



Your Environment

STAGE 2: SITE INVESTIGATION REPORT - PROGRESS GARAGE, YAPTON LANE, ARUNDEL, BN18 0AS

For
Domusea Developments

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1.0 Introduction

YourEnvironment (YE) was instructed by Domusea Developments (Quote No: Q2715, Dated: March 1st 2016) to conduct a Stage 2: Site Investigation (SI) at a site known as Progress Garage, Yaptan Lane, Walberton, Arundel, BN18 0AS.

The SI undertaken is as a result of recommendations made by YE in our previously issued Stage 1: Desktop Study & Preliminary Risk Assessment Report for the site (Report Reference: YE2690, Issued: November 2016), to which this report should be read in conjunction with. As such this report seeks to address the potential pollutant linkages identified within the Preliminary Conceptual Site Model contained within our Stage 1: Desktop Study report.

The purpose of this report is to accompany other documentation for the purposes of obtaining planning permission for the proposed redevelopment through the Local Planning Authority, namely Arun District Council (ADC).

This report presents a full factual record of all site works carried out, the results of *insitu* testing and subsequent laboratory testing of selected samples obtained during these works. The report has been formulated in accordance with BS10175:2015 '*Investigation into Potentially Contaminated Sites – Code of Practice*' and CLR11 – '*Model Procedures for the Management of Land Contamination*' and from the National Planning Policy Framework.

We are content that as a result of the actual site investigation works and subsequent soil testing undertaken, as outlined within this report, we have comprehensively characterised the ground conditions and consequently the potential for contamination to exist on site. These works and ensuing assessment have been detailed in this report.

YE take no responsibility for conditions which have not been revealed by the windowless sampler boreholes, or which occur between windowless sampler boreholes. Whilst every effort has been made to interpret the conditions between investigation locations, such information is only indicative and liability cannot be accepted for its accuracy.

The information contained in this report is intended for the use of the named client (or their approved contractors). Should any part of this report be relied on by a third party, that party does so wholly at its own risk and YE disclaim any liability to such parties. Should the purposes for which the report is used, or the proposed use of the site change, this report may no longer be valid and further use of reliance upon the report in those circumstances shall be at the client's sole and own risk. The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable. YE should in all such altered circumstances be commissioned to review and update this report accordingly.

2.0 Proposed Development

As we understand current plans for the redevelopment of the site are to demolish the present structures and replace with a number of residential dwellings. No proposed redevelopment plans have been forwarded to YE for review and inclusion into this report.

3.0 Physical Setting

3.1 Site Information

Access

The site is located directly to the west of Yapton Lane.

Topography

The site is flat with a very mild incline rising to the north.

Vegetation

Very little vegetation exists on site, however the boundary to the west, north and east consists of an evergreen hedgerow, and a small portion to the south is vegetated with a grass verge. An ivy shrub is found in the centre of the site.

Buildings and Structures / Floor Covering

There is the remains of a petrol station with a covered forecourt to the south of the site, with the main station and car show room beyond, to the west. A temporary structure acting as a security booth is found in the east of the site. To the rear (north) of the site large workshops are located.

Surface Permeability / Ground Covering

It is estimated that approximately 90% of the site is impermeable hardstanding, including the structure's footprint, with 10% permeable soft landscaping around the perimeter of the site.

Drainage Features

Several drainage features were noted onsite, including interceptor traps, drain covers, and a drainage pipe running through the hardstanding at the rear.

Other Services

The workshops on the north of the site, were still in use, so it is assumed the site is still fully serviced.

Surrounds

The site neighbours residential and commercial properties.

3.2 Geology

The relevant British Geological Survey (BGS) online mapping information indicates the site's superficial drift deposits to be comprised of River Terrace Deposits (sand, silt and clay). This is underlain by bedrock geology composed of London Clay Formation, which is predominantly argillaceous, slightly calcareous, grey to bluish grey, silty to very silty Clay which is characteristically fissured, and brown where weathered.

3.3 Hydrogeology

The Environment Agency designate aquifers in accordance with the Water Framework Directive. These designations reflect not only the importance of aquifers in terms of groundwater as a resource (drinking water supply) but also their role in supporting surface

water flows and wetlands ecosystems. The aquifer designation data is based on geological mapping provided by the BGS.

As a result of the superficial geology on site the aquifer is designated as being a Secondary (A) Aquifer. These are 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. These are generally aquifers formerly classified as Minor Aquifers.

The aquifer within the bedrock ground is recorded as being an Unproductive Aquifer. These are rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow.

3.4 Hydrology

Groundwater Abstraction Licences

There are no active groundwater abstraction licences within 2000m.

Surface Water Abstraction Licences

There are a number of surface abstraction licences within 2000m, the closest of which is 515m south for spray irrigation.

Potable Water Abstraction Licences

There are no potable abstraction licences within 2000m.

Groundwater Vulnerability and Soil Leaching Potential

The on site soil vulnerability category is listed as being 'I1' this is defined as soils which can possibly transmit a wide range of pollutants.

Surface Water Features

There are no surface water features recorded within 250m.

Source Protection Zone

The study site is not located within a Source Protection Zone.

Detailed River Networks

There are a number of network entries within 500m, the closest of which is located 279m south.

Records of Licensed Discharge Consents

There is one active record within 500m, which is 395m southwest for the purposes of final/treated sewage discharge.

3.5 Summary of Possible Contamination Sources

The earliest mapping (c.1876) indicates the site to be undeveloped and consisted of a large plot of arable land, with a road running at an orientation of north to south on the eastern boundary; this remains to be the case until mapping of 1939 when the site is redeveloped and two structures are noted in central northern and southern flanks. It is not until mapping of 1975 that the site is noted to have undergone redevelopment with a listed garage located in the south and an apparent residential property labelled as being 'The Neuk' in the north, there is also a canopy located adjacent to the road immediately east of the site. Furthermore, there two detached structures of unknown usage on the

western portion of the site. These features identified from historic mapping are later observed from the walkover survey undertaken.

The immediate surrounding environs were predominately rural in nature which, during the course of mapping, reviewed remain largely unchanged. However, limited development mainly in the form of residential dwellings and associated garden areas were observed with notable land uses identified such as a smithy (550m north), various nurseries (110m and 260m south) and tanks (80m and 150m southwest). However, given the distances from these features to the study site they were not considered to pose a potential risk.

The walkover survey completed indicates there to be the remains of a petrol station with a covered forecourt to the south of the site, with the main station and car show room beyond, to the west. A temporary structure acting as a security booth is found in the east of the site. To the rear (north) of the site large workshops are located. Very little vegetation exists on site, however the boundary to the west, north and east consists of an evergreen hedgerow, and a small portion to the south is vegetated with a grass verge. It is estimated that approximately 90% of the site is impermeable hardstanding, including the structure's footprint, with 10% permeable soft landscaping around the perimeter of the site.

The surrounding land uses were a mixture of predominately residential and commercial usage, i.e. hotel, nursery and agricultural land.

The superficial ground on site is composed of River Terrace Deposits (sand, silt and clay) which overlies bedrock geology formed of the London Clay Formation. There are no records of artificial/Made Ground within 500m and no recorded landfill sites within 2000m, however, there are twenty one records of potentially infilled land within 500m, the nearest of which is 266-268m northwest for ponds.

The hydrogeological and hydrological setting of the site is considered to be low given the presence of a Secondary (A) Aquifer within the superficial drift deposits which overlies an Unproductive Aquifer in the bedrock. There are no groundwater and potable water abstraction points within 2000m, the closest surface point is approximately 515m south. In addition, there are no surface water features located within 250m.

There are fifteen records of sites with a potentially contaminative past land use within 500m, two of which are recorded as being on site for a garage. Off site, the nearest is 25m west for a nursery, with additional records 29m and 72m west for nurseries, an unspecified tank is 95m west and a nursery 99-100m south. Other records are over 150m away. In respect of historical tanks the nearest is 70-72m southwest. It is noted that there are five records of sites with a potentially contaminative industrial usage within 250m, one of which is listed as being on site for a vehicle repair, testing and servicing firm. In respect of off site the nearest is a tank 73m southwest with others features are over 100m away. There are three records of historical garage and motor vehicles within 500m, these are all listed as being on site.

Feedback received from the Environmental Health Department at Arun District Council by YE regarding the status of any on site underground storage tanks indicated that tanks were installed pre-1953 (License No. 488006), there were three (3no.) tanks with a capacity of 22730L. Furthermore, the tanks were made safe by slurry infilling in October 1992.

Based on the foregoing, we identified potential sources of contamination which relate to historical/ current land uses on site, i.e. garage, associated infrastructure, underground

storage tanks and namely the vehicle repair, testing and servicing workshops, with the storage and usage of associated chemicals. Furthermore, potential cement bonded roofing material was also observed. Therefore, we recommended a site investigation to be undertaken to determine the actual risks these potential sources may pose to various receptors identified in the following section.

4.0 Feedback from ADC

YE contacted the Environmental Health Department at ADC to ascertain what information they held with regard to the status of any on site underground storage tanks.

The Pollution Officer responded to confirm that the information held was that the tanks were installed pre-1953 (License No. 488006), there were three (3no.) tanks with a capacity of 22730L. Furthermore, the tanks were made safe by slurry infilling in October 1992.

A copy of the feedback provided to YE by our client, from ADC, can be reviewed within Appendix B.

5.0 Preliminary Conceptual Site Model and Risk Assessment

This presented Conceptual Site Model has been re-issued from the earlier issued Stage 1: Desktop Study and feedback from ADC to provide information regarding the possible **sources** of contamination on site, the **pathway** in which the contamination can migrate and a vulnerable **receptor** to the contamination, all of which need to be present for there to be a risk. Given the proposed end use of the site as being residential the generic land use of 'residential with homegrown produce' has been applied. Consequently, the following Source – Pathway – Receptor relationships have been identified.

Hazard / Pollutant	Pathways	Receptor	Potential Severity	Probability of Risk	Level of Risk	Justification
Hydrocarbons (TPH, PAH, BTEX & MTBE). Heavy metals, SVOCs, VOCs and asbestos.	Ingestion, dermal contact, inhalation	Future end users, site visitors and site visitors	Medium	Low Likelihood	Moderate	A moderate risk is considered given the historic/current setting of the site combined with the proposed generic end land use of 'residential' which is assumed to feature areas of soft landscaping.
		Construction Workers	Medium	Likely	Moderate	A moderate risk is considered given the historic/current setting of the site and surrounding environs. Construction workers are likely to come into direct contact with soils during groundworks therefore the use of appropriate PPE should be adopted to mitigate against any potential risks.
	Leaching through soils and migration via groundwater or soil pore moisture	Controlled Waters	Medium	Low Likelihood	Low	A low risk is considered given the site is recorded as having a Secondary (A) Aquifer within the superficial drift deposits which overlies an Unproductive Aquifer in the bedrock. There are no groundwater and potable water abstraction points within 2000m, the closest surface point is approximately 515m south. In addition, there are no surface water features located within 250m.
	Uptake	Plant and Wildlife	Mid	Low Likelihood	Moderate	A moderate risk is considered given that the proposed development which is assumed to incorporate areas of soft landscaping.
Ground Gases.	Gas generation, migration and build up within properties	Future end users, site visitors, site workers and proposed site structures	Medium	Low Likelihood	Moderate	A moderate risk is considered given the potential for ground gases and volatilisation of hydrocarbons to transport through the superficial deposits from on site historical garage and current workshops.

Table 1: Preliminary Conceptual Site Model

6.0 Fieldworks

6.1 Site Investigation

All SI works were completed on March 30th 2017 under the supervision of a Geo-Environmental Engineer contracted from YE. In summary the investigation included:

- A two man team ascertained the routes of any below ground services in close proximity to the proposed exploratory hole positions, using a CAT scan and lifting up of any man hole covers. Following the CAT scan, hand dug starter pits were completed to a depth of 1.2 metres below ground level (mbgl).
- Five (5no.) windowless sampler boreholes (WS1 to WS5) were completed, by means of a track mounted competitor dart rig, to a maximum depth of 3.00mbgl, due to shallow refusal because of dense ground conditions encountered. The locations of exploratory positions were selected relative to the historic land use and current proposed redevelopment plans for the site whilst providing a broad coverage of the site as feasibly as possible.
- The windowless sampler boreholes were logged with any groundwater conditions noted and representative soil samples removed in accordance with current guidelines.
- Soil samples were removed from shallow sub surface locations, with further samples taken at depth at every 0.5mbgl or when the underlying stratum changed. Samples were subsequently placed in suitable containers including 1kg tubs and 250ml glass jars and placed in cool boxes with cool packs prior to storage within our *in-house* laboratory fridges and then subsequent forwarding to our designated laboratory for analysis.
- Two (2no.) windowless sampler boreholes (WS3 and WS4) were installed with standpipes comprising of 50mm pipework to a maximum depth of 2.00mbgl (due to refusal) to enable future gas and groundwater monitoring to be undertaken. These were completed with a lockable cover, flush with the ground, to protect the installation.
- Upon completion, all exploratory holes not installed with standpipes, were back filled, compacted, with any surplus spoil bagged up and removed from site.

The positions of exploratory holes in relation to the existing site layout can be reviewed within Appendix C with exploratory windowless sampler logs located in Appendix D.

6.2 Ground Gas and Groundwater Monitoring

Three rounds of ground gas and groundwater monitoring were carried out dated 7th, 21st and 28th April 2017 using the standpipe installations of exploratory hole locations WS3 and WS4.

6.2.1 Ground Gas

Ground gas monitoring was carried out in accordance with the guidelines presented in CIRIA C665 'Assessing risk posed by hazard ground gases to buildings' using a GA5000 and involved the following steps:

Flow was monitored for a period of two minutes where possible; maximum flow was recorded. Ground gases, including concentrations of methane, carbon dioxide, hydrogen sulphide and carbon monoxide were monitored for up to five minutes. During monitoring, ground gas readings were logged every thirty seconds.

6.2.2 Groundwater

A groundwater sample was recovered, where possible, from each of the installations.

Groundwater monitoring was completed in accordance with BS6068:2009 Water Quality Sampling: Guidance on Sampling of Groundwater.

A two phase dip meter was used to determine the presence of Light Non Aqueous Phase Liquids (LNAPL) and Dense Non Aqueous Phase Liquids (DNAPL). Each well was purged before a sample was taken and retained in a 1 litre coloured glass bottle (Winchester).

The samples were then placed in a cool box prior to transit to the laboratory.

The monitoring results are presented in Appendix F.

7.0 Geology & Ground Conditions

The following ground conditions were encountered during the SI;

Concrete/ tarmac – Encountered in all exploratory holes to a maximum depth of 0.20mbgl.

Made Ground – Encountered in two exploratory holes to maximum depth of 0.40mbgl in WS2 and WS3 and generally comprised a dark brown/ grey organic silty sandy gravelly Clay with frequent rootlets present. Common flint and pebble sized brick fragments.

River Terrace Deposits – These deposits were identified within all positions undertaken from 0.40mbgl to the maximum drilled depth of 3.00mbgl. This stratum generally comprised of a light brown sandy silty gravelley CLAY. Common cobble sized flint fragments. Gravels sub-angular to angular.

8.0 Groundwater Conditions

Two windowless sampler boreholes (WS3 and WS4) encountered water at 1.80mbgl and 2.0mbgl respectively, when drilled. In addition, during the three rounds of monitoring undertaken, groundwater was encountered in WS4 on each occasion. The following table presents the levels recorded in each installation and round of monitoring.

Exploratory Hole	MON1 Standing Level (mbgl)	MON2 Standing Level (mbgl)	MON3 Standing Level (mbgl)
WS3	Dry	Dry	Dry
WS4	1.62	1.78	1.82

Table 2: Groundwater levels recorded in installed positions

It should be noted that groundwater levels are dependent upon seasonal variations and can change after periods of prolonged rainfall or drought.

9.0 Visual and Olfactory Observations

With exception of general anthropogenic material identified, no visual and/or olfactory evidence of potential contamination was noted within any soils encountered during the drilling of exploratory holes.

In addition, in respect of groundwater samples retrieved during the course of monitoring undertaken no visual and/or olfactory evidence of potential contamination was noted. Furthermore, no presence of LNAPL/ DNAPL was observed during SI works or monitoring undertaken.

10.0 Contamination

10.1 Soil Testing

A total of nine (9no.) samples from both the Made Ground and underlying natural soils have been analysed by Messrs QTS Environmental Ltd in their UKAS and MCERTS accredited laboratory-testing facility in accordance with laboratory protocol.

The testing completed comprised of a focused suite of heavy metals, pH, speciated Total Petroleum Hydrocarbons (Aromatic/ Aliphatic Split) and speciated Polycyclic Aromatic Hydrocarbons (PAH – including the more toxic/ carcinogenic forms naphthalene and benzo(a)pyrene), total cyanide, total phenols, benzene, toluene, ethylbenzene and xylenes (BTEX), methyl tert butyl ether (MTBE), soil organic matter content, asbestos screening and pH.

The results of this laboratory testing have been compared to the Soil Guideline Values (SGVs) as well as the CIEH 'LQM' guideline values for inorganic and organic contaminants in soils. The proposed development of the site is intended to comprise of residential and therefore screening has been made against a land use of 'residential with homegrown produce'.

10.2 Selection of Screening Criteria

The on site receptors for the site are considered to be:

- Construction workers (during redevelopment of the site only);
- Future maintenance workers (following redevelopment);
- Future residents and visitors (following redevelopment); and
- Trespassers (during redevelopment).

The off site receptors for the site are considered to be:

- Residents and visitors to the nearby residential dwellings in the immediate vicinity of the site.

Risks to construction workers during the redevelopment process will be mitigated by adhering to appropriate health and safety legislation, and the wearing of appropriate personal protective equipment (PPE). During redevelopment, the site will be securely fenced to prevent trespassers from accessing the site, and good site management practices will be implemented to mitigate exposure to off site receptors.

The potential pathways for contaminants within the soil to human health receptors following redevelopment are considered to be:

- Direct ingestion of soil and soil derived dust;
- Dermal contact with soil outside and soil derived dust inside;
- Inhalation of soil derived dust inside and outside; and
- Inhalation of soil derived vapours inside and outside.

Potential risks via permeation of drinking pipes, and risks to concrete from attack by aggressive ground conditions should be considered at design stage.

The potential pathways for contaminants within the soil to off site human health receptors following redevelopment are considered to be:

- Direct ingestion of soil and soil derived dust;
- Dermal contact with soil outside and soil derived dust inside;
- Inhalation of soil derived dust inside and outside; and
- Inhalation of soil derived vapours inside and outside if contamination within soil is able to migrate across the site boundary within.

In the first instance, the results of this laboratory testing have been compared to generic assessment criteria (GAC) for the residential with consumption of homegrown produce land use scenario. These incorporate the following pathways:

- Direct ingestion of soil and soil derived dust;
- Dermal contact with soil outside and soil derived dust inside;
- Inhalation of soil derived dust inside and outside; and
- Inhalation of soil derived vapours inside and outside.

Given that these incorporate a number of pathways that will not be relevant to the site following redevelopment, this is a highly conservative approach and exceedances will be discussed in this light.

Contaminants have been screened against revised LQM/ CIEH S4UL criteria¹ where available. These GAC have been designed for use under planning, using Health Criteria Values based on minimal risk, and updated exposure parameters. The S4UL are intended to replace the previous LQM/ CIEH GAC. The S4UL are based on the assumption of a sandy loam soil the 6% soil organic matter (SOM) criteria have been used, where available and appropriate, in the first instance. All soil samples were analysed for %SOM, the range was from <0.1% to 1.2% and so this conservative approach is considered appropriate for initial screening.

Where no S4UL are available, the EIC/ AGS/ CL:AIRE/ GAC² have been used. The toxicological criteria within these are also based on minimal risk. It is recognised that these criteria have not recently been updated, and in particular, do not incorporate the

¹ Nathanail et al. (2015) The LQM/ CIEH S4ULs for Human Health Risk Assessment. Land Quality Press, 2015. Copyright Land Quality Management Limited reproduced with permission; Publication Number S4UL3495

² CL:AIRE (2010) The EIC/ AGS/ CL:AIRE Generic Assessment Criteria for Human Health Risk Assessment

slightly higher inhalation rates that have been used within the S4UL. However, given that they incorporate additional pathways, they are considered suitable for an initial screen. The EIC/ AGS/ CL:AIRE/ GAC are also based on a sandy loam soil and the 1% SOM criteria have been used in the first instance.

There is neither an S4UL nor a EIC/ AGS/ CL:AIRE/ GAC available for lead. In the absence of a GAC based on minimal risk, the C4SL for lead has been used. It is recognised that this is based on a “low level of toxicological concern” rather than on a minimal risk level. However, it is considered appropriate for use under planning, especially for a site where there will effectively be no pathways for inorganic metals following redevelopment.

All the GAC are based on a sandy loam soil. This is considered appropriate for use for initial screening. Although it is apparent from the laboratory soil descriptions, that the Made Ground is heterogeneous, and often has a significant sand/gravel component, especially at shallow depths, it is noted that many of the soil descriptions have a significant clay component.

All of the GAC assume unsaturated soils. However, the use of the GAC are considered to be conservative, because they assume a certain air-filled porosity and water-filled porosity.

The GAC also assume that no free phase product is present, and are not intended for use in this instance. No free product was observed within soils during the site investigation.

10.3 Soil Testing Results & Screening

All metals, PAHs and TPH CWG analytes are presented in the following tables. Other potential contaminants of concern are only shown where there is at least one result exceeding the limit of detection or above a GAC. All of the soil laboratory analytical results are presented within Appendix E. It should be noted that in respect of returned concentrations in µg/ kg these GACs have been multiplied by a factor of 1000, as these are in mg/ kg.

Metalloids

Determinant	Min	Max	GAC	Number of exceedances
Arsenic	4	10	37*	0
Cadmium	<0.2	1.7	10*	0
Chromium (III)	17	30	910*	0
Chromium (VI)	<2	<2	6	0
Copper	5	31	2400*	0
Lead	8	58	200	0
Mercury	<1	<1	40 ^{*a}	0
Nickel	<3	34	180 ^{*b}	0
Selenium	<3	<3	250*	0
Zinc	32	94	3700*	0
Total Phenols	<2	<2	420*	0

Table 3: Metalloids Soil Exceedances

*LQM/ CIEH GAC for Residential with consumption of homegrown produce land use scenario based on a sandy loam soil and 1%SOM.

#EIC/ AGS/ CL:AIRE GAC for Residential with consumption of homegrown produce land use scenario and 1% SOM+ C4SL Residential with consumption of homegrown produce land use scenario based on a sandy loam soil.

+C4SL for Residential with consumption of homegrown produce land use scenario based on a sandy loam soil.

- Based on the inorganic mercury GAC as the conceptual site model does not suggest that other forms of mercury are likely to be present on site.
- LQM issued an update to the nickel S4ULs in August 2015 and this has been taken into account.

➤ There no exceedances for metalloids screened.

Organics

Determinant	Min	Max	GAC	Number of exceedances
Naphthalene	<0.1	<0.1	5.6*	0
Acenaphthylene	<0.1	<0.1	420*	0
Acenaphthene	<0.1	<0.1	510*	0
Fluorene	<0.1	<0.1	400*	0
Phenanthrene	<0.1	1.57	220*	0
Anthracene	<0.1	0.39	5400*	0
Fluoranthene	<0.1	4.47	560*	0
Pyrene	<0.1	4.55	1200*	0
Benzo(a)anthracene	<0.1	3.23	11*	0
Chrysene	<0.1	2.79	22*	0
Benzo(b)fluoranthene	<0.1	5.04	3.3*	1
Benzo(k)fluoranthene	<0.1	1.57	93*	0
Benzo(a)pyrene	<0.1	3.80	2.7*	1
Indeno(1,2,3-cd)pyrene	<0.1	2.05	340*	0
Dibenz(a,h)anthracene	<0.1	0.29	0.28*	1
Benzo(ghi)perylene	<0.1	1.64	340*	0

Table 4: PAH Soil Exceedances

Determinant	Min	Max	GAC	Number of exceedances
Aliphatic >C5 - C6	< 0.01	< 0.01	78*	0
Aliphatic >C6 - C8	< 0.05	< 0.05	230*	0
Aliphatic >C8 - C10	< 2	< 2	65*	0
Aliphatic >C10 - C12	< 2	< 2	330*	0
Aliphatic >C12 - C16	< 3	< 3	2400*	0
Aliphatic >C16 - C21	< 3	< 3	92000*	0
Aliphatic >C21 - C34	< 10	<10	92000*	0
Aromatic >C5 - C7	< 0.01	< 0.01	140*	0
Aromatic >C7 - C8	< 0.05	< 0.05	290*	0
Aromatic >C8 - C10	< 2	< 2	83*	0
Aromatic >C10 - C12	< 2	< 2	180*	0
Aromatic >C12 - C16	< 2	< 2	330*	0
Aromatic >C16 - C21	< 3	8	540*	0
Aromatic >C21 - C35	< 10	36	1500*	0

Table 5: TPH CWG Aliphatic/ Aromatic Soil Exceedances

* LQM/ CIEH GAC for Residential with consumption of homegrown produce land use scenario based on a sandy loam soil and 2.5% SOM.

It is noted that the LQM/ CIEH S4UL guidance recommends an additive approach for the TPH fraction, so that a hazard index approach is used. Based on a preliminary conservative comparison of maximum concentrations to S4ULs, no forward modelling is necessary to prove that this would still result in no exceedances at the site.

- There are three exceedances noted from the screening undertaken on PAH congeners in the form of Benzo(b)fluoranthene, Benzo(a)pyrene and Dibenz(a,h)anthracene in W1 at a depth of 0.20mbgl.
- There are no exceedances noted from the screening undertaken on respective TPH CWG bands.

Others

The asbestos screening returned a negative result for the presence of fibrous material. In addition, the BTEX/ MTBE congeners returned concentrations below the Limit of Detection (LoD) with majority of VOCs/ VOCs congeners also below LoDs.

The soil contamination laboratory certificates can be reviewed within [Appendix E](#).

10.4 Groundwater Testing

Samples were analysed by Messrs QTS Environmental Ltd in their UKAS and MCERTS accredited laboratory testing facility in accordance with laboratory protocol.

The testing completed comprised of a suite of testing similar to that undertaken for soils such as heavy metals, Total Petroleum Hydrocarbons (TPH) and speciated Polycyclic Aromatic Hydrocarbons (PAH – including the more carcinogenic forms naphthalene and benzo(a)pyrene), BTEX/ MTBE, VOC, SVOCs, and pH.

The results of this laboratory testing have been compared to the UK Drinking Water Standards (DWS) for inorganic and contaminants, where available.

10.5 Groundwater Results

The results of the groundwater testing are shown in the following tables below where they are compared to the available Drinking Water Standards.

Metalloids

Determinant	Max	GAC	Number of exceedances
Arsenic	<5	10 µg/ l	0
Beryllium	<3		0
Boron	68 µg/ l	1 mg/ l	0
Cadmium	<0.4	5.0 µg/ l	0
Chromium	8	50 µg/ l	0
Copper	<5 µg/ l	2.0 mg/ l	0
Lead	<5	10 µg/ l	0
Mercury	<0.05	1.0 µg/ l	0
Nickel	<5	20 µg/ l	0
Selenium	<5	10 µg/ l	0
Vanadium	<5		0
Total Phenols	<10		0
Total Cyanide	<5	50	0

Table 6: Metalloids Groundwater Exceedances

Organics

Determinant	Min	Max	GAC	Number of exceedances
Polycyclic Aromatic Hydrocarbons	<0.01	0.02	0.10 µg/ l *	0

Table 7: PAH Groundwater Exceedances

Determinant	Max	GAC	Number of exceedances
Total TPH >C5 – C35	<10	10+	0

Table 8: TPH Groundwater Exceedances

Determinant	Max	GAC	Number of exceedances
Benzene	<1		0
Toluene	<5		0
Ethylbenzene	<5		0
p & m-xylene	<10		0
o-xylene	<5		0
MTBE	<10		0

Table 9: BTEX and MTBE Groundwater Exceedances

* Based on the sum of 4 named PAH congeners (benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene and indeno(1,2,3-cd)pyrene).

+ Based on individual TPH fractions.

In summary, the groundwater monitoring results show:

- There were no exceedances of metalloids.
- No exceedances have been returned from the total sum of PAHs in respect of all monitoring rounds.
- There are no elevated concentrations of any of the individual TPH fractions compared to the withdrawn drinking water standards for TPH of 10 µg/l.
- All results in respect for BTEX and MTBE indicate none are above the LoD.

The groundwater contamination laboratory certificates can be reviewed within [Appendix G](#).

10.6 Gas Monitoring Results

Gas monitoring was carried out on three separate occasions using a Gas monitor (GA5000). Readings were taken from the installed window sampler boreholes of WS3 and WS4.

The standpipes were tested for the presence of methane, oxygen, carbon dioxide and hydrogen sulphide. The flow rates of the gas and barometric pressure were also recorded.

On all of three occasions, bar the last round of monitoring undertaken, the ground conditions were noted to be dry, with the wind recorded as being calm/ light. Two of the rounds of monitoring were completed during steady pressure conditions, with the first round in rising pressure conditions.

From all monitoring visits, methane was recorded at a maximum peak and steady concentration of 0% volume in all installed positions during the course of all monitoring rounds completed. Oxygen concentrations ranged from a minimum of 15.8% obtained from WS3 during monitoring round 1 to a maximum of 20.5% obtained from WS4 during monitoring round 2. The maximum peak concentration of carbon dioxide obtained of 2.2% from installation WS3 during the 1st round of monitoring completed.

Flow rates were recorded during each round of monitoring from all installations, ranging from a minimum of 0.0l/hr to a maximum of +0.4l/hr. No concentrations of hydrogen sulphide were returned from any of the rounds of monitoring undertaken, i.e. 0.0ppm respectively, with a maximum 6ppm returned in respect of carbon monoxide from WS3 during the 1st monitoring round undertaken.

Barometric pressure ranged from a low of 1014mBars during the 3rd monitoring round to a high of 1030mBars attained during the 2nd round of monitoring.

The recorded concentrations of methane and carbon dioxide have been used to calculate a Gas Screening Value (GSV) for the gassing regime at this site. This value has been subsequently compared against CIRIA values supplied within CIRIA Document C665 *Assessing risks posed by hazardous ground gases to buildings* (2007) using Situation B for carbon dioxide and methane.

The values used represent the worst case CO₂ and CH₄ concentrations across all installations.

The maximum flow rate was 0.4l/ hr and this was taken from all locations and/or monitoring visits.

The GSV is calculated as:

(Worst case CO₂ and CH₄ concentration / 100) x worst case flow rate = GSV

Peak Flow Rate (l/hr)	Worst Case CO ₂	CO ₂ GSV	Worst Case CH ₄	CH ₄ GSV
+0.4	2.2l/ hr CO ₂	0.009l/ hr CO ₂	0.0l/ hr CH ₄	0.0l/ hr CH ₄

Table 10: Calculated GSV's

This GSV is a conservative estimate based on the maximum concentrations and flow rate.

This approach has been taken at this stage based upon the six monitoring visits that have been undertaken.

Based on the maximum calculated GSV of 0.009l/ hr, the site was below the threshold given by CIRIA C665 for Situation B and is characterised as 'Green'. Based on this data, the indication is that there is a negligible gas regime identified. As a consequence, gas protection measures are not considered necessary to be incorporated into the proposed development.

11.0 Discussion of Results

11.1 Soils

Selected soil samples taken during the SI were submitted for a robust focused suite of laboratory testing commensurate with potential current/historical on and off site land uses and activities to assess the potential risks posed to the various on and off site receptors.

Three returned laboratory results have identified exceedances of PAH congeners in the shallow Made Ground in the form of Benzo(b)fluoranthene with 5.04mg/ kg, Benzo(a)pyrene with 3.80mg/ kg and Dibenzo(a,h)anthracene with 0.29mg/ kg, within WS1 at a depth of 0.20mbgl. In addition, in respect of those determinands whereby there are no available generic screening criteria available it is noted that the majority of concentrations are at the limit of detection possible.

Once redevelopment plans have been finalised for the site, if this position falls within an area of soft landscaping, given the continued presence this would pose a risk in respect of ingestion, dermal contact and inhalation pathways to human health (end users and visitors), particularly at this shallow depth, this should be removed by means of hotspot delineation, excavation and testing.

11.2 Groundwater

The results of groundwater laboratory testing and subsequent screening on waters retrieved from installations on site show there were no exceedances of metalloids, the total sum of PAHs, individual TPH congeners, BTEX/ MTBE and the majority of metals in comparison to DWS guidance levels.

The site is considered to be of relatively low sensitivity due its historical/current and proposed site setting given the absence of contamination identified on site. Furthermore,

the controlled waters are considered to be of relatively low importance, as a potable resource.

It should be noted that groundwater levels are dependent upon seasonal variations and can change after periods of prolonged rainfall or drought.

11.3 Gas

The result of the three rounds of gas monitoring and subsequent calculations has identified that the site is below the threshold given by CIRIA C665 for Situation B and is characterised as 'Green'. Based on this data, the indication is that there is a negligible gas regime identified. In addition, given the limited amount of Made Ground identified during investigative works coupled with the results of the calculated GSV the gassing regime on site has been sufficiently characterised and is considered representative of soil conditions present.

As a consequence, gas protection measures are not considered necessary to be incorporated into the future proposed development.

12.0 Updated Conceptual Site Model and Risk Assessment

The Conceptual Site Model has been re-formulated based upon the results from the SI in accordance with BS10175:2015. It aims to provide information regarding the sources of contamination and the pathways in which contamination can migrate to a vulnerable receptor, all of which need to be present for there to be a risk. This is in relation to the proposed end use being classified as 'residential with homegrown produce'. The following linkages have been identified:

Contaminant Source	Pathways	Receptor	Potential Severity	Probability of Risk	Level of Risk	Justification
On Site: Made Ground soils on site possibly containing elevated metals, other inorganics, TPH, BTEX and MTBE, PAH, VOC and SVOCs.	Ingestion, dermal contact, inhalation of dusts/ vapours	Future end users and site visitors	Medium	Likely	Moderate	A moderate risk is considered given the overall context of returned laboratory results which has identified an isolated hotspot of soil contamination from exploratory hole WSI at a depth of 0.20mbgl in the form of Benzo(b)fluoranthene Benzo(a)pyrene and Dibenzo(a,h)anthracene.
		Construction Workers	Medium	Likely	Moderate	A moderate risk is assessed given the organic contaminants identified on site from investigative works undertaken within Made Ground and arising from on site historical/ current sources. Therefore, construction workers are likely to come into direct contact with soils during groundworks safe working practices should still be implemented and appropriate personal protective equipment (PPE) should be used to mitigate any potential risk from contact with soils and shallow/ perched groundwater.
	Leaching through soils and migration via groundwater or soil pore moisture	Controlled Waters	Medium	Low Likelihood	Low	A low risk has been attributed given the returned laboratory results that have not identified any contaminants above the DWS guidelines. Furthermore, the area is of a low relative importance for using groundwater as a potable resource. A Secondary (A) Aquifer within the superficial drift deposits which overlies an Unproductive Aquifer in the bedrock. There are no groundwater and potable water abstraction points within 2000m, the closest surface point is approximately 515m south. In addition, there are no surface water features located within 250m.
	Permeation of water pipes	Construction materials, future end users and site visitors	Medium	Likely	Moderate	As a result of the returned laboratory results and subsequent screening which shows there are some potential risks. Hydrocarbons, especially aromatics and chlorinated solvents, are known to permeate plastic pipes. Provision of water supply pipes and connectors formed from proprietary "barrier pipe" materials (eg polyethylene-aluminium-polyethylene) may be required by the water supply company particularly as Made Ground has been identified on site.
	Uptake	Plant and Wildlife	Mid	Low Likelihood	Low	As a result of the returned laboratory results which shows an absence of phytotoxic contaminants.

On Site: Asbestos at/ near ground surface in Made Ground soils	Inhalation of fibres in airborne dust	Future end users and site visitors	High	Low Likelihood	Low	The results of screening indicates there to be no asbestos in soils sampled suggesting an absence across the site. However, it cannot be guaranteed that asbestos is not present within the soils across the remainder of the site. Consequently, a watching brief should be adopted with regards to the site for the potential of finding any Asbestos Containing Materials (ACMs).
		Construction Workers	High	Low Likelihood	Low	The results of screening indicates there to be no asbestos in soils sampled suggesting an absence across the site. However, it cannot be guaranteed that asbestos is not present within the soils across the remainder of the site. Consequently, a watching brief should be adopted with regards to the site for the potential of finding any Asbestos Containing Materials (ACMs).
On Site: Ground Gases (CH ₄ , CO ₂) from on site Made Ground.	Gas migration and build up within buildings (explosion/ asphyxiation risk)	Future end users and building structures	High	Low Likelihood	Low	A low risk has been assigned given the results of gas monitoring undertaken and subsequently calculated GSV which demonstrates that no gas protection measures are required to be incorporated within the proposed development.
Off Site: Made Ground soils and landfilled waste possibly containing elevated metals, other inorganics, TPH, PAH, VOC and SVOCs.	Leaching through soils and migration via groundwater or soil pore moisture	Future end users and site visitors	Mid	Low Likelihood	Low	The results of preliminary screening and subsequent assessment of risk undertaken on soils and groundwater samples retrieved from investigative works which shows low risk as a result of off site historical/ current land uses and activities in proximity to the study site. Furthermore, contaminants present in Made Ground off site considered unlikely to exhibit significant leachability.
	Inhalation of vapours	Future end users and site visitors	Medium	Low Likelihood	Low	Contaminants present in Made Ground off site considered unlikely to exhibit significant leachability.
Off Site: Ground Gases (CH ₄ , CO ₂ , H ₂ S) from off site Made Ground and landfilled waste	Gas migration and build up within buildings (explosion/ asphyxiation risk)	Future end users and building structures	High	Low Likelihood	Low	A low risk has been assigned given the results of gas monitoring undertaken and subsequently calculated GSV which demonstrates that no gas protection measures are required to be incorporated within the proposed development.

Table 11: Updated Conceptual Site Model

13.0 Recommendations

The following recommendations are based on the results of chemical laboratory testing to date. Additionally, due to the site having no redevelopment plans, a subsequent review of the report may have to be undertaken when plans are finalised. It should be further noted that the soils were compared to guidelines for 'residential with consumption of homegrown produce' end land use, to target the most sensitive receptor, in the eventuality of soft landscaping being incorporated in the future site redevelopment.

The following recommendations made do not constitute a formal remediation strategy and/or validation report. A remediation strategy should be agreed with the relevant local authority prior to such works commencing and/or the production of a validation report.

13.1 Soils

An isolated hotspot of organic contamination has been identified from within the shallow Made Ground in the form of Benzo(b)fluoranthene, Benzo(a)pyrene and Dibenz(a,h)anthracene in WS1 at a depth of 0.20mbgl. A review of the borehole log indicates that natural soils are present at a depth of 0.40mbgl it would therefore be reasonable to conclude that these forms of contaminants would cease at this depth.

Once redevelopment plans have been finalised for the site, if this position falls within an area of soft landscaping, given the continued presence this would pose a risk in respect of ingestion, dermal contact and inhalation pathways to human health (end users and visitors), particularly at this shallow depth, this should be removed by means of hotspot delineation, excavation and testing.

Therefore, we would recommend that soils in this area are delineated to a depth of 1.0mbgl (to ensure natural soils are definitively encountered) and laterally by a proposed diameter of 1.0m. An appropriate number of soil samples should be taken from the sides and submitted to an UKAS and MCERTS accredited laboratory for the purposes of validating that none of the contamination remains *insitu*.

A more economical approach maybe to cover the area in hardstanding, breaking the pollutant pathway. This will allow for any contamination within the Made Ground, which may be present between the investigative boreholes to be taken into account.

However, a remedial strategy should be formulated and presented to the Local Authority Planning Authority to seek their comments and approval in advance of such works proceeding.

13.2 Groundwater

Given the returned laboratory analysis from the groundwater samples tested for, which show there are no exceedances of metalloids, the total sum of PAHs, individual TPH congeners, BTEX/ MTBE in comparison to DWS guidance levels.

Therefore, it would be safe to assume that the risk posed to groundwater is low and that the isolated hotspot of contamination within the soil is situated within the shallow Made Ground and not within natural soils that surround the local water table level.

13.3 Watching Brief and Discovery Strategy

A watching brief should be maintained by the Main Contractor at all times during the groundworks stage. Should any unforeseen contamination, such as oils or soils/groundwater with an unusual colour or odour, be encountered during groundworks then the following procedure should be implemented:

- Work to cease in that area to prevent exposure to ground workers and potential contaminants being spread around;
- Notify a Geo-Environmental Consultant, to attend site and sample material;
- Notify the Environmental Health Department / Contaminated Land Officer(s) of Arun District Council;

If the nature and extent of the contamination is unmanageable under the procedure set out above, then a suitable management, mitigation or remediation procedure will be agreed with the CLO. However, this is considered unlikely at this particular site.

13.4 Asbestos

Although screening has revealed no asbestos to be present within the samples analysed from exploratory holes undertaken, it cannot be guaranteed that asbestos is not present within the soils across the remainder of the site. Consequently, we would recommend that a watching brief be adopted with regards to the site for the potential of finding any Asbestos Containing Materials (ACMs). If any ACMs are identified these need to be dealt with accordingly in relation to the Hazardous Waste Regulations 2005.

13.5 Services

New services, in particular potable water supply pipework is likely to be required as part of the redevelopment of the site. Therefore, it is recommended that the local water board are contacted to determine their specifications for the type of pipework which should be used on this site, by providing them a copy of this report and accompanying appendices which contains the results of laboratory testing undertaken on soil samples taken from the site.

All services and in particular potable water supply pipework should comprise of material that is resistant to attack and degradation to chemical attack.

Further information can be found within the published guidance for the '*Selection of Water Supply Pipes to be used in Brownfield Sites*', issued in January 2011 by the UK Water Industry Research (UKWIR), this supersedes the Water Regulations Advisory Scheme (WRAS) Information and Guidance Note – '*Laying Pipes in Contaminated Land*' which has been withdrawn.

13.6 Surface Water

It should be noted that the Environment Agency does not recommend that soakaways be placed within Made Ground, potentially contaminative land or in ground previously identified as contaminated.

13.7 Installed Boreholes

The boreholes which have been installed may be required to be decommissioned in accordance with the EA guidance document '*Decommissioning Redundant Boreholes and Wells*'.

This should be undertaken once appropriate consultation has been concluded within the relevant consultees.

13.8 Verification Reporting

It is recommended that you confirm with the relevant environmental consultees whether they require a validation and/ or closure report providing documentation/ audit trail for the completion of any remediation/ mitigation works completed on site.

If a verification Report is required it should include, but not be limited to, the following:

- Site visit records and photographic records from the watching brief;
- Site visit records and photos from visits completed by a Geo-Environmental Consultant;
- Duty of care records for disposal of waste material including the landfill site(s) or disposal facility where the material has been disposed and a copy of the Contractor's current waste carrier's licence (to be provided by Contractor);
- Records and test certificates relating to the management and disposal or unforeseen contaminants and/ or ACMs (if any);
- Details of source and chemical test results for imported materials; and
- Confirmation of water supply pipe materials installed.

13.9 Report Submission

This report should be submitted to Arun District Council at the earliest opportunity to seek their acceptance of the findings of this report.

14.0 Limitations

YE have prepared this report with all reasonable skill, care and diligence. The work undertaken to provide the basis of this report comprised a study of available documented information from a variety of sources.

The opinions given in this report have been dictated by the finite data on which are they based and are relevant only to the purpose for which the report was commissioned.

Information reviewed should not be considered exhaustive and has accepted in good faith as providing true and representative data with respect to site conditions. Should additional information become available which may influence the opinion expressed in this report, YE reserves the right to review such information and, if warranted, to alter the opinions accordingly.

It should be noted that any risks identified in this report are perceived risks based on the information reviewed.

The recommendations contained in this report represent our professional opinions. These opinions were arrived at in accordance with currently accepted industry practices at this time and as such is not a guarantee that the study site is free of hazardous conditions.

This report has been prepared solely for the use of the named client, and may not be relied upon by other parties without written consent from YE. YE disclaims any

responsibility to the client and others in respect of any matters outside the agreed scope of the work.