve, a Ramsar Site, Sites of Special Scientific Interest, Special Areas of Conservation and Special Protection Areas between 501m and 1000m of the site.

3.9 Geology

3.9.1 Details of the geology underlying the site have been obtained from the British Geological Survey map, Sheet No. 66, 'Blackpool', solid and drift edition, 1:50,000 scale, published 1975.

3.9.2 The geological map indicates most of the site to be underlain by superficial deposits of Tidal Flat Deposits 1 described typically as a ‘soft silty silt’.

3.9.3 Bedrock is recorded as the Kirkham Mudstone Member.

3.9.4 The site is not built upon and surrounded mostly by residential properties, although not indicated as present on the site from the geological maps, the possibility that Made Ground could exist on site cannot be discounted.

3.9.5 No geological faulting is identified upon the site.

3.9.6 The site is located within an area where less than 1% of properties are above the action level for radon gas and therefore no radon protective measures are necessary within this development.

3.9.7 No coal mining areas are thought to be affected upon or within 1km of the site.

3.10 Site History

3.10.1 Table 1 – Review of Historical Maps

<table>
<thead>
<tr>
<th>Date</th>
<th>Site</th>
<th>Adjacent Land</th>
</tr>
</thead>
<tbody>
<tr>
<td>1847 to 1848</td>
<td>The site appears to be located on undeveloped land (possibly agricultural) with no structures.</td>
<td>Approximately 200m south and southwest numerous ponds are identified.</td>
</tr>
<tr>
<td>(1:10,560)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1892</td>
<td>No significant change.</td>
<td>Two old clay pits are identified approximately 200m to the west of the site with 'The Hutments’ development approximately 150m to the north and a possible water feature 100m north.</td>
</tr>
<tr>
<td>(1:2,500)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1892</td>
<td>Site not displayed.</td>
<td>A rifle range is identified approximately 600m the west north west.</td>
</tr>
<tr>
<td>(1:10,560)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Scale</td>
<td>Change Description</td>
</tr>
<tr>
<td>-----------</td>
<td>-------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1894-1985</td>
<td>(1:10,560)</td>
<td>No significant change.</td>
</tr>
<tr>
<td>1894-1985</td>
<td>(1:10,560)</td>
<td>Brick works identified approximately 400m to the south. The ‘L &amp; Y &amp; NW Joint Railway / Preston &amp; Wyre Line’ with associated timber ponds, yards, engineer sheds and reservoir situated approximately 600m east and beyond. A cemetery identified 500m to the northwest and development of some residential properties approximately 1km northeast of the site</td>
</tr>
<tr>
<td>1912</td>
<td>(1:2,500)</td>
<td>No significant change. The two clay pits to the west appear filled in.</td>
</tr>
<tr>
<td>1912</td>
<td>(1:2,500)</td>
<td>New residential properties 300m to the north and northwest of the site. Further expansion of the residential properties to the northeast of the site. The timber pond to the east is now renamed as ‘Fish Dock’. The railway line is no longer labelled. New sewage pumping station approximately 950m to the southwest.</td>
</tr>
<tr>
<td>1930</td>
<td>(1:10,560)</td>
<td>No significant change.</td>
</tr>
<tr>
<td>1930</td>
<td>(1:10,560)</td>
<td>Further expansion of residential properties from the northeast towards the north of the site. Only the top right corner of the map is displayed.</td>
</tr>
<tr>
<td>1932</td>
<td>(1:2,500)</td>
<td>No significant change except the eastern perimeter of the site in bordered by ‘Broadway’ Road. Directly to the west of the site is a school, with residential properties, church and launderette approximately 50m to the north. Beyond Broadway road to the east was new residential properties and ‘St Nicholas Mission Church’, with a Grammar School approximately 250m to the northwest.</td>
</tr>
<tr>
<td>1938</td>
<td>(1:10,560)</td>
<td>No significant change. School approximately 100m to the north with new minor road directly to the southeast of the site and beyond. Allotment gardens approximately 400m to the southeast. New boating lake 850m to the north. ‘The Hutments’ and rifle range to the north and northwest are no longer noted.</td>
</tr>
<tr>
<td>1955</td>
<td>(1:10,560)</td>
<td>No significant change.</td>
</tr>
<tr>
<td>1955</td>
<td>(1:10,560)</td>
<td>No significant development except for the increased residential properties surround the site.</td>
</tr>
<tr>
<td>1959-1960</td>
<td>(1:1,250)</td>
<td>Several some structures to the south of the site with an access path from Broadway road. No significant change.</td>
</tr>
<tr>
<td>1960</td>
<td>(1:2,500)</td>
<td>No significant change.</td>
</tr>
<tr>
<td>1967-1976</td>
<td>(1:1,250)</td>
<td>No significant change.</td>
</tr>
<tr>
<td>1973</td>
<td>(1:10,000)</td>
<td>No significant change. The railway line 600m to the southeast is no longer present. Increased residential development expanding out from the west and south of the site. The sewage pumping station the southwest is now labelled as works.</td>
</tr>
<tr>
<td>1979-1985</td>
<td>(1:1,250)</td>
<td>Three substations identified, one approximately 90m northwest by Queen’s Hotel, second 80m to the west of the most southwest corner of the site and the third 80m to the east. No significant change with some new residential properties surrounding the site.</td>
</tr>
<tr>
<td>1983</td>
<td>(1:10,000)</td>
<td>No significant change. The ‘Works’ previously called the sewage pumping station to the southwest has now been replaced by residential properties. The railway line to the east has been labelled as ‘Dismantled’. With several depots and factories close by. Beyond the dismantled railway line is a ‘Bird Sanctuary’.</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Year</th>
<th>Map Scale</th>
<th>Description 1</th>
<th>Description 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td>(1:1,250)</td>
<td>No significant change.</td>
<td>No significant change.</td>
</tr>
<tr>
<td>2000</td>
<td>(Aerial)</td>
<td>No significant change.</td>
<td>Approximately 150m to the northeast the tennis courts have been replaced by structure and a carpark.</td>
</tr>
<tr>
<td>2001</td>
<td>(1:10,000)</td>
<td>No significant change.</td>
<td>Approximately 1km to the southeast of the site (beyond the dismantled railway line) is a ‘Waste Water Treatment Works’.</td>
</tr>
<tr>
<td>2006</td>
<td>(1:10,000)</td>
<td>No significant change.</td>
<td>No significant change.</td>
</tr>
<tr>
<td>2019</td>
<td>(1:10,000)</td>
<td>Removal of the several structural upon the southern perimeter of the site.</td>
<td>Directly west of the site the school has been replaced by residential properties. Expansion of the sewage works to the southeast of the site.</td>
</tr>
</tbody>
</table>

3.10.2 In summary, the site appeared to be agricultural land from 1892 to 1932. By 1932 a school had been built to the west of the site and the site appears to be included within the school boundary as an open area. By 1959 the site was renamed as ‘Playing Fields’ with structures were built on the south of the site. The school to the west of the site appears to have been redeveloped between 1932 and 1959. The site remained the same until 2019 when the structures on the south are no longer present.

3.10.3 The site was surrounded by agricultural land with several farms since the earliest map (1847-1848). It was not until 1930 that vast development of residential properties began to surround the site to the north and east, further residential and commercial structures surrounded the site to the west and south after 1973.
3.11 Anticipated Ground Conditions

3.11.1 Based upon the information obtained during the initial desk study phase, the ground conditions are expected to comprise strata as outlined in Table 2 below.

Table 2 – Anticipated Ground Conditions

<table>
<thead>
<tr>
<th>Ground Material</th>
<th>Anticipated Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topsoil</td>
<td>Topsoil deposits are likely to be present within the site boundaries to support the observed vegetation.</td>
</tr>
<tr>
<td>Made Ground</td>
<td>Made ground may be locally present due to possible agricultural work and the presence of building within the south of the site.</td>
</tr>
<tr>
<td>Tidal Flat Deposits 1</td>
<td>Likely to be present across the site likely to comprise of silty clays with the possibility of sand and gravels.</td>
</tr>
<tr>
<td>Other superficial strata</td>
<td>Other superficial strata may be present within the sequence</td>
</tr>
<tr>
<td>Bedrock</td>
<td>The Kirkham Mudstone Formation to underlie the superficial Tidal Flat Deposits 1.</td>
</tr>
</tbody>
</table>

3.11.2 Based upon the data available within the desk study, potential ground related issues associated with the proposed redevelopment of this site are likely to include the elements noted in Table 3 below.

Table 3 – Potential Ground Related Issues

<table>
<thead>
<tr>
<th>Type of Issue</th>
<th>Site Specific issue</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential on Site Contamination Sources</td>
<td>1. Made ground deposits associated with localised historic development.</td>
<td></td>
</tr>
<tr>
<td>Potential off site Contamination Sources</td>
<td>1. None significant sources identified.</td>
<td></td>
</tr>
<tr>
<td>Potential Geotechnical Hazards</td>
<td>1. Localised Made ground</td>
<td>1. Made ground may be unsuitable for shallow foundations</td>
</tr>
<tr>
<td></td>
<td>2. Soft silts and clays or lose sands from the superficial deposits.</td>
<td>2. Natural strata may be unsuitable for shallow foundations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. High groundwater table may impact on construction</td>
</tr>
</tbody>
</table>
### 3.12 Preliminary Conceptual Model

3.12.1 The research has identified the following pollutant linkages that require further consideration and have been used to formulate the Preliminary Conceptual Site Model.

#### Table 4 – Preliminary Conceptual Site Model

<table>
<thead>
<tr>
<th>Potential Source</th>
<th>Potential Receptor</th>
<th>Possible Pathway</th>
<th>Probability</th>
<th>Consequence</th>
<th>Risk</th>
<th>Mitigation / Investigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contaminated soils</td>
<td>Future site users</td>
<td>Direct contact of soils</td>
<td>Lw</td>
<td>Md</td>
<td>Moderate / Low</td>
<td>Soil sampling during intrusive investigations. Laboratory analysis of samples.</td>
</tr>
<tr>
<td></td>
<td>Ground water in aquifer</td>
<td>Leaching of contaminants to ground water</td>
<td>Ul</td>
<td>Md</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Future site users</td>
<td>Vapour migration from soils</td>
<td>Lw</td>
<td>Md</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Proposed buildings and services</td>
<td>Direct contact with contaminated soils</td>
<td>Lw</td>
<td>Mr</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plants in gardens and soft landscaping</td>
<td>Direct contact</td>
<td>Li</td>
<td>Md</td>
<td>Moderate</td>
<td></td>
</tr>
<tr>
<td>Contaminated ground water</td>
<td>Site personnel during construction</td>
<td>Water entering excavation</td>
<td>Lw</td>
<td>Mr</td>
<td>Low</td>
<td>Sampling of ground water (where encountered)</td>
</tr>
<tr>
<td></td>
<td>Future site users</td>
<td>Retained surface water</td>
<td>Lw</td>
<td>Mi</td>
<td>Low</td>
<td></td>
</tr>
</tbody>
</table>

**Key:** Consequence: Sv = Severe, Md = Medium, Mi = Mild, Mr = Minor  
Probability: Hi = High, Li = Likely, Lw = Low Likelihood, Ul = Unlikely

### 3.13 Summary of Desk Study

3.13.1 The research has identified evidence of potential sources of contamination on or which may impact on the site, with plausible pathways to the likely receptors, and therefore potential pollutant linkages have been suggested.

3.13.2 The desk study has indicated a requirement for further work be carried out to confirm the presence, nature or extent of any contamination and geotechnical properties which is anticipated to impact on the site as follows:

- Boreholes to determine distribution and nature of made ground and superficial deposits.
- The sinking of boreholes for the recovery of samples for geotechnical and chemical contamination analysis.
- A suite of geotechnical and chemical contamination testing.
4 GROUND INVESTIGATION

4.1 Intrusive Works

4.1.1 Intrusive works to determine ground conditions comprised the following:

- 3 No. Cable percussion boreholes (BH01 to BH03)
- 6 No. Window sampler boreholes (WS01 to WS06)

4.1.2 Site work records are presented in Appendix D.

4.1.3 Representative samples of soil have been obtained to enable geotechnical and contamination laboratory testing to be undertaken.

4.1.4 Standard penetration tests (SPT's) were carried out in boreholes.

4.1.5 Boreholes were backfilled upon completion with no monitoring standpipes installed.

4.2 Records

4.2.1 During the investigations records including strata types, water entries, ground conditions and levels have been maintained by the site engineer. This information has been collated into a series of borehole logs which are appended to this report for reference.

4.3 Locations

4.3.1 The locations of the exploratory holes were proposed by LCC, see Figure A1.2 in Appendix A.

4.4 Targeting

4.4.1 The majority of the boreholes were undertaken to identify the superficial strata present over the whole site area, though it is acknowledged that ground conditions may vary between borehole locations.

4.4.2 The investigation locations have been spread over the area of the site in accordance with the recommendations laid down in BS10175: 2011 “Investigation of Potentially Contaminated Sites”. The initial ground investigation strategy is detailed within table 5 below.

Table 5 - Initial Ground Investigation Strategy

<table>
<thead>
<tr>
<th>Exploratory Hole No.</th>
<th>Target</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>WS01 to WS06</td>
<td>Shallow superficial deposits across the site.</td>
<td>To determine the general nature of underlying soils and geology including:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Suitability of the ground for the founding of structures.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Engineering properties of the ground.</td>
</tr>
</tbody>
</table>

BH01 to BH03

Superficial
4.5 Sampling

4.5.1 Based upon the initial site appraisal in conjunction with the findings of the intrusive investigations a series of samples of the strata encountered have been retained for laboratory analyses. These analyses have been intended to determine the presence of any potential contamination which may represent a hazard to site operatives or end users of the site. This section of the work is considered in more detail in section 7 of this report.

4.6 Soil analysis

4.6.1 Soil samples have been analysed for a range of common inorganic and organic contaminants.

4.6.2 Analysis was undertaken on samples of made ground and natural strata.

4.6.3 Copies of the analytical test reports are appended to this report for reference.

4.7 Geotechnical Testing

4.7.1 The majority of geotechnical testing was undertaken by Ian Farmer Associates at their Washington Laboratory. Sulphate and pH testing were undertaken by Envirolab.

4.7.2 The following tests were carried out:

- 19 No. Moisture content
- 19 No. Plasticity indices
- 6 No. Particle Size Distribution by wet sieve
- 2 No. Particle Size Distribution by sedimentation
- 7 No. Undrained shear strength
- 16 No. Water soluble sulphate (Envirolab)
- 16 No. pH value (Envirolab)

4.7.3 Copies of the laboratory tests are appended to this report for reference (reports 42315, and 17-06716).
5  **GROUND CONDITIONS**

5.1 **Made Ground**

5.1.1 Made Ground was limited across the site and identified as topsoil within BH01, BH02 and WS04.

5.1.2 The deepest made ground was located within BH02 situated to the northwest of the site with a thickness of 400mm.

5.1.3 The Made Ground typically comprised of a clay or clayey sand topsoil with brick and charcoal gravel.

5.1.4 Laboratory analysis of made ground indicated pH values of 6.59 and 6.92.

5.2 **Superficial Deposits**

5.2.1 The investigation has identified the presence of natural strata at surface at all locations apart from BH01, BH02 and WS04.

5.2.2 The superficial deposits comprised of cohesive material (clay, silt) and sand and gravel. These may represent Tidal Flat Deposits.

5.2.3 Clay was encountered within all locations apart from BH02 and described has a soft brown or orangish brown localised grey clay at shallow depths in range of 0.10m and 0.40m.

5.2.4 Silt was encountered within BH01, BH02, BH03, WS01, WS02 and WS06 at depths in the range of 0.50m to 2.70m and described as very soft to soft grey slightly sandy and or clayey silt.

5.2.5 A summary of the geotechnical parameters derived from the laboratory and in-situ testing on cohesive material is as follows:

<table>
<thead>
<tr>
<th></th>
<th>Clay</th>
<th>Silt</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>Max</td>
</tr>
<tr>
<td>Moisture Content (%)</td>
<td>8</td>
<td>32</td>
</tr>
<tr>
<td>Plasticity Index (%)</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>pH</td>
<td>4</td>
<td>7.56</td>
</tr>
<tr>
<td>Soluble SO(_4) content</td>
<td>4</td>
<td>30</td>
</tr>
<tr>
<td>SPT 'N' value</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>Cu (kN/m(^2))</td>
<td>6</td>
<td>123</td>
</tr>
<tr>
<td>Cu derived from SPTs *</td>
<td>13</td>
<td>70</td>
</tr>
</tbody>
</table>

* based upon F\(_1\) value of 7.

5.2.6 Based on these results the cohesive material may be classified low plasticity silt (four samples) and low plasticity clay (seven samples). Seven samples recorded as non-plastic.
5.2.7 Based on the measured plastic index values the cohesive materials may be classified as low volume change potential as defined by the National House Building Council.

5.2.8 Six triaxial tests on clay recorded undrained shear strength (Cu) in the range of 46kN/m² to 123kN/m². These values indicate the material is medium strength through to high strength.

5.2.9 One triaxial test on silt recorded undrained shear strength (Cu) of 158kN/m². This value indicates the material is very high strength.

5.2.10 Thirteen SPT ‘N’ values were obtained within clay with values in the range of 1 to 10. SPT ‘N’ values generally increase with depth. Thirteen SPT ‘N’ values were obtained within silt with values in the range of 0 to 8. SPT ‘N’ values generally increase with depth.

5.2.11 SPT values are plotted against depth in Figure A1.3 below.

5.2.12 Based on published relationships undrained shear strengths and SPT ‘N’ values where full penetration was achieved indicates clay and silt consistencies of very soft, soft through to firm. material.

5.2.13 Three Cu values of 88kN/m², 114 kN/m² and 123kN/m² recorded at depths between 1.10m to 3.00m within WS02, WS03 and WS04 are higher in comparison to the general dataset of shear strength data for the clay.

5.2.14 One Cu value of 158kN/m² recorded at depth 3.20m BH01 is higher in comparison to the general dataset of shear strength data for the silt. This may be affected by the sand content of the silt.

5.2.15 Laboratory analysis of clay indicated pH values between 5.2 to 7.56 and soluble SO₄ contents between <10 to 30mg/l.

5.2.16 The base of the cohesive material was encountered at depths in range of 3.20m to 5.00m.

5.2.17 Sand and gravel were encountered beneath cohesive deposits at depths in the range of 3.20m to 5.00m. Sand was encountered within all locations apart from BH01 and BH02.

5.2.18 Sand predominantly described as grey, silty fine to coarse. The base of the sand was proven within BH03 at depth of 6.00m.

5.2.19 Gravel was encountered at depths in range of 4.50m and 6.00m within BH01, BH02 and BH03. The material comprised multicoloured brown grey and light brown, sandy gravel.

<table>
<thead>
<tr>
<th></th>
<th>Sand</th>
<th>Gravel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>Max</td>
</tr>
<tr>
<td>SPT ‘N’ value</td>
<td>12</td>
<td>50</td>
</tr>
</tbody>
</table>

5.2.20 Based upon the SPT values for the sand indicate relative densities of loose through to medium dense. The relative densities of the gravel is dense to very dense.

5.2.21 The relative density predominantly increases with depth. The base of the gravel has not been proven. BH01, BH02 and BH03 were terminated at 10.00m within gravel.
5.3 Groundwater

5.3.1 Groundwater was noted in any of the exploratory holes.
6 CONTAMINATION ANALYSIS & ASSESSMENT CRITERIA

6.1 Sampling

6.1.1 Chemical analysis has been undertaken on 3 number samples of topsoil / made ground and 5 samples of natural strata. These samples are considered to be representative of the ground conditions within the site and form a basis of a general assessment of contamination within a residential environment.

6.1.2 Each suite of environmental soil samples comprised a range of containers appropriate to the analysis suite. All soil samples were stored in cool boxes at temperatures of approximately 4º (+ or - 2ºC) until delivery to the selected laboratory. All sample containers were marked with the site name, trial pit or borehole number, depth and date of sampling. All samples have been tested within the specified handling period to accord with the sampling protocol presented by Envirolab.

6.2 Laboratory

6.2.1 All samples selected for chemical analyses were returned to Envirolab., who are an MCERTS and UKAS accredited laboratory facility. Each sample has been subject to a range of chemical analyses to determine the concentrations of a wide range of common contaminants applicable to the former use of this site and the materials present. Details of the analysis programme are shown in table 8 below. Confirmation of the UKAS and MCERTS accreditations for each test is indicated within the results which are appended to this report.

6.3 Development Proposals

6.3.1 No development plans available at time of writing the report.

6.4 Analysis Range

6.4.1 The preliminary conceptual model identifies the potential for a pollutant pathway linkage to be present at the site and that further assessment is required. Table 8 below confirms the range of analyses undertaken upon the samples of made ground and natural strata.

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Determinands</th>
<th>No. of Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metals</td>
<td>Arsenic, Cadmium, Chromium (total), Copper, Lead, Mercury, Nickel, Selenium, Zinc</td>
<td>8</td>
</tr>
<tr>
<td>Organics 1</td>
<td>PAH – USEPA 16 suite, Phenol</td>
<td>5</td>
</tr>
<tr>
<td>Organics 2</td>
<td>TPH (CWG), BTEX</td>
<td>4</td>
</tr>
<tr>
<td>Inorganics</td>
<td>Cyanide, Soluble sulphates, Sulphide, pH, TOC</td>
<td>8</td>
</tr>
<tr>
<td>Asbestos</td>
<td>Asbestos Screen</td>
<td>6</td>
</tr>
<tr>
<td>PCBs</td>
<td>WHO12</td>
<td>2</td>
</tr>
</tbody>
</table>
6.5 Results

6.5.1 Full details of the chemical analyses results are presented in Appendix F and should be read in conjunction with the comments and recommendations regarding risk assessments. Summaries of the test results are presented in conjunction with the current assessment criteria in Section 7 of this report.

6.6 Approach

6.6.1 The current UK approach to the consideration of contaminated land is based upon the principles of risk assessment. This in turn is founded upon the use of a source-pathway-target principle to establish the presence of a potential pollutant linkage. This approach to the risk assessment is consistent with UK guidance and best practice. As advocated in the EA Policy Statement: Guidelines for Environmental Risk Assessment and Management a tiered approach has been adopted. This tiered approach is central to Part IIA of the Environmental Protection Act 1990 and the Town and Country Planning Act 1990.

6.7 Site Classification

6.7.1 The development proposals are not available at the present time. However the site usage has been considered on the basis of an end land use of residential with home grown produce as defined by EA Science Report SC050021/SR3 2009 in relation to the most recent soil guideline values.

6.8 Criteria

6.8.1 The concentrations of soil contaminants have been compared to a range of generic soil guideline values. Where published, these values have been utilised as intervention values for an initial tier 1 assessment.

6.8.2 In March 2014 the Department for Environment Food & Rural Affairs published SP1010: Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination Policy Companion Document. This document provides a series of Category 4 screening levels based upon differing land uses. Reference has been made to the values presented within this report in relation to the appropriate land usage.

6.8.3 Where soil guideline values were not published at the time of preparing this report, generic assessment criteria (GAC) published by Land Quality Management Ltd., in conjunction with the Chartered Institute Of Environmental Health have been adopted. The values are published in the “LQM/CIEH S4UL’s for Human Health Risk Assessment” Registration No. S4UL3265.
7 RESULTS OF ANALYSIS & QUALITATIVE RISK ASSESSMENT

7.1 Model

7.1.1 As discussed above, assessment of contaminated land is based upon a simple assessment of pollutant linkages referred to as the source-pathway-target model. This assessment considers the current or proposed usage of the site in terms of suitability for use. This implies the use of risk assessment in principle in order to evaluate the potential effects and concerns of contamination on a site-specific basis.

7.1.2 Initial assessment of the chemical analysis results has been undertaken to assess the concentrations of determinands in relation to tier 1 assessment criteria. The summary of these test results is detailed below.

7.2 Results

7.2.1 The test results have been compared to the adopted assessment criteria, relating to a proposed residential with home grown produce land usage.

7.2.2 All the contaminant concentrations are below their respective guidance levels.

7.2.3 No asbestos was detected.
8 DISCUSSIONS

8.1 General

8.1.1 The desk study information has recorded the history of the site as located within agricultural land since 1892 and became an undeveloped part of school premises by 1932. Since 1959 the site was occupied by playing fields and several structures were built on the south of the site and remained until present day. The structures on the south are no longer present in 2019.

8.1.2 Intrusive investigations have identified the presence of a thin veneer of topsoil/made ground across the whole site area and soft clay, silt with sand and gravel at depths greater than 4m.

8.1.3 The results of the chemical analyses undertaken upon representative samples of strata obtained from this site have been summarised against contamination assessment criteria in Section 7 above and subject to further discussion below.

8.2 Soil Contamination

8.2.1 All the contaminant concentrations are below their respective guidance levels.

8.2.2 No asbestos was detected.

8.3 Preliminary Remediation Proposals

8.3.1 This initial risk assessment has not identified any sources of soil contamination at the site.

8.3.2 In the absence of a soil contamination source and pollutant linkage a remediation strategy would not be appropriate for this site.

8.3.3 In the absence of a site remediation strategy no validation would be required with respect to soil contamination.

8.3.4 Copies of this ground investigation report should be presented to the regulatory authorities for confirmation of their acceptance and agreement of these preliminary proposals.

8.4 Foundations

8.4.1 The investigation has proved made ground and soft clay and silt across the site at depths in range from surface to depths in range of 3.20m to 6.00m.

8.4.2 Due to the thickness of the made ground, soft clay and silt beneath the site a piled foundation solution may be considered to transfer structural loads to dense gravel at depth greater than 4.50m to 6.00m.

8.4.3 The carrying capacity of piles depends not only on their size and the ground conditions but also on their method of installation. Pile design and installation are continuously evolving processes and state-of-the-art methods are often employed before they reach the public domain, perhaps several years down the line. Therefore, it is recommended that specialist Piling Contractors be contacted as to the suitability and carrying capacity of their piles in the ground conditions pertaining to the site.
8.4.4 As an alternative to piling a foundation solution based on ground improvement, for example by vibrated stone columns, may be considered.

8.5 Excavations

8.5.1 Based on observations on site, together with the results of in-situ and laboratory tests, it is considered that excavations to less than 1.00m may not stand unsupported in the short term. Side support for safety purposes should of course be provided to all excavations which appear unstable, and those in excess of 1.20m deep, in accordance with Health and Safety Regulations.
9 **NOTES**

9.1 All reports are for advisory purposes only and all design decisions are the ultimate responsibility of others.

9.2 Unless stated otherwise the investigation has been undertaken in general accordance with the recommendations given in BS 5930: 2015 "A Code of Practice for site Investigations" and the laboratory testing has been carried out in accordance with BS 1377: 1990 "Methods of Test for Civil Engineering Purposes" or other relevant standards.

9.3 Soil and rock descriptions are generally based on the scales of strength and relative density within BS 5930 although it should be noted that in certain circumstances descriptions are based on site records or a qualitative assessment without the benefit of in-situ or laboratory test results.

9.4 The assessment of ground conditions given in this report is based on the results of the fieldwork and laboratory testing carried out and there may be other conditions at the site not encountered by these works, which have not been taken into account.

9.5 The scope of the investigation and information provided may not necessarily reflect all the geotechnical and environmental aspects related to the site, and the omission of certain items does not mean that the site is unaffected by such problems.

9.6 It should be noted that groundwater levels can vary and may at times be significantly different to those recorded during the investigation and attention is drawn to BS 5930 which indicates that measurements may be necessary over an extended period of time to investigate changes in groundwater pressures due to seasonal, tidal and other causes.

9.7 Any recommendations on construction methods within this report are for initial guidance only and all design proposals remain the responsibility of the appropriate contractor/consultant.

9.8 Further assessment, investigation, construction activities or time may reveal conditions that were not found during the period of investigation and, therefore, could not have been taken into account in the preparation of the report.

9.9 Where information has been obtained from sources other than the direct findings of the investigation, the authenticity or reliability of this information cannot be guaranteed.

9.10 Future changes to guidelines and legislation used in this report may influence the findings of this report. No liability can be accepted for the effects of any future changes to such guidelines and legislation.

9.11 This report has been prepared on the instructions and to the requirements of the named client and any unauthorised party using this information for any purpose does so at his own risk and any duty of care to that party is excluded.