Land Quality Investigation Novartis Horsham

NOVARTIS PHARMACEUTICALS UK LIMITED

Further Land Quality Investigation Novartis Horsham

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Executive Summary

Jacobs (formerly SKM / SKM Enviros / Enviros Consulting) was commissioned by Novartis Pharmaceuticals UK Limited (Novartis) in May 2014 to undertake further Land Quality Assessment (LQA) of their Horsham Campus in support of site decommissioning. The objectives of this further LQA were; to supplement previous investigations to enable Novartis to supply the required level of information to decommissioning contractors and potential purchasers and to support radiological investigations by Aurora Health Physics Limited (Aurora) as part of Novartis' process for surrendering its permits issued under the Environmental Permitting (England and Wales) Regulations 2010 (EPR10).

Methodology

The further LQA by Jacobs comprised;

- The completion of twenty four exploratory positions by hand digging / drilling and the collection of soil samples for chemical analysis;
- The completion of radiological on site monitoring of soil and radiological laboratory analysis of soil and water samples by Aurora from selected exploratory positions close to the drainage system and former incinerator; and
- The revision of the previous risk assessment (SKM report 2013 – Ref. 2) based on the findings of the 2014 further investigation and the provision of advice and recommendations to mitigate risk to decommissioning / construction workers and end users of a commercial industrial and residential developed site.

Findings of 2014 Further Investigation

The following potentially unacceptable contamination sources were identified in made ground in this further investigation:

1. Anomalous elevated lead concentration in single sample (in sub-base beneath existing car park)
2. Widespread marginally elevated benzo(a)pyrene
3. Localised suspect asbestos cement (single sample) and asbestos fibres (2 samples). Overall the further investigation found asbestos in 2 out of 24 positions.

As in previous investigations, the 2014 further investigation found no evidence of radiological contamination associated with drain leakage at the site.

Revision of Risk Assessment

As a result of the contamination sources identified, the risk posed by made ground to decommissioning / construction workers was increased from moderate / low to moderate and the risk posed by made ground to end users of a future residential site was increased from moderate / low to moderate with localised high risk. These changes reflected a change in the site conceptual model (from proposed residential development in part of site to potential residential development anywhere on the site) and the finding of additional asbestos and localised lead. The benzo(a)pyrene concentrations recorded were consistent with previous investigations and therefore did not change the risk assessment.

Comment and Recommendations

With appropriate health and safety protection measures, the risks identified to decommissioning / construction workers can be reduced to acceptably low for all sources. The measures need to ensure that there is no direct contact with the ground (such as wearing gloves and overalls, using a breathing mask if dust mobilised, avoid eating or drinking in the work area and washing hands) and that appropriate precautions are taken with respect to possible asbestos. In addition, although elevated radioactivity has not been detected in ground near to drainage, it is recommended that specialist advice is sought from a Radiation Protection Advisor (RPA) if work is carried out either directly on the drainage or nearby. It is possible that the RPA will require health physics support for this work.

If decommissioning or redevelopment requires the removal of fuel storage, electricity sub-stations and drainage facilities, verification soil sampling will be required and any localised contamination identified may require remediation. Remediation of asbestos and lead, and potentially benzo(a)pyrene, may also be required for residential redevelopment.

In addition, based on the findings of the previous 2013 investigation (Ref. 2), supplementary gas monitoring to confirm the gas regime will be required in any new development, and depending on the results, gas protection measures may need to be incorporated into the new construction.

Important note about your report

The sole purpose of this report and the associated services performed by Jacobs is to further assess land quality at the Novartis Horsham site in accordance with the scope of services set out in the contract between Jacobs and Novartis Pharmaceuticals UK Limited (Novartis). That scope of services, as described in this report, was developed with Novartis.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by Novartis and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report from information sourced from Novartis (if any) and/or available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context.

The constraints and limitations of the site investigation were agreed with Novartis to enable them to satisfy their wider operational and decommissioning objectives.

This report has been prepared on behalf of, and for the exclusive use of, Novartis, and is subject to, and issued in accordance with, the provisions of the contract between Jacobs and Novartis Pharmaceuticals UK Limited. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

1. Introduction

Jacobs (formerly SKM / SKM Enviros / Enviros Consulting) was commissioned by Novartis Pharmaceuticals UK Limited (Novartis) in May 2014 to undertake further Land Quality Assessment (LQA) of their Horsham Campus in support of site decommissioning. The location of the site 1.1km to the north-east of Horsham town centre is shown on Figure 1. The site, which has been used for pharmaceuticals research, development and manufacture since 1939, has recently ceased operations and has entered a decommissioning phase.

1.1 Objectives

The objectives of the work were to:

- Supplement previous investigation data from 2008 (Ref. 1) and 2013 (Ref. 2), to enable Novartis to supply the required level of information to decommissioning and demolition contractors and potential purchasers;
- Support radiological investigations by Aurora Health Physics Limited (Aurora) as part of Novartis' process for surrendering its permits issued under the Environmental Permitting (England and Wales) Regulations 2010 (EPR10); and
- Provide advice on possible residual contamination that could impact on Novartis' 'No Legacy' corporate policy and to identify any remediation required.

1.2 Methodology

The LQA completed by Jacobs comprised targeted supplementary investigation at locations on the site not previously investigated in 2013, followed by data assessment. The locations included positions close to the drainage system and in particular near sections of drain which had previously been repaired.

- The intrusive investigation was undertaken by Jacobs, in collaboration with Aurora, between the 7th and 14th July 2014. The investigation comprised the completion of twenty four exploratory positions using a combination of hand digging (service pits to 1.2m) and drilling by Terrier Mini Percussion sampling rig / Pioneer Rotary drilling rig and the collection of soil samples for chemical analysis. Follow on drilling was carried out at eight of the positions, while hand digging only was completed at the remaining sixteen;
- Radiological on site monitoring of soil and radiological laboratory analysis of soil samples was completed by Aurora from selected exploratory positions close to the drainage system and former incinerator.
- Groundwater was collected by Jacobs from existing boreholes WS18 and 44 (installed by Jacobs in 2013) and passed to Aurora for laboratory radiological analysis.
- A generic quantitative risk assessment was undertaken on the chemical data collected to assess the significance of any potential contamination identified. The 2013 qualitative risk assessment (Ref. 2) was then revised based on the findings of the 2014 further investigation in order to re-assess the significance of any potential contamination identified to construction workers, end users of a future commercial / industrial and residential site and any identified sensitive environmental receptors.

1.3 Framework for Contaminated Land Assessment

Contaminated land risk assessment is based on development of a conceptual model for the site. This model is a representation of the relationship between contaminant sources, pathways and receptors developed on the basis of hazard identification. Risk assessment is the process of collating known information on a hazard or set of hazards in order to estimate actual or potential risks to receptors. The guiding principle behind this approach is an attempt to establish connecting links between a hazardous source, via an exposure pathway to a potential receptor, referred to as a 'contaminant linkage'. If there is no linkage, then there is no risk. Therefore, only where a viable contaminant linkage is established does this assessment go on to consider the level of risk.

This approach is in accordance with the Department for the Environment Food and Rural Affairs (DEFRA) Statutory Guidance on Contaminated Land (Ref. 3) and the DEFRA / Environment Agency (EA) Model Procedures (Contaminated Land Report 11 - CLR11, Ref. 4). The risk assessment undertaken in this document

comprises a 'preliminary risk assessment' and a 'generic quantitative risk assessment' in the terminology used in CLR11.

1.4 Structure of Report

This report is structured as follows:

- Chapter 2: Site background, summary of previous investigations, rationale for further investigation, design and methodology for further investigation.
- Chapter 3: Description of ground conditions encountered and assessment of chemical and radiological contamination (generic quantitative risk assessment);
- Chapter 4: Revision of environmental risk assessment to re-assess the significance of contamination identified at the site (qualitative risk assessment);
- Chapter 5: Conclusions and recommendations with respect to the land use scenario and re-development proposals; and
- Chapter 6: List of References

This report should be read in junction with Jacobs (formerly SKM) previous land quality report in 2013 (Ref. 2).

1.5 Limitations

Whilst this report contains useful land quality information and data in relation to potential redevelopment of part of the existing site for residential use, Jacobs consider it likely that supplementary / additional land quality data would be required to support specific development proposals.

2. Site Background and Further Investigation Design

2.1 Site Description

The site is located 1.1km to the north-east of Horsham town centre in Sussex (Figure 1) and covers an area of approximately eight hectares. The site is bounded by railway lines to the east and west, Wimblehurst Road to the north and residential land to the north-east. The site is bisected by Parsonage Road. The current layout of the site is shown on Figures 2 and 3 (except for some buildings which have been demolished including T1, 45 and 46). The site comprises areas of hardstanding and grass cover and numerous buildings used for pharmaceutical related activities; research, administration, manufacture and warehousing. The eastern boundary of the site slopes up steeply to the adjacent railway line, while the area of the site occupied by buildings is flat. All the pharmaceutical related buildings are found to the south-west of Parsonage Road, while north-east of the road is car parking and a sports pavilion. The buildings are of various ages, the earliest dating from 1939. The oldest buildings on site (including buildings 11, 15, 18 and 21) are known to have originally contained asbestos containing material (ACM), the current status of which are identified in the site asbestos and mark-and-manage registers.

At the time of the further investigation, all operations other than administration and maintenance, had ceased at the site.

2.2 Previous Investigations

Jacobs are aware of the following previous land quality investigations at the site:

1) Phase 1 / Desk Study completed by Enviros Consulting in May 2006 (Ref. 5)

   The study identified the pharmaceutical works and an infilled clay pit as potential contamination sources.

2) Phase 2 Intrusive Investigation completed by Enviros Consulting in March 2008 (Ref. 1)

   The investigation comprised the drilling of seven window sample boreholes and targeted the infilled clay pit, possible migration from an off-site oil depot (to east) and on site solvent and fuel storage. Fourteen soil samples were chemically analysed and elevated levels of contamination with respect to commercial / industrial generic assessment criteria (GAC) were recorded in a single sample (elevated lead). Soil was monitored on site for radiation (using an EP 15 probe for beta and gamma radiation) and radiation was not recorded above background levels. Recommendations were made with respect to ground gas risk in confined spaces, further assessment of radioactivity around drains and the potential migration of contamination from off-site sources (e.g. railway and oil depot).

3) Targeted Investigation into potential leaks from drains completed by Enviros Consulting in October 2008 (Ref. 6).

   The investigation comprised the drilling of six window sample boreholes and targeted soil within 3m of known fissures in pipework. Soil was monitored on site for radiation (using an EP 15 probe for beta and gamma radiation) and radiation was not recorded above background levels. Six soil samples were chemically analysed for inorganic and organic determinands, and for selected radionuclides known to have been discharged from buildings 18, 38 and 42 (tritium - ^{3}H, Carbon 14 - ^{14}C, Iodine 125 - ^{125}I). The chemical analysis results indicated no exceedences of inorganic or organic determinands with respect to GAC for a commercial industrial setting. The measured radioactivity of ^{3}H, ^{14}C, ^{125}I were below detection limits. The investigation therefore identified no significant additional risk to workers laying new foul sewerage pipework in soils 3m from the existing pipes.

4) Gap Analysis and Phase 2 LQA completed by SKM in May and June 2013 (Ref. 2).

   The LQA comprised a gap analysis of existing information followed by a targeted phase 2 / intrusive investigation of potentially significant sources of chemical and radiological contamination that were identified in the gap analysis. The intrusive investigation of potential contamination sources was undertaken by SKM between the 13th and 24th May 2013, with follow on groundwater and ground gas

monitoring completed on the 4th and 11th June 2013. Potential contamination sources investigated included made ground (including in vicinity of previous demolished buildings), former and current fuel storage and electricity sub-stations, an infilled former clay pit, foul drainage, the former incinerator and off-site fuel storage and railways. The investigation comprised fifty four exploratory positons using a combination of hand digging and windowless sampling drilling rig.

For current and future pharmaceutical use, all risks were defined as low with the single exception of ground gas where a low to moderate / low risk was defined due to the measurement of localised elevated methane and carbon dioxide. It was recommended that additional monitoring and assessment was carried out to constrain this potential risk. For potential future residential use, moderate / low risks were defined with respect to all the identified contamination sources which reflected the presence of marginally elevated levels of organic contamination in the made ground and the potential for residual contamination when / if fuel storage facilities and / or drainage are removed.

2.3 Rationale for Further Investigation

Proposals for the future use of the site are not known at the time of writing but could include continued commercial industrial use and / or future residential use. However, decommissioning of the site will be carried out and it is understood this will include the demolition and removal of at least some of the buildings and infrastructure (note – decommissioning will need to be consistent with Novartis' 'No Legacy' corporate policy, but will also be appropriate for future use / development proposals i.e. it is possible that some infrastructure such as the new boiler house could be retained). Decommissioning also needs to satisfy the requirements of regulators for permit surrender (such as permits issued under EPR10 for the use and discharge of radionuclides).

It is envisaged that a phased approach will be required for the assessment and potential mitigation of ground contamination during the decommissioning of the site. This approach needs to be flexible and dependent on the future use proposals for the site. The first stage of further land quality investigation required comprises the investigation of ground not previously assessed, the investigation of soil in close proximity to drainage (which until earlier this year discharged water containing radionuclides) and the investigation of soil at the location of the infilled clay pit and former incinerator (where residual radiological contamination is possible). This further investigation will satisfy the objectives detailed in section 1.1:

- to increase confidence in understanding of land quality of the site in order to supply the required level of information to decommissioning and demolition contractors and potential purchasers;
- to support radiological investigations by Aurora as part of Novartis' process for surrendering its permits issued under EPR10; and
- to provide advice on possible residual contamination that could impact on Novartis' 'No Legacy' corporate policy and to identify any remediation required.

2.4 Design and Methodology of Further Investigation

The investigation was designed and implemented in accordance with the principals set out in the British Standard BS10175:2011 for the investigation of potentially contaminated sites (Ref. 7). In the terminology of this British Standard, the investigation comprised '*targeted (judgmental) sampling at locations selected on the basis of the conceptual model that are known or suspected to be sources of areas of contamination*.'

The design of the investigation was to target made ground not previously investigated and to target locations of potential radiological risk (soils in close proximity to drainage where repairs have been carried out, soil underlying the former incinerator and soil at the infilled former clay pit). In addition, two locations were selected away from potential radiological sources as controls. Aurora also required two groundwater samples to assess radiological impact and therefore two existing boreholes from the previous phase of investigation in 2013 were selected to collect water samples from.

2.4.1 Scope of works for intrusive investigation

The investigation by Jacobs comprised the completion of twenty four exploratory positions using a combination of hand digging (service pits to 1.2m) and drilling by Terrier Mini Percussion sampling rig / Pioneer Rotary drilling rig and the collection of twenty seven soil samples for chemical analysis. Follow on drilling was carried out at eight of the positions, while hand digging only was completed at the remaining sixteen. Radiological monitoring and the collection of samples for laboratory analysis were completed by Aurora at select positions (close to drainage, former incinerator and infilled pit). The investigation positions close to drainage were drilled to greater than the depth of the drain to ensure potential leaked contamination would be assessed. Soil arisings from the remaining positions were screened by Jacobs using an EP15 probe which screens for beta and gamma radiation (including radionuclide carbon-14). All positions were backfilled with arisings and bentonite and reinstated with concrete / tarmac at the surface in hardstanding areas.

Soil arisings from each hole were carefully examined and logged in general accordance with British Standard BS5930:1999 code of practice for site investigations (Ref. 7) and recorded by an experienced consultant from Jacobs.

Soil samples for chemical analysis were collected by Jacobs from the arisings using a stainless steel trowel. All sampling equipment was cleaned between samples to minimise the potential for cross-contamination. Visible dirt was removed from the stainless steel trowel after the collection of each sample and if further cleaning was necessary the trowel was also washed with deionised water. Soil samples were placed in clean sample containers provided by the laboratory, appropriate for the analytical suite. Samples were then dispatched to i2 Analytical Ltd by courier for chemical analysis of selected samples.

Water samples were collected by Jacobs from two existing boreholes from the 2013 investigation (Ref. 2) using dedicated disposable plastic balers. The standard practice is to purge each borehole of water with three times the well volume prior to sampling. However, on this site, there was insufficient groundwater for recharge and therefore grab samples were collected from each borehole without purging.

Details of Aurora's radiological monitoring and laboratory radiological analysis and interpretation is included in their separate report (Ref. 8) which is appended (Appendix A).

All exploratory positions from the previous 2013 investigation and this recent further investigation are shown on Figures 2 and 3. The identification, location, purpose and monitoring / screening of / at each new exploratory position in the further investigation are detailed in the following table.

Table 2.1 Exploratory Position Explanations

Potential Source Targeted	Exploratory Position ID (drilling method)	Location	Jacobs monitoring & sampling	*Aurora monitoring & sampling
Former incinerator (potential radiological and chemical contamination)	WS46 (hand dug)	Beneath former incinerator building (Building 27)	Soil sample WS46 0.5-0.6m	Radiological site monitoring, two solid samples for radiological laboratory analysis
Former clay pit – infilled (potential radiological and chemical contamination)	WS47, WS49 (hand dug)	Southern corner of site	Soil samples WS47 0.6-0.7m & WS49 0.6-0.7m	Radiological site monitoring, two solid samples for radiological

				laboratory analysis from WS49
Drainage System (potential radiological and chemical contamination)	WS50, 51, 51A, 52, 53, 54, 55, 56 (hand dug, windowless sample drilling except WS51 – rotary drilling follow on)	West side of site close to drains (see Figures 2 & 3)	Soil samples WS50 0.5-0.6m, WS51 0.1-0.2m, WS52 0.5-0.6m, WS53 0.1-0.2m, WS54 0.3-0.4m, WS55 0.3-0.4, WS55 0.5-0.6m, WS56 0.3-0.35m	Radiological site monitoring, two solid samples for radiological laboratory analysis from each of WS50, WS51, WS52, WS53, WS54, WS55 & WS56
Radiological background (away from drainage, incinerator and former clay pit)	WS57, WS58	South (WS57) and north (WS58) of Building 15	Soil samples WS57 0.9-1m, WS58 0.3-0.4m	Radiological site monitoring, two solid samples for radiological laboratory analysis from each of WS57 & WS58.
Made ground (locations not previously investigated) (potential chemical contamination)	WS59, WS60, WS60A, WS61, WS62, WS63, WS65, WS68, WS69, WS70, WS71 (hand dug) (also all exploratory positions in rows above targeted made ground)	Site wide (see Figures 2 & 3)	Soil samples WS59 0.2-0.25m, WS59 0.3-0.4m, WS60A 0.4-0.5m, WS61 0.3-0.4m, WS61 0.6-0.7m, WS62 0.1-0.2m, WS62 0.5-0.6m, WS63 0.2-0.3, WS65 0.2-0.3m, WS65 0.5-0.6m, WS68 0.3-0.4m, WS69 0.3-0.4m, WS70 0.7-0.8m, WS71 0.1-0.2m. EP15 radiological monitoring all arisings.	None.
Potential radiological contamination in groundwater	BH18 & 44 from 2013 investigation (Ref. 2)	See Figures 2 & 3	Collected one water sample from BH18 and two water samples from BH44.	Water samples dispatched for radiological laboratory analysis

3. Description of Ground Conditions and Assessment of Chemical and Radiological Contamination

3.1 Ground Conditions Encountered

The design of the investigation was to target made ground and shallow potential radiological contamination sources (such as the drainage) and therefore the ground conditions encountered were shallow to a maximum depth of 4.2m below ground level (bgl). The ground conditions encountered comprised made ground and Upper Tunbridge Wells Sand. Detailed logs are appended to the report in Appendix B and a selection of photographs are included in Appendix C.

Anthropogenic materials in the made ground included brick and concrete, and rare rusted metal wire, plastic sheeting, charcoal, clinker and glass. One piece of suspected asbestos cement material (ACM) was noted at 0.25-0.7m in WS61. The only visual indications of potential chemical contamination were black / dark staining but no odour at 0.3-0.4m in WS55 and at 0.3-0.35m in WS56 and rare black staining at 0.4-0.6m in WS62.

The Upper Tunbridge Wells Sand comprised light brown and blue-grey slightly clayey SILT and light brown and blue grey slightly gravelly SILT to grey / light blue grey – orange brown SILT.

3.2 Chemical and Radiological Contamination Assessment

Selected soil samples obtained during the investigation were scheduled for analysis for a range of determinants. Copies of the laboratory certificates are supplied in Appendix D.

3.2.1 Chemical Data Assessment for Human Health

Methodology

The data has been assessed against generic assessment criteria (GAC) for risk to human health. Where available and applicable the GACs are equal to the Soil Guideline Values (SGVs) published by the Environment Agency. However SGVs are only available for a limited number of contaminants and where published they apply to a limited range of land uses and soil organic matter (SOM) content. Jacobs has thus extended their GACs to include a range of SOM and land uses not covered by the Environment Agency. In addition, Jacobs has extended the range of contaminants assessed to include some contaminants with no SGV. A methodology for the derivation of GACs is provided in Appendix E.

The future land use of the site is not known but for the purpose of this assessment it is assumed that it could be either or both of residential with plant uptake and commercial industrial. Therefore, for the purpose of this Tier 1 assessment, all the data from this further investigation has been compared with GACs for residential use with plant uptake and for commercial / industrial use.

For this Tier 1 assessment, a conservative approach with respect to soil organic matter (SOM) has been chosen and GACs based on 1% SOM have been used.

Consideration has been given to the most appropriate method of grouping the data. This can include separating data spatially or by the different types of strata which underlie the site. This is because different types of contaminants may be associated with particular historical activities or with different geological units. In this case the data has not been sub-divided as the samples were taken site wide from made ground.

Data Assessment

A full Tier 1 assessment of the data is presented in Appendix F. None of the determinands analysed were recorded above commercial industrial GACs. Only arsenic, lead and three of the poly-aromatic hydrocarbons,

were recorded at concentrations above the GAC for residential use with plant uptake, as shown in the table below.

Table 3.1 Determinands with one or more exceedences of GAC for residential with plant uptake use

Determinand	Number of Samples	Residential with plant uptake	Minimum	Maximum	Location of Maximum	UCL95	Normality
Arsenic	27	32 (1)	5.1	48	48mg/kg at WS68 at 0.30-0.40m	17.7	Data not Normally distributed - Shapiro-Wilks W statistic of 0.539 < Wcrit of 0.923
Lead	27	200 (2)	11	1200	1200mg/kg at WS68 at 0.30-0.40m	281 (93.8 if maximum removed)	Data not Normally distributed - Shapiro-Wilks W statistic of 0.328 < Wcrit of 0.923
Benzo(a)anthracene	27	4.5 (2)	< 0.10	6.3	6.3mg/kg at WS70 at 0.70-0.80m	2.25	Data not Normally distributed - Shapiro-Wilks W statistic of 0.61 < Wcrit of 0.923
Benzo(a)pyrene	27	0.83 (10)	< 0.10	6.8	6.8mg/kg at WS70 at 0.70-0.80m	2.67	Data not Normally distributed - Shapiro-Wilks W statistic of 0.59 < Wcrit of 0.923
Chrysene	27	6 (1)	< 0.05	6.9	6.9mg/kg at WS70 at 0.70-0.80m	2.59	Data not Normally distributed - Shapiro-Wilks W statistic of 0.631 < Wcrit of 0.923

All units mg/kg, values in brackets indicate the number of locations where GACs are exceeded. GACs based on 1% Soil Organic Matter.

Arsenic was recorded above the GAC in a single sample. Statistical assessment of arsenic calculates a Chebyshev 95% Upper Confidence Limits (UCL95) of 17.7mg/kg, which is significantly below the GAC of 32 mg/kg. The arsenic concentrations recorded in this data set are therefore considered to pose an acceptable risk in a residential use scenario.

In the case of lead, there is a single anomalously elevated concentration (1,200mg/kg in WS68 at 0.3-0.4m) which can be considered an outlier. The next highest concentration recorded was 290mg/kg, which is only marginally elevated relative to the residential with plant uptake GAC. If the highest concentration of 1,200mg/kg is removed from the dataset, statistical assessment of lead calculates a Chebyshev 95% Upper Confidence Limits (UCL95) of 93.4mg/kg, which is significantly below the GAC of 200mg/kg. It is noted that the maximum for lead is the same sample as the maximum for arsenic (WS68 0.3-0.4m). Made ground at the location of the maximum recorded lead and arsenic concentration is described as black sandy cobbly fine to coarse gravel of brick, concrete and occasional clinker (sub base / gravel fill). The material described is only 250mm thick, and directly underlies concrete and overlies Upper Tunbridge Wells Sand. The material is located beneath the current car park between Buildings 3 and 18.

Benzo(a)pyrene is considered an appropriate marker compound for the PAHs. The table above shows that benzo(a)pyrene was recorded above the residential with plant uptake GAC in ten out of the twenty seven samples analysed. Statistical assessment of benzo(a)pyrene calculates a Chebyshev 95% Upper Confidence Limits (UCL95) of 2.67mg/kg, which is marginally above the GAC of 0.83mg/kg. It is noted however, that the UCL95 is below the new Category 4 Screening Level (C4SL) for benzo(a)pyrene of 5mg/kg which is considered to represent a concentration below which the level of risk is acceptably low (Ref. 9). The new approach represents a change from minimal risk to human health (as with existing GACs based on CLEA methodology) to low risk to human health.

3.2.2 Asbestos

A piece of suspect ACM was observed in 0.25-0.7m in WS61. The ACM was identified by analysis as amosite hard cement type material. Asbestos fibres were reported in two out twenty seven samples analysed; amosite loose fibres reported in WS54 0.3-0.4m and WS61 0.6-0.7m. WS61 is located to the north of Building 15, while WS54 is located to the north of Building 18.

3.2.3 Radiation Screening and Radiological Analysis

No above background readings were recorded during screening of arisings by Jacobs for radioactivity using an EP15 probe.

The results of extensive monitoring of arisings and laboratory analysis by Aurora is reported separately in their report (Ref. 8). The Aurora report is included in Appendix A. Aurora reported that '*high resolution gamma spectroscopy (HRGS) and tritium and carbon-14 combustion analysis of samples obtained during the works recorded values below the out of scope levels stated in the EPR10, demonstrating that no radiological contamination of the ground is present*'. They further stated that the results were consistent with background control samples taken from the site.

4. Revision of Conceptual Model and Risk Assessment

4.1 Conceptual Site Model

The following section outlines the principal findings from the recent further investigation and describes any resultant changes to the conceptual site model (CSM) presented in the 2013 report (Ref. 2).

4.1.1 Contamination Sources

The following potentially unacceptable contamination sources have been identified in this further investigation:

1. Anomalous elevated lead concentration in single sample significantly above residential GAC (in sub-base beneath existing car park)

   There were no exceedences of the lead GAC in the 2013 investigation (Ref. 2) and therefore this localised exceedence in the 2014 further investigation constitutes a new contamination source.

2. Widespread marginally elevated benzo(a)pyrene above residential GAC (although UCL95 2.67mg/kg is below new C4SL)

   The recent 2014 investigation findings of elevated benzo(a)pyrene in 10 out of 27 samples (maximum 6.8mg/kg, UCL95 2.67mg/kg) are consistent with findings in the 2013 investigation where elevated benzo(a)pyrene was recorded in 9 out of 42 made ground samples (maximum 14mg/kg, UCL 2.85mg/kg) (Ref. 2). The further 2014 investigation has therefore confirmed this contamination source (widespread marginally elevated PAHs), previously identified in 2013.

3. Localised suspect asbestos cement (single sample) and asbestos fibres (2 samples). Overall the further investigation found asbestos in 2 out of 24 positions (fibres were found at the same location as the asbestos cement piece).

   The further 2014 investigation findings are consistent with findings in the 2013 investigation where suspect asbestos cement was identified in 2 samples and asbestos fibres in 3 samples (amosite and chrysotile) out of a total of 54 exploratory positions (Ref. 2). The further 2014 investigation has therefore confirmed the presence of rare asbestos in the made ground, previously identified in 2013.

As in the 2013 (Ref. 2) and the 2008 drainage (Ref. 6) investigations, the 2014 further investigation found no evidence of radiological contamination (3H and 14C) associated with drain leakage at the site.

4.1.2 Pathways

Pathways identified and presented in the 2013 report (Ref. 2) remain unchanged as a result of the 2014 further investigation.

4.1.3 Receptors

When the site was assessed in 2013 (Ref. 2), there was an understanding that the north western end of the site was to be redeveloped for residential use while the remainder of the site would be retained for commercial industrial use. These proposals have changed and Jacobs has been asked to assess the site on the basis of potential residential and / or commercial industrial redevelopment and / or continued use across the whole site. The CSM is therefore changed to reflect the possibility of residential end use anywhere on the site.

4.2 Revision of 2013 (Ref. 2) Risk Assessment

The qualitative risk assessment completed in 2013 is reassessed in light of the findings from the recent further investigation. The following revisions have been made:

- The risk posed by made ground, and associated contamination, to users of a future residential site is increased from moderate / low to **moderate with localised high risk**. The increase in risk from moderate / low to moderate is driven by the confirmation of the presence of rare asbestos (at 7 out of 78 exploratory positions over both investigations) and the change in the conceptual site model, where residential development might now take place anywhere on the site (at the time of the previous 2013 report, only a part of the site was identified for residential use and no asbestos had been identified in that area). Therefore, although asbestos material has been observed, and asbestos fibres detected, in relatively few exploratory positions and samples, the new data together with the revised conceptual model with respect to residential development, result in an increased likelihood of exposure to asbestos and therefor a higher risk to end users. The localised high risk is driven by the presence of anomalously high lead concentration at one location.
- The risk posed by made ground, and associated contamination to construction workers (including demolition and ground workers for proposed demolition and site re-profiling works) is increased from moderate / low to **moderate** risk due to the findings of additional, albeit still rare, asbestos at the site.

The risk posed by drainage to maintenance / construction workers and future residential users remains moderate / low. Although the radiological survey by Aurora found no evidence of residual radiological contamination in ground close to the drainage and there is no longer any discharge from building 42, it is considered possible that minor localised chemical contamination associated with the drainage may remain.

The results of the revised risk assessment are shown in the following table.

Contaminant Sources	Receptors				
	Current & Future Commercial Industrial Users	Maintenance, Construction Workers	Future Residential Users	Groundwater	Surface Water
Made ground across site incl former clay pit (widespread marginally elevated PAHs, rare asbestos, localised elevated lead)	Low	Moderate	Moderate (Localised High*)	Low	Low
Made Ground (ground gas)	Low to Moderate / Low			-	-
Current & former fuel storage & electricity substations – on-site	Low	Moderate / Low	Moderate / Low	Low**	Low**
Drainage system	Low	Moderate / Low	Moderate / Low	Low	Low

* Localised high risk relating to localised lead contamination (single sample)

** Providing fuel storage facilities continue to be well maintained with appropriate leakage protection measures.

5. Conclusions and Recommendations

The further investigation has increased our confidence in the land quality data at the site and the risk posed by made ground to maintenance / construction workers and future residential users has been increased to moderate. This revision reflects the changed conceptual model (potential residential over the whole site not just one area) and the identification of rare asbestos and localised lead. The investigation found no evidence of radiological contamination (3H and 14C) associated with drain leakage at the site.

On the basis of the findings of the 2013 (Ref. 2) and 2014 investigations and the current decommissioning and redevelopment proposals (possible commercial industrial and or residential use), the following comments and recommendations are made.

5.1 Decommissioning / Redevelopment

5.1.1 Mitigation of Risk to Maintenance / Decommissioning / Construction Workers

Moderate to moderate / low risks from contamination sources to maintenance / decommissioning / construction workers have been derived. With appropriate health and safety protection measures, these risks can be reduced to acceptably low for all sources. The measures need to ensure that there is no direct contact with the ground (such as wearing gloves and overalls, using a breathing mask if dust mobilised, avoid eating or drinking in the work area and washing hands) and that appropriate precautions are taken with respect to possible asbestos. In addition, although elevated radioactivity has not been detected in ground near to drainage, it is recommended that specialist advice is sought from a Radiation Protection Advisor (RPA) if work is carried out either directly on the drainage or nearby. It is possible that the RPA will require health physics support for this work. Appropriate assessments should also be made and precautions taken for any staff working in confined spaces in light of the localised ground gas exceedences reported in Ref. 2.

5.1.2 Commercial Industrial Use

No significant constraints were identified for commercial industrial continued use at the site. With the exception of a moderate / low risk from ground gas, all risks were identified as low. However, it is possible that localised contamination associated with fuel storage, electricity sub-stations and drainage will be identified when / if these facilities are removed. During decommissioning / redevelopment, verification soil sampling will be required following the removal of these facilities and any localised contamination identified may require remediation. With respect to ground gas, supplementary gas monitoring to confirm the gas regime will be required in any new development, and depending on the results, gas protection measures may need to be incorporated into the new construction.

Consideration as to the waste definition of material excavated and reused on site during the re-profiling of the site should also be made. This is best achieved by adherence to and implementation of the CLAIRE Code of Practice for the Definition of Waste (Ref. 10).

5.1.3 Residential Use

Potentially unacceptable risks to end users identified include widespread marginally elevated benzo(a)pyrene, rare asbestos and localised elevated lead in the made ground. Further investigation and assessment should be carried out with respect to a specific development layout and it is possible that garden areas may require the placement of a clean soil cover layer to protect end users from benzo(a)pyrene. However, in light of the new Category 4 Screening Levels (C4SL), it is also possible that the existing concentrations of benzo(a)pyrene may be considered acceptable by regulators. Remediation of asbestos and lead may also be required, depending on the distribution of these contaminants and whether they are located in soft standing areas.

As in the case of industrial commercial development, verification soil sampling will be required following the removal of fuel storage, electricity sub-stations and drainage facilities and any localised contamination identified

may require remediation. The level of remediation required may be greater than with a commercial industrial development due to the more sensitive residential end use. Also, supplementary gas monitoring to confirm the gas regime will be required in any new development, and depending on the results, gas protection measures may need to be incorporated into the new construction.

As in the case of industrial commercial development, consideration as to the waste definition of material excavated and reused on site during the re-profiling of the site should also be made. This is best achieved by adherence to and implementation of the CLAIRE Code of Practice for the Definition of Waste (Ref. 10).

6. References

1) Enviros Consulting Limited, Phase 2 Investigation: Novartis Pharmaceutical, Wimblehurst Road, Horsham, Sussex, March 2008.

2) SKM Enviros, Phase 2 Land Quality Assessment, Horsham, July 2013.

3) Department for Environment, Food and Rural Affairs. Environmental Protection Act 1990: Part 2A, Contaminated Land Statutory Guidance, April 2012.

4) DEFRA/ Environment Agency, Model Procedures for the Management of Land Contamination, CLR11, September 2004.

5) Enviros Consulting Limited, Phase 1 Land Quality Assessment, Novartis, Horsham, May 2006.

6) Enviros Consulting Limited, Drainage Works Site Investigation: Novartis, Horsham, October 2008.

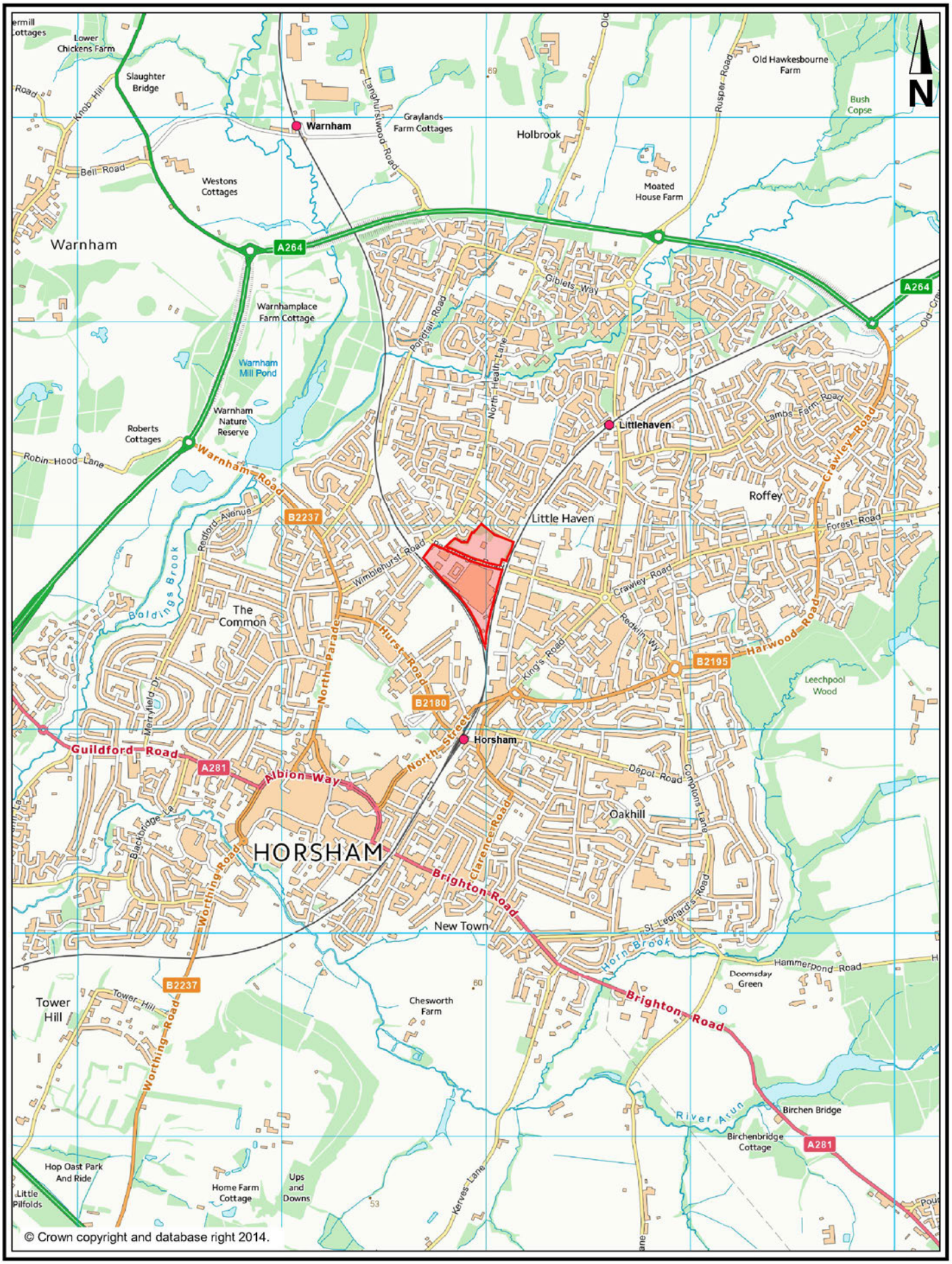
7) British Standards Institution (BSI) BS10175:2011 Investigation of Potentially Contaminated Sites – Code of Practice, March 2011.

8) Aurora Health Physics services Limited, Independent Radiological Ground Investigation at Novartis, Wimblehurst Road, Horsham, September 2014.

9) Defra, SP1010: Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination – Policy Companion Document, March 2014.

10) CLAIRE, the Definition of Waste: Development Industry Code of Practice, Version 2, March 2011.

Figures



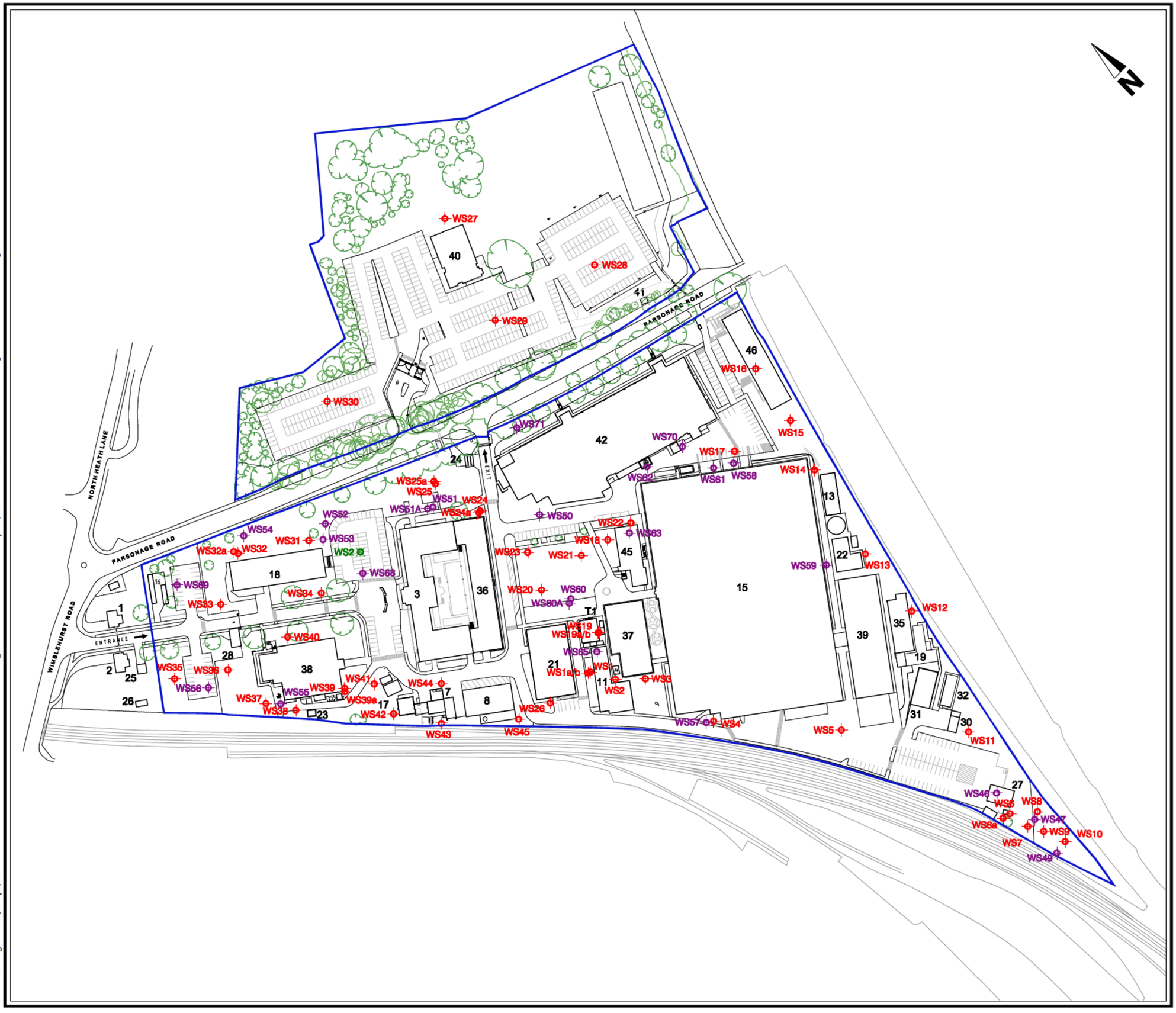
NOVARTIS

JACOBS

SCALE	PROJECT No.
1:25,000 @ A4	KU043500
CONTENT	DRAWN
DA	AJR
CHECKED	DATE
DA	SEPTEMBER 2014

LAND QUALITY INVESTIGATION
NOVARTIS, HORSHAM

FIGURE 1
SITE LOCATION PLAN



KEY:

- Investigation Site Boundary
- Enviros March 2008 Investigation
- Window Sample Location 2013 Investigation
- Window Sample Location 2014 Investigation

46 - 56 Radiological Investigation Positions
46 - 49 Hand Pit/Windows Sample
50 - 56 Hand Pit to Drain Repairs - see 'Foul Drainage Remedial Works' Drawing 4
57 - 57 Background Radiological Positions
18 & 44 Existing borehole to Sample for Radiological Easement
59 - 71 Hand Pit/Window Sample

NOVARTIS

LAND QUALITY INVESTIGATION
NOVARTIS, HORSHAM

FIGURE 2

SITE BASE PLAN WITH
EXPLORATORY HOLE LOCATIONS

SCALE	PROJECT No.
1:2000 @ A3	KU043800
CONTENT	DRAWN
PH	AJR
CHECKED	DATE
DA	SEPTEMBER 2014

JACOBS

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KEY:

- Investigation Site Boundary
- Window Sample Location 2013 Investigation
- Window Sample Location 2014 Investigation

46 - 56	Radiological Investigation Positions
46 - 49	Hand Pit/Windows Sample
50 - 56	Hand Pit to Drain Repairs - see 'Foul Drainage Remedial Works' Drawing 4
57 - 57	Background Radiological Positions
18 & 44	Existing borehole to Sample for Radiological Easement
59 - 71	Hand Pit/Window Sample

0 50 100
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NOVARTIS

LAND QUALITY INVESTIGATION
NOVARTIS, HORSHAM

FIGURE 3

AERIAL PHOTOGRAPH WITH EXPLORATORY HOLE LOCATIONS

SCALE AS SHOWN	*PROJECT No.* KU043500
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Plot date: Sep 16, 2014 - 1:56pm

Appendix A. Aurora Report (Ref. 8)

Independent Radiological Ground Investigation at Novartis, Wimblehurst Road, Horsham.

August 2014

Issue 1

aurora health physics services ltd

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Report Title:	Independent Radiological Ground Investigation at Novartis, Wimblehurst Road, Horsham.
Customer Contact:	Lee Porter, Manager Project Engineering
Address:	Novartis Institutes for Biomedical Research Wimblehurst Rd Horsham West Sussex RH12 5AB
Telephone:	01403 323258
Dates of Survey:	7 – 10 July 2014
Dates of Analysis:	11 – 20 August 2014
Date of Report:	2 September 2014
Report Ref.:	AHP/RPA/NOV/GI/REP/JUL14 – ISSUE 1

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	Name	Position	Date	Signature
Author	Steve Bramley	Senior Health Physicist, Site Manager & Radiation Protection Supervisor (RPS)	02/09/2014	
Reviewer	Glenn Hardcastle	Radiation Protection Adviser (RPA), Radioactive Waste Adviser (RWA)	02/09/2014	

EXECUTIVE SUMMARY

Aurora Health Physics Services Ltd (Aurora) was commissioned by Novartis Institute for Biomedical Research (Novartis) to support SKM / Jacobs to take radiological samples and provide reassurance monitoring during ground investigation works at Novartis, Wimblehurst Rd, Horsham, West Sussex, RH12 5AB.

The purpose of the ground investigation was to ascertain the radiological nature in the local ground environment at the Novartis site following the identification of a number of integrity issues associated with the drainage system which had previously been repaired.

Solid samples of excavated material were obtained from the local vicinity surrounding the areas where integrity issues were identified in the drainage system for subsequent high resolution gamma spectrometry and tritium and carbon-14 combustion analysis. Samples were also taken from other potential areas of interest on the site such as the ground underneath and adjacent to the site where an incinerator was previously located.

Reassurance monitoring during the ground works reported no significant contamination. Subsequent high resolution gamma spectrometry analysis and tritium and carbon-14 combustion analysis of the samples obtained during the works reported values below the out of scope levels stated in the Environmental Permitting (England and Wales) Regulations 2010, indicating that no radiological contamination of the ground is present.

CONTENTS

1. INTRODUCTION

Aurora Health Physics Services Ltd (Aurora) was commissioned by Novartis Institute for Biomedical Research (Novartis) to support SKM / Jacobs to take radiological samples and provide reassurance monitoring during ground investigation works at Novartis, Wimblehurst Rd, Horsham, West Sussex, RH12 5AB.

The work was carried out between 7 July 2014 to 10 July 2014. Samples of excavated material were taken from the immediate vicinity surrounding existing drainage system locations where integrity issues to the system had previously been identified and repaired.

The ground investigation also examined other potential areas of interest on the site such as the ground underneath and adjacent to the site where an incinerator was previously located.

The drains and incinerator had potentially been associated with the historical use of radioactive materials. Liquid samples were also taken from boreholes on site to check the radiological status of the ground water.

The purpose of the ground investigation was to help to determine the radiological status of the site as part of Novartis's process for surrendering its permits issued under The Environmental Permitting (England & Wales) Regulations 2010 (EPR10).

A number of positions of interest close to repairs of the drainage system that had potentially been used as radioactive discharge routes were identified by SKM / Jacobs as shown in Figure 1. The locations highlighted in yellow show the points of radiological interest and those highlighted in pink show the locations of control (background) samples. Detailed images of the sample locations can be found in Appendix 1.

Water samples were also taken from boreholes 18 and 44 for subsequent radiological analysis of the groundwater.

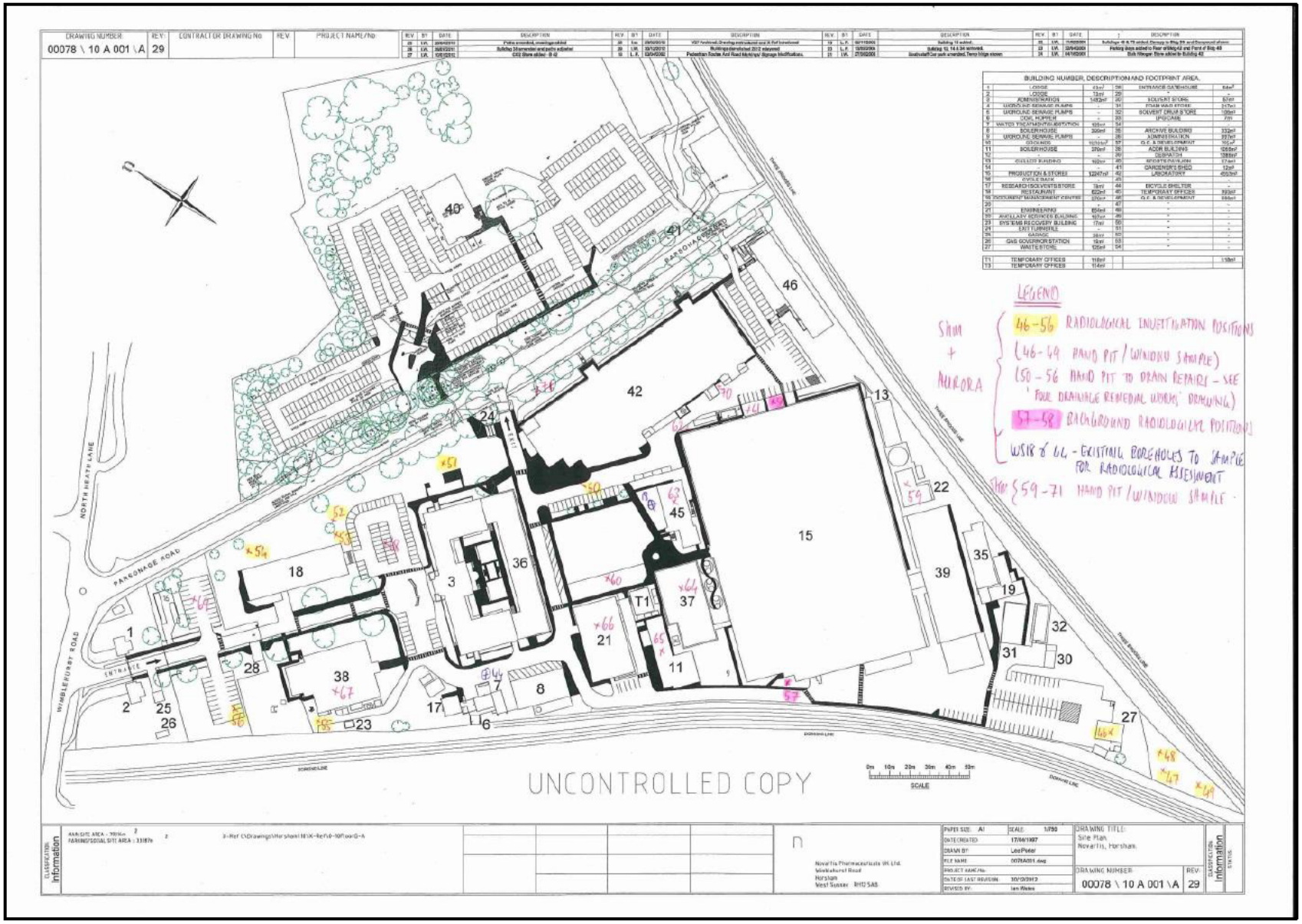

Figure 1: Proposed positions

2. SITE HISTORY & INFORMATION

The drainage system had previously used to dispose aqueous radioactive waste. The drainage system had previously been surveyed and repaired when damage to the integrity of the system had been identified in 2008. The key radioactive materials used in Building 42 and Building 18 at that time included tritium, carbon-14 and iodine-125. Iodine-125 has a 59.4 day half-life and so is unlikely to be present in any significant levels within the drainage system following decay. Further information about the radioactive disposal routes from Building 38 and Building 18 can be found in the Aurora report "Independent Radiological Survey and Sampling of Novartis Buildings B18 and B38 and Associated Drainage Systems, Horsham" – Ref: AHP/RPA/NOV/REP/13/01 dated December 2013.

3. HEALTH, SAFETY & SECURITY

On the morning of 7 July 2014, a site induction was held between Aurora, Novartis and members of the SKM / Jacobs's team to discuss and agree health, safety and security issues associated with the survey work.

Copies of the following Aurora documents were submitted to Novartis and SKM / Jacobs for approval prior to commencing work. The risk assessment and method statement was agreed and signed on 7 July 2014 and the copies subsequently sent to Novartis:

- Aurora Project Health, Safety & Security Questionnaire – AHP/PHSSQ/NOV/GI/JUL 2014;
- Aurora Survey Risk Assessment & Method Statement – AHP/H&S/RAMS/NOV/GI/July 2014.

Scanned copies of the documents were subsequently provided to Novartis.

Novartis access area permit (AAP) No. 23794 was signed off each day before work commenced and a team toolbox briefing was held.

4. REASSURANCE MONITORING

Before excavation started in each location the area was monitored for any elevated radiation levels above background.

Once ground excavation works commenced the Geotechnical Engineering Ltd. personnel's equipment, gloves and boots were continuously monitored by direct probe for reassurance

purposes, to check for any possible radioactive contamination generated from the excavation material.

The instruments in Table 1 were used to carry out this monitoring

Table 1: Instruments used

Instrument	Used For	Serial number	Calibration Date	Background Reading on Site
Thermo Electra BP19	Low Energy Beta Contamination	AHP0093	28/02/2014	6-8 counts per second (cps)
Exploranium GR-135	Gamma Radiation	AHP0053	18/03/2014	50-100 cps
Mini Rad 1000	Radiation Dose Rate	AHP0191	01/05/2014	<0.1μSv/h

The background radiation readings measured on site are provided in Table 1 above. All organic materials contain some level of radioactivity. Naturally occurring radionuclides include the uranium (^{238}U and ^{235}U) and thorium (^{232}Th) decay chains commonly found in soils and rock and radioactive potassium (^{40}K) commonly found in wood, clay and brick. These background levels vary between different materials (e.g. rock and soil) and in different areas of the UK. The background readings for different instruments are detailed in this report as measured on the site however they are also typical of average background levels found throughout the UK.

Indirect surveying was carried out due to the possible presence of low energy beta emitters (tritium and carbon-14). The indirect survey was carried out by taking smears (wipes) of gloves, tools, and the drilling equipment for subsequent liquid scintillation analysis.

5. SOLID SAMPLES

Two solid samples were collected from each location in the immediate vicinity around the repair points on drainage system and the samples taken for subsequent high resolution gamma spectrometry (HRGS) and tritium and carbon-14 combustion analysis. The following list of samples in Table 2 was collected:

Table 2: Sample locations

Sample Id	Location / Depth	Notes
NHO-46 HRGS NHO-46 3H/14C Combustion	Position 46 / 0.8m	Original location of site of incinerator in Building 27. Core drilled through concrete and hand dug. See Figure 2 in Appendix 1.
NHO-49 HRGS NHO-49 3H/14C Combustion	Position 49 / 0.8m	Land close to incinerator building. Hand dug. See Figure 2 in Appendix 1.
NHO-50 HRGS NHO-50 3H/14C Combustion	Position 50 / 3.5m	Hand dug to 1.2m then core drilled. See Figure 3 in Appendix 1.
NHO-51 HRGS NHO-51 3H/14C Combustion	Position 51 / 4.2m	Hand dug to 1.2m then core drilled. See Figure 4 in Appendix 1.
NHO-52 HRGS NHO-52 3H/14C Combustion	Position 52 / 2.65m	Hand dug to 1.2m then core drilled. See Figure 5 in Appendix 1.
NHO-53 HRGS NHO-53 3H/14C Combustion	Position 53 / 2.55m	Hand dug to 1.2m then core drilled. See Figure 6 in Appendix 1.
NHO-54 HRGS NHO-54 3H/14C Combustion	Position 54 / 2.48m	Hand dug to 1.2m then core drilled. See Figure 7 in Appendix 1.
NHO-55 HRGS NHO-55 3H/14C Combustion	Position 55 / 2.61m	Hand dug to 1.2m then core drilled. See Figure 8 in Appendix 1.
NHO-56 HRGS NHO-56 3H/14C Combustion	Position 56 / 3.0m	Hand dug to 1.2m then core drilled. See Figure 9 in Appendix 1.
NHO-57 HRGS NHO-57 3H/14C Combustion	Position 57 / 1.2m	Control samples. Hand dug. See Figure 10 in Appendix 1. Background control sample.
NHO-58 HRGS NHO-58 3H/14C Combustion	Position 58 / 1.2m	Control sample. See Figure 11 in Appendix 1. Background control sample.
NHO-WS18 HRGS NHO-WS18 3H/14C Combustion	Borehole 18 / post-purge	Water collected after initial purge of water from borehole.
NHO-WS44A HRGS NHO-WS44A 3H/14C Combustion	Borehole 44 / pre-purge	Water collected from borehole before purge.
NHO-WS44B HRGS NHO-WS44B 3H/14C Combustion	Borehole 44 / post-purge	Water collected after initial purge of water from borehole.

6. RESULTS

6.1 Solid Samples

No radioactive material was reported at levels above regulatory concern. The detailed laboratory analysis can be found in Appendix 2.

High resolution gamma spectrometry and tritium and carbon-14 combustion analysis of the solid samples from the area around the damaged drainage system reported results consistent with background control samples for the site.

6.2 Reassurance Monitoring

No significant contamination was detected either by direct monitoring or indirect monitoring on the equipment or Personal Protective Equipment (PPE) of the operatives. The liquid scintillation analysis results can be found in Appendix 3.

7. CONCLUSIONS

Ground investigation works were undertaken on the Novartis site to ascertain the radiological status of local environment surrounding previously identified and repaired integrity issues with the drainage system associated with Building 42 and 18. Ground investigation works were also undertaken in the area where the site incinerator used to be located.

Subsequent HRGS and tritium and carbon-14 combustion analysis of the samples obtained during the works reported values below the out of scope levels stated in the Environmental Permitting (England and Wales) Regulations 2010, demonstrating that no radiological contamination of the ground is present. The results were also consistent with background control samples taken from the site.

APPENDIX 1. SAMPLE LOCATIONS

Approximate positions of sampling locations (shown with a green star) and their proximity to drain repairs. Drawings taken from Drawing Numbers 00078/10A001/A “Site Plan” and ME041_5601_EX “Foul Drainage Remedial Works”

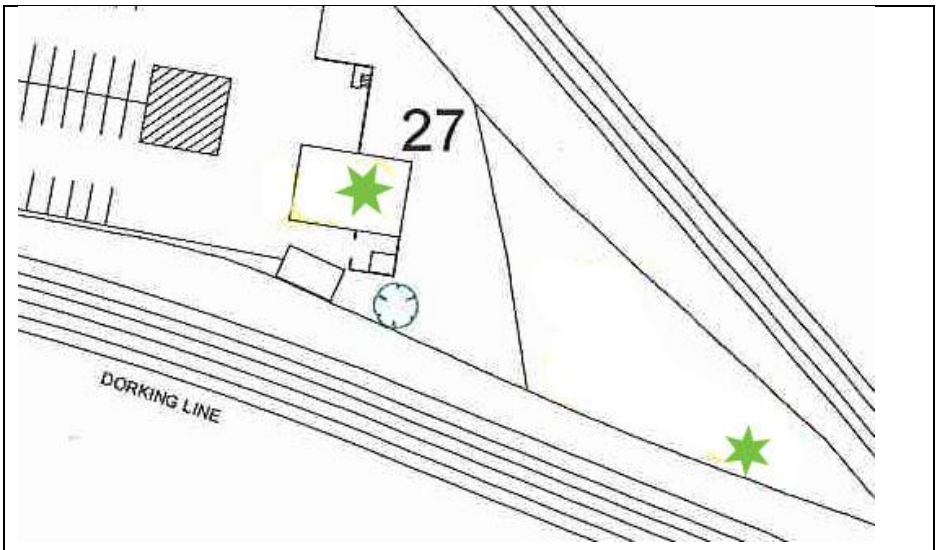

Figure 2: Positions 46 (in building) and 49

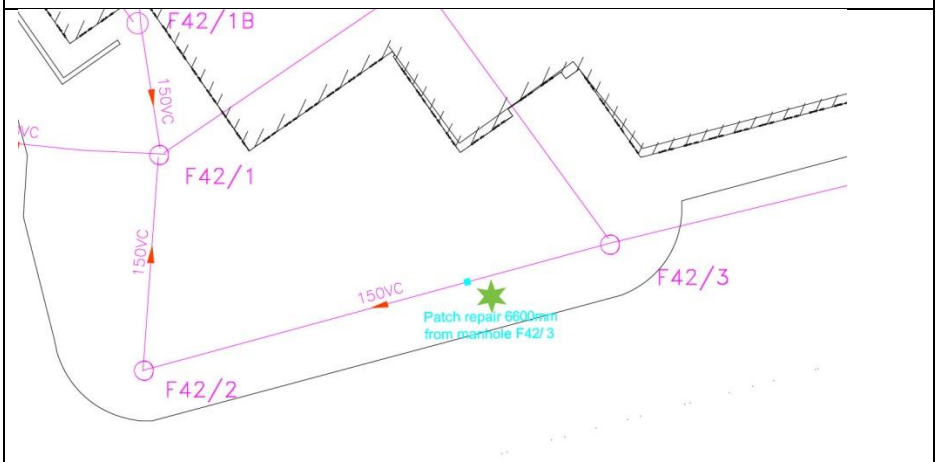

Figure 3: Position 50

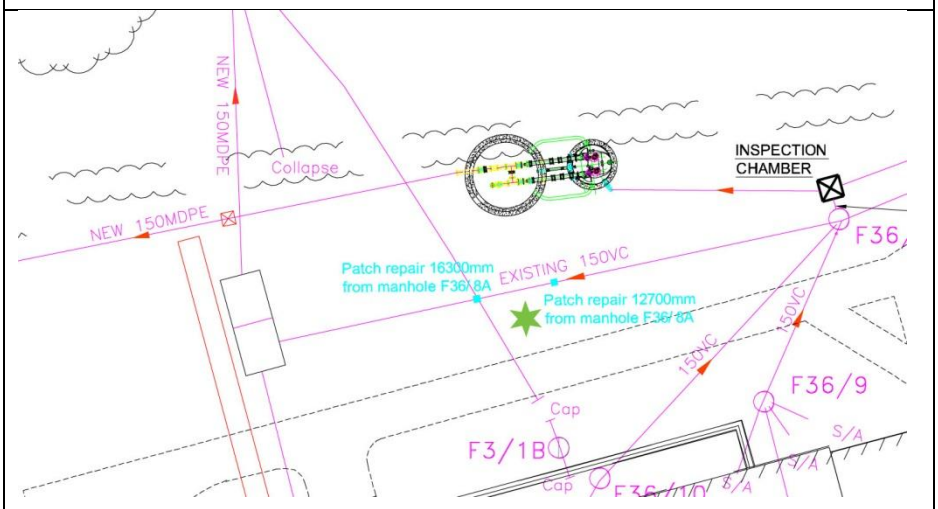

Figure 4: Position 51

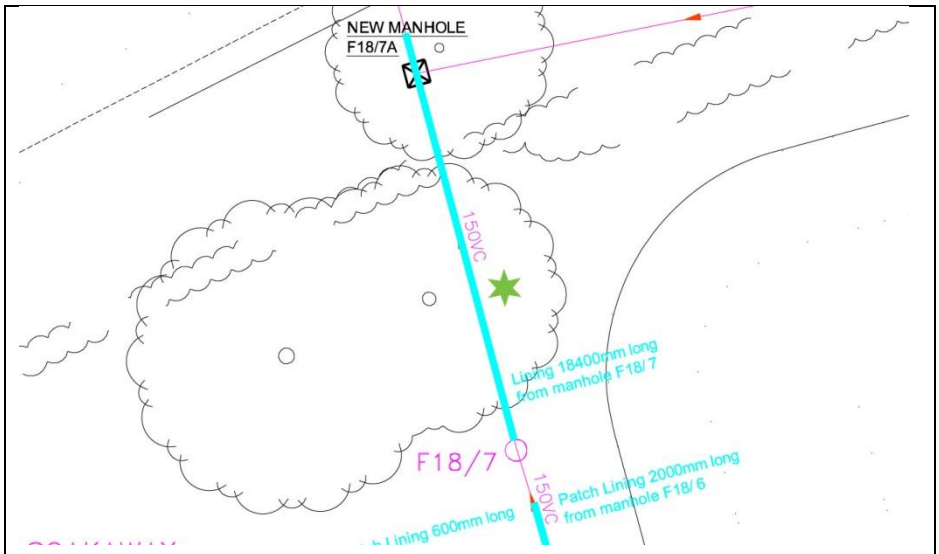

Figure 5: Position 52

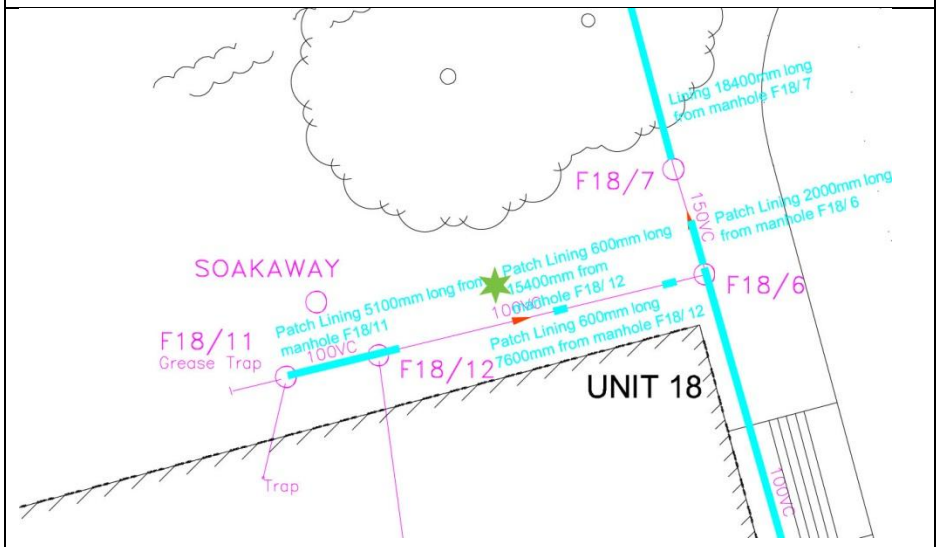

Figure 6: Position 53

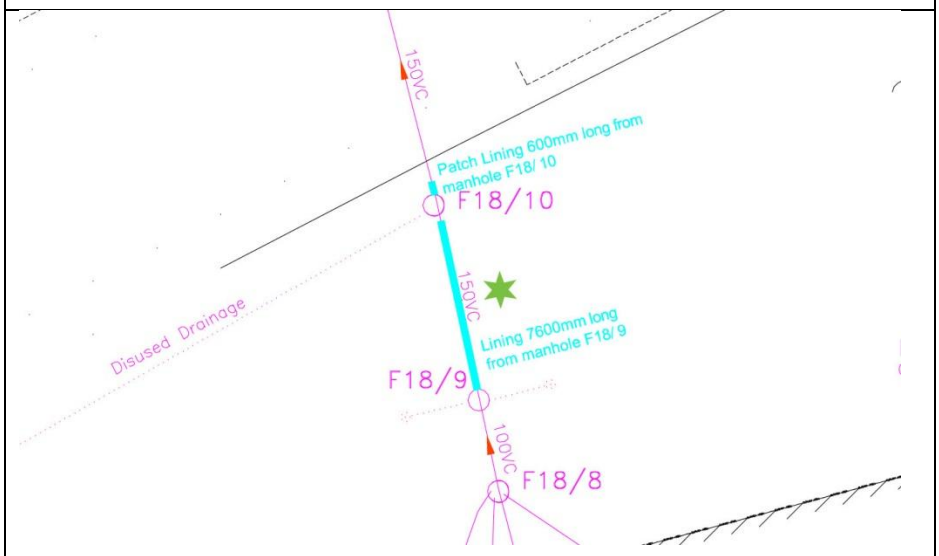

Figure 7: Position 54

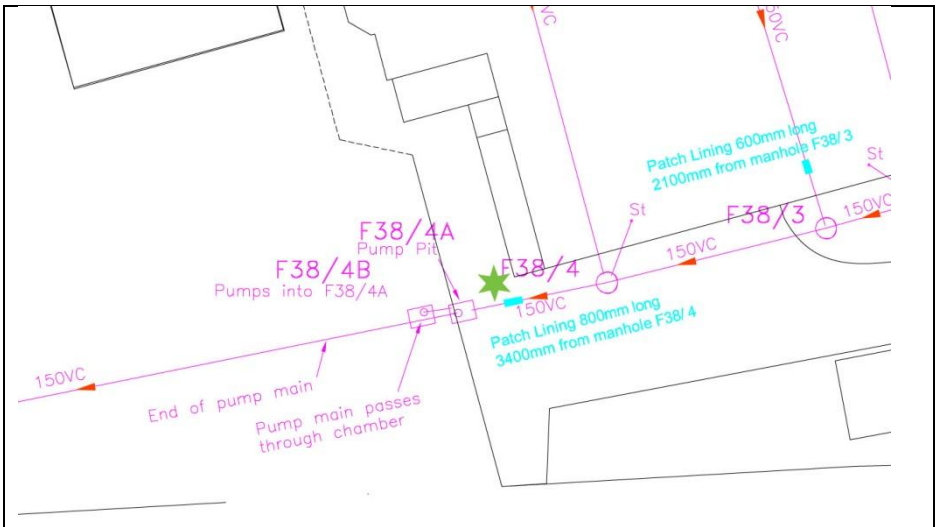

Figure 8: Position 55

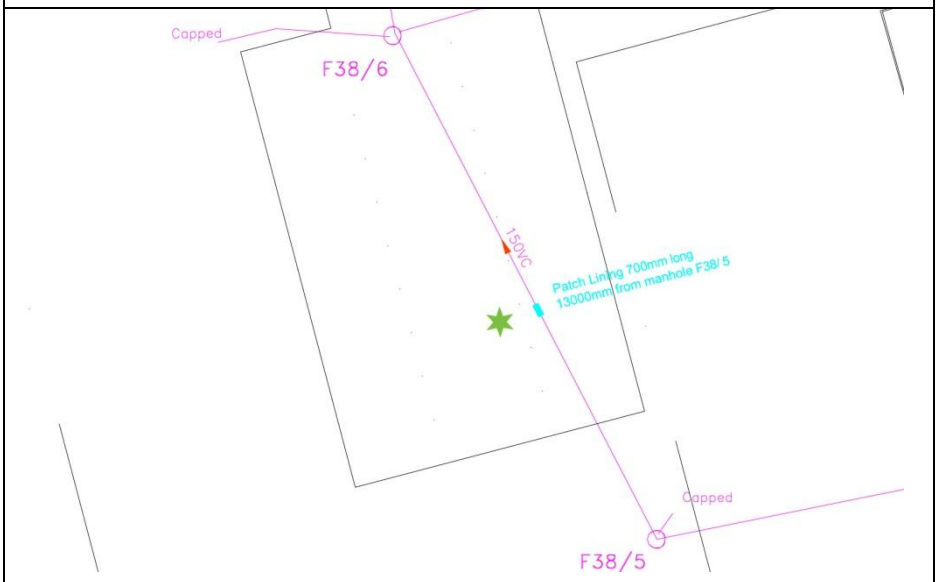

Figure 9: Position 56

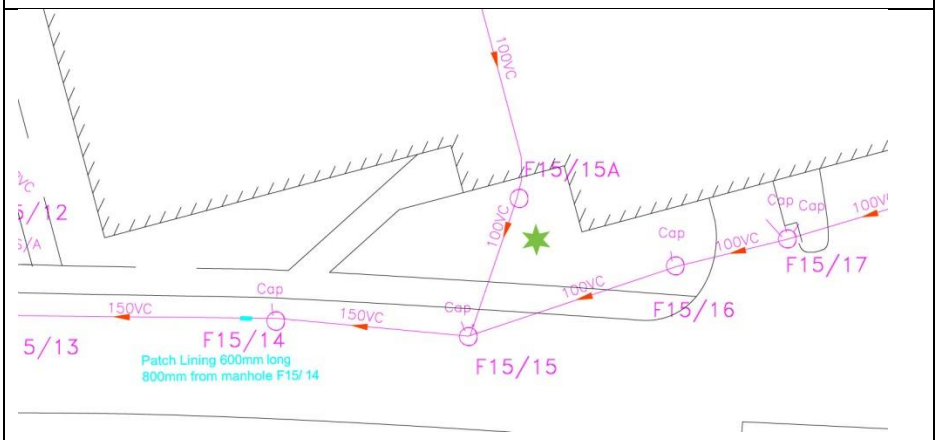

Figure 10: Position 57 (Control)

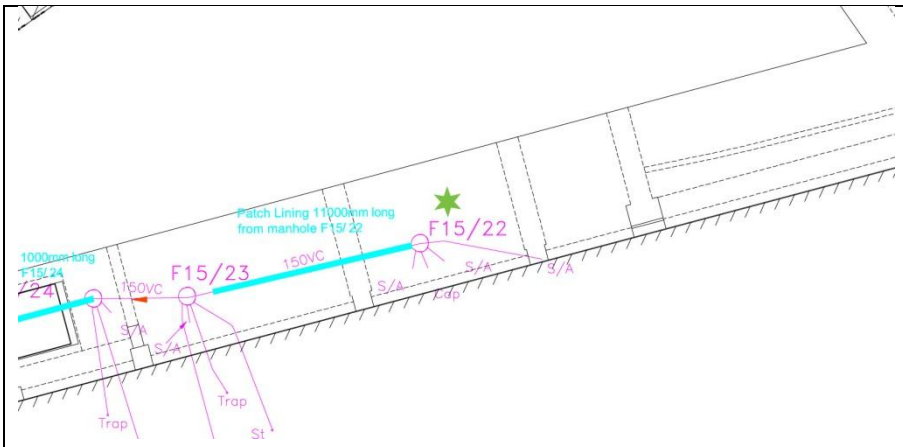

Figure 11: Position 58 (Control)

APPENDIX 2. LIQUID SCINTILLATION ANALYSIS RESULTS

Counter details - Packard Tri-Carb Liquid Scintillation Counter (LSC), Model TR2900, Serial number 431291

Key & Liquid Scintillation Counter information/details	
Batch Control (BC)	Un-used wipe counted due to varying backgrounds within the areas surveyed
BG	Background
Count Time	10 minutes per sample
PPE Control (PPE)	Wipe of gloves to check for contamination (and cross contamination) during survey
Area wiped	100 cm^2
Pick up factor for wipes	10%
Tritium efficiency	52%
carbon-14 efficiency	91%
Average tritium Background (counts per minute - CPM)	15
Average carbon-14 Background (CPM)	7
tritium investigation level (CPM) BG plus two standard deviations	23
carbon-14 investigation level (CPM) BG plus two standard deviations	12

Sample No	Room / Location	Description	Tritium Channel CPM A (0-18.6keV)	Carbon 14 Channel CPM B (18.6-156 keV)	Wide Channel CPM C (156-2000 keV)
Blank Bkg	-	Calibration Blank	11	7	10
tritium	-	Tritium Calibration Standard	120420	647	12
carbon-14	-	Carbon-14 Calibration Standard	26081	100356	522
NHO 1	Position Number 57	Pick	9	12	17
NHO 2	Position Number 57	Tongs	11	11	16
NHO 3	Position Number 57	Shovel	18	11	18
NHO 4	Position Number 57	Tamper	9	10	15
NHO 5	Position Number 46	Gravel at 0.4m, under concrete	9	10	16
NHO 6	Position Number 46	Tools	9	11	17
NHO 7	Position Number 46	Core drill	10	10	16
NHO 8	Position Number 46	Surfaces of concrete	12	12	17
NHO 9	Position Number 46	Gloves	10	11	18
NHO 10	Position Number 47	Tools	9	13	16
NHO 11	Position Number 47	Wire from trial pit	10	12	19
NHO 12	Position Number 47	Boots	10	11	16
NHO 13	Position Number 49	Tools	8	11	15

Sample No	Room / Location	Description	Tritium Channel CPM A (0-18.6keV)	Carbon 14 Channel CPM B (18.6-156 keV)	Wide Channel CPM C (156-2000 keV)
NHO 14	Position Number 49	Soil	8	9	16
NHO 15	Position Number 49	Operators gloves	9	10	16
NHO 16	BC	Batch control	13	11	15
NHO 17	Position Number 50	Drill bit	9	12	19
NHO 18	Position Number 50	Tools	25	11	16
NHO 19	Position Number 50	Operators gloves	12	11	16
NHO 20	Position Number 58	Tools	10	11	14
NHO 21	Position Number 58	Operators gloves	9	12	17
NHO 22	Position Number 51	Tools	9	12	18
NHO 23	Position Number 51	Drill bit	10	10	15
NHO 24	Position Number 52	Tools	8	11	17
NHO 25	Position Number 52	Drill bit	28	19	18
NHO 26	Position Number 52	Operators gloves	84	15	18
NHO 27	BC	Batch control	9	12	17
NHO 28	Position Number 53	Tools	10	10	15
NHO 29	Position Number 53	Drill bit	12	12	18

Sample No	Room / Location	Description	Tritium Channel CPM A (0-18.6keV)	Carbon 14 Channel CPM B (18.6-156 keV)	Wide Channel CPM C (156-2000 keV)
NHO 30	Position Number 53	Operators gloves	17	12	17
NHO 31	Position Number 54	Tools	9	12	17
NHO 32	Position Number 54	Drill bit	9	12	17
NHO 33	Position Number 54	Operators gloves	13	10	18
NHO 34	Position Number 55	Tools	9	12	16
NHO 35	Position Number 55	Drill bit	10	13	16
NHO 36	Position Number 55	Operators gloves	12	12	17
NHO 37	BC	Batch control	11	12	15
NHO 38	Position Number 56	Tools	12	11	16
NHO 39	Position Number 56	Drill bit	9	11	15
NHO 40	Position Number 56	Operators gloves	12	11	16
NHO 41	WS18	Water sample post purge	4	13	13
NHO 42	WS44	Water sample pre purge	10	15	12
NHO 43	WS44	Water sample post purge	6	11	12

APPENDIX 3. SOLID SAMPLE RESULTS

ESG
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Test Report: **RP2891**

Radiochemical Analysis of Soil and Water Samples

Prepared for Craig Morrissey
Aurora Health Physics
August 2014

ESG Environmental Scientifics Group

Radiochemical Analysis of Soil and Water Samples

Customer:	Aurora Health Physics 3 The Terrace Library Avenue Harwell Oxford Oxfordshire OX11 0SG
Testing Facility:	Environmental Scientifics Group Unit 12 Moorbrook Southmead Industrial Park Didcot Oxon OX11 7HP
Quote Number:	ENR-ANU-7512Rev5
Customer Reference:	AHP/SAM/NHO
Laboratory Reference:	RP2891
Samples Received:	10 July 2014
Sample Condition:	Satisfactory, Ambient
Analysis Completed:	14 August 2014
Report Author:	[redacted]
Author's Name:	Trevor Harding
Job Title:	Senior Analyst
Approved by	[redacted]
Date:	14/8/14.
Approver's name:	Gary Shaw
Job Title:	Senior Analyst
Report Date:	14 August 2014

UKAS TESTING 1015

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Introduction

Thirteen samples were received from Aurora Health Physics on 10 July 2014. Additional information was included indicating the analysis required. The samples were received in a satisfactory condition. Upon receipt, the samples were logged into the ESG Didcot system.

Experimental

Tests/sampling marked 'Not UKAS Accredited' in this report are not included in the UKAS accreditation schedule for the laboratory.

It should be noted that UKAS accreditation only covers soils, sediments, silts, sands and vegetation for radiochemistry analysis with the exception of tritium. Any other matrix should be considered unaccredited.

Samples were analysed using the methods summarised below.

Total Tritium by Combustion and Liquid Scintillation Counting (SOP/2094 Issue 1)
A sub-sample of known weight was taken from the sample and combusted in an oxygen rich atmosphere in the presence of a copper oxide catalyst. Under these conditions the hydrogen and tritium were converted to water vapour. These were then selectively trapped in a series of gas-bubblers containing dilute acid. Aliquots of known weight were then assessed for their tritium content by liquid scintillation counting (LSC). The tritium activity was corrected for the proportion of the bubbler trapping solution taken and for the weight of combusted sample.

Carbon-14 by Combustion and Liquid Scintillation Counting (SOP/2103 Issue 1)
A sub-sample of known weight was taken from the sample and combusted in an oxygen rich atmosphere in the presence of a copper oxide catalyst. Under these conditions the carbon species were converted to carbon dioxide, which were then selectively trapped in a series of gas-bubblers containing a trapping medium. Aliquots of known weight were then assessed for their ^{14}C content by LSC. Hence the total recovered ^{14}C was calculated from the total weights of each respective trapping medium. (Not UKAS accredited)

Radioactivity Analysis by Gamma Ray Spectrometry (SOP/2029 Issue 4)
The samples were placed in containers to match the appropriate calibration geometries and then measured by high-resolution gamma ray spectrometry.

The measurement technique is based on the use of high purity germanium (HPGe) detectors coupled to an Ortec gamma ray spectroscopy system. The gamma ray spectra are stored on a computer and analysed using the software programme Fitzpeaks for photopeak identification and quantification. The detectors are calibrated for efficiency using a mixed radionuclide standard, which covers an energy range of approximately 60-2000 keV. The efficiency of gamma rays between 30 keV and 120 keV are determined on an individual basis.

Application of decay corrections for the naturally occurring daughter radionuclides of uranium and thorium assumes that the series daughter radionuclides are all in secular equilibrium and therefore decay with the half-life of the first radionuclide in the series.

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Results

Results are presented in the following tables.

Result uncertainty for the analyses is given in the table notes. Result confidence is reduced for results within an order of magnitude of the limit of detection (LoD in the tables).

Results Summary – Tritium and Carbon-14

Customer Reference	Laboratory Reference	H-3	C-14*
NHO-46	RP2891	<20	<10
NHO-49	RP2892	<20	<10
NHO-57	RP2893	<20	<10
NHO-58	RP2894	<20	<10
NHO-50	RP2895	<20	<10
NHO-52	RP2896	<20	<10
NHO-53	RP2897	<20	<10
NHO-54	RP2898	<20	<10
NHO-55	RP2899	<20	<10
NHO-56	RP2900	<20	<10
NHO-WS18	RP2901	<20	<10
NHO-WS44A	RP2902	<20	<10
NHO-WS44B	RP2903	<20	<10

Notes:

1. Results are presented as $Bq.kg^{-1}$ of sample as received and are decay corrected to the reference date given on the chain of custody form.
2. An asterisk "*" indicates that the analysis is not covered by the laboratories UKAS accreditation.
3. LoD is 50 $Bq.kg^{-1}$ unless otherwise stated.

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Results Summary – Gamma Spectrometry

Customer Reference	Laboratory Reference	Be-7	K-40	Co-60	Cs-134	Cs-137	Tl-208	Pb-210	Pb-212	Bi-212
NHO-46	RP2891	<8	322 ± 37	<2	<2	<2	13.4 ± 1.5	<30	42 ± 3.8	39 ± 13
NHO-49	RP2892	<8	156 ± 23	<2	<2	<2	9 ± 1.3	<30	25.8 ± 2.7	29 ± 11
NHO-57	RP2893	<9	205 ± 28	<2	<2	<2	12.5 ± 1.6	<30	36.4 ± 3.6	31 ± 13
NHO-58	RP2894	<8	250 ± 31	<2	<2	<1	12.8 ± 1.5	<30	34 ± 3.3	40 ± 11
NHO-50	RP2895	<8	216 ± 27	<2	<2	<1	10.5 ± 1.3	<40	31.5 ± 3	36 ± 11
NHO-52	RP2896	<8	401 ± 45	<2	<2	<1	15.7 ± 1.7	<30	44 ± 4	50 ± 14
NHO-53	RP2897	<9	347 ± 40	<2	<2	<2	14.4 ± 1.8	<30	42.9 ± 4.1	54 ± 14
NHO-54	RP2898	<8	354 ± 40	<2	<2	<1	14.4 ± 1.6	<30	40.9 ± 3.7	42 ± 12
NHO-55	RP2899	<9	262 ± 33	<2	<2	<2	15.4 ± 1.9	<30	41.9 ± 4	61 ± 15
NHO-56	RP2900	<9	411 ± 46	<2	<2	<2	16.8 ± 2	59 ± 23	46.8 ± 4.4	56 ± 15
NHO-WS18	RP2901	<20	<40	<2	<2	<2	<2	<20	<3	<20
NHO-WS44A	RP2902	<20	<30	<2	<2	<2	<2	<30	<2	<20
NHO-WS44B	RP2903	<9	<30	<2	<2	<2	<2	<20	<2	<20

Notes:

1. Results are presented as $Bq.kg^{-1}$ of sample as received decay corrected to the reference date: 25 June 2014.
2. Detector calibrations are based upon homogeneous standard solutions. For quantification purposes the sample is assumed to be homogeneous.
3. ^{226}Ra has only one gamma ray at 186 keV and the major gamma ray from ^{235}U also occurs at 186 keV. ^{235}U can be measured by the lower abundance gamma ray at 144 keV and if a positive result for ^{235}U is reported the ^{226}Ra result will be unreliable and overestimated. However even if ^{235}U is below the LoD there may still be a contribution to the ^{226}Ra from ^{235}U and the ^{226}Ra result may be unreliable and overestimated. If an accurate result for ^{226}Ra is required this is better obtained by radiochemical analysis.
4. Results below and above the LoD are reported to 1 significant figure.
5. An asterisk "*" indicates that the analysis is not covered by UKAS accreditation.

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Results Summary – Gamma Spectrometry

Customer Reference	Laboratory Reference	Pb-214	Bi-214	Ra-224	Ra-226*	Ac-228	Th-234	Pa-234m	U-235	Am-241
NHO-46	RP2891	31.1 ± 3	29 ± 3.2	<20	59 ± 18	39 ± 4.2	<30	<200	<10	<3
NHO-49	RP2892	22.4 ± 2.4	18.7 ± 2.5	<20	42 ± 16	25.8 ± 3.4	<30	<200	<9	<3
NHO-57	RP2893	27.3 ± 2.8	26.2 ± 3.1	<20	66 ± 16	37.4 ± 4.2	<30	<200	<10	<3
NHO-58	RP2894	30.4 ± 2.9	30 ± 3	<20	44 ± 13	36.7 ± 4	<30	<200	<9	<3
NHO-50	RP2895	25.4 ± 2.5	26.8 ± 2.8	<30	43 ± 14	33.3 ± 3.8	<40	<200	<9	<3
NHO-52	RP2896	30.5 ± 2.9	28.6 ± 3	50 ± 13	67 ± 17	47.1 ± 4.5	<30	<200	<10	<3
NHO-53	RP2897	31.5 ± 3.1	32.1 ± 3.4	<40	71 ± 18	45.5 ± 4.9	<30	<200	<20	<3
NHO-54	RP2898	32.4 ± 3	27.7 ± 2.9	41 ± 12	64 ± 17	39.8 ± 4.1	65 ± 24	<200	<9	<3
NHO-55	RP2899	33.7 ± 3.4	33.2 ± 3.5	<20	60 ± 17	45.1 ± 4.7	<30	<200	<20	<3
NHO-56	RP2900	32.2 ± 3.2	31.2 ± 3.4	<30	67 ± 19	45.4 ± 4.9	<30	<200	<20	<3
NHO-WS18	RP2901	<3	<4	<30	<30	<8	<20	<200	<2	<2
NHO-WS44A	RP2902	<3	<3	<20	<30	<8	<20	<200	<20	<2
NHO-WS44B	RP2903	<3	<3	<20	<30	<7	<30	<200	<2	<2

Notes:

1. Results are presented as Bq.kg-1 of sample as received decay corrected to the reference date: 25 June 2014.
2. Detector calibrations are based upon homogeneous standard solutions. For quantification purposes the sample is assumed to be homogeneous.
3. ^{226}Ra has only one gamma ray at 186 keV and the major gamma ray from ^{235}U also occurs at 186 keV. ^{235}U can be measured by the lower abundance gamma ray at 144 keV and if a positive result for ^{235}U is reported the ^{226}Ra result will be unreliable and overestimated. However even if ^{235}U is below the LoD there may still be a contribution to the ^{226}Ra from ^{235}U and the ^{226}Ra result may be unreliable and overestimated. If an accurate result for ^{226}Ra is required this is better obtained by radiochemical analysis.
4. Results below and above the LoD are reported to 1 significant figure.
5. An asterisk "*" indicates that the analysis is not covered by UKAS accreditation.

UKAS TESTING
1015

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Test Report: **RP2920**

Radiochemical Analysis of A Solid Sample

Prepared for Emma Leishman

Aurora Health Physics

August 2014

Radiochemical Analysis of a Solid Sample

Customer:	Aurora Health Physics 3 The Terrace Library Avenue Harwell Oxford Oxfordshire OX11 0SG
Testing Facility:	Environmental Scientifics Group Unit 12 Moorbrook Southmead Industrial Park Didcot Oxon OX11 7HP
Quote Number:	ENR-ANU-7512Rev5
Customer Reference:	NHO-51
Laboratory Reference:	RP2920
Sample Received:	18 July 2014
Sample Condition:	Satisfactory, Ambient
Analysis Completed:	19 August 2014
Report Author:	[redacted]
Author's Name:	Trevor Harding
Job Title:	Senior Analyst
Approved by:	[redacted]
Date:	20/08/14
Approver's name:	Carla Thompson
Job Title:	Senior Analyst
Report Date:	20 August 2014

Introduction

One sample was received from Aurora Health Physics on 18 July 2014. Additional information was included indicating the analysis required. The sample was received in a satisfactory condition and logged into the ESG Didcot system upon receipt.

Experimental

It should be noted that UKAS accreditation only covers soils, sediments, silts, sands and vegetation for radiochemistry analysis with the exception of tritium. Any other matrix should be considered unaccredited.

Samples were analysed using the methods summarised below.

Total Tritium by Combustion and Liquid Scintillation Counting (SOP/2094 Issue 1)
A sub-sample of known weight was taken from the sample and combusted in an oxygen rich atmosphere in the presence of a copper oxide catalyst. Under these conditions the hydrogen and tritium were converted to water vapour. These were then selectively trapped in a series of gas-bubblers containing dilute acid. Aliquots of known weight were then assessed for their tritium content by liquid scintillation counting (LSC). The tritium activity was corrected for the proportion of the bubbler trapping solution taken and for the weight of combusted sample.

Carbon-14 by Combustion and Liquid Scintillation Counting (SOP/2103 Issue 1)
A sub-sample of known weight was taken from the sample and combusted in an oxygen rich atmosphere in the presence of a copper oxide catalyst. Under these conditions the carbon species were converted to carbon dioxide, which were then selectively trapped in a series of gas-bubblers containing a trapping medium. Aliquots of known weight were then assessed for their ^{14}C content by LSC. Hence the total recovered ^{14}C was calculated from the total weights of each respective trapping medium. (Not UKAS accredited)

Radioactivity Analysis by Gamma Ray Spectrometry (SOP/2029 Issue 4)
The sample was placed in a container to match the appropriate calibration geometry and then measured by high-resolution gamma ray spectrometry.

The measurement technique is based on the use of high purity germanium (HPGe) detectors coupled to an Ortec gamma ray spectroscopy system. The gamma ray spectra are stored on a computer and analysed using the software programme Fitzpeaks for photopeak identification and quantification. The detectors are calibrated for efficiency using a mixed radionuclide standard, which covers an energy range of approximately 60-2000 keV. The efficiency of gamma rays between 30 keV and 120 keV are determined on an individual basis.

Application of decay corrections for the naturally occurring daughter radionuclides of uranium and thorium assumes that the series daughter radionuclides are all in secular equilibrium and therefore decay with the half-life of the first radionuclide in the series.

Results

Results are presented in the following tables.

Result uncertainty for the analyses is given in the table notes. Result confidence is reduced for results within an order of magnitude of the limit of detection (LoD in the tables).

Results Summary – Tritium and Carbon-14

Customer Reference	Laboratory Reference	H-3	C-14*
NHO-51	RP2920	<5	<5

Notes:
1. Results are presented as $Bq.kg^{-1}$ of sample as received.
2. An asterisk "*" indicates that the analysis is not covered by UKAS accreditation.
3. Results are decay corrected to the reference date: 14/07/2014
4. LoD is 5 $Bq.kg^{-1}$.

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Results Summary – Gamma Spectrometry*

Customer Reference	Laboratory Reference	Be-7	K-40	Co-60	Cs-134	Cs-137	Tl-208	Pb-210	Pb-212	Bi-212
NHO-51	RP2920	< 9	222 ± 31	< 2	< 2	< 2	12.3 ± 1.6	< 30	33.0 ± 3.3	37 ± 14

Customer Reference	Laboratory Reference	Pb-214	Bi-214	Ra-224	Ra-226	Ac-228	Th-234	Pa-234m	U-235	Am-241
NHO-51	RP2920	29.0 ± 2.9	27.8 ± 3.1	< 40	45 ± 18	36.0 ± 4.4	< 30	< 200	< 20	< 3

Notes:

1. Results are presented as $Bq.kg^{-1}$ of sample as received.
2. Detector calibrations are based upon homogeneous standard solutions. For quantification purposes the sample is assumed to be homogeneous.
3. An asterisk "*" indicates that the analysis is not covered under the UKAS accreditation of the laboratory with UKAS 1015. It should be noted that UKAS accreditation only covers soils, sediments, silts, sands and vegetation. Any other matrix should be considered unaccredited, therefore accreditation for these samples has been withdrawn.
4. ^{226}Ra has only one gamma ray at 186 keV and the major gamma ray from ^{235}U also occurs at 186 keV. ^{235}U can be measured by the lower abundance gamma ray at 144 keV and if a positive result for ^{235}U is reported the ^{226}Ra result will be unreliable and overestimated. However even if ^{235}U is below the LoD there may still be a contribution to the ^{226}Ra from ^{235}U and the ^{226}Ra result may be unreliable and overestimated. If an accurate result for ^{226}Ra is required this is better obtained by radiochemical analysis.
5. Results below the LoD are reported to 1 significant figure. For results above the LoD the uncertainty values are rounded to 2 significant figures, with the activity values rounded to the same precision as the uncertainty.

UKAS TESTING

Appendix B. Borehole Logs

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BOREHOLE LOG

Borehole No **WS46** Sheet 1 of 1

Project Name: **Further LQA, Novartis, Horsham**	Project No.: KU043500/1	Co-ords: 517986E - 131485N	Hole Type OP
Location: Novartis, Horsham, West Sussex		Level: -	Scale 1:50
Client: Novartis		Dates: 07/07/2014	Logged By PJH

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
		0.20-0.30	ES		0.17			MADE GROUND: CONCRETE.
		0.50-0.60	ES		0.50			MADE GROUND: Brown slightly sandy fine to coarse subangular GRAVEL of flint. [SUB BASE]
					0.70			Firm friable light brown and blue-grey slightly clayey SILT. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
					1.10			Stiff friable light brown and blue-grey slightly gravelly SILT. Gravel is medium to coarse of siltstone. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
								End of Borehole at 1.10 m

Type Results

Remarks: Target: former incinerator. Terminated at 1.1m bgl as natural ground confirmed.

AGS

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BOREHOLE LOG

Borehole No **WS47** Sheet 1 of 1

Project Name: **Further LQA, Novartis, Horsham**	Project No.: KU043500/1	Co-ords: 517991E - 131460N	Hole Type OP
Location: Novartis, Horsham, West Sussex		Level: 59.54 m AOD	Scale 1:50
Client: Novartis		Dates: 08/07/2014	Logged By PJH

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
		0.60-0.70	ES		0.40	59.14		MADE GROUND: Firm friable dark brown slightly gravelly SILT. Gravel is fine to coarse subangular of brick, flint and concrete. [SILT FILL]
					0.60	58.94		MADE GROUND: Stiff friable light blue-grey and orange-brown SILT. [SILT FILL / REWORKED NATURAL STRATA]
					1.10	58.44		MADE GROUND: Stiff friable brown slightly gravelly SILT. Gravel is medium to coarse of flint and occasional brick. Frequent rusted wire. [SILT FILL / REWORKED NATURAL STRATA]
					1.40	58.14		Stiff friable light blue-grey and orange-brown SILT. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
								End of Borehole at 1.40 m
			Type	Results				

Remarks: Target: potential radiological contamination in area of old landfill. Terminated at 1.4m bgl as natural ground confirmed.

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BOREHOLE LOG

Borehole No **WS49** Sheet 1 of 1

Project Name: **Further LQA, Novartis, Horsham**	Project No.: KU043500/1	Co-ords: 517986E - 131438N	Hole Type OP
Location: Novartis, Horsham, West Sussex		Level: 57.62 m AOD	Scale 1:50
Client: Novartis		Dates: 08/07/2014	Logged By PJH

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
		0.60-0.70	ES		0.20	57.42		MADE GROUND: Soft to firm orange-brown and light blue-grey slightly clayey SILT. [SILT FILL]
					0.90	56.72		MADE GROUND: Dark brown-black uncompact slightly clayey slightly sandy slightly gravelly SILT. Gravel is medium to coarse predominantly of flint and possible rare chalk. Rare rusted metal wire. [SILT FILL]
					1.30	56.32		Stiff friable light blue-grey and orange-brown SILT. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
								End of Borehole at 1.30 m

Type Results

Remarks: Target: potential radiological contamination in area of old landfill. Terminated at 1.3m bgl as natural ground confirmed.

AGS

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BOREHOLE LOG

Borehole No **WS50** Sheet 1 of 1

Project Name: **Further LQA, Novartis, Horsham**	Project No.: KU043500/1	Co-ords: 517917E - 131771N	Hole Type WS
Location: Novartis, Horsham, West Sussex		Level: 56.77 m AOD	Scale 1:50
Client: Novartis		Dates: 08/07/2014	Logged By PJH

Well	Water Strikes	Samples & In Situ Testing: Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
					0.06	56.71		MADE GROUND: Parquet BRICKWORK.
					0.15	56.62		MADE GROUND: Orange-brown medium to coarse SAND. [SUB BASE]
					0.35	56.42		
		0.50-0.60	ES		0.50	56.27		MADE GROUND: Red-brown slightly sandy medium to coarse subangular GRAVEL of concrete and flint. [SUB BASE]
					1.10	55.67		MADE GROUND: Grey slightly sandy medium to coarse subangular GRAVEL of concrete and flint. Geotextile at base. [SUB BASE]
					1.80	54.97		Firm to stiff friable blue-grey and orange-brown slightly clayey SILT. Becoming slightly sandy with depth and slightly gravelly with depth. Gravel of siltstone. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
					2.00	54.77		Very stiff friable orange-brown gravelly SILT. Gravel is medium to coarse subangular of siltstone. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
								Stiff friable light brown with light grey veining SILT. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
								Very stiff fissile brown and grey SILT. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
					3.00	53.77		Very stiff grey SILTSTONE. [UPPER TUNBRIDGE WELLS SAND]
					4.00	52.77		End of Borehole at 4.00 m
			Type	Results				

Remarks: Target: potential radiological contamination at repaired broken drain (2.85m deep).

AGS

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BOREHOLE LOG

Borehole No **WS51** Sheet 1 of 1

Project Name: **Further LQA, Novartis, Horsham**	Project No.: KU043500/1	Co-ords: 517878E - 131815N	Hole Type WS
Location: Novartis, Horsham, West Sussex		Level: 56.95 m AOD	Scale 1:50
Client: Novartis		Dates: 08/07/2014	Logged By PJH

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
		0.10-0.20	ES		0.25	56.70		MADE GROUND: Dark brown organic slightly clayey slightly gravelly SILT. Gravel is medium subangular of flint, brick and carbonaceous material. [TOPSOIL]
		0.40-0.50	ES		0.70	56.25		Firm friable light blue-grey and orange-brown SILT. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
					0.90	56.05		Firm friable light blue-grey and orange-brown clayey SILT. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
					1.10	55.85		Firm friable light blue-grey and orange-brown SILT. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
								Very stiff light brown and light khaki SILTSTONE. [UPPER TUNBRIDGE WELLS SAND]
					2.70	54.25		Very stiff light grey SILTSTONE. [UPPER TUNBRIDGE WELLS SAND]
								2.70m - 3.50m: Horizontal and sub-horizontal fractures.
					4.00	52.95		End of Borehole at 4.20 m
			Type	Results				

Remarks: Target: potential radiological contamination at repaired broken drain (3.6m deep at manhole, estimated to be 4m deep at WS). Refused at 2.04m bgl due to very stiff ground. Rotary core follow-on on to 4.20m bgl 14/07/14.

AGS

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BOREHOLE LOG

Borehole No
WS51A
Sheet 1 of 1

Project Name: **Further LQA, Novartis, Horsham**	Project No.: KU043500/1	Co-ords: 517875E - 131817N	Hole Type WS
Location: Novartis, Horsham, West Sussex		Level: 56.86 m AOD	Scale 1:50
Client: Novartis		Dates: 09/07/2014	Logged By PJH

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
					0.20	56.66		MADE GROUND: Dark brown organic slightly clayey slightly gravelly SILT. Gravel is medium subangular of flint, brick and carbonaceous material. [TOPSOIL]
					0.60	56.26		Firm friable light blue-grey and orange-brown SILT. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
					0.80	56.06		Firm friable light blue-grey and orange-brown clayey SILT. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
					1.00	55.86		Firm friable light blue-grey and orange-brown SILT. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
					2.07	54.79		Stiff becoming very stiff grey SILTSTONE. [UPPER TUNBRIDGE WELLS SAND]
								End of Borehole at 2.07 m
			Type	Results				

Remarks: Target: potential radiological contamination at repaired broken drain (3.6m deep at manhole, estimated to be 4m deep at WS). Refused at 2.07m bgl due to very stiff ground. Second attempt at WS51.

AGS

SKM ENVIROS

BOREHOLE LOG

Borehole No **WS52** Sheet 1 of 1

Project Name: **Further LQA, Novartis, Horsham**	Project No.: KU043500/1	Co-ords: 517830E - 131851N	Hole Type WS
Location: Novartis, Horsham, West Sussex		Level: -	Scale 1:50
Client: Novartis		Dates: 09/07/2014	Logged By PJH

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
		0.10-0.20	ES		0.00			MADE GROUND: Grass over light blue-grey and orange-brown slightly clayey slightly gravelly SILT. Gravel is fine to coarse subangular of flint and occasional brick. Cobbles of brick from 0.2 to 0.4m. [SILT FILL]
		0.50-0.60	ES		0.45			MADE GROUND: Brown uncompact gravelly cobbly SILT. Gravel is fine to coarse angular subangular of brick and occasional concrete. Cobbles of brick and occasional concrete. [SILT RUBBLE FILL]
					0.70			Firm becoming stiff friable light blue-grey and orange-brown SILT. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
					1.50			Stiff becoming very stiff orange-brown and blue-grey SILTSTONE. [UPPER TUNBRIDGE WELLS SAND]
					2.65			End of Borehole at 2.65 m

Type Results

Remarks: Target: potential radiological contamination at repaired broken drain (1.65m deep at manhole, estimated to be approximately 2.0 - 2.5m deep at WS). Refused at 2.65m bgl due to very stiff ground.

AGS

SKM ENVIROS

BOREHOLE LOG

Borehole No **WS53** Sheet 1 of 1

Project Name: **Further LQA, Novartis, Horsham**	Project No.: KU043500/1	Co-ords: 517823E - 131845N	Hole Type WS
Location: Novartis, Horsham, West Sussex		Level: -	Scale 1:50
Client: Novartis		Dates: 09/07/2014	Logged By PJH

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
		0.10-0.20	ES		0.20			MADE GROUND: Grass over dark brown uncompact organic slightly gravelly SILT. Gravel is fine to medium subangular to rounded of flint and rare brick. [TOPSOIL]
					1.10			Firm friable orange-brown and light blue-grey slightly clayey SILT. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
					1.90			Firm becoming stiff friable orange-brown with light blue-grey SILT. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
					2.55			Stiff becoming very stiff fissile orange-brown SILTSTONE. [UPPER TUNBRIDGE WELLS SAND]
								End of Borehole at 2.55 m
			Type	Results				

Remarks: Target: potential radiological contamination at repaired broken drain (1.65m deep at manhole, estimated to be approximately 1.7m deep at WS). Refused at 2.55m bgl due to very stiff ground.

AGS

BOREHOLE LOG

SKM ENVIROS

Borehole No **WS54** Sheet 1 of 1

Project Name: **Further LQA, Novartis, Horsham**	Project No.: KU043500/1	Co-ords: 517793E - 131878N	Hole Type WS
Location: Novartis, Horsham, West Sussex		Level: -	Scale 1:50
Client: Novartis		Dates: 09/07/2014	Logged By PJH

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
		0.30-0.40	ES		0.05			MADE GROUND: Grass over dark brown uncompact organic SILT. [TOPSOIL]
					0.50			MADE GROUND: Firm friable brown and orange-brown slightly gravelly SILT. Gravel is fine to coarse subangular of flint with rare brick and concrete. [REWORKED NATURAL STRATA]
					1			Firm becoming stiff friable orange-brown with light blue-grey SILT. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
					1.90			Stiff becoming very stiff fissile orange-brown SILTSTONE. [UPPER TUNBRIDGE WELLS SAND]
					2.48			End of Borehole at 2.48 m
			Type	Results				

Remarks: Target: potential radiological contamination at repaired broken drain (2m deep at manhole, estimated to be between 1.5 - 2m deep at WS). Refused at 2.48m bgl due to very stiff ground.

AGS

SKM ENVIROS

BOREHOLE LOG

Borehole No **WS55** Sheet 1 of 1

Project Name: **Further LQA, Novartis, Horsham**	Project No.: KU043500/1	Co-ords: 517742E - 131798N	Hole Type WS
Location: Novartis, Horsham, West Sussex		Level: 55.18 m AOD	Scale 1:50
Client: Novartis		Dates: 09/07/2014	Logged By PJH

Well	Water Strikes	Samples & In Situ Testing: Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
					0.07	55.11		MADE GROUND: TARMAC
		0.30-0.40	ES		0.30	54.88		MADE GROUND: Light brown sandy medium to coarse subangular GRAVEL of concrete. Geotextile at base. [SUB BASE]
		0.50-0.60	ES		0.40	54.78		MADE GROUND: Soft to firm light blue clayey SILT with some black/dark staining. No odour. [REWORKED NATURAL STRATA]
					1.00	54.18		MADE GROUND: Soft to firm light blue clayey slightly gravelly SILT. Gravel is medium subangular of siltstone. [REWORKED NATURAL STRATA] 0.70m - 0.77m: Narrow diameter clay land drain.
					1.70	53.48		Firm becoming stiff friable light orange-brown and light blue-grey slightly clayey SILT. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
								Stiff becoming very stiff fissile light brown SILTSTONE. [UPPER TUNBRIDGE WELLS SAND]
					2.61	52.57		End of Borehole at 2.61 m

Type Results

Remarks: Target: potential radiological contamination at repaired broken drain (0.9m deep at manhole, estimated to be between 1 - 1.5m deep at WS). Refused at 2.61m bgl due to very stiff ground.

AGS

SKM ENVIROS

BOREHOLE LOG

Borehole No **WS56** Sheet 1 of 1

Project Name: **Further LQA, Novartis, Horsham**	Project No.: KU043500/1	Co-ords: 517720E - 131832N	Hole Type WS
Location: Novartis, Horsham, West Sussex		Level: -	Scale 1:50
Client: Novartis		Dates: 10/07/2014	Logged By PJH

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
		0.30-0.35	ES		0.10			MADE GROUND: TARMAC
					0.30			MADE GROUND: Light brown sandy medium to coarse subangular GRAVEL of concrete. Geotextile at base. [SUB BASE]
		0.50-1.00	ES		0.35			
					0.70			MADE GROUND: Soft to firm blue-grey clayey SILT with some black/dark staining. No odour. [REWORKED NATURAL STRATA]
					0.90			MADE GROUND: Soft to firm light blue-grey and orange-brown clayey slightly gravelly SILT. Gravel is medium subangular of siltstone. [REWORKED NATURAL STRATA]
					1.90			Firm friable light orange-brown with light blue-grey slightly sandy slightly gravelly SILT. Sand is fine to medium. Gravel is fine to medium subangular of siltstone. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
								Firm to stiff friable orange-brown with light blue-grey SILT. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
					2.85			Stiff light brown slightly gravelly SILT. Gravel is fine to medium subangular of siltstone. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
					3.00			2.10m - 2.30m: Very stiff fissile.
								Very stiff fissile orange-brown very gravelly SILT. Gravel is fine to medium subangular of siltstone. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
								End of Borehole at 3.00 m
			Type	Results				

Remarks: Target: potential radiological contamination at repaired broken drain (2.18m deep at manhole, estimated to be approximately 2.5m deep at WS).

AGS

SKM ENVIROS

BOREHOLE LOG

Borehole No **WS57** Sheet 1 of 1

Project Name: **Further LQA, Novartis, Horsham**	Project No.: KU043500/1	Co-ords: 517901E - 131625N	Hole Type OP
Location: Novartis, Horsham, West Sussex		Level: 57.58 m AOD	Scale 1:50
Client: Novartis		Dates: 07/07/2014	Logged By PJH

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
					0.25	57.33		MADE GROUND: Grass over brown uncompact organic clayey slightly gravelly SILT. Gravel is medium subangular of concrete. One cobble of concrete. [TOPSOIL]
					0.60	56.98		MADE GROUND: Firm friable light brown slightly gravelly SILT. Gravel is medium to coarse subrounded of flint. Becoming slightly clayey with depth. [SILT FILL / REWORKED NATURAL STRATA]
		0.90-1.00	ES		0.80	56.78		
					1.00	56.58		MADE GROUND: Firm slightly friable orange-brown mottled grey silty slightly gravelly CLAY. Gravel is medium to coarse subrounded of flint. Concrete block at 0.75m. [CLAY FILL / REWORKED NATURAL STRATA]
					1.40	56.18		MADE GROUND:MADE GROUND: Soft dark brown slightly silty slightly gravelly CLAY. Gravel is fine of brick, flint, concrete and carbonaceous material. [CLAY FILL / REWORKED NATURAL STRATA]
								Soft light grey and orange-brown slightly silty slightly sandy CLAY with occasional laminae of fine sand. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
								End of Borehole at 1.40 m
			Type	Results				

Remarks: Target: background radiological. Terminated at 1.4m bgl as natural ground confirmed.

AGS

SKM ENVIROS

BOREHOLE LOG

Borehole No **WS58** Sheet 1 of 1

Project Name: **Further LQA, Novartis, Horsham**	Project No.: KU043500/1	Co-ords: 518012E - 131715N	Hole Type OP
Location: Novartis, Horsham, West Sussex		Level: 56.95 m AOD	Scale 1:50
Client: Novartis		Dates: 08/07/2014	Logged By PJH

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
		0.30-0.40	ES		0.50	56.45		MADE GROUND: Grass over brown uncompact slightly clayey gravelly SILT. Gravel is fine to coarse subangular of concrete, flint, brick and possible carbonaceous material. [SILT FILL]
					1.20	55.75		Firm friable light brown and blue-grey slightly clayey slightly gravelly SILT. Gravel is medium to coarse subangular of siltstone. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
								End of Borehole at 1.20 m

Type Results

Remarks: Target: background radiological. Terminated at 1.2m bgl as natural ground confirmed.

AGS

SKM ENVIROS

BOREHOLE LOG

Borehole No **WS59** Sheet 1 of 1

Project Name: **Further LQA, Novartis, Horsham**	Project No.: KU043500/1	Co-ords: 518009E - 131640N	Hole Type OP
Location: Novartis, Horsham, West Sussex		Level: -	Scale 1:50
Client: Novartis		Dates: 11/07/2014	Logged By PJH

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
		0.20-0.25	ES		0.20			MADE GROUND: Coarse flint gravel over brown silty sandy medium to coarse subrounded to rounded GRAVEL of flint and occasional brick. [GRAVEL FILL]
		0.30-0.40	ES		0.25			MADE GROUND: Dark grey/black silty sandy medium to coarse subrounded to rounded GRAVEL of flint and occasional brick. [GRAVEL FILL]
		0.90-1.00	ES		1.20			Firm friable orange-brown and light blue-grey slightly gravelly SILT. Gravel is fine to medium subangular of siltstone and rare flint. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
								End of Borehole at 1.20 m

Type	Results

Remarks: Target: general land quality. Located outside building 22 as drilling inside buildings has been postponed. Terminated as natural strata confirmed. EP15 readings not elevated above background.

AGS

SKM ENVIROS

BOREHOLE LOG

Borehole No **WS60** Sheet 1 of 1

Project Name: **Further LQA, Novartis, Horsham**	Project No.: KU043500/1	Co-ords: 517896E - 131726N	Hole Type OP
Location: Novartis, Horsham, West Sussex		Level: 56.35 m AOD	Scale 1:50
Client: Novartis		Dates: 07/07/2014	Logged By PJH

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
					0.15	56.20		MADE GROUND: Grass over dark brown uncompact organic gravelly SILT. Gravel is fine to coarse subangular to rounded of flint, brick and concrete. [TOPSOIL]
					0.30	56.05		MADE GROUND: Firm to stiff light brown gravelly SILT. Gravel is fine to coarse subangular to subrounded of brick, concrete and flint. Cobbles of concrete and brick. Concrete and rebar across the base of the pit. [SILT RUBBLE FILL]
								End of Borehole at 0.30 m
			Type	Results				

Remarks: Target: general land quality. Terminated due to concrete and rebar across base of pit. EP15 readings not elevated above background.

AGS

SKM ENVIROS

BOREHOLE LOG

Borehole No
WS60A
Sheet 1 of 1

Project Name: **Further LQA, Novartis, Horsham**	Project No.: KU043500/1	Co-ords: 517894E - 131725N	Hole Type OP
Location: Novartis, Horsham, West Sussex		Level: 56.35 m AOD	Scale 1:50
Client: Novartis		Dates: 07/07/2014	Logged By PJH

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
					0.09	56.26		MADE GROUND: PLASTIC MATTING.
					0.30	56.05		MADE GROUND: Light grey silty medium SAND.[SUB BASE]
		0.40-0.50	ES		0.50	55.85		MADE GROUND: Soft light grey and orange-brown slightly sandy gravelly CLAY. Gravel is fine to coarse subangular of concrete and occasional brick. Concrete across the base of the pit. [CLAY RUBBLE FILL]
								End of Borehole at 0.50 m
			Type	Results				

Remarks: Target: general land quality. Terminated due to concrete across base of pit. EP15 readings not elevated above background.

AGS

SKM ENVIROS

BOREHOLE LOG

Borehole No **WS61** Sheet 1 of 1

Project Name: **Further LQA, Novartis, Horsham**	Project No.: KU043500/1	Co-ords: 518003E - 131721N	Hole Type OP
Location: Novartis, Horsham, West Sussex		Level: -	Scale 1:50
Client: Novartis		Dates: 09/07/2014	Logged By PJH

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
		0.30	ES		0.25			MADE GROUND: Grass over dark brown uncompact clayey slightly gravelly organic SILT. Gravel is fine to medium subangular of brick and concrete. [TOPSOIL]
		0.30-0.40	ES					
		0.60-0.70	ES		0.70			MADE GROUND: Dark brown silty slightly sandy cobbly fine to coarse angular to subrounded GRAVEL of flint, brick, concrete and possible carbonaceous material. Cobbles of concrete. Also includes 1 piece of plastic sheeting, 1 rebar and 1 piece of suspected ACM (cement-bound tile). [SILT / RUBBLE FILL]
					0.75			Firm light brown SILT. [Possible REWORKED NATURAL STRATA]
								End of Borehole at 0.75 m

Type Results

Remarks: Target: general land quality. Terminated due to metal obstruction - possible narrow diameter pipe - at base and no option to extend pit or suitable alternative location. EP15 not elevated above background.

AGS

SKM ENVIROS

BOREHOLE LOG

Borehole No **WS62** Sheet 1 of 1

Project Name: **Further LQA, Novartis, Horsham**	Project No.: KU043500/1	Co-ords: 517977E - 131748N	Hole Type OP
Location: Novartis, Horsham, West Sussex		Level: -	Scale 1:50
Client: Novartis		Dates: 10/07/2014	Logged By PJH

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
		0.10-0.20	ES		0.10			MADE GROUND: Grass over brown clayey organic SILT. [TOPSOIL]
		0.50-0.60	ES		0.40			MADE GROUND: Brown silty very sandy fine to coarse subangular to subrounded GRAVEL of flint, concrete, brick and rare charcoal. [GRAVEL FILL]
					0.60			
					0.75			MADE GROUND: Firm blue-grey silty slightly gravelly CLAY. Gravel is fine to medium of brick and concrete. Rare black staining. [CLAY FILL]
					1.20			MADE GROUND: Orange-brown gravelly medium to coarse SAND. Gravel is fine to coarse of brick, concrete and flint. [SAND FILL]
								Firm friable orange-brown slightly gravelly SILT. Gravel is fine to medium subangular of siltstone. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
								End of Borehole at 1.20 m
			Type	Results				

Remarks: Target: general land quality. Terminated as natural strata confirmed. EP15 readings not elevated above background.

AGS

SKM ENVIROS

BOREHOLE LOG

Borehole No **WS63** Sheet 1 of 1

Project Name: **Further LQA, Novartis, Horsham**	Project No.: KU043500/1	Co-ords: 517944E - 131729N	Hole Type OP
Location: Novartis, Horsham, West Sussex		Level: 56.47 m AOD	Scale 1:50
Client: Novartis		Dates: 10/07/2014	Logged By PJH

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
		0.20-0.30	ES					MADE GROUND: Firm friable red-brown slightly clayey slightly gravelly SILT. Gravel is fine to coarse subangular to rounded of flint, brick and concrete. [SILT FILL]
					0.60	55.87		
		0.70-0.80	ES					MADE GROUND: Orange-brown silty sandy fine to coarse subangular to subrounded GRAVEL of siltstone with rare brick and concrete. [REWORKED NATURAL STRATA]
					0.85	55.62		
					1.20	55.27		Firm friable orange-brown and light blue-grey slightly gravelly SILT. Gravel is fine to medium subangular of siltstone. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
								End of Borehole at 1.20 m
			Type	Results				

Remarks: Target: general land quality. Terminated as natural strata confirmed. EP15 readings not elevated above background.

AGS

SKM ENVIROS

BOREHOLE LOG

Borehole No **WS65** Sheet 1 of 1

Project Name:	Project No.:	Co-ords:	Hole Type
Further LQA, Novartis, Horsham	KU043500/1	517890E - 131702N	OP
Location: Novartis, Horsham, West Sussex		Level: 56.32 m AOD	Scale 1:50
Client: Novartis		Dates: 11/07/2014	Logged By PJH

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
		0.20-0.30	ES					MADE GROUND: Brown sandy gravelly SILT / CLAY. Gravel is fine to coarse subangular to subrounded of flint, brick, and concrete. [SILT / CLAY FILL]
		0.50-0.60	ES		0.40	55.92		
					0.70	55.62		MADE GROUND: Firm orange-brown and light blue-grey clayey slightly gravelly SILT. Gravel is fine to coarse subangular of siltstone and rare brick and concrete. [REWORKED NATURAL STRATA]
					1.20	55.12		Firm friable orange-brown and light blue-grey slightly gravelly SILT. Gravel is fine to medium subangular of siltstone. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
								End of Borehole at 1.20 m
			Type	Results				

Remarks: Target: general land quality. Under former building T
T1. Location in lieu of locations in adjacent buildings. Terminated as natural strata confirmed. EP15 readings not elevated above background.

AGS

SKM ENVIROS

BOREHOLE LOG

Borehole No **WS68** Sheet 1 of 1

Project Name: **Further LQA, Novartis, Horsham**	Project No.: KU043500/1	Co-ords: 517826E - 131814N	Hole Type OP
Location: Novartis, Horsham, West Sussex		Level: 56.19 m AOD	Scale 1:50
Client: Novartis		Dates: 10/07/2014	Logged By PJH

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
					0.06	56.13		MADE GROUND: TARMAC.
		0.30-0.40	ES		0.30	55.89		MADE GROUND: Reinforced CONCRETE.
		0.60-0.70	ES		0.55	55.64		MADE GROUND: Black sandy cobbly fine to coarse subangular GRAVEL of brick, concrete and occasional clinker. Cobbles of brick. [SUB BASE / GRAVEL FILL]
					0.90	55.29		Firm orange-brown clayey SILT. Becoming less clayey and more friable with depth. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
								End of Borehole at 0.90 m
			Type	Results				

Remarks: Target: general land quality. Terminated as natural strata confirmed. EP15 readings not elevated above background.

AGS

SKM ENVIROS

BOREHOLE LOG

Borehole No **WS69** Sheet 1 of 1

Project Name: **Further LQA, Novartis, Horsham**	Project No.: KU043500/1	Co-ords: 517748E - 131885N	Hole Type OP
Location: Novartis, Horsham, West Sussex		Level: 57.80 m AOD	Scale 1:50
Client: Novartis		Dates: 10/07/2014	Logged By PJH

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
		0.30-0.40	ES		0.10	57.70		MADE GROUND: TARMAC
					0.30	57.50		MADE GROUND: Light brown sandy medium to coarse subangular GRAVEL of concrete. Geotextile at base. [SUB BASE]
					1.00	56.80		Soft to firm light blue-grey and orange-brown clayey slightly gravelly SILT. Gravel is medium subangular of siltstone. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
					1.20	56.60		Firm friable light orange-brown with light blue-grey slightly sandy slightly gravelly SILT. Sand is fine to medium. Gravel is fine to medium subangular of siltstone. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
								End of Borehole at 1.20 m
			Type	Results				

Remarks: Target: general land quality. Terminated as natural strata confirmed. EP15 readings not elevated above background.

AGS

SKM ENVIROS

BOREHOLE LOG

Borehole No **WS70** Sheet 1 of 1

Project Name: **Further LQA, Novartis, Horsham**	Project No.: KU043500/1	Co-ords: 517999E - 131742N	Hole Type OP
Location: Novartis, Horsham, West Sussex		Level: -	Scale 1:50
Client: Novartis		Dates: 10/07/2014	Logged By PJH

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
		0.70-0.80	ES		0.25			MADE GROUND: TARMAC.
					0.55			MADE GROUND: Grey sandy medium to coarse subangular to subrounded GRAVEL of concrete. [SUB BASE]
					1.00			MADE GROUND: Grey-brown very sandy fine to coarse subangular to subrounded GRAVEL of concrete, brick, occasional flint and rare glass. [GRAVEL FILL]
								End of Borehole at 1.00 m

Type Results

Remarks: Target: general land quality. Terminated due to concrete obstruction across base of pit at 1.0m bgl. EP15 readings not elevated above background.

AGS

SKM ENVIROS

BOREHOLE LOG

Borehole No **WS71** Sheet 1 of 1

Project Name: **Further LQA, Novartis, Horsham**	Project No.: KU043500/1	Co-ords: 517942E - 131814N	Hole Type OP
Location: Novartis, Horsham, West Sussex		Level: -	Scale 1:50
Client: Novartis		Dates: 10/07/2014	Logged By PJH

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
		0.10-0.20	ES		0.15			Grass over soft to firm dark brown organic SILT. [TOPSOIL]
					0.60			Firm friable dark brown SILT. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
					1.10			Firm friable light brown and light blue-grey slightly gravelly SILT. Gravel is fine to medium subangular of siltstone. [Weathered SILTSTONE, UPPER TUNBRIDGE WELLS SAND]
								End of Borehole at 1.10 m
			Type	Results				

Remarks: Target: general land quality. Terminated as natural strata confirmed. EP15 readings not elevated above background.

AGS

Appendix C. Selected Photographs

WS46 – hand dug position beneath former incinerator (sub-base made ground over Upper Tunbridge Wells Sand Formation)

WS49 – made ground in hand dug pit targeting location of infilled former clay pit

WS51 – rotary drilling targeting ground near to drainage from Building 42

WS51 – rotary drill core (Upper Tunbridge Wells Sand Formation)

WS61 – piece of suspect asbestos cement

WS68 – made ground arisings

WS56 – hand digging through made ground

WS56 – drill core of Upper Tunbridge Wells Sand Formation

Appendix D. Chemical Analysis Certificates

Duncan Anderson
Jacobs
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Analytical Report Number : 14-57191

Project / Site name:	Horsham	**Samples received on:**	14/07/2014
Your job number:	JL30706	**Samples instructed on:**	14/07/2014
Your order number:		**Analysis completed by:**	21/07/2014
Report Issue Number:	1	**Report issued on:**	21/07/2014
Samples Analysed:	1 bulk sample - 17 soil samples		

Signed: [redacted]

Dr Claire Stone
Quality Manager
For & on behalf of i2 Analytical Ltd.

Signed: [redacted]

Rexona Rahman
Customer Services Manager
For & on behalf of i2 Analytical Ltd.

Other office located at: ul. Pionierów 39, 41 -711 Ruda Śląska, Poland

Standard sample disposal times, unless otherwise agreed with the laboratory, are :

soils	- 4 weeks from reporting
leachates	- 2 weeks from reporting
waters	- 2 weeks from reporting
asbestos	- 6 months from reporting

Excel copies of reports are only valid when accompanied by this PDF certificate.

Analytical Report Number: 14-57191

Project / Site name: Horsham

Lab Sample Number				355340	355341	355342	355343	355345
Sample Reference				WS55	WS55	WS61	WS61	WS54
Sample Number				ES1	ES2	ES1	ES2	ES1
Depth (m)				0.30-0.40	0.50-0.60	0.30-0.40	0.60-0.70	0.30-0.40
Date Sampled				09/07/2014	09/07/2014	09/07/2014	09/07/2014	09/07/2014
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Stone Content	%	0.1	NONE	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Moisture Content	%	N/A	NONE	15	15	10	10	9.5
Total mass of sample received	kg	0.001	NONE	0.49	0.48	0.50	0.50	0.48
Asbestos in Soil Screen / Identification Name	Type	N/A	ISO 17025	-	-	-	Amosite - Loose fibres	Amosite - Loose fibres
Asbestos in Soil	Type	N/A	ISO 17025	Not-detected	Not-detected	Not-detected	Detected	Detected
General Inorganics								
pH	pH Units	N/A	MCERTS	9.0	6.6	8.8	8.6	8.2
Total Cyanide	mg/kg	1	MCERTS	< 1	< 1	< 1	< 1	< 1
Total Organic Carbon (TOC)	%	0.1	MCERTS	0.3	0.3	1.5	1.3	0.6
Total Phenols								
Total Phenols (monohydric)	mg/kg	2	MCERTS	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Speciated PAHs								
Naphthalene	mg/kg	0.05	MCERTS	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Acenaphthylene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	0.39	< 0.10	< 0.10
Acenaphthene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	0.46	< 0.10	< 0.10
Fluorene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	0.39	0.19	< 0.10
Phenanthrene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	5.1	2.5	0.98
Anthracene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	1.6	0.81	0.25
Fluoranthene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	8.8	5.2	2.0
Pyrene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	7.4	4.5	1.8
Benzo(a)anthracene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	3.7	2.6	0.81
Chrysene	mg/kg	0.05	MCERTS	< 0.05	< 0.05	5.2	3.1	0.98
Benzo(b)fluoranthene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	7.1	4.0	0.97
Benzo(k)fluoranthene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	2.8	2.0	0.58
Benzo(a)pyrene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	6.3	3.6	0.93
Indeno(1,2,3-cd)pyrene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	3.3	1.8	0.46
Dibenz(a,h)anthracene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	0.35	0.22	< 0.10
Benzo(ghi)perylene	mg/kg	0.05	MCERTS	< 0.05	< 0.05	4.2	2.4	0.56
Total PAH								
Speciated Total EPA-16 PAHs	mg/kg	1.6	MCERTS	< 1.60	< 1.60	57.1	32.8	10.3
Heavy Metals / Metalloids								
Arsenic (aqua regia extractable)	mg/kg	1	MCERTS	6.6	8.2	9.1	7.8	10
Boron (water soluble)	mg/kg	0.2	MCERTS	0.7	0.5	1.3	1.3	0.4
Cadmium (aqua regia extractable)	mg/kg	0.2	MCERTS	< 0.2	< 0.2	0.3	0.2	< 0.2
Chromium (aqua regia extractable)	mg/kg	1	MCERTS	24	31	39	24	22
Copper (aqua regia extractable)	mg/kg	1	MCERTS	15	24	31	30	22
Lead (aqua regia extractable)	mg/kg	1	MCERTS	13	18	55	46	27
Mercury (aqua regia extractable)	mg/kg	0.3	MCERTS	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Nickel (aqua regia extractable)	mg/kg	1	MCERTS	15	21	19	20	16
Selenium (aqua regia extractable)	mg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Zinc (aqua regia extractable)	mg/kg	1	MCERTS	50	48	75	120	52

Analytical Report Number: 14-57191

Project / Site name: Horsham

Lab Sample Number				355340	355341	355342	355343	355345
Sample Reference				WS55	WS55	WS61	WS61	WS54
Sample Number				ES1	ES2	ES1	ES2	ES1
Depth (m)				0.30-0.40	0.50-0.60	0.30-0.40	0.60-0.70	0.30-0.40
Date Sampled				09/07/2014	09/07/2014	09/07/2014	09/07/2014	09/07/2014
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Monoaromatics								
Benzene	µg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Toluene	µg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethylbenzene	µg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
p & m-xylene	µg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-xylene	µg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
MTBE (Methyl Tertiary Butyl Ether)	µg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Petroleum Hydrocarbons								
TPH-CWG - Aliphatic >EC5 - EC6	mg/kg	0.1	MCERTS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPH-CWG - Aliphatic >EC6 - EC8	mg/kg	0.1	MCERTS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPH-CWG - Aliphatic >EC8 - EC10	mg/kg	0.1	MCERTS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPH-CWG - Aliphatic >EC10 - EC12	mg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aliphatic >EC12 - EC16	mg/kg	2	MCERTS	< 2.0	< 2.0	3.0	< 2.0	< 2.0
TPH-CWG - Aliphatic >EC16 - EC21	mg/kg	8	MCERTS	< 8.0	< 8.0	19	16	< 8.0
TPH-CWG - Aliphatic >EC21 - EC35	mg/kg	8	MCERTS	< 8.0	< 8.0	180	150	< 8.0
TPH-CWG - Aliphatic (EC5 - EC35)	mg/kg	10	MCERTS	< 10	< 10	200	170	< 10
TPH-CWG - Aromatic >EC5 - EC7	mg/kg	0.1	MCERTS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPH-CWG - Aromatic >EC7 - EC8	mg/kg	0.1	MCERTS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPH-CWG - Aromatic >EC8 - EC10	mg/kg	0.1	MCERTS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPH-CWG - Aromatic >EC10 - EC12	mg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aromatic >EC12 - EC16	mg/kg	2	MCERTS	< 2.0	< 2.0	7.1	2.9	< 2.0
TPH-CWG - Aromatic >EC16 - EC21	mg/kg	10	MCERTS	< 10	< 10	59	36	< 10
TPH-CWG - Aromatic >EC21 - EC35	mg/kg	10	MCERTS	< 10	< 10	390	260	< 10
TPH-CWG - Aromatic (EC5 - EC35)	mg/kg	10	MCERTS	< 10	< 10	460	300	< 10

Analytical Report Number: 14-57191

Project / Site name: Horsham

Lab Sample Number				355346	355347	355348	355349	355350
Sample Reference				WS71	WS63	WS69	WS56	WS62
Sample Number				ES1	ES1	ES1	ES1	ES1
Depth (m)				0.10-0.20	0.20-0.30	0.30-0.40	0.30-0.35	0.10-0.20
Date Sampled				10/07/2014	10/07/2014	10/07/2014	10/07/2014	10/07/2014
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Stone Content	%	0.1	NONE	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Moisture Content	%	N/A	NONE	16	15	12	15	8.9
Total mass of sample received	kg	0.001	NONE	0.46	0.50	0.52	0.45	0.51
Asbestos in Soil Screen / Identification Name	Type	N/A	ISO 17025	-	-	-	-	-
Asbestos in Soil	Type	N/A	ISO 17025	Not-detected	Not-detected	Not-detected	Not-detected	Not-detected
General Inorganics								
pH	pH Units	N/A	MCERTS	7.9	8.0	8.0	7.6	8.2
Total Cyanide	mg/kg	1	MCERTS	< 1	< 1	< 1	< 1	< 1
Total Organic Carbon (TOC)	%	0.1	MCERTS	1.9	0.4	0.2	1.6	0.6
Total Phenols								
Total Phenols (monohydric)	mg/kg	2	MCERTS	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Speciated PAHs								
Naphthalene	mg/kg	0.05	MCERTS	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Acenaphthylene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Acenaphthene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Fluorene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Phenanthrene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Anthracene	mg/kg	0.1	MCERTS	0.18	< 0.10	< 0.10	< 0.10	< 0.10
Fluoranthene	mg/kg	0.1	MCERTS	1.6	< 0.10	< 0.10	0.31	1.2
Pyrene	mg/kg	0.1	MCERTS	1.4	< 0.10	< 0.10	0.26	1.1
Benzo(a)anthracene	mg/kg	0.1	MCERTS	0.69	< 0.10	< 0.10	0.16	0.64
Chrysene	mg/kg	0.05	MCERTS	1.0	< 0.05	< 0.05	0.24	0.84
Benzo(b)fluoranthene	mg/kg	0.1	MCERTS	1.2	< 0.10	< 0.10	0.25	0.89
Benzo(k)fluoranthene	mg/kg	0.1	MCERTS	0.39	< 0.10	< 0.10	0.15	0.52
Benzo(a)pyrene	mg/kg	0.1	MCERTS	0.93	< 0.10	< 0.10	0.18	0.88
Indeno(1,2,3-cd)pyrene	mg/kg	0.1	MCERTS	0.44	< 0.10	< 0.10	< 0.10	0.50
Dibenz(a,h)anthracene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo(ghi)perylene	mg/kg	0.05	MCERTS	0.56	< 0.05	< 0.05	< 0.05	0.70
Total PAH								
Speciated Total EPA-16 PAHs	mg/kg	1.6	MCERTS	8.44	< 1.60	< 1.60	< 1.60	7.32
Heavy Metals / Metalloids								
Arsenic (aqua regia extractable)	mg/kg	1	MCERTS	9.8	12	6.4	6.6	7.9
Boron (water soluble)	mg/kg	0.2	MCERTS	0.9	1.2	0.2	1.4	2.1
Cadmium (aqua regia extractable)	mg/kg	0.2	MCERTS	0.2	< 0.2	< 0.2	< 0.2	< 0.2
Chromium (aqua regia extractable)	mg/kg	1	MCERTS	23	28	17	15	17
Copper (aqua regia extractable)	mg/kg	1	MCERTS	27	26	9.6	14	27
Lead (aqua regia extractable)	mg/kg	1	MCERTS	54	19	12	45	58
Mercury (aqua regia extractable)	mg/kg	0.3	MCERTS	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Nickel (aqua regia extractable)	mg/kg	1	MCERTS	14	28	11	7.7	15
Selenium (aqua regia extractable)	mg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Zinc (aqua regia extractable)	mg/kg	1	MCERTS	65	60	38	35	66

Analytical Report Number: 14-57191

Project / Site name: Horsham

Lab Sample Number				355346	355347	355348	355349	355350
Sample Reference				WS71	WS63	WS69	WS56	WS62
Sample Number				ES1	ES1	ES1	ES1	ES1
Depth (m)				0.10-0.20	0.20-0.30	0.30-0.40	0.30-0.35	0.10-0.20
Date Sampled				10/07/2014	10/07/2014	10/07/2014	10/07/2014	10/07/2014
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Monoaromatics								
Benzene	µg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Toluene	µg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethylbenzene	µg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
p & m-xylene	µg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-xylene	µg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
MTBE (Methyl Tertiary Butyl Ether)	µg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0

Petroleum Hydrocarbons

TPH-CWG - Aliphatic >EC5 - EC6	mg/kg	0.1	MCERTS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPH-CWG - Aliphatic >EC6 - EC8	mg/kg	0.1	MCERTS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPH-CWG - Aliphatic >EC8 - EC10	mg/kg	0.1	MCERTS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPH-CWG - Aliphatic >EC10 - EC12	mg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aliphatic >EC12 - EC16	mg/kg	2	MCERTS	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
TPH-CWG - Aliphatic >EC16 - EC21	mg/kg	8	MCERTS	< 8.0	< 8.0	< 8.0	< 8.0	< 8.0
TPH-CWG - Aliphatic >EC21 - EC35	mg/kg	8	MCERTS	< 8.0	< 8.0	< 8.0	< 8.0	33
TPH-CWG - Aliphatic (EC5 - EC35)	mg/kg	10	MCERTS	< 10	< 10	< 10	< 10	33

TPH-CWG - Aromatic >EC5 - EC7	mg/kg	0.1	MCERTS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPH-CWG - Aromatic >EC7 - EC8	mg/kg	0.1	MCERTS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPH-CWG - Aromatic >EC8 - EC10	mg/kg	0.1	MCERTS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPH-CWG - Aromatic >EC10 - EC12	mg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aromatic >EC12 - EC16	mg/kg	2	MCERTS	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
TPH-CWG - Aromatic >EC16 - EC21	mg/kg	10	MCERTS	11	< 10	< 10	< 10	< 10
TPH-CWG - Aromatic >EC21 - EC35	mg/kg	10	MCERTS	23	< 10	< 10	< 10	31
TPH-CWG - Aromatic (EC5 - EC35)	mg/kg	10	MCERTS	34	< 10	< 10	< 10	31

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Project / Site name: Horsham

Lab Sample Number				355351	355352	355353	355354	355355
Sample Reference				WS62	WS70	WS68	WS65	WS65
Sample Number				ES2	ES1	ES1	ES1	ES2
Depth (m)				0.50-0.60	0.70-0.80	0.30-0.40	0.20-0.30	0.50-0.60
Date Sampled				10/07/2014	10/07/2014	10/07/2014	11/07/2014	11/07/2014
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Stone Content	%	0.1	NONE	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Moisture Content	%	N/A	NONE	17	6.2	16	11	17
Total mass of sample received	kg	0.001	NONE	0.51	0.50	0.50	0.56	0.57
Asbestos in Soil Screen / Identification Name	Type	N/A	ISO 17025	-	-	-	-	-
Asbestos in Soil	Type	N/A	ISO 17025	Not-detected	Not-detected	Not-detected	Not-detected	Not-detected
General Inorganics								
pH	pH Units	N/A	MCERTS	7.9	11.3	10.3	7.1	7.6
Total Cyanide	mg/kg	1	MCERTS	< 1	< 1	< 1	< 1	< 1
Total Organic Carbon (TOC)	%	0.1	MCERTS	0.7	0.8	1.2	0.9	0.4
Total Phenols								
Total Phenols (monohydric)	mg/kg	2	MCERTS	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Speciated PAHs								
Naphthalene	mg/kg	0.05	MCERTS	< 0.05	0.25	< 0.05	< 0.05	< 0.05
Acenaphthylene	mg/kg	0.1	MCERTS	< 0.10	1.1	< 0.10	< 0.10	< 0.10
Acenaphthene	mg/kg	0.1	MCERTS	< 0.10	0.35	0.57	< 0.10	< 0.10
Fluorene	mg/kg	0.1	MCERTS	< 0.10	0.66	0.45	< 0.10	< 0.10
Phenanthrene	mg/kg	0.1	MCERTS	< 0.10	15	3.2	< 0.10	< 0.10
Anthracene	mg/kg	0.1	MCERTS	< 0.10	2.8	0.94	< 0.10	< 0.10
Fluoranthene	mg/kg	0.1	MCERTS	0.85	15	3.4	< 0.10	< 0.10
Pyrene	mg/kg	0.1	MCERTS	0.73	13	2.9	< 0.10	< 0.10
Benzo(a)anthracene	mg/kg	0.1	MCERTS	0.32	6.3	1.1	< 0.10	< 0.10
Chrysene	mg/kg	0.05	MCERTS	0.46	6.9	1.4	< 0.05	< 0.05
Benzo(b)fluoranthene	mg/kg	0.1	MCERTS	0.34	7.5	1.3	< 0.10	< 0.10
Benzo(k)fluoranthene	mg/kg	0.1	MCERTS	0.14	3.6	0.73	< 0.10	< 0.10
Benzo(a)pyrene	mg/kg	0.1	MCERTS	0.33	6.8	1.2	< 0.10	< 0.10
Indeno(1,2,3-cd)pyrene	mg/kg	0.1	MCERTS	< 0.10	3.0	0.54	< 0.10	< 0.10
Dibenz(a,h)anthracene	mg/kg	0.1	MCERTS	< 0.10	0.50	0.10	< 0.10	< 0.10
Benzo(ghi)perylene	mg/kg	0.05	MCERTS	< 0.05	3.5	0.65	< 0.05	< 0.05
Total PAH								
Speciated Total EPA-16 PAHs	mg/kg	1.6	MCERTS	3.18	86.0	18.4	< 1.60	< 1.60
Heavy Metals / Metalloids								
Arsenic (aqua regia extractable)	mg/kg	1	MCERTS	9.6	13	48	13	7.5
Boron (water soluble)	mg/kg	0.2	MCERTS	1.6	3.2	1.6	0.9	0.7
Cadmium (aqua regia extractable)	mg/kg	0.2	MCERTS	< 0.2	< 0.2	1.8	< 0.2	< 0.2
Chromium (aqua regia extractable)	mg/kg	1	MCERTS	18	20	37	18	20
Copper (aqua regia extractable)	mg/kg	1	MCERTS	21	140	1100	23	16
Lead (aqua regia extractable)	mg/kg	1	MCERTS	24	130	1200	40	19
Mercury (aqua regia extractable)	mg/kg	0.3	MCERTS	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Nickel (aqua regia extractable)	mg/kg	1	MCERTS	12	20	80	21	9.2
Selenium (aqua regia extractable)	mg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Zinc (aqua regia extractable)	mg/kg	1	MCERTS	49	130	1800	50	41

Analytical Report Number: 14-57191

Project / Site name: Horsham

Lab Sample Number				355351	355352	355353	355354	355355
Sample Reference				WS62	WS70	WS68	WS65	WS65
Sample Number				ES2	ES1	ES1	ES1	ES2
Depth (m)				0.50-0.60	0.70-0.80	0.30-0.40	0.20-0.30	0.50-0.60
Date Sampled				10/07/2014	10/07/2014	10/07/2014	11/07/2014	11/07/2014
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Monoaromatics								
Benzene	µg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Toluene	µg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethylbenzene	µg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
p & m-xylene	µg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-xylene	µg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
MTBE (Methyl Tertiary Butyl Ether)	µg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0

Petroleum Hydrocarbons

TPH-CWG - Aliphatic >EC5 - EC6	mg/kg	0.1	MCERTS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPH-CWG - Aliphatic >EC6 - EC8	mg/kg	0.1	MCERTS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPH-CWG - Aliphatic >EC8 - EC10	mg/kg	0.1	MCERTS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPH-CWG - Aliphatic >EC10 - EC12	mg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aliphatic >EC12 - EC16	mg/kg	2	MCERTS	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
TPH-CWG - Aliphatic >EC16 - EC21	mg/kg	8	MCERTS	< 8.0	< 8.0	< 8.0	< 8.0	< 8.0
TPH-CWG - Aliphatic >EC21 - EC35	mg/kg	8	MCERTS	< 8.0	60	< 8.0	< 8.0	< 8.0
TPH-CWG - Aliphatic (EC5 - EC35)	mg/kg	10	MCERTS	< 10	60	< 10	< 10	< 10

TPH-CWG - Aromatic >EC5 - EC7	mg/kg	0.1	MCERTS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPH-CWG - Aromatic >EC7 - EC8	mg/kg	0.1	MCERTS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPH-CWG - Aromatic >EC8 - EC10	mg/kg	0.1	MCERTS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPH-CWG - Aromatic >EC10 - EC12	mg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aromatic >EC12 - EC16	mg/kg	2	MCERTS	< 2.0	11	2.7	< 2.0	< 2.0
TPH-CWG - Aromatic >EC16 - EC21	mg/kg	10	MCERTS	< 10	100	15	< 10	< 10
TPH-CWG - Aromatic >EC21 - EC35	mg/kg	10	MCERTS	< 10	200	14	< 10	< 10
TPH-CWG - Aromatic (EC5 - EC35)	mg/kg	10	MCERTS	< 10	310	32	< 10	< 10

Analytical Report Number: 14-57191

Project / Site name: Horsham

Lab Sample Number				355356	355357			
Sample Reference				WS59	WS59			
Sample Number				ES1	ES2			
Depth (m)				0.20-0.25	0.30-0.40			
Date Sampled				11/07/2014	11/07/2014			
Time Taken				None Supplied	None Supplied			
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Stone Content	%	0.1	NONE	< 0.1	< 0.1			
Moisture Content	%	N/A	NONE	6.5	9.8			
Total mass of sample received	kg	0.001	NONE	0.52	0.47			
Asbestos in Soil Screen / Identification Name	Type	N/A	ISO 17025	-	-			
Asbestos in Soil	Type	N/A	ISO 17025	Not-detected	Not-detected			
General Inorganics								
pH	pH Units	N/A	MCERTS	9.9	8.8			
Total Cyanide	mg/kg	1	MCERTS	< 1	< 1			
Total Organic Carbon (TOC)	%	0.1	MCERTS	0.6	0.4			
Total Phenols								
Total Phenols (monohydric)	mg/kg	2	MCERTS	< 2.0	< 2.0			
Speciated PAHs								
Naphthalene	mg/kg	0.05	MCERTS	< 0.05	< 0.05			
Acenaphthylene	mg/kg	0.1	MCERTS	< 0.10	< 0.10			
Acenaphthene	mg/kg	0.1	MCERTS	< 0.10	< 0.10			
Fluorene	mg/kg	0.1	MCERTS	< 0.10	< 0.10			
Phenanthrene	mg/kg	0.1	MCERTS	< 0.10	< 0.10			
Anthracene	mg/kg	0.1	MCERTS	0.22	< 0.10			
Fluoranthene	mg/kg	0.1	MCERTS	0.92	< 0.10			
Pyrene	mg/kg	0.1	MCERTS	0.82	< 0.10			
Benzo(a)anthracene	mg/kg	0.1	MCERTS	0.37	< 0.10			
Chrysene	mg/kg	0.05	MCERTS	0.48	< 0.05			
Benzo(b)fluoranthene	mg/kg	0.1	MCERTS	0.53	< 0.10			
Benzo(k)fluoranthene	mg/kg	0.1	MCERTS	0.30	< 0.10			
Benzo(a)pyrene	mg/kg	0.1	MCERTS	0.44	< 0.10			
Indeno(1,2,3-cd)pyrene	mg/kg	0.1	MCERTS	< 0.10	< 0.10			
Dibenz(a,h)anthracene	mg/kg	0.1	MCERTS	< 0.10	< 0.10			
Benzo(ghi)perylene	mg/kg	0.05	MCERTS	0.26	< 0.05			
Total PAH								
Speciated Total EPA-16 PAHs	mg/kg	1.6	MCERTS	4.34	< 1.60			
Heavy Metals / Metalloids								
Arsenic (aqua regia extractable)	mg/kg	1	MCERTS	12	14			
Boron (water soluble)	mg/kg	0.2	MCERTS	2.1	0.8			
Cadmium (aqua regia extractable)	mg/kg	0.2	MCERTS	0.4	1.3			
Chromium (aqua regia extractable)	mg/kg	1	MCERTS	23	22			
Copper (aqua regia extractable)	mg/kg	1	MCERTS	74	34			
Lead (aqua regia extractable)	mg/kg	1	MCERTS	49	33			
Mercury (aqua regia extractable)	mg/kg	0.3	MCERTS	< 0.3	< 0.3			
Nickel (aqua regia extractable)	mg/kg	1	MCERTS	23	26			
Selenium (aqua regia extractable)	mg/kg	1	MCERTS	< 1.0	< 1.0			
Zinc (aqua regia extractable)	mg/kg	1	MCERTS	140	210			

Analytical Report Number: 14-57191

Project / Site name: Horsham

Lab Sample Number				355356	355357			
Sample Reference				WS59	WS59			
Sample Number				ES1	ES2			
Depth (m)				0.20-0.25	0.30-0.40			
Date Sampled				11/07/2014	11/07/2014			
Time Taken				None Supplied	None Supplied			
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Monoaromatics								
Benzene	µg/kg	1	MCERTS	< 1.0	< 1.0			
Toluene	µg/kg	1	MCERTS	< 1.0	< 1.0			
Ethylbenzene	µg/kg	1	MCERTS	< 1.0	< 1.0			
p & m-xylene	µg/kg	1	MCERTS	< 1.0	< 1.0			
o-xylene	µg/kg	1	MCERTS	< 1.0	< 1.0			
MTBE (Methyl Tertiary Butyl Ether)	µg/kg	1	MCERTS	< 1.0	< 1.0			

Petroleum Hydrocarbons

TPH-CWG - Aliphatic >EC5 - EC6	mg/kg	0.1	MCERTS	< 0.1	< 0.1			
TPH-CWG - Aliphatic >EC6 - EC8	mg/kg	0.1	MCERTS	< 0.1	< 0.1			
TPH-CWG - Aliphatic >EC8 - EC10	mg/kg	0.1	MCERTS	< 0.1	< 0.1			
TPH-CWG - Aliphatic >EC10 - EC12	mg/kg	1	MCERTS	< 1.0	< 1.0			
TPH-CWG - Aliphatic >EC12 - EC16	mg/kg	2	MCERTS	2.2	< 2.0			
TPH-CWG - Aliphatic >EC16 - EC21	mg/kg	8	MCERTS	36	12			
TPH-CWG - Aliphatic >EC21 - EC35	mg/kg	8	MCERTS	200	88			
TPH-CWG - Aliphatic (EC5 - EC35)	mg/kg	10	MCERTS	240	100			

TPH-CWG - Aromatic >EC5 - EC7	mg/kg	0.1	MCERTS	< 0.1	< 0.1			
TPH-CWG - Aromatic >EC7 - EC8	mg/kg	0.1	MCERTS	< 0.1	< 0.1			
TPH-CWG - Aromatic >EC8 - EC10	mg/kg	0.1	MCERTS	< 0.1	< 0.1			
TPH-CWG - Aromatic >EC10 - EC12	mg/kg	1	MCERTS	< 1.0	< 1.0			
TPH-CWG - Aromatic >EC12 - EC16	mg/kg	2	MCERTS	2.1	< 2.0			
TPH-CWG - Aromatic >EC16 - EC21	mg/kg	10	MCERTS	21	< 10			
TPH-CWG - Aromatic >EC21 - EC35	mg/kg	10	MCERTS	67	< 10			
TPH-CWG - Aromatic (EC5 - EC35)	mg/kg	10	MCERTS	91	< 10			

Analytical Report Number: 14-57191

Project / Site name: Horsham

Lab Sample Number				355344				
Sample Reference				WS61				
Sample Number				ES3				
Depth (m)				0.30				
Date Sampled				09/07/2014				
Time Taken				None Supplied				
Analytical Parameter (Bulk Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Asbestos Identification Name	Type	N/A	ISO 17025	Amosite - Hard/cement type material				

Analytical Report Number : 14-57191

Project / Site name: Horsham

* These descriptions are only intended to act as a cross check if sample identities are questioned. The major constituent of the sample is intended to act with respect to MCERTS validation. The laboratory is accredited for sand, clay and topsoil/loam soil types. Data for unaccredited types of solid should be interpreted with care.

Stone content of a sample is calculated as the % weight of the stones not passing a 2 mm sieve. Results are not corrected for stone content.

Lab Sample Number	Sample Reference	Sample Number	Depth (m)	Sample Description *
355340	WS55	ES1	0.30-0.40	Light brown clay and sand.
355341	WS55	ES2	0.50-0.60	Light brown clay and sand.
355342	WS61	ES1	0.30-0.40	Brown sandy topsoil with gravel and vegetation.
355343	WS61	ES2	0.60-0.70	Brown topsoil and clay with gravel.
355345	WS54	ES1	0.30-0.40	Light brown sandy topsoil with gravel and vegetation.
355346	WS71	ES1	0.10-0.20	Brown sandy topsoil with gravel and vegetation.
355347	WS63	ES1	0.20-0.30	Brown clay and sand.
355348	WS69	ES1	0.30-0.40	Light brown clay and sand.
355349	WS56	ES1	0.30-0.35	Brown clay and sand.
355350	WS62	ES1	0.10-0.20	Light brown sandy topsoil with gravel and vegetation.
355351	WS62	ES2	0.50-0.60	Light brown clay and sand.
355352	WS70	ES1	0.70-0.80	Light brown sandy topsoil with gravel.
355353	WS68	ES1	0.30-0.40	Brown gravelly topsoil with glass.
355354	WS65	ES1	0.20-0.30	Brown topsoil and clay with gravel.
355355	WS65	ES2	0.50-0.60	Light brown clay and sand.
355356	WS59	ES1	0.20-0.25	Brown topsoil and sand with gravel.
355357	WS59	ES2	0.30-0.40	Light brown topsoil and sand with gravel.

Analytical Report Number : 14-57191

Project / Site name: Horsham

Water matrix abbreviations: Surface Water (SW) Potable Water (PW) Ground Water (GW)

Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
Asbestos identification in Bulks	Asbestos Identification with the use of polarised light microscopy in conjunction with disperion staining techniques.	In house method based on HSG 248	A001-PL	W	ISO 17025
Boron, water soluble, in soil	Determination of water soluble boron in soil by hot water extract followed by ICP-OES.	In-house method based on Second Site Properties version 3	L038-PL	D	MCERTS
BTEX and MTBE in soil	Determination of BTEX in soil by headspace GC-MS.	In-house method based on USEPA8260	L073S-PL	W	MCERTS
Metals in soil by ICP-OES	Determination of metals in soil by aqua-regia digestion followed by ICP-OES.	In-house method based on MEWAM 2006 Methods for the Determination of Metals in Soil.	L038-PL	D	MCERTS
Moisture Content	Moisture content, determined gravimetrically.	In-house method based on BS1377 Part 3, 1990, Chemical and Electrochemical Tests	L019-UK/PL	W	NONE
Monohydric phenols in soil	Determination of phenols in soil by extraction with sodium hydroxide followed by distillation followed by colorimetry.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton (skalar)	L080-PL	W	MCERTS
pH in soil	Determination of pH in soil by addition of water followed by electrometric measurement.	In-house method based on BS1377 Part 3, 1990, Chemical and Electrochemical Tests	L005-PL	W	MCERTS
Speciated EPA-16 PAHs in soil	Determination of PAH compounds in soil by extraction in dichloromethane and hexane followed by GC-MS with the use of surrogate and internal standards.	In-house method based on USEPA 8270	L064-PL	D	MCERTS
Stones content of soil	Standard preparation for all samples unless otherwise detailed. Stones not passing through a 10 mm sieve is determined gravimetrically and reported as a percentage of the dry weight.	In-house method based on British Standard Methods and MCERTS requirements.	L019-UK/PL	D	NONE
Total cyanide in soil	Determination of total cyanide by distillation followed by colorimetry.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton (Skalar)	L080-PL	W	MCERTS
Total organic carbon in soil	Determination of organic matter in soil by oxidising with potassium dichromate followed by titration with iron (II) sulphate.	In-house method based on BS1377 Part 3, 1990, Chemical and Electrochemical Tests	L023-PL	D	MCERTS
TPHCWG (Soil)	Determination of pentane extractable hydrocarbons in soil by GC-MS/GC-FID.	In-house method	L076-PL	W	MCERTS

For method numbers ending in 'UK' analysis have been carried out in our laboratory in the United Kingdom.
For method numbers ending in 'PL' analysis have been carried out in our laboratory in Poland.
Soil analytical results are expressed on a dry weight basis. Where analysis is carried out on as-received the results obtained are multiplied by a moisture correction factor that is determined gravimetrically using the moisture content which is carried out at a maximum of 30oC.

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Analytical Report Number : 14-57117

Project / Site name:	Horsham	**Samples received on:**	09/07/2014
Your job number:	JL30706	**Samples instructed on:**	10/07/2014
Your order number:		**Analysis completed by:**	18/07/2014
Report Issue Number:	1	**Report issued on:**	21/07/2014
Samples Analysed:	10 soil samples		

Signed: [redacted]

Dr Claire Stone
Quality Manager
For & on behalf of i2 Analytical Ltd.

Signed: [redacted]

Rexona Rahman
Customer Services Manager
For & on behalf of i2 Analytical Ltd.

Other office located at: ul. Pionierów 39, 41 -711 Ruda Śląska, Poland

Standard sample disposal times, unless otherwise agreed with the laboratory, are :

soils	- 4 weeks from reporting
leachates	- 2 weeks from reporting
waters	- 2 weeks from reporting
asbestos	- 6 months from reporting

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Analytical Report Number: 14-57117

Project / Site name: Horsham

Lab Sample Number				354923	354924	354925	354926	354927
Sample Reference				WS46 ES2	WS60A ES1	WS57 ES1	WS58 ES1	WS50 ES1
Sample Number				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Depth (m)				0.50-0.60	0.40-0.50	0.90-1.00	0.30-0.40	0.50-0.60
Date Sampled				07/07/2014	07/07/2014	07/07/2014	07/07/2014	07/07/2014
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Stone Content	%	0.1	NONE	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Moisture Content	%	N/A	NONE	11	12	9.3	7.7	9.6
Total mass of sample received	kg	0.001	NONE	0.45	0.51	0.51	0.46	0.45
Asbestos in Soil	Type	N/A	ISO 17025	Not-detected	Not-detected	Not-detected	Not-detected	Not-detected
General Inorganics								
pH	pH Units	N/A	MCERTS	7.1	7.2	7.3	7.3	7.4
Total Cyanide	mg/kg	1	MCERTS	< 1	< 1	< 1	< 1	< 1
Total Organic Carbon (TOC)	%	0.1	MCERTS	0.3	0.4	0.6	0.8	0.3
Total Phenols								
Total Phenols (monohydric)	mg/kg	2	MCERTS	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Speciated PAHs								
Naphthalene	mg/kg	0.05	MCERTS	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Acenaphthylene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Acenaphthene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	< 0.10	0.19	< 0.10
Fluorene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	< 0.10	0.18	< 0.10
Phenanthrene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	1.1	3.8	< 0.10
Anthracene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	0.17	0.92	< 0.10
Fluoranthene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	2.4	9.5	< 0.10
Pyrene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	1.9	8.1	< 0.10
Benzo(a)anthracene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	1.1	4.6	< 0.10
Chrysene	mg/kg	0.05	MCERTS	< 0.05	< 0.05	1.0	4.8	< 0.05
Benzo(b)fluoranthene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	0.82	5.6	< 0.10
Benzo(k)fluoranthene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	0.43	2.1	< 0.10
Benzo(a)pyrene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	0.84	4.3	< 0.10
Indeno(1,2,3-cd)pyrene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	0.29	2.4	< 0.10
Dibenz(a,h)anthracene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	< 0.10	0.32	< 0.10
Benzo(ghi)perylene	mg/kg	0.05	MCERTS	< 0.05	< 0.05	0.45	3.0	< 0.05
Total PAH								
Speciated Total EPA-16 PAHs	mg/kg	1.6	MCERTS	< 1.60	< 1.60	10.5	49.8	< 1.60
Heavy Metals / Metalloids								
Arsenic (aqua regia extractable)	mg/kg	1	MCERTS	7.1	6.9	8.1	5.7	5.1
Boron (water soluble)	mg/kg	0.2	MCERTS	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Cadmium (aqua regia extractable)	mg/kg	0.2	MCERTS	0.2	< 0.2	< 0.2	< 0.2	< 0.2
Chromium (aqua regia extractable)	mg/kg	1	MCERTS	19	21	17	16	18
Copper (aqua regia extractable)	mg/kg	1	MCERTS	23	18	21	18	14
Lead (aqua regia extractable)	mg/kg	1	MCERTS	20	21	30	31	11
Mercury (aqua regia extractable)	mg/kg	0.3	MCERTS	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Nickel (aqua regia extractable)	mg/kg	1	MCERTS	19	14	9.5	10	7.4
Selenium (aqua regia extractable)	mg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Zinc (aqua regia extractable)	mg/kg	1	MCERTS	75	43	38	69	47

Analytical Report Number: 14-57117

Project / Site name: Horsham

Lab Sample Number				354923	354924	354925	354926	354927
Sample Reference				WS46 ES2	WS60A ES1	WS57 ES1	WS58 ES1	WS50 ES1
Sample Number				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Depth (m)				0.50-0.60	0.40-0.50	0.90-1.00	0.30-0.40	0.50-0.60
Date Sampled				07/07/2014	07/07/2014	07/07/2014	07/07/2014	07/07/2014
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Monoaromatics								
Benzene	µg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Toluene	µg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethylbenzene	µg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
p & m-xylene	µg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-xylene	µg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
MTBE (Methyl Tertiary Butyl Ether)	µg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Petroleum Hydrocarbons								
TPH-CWG - Aliphatic >EC5 - EC6	mg/kg	0.1	MCERTS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPH-CWG - Aliphatic >EC6 - EC8	mg/kg	0.1	MCERTS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPH-CWG - Aliphatic >EC8 - EC10	mg/kg	0.1	MCERTS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPH-CWG - Aliphatic >EC10 - EC12	mg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aliphatic >EC12 - EC16	mg/kg	2	MCERTS	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
TPH-CWG - Aliphatic >EC16 - EC21	mg/kg	8	MCERTS	< 8.0	< 8.0	< 8.0	< 8.0	< 8.0
TPH-CWG - Aliphatic >EC21 - EC35	mg/kg	8	MCERTS	< 8.0	< 8.0	< 8.0	< 8.0	< 8.0
TPH-CWG - Aliphatic (EC5 - EC35)	mg/kg	10	MCERTS	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aromatic >EC5 - EC7	mg/kg	0.1	MCERTS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPH-CWG - Aromatic >EC7 - EC8	mg/kg	0.1	MCERTS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPH-CWG - Aromatic >EC8 - EC10	mg/kg	0.1	MCERTS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPH-CWG - Aromatic >EC10 - EC12	mg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aromatic >EC12 - EC16	mg/kg	2	MCERTS	< 2.0	< 2.0	< 2.0	2.2	< 2.0
TPH-CWG - Aromatic >EC16 - EC21	mg/kg	10	MCERTS	< 10	< 10	12	35	< 10
TPH-CWG - Aromatic >EC21 - EC35	mg/kg	10	MCERTS	< 10	< 10	14	79	< 10
TPH-CWG - Aromatic (EC5 - EC35)	mg/kg	10	MCERTS	< 10	< 10	26	120	< 10

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Lab Sample Number				354928	354929	354930	354931	354932
Sample Reference				WS49 ES1	WS51 ES1	WS47 ES1	WS52 ES2	WS53 ES1
Sample Number				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Depth (m)				0.60-0.70	0.10-0.20	0.60-0.70	0.50-0.60	0.10-0.20
Date Sampled				07/07/2014	07/07/2014	07/07/2014	07/07/2014	07/07/2014
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Stone Content	%	0.1	NONE	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Moisture Content	%	N/A	NONE	10	9.4	14	8.5	10
Total mass of sample received	kg	0.001	NONE	0.43	0.45	0.47	0.44	0.47
Asbestos in Soil	Type	N/A	ISO 17025	Not-detected	Not-detected	Not-detected	Not-detected	Not-detected
General Inorganics								
pH	pH Units	N/A	MCERTS	7.2	7.2	7.3	7.6	7.2
Total Cyanide	mg/kg	1	MCERTS	< 1	< 1	< 1	< 1	< 1
Total Organic Carbon (TOC)	%	0.1	MCERTS	0.7	1.4	2.2	0.6	0.7
Total Phenols								
Total Phenols (monohydric)	mg/kg	2	MCERTS	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Speciated PAHs								
Naphthalene	mg/kg	0.05	MCERTS	< 0.05	< 0.05	0.39	< 0.05	< 0.05
Acenaphthylene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Acenaphthene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Fluorene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Phenanthrene	mg/kg	0.1	MCERTS	< 0.10	0.85	0.72	< 0.10	0.19
Anthracene	mg/kg	0.1	MCERTS	< 0.10	0.17	0.14	< 0.10	< 0.10
Fluoranthene	mg/kg	0.1	MCERTS	< 0.10	2.2	1.3	< 0.10	0.58
Pyrene	mg/kg	0.1	MCERTS	< 0.10	1.8	1.2	< 0.10	0.50
Benzo(a)anthracene	mg/kg	0.1	MCERTS	< 0.10	1.1	0.61	< 0.10	0.26
Chrysene	mg/kg	0.05	MCERTS	< 0.05	1.1	0.97	< 0.05	0.29
Benzo(b)fluoranthene	mg/kg	0.1	MCERTS	< 0.10	0.92	1.1	< 0.10	0.25
Benzo(k)fluoranthene	mg/kg	0.1	MCERTS	< 0.10	0.57	0.56	< 0.10	0.16
Benzo(a)pyrene	mg/kg	0.1	MCERTS	< 0.10	0.93	0.73	< 0.10	0.26
Indeno(1,2,3-cd)pyrene	mg/kg	0.1	MCERTS	< 0.10	0.50	0.55	< 0.10	< 0.10
Dibenz(a,h)anthracene	mg/kg	0.1	MCERTS	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo(ghi)perylene	mg/kg	0.05	MCERTS	< 0.05	0.58	0.63	< 0.05	< 0.05
Total PAH								
Speciated Total EPA-16 PAHs	mg/kg	1.6	MCERTS	< 1.60	10.6	8.82	< 1.60	2.50
Heavy Metals / Metalloids								
Arsenic (aqua regia extractable)	mg/kg	1	MCERTS	9.9	9.5	23	6.3	6.8
Boron (water soluble)	mg/kg	0.2	MCERTS	< 0.2	< 0.2	0.4	< 0.2	< 0.2
Cadmium (aqua regia extractable)	mg/kg	0.2	MCERTS	0.2	< 0.2	0.6	< 0.2	< 0.2
Chromium (aqua regia extractable)	mg/kg	1	MCERTS	20	21	21	13	15
Copper (aqua regia extractable)	mg/kg	1	MCERTS	33	37	270	13	13
Lead (aqua regia extractable)	mg/kg	1	MCERTS	40	60	290	22	34
Mercury (aqua regia extractable)	mg/kg	0.3	MCERTS	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Nickel (aqua regia extractable)	mg/kg	1	MCERTS	12	14	31	9.8	10
Selenium (aqua regia extractable)	mg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Zinc (aqua regia extractable)	mg/kg	1	MCERTS	1300	110	1200	110	37

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Lab Sample Number				354928	354929	354930	354931	354932
Sample Reference				WS49 ES1	WS51 ES1	WS47 ES1	WS52 ES2	WS53 ES1
Sample Number				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Depth (m)				0.60-0.70	0.10-0.20	0.60-0.70	0.50-0.60	0.10-0.20
Date Sampled				07/07/2014	07/07/2014	07/07/2014	07/07/2014	07/07/2014
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Monoaromatics								
Benzene	µg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Toluene	µg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethylbenzene	µg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
p & m-xylene	µg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-xylene	µg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
MTBE (Methyl Tertiary Butyl Ether)	µg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0

Petroleum Hydrocarbons

TPH-CWG - Aliphatic >EC5 - EC6	mg/kg	0.1	MCERTS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPH-CWG - Aliphatic >EC6 - EC8	mg/kg	0.1	MCERTS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPH-CWG - Aliphatic >EC8 - EC10	mg/kg	0.1	MCERTS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPH-CWG - Aliphatic >EC10 - EC12	mg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aliphatic >EC12 - EC16	mg/kg	2	MCERTS	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
TPH-CWG - Aliphatic >EC16 - EC21	mg/kg	8	MCERTS	< 8.0	< 8.0	< 8.0	< 8.0	< 8.0
TPH-CWG - Aliphatic >EC21 - EC35	mg/kg	8	MCERTS	< 8.0	< 8.0	15	< 8.0	< 8.0
TPH-CWG - Aliphatic (EC5 - EC35)	mg/kg	10	MCERTS	< 10	< 10	15	< 10	< 10

TPH-CWG - Aromatic >EC5 - EC7	mg/kg	0.1	MCERTS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPH-CWG - Aromatic >EC7 - EC8	mg/kg	0.1	MCERTS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPH-CWG - Aromatic >EC8 - EC10	mg/kg	0.1	MCERTS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPH-CWG - Aromatic >EC10 - EC12	mg/kg	1	MCERTS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aromatic >EC12 - EC16	mg/kg	2	MCERTS	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
TPH-CWG - Aromatic >EC16 - EC21	mg/kg	10	MCERTS	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aromatic >EC21 - EC35	mg/kg	10	MCERTS	< 10	< 10	12	< 10	< 10
TPH-CWG - Aromatic (EC5 - EC35)	mg/kg	10	MCERTS	< 10	< 10	12	< 10	< 10

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* These descriptions are only intended to act as a cross check if sample identities are questioned. The major constituent of the sample is intended to act with respect to MCERTS validation. The laboratory is accredited for sand, clay and topsoil/loam soil types. Data for unaccredited types of solid should be interpreted with care.

Stone content of a sample is calculated as the % weight of the stones not passing a 2 mm sieve. Results are not corrected for stone content.

Lab Sample Number	Sample Reference	Sample Number	Depth (m)	Sample Description *
354923	WS46 ES2	None Supplied	0.50-0.60	Light brown clay and sand.
354924	WS60A ES1	None Supplied	0.40-0.50	Light brown clay and sand.
354925	WS57 ES1	None Supplied	0.90-1.00	Light brown clay and sand.
354926	WS58 ES1	None Supplied	0.30-0.40	Light brown sandy topsoil with gravel and vegetation.
354927	WS50 ES1	None Supplied	0.50-0.60	Beige clay and sand with gravel.
354928	WS49 ES1	None Supplied	0.60-0.70	Light brown sandy topsoil with gravel and vegetation.
354929	WS51 ES1	None Supplied	0.10-0.20	Light brown sandy topsoil with gravel and vegetation.
354930	WS47 ES1	None Supplied	0.60-0.70	Brown sandy topsoil with gravel and vegetation.
354931	WS52 ES2	None Supplied	0.50-0.60	Light brown sandy topsoil with gravel and vegetation.
354932	WS53 ES1	None Supplied	0.10-0.20	Light brown sandy topsoil with gravel and vegetation.

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Water matrix abbreviations: Surface Water (SW) Potable Water (PW) Ground Water (GW)

Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
Asbestos identification in soil	Asbestos Identification with the use of polarised light microscopy in conjunction with disperion staining techniques.	In house method based on HSG 248	A001-PL	D	ISO 17025
Boron, water soluble, in soil	Determination of water soluble boron in soil by hot water extract followed by ICP-OES.	In-house method based on Second Site Properties version 3	L038-PL	D	MCERTS
BTEX and MTBE in soil	Determination of BTEX in soil by headspace GC-MS.	In-house method based on USEPA8260	L073S-PL	W	MCERTS
Metals in soil by ICP-OES	Determination of metals in soil by aqua-regia digestion followed by ICP-OES.	In-house method based on MEWAM 2006 Methods for the Determination of Metals in Soil.	L038-PL	D	MCERTS
Moisture Content	Moisture content, determined gravimetrically.	In-house method based on BS1377 Part 3, 1990, Chemical and Electrochemical Tests	L019-UK/PL	W	NONE
Monohydric phenols in soil	Determination of phenols in soil by extraction with sodium hydroxide followed by distillation followed by colorimetry.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton (skalar)	L080-PL	W	MCERTS
pH in soil	Determination of pH in soil by addition of water followed by electrometric measurement.	In-house method based on BS1377 Part 3, 1990, Chemical and Electrochemical Tests	L005-PL	W	MCERTS
Speciated EPA-16 PAHs in soil	Determination of PAH compounds in soil by extraction in dichloromethane and hexane followed by GC-MS with the use of surrogate and internal standards.	In-house method based on USEPA 8270	L064-PL	D	MCERTS
Stones content of soil	Standard preparation for all samples unless otherwise detailed. Stones not passing through a 10 mm sieve is determined gravimetrically and reported as a percentage of the dry weight. Sample	In-house method based on British Standard Methods and MCERTS requirements.	L019-UK/PL	D	NONE
Total cyanide in soil	Determination of total cyanide by distillation followed by colorimetry.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton (Skalar)	L080-PL	W	MCERTS
Total organic carbon in soil	Determination of organic matter in soil by oxidising with potassium dichromate followed by titration with iron (II) sulphate.	In-house method based on BS1377 Part 3, 1990, Chemical and Electrochemical Tests	L023-PL	D	MCERTS
TPHCWG (Soil)	Determination of pentane extractable hydrocarbons in soil by GC-MS/GC-FID.	In-house method	L076-PL	W	MCERTS

For method numbers ending in 'UK' analysis have been carried out in our laboratory in the United Kingdom.
For method numbers ending in 'PL' analysis have been carried out in our laboratory in Poland.
Soil analytical results are expressed on a dry weight basis. Where analysis is carried out on as-received the results obtained are multiplied by a moisture correction factor that is determined gravimetrically using the moisture content which is carried out at a maximum of 30oC.

Appendix E. Derivation of GACs Methodology

Screening Values for Chronic Risks to Human Health from Contaminants in Shallow Soil

1.1 Introduction

The standard methodology for assessment of chronic risks to human health from was originally produced in 2002 and titled the "Contaminated Land Exposure Assessment" (CLEA) methodology. This comprised a number of documents providing information on how to assess the exposure to soil contaminants from typical behaviour as well as providing UK data such as standard body weights, soil ingestion, and vegetable consumption rates.

Information on toxicology was also provided for a number of substances and soil guideline values (SGVs) were produced by using the toxicological data as well as data collated on chemical and physical properties of these substances.

1.2 Revisions to the CLEA Model

Between August 2008 and January 2009 the Environment Agency reviewed and made a large number of changes to the CLEA methodology and exposure data. As part of this the Environment Agency:

- withdrew all the SGV reports;
- issued draft and final new versions of the CLEA methodology (SR3), formerly called CLR10, and the CLEA model;
- issued draft and final versions of the methodology used to calculate the toxicity data entered into the model (SR2), formerly called CLR9; and
- stated that the current TOX reports will be replaced by new ones by March 2009 (old reports to be withdrawn as each new one is issued).

Since then the Environment Agency has begun publishing revised SGV and TOX reports on a rolling programme. In October 2009 this comprised eleven revised SGV and TOX reports substances including five for metals and metalloids (arsenic, cadmium, selenium, nickel and mercury) and six for organics (benzene, xylene, toluene, ethylbenzene, phenol and for dioxins, furans and dioxin-like PCBs).

The revised CLEA SGV sets out exposure data for three standard scenarios:

- Residential areas where vegetables are grown and consumed;
- Allotments;
- Commercial and industrial areas.

In addition the CLEA SGV calculated their SGV assuming a sandy loam soil with 6% Soil Organic Matter. For each of the substances the Environment Agency have made a number of substance specific decisions in their assessment.

1.3 Jacobs Generic Assessment Criteria

1.3.1 Approach for contaminants where SGVs have been published

Jacobs has adopted the SGVs where they have been published and as each SGVs is produced by the Environment Agency they will replace the current interim GAC values. However the standard scenarios did not include residential areas where no plants are grown. This is a common land use and one often used in screening for public open spaces. In addition they are not conservative for soil where the organic matter is less

than 6% (where volatilisation and uptake by plants may be higher). Therefore, Jacobs has developed a set of internal generic assessment criteria (GACs) for all contaminants where the EA issued an SGV report or toxicological data to allow initial assessment of data for standard scenarios and to cover a wider range of scenarios including residential areas where no plants are grown.

1.3.2 Approach for contaminants where no SGV has been published

The current range of published SGVs is limited. In order to expand the range of GACs, Jacobshave reviewed toxicological and physicochemical data from a number of sources. This has included:

- Information in the TOX report which have not been revised;
- Information from a report by LQM/CIEH (Ref 9) revised in 2009 to assess contaminant not due to be assessed by the Environment Agency
- Information from the CLAIRE/CIEH initiative to (ref. 16);
- Information on physical and chemical properties of various organics provided in and Environment Agency report SR7.

The CLEA model outputs do not include the data justification, if this is required Jacobs are happy to provide the CLEA model, which includes the chemical database and justifications, on CD for review.

1.3.3 C4SLS Approach for lead

For lead, there have been a number fo changes to the toxicological data for lead and the SGV and TOX report have been withdrawn.

Thresholds derived for some substances including lead for residential, allotments and commercial areas in a DEFRA sponsored project for defining concentrations posing low or no risk (the C4SLs).[1] These made changes to the standard CLEA exposure model removing some of its conservatism. In addition there were changes to the approach for assessing the toxicology with a move form minimal risk levels generally used in the TOX reports to Low levels of toxicological concern. These values and approach have been endorsed by DCLG in providing a simple test for deciding when land is suitable for use and definitely not contaminated land." [2] In general this means that te C4SLs are above generic assessment criteria. For lead due to the changes in the understanding of lead's toxicity to children in particular, the residential C4SLs for lead are lower than the now withdrawn SGV for residential end use.

Reference to C4SLs for other substances may be used in the main report where the Generic Assessment criteria has been exceeded.

1.4 Sources used for physic-chemical parameters

Where available, physico-chemical parameters for metals have been taken from former SGV reports, and parameters for organic chemicals have been taken from Environment Agency Report SR7. For all other contaminants a literature search for suitable data has been undertaken in line with the approach set out in line with the approach set out in SR2. References for all input parameters are in the CLEA model but do not appear

[1] Department for Environment, Food and Rural Affairs SP1010: Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination – Policy Companion Document March 2014

[2] http://planningguidance.planningportal.gov.uk/blog/guidance/land-affected-by-contamination/land-affected-by-contamination-guidance/

on the CLEA out put sheets. We are happy to provide an electronic copy of the CLEA model with this data is required.

For the hydrocarbons, the threshold risk has been considered using the approach devised by the TPH criteria working group (TPH CWG) (Ref 12) where the total petroleum hydrocarbons are divided into fractions based on their mobility and toxicity. As part of the work in deriving appropriate fractions, characteristic physicochemical data has been derived for these fractions and this has been used to calculate GACs.

Henry's Law Constants are generally measured or reported at 25°C whereas the soil temperature is generally assumed to be 10°C in the UK. As the temperature falls, the Henry's Law Constant falls. The changes can be estimated using the Clausius-Clapeyron equation which is described by the USEPA (Ref 12) and referenced by SR7. In order to implement these changes knowledge of the boiling point, critical temperature, and enthalpy of vaporisation is required.

When sufficient information is available, adjustments have been made to Henry's Law Constant in line with SR7. For contaminants in the report these calculations are already provided in the associated database. For TPH fractions the data have been derived from the TPH CWG tables, and the enthalpy of vaporisation calculated according to the method described by the USEPA (Ref. 13). For all other substances no adjustment has been made and the Henry's Law Constant is slightly conservative.

1.5 Sources used for toxicological input data

The majority of contaminants being assessed are those for which toxicological data has been published by the Environment Agency. To expand the list of contaminants we have also use:

- Information in the former TOX reports which have not been revised;
- Information from a report by LQM/CIEH (Ref 9) revised in 2009 to assess contaminant not due to be assessed by the Environment Agency.

For the assessment of hydrocarbons a two stage approach is employed. The non-threshold risk is assessed by an assessment of known carcinogenic indicators. These include benzene, and seven PAHs with non-threshold effects (benzo(a)pyrene, chrysene, benz[a]athracene, benzo[b]fluoranthere, benzo[k]fluoranthere, dibenz[ah]anthracene, indeno[1,2,3 c,d]pyrene) identified by the Environment Agency (Ref 3). The relative carcinogenicity of the PAHs has been based on that of benzo(a)pyrene.

The threshold risk is then assessed in accordance with the TPH criteria working group fractions and methodology which is described below in Section 6. The threshold risk from benzene has been assessed by assessing benzene concentrations against a value derived using the toxic risk from toluene, and the non-threshold risk from benzene has been assessed in line with the TOX and SGV reports.

The sources for each of the substances assessed (except hydrocarbons) are included in Annex 1.

1.6 Assessment Approach for Hydrocarbons

Thresholds for individual hydrocarbon fractions in the TPH CWG analysis have been calculated using the CLEA model with toxicological and physicochemical data for the individual fractions derived from the TPH Criteria Working Group Documents (Ref 12).

Comparing individual fractions against these thresholds may not be sufficiently conservative. This is because a number of the hydrocarbons have similar toxic effects on the liver. The approach in SR2 is that additivity should be considered for contaminants where substances may act on the same target organ system. The critical effect for the aliphatic fractions is hepatoxicity (toxicity to the liver). Thresholds for the majority aromatic fractions are not based on this effect, however other studies (such as those detailed in the TOX report for naphthalene)

indicate that aromatic fractions may also affect the liver. Therefore, combined (or "additive") exposure close to the threshold for two separate fractions could lead to a total unacceptable exposure from hydrocarbons.

Therefore, the petroleum fractions are assumed to be additive and a spreadsheet has been set up to carry out a simple additivity calculation i.e. does not allow for synergistic or antagonistic effects. To assess this we have used the approach set out in the Environment Agency guidance "The UK Approach for Evaluating the Human Health Risks from Petroleum Hydrocarbons in Soils" to examine the effect of additivity. This involves calculating the hazard Index using the equation set out below) for each sample and determining if this is greater of less than 1.

$$Hazard\_Index = \sum_{\substack{Each hydrcarbon \\ Fraction}} \frac{Actual\_concentration\_in\_soil}{Screening\_value\_in\_soil}$$

As the concept of the Hazard Index can be quite difficult to communicate, Jacobs has also gone a stage further - by dividing the total concentration in the sample by the Hazard Index we have converted this back into a mixture specific threshold for each sample in mg/kg or µg/kg as appropriate. By employing this approach we have addressed the additive risk from Total Petroleum Hydrocarbons.

For hydrocarbons a sub-soil to indoor air correction factor of 10 has been applied to account for over-estimation of hydrocarbon vapour transport into buildings using the Johnson & Ettinger model, this is in line with the approach adopted in the SGV reports for BTEX compounds. It is noted in the SGV report for toluene that:

"the reasons for the difference between empirical and theoretical calculations is the subject of continued debate (CIRIA, in press), reported factors include sampling technique, biodegradation in the vapour phase, and natural ground heterogeneity. As soil vapour is transported upwards towards the building, biodegradation of petroleum hydrocarbons commonly occurs which can significantly affect the amount of vapour that will enter the building. Among other factors, this is dependent on the oxygen availability in the unsaturated zone)".

This adjustment approach is also used in the LQM/CIEH report (Ref. 9).

Where EPH analysis with risk banding has been undertaken the sum of the aliphatic and aromatic hydrocarbons in each fraction is reported. In this instance we have assumed the worst case, which is that all of the hydrocarbons in each band are the more toxic aromatic fraction, and thus produce conservative mixture specific thresholds.

In all assessments the additivity calculation assumes that non-detects are actual concentrations. Where no data is available for a band then zero is entered.

1.7 Background Exposure for Hydrocarbons

In accordance with the SR2 when considering threshold substances it is important to consider the background exposure to these substances and reduce the TDI accordingly to give a tolerable daily soil intake (TDSI). SR2 states that where there is no background data the exposure should be consider as zero.

For hydrocarbons the situation is complicated. CIEH/LQM have assumed the intake of TPH in food and air is very high. Thus in accordance with the SR2 guidance on where the background is known to be a high proportion of the TDI (50% or greater), TDSI has been reduced to 50% of the TDI. We believe the approach taken by LQM and CIEH is overly conservative.

The composition of the mixture is paramount. There is data from the Food Standards Agency looking at addition of C10-C40 food grade mineral oils to food. The amount of these substances present in food is very high and daily intakes of up to 14.28mg/day and 61.25mg/day have been noted in the UK and US, respectively. It is however noted that the Acceptable Daily Intakes for these food grade hydrocarbon mixtures are much

higher than the tolerable daily intakes produced by the TPH criteria Working Group who were considering fuels. It is thus not appropriate to cite a mean daily intake based on food grade hydrocarbons as background exposure to fuel based hydrocarbons.

We note that recent reviews of hydrocarbon exposure in Canada quote:

"Excluding PAH, no reports of generalized background contamination of air, water, food or soil (unrelated to contaminated sites) were located for component PHC [petroleum hydrocarbons] in fractions 2, 3 and 4 (i.e., C>10). This likely stems from their generally low or negligible solubility and volatility. PAH are evaluated separately from PHC for purposes of risk assessment of contaminated sites and, therefore, they are not considered within the various PHC fractions being evaluated here.

Due to the lack of evidence for, and low probability of, ubiquitous environmental contamination with PHC in fractions 2, 3 and 4, the estimated daily intakes (EDI) of PHC in fractions 2, 3 and 4 from background sources are considered to be zero. PHC in fraction 1 (C6 to C10) are relatively volatile and soluble.

As a result, aliphatic and aromatic compounds in this carbon range have been reported in drinking water, outdoor air, ambient air and some foods." (Ref. 14).

For PAHs the first edition of the Air Quality Guidelines for Europe (Ref. 15) considered the total concentration of 22 PAHs in a busy street as having a total concentration of 90.26ng/m3 in an urban street equating to 1.6μg/day of these PAHs. This is much lower than the value of 420μg/day representing 10% of the TDI inhalation used. Even scaling this up to represent the 500 PAH detected in air in first edition of the Air Quality Guidelines for Europe (and assuming that there other PAHS are in a similar proportion which is unlikely), the total exposure will be very low compared to the TDI.

It is therefore considered that the assumptions used by LQM/CIEH that at least 50% of the TDI derives from diet is overly conservative.

We have adopted the same approach as described for Canada and have adopted the Estimated Daily Intakes via **all** pathways estimated by CCME for specific fractions (with the exception of benzene and toluene where the UK data has been used). We would anticipate that the concentrations of hydrocarbons in air will decrease with decreasing volatility. For inhalation exposure we have used the total daily intake produced by Mole Valley and cited by LQM/CIEH (Ref. 9).

The MDIs adopted by Jacobs are tabulated below. We have also included for comparison the MDI representing 10% of the TDI (and hence making 10% difference to the tolerable exposure by oral or inhalation routes). This is useful in that it demonstrates the high background exposure required to make a 10% difference to the tolerable daily intakes from soil due to hydrocarbons.

Fraction	Oral Dose representing 10% of TDI oral (μg/day)	Ingestion exposure adopted by Jacobs (μg/day)	Reference for adopted value	Inhalation dose representing 10% of TDI inhalation (μg/day)[1]	Inhalation exposure adopted by Jacobs (μg/day)	Reference for inhalation dose
Aliphatic C5-6	17500	3180	CCME January 2008	184000	380	Mole Valley cited by LQM/CIEH

Fraction	Oral Dose representing 10% of TDI oral (µg/day)	Ingestion exposure adopted by Jacobs (µg/day)	Reference for adopted value	Inhalation dose representing 10% of TDI inhalation (µg/day)[1]	Inhalation exposure adopted by Jacobs (µg/day)	Reference for inhalation dose
Aliphatic C6-8	35000	1630	CCME January 2008	36800	144	Mole Valley cited by LQM/CIEH
Aliphatic C8-10	700	721	CCME January 2008	2030	104	Mole Valley cited by LQM/CIEH
Aliphatic C10-12	700	0	CCME January 2008	2030	55.4	Mole Valley cited by LQM/CIEH
Aliphatic C12-16	700	0	CCME January 2008	2030	12.2	Mole Valley cited by LQM/CIEH
Aliphatic C16-21	14000	0	CCME January 2008	N/A	NR	Mole Valley cited by LQM/CIEH
Aliphatic C21-35	14000	0	CCME January 2008	N/A	NR	Mole Valley cited by LQM/CIEH
Aromatic C6-7 (benzene)	N/A	10	Environment Agency, Contaminants in soil: updated collation of toxicological data and intake values for humans -Benzene, Science report: SC050021/SR TOX11, March	N/A	3	Environment Agency, Contaminants in soil: updated collation of toxicological data and intake values for humans - Benzene, Science report: SC050021/SR TOX11, March 2009

Fraction	Oral Dose representing 10% of TDI oral (µg/day)	Ingestion exposure adopted by Jacobs (µg/day)	Reference for adopted value	Inhalation dose representing 10% of TDI inhalation (µg/day)[1]	Inhalation exposure adopted by Jacobs (µg/day)	Reference for inhalation dose
Aromatic C7-8 (toluene)	N/A	10	Environment Agency, Contaminants in soil: updated collation of toxicological data and intake values for humans -Toluene, Science report: SC050021/SR TOX14, March	N/A	520	Environment Agency, Contaminants in soil: updated collation of toxicological data and intake values for humans - Toluene, Science report: SC050021/SR TOX14, March 2009
Aromatic C8-10	280	657	CCME January 2008	420	353	Mole Valley cited by LQM/CIEH
Aromatic C10-12	280	0	CCME January 2008	420	304	Mole Valley cited by LQM/CIEH
Aromatic C12-16	280	0	CCME January 2008	420	0.96	Mole Valley cited by LQM/CIEH
Aromatic C16-21	210	0	CCME January 2008	N/A	0.89	Mole Valley cited by LQM/CIEH
Aromatic C21-35	210	0	CCME January 2008	N/A	0.19	Mole Valley cited by LQM/CIEH

CCME 2008 -Canada-Wide Standard for Petroleum Hydrocarbons (PHC) in Soil: Scientific Rationale Supporting Technical Document, January 2008

Notes: 1 = provided for comparative purposes only

1.8 Review of CLEA Methodology

In adopting the CLEA model it is important to consider the standard use and confirm the assumption made. These assumptions are considered below.

1.8.1 Exposure Paramters

All exposure parameters applied to the GACs are the default values set out in SR3, which are for the standard CLEA critical receptors as follows:

- 0-6 year old female child living at home (residential land uses);
- 0-6 year old female child visiting allotments with parent (allotments land use);
- 16-65 year old female adult (commercial and industrial use).

In addition for cadmium consideration has been given to lifetime exposure for the residential and allotment setting in line with the revised SGV report on cadmium.

1.8.2 Exposure Pathways

The following table shows the pathways that have been considered under each of the scenarios considered.

Pathway	Direct ingestion of soil and indoor dust	Ingestion of home grown vegetables and attached soils	Inhalation of vapour intruding into buildings	Inhalation of vapour in outdoor areas	Inhalation of dust indoors	Inhalation of dust outdoors	Dermal uptake
Residential with vegetable consumption	□	□	□	□	□	□	□
Residential without vegetable consumption	□	x	□	□	□	□	□
Residential without vegetable consumption or indoor air inhalation	□	x	x	□	□	□	□
Allotments	□	□	□	□	x	x	□

Pathway	Direct ingestion of soil and indoor dust	Ingestion of home grown vegetables and attached soils	Inhalation of vapour intruding into buildings	Inhalation of vapour in outdoor areas	Inhalation of dust indoors	Inhalation of dust outdoors	Dermal uptake
Commercial/ industrial	☐	x	☐	☐	☐	☐	☐

1.9 Soil Parameters

The GACs have been based on a sandy loam soil which is the default soil type for use when calculating SGVs as described in SR3. This is the most conservative soil type commonly encountered in UK soils. If site soils are sands or gravels with no fines content then further assessment should be undertaken for volatile compounds.

For volatile contaminants the soil air permeability is highest for sand. For non-volatile contaminants or pathways where inhalation of vapour is not considered the soil type has very little effect on the exposure.

The fraction of organic content has a significant effect on the partitioning of organic contaminants. Thus less contaminant is in the vapour form or available for plant uptake in soil with higher organic content. The GACs have thus been calculated for a series of soil organic contents; 1%, 2.5% and 6%. The 6% value is the default soil organic mater content to be used in calculation of SGVs (Ref 10), the 1% and 2.5% values are taken from the former SGV reports for organic contaminants as being representative of concentrations typically encountered in UK soils. Therefore, the choice of GAC to use depends on the organic carbon content of the soil on the site. The only pathways that are significantly affected by soil organic matter content are vapour inhalation and plant uptake by organic compounds and methylmercury.

1.10 Pathways Considered for the GACs

1.10.1 Direct soil ingestion and ingestion of indoor dust

The ingestion rate, exposure frequency and all other parameters relating to soil ingestion have been set to the default parameters in the CLEA model.

1.10.2 Vegetable Consumption

All vegetable consumption rates, exposure frequencies and durations are set to the default values in the CLEA model. The allotments calculation assumes a moderate rather than high-end consumer.

For heavy metals, Jacobs has applied the soil to plant uptake factors published in the former SGV reports, where available and for other metals the values derived by Baes et al have been applied (Ref. 11). The pH as entered into the CLEA model in Basic Settings has been set to pH 7 for all assessments. However, where there are literature data for plant uptake factors at different pH levels, these factors have been applied to the model and the contaminant labelled accordingly e.g. Cadmium pH 6-8. For mercury, where plant uptake is affected by soil organic matter content, plant uptake factors for each default organic content have been applied.

For all other contaminants the default vegetable uptake models in CLEA have been used to predict plant uptake.

1.11 Inhalation of indoor vapours and dust

All assumptions for the indoor vapour inhalation model are the same as the default parameters set out in SR3. The building types applied are 'small house' and 'pre-1970s office'.

The indoor dust inhalation pathway assumes that 50% of indoor dust is derived from soil (the soil to dust transport factor). We understand that contaminant-specific transport factors are to be published by the Environment Agency, however until these are released the baseline assumption from SR3 of 50% has been applied.

Saturation

The CLEA model includes a default calculation to check whether the calculated safe levels of organic contaminants exceed the concentration at which either the water solubility limit or maximum vapour concentration has been exceeded. This is indicated by a traffic light system of amber, red, and green. Where theoretical saturation limits are exceeded further assessment may show that a higher soil concentration is safe for future users, but this has not been undertaken for GACs. Where an SGV has been published that is based upon the predicted saturation limit Jacobs have adopted the saturation limit approach and adjusted the corresponding GACs at lower organic contents or non-standard land uses.

For the remaining substances (particularly the hydrocarbons in a commercial/industrial end use) no adjustment has been made to reduce the threshold to saturation. This is in part as saturation of hydrocarbon mixture is complex and should be assessed on a mixture specific basis. Furthermore, where saturation occurs it implies that the vapour pathway lead to exceedance of the acceptable dose principally via inhalation and thus by not allowing for saturation the oral and dermal exposure pathways are considered but in a conservative fashion. Where site observations report that free-phase organics are present, as opposed to modelling predicting that it may be present, then more detailed consideration of risks is undertaken.

1.11.1 Dermal uptake

All parameters for dermal uptake have been set to the default parameters in the CLEA model. Dermal uptake factors applied are the default values from SR3. For metals where no literature value is available, dermal uptake factors have been set to zero as advised in SR3. For contaminants such as phenol, which can have a corrosive effect upon dermal contact, consideration has also been given to acute dermal effects.

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16) Environment Agency. Compilation of Data for Priority Organic Pollutants for Derivation of Soil Guideline Values. SC050021/SR7. November 2008.

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MODEL OUTPUT SHEETS ARE AVAILABLE ON REQUEST

ANNEX 1

SOURCES OF TOXICOLOGICAL DATA

Determinand	Type	Reference dose µg/kgbw/day	Source	Type	Reference dose µg/kgbw/day	Source
Chlorinated Solvents						
Tetrachloroethene	TDI	14	Environment Agency R&D Publication TOX 23 April 2003	TDI	71	Environment Agency R&D Publication TOX 23 April 2003
Trichloroethene	ID	5.2	Environment Agency R&D Publication TOX 24 October 2004	ID	5.2	Environment Agency R&D Publication TOX 24 October 2004
Vinyl Chloride	ID	0.014	Environment Agency R&D Publication TOX 18 April 2003	ID	0.3	Environment Agency R&D Publication TOX 18 April 2003
1,2 Dichloroethane	ID	0.12	Environment Agency R&D Publication TOX 22 August 2004	ID	0.12	Environment Agency R&D Publication TOX 22 August 2004
1,1,1 Trichloroethane	TDI	600	Environment Agency R&D Publication TOX 25 April 2003	TDI	600	Environment Agency R&D Publication TOX 25 April 2003
1,1,2,2 Tetrachloroethane	TDI	5.8	Environment Agency R&D Publication TOX 16 April 2003	TDI	5.8	Environment Agency R&D Publication TOX 16 April 2003
1,1,1,2 Tetrachloroethane	TDI	5.8	Environment Agency R&D Publication TOX 16 April 2003	TDI	5.8	Environment Agency R&D Publication TOX 16 April 2003

Determinand	Type	Reference dose	Source	Type	Reference dose	Source
Carbon Tetrachloride	TDI	1.42	Environment Agency TOX 21 April 2005	TDI	3.26	Environment Agency TOX 21 April 2005
Trichloromethane	TDI	13.7	LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment 2nd Edition, 2009	TDI	40	LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment 2nd Edition, 2009
Polycyclic Aromatic Hydrocarbons						
Benzo(a)pyrene	ID	0.02	Environment Agency R&D Publication TOX 2 April 2002	ID	0.00007	Environment Agency R&D Publication TOX 2 April 2002
Benzo(b)fluoranthene	ID	0.2	Based on ten times the index dose for benzo(a)pyrene (Environment Agency R&D Publication TOX 2 April 2002)	ID	0.0007	Based on ten times the index dose for benzo(a)pyrene (Environment Agency R&D Publication TOX 2 April 2002)
Benzo(k)fluoranthene	ID	0.2	Based on ten times the index dose for benzo(a)pyrene (Environment Agency R&D Publication TOX 2 April 2002)	ID	0.0007	Based on ten times the index dose for benzo(a)pyrene (Environment Agency R&D Publication TOX 2 April 2002)

Determinand	Type	Reference dose	Source	Type	Reference dose	Source
Chrysene	ID	0.2	Based on ten times the index dose for benzo(a)pyrene (Environment Agency R&D Publication TOX 2 April 2002)	ID	0.0007	Based on ten times the index dose for benzo(a)pyrene (Environment Agency R&D Publication TOX 2 April 2002)
Dibenz(ah)anthracene	ID	0.02	Based on ten times the index dose for benzo(a)pyrene (Environment Agency R&D Publication TOX 2 April 2002)	ID	0.00007	Based on ten times the index dose for benzo(a)pyrene (Environment Agency R&D Publication TOX 2 April 2002)
Indeno(1,2,3,cd)pyrene	ID	0.2	Based on ten times the index dose for benzo(a)pyrene (Environment Agency R&D Publication TOX 2 April 2002)	ID	0.0007	Based on ten times the index dose for benzo(a)pyrene (Environment Agency R&D Publication TOX 2 April 2002)
Naphthalene	TDI	20	Environment Agency R&D Publication TOX 20 December 2003	TDI	0.86	Environment Agency R&D Publication TOX 20 December 2003
Benzo(a)anthracene	ID	0.2	Based on ten times the index dose for benzo(a)pyrene (Environment Agency R&D Publication TOX 2 April 2002)	ID	0.0007	Based on ten times the index dose for benzo(a)pyrene (Environment Agency R&D Publication TOX 2 April 2002)

Determinand	Type	Reference dose	Source	Type	Reference dose	Source
Miscellaneous Organics						
Carbon disulphide	TDI	100	LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment 2nd Edition, 2009	TDI	28.6	LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment 2nd Edition, 2009
Hexachloro-1,3-butadiene	TDI	0.2	LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment 2nd Edition, 2009	TDI	0.2	LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment 2nd Edition, 2009
Metals and inorganics						
Beryllium	TDI	2	LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment 2nd Edition, 2009	ID	0.0012	LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment 2nd Edition, 2009
Boron	TDI	160	LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment 2nd Edition, 2009	TDI	2.9	LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment 2nd Edition, 2009

Determinand	Type	Reference dose	Source	Type	Reference dose	Source
Chromium III	TDI	150	LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment 2nd Edition, 2009. Based on FSA NOAEL from 2003 not available for the TOX4 report	TDI	0.1	LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment 2nd Edition, 2009. Not commented on in TOX4
Chromium VI	TDI	1	LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment 2nd Edition, 2009. Based on More recent data from USEPA in 2008 not available for the TOX 4 report	ID	0.001	TOX4 inhalation dose for chromium based on Chromium VI derived from the WHO 2000 report. (Note this is the same report used by LQM/CIEH although LQM/CIEH used a different basis for the dose derived and do not cite the TOX4 report in this context although it is not yet withdrawn.)
Copper	TDI	160	LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment 2nd Edition, 2009	TDI	0.286	LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment 2nd Edition, 2009

Determinand	Type	Reference dose	Source	Type	Reference dose	Source
Vanadium	TDI	3	LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment 2nd Edition, 2009	TDI	0.0286	LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment 2nd Edition, 2009
Zinc	TDI	600	LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment 2nd Edition, 2009	TDI	600	LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment 2nd Edition, 2009

Appendix F. Chemical Data Assessment

Residential with plant uptake screening

Determinand	Units	Number of Samples	Residential with plant uptake	Minimum	Maximum	Location of Maximum	UCL95	Normality
pH	pH Units	27	-	6.6	11.3	11.3pH Units at WS70 at 0.70-0.80m	8.94	Data not Normally distributed - Shapiro-Wilks W statistic of 0.851 < Wcrit of 0.923
Arsenic	mg/kg	27	32 (1)	5.1	48	48mg/kg at WS68 at 0.30-0.40m	17.7	Data not Normally distributed - Shapiro-Wilks W statistic of 0.539 < Wcrit of 0.923
Cadmium	mg/kg	27	10 (0)	< 0.2	1.8	1.8mg/kg at WS68 at 0.30-0.40m	0.636	Data not Normally distributed - Shapiro-Wilks W statistic of 0.401 < Wcrit of 0.923
Copper	mg/kg	27	2300 (0)	9.6	1100	1100mg/kg at WS68 at 0.30-0.40m	255	Data not Normally distributed - Shapiro-Wilks W statistic of 0.323 < Wcrit of 0.923
Chromium	mg/kg	27	-	13	39	39mg/kg at WS61 at 0.30-0.40m	26.6	Data not Normally distributed - Shapiro-Wilks W

								statistic of 0.858 < Wcrit of 0.923
Lead	mg/kg	27	200 (2)	11	1200	1200mg/kg at WS68 at 0.30-0.40m	281	Data not Normally distributed - Shapiro-Wilks W statistic of 0.328 < Wcrit of 0.923
Mercury	mg/kg	27	7.4 (0)	< 0.3	< 0.3	-	no range of value hence Standard deveiauton and UCLcannot be calculated	Data has no variability to assess
Nickel	mg/kg	27	130 (0)	7.4	80	80mg/kg at WS68 at 0.30-0.40m	29.9	Data not Normally distributed - Shapiro-Wilks W statistic of 0.615 < Wcrit of 0.923
Selenium	mg/kg	27	350 (0)	< 1.0	< 1.0	-	no range of value hence Standard deveiauton and UCLcannot be calculated	Data has no variability to assess
Zinc	mg/kg	27	3700 (0)	35	1800	1800mg/kg at WS68 at 0.30-0.40m	599	Data not Normally distributed - Shapiro-Wilks W statistic of 0.458 <

								Wcrit of 0.923
Acenaphthene	mg/kg	27	-	< 0.10	0.57	0.57mg/kg at WS68 at 0.30-0.40m	0.243	Data not Normally distributed - Shapiro-Wilks W statistic of 0.424 < Wcrit of 0.923
Acenaphthylene	mg/kg	27	-	< 0.10	1.1	1.1mg/kg at WS70 at 0.70-0.80m	0.314	Data not Normally distributed - Shapiro-Wilks W statistic of 0.269 < Wcrit of 0.923
Anthracene	mg/kg	27	-	< 0.10	2.8	2.8mg/kg at WS70 at 0.70-0.80m	0.873	Data not Normally distributed - Shapiro-Wilks W statistic of 0.51 < Wcrit of 0.923
Benzo(a)anthracene	mg/kg	27	4.5 (2)	< 0.10	6.3	6.3mg/kg at WS70 at 0.70-0.80m	2.25	Data not Normally distributed - Shapiro-Wilks W statistic of 0.61 < Wcrit of 0.923
Benzo(a)pyrene	mg/kg	27	0.83 (10)	< 0.10	6.8	6.8mg/kg at WS70 at 0.70-0.80m	2.67	Data not Normally distributed - Shapiro-Wilks W statistic of 0.59 < Wcrit of 0.923
Benzo(b)fluoranthene	mg/kg	27	7.8 (0)	< 0.10	7.5	7.5mg/kg at WS70 at	3.06	Data not Normally

						0.70-0.80m		distributed - Shapiro-Wilks W statistic of 0.589 < Wcrit of 0.923
Benzo(ghi)perylene	mg/kg	27	-	< 0.05	4.2	4.2mg/kg at WS61 at 0.30-0.40m	1.65	Data not Normally distributed - Shapiro-Wilks W statistic of 0.598 < Wcrit of 0.923
Benzo(k)fluoranthene	mg/kg	27	8.5 (0)	< 0.10	3.6	3.6mg/kg at WS70 at 0.70-0.80m	1.37	Data not Normally distributed - Shapiro-Wilks W statistic of 0.61 < Wcrit of 0.923
Chrysene	mg/kg	27	6 (1)	< 0.05	6.9	6.9mg/kg at WS70 at 0.70-0.80m	2.59	Data not Normally distributed - Shapiro-Wilks W statistic of 0.631 < Wcrit of 0.923
Dibenz(a,h)anthracene	mg/kg	27	-	< 0.10	0.5	0.5mg/kg at WS70 at 0.70-0.80m	0.219	Data not Normally distributed - Shapiro-Wilks W statistic of 0.441 < Wcrit of 0.923
Fluoranthene	mg/kg	27	-	< 0.10	15	15mg/kg at WS70 at 0.70-0.80m	5.11	Data not Normally distributed - Shapiro-Wilks W

								statistic of 0.621 < Wcrit of 0.923
Fluorene	mg/kg	27	-	< 0.10	0.66	0.66mg/kg at WS70 at 0.70-0.80m	0.263	Data not Normally distributed - Shapiro-Wilks W statistic of 0.45 < Wcrit of 0.923
Indeno(1,2,3-cd)pyrene	mg/kg	27	-	< 0.10	3.3	3.3mg/kg at WS61 at 0.30-0.40m	1.34	Data not Normally distributed - Shapiro-Wilks W statistic of 0.573 < Wcrit of 0.923
Naphthalene	mg/kg	27	1.5 (0)	< 0.05	0.39	0.39mg/kg at WS47 ES1 at 0.60-0.70m	0.133	Data not Normally distributed - Shapiro-Wilks W statistic of 0.302 < Wcrit of 0.923
Phenanthrene	mg/kg	27	-	< 0.10	15	15mg/kg at WS70 at 0.70-0.80m	3.85	Data not Normally distributed - Shapiro-Wilks W statistic of 0.459 < Wcrit of 0.923
Pyrene	mg/kg	27	-	< 0.10	13	13mg/kg at WS70 at 0.70-0.80m	4.39	Data not Normally distributed - Shapiro-Wilks W statistic of 0.618 < Wcrit of

								0.923
Benzene	µg/kg	27	79 (0)	< 1.0	< 1.0	-	no range of value hence Standard deveiauton and UCLcannot be calculated	Data has no variability to assess
Toluene	µg/kg	27	120000 (0)	< 1.0	< 1.0	-	no range of value hence Standard deveiauton and UCLcannot be calculated	Data has no variability to assess

Commercial industrial screening

Determinand	Units	Number of Samples	Commercial/Industrial	Minimum	Maximum	Location of Maximum	UCL95	Normality
pH	pH Units	27	-	6.6	11.3	11.3pH Units at WS70 at 0.70-0.80m	8.94	Data not Normally distributed - Shapiro-Wilks W statistic of 0.851 < Wcrit of 0.923
Arsenic	mg/kg	27	640 (0)	5.1	48	48mg/kg at WS68 at 0.30-0.40m	17.7	Data not Normally distributed - Shapiro-Wilks W statistic of 0.539 < Wcrit of

								0.923
Cadmium	mg/kg	27	230 (0)	< 0.2	1.8	1.8mg/kg at WS68 at 0.30-0.40m	0.636	Data not Normally distributed - Shapiro-Wilks W statistic of 0.401 < Wcrit of 0.923
Copper	mg/kg	27	72000 (0)	9.6	1100	1100mg/kg at WS68 at 0.30-0.40m	255	Data not Normally distributed - Shapiro-Wilks W statistic of 0.323 < Wcrit of 0.923
Chromium	mg/kg	27	-	13	39	39mg/kg at WS61 at 0.30-0.40m	26.6	Data not Normally distributed - Shapiro-Wilks W statistic of 0.858 < Wcrit of 0.923
Lead	mg/kg	27	2300 (0)	11	1200	1200mg/kg at WS68 at 0.30-0.40m	281	Data not Normally distributed - Shapiro-Wilks W statistic of 0.328 < Wcrit of 0.923
Mercury	mg/kg	27	370 (0)	< 0.3	< 0.3	-	no range of value hence Standard deveiauton	Data has no variability to assess

							and UCLcannot be calculated	
Nickel	mg/kg	27	1800 (0)	7.4	80	80mg/kg at WS68 at 0.30-0.40m	29.9	Data not Normally distributed - Shapiro-Wilks W statistic of 0.615 < Wcrit of 0.923
Selenium	mg/kg	27	13000 (0)	< 1.0	< 1.0	-	no range of value hence Standard deveiauton and UCLcannot be calculated	Data has no variability to assess
Zinc	mg/kg	27	670000 (0)	35	1800	1800mg/kg at WS68 at 0.30-0.40m	599	Data not Normally distributed - Shapiro-Wilks W statistic of 0.458 < Wcrit of 0.923
Benzo(a)anthracene	mg/kg	27	130 (0)	< 0.10	6.3	6.3mg/kg at WS70 at 0.70-0.80m	2.25	Data not Normally distributed - Shapiro-Wilks W statistic of 0.61 < Wcrit of 0.923
Benzo(a)pyrene	mg/kg	27	14 (0)	< 0.10	6.8	6.8mg/kg at WS70 at 0.70-	2.67	Data not Normally distribute

						0.80m		d - Shapiro-Wilks W statistic of 0.59 < Wcrit of 0.923
Benzo(b)fluoranthene	mg/kg	27	140 (0)	< 0.10	7.5	7.5mg/kg at WS70 at 0.70-0.80m	3.06	Data not Normally distributed - Shapiro-Wilks W statistic of 0.589 < Wcrit of 0.923
Benzo(k)fluoranthene	mg/kg	27	140 (0)	< 0.10	3.6	3.6mg/kg at WS70 at 0.70-0.80m	1.37	Data not Normally distributed - Shapiro-Wilks W statistic of 0.61 < Wcrit of 0.923
Chrysene	mg/kg	27	140 (0)	< 0.05	6.9	6.9mg/kg at WS70 at 0.70-0.80m	2.59	Data not Normally distributed - Shapiro-Wilks W statistic of 0.631 < Wcrit of 0.923
Naphthalene	mg/kg	27	200 (0)	< 0.05	0.39	0.39mg/kg at WS47 ES1 at 0.60-0.70m	0.133	Data not Normally distributed - Shapiro-Wilks W statistic of 0.302 < Wcrit of 0.923

Benzene	µg/kg	27	28000 (0)	< 1.0	< 1.0	-	no range of value hence Standard deveiauton and UCLcanno t be calculated	Data has no variability to assess
Toluene	µg/kg	27	870000 (0)	< 1.0	< 1.0	-	no range of value hence Standard deveiauton and UCLcanno t be calculated	Data has no variability to assess