REMEDIAL OPTIONS APPRAISAL, REMEDIATION STRATEGY AND VERIFICATION PLAN FOR FREDERICK HOUSE, YORK

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EXECUTIVE SUMMARY

Introduction	Tier Environmental was commissioned by Watkin Jones & Son to undertake a Remedial Options Appraisal, Remediation Strategy and Verification Plan of land at Frederick House, Fulford Road, York, YO10 4EA based on the results of previous Geoenvironmental risk assessments.
Proposed land use	Under current proposals the development will comprise redevelopment of the existing 'Guard House' in the west of the site following the demolition of 'Frederick House' in the centre of the site for replacement with student accommodation in the form of 6 No. buildings of up to 4 No. storeys, with associated areas of soft landscaping across the Site and car parking spaces to the west of the Site.
Remediation Options Appraisal and Remediation Strategy	Localised potential risks to end-users associated with low level asbestos have been reported at CP3 and WS9 in the western part of the Site, along with a localised measured concentration of dibenzo(ah)anthracene reported at WS10 in the western part of the Site. It is considered that the risks may only be realised where impacted Made Ground remains *in situ* in the CP3, WS9 and WS10 areas and, as such in the event that the Made Ground is removed and this may be verified via photographic evidence, then no clean cover system would be required. However, in the event that Made Ground remains in these areas then a localised 600mm clean cover system would be required underlain by a geotextile membrane. This will be locally reduced to 150mm underlain by a geotextile membrane in the areas of the tree root protection zone in the WS10 area due to an identified conflict between contaminated land and aboricultural requirements. It is considered; however, that this would remain sufficient thickness to mitigate risks from the dibenzo(ah)anthracene given that this area of the site is proposed to comprise a wild meadow. **600mm Clean Cover System Underlain by Terram Geotextile Membrane at WS10, WS9 and CP3 areas** • Required to mitigate potential risks via direct contact, dust inhalation and ingestion pathways from PAHs at WS10 and to mitigate potential risks via the dust inhalation pathway from low level asbestos at CP3 and WS9; • Source(s) of topsoil / subsoil materials to be identified by the contractor; • Tier Environmental to obtain samples of the materials **before** they are imported to Site; • Suite of analysis on the samples and frequency of testing to be as per Table 5.1 in this report; • Results to be compared against appropriate Generic Assessment Criteria (GACs) protective of future land users; • Once imported, hand pits to be excavated in soft landscaped areas on a 1 per 25m grid basis to confirm that the minimum thickness has been achieved and the geotextile membrane is present; • Verification report to be prepared Drawing No. TE1179-TE-00-XX-DR-GE-001-V02 included in Appendix A shows the proposed extent of the clean cover system requirements.

1. INTRODUCTION

Tier Environmental was commissioned by Watkin Jones & Son Ltd to undertake a Land Contamination Risk Management (LCRM) Remedial Options Appraisal, Remediation Strategy and Verification Plan for an area of land referred to as Frederick House, located at Fulford Road, York, YO10 4EA (the "Site").

The title of this report is in accordance with that described in the Land Contamination Risk Management guidance (available at https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm) which has superseded CLR 11:

- Stage 2 - LCRM Options Appraisal Report
- Stage 3 - LCRM Remediation Strategy

1.1. Proposed Development

Under current proposals the development will comprise redevelopment of the existing 'Guard House' in the west of the site following the demolition of 'Frederick House' in the centre of the site for replacement with student accommodation in the form of 6 No. buildings of up to 4 No. storeys, with associated areas of soft landscaping across the Site and car parking spaces to the west of the Site, as presented in Appendix A. As such, in accordance with the *'Updated technical background to the CLEA model'* (Environment Agency, 2009) and *'Suitable 4 Use Levels'* (LQM / CIEH 2015) the proposed generic land use for this development is residential without homegrown produce.

Soft landscaping will comprised of three forms:

- 'wildflower meadow' landscaping in the southwest, and in three sections along the southern boundary extending up the eastern boundary.
- Mixed shrub and herbaceous planting typically along building edges within courtyard spaces and along the northern boundary
- Lawn areas comprising patches within courtyard areas

1.2. Previous Reports

Tier Environmental have completed the following reports for the site.

- 'A Ground Investigation Report for Frederick House, York' by Tier Environmental (Ref: TE1179GIR1.1, dated September 2019) - It should be noted this report contained a review of a third part Preliminary Risk Assessment Report by Delta Simons (18-1207.01, dated December 2018);
- 'Supplementary Ground Investigation Letter Report' by Tier Environmental (Ref: TE1179GIRL1.0, dated 29th January 2021) which targeted an area that was previously inaccessible below Frederick House.

1.3. Background and Previous Works Summary

Following intrusive investigations, the Tier Environmental Ground Investigation Report (reference TE1179GIR1.1, dated September 2019), hereafter referred to as the 'GIR' report, included a generic quantitative risk assessment of laboratory chemical analysis data obtained from soil and groundwater to determine potential risks to human health for the proposed land use and the controlled waters environment.

The results of a generic quantitative human health risk assessment have determined the following:

- PAHs were found to exceed their relevant GAC and present a potential risk to human health locally in 1 No of the 13 No. samples tested. Provenance analysis indicates the source of the PAH as being derived from the presence of coal ash within an area of existing soft landscaping in the western area of the Site. TPH present a risk to residential end-users in proposed soft landscaping areas via direct contact, ingestion and dust inhalation pathways;
- A single concentration of aromatics >E21-35 was reported in the Made Ground within the northwestern area of the Site that exceeded the respective GAC protective of the proposed residential without home-grown produce land use. TPH present a risk to residential end-users in proposed soft landscaping areas via direct contact, ingestion and dust inhalation pathways;
- A total of 2 No. of the 18 No. samples tested for asbestos were found to contain less than 0.1% fibre bundles of Chrysotile. Asbestos presents a risk to commercial and residential end-users via the dust inhalation pathway;

The results of a generic quantitative controlled waters environment risk assessment have determined the following:

- Measured groundwater concentrations of PAHs have been reported in excess of the Water Quality Standards beneath the Site protective of the Secondary A Aquifer, and Principal Aquifer bedrock. The results of further assessment and consideration of the conceptual site model has concluded that the reported concentrations do not represent a potentially significant risk to the controlled waters environment.

1.4. Anticipated Outline Remedial Works

The GIR report included the following outline remediation requirements on the basis of the risk assessment conclusions summarised above. In essence, the outline remedial strategy and verification plan is:

- Areas of Made Ground soils containing asbestos not proposed to be covered by hard standing may require either removal from Site or the implementation of a 600mm clean cover system.
- Areas of soils around WS10 which was found to exceed the GAC for Dibenzo(ah)anthracene may require either removal from Site or use of a clean cover system the break the direct contact/dust inhalation pathway. Section 9.2 of the report included justifications on why other PAH exceedances (CP2 at 0.40m bgl, WS14 at 0.50m bgl and WS13 at 0.30m bgl) are likely to not pose a significant risk to human health.
- TPH pathways are broken by the development hardstanding under current proposals. If layout plans change, this will require reassessment. If the area becomes a plot of soft landscaping, then a 600mm clean cover system may be required.
- Due consideration has been given to elevated concentrations of carbon dioxide and flow rate. In accordance with CIRIA C665, the assessment of the ground gas monitoring data obtained to date produces a maximum Gas Screening Value of 0.0484l/hr, derived using the carbon dioxide concentration of 4.4%v/v and the flow rate of 1.1l/hr. Assessment of this gas screening value alone places the Site in a Characteristic Situation 1 – A very low risk scenario in accordance with CIRIA C665 for which ground gas protection measures will not be required.
- Basic radon protection measures will not be currently required for the proposed development on this site.

The Supplementary Ground Investigation letter report did not identify any additional areas beneath the former Frederick House that presented a potential risk to human health. In addition, no significant or gross contamination was identified that would suggest an increased risk to the controlled waters environment. As such, it was considered that the outline remediation strategy described above remained unchanged.

1.5. Objectives

On the basis of the above, the objectives of this report are to:

- To reproduce the Refined Conceptual Site Model derived within the previous Tier Environmental GIR report;
- Undertake a Remediation Options Appraisal to address reported:
    - Localised concentrations of dibenzo(ah)anthracene and TPHs which presents a potential risk to the residential end-users in proposed soft landscaping areas;
    - asbestos reported in soils at the Site in the form of Chrysotile fibre bundles of <0.1%;
- Produce a Remediation Strategy and Verification Plan on the basis of the selected viable approaches determined during the Remedial Options Appraisal.

This report, which was designed to meet the requirements of all relevant current guidance including 'Land contamination: risk management' (LC:RM) (which supersedes CLR11) presents the factual information available during this appraisal, interpretation of the data obtained and recommendations relevant to the defined objectives.

1.6. Assumptions

The following assumptions are made in this report:

- It is assumed that ground levels will not change significantly from those described in this report or a shown on proposed development drawings. If this is not the case, then amendments to the recommendations made in this report may be required.
- The ground investigations that have informed this remediation strategy were designed with due consideration of known or suspected constraints (including underground services and access constraints).
- Any references to observations of suspected asbestos-containing materials are for information only and should be verified by a suitably qualified asbestos specialist and/or confirmed by laboratory analysis.
- The use of the term 'Topsoil' within this report is based on a visual identification only and that these materials have not been classified in accordance with BS3882:2015.
- The use of the terms 'shallow' and 'deep' within this report assume *typically* between ground level to circa 5.00m below ground level (bgl) for 'shallow' and greater than 5.00m bgl regarded as 'deep';
- The comments and opinions presented in this report are based on the findings of the desk study, ground conditions encountered during intrusive investigation works performed by Tier Environmental and the results of tests carried out within one or more laboratories. There may be other conditions prevailing on the Site which have not been revealed by these previous investigations and which have not been taken into account by this report.
- Responsibility cannot be accepted for any conditions not revealed by the previous investigations. Any diagram or opinion on the possible configuration of the findings is conjectural and given for guidance only. Confirmation of intermediate ground conditions should be undertaken if deemed necessary.

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2. SITE DETAILS AND DESCRIPTION

Table 2.1 Current Site Overview.

Site name	Frederick House, York
Site address	Frederick House, Fulford Road, York, YO10 4EA. A site location plan is included as Drawing No. TE1179GIRL1.0 within Appendix A.
National Grid Reference (NGR)	460936, 450493
Approximate Site area	0.99 ha.
Site shape	The Site is broadly rectangular in shape.
Current land use on the Site	The Site was occupied by 2 No. buildings referred to as the Guard House and Frederick House as rented accommodation with an associated smaller outbuilding. The car park to the east of the Site was used by a car rental company to keep their cars. The Guard House is of single storey located to the west, Frederick House with two storeys located in the centre, and a smaller outbuilding resides along the northern boundary of the Site. The concrete foundations of a former building exists in the south-eastern corner of the Site. The Site was predominantly covered with asphalt and concrete hardstanding. Some areas of soft landscaping existed in the very northeast corner of the Site, as two thin strips along the south boundary of the Site and to the west of the Site. Numerous underground services were known to exist beneath the Site including power cables, gas pipes, drains, a BT line and a high pressure water mains
Surrounding land uses	The Site is located to the south of York, approximately 1.5km south from the city centre. To the north and west of the Site are predominantly residential areas. Immediately south of the Site is a police station and a barracks. To the east of the Site is an area of public open space referred to a Walmgate Stray.
General topography and ground levels	The Site has a slight topographic slope from 12.70m AOD in the east of the Site to 14.60m AOD in the west of the Site.

3. REVISED CONCEPTUAL MODEL

The revised combined conceptual site model and conceptual exposure model, developed for the proposed future land use from the desk study information and subsequent ground investigation and the chemical analysis results presented in the GIR report has been reproduced below.

The potential pollutant linkages identified and a generic quantitative risk assessment are presented in Table 3.1. The terms used in the generic quantitative risk assessment are defined in Appendix C.

Table 3.1 Revised Assessment of Potential Pollutant Linkages.

Pollutant linkage				Qualitative risk assessment
	Source	**Pathway(s)**	**Receptor(s)**	
1	PAHs, asbestos and petroleum hydrocarbons associated with on-Site Made Ground.	Dermal contact, ingestion and inhalation of contaminants including contaminated dust migration.	Future site users.	Medium x Likely = Moderate
			Adjacent site users.	Medium x Low Likelihood = Moderate/Low
			Site investigation, demolition and construction staff and future underground service maintenance workers from hazardous short term exposure.	Medium x Likely = Moderate
		Migration of mobile contaminants from Made Ground soils to adjacent sites along services and conduits.	Adjacent site users.	Medium x Low Likelihood = Moderate/Low
		Lateral and/or vertical migration of mobile contaminants.	Groundwater (Secondary Undifferentiated Aquifer and Principal Aquifer beneath the Site).	Medium x Low Likelihood = Moderate/Low
			Surface waters (River Ouse and unspecified river).	Medium x Unlikely = Low

For definition of the terms used in the qualitative risk assessment, please see Appendix C.

4. REMEDIAL OPTIONS APPRAISAL

The information presented in the previous GIR report summarises the physical conditions of the site, the nature of the soils, the contamination status of the Made Ground soils and presents an overview of the controlled waters regime. For completeness, however, it would be prudent to refer to the previous ground investigation reports should additional information be required. The following section identifies the remediation strategy that could be utilised to effectively manage/mitigate the identified pollutant linkages associated with the soils at the site. In determining the most effective remediation option(s) for the site, consideration needs to be given to a number of techniques, stating (where appropriate) the suitability and limitations of each chosen method.

4.1. Ground Gas Risk Considerations

The conclusions of the previously conducted ground gas risk assessment have demonstrated that no ground gas protection measures are required. In addition, the report determine that the Site was not at risk from radon. As such, ground gas / radon gas mitigation has therefore not been considered further within the remediation options appraisal.

4.2. TPH Considerations

The previous GIR identified a single concentration of aromatics >E21-35 in the Made Ground within the northwestern area of the Site (WS13 at 0.30m bgl) that exceeded the respective GAC protective of the proposed residential without home-grown produce land use. It was considered that this heavy end TPH fraction presented a risk to residential end-users in any proposed soft landscaping areas only via direct contact, ingestion and dust inhalation pathways.

The outline remediation strategy included within the previous GIR report determined that these TPH pathways are broken by the development hardstanding under current proposals. If layout plans change, this will require reassessment. If the area becomes a plot of soft landscaping, then a 600mm clean cover system may be required.

As such, Tier Environmental has re-assessed whether the soils beneath the WS13 area remain under hardstanding under current proposals via assessment of Drawing No. 3473 101, dated 18th November 2021 produced by TPM Landscape included in Appendix A and it can be confirmed that this remains the case. As such, no remedial actions are required to address the reported concentrations of aromatics >E21-35 in the Made Ground at WS13.

4.3. Remedial Options Appraisal

The following elements have been considered for the Site with respect to remedial options, where necessary/appropriate, during the feasibility and options appraisal stage:

- degree to which risks need to be reduced or controlled;
- time within which the remediation strategy is required to take effect;
- practicability of implementing and, where appropriate, maintaining the strategy;
- technical effectiveness of the strategy in reducing or controlling risks;
- longevity of the strategy - i.e. the potential for the proposed remediation technologies to mitigate against contaminant rebound;

- sustainability of the strategy (i.e., how well it meets other environmental objectives, for example on the use of energy and other material resources, and avoids or minimises adverse environmental impacts in off-site locations, e.g. neighbouring residents, or on other environmental compartments, such as air and water);
- cost of the strategy; benefits of the strategy – all remediation strategies should deliver direct benefits (the reduction or control of unacceptable risks) – but many have merits that extend well beyond the boundaries of the site; and
- legal, financial and commercial context within which the site is being handled including the specific legal requirements that remediation has to comply with, and the views of stakeholders on how unacceptable risks should be managed.

Due consideration has been given for possible feasible options, as presented in the tables below to effectively evaluate the practicality, effectiveness, durability and sustainability of potential remedial solutions.

It is also considered that all risks to construction/maintenance workers will be effectively managed via the measures detailed in Section 11.5 of the Tier Environmental GIR Report As such, risks to construction/maintenance workers fall outside the remit of this Remedial Options Appraisal.

4.4. Remedial Options Appraisal

Table 4.1 Remedial Options Appraisal – Localised Asbestos

Contaminant Source	Asbestos chrysotile fibre bundles encountered at CP3 at 0.40m bgl and WS9 at 0.20m bgl
Pollutant Linkage	Inhalation of dust by end users/ and site operatives
Excavation with Disposal	Wholesale removal of impacted Made Ground soils. Pollutant linkage is broken, and site works can commence quickly. Given the localised nature this may be commercially viable but may not be as sustainable as some other options as impacted materials would need to be landfilled. Made Ground soils at CP3 were reported to a depth of 0.49m bgl and at WS9 to a depth of 0.30m bgl.
Capping including Membrane / Break layer	Could be readily implemented at the Site and would only be required in the soft landscaped areas as proposed hardstanding and building footprints would act as a capping layer elsewhere. Economic, practicable, feasible and commonly used and well understood approach to break dermal contact, ingestion and dust inhalation pathways.
On site re-use	Excavation and on-site retention of impacted soils as geotechnical materials for any proposed areas of fill under a Materials Management Plan. Impacted materials remain on Site which is a sustainable solution but would have to be used in conjunction with other techniques. Re-use and associated double handling would need to be safely managed in accordance with Control of Asbestos Regulations 2012.
Stabilisation / solidification	This is unlikely to be commercially or practicably viable when compared to other viable techniques. May create geotechnical 'hardspot' given localised nature of the impacts. Stabilisation and solidification process may promote temporary fibre release as the materials are being treated.
Justification	The asbestos impacted materials are at CP3 at 0.40m bgl and WS9 at 0.20m bgl. These areas recorded Made Ground in the order of 0.30-0.49m thick. As such if levels are reduced to facilitate site levels or to accommodate a clean cover system, it may be that clean cover is not required as the Made Ground source may be removed as a function of this lowering. Alternatively, implementation of a *localised* 600mm clean cover system at CP3 and WS09 areas would be sufficient in the event that Made Ground soils remain at the surface in these areas. Buildings and hardstanding would break the viable pathways elsewhere.

Table 4.2 Remedial Options Appraisal – Localised PAH impacts

Contaminant Source	Elevated PAHs of dibenzo(a,h)anthracene reported in Made Ground in the west of the site locally at WS10.
Pollutant Linkage	Dermal contact, ingestion and dust inhalation of PAHs on site.

Excavation with Disposal	Wholesale removal of impacted Made Ground soils. Pollutant linkage is broken, and site works can commence quickly. Given the localised nature this may be commercially viable but may not be as sustainable as some other options as impacted materials would need to be landfilled. Made Ground soils at WS10 were reported to a depth of 0.39m bgl. Would not be viable in the vicinity of tree root protection zone that exists within the soft landscaping area near WS10.
Capping including Membrane / Break layer	Could be readily implemented at the Site and would only be required in the soft landscaped areas as proposed hardstanding and building footprints would act as a capping layer elsewhere. Economic, practicable, feasible and commonly used and well understood approach to break dermal contact, ingestion and dust inhalation pathways. Due consideration of a reduced cover system would be needed within the area of the tree root protection zone that exists within the soft landscaping area near WS10.
On site re-use	Excavation and on-site retention of impacted soils as geotechnical material may be viable areas of fill under a Materials Management Plan in accordance with the CL:AIRE DoWCoP. Impacted materials remain on Site which is a sustainable solution but would have to be used in conjunction with other techniques. Materials would need to be suitably re-engineered and emplaced beneath hardstanding and / or buildings and preferentially not beneath soft landscaped areas. May be used in conjunction with a capping solution in the event that some materials are emplaced beneath soft landscaped areas.
Stabilisation / solidification	This is unlikely to be commercially or practicably viable when compared to other viable techniques across the entire site.
Justification	The PAH impacted soil at WS10 is approximately 0.39m thick. As such if levels are reduced to facilitate site levels or to accommodate a clean cover system, it may be that clean cover is not required as the Made Ground source may be removed as a function of this lowering of levels. Alternatively, implementation of a *localised* 600mm clean cover system at WS10 areas would be sufficient in the event that Made Ground soils remain at the surface in these areas. Buildings and hardstanding would break the viable pathways elsewhere. Due consideration of a localised lesser thickness of clean cover system would be required in the vicinity of the WS10 areas.

On the basis of the above table, the following techniques are considered the Best Practicable Techniques (BPT) in accordance with LCRM:

For the localised asbestos Chrysotile fibre bundles reported at the Site

It is proposed that a 600mm clean cover system for the localised soft landscaping areas around CP3 and WS9 will be sufficient to break the dust inhalation pathways associated with asbestos. The remaining areas of building footprint and external hardstanding will be sufficient to act as a physical barrier and effectively form a barrier between the end-users and the impacted Made Ground. The clean cover system will only be required in those areas where Made Ground would otherwise remain at the surface (i.e. soft landscaping areas). As such, if the Made Ground soils are alternatively removed then no clean cover will be required subject to verification that the Made Ground has been removed.

For the localised non-volatile PAHs which present a risk to residential end-users in proposed soft landscaping areas

It is proposed that a 600mm clean cover system for the localised soft landscaping areas around WS10 will be sufficient to break the dust inhalation pathways associated with asbestos. The remaining areas of building footprint and external hardstanding will be sufficient to act as a physical barrier and effectively form a barrier between the end-users and the impacted Made Ground. The clean cover system will only be required in those areas where Made Ground would otherwise remain at the surface (i.e. soft landscaping areas). As such, if the Made Ground soils are alternatively removed then no clean cover will be required subject to verification that the Made Ground has been removed.

It should be noted; however, that the clean cover system would have to be reduced within the footprint of the tree root protection zones around WS10. This would represent a solution for addressing incompatibility between contaminated land clean cover requirements and arboricultural / TPO requirements.

5. REMEDIATION STRATEGY

5.1. Introduction

Tier Environmental considers that a combined remedial approach will be required to address the following potential contaminants of concern:

- Localised concentrations of dibenzo(ah)anthracene at WS10 which presents a localised potential risk to the residential end-users in the nearby proposed soft landscaping area;
- Localised asbestos reported in soils at the Site at CP3 and WS9 in the form of Chrysotile fibre bundles of <0.1% which presents a localised potential risk to the residential end-users in the nearby proposed soft landscaping areas;

In addition, due consideration has been made within this remediation strategy for previously unidentified and localised visual / olfactory evidence of gross contamination.

5.2. Anticipated Remedial Works

Based upon the findings of the Ground Investigation and the above Remedial Options Appraisal the following remediation strategy has been devised in order to make the Site safe and suitable for redevelopment, as proposed:

- Removal and verification of any previously **unidentified** areas of contamination, where required. Such measures to achieve this may include one or more of the following, depending on the nature and extent of the previously unidentified contamination:
    - Localised excavation and off-site disposal of grossly contaminated soils (if encountered);
    - Verification soil and groundwater chemical analysis (as required);
    - Lines of evidence approach to demonstrate local betterment of ground conditions and consideration of other remedial measures being implemented to break and residual pathways identified
- Removal, crushing and screening of any oversized material and obstructions in the ground;
- Bulk earthworks to achieve the proposed development levels, including with fill materials compacted in accordance with a recognised specification, such as Specification for Highways Works Series 600;
- Earthworks and groundworks in the vicinity of those locations where asbestos has been reported to be conducted in accordance with the Control of Asbestos Regulations (CAR) 2012;
- Laboratory chemical testing and risk assessment of all imported materials; and,
- Installation of a minimum 600mm clean cover system underlain by a geotextile membrane in some localised soft landscaped areas to act as a growing medium and physical barrier between impacted Made Ground soils and the end-users **or** localised removal of impacted Made Ground in some affected soft landscaped areas;
- Reduction of clean cover to 150mm within areas of tree root protection zone.

The above integrated strategy is designed to:

- Mitigate risks to human health via direct contact, ingestion and dust inhalation pathways;
- Provide flexibility in the event that localised unexpected gross contamination is identified beneath the Site;
- Take into consideration the conflict between contaminated land clean cover requirements and arboricultural / TPO requirements.

Drawing No. TE1179-TE-00-XX-DR-GE-001-V02 included in Appendix A shows the proposed extent of the clean cover system requirements.

5.3. Clean Cover System

Installation

In order to remove the direct contact, dust inhalation and ingestion pollutant linkages, it is considered that the soft landscaped areas of the Site in the vicinity of WS10, CP3 and WS9 should be covered with a 600mm deep clean cover system (typical make up would comprise 150mm Topsoil layer underlain by 450mm subsoil underlain by a Terram geotextile membrane **or** a full 600mm of topsoil underlain by a Terram geotextile membrane). It is considered that as the proposed development is for residential without homegrown produce land use purposes, that a 600mm clean cover system with a geotextile membrane will provide sufficient thickness for the exposure scenarios typical for this land use and the geotextile will provide a physical barrier in the unlikely event that any excavations are undertaken to this depth. Whilst the above system is preferable, the clean cover system may also comprise a minimum 300mm topsoil (or 150mm Topsoil and 150mm subsoil to make a total thickness of 300mm) underlain by a minimum 300mm hard dig layer constructed from 'clean' crush / stone.

A potential conflict has been identified between the clean cover requirement and the tree root protection zone in the WS10 area. It is proposed that a localised reduction in the clean cover system to 150mm underlain by a geotextile membrane is implemented which will still afford protection from end-users whilst reducing the risk to the tree root protection zone. It is noted that this area at WS10 will be used as a wild meadow and so it is considered that this will reduce the interaction between the soils and the end-users around the tree root zones and provides further confidence that this reduction in the clean cover system will not significantly increase the risk to the end-user.

It should be noted that the clean cover system should only be implemented in those areas for which shallow soils still lie at ground surface in the WS10, CP3 and WS9 areas, i.e. soft landscaped areas as all other areas will either be covered in hardstanding and/or buildings which will be sufficient to break the direct contact and dust inhalation pathways in these areas or will comprise soft landscaping areas outside the localised impacts at WS10, CP3 and WS9.

The source of the imported subsoil and Topsoil material (and crush materials if a hard dig layer system is to be implemented) should be inspected and tested **prior to being brought to site** on site to ensure its chemical suitability and absence of any deleterious materials such as glass, metal, roots, invasive weed species and the like.

Drawing No. TE1179-TE-00-XX-DR-GE-001-V02 included in Appendix A shows the proposed extent of the clean cover system requirements.

Verification

Tier Environmental has taken into due consideration the requirements of York council inclusive of YALPAG (Yorkshire And Lincolnshire Pollution Advisory Group) Guidance.

Table 5.1 Clean Cover Verification Requirements

Objective	It will be necessary to ensure that the development of the site does not cause an increased risk to receptors. All clean cover materials imported to the site will be tested to determine its suitability for use on the Site in communal landscaping areas.
Testing frequency	Imported materials will need to be tested **before they are imported to Site** at a rate of: • 1 No. sample per 100m^3 for Topsoil / subsoil (with a minimum of 6 No. samples) from a brownfield / screened site; **or** • 1 No. sample per 250m^3 for Topsoil / subsoil (with a minimum of 3 No. samples) from a greenfield / manufactured soils site • 1 No. per 1,000m^3 for any crush used to form a hard dig layer.
Testing Suite	• Metals;

	• Speciated PAH; • Speciated TPH; • Total phenol; • pH; • Asbestos
Screening Criteria	The purpose of the testing is to verify the quality of any materials imported to the site and to determine the contaminant concentrations of materials. The samples will be compared with appropriate LQM / CIEH 2015 S4UL values protective of a residential without homegrown produce land use to confirm suitability for re-use.
On-site Verification Requirements	In addition to the chemical testing, the depth of clean cover will also be verified. Hand dug pits will be excavated on a 25m grid within landscaped areas to ensure that a minimum combined thickness of 600mm subsoil and Topsoil underlain by Terram geotextile (or 300mm topsoil/subsoil and 300mm hard dig layer) has been achieved. In the event that some or all of the soft landscaped areas have a clean cover system incorporating a hard dig layer, it may not be possible to advance through some hand pits through the full thickness of the hard dig layer due to density of the layer. It is considered; however, in these instances such refusals would be sufficient to demonstrate that the fundamental objective of the clean cover system has been achieved. Hand dug pits will be photographed and photographs will be submitted as part of the verification.

5.4. Contingency for any Unknowns or Previously Unidentified Localised Contamination

Whilst the ground investigation works conducted to date are regarded as comprehensive Tier Environmental wishes to demonstrate that due consideration has been given at an early stage on possible remedial solutions in the event that local grossly impacted soils or groundwater are identified on Site.

Should any suspicious material be encountered during the redevelopment works, works shall be ceased within this part of the site and the area should then be investigated further by a suitably qualified geo-environmental engineer and sampled as necessary. The Contaminated Land Officer (or equivalent) at the Local Authority should also be notified immediately. Samples (if deemed necessary) will be forwarded to a UKAS/MCERTS accredited laboratory for a suite of analytical testing deemed appropriate based upon an appraisal of the material identified.

Once the results of the analysis are known and have been interpreted, the final required remedial action (if any) and remedial targets (as appropriate) will be determined and approved with the relevant regulatory authorities.

5.5. Environmental Monitoring and Mitigation

Introduction

In order to mitigate the environmental impacts of the works on nearby surrounding land users, a programme of measures will be implemented during the remediation works.

Dust Mitigation

Appropriate measures shall be implemented at all times during the remediation works, to minimise dust emissions. Soils will be dampened down, as necessary, and activity will be minimised in extremely windy conditions to prevent dust nuisance. An adequate supply of water shall be maintained on site at all times to allow for dust suppression activities to be carried out at short notice.

When dusty material is being loaded onto trucks, extra care will be taken to ensure that the drop height is minimised. Trucks will be suitably covered when leaving the site with contaminated material to prevent dust migration.

The amount of disturbed surfaces left exposed for significant time periods will be minimised. Stockpiles of fine or loose materials should be tamped down or covered, if necessary, to reduce the production of dust. Traffic both entering and working on the site shall obey a maximum speed limit of 10 mph.

Noise

The requirements of BS 5228:1997 "Noise and Vibration Control on Construction Sites" shall be adhered to at all times. All machinery shall be fitted with effective silencers and shall be serviced at regular intervals. No plant shall be operated with engine covers raised.

Run-off into Drains

All potential drainage on site and any discharge points will be identified, including land drains, foul sewers, surface water drains and any combined drains. These will be marked, as appropriate, for easy identification.

Works will be minimised during periods of heavy rainfall to reduce the likelihood of contaminated run-off. Temporary containment and cover measures or tamping down of stockpiles to reduce run-off shall be used where necessary.

5.6. Waste Soils – Basic Characterisation and WAC

Any materials that require removal from the Site will be exported from the site to the appropriate landfill and shall be hauled by a registered waste carrier in accordance with Duty of Care Regulations, 1991 and the Hazardous Waste Regulations, 2005.

Tier Environmental have assessed the chemical results in terms of basic characterisation of soils for waste within the Site. This provides a preliminary assessment of whether a material is potentially either inert/non-hazardous or hazardous waste, with the final outcome having been determined by WAC testing.

Basic waste characterisation demonstrates that the Made Ground and natural soils beneath the Site are non-hazardous with the following exceptions:

- Made Ground at WS13 (0.30m bgl) due to elevated TPH which WAC testing has demonstrated is suitable for disposal to a dedicated stable non-reactive hazardous waste cell in a non-hazardous landfill;
- Made Ground at CP3 (0.40m bgl) due to alkaline pH; however, fragments of concrete were observed within this Made Ground and on this basis it is recommended that the receiving landfill may accept this materials as non-hazardous, subject to this justification being provided and accepted.

All other Made Ground materials should be classified as non-hazardous and further WAC testing may be conducted to confirm the suitability of these materials for disposal to an inert landfill. WAC testing of a single Made Ground sample obtained from CP2 (0.40m bgl) demonstrates that Made Ground in this area of the Site is suitable for disposal to an inert waste landfill.

The presence of asbestos reported in Made Ground soils at CP3 (0.40m bgl) and WS9 (0.20m bgl) means that Made Ground from these areas are not suitable for disposal to an inert waste landfill and should be instead disposed to a non-hazardous landfill.

Representative natural soil analysis and WAC tests have demonstrated that all natural soils are suitable for disposal to an inert waste landfill.

There will be requirement for the waste producer to provide appropriate Waste Acceptance Criteria (WAC) testing of the soils for disposal to ensure that the soils are appropriately classified and that the landfill is licensed to receive such soils.

5.7. Verification Report

The SE should ensure that the requirements of the strategy are complied with. On satisfactory completion of all remedial works, a verification report should be produced. This report will comprise all relevant site records and act as certification that the remedial preparation works have been carried out in accordance with this remediation strategy.

The Verification Report shall include the following:

- A description of the works undertaken in accordance with the Remediation Strategy described above;
- Records of the works;
- Progress photographs;
- Waste Transfer Notes;
- Chemical verification test results.

6. REGULATORY APPROVALS

The conclusions and recommendations presented above are considered reasonable based on the findings of the site investigations. However, these cannot be guaranteed to gain regulatory approval and, therefore, the report should be passed to the appropriate regulatory authorities and/or other organisations for their comment and approval.

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8. GLOSSARY OF TERMS

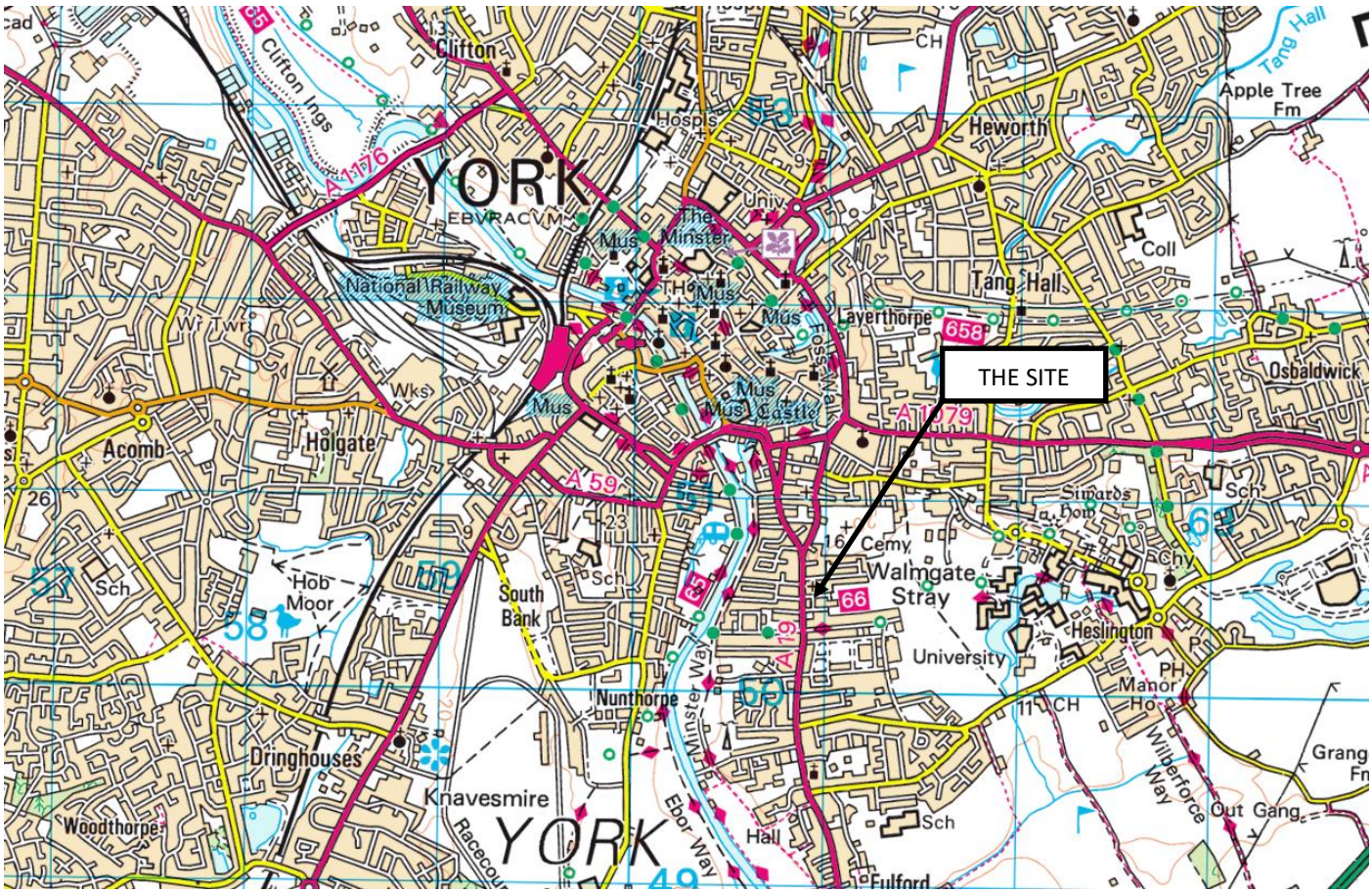
ACEC	Aggressive Chemical Environment for Concrete (classification)
aOD	Above Ordnance Datum
bgl	Below ground level
BGS	British Geological Survey
BRE	Building Research Establishment
CBR	California Bearing Ratio (test)
COMAH	Control of Major Accident Hazards (regulations)
Designated location	Site (and the ecosystem on that site) protected under national of international legislation. A potential ecological receptor to be considered as part of the assessment of land contamination. Example designated locations include SSSIs (q.v.), SACs (q.v.), national nature reserves, Ramsar sites and bird special protection areas.
DQA	Data Quality Assessment
DQO	Data Quality Objective
DQRA	Detailed Quantitative Risk Assessment
DWS	Drinking Water Standard
EQS	Environmental Quality Standard
GAC	Generic Assessment Criterion
GQA	General Quality Assessment (Environment Agency)
GSV	Gas Screening Value
HCV	Health Criteria Value
IPPC	Integrated Pollution Prevention and Control (regulations)
K_{ow}	Octanol-water partition coefficient
LEL	Lower Explosive Limit
LL	Liquid Limit
LoD	Limit of Detection (analytical)
LoQ	Limit of Quantification (analytical)
Mean Value Test	Statistical test (described in the CIEH Guidance) to estimate the mean value of a normally distributed population of data at a given level of confidence. Normally for contaminated land assessment, the 95th percentile (referred to as the 95%UCL or US95) is applied as a reasonable but conservative estimate of the mean concentration for comparison with the relevant assessment criteria.
Maximum Value Test	Statistical test (described in the CIEH Guidance) to identify whether an elevated concentration within a normally distributed data set forms part of the underlying population from which it has been sampled or whether it is an outlier (such as a localised area of contamination) that merits further consideration.
MC	Moisture Content
NGR	National Grid Reference
NIHHS	Notification of Installations Handling Hazardous Substances (regulations)
OS	Ordnance Survey
PI	Plasticity Index
PID	Photoionisation Detector
PL	Plastic Limit
ppm	Parts per million
ppmv	Parts per million by volume
QA	Quality Assurance
QC	Quality Control
SAC	Special Area of Conservation
SOM	Soil Organic Matter

SPT	Standard Penetration Test
SPZ	Source Protection Zone (see Appendix E)
SSAC	Site-Specific Assessment Criterion
SSSI	Site of Special Scientific Interest
SVOC	Semi-Volatile Organic Compound
TEF	Toxicity Equivalent Factor
TPH	Total Petroleum Hydrocarbons
TWA	Time Weighted Average
US95	95th percentile estimate of the true mean value of a data population (also known as 95%UCL).
VOC	Volatile Organic Compound

APPENDIX A - DRAWINGS

Contract Number: TE1179
Contract: Frederick House, York
Client: Watkin Jones & Son Limited

Site Location Plan



Scale: NTS	
Drawn by: ER	**Approved: AR**
Drawing Number: TE1179GIRL1.0	

LEGEND

Large Trees
Extra-heavy standard, 16-18cm girth, 4-4.5m height. Secured with timber stake and rubber tree tie. Irrigation ring. Example species: Betula pendula, Liquidambar styraciflua, Ginkgo biloba

Trees within Self Binding Gravel
Irrigation ring Extra-heavy standard. Example species: Tilia henryana in 'Rooftop' form.

Small Multi-Stemmed Trees
2.5-3.5m height. Secured with double timber stakes and rubber tree ties. Irrigation ring. Example species: Amelanchier, Prunus serrula

Shrub and Herbaceous Planting
Plated as 5L pots, 3-5 per m². 50mm bark mulch

Lawn
Hard wearing turf/grass seed

Wildflower Meadow
Standard General Purpose Meadow Mix by Emorsgate or similar approved. Sown at 5 per m²

Timber Picnic Style Tables
Brunswick Picnic Set by Bailey Streescene or similar approved. Douglas fir and powder coated steel, RAL to match building details

Timber Benches
Deacon Bench by Bailey Streetscene or similar approved. Douglas fir.

Timber Stool
Deacon Cube by Bailey Streetscene or similar approved. Douglas fir

Table Tennis Table
Cornilleau Park Outdoor Table Tennis Table by Eveque or similar approved

Light Buff Tarmac finish
Tarmac buff
by Tarmac or contractor choice as apporoved

Concrete Block Paving
Tegula Trio 60mm in Cedar by Tobermore or similar approved. Mixed plan sizes.

Green Paving (Grasscrete style)
Exact type tbc by Hardscape or similar approved. Mixed plan sizes.

Linear Concrete Slab Paving
Manhattan in Graphite by Tobermore or similar approved. 600x150x80mm.

Self Binding Gravel
Golden Amber Gravel by Breedon or similar approved. To provide permeable surface for trees. Tegula block paving laid in soldier course for edging

Pea Gravel Border
400mm wide pea gravel border around buildings for drainage and maintenance. 50mm depth, terram membrane under gravel and timber edging to separate from planting

Textured Concrete Kerb with 100mm upstand
Conservation Kerb in Cream by Marshalls or similar approved. 145x255x915mm

Block Paving Border
Tegula 60mm in natural by Tobermore or similar approved. Two blocks deep laid in running bond.

Dwarf Retaining Wall
Details tbc

1.8m Railings
1.8m tall powder coated steel railings and gate with RPA of existing trees

1.8m Brick Wall and Railings
1050mm brick wall with 1800mm brick piers and 750mm railings. RAL 7006. Bricks to match building materials

1.8m Railings
1.8m Powder Coated Railings. RAL 7006

Existing Brick Wall and New Fence
Existing 1.5m brick wall with new 300mm timber fence fixed to top of wall

Existing Brick Wall to be Retained

Outline of below ground water storage tanks

Permeable Tarmac finish to pedestrian footpath over root zones
supplier-contractor choice as approved

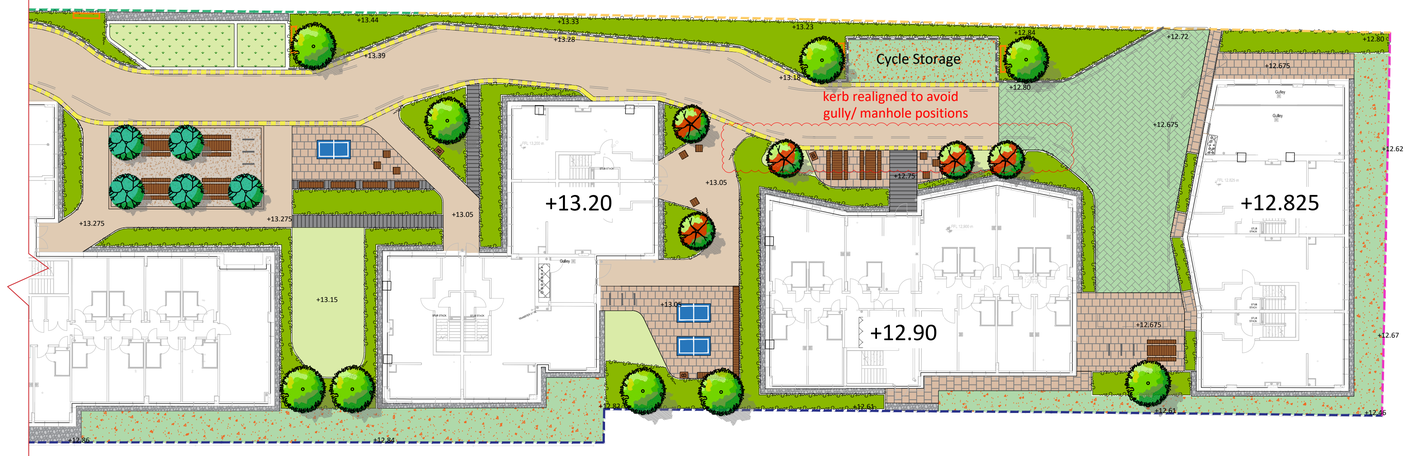
Sedum Roof
Green Sedum roof

Insect Wall
Insect hotel wall. Filled with recycled materials from the site.

Bat Boxes
see also ecologist report

Swift Boxes
See also ecologist report

Electric Charging Point



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2. This drawing is to be read in conjunction with detail landscape drawings, details and specification.
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4. The insertion of any firm or proprietary brand on this drawing is an indication of the class or quality required and does not exclude the use of alternative materials that are equal in performance, quality and appearance, provided that they have been approved in writing by the Landscape Architect.
5. The Contractor is responsible for accurately ascertaining the position of underground services and responding to all relevant service easement requirements.
6. All dimensions are in millimetres unless stated otherwise, for the purposes of construction this drawing must not be scaled and only written dimensions used. Written and scaled dimensions to be checked on site, any discrepancies reported prior to work commencing. IF IN DOUBT PLEASE ASK.
7. All work and materials are to be in accordance with the relevant British Standards and Code of Practice.
8. All Proprietary products are to be used strictly in accordance with the manufacturer's instructions and details.

REVISION NOTES

Rev	By	Description	Date
L	AK	Updated in line with drainage layout	12.05.21
J	GBS	Updated in line with comments	07.05.21
H	CT	Bat and swift boxes added	08.04.21
G	FY	Planting beds added, coordinate reposition	06.04.21
F	CT	sedum roof to out buildings	25:03.21
E	SB	Green paving added	23:03.21
D	SB	entrance realigned to existing kerb	16:03.21
C	EG	Levels around Block G amended	22.01.21
B	EG	Levels amended and drainage	12.01.21
A	EG	Detail added	02.12.20

Client
Watkin Jones

Project
Frederick House, York

Description
Landscape Layout

Status
For Approval

Scale @ A1	Drawn	Checked	Date
1:250	EG	CT	18.11.20
Job number	Drawing number		Revision
3473	101		L

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chartered landscape architects
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DO NOT SCALE

Cable Percussion Borehole Location

Window Sample Borehole Location (install)

Window Sample Borehole Location (no install)

Potential area of former well location (c.1946 - 1949)

Potential area of former well location (c.1891)

Approximate location of LV cables

REV	DATE	BY	DESCRIPTION	CHK	APD
B	25/03/19	PB	Exploratory Hole Location Plan	AR	AR
A	12/03/19	PB	Proposed Exploratory Hole Location Plan	AR	AR

DRAWING STATUS: DRAFT

Tier Consult Ltd.
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CLIENT: Watkin Jones & Son Ltd and Summix Ltd

ARCHITECT: -

PROJECT: TE1179
Frederick House, York

TITLE: Exploratory Hole Location Plan

SCALE @ SIZE:	CHECKED:	APPROVED:
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CAD FILE:	DESIGN/DRAWN: PB	DATE: Mar '19

PROJECT No:	DRAWING No:	REV:
TE1179	TE1179/GIR2	B

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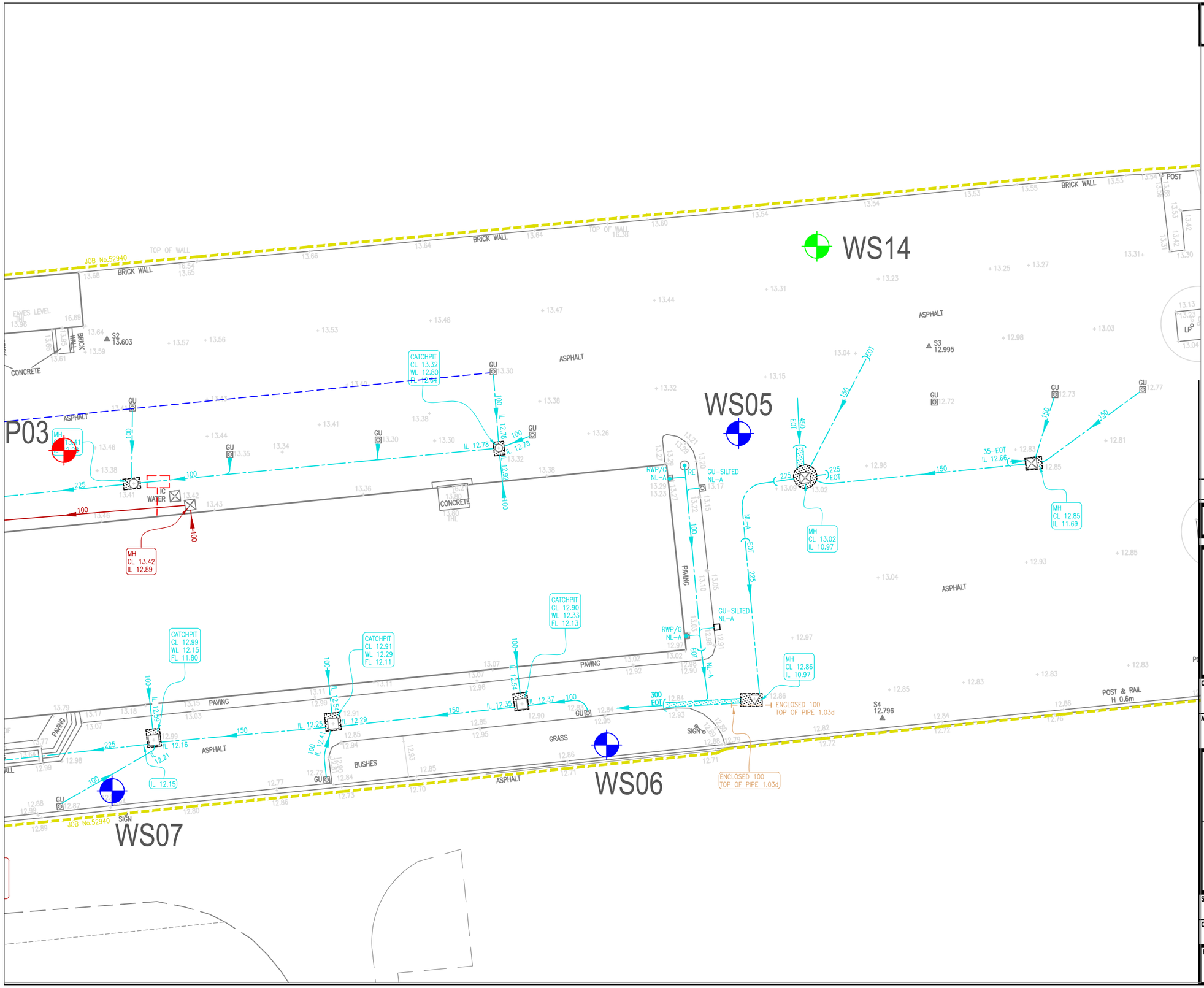

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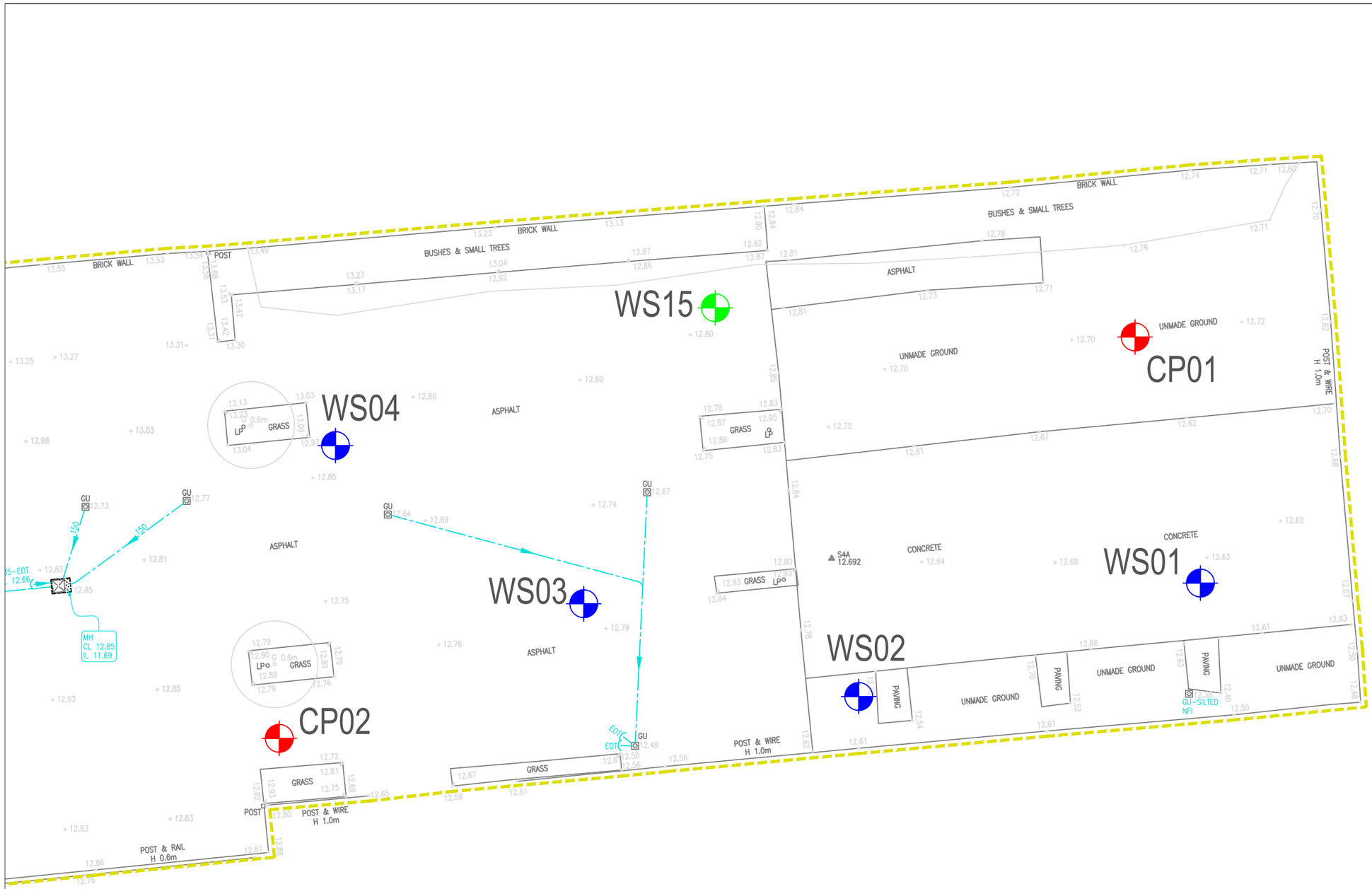

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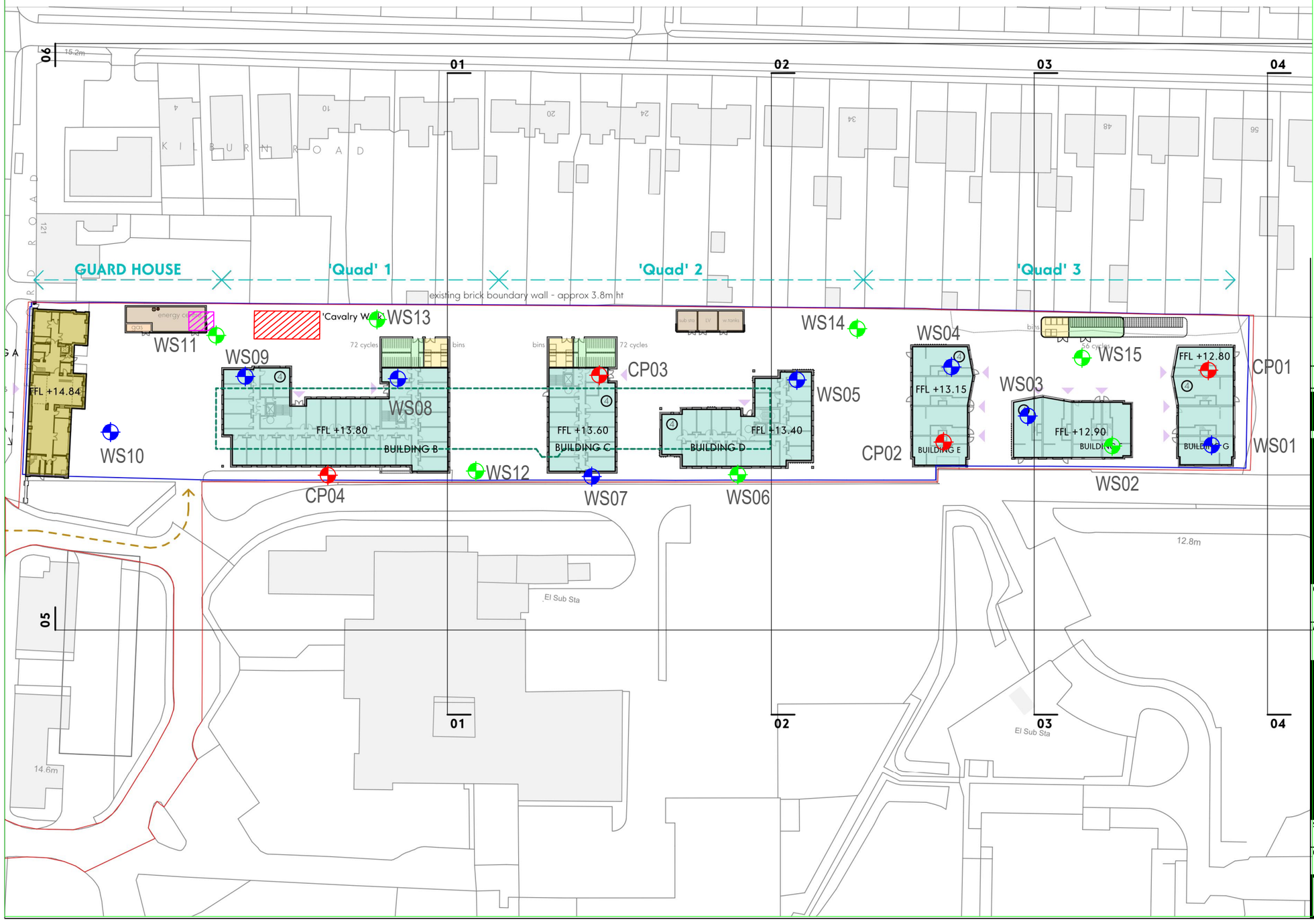

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CLIENT: Watkin Jones & Son Ltd and Summix Ltd

ARCHITECT:

PROJECT: Frederick House, York

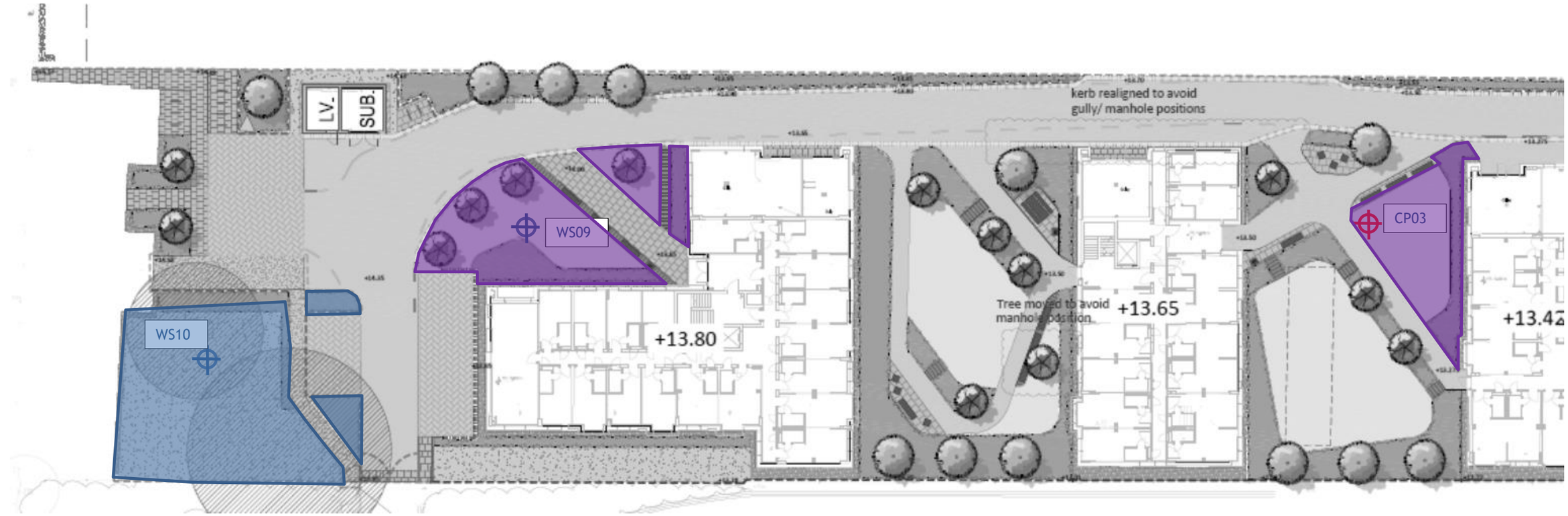
TITLE: Exploratory Hole Location Plan

SCALE @ SIZE:	CHECKED:	APPROVED:
DNS	AR	AR
CAD FILE:	DESIGN/DRAWN: JS	DATE: MARCH 2019

PROJECT No:	DRAWING No:	REV:
TE1179	TE1179GIR2	A

Contract Number	TE1179
Contract	Frederick House, York
Client	Watkin Jones

Proposed Localised Clean Cover System Requirements



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Light Buff Tarmac finish
Tarmac buff
by Tarmac or contractor choice as approved

Concrete Block Paving
Tegula Trio 60mm in Cedar by Tobermore or similar approved. Mixed plan sizes.

Green Paving (Grasscrete style)
Exact type tbc by Hardscape or similar approved. Mixed plan sizes.

Linear Concrete Slab Paving
Manhattan in Graphite by Tobermore or similar approved. 600x150x80mm.

Self Binding Gravel
Golden Amber Gravel by Breedon or similar approved. To provide permeable surface for trees. Tegula block paving laid in soldier course for edging

Pea Gravel Border
400mm wide pea gravel border around buildings for drainage and maintenance. 50mm depth, terram membrane under gravel and timber edging to separate from planting

Textured Concrete Kerb with 100mm upstand
Conservation Kerb in Cream by Marshalls or similar approved. 145x255x915mm

Block Paving Border
Tegula 60mm in natural by Tobermore or similar approved. Two blocks deep laid in running bond.

Dwarf Retaining Wall
Details tbc

1.8m Railings
1.8m tall powder coated steel railings and gate with RPA of existing trees

1.8m Brick Wall and Railings
1050mm brick wall with 1800mm brick piers and 750mm railings. RAL 7006. Bricks to match building materials

1.8m Railings
1.8m Powder Coated Railings. RAL 7006

Existing Brick Wall and New Fence
Existing 1.5m brick wall with new 300mm timber fence fixed to top of wall

Existing Brick Wall to be Retained

Outline of below ground water storage tanks

Permeable Tarmac finish to pedestrian footpath over root zones
supplier-contractor choice as approved

Sedum Roof
Green Sedum roof

Insect Wall
Insect hotel wall. Filled with recycled materials from the site.

Bat Boxes
see also ecologist report

Swift Boxes
See also ecologist report

Electric Charging Point

Proposed areas of 600mm clean cover system underlain by geotextile membrane

Proposed areas of reduced 150mm clean cover system underlain by geotextile membrane due to presence of tree root protection zones

Scale	**NTS**		
Drawn by	AR	**Approved**	SL
Drawing Number	TE1179-TE-00-XX-DR-GE-001-V02		

APPENDIX B - PREVIOUS SITE INVESTIGATION REPORT (AVAILABLE AS A SEPARATE DOCUMENT)

APPENDIX C - DEFINITIONS OF TERMS USED IN QUALITATIVE AND QUANTITATIVE RISK ASSESSMENTS

CIRIA C552 Terminology

For the qualitative and quantitative assessment of risks posed by potential pollutant linkages have been undertaken using the risk matrix adapted from CIRIA C552 and outlined in the table below.

	Category	Definition
Potential severity	Severe	Acute (short term) risk to human health, Major pollution of sensitive controlled waters, ecosystems or habitat. Catastrophic damage to buildings or property or crops.
	Medium	Chronic (Medium / long term) risk to human health Pollution of sensitive controlled waters, ecosystems or species, Significant damage to crops, buildings or structures
	Mild	Easily preventable permanent health effects on humans. Pollution of non-sensitive controlled waters. Minor damage to buildings or structures.
	Minor	Easily preventable non-permanent health effects on humans, or no effects. Minor, low level and localised contamination of on-site soil. Easily repairable damage to buildings or structures.
Probability of risk	High Likelihood	Pollutant linkage may be present, and the risk is almost certain to occur , or there is evidence of harm already occurring.
	Likely	Pollutant linkage may be present, and it is probable that the risk will occur over the long term.
	Low Likelihood	Pollutant linkages may be present and there is a possibility of the risk occurring, although there is no certainty that it will do so.
	Unlikely	Pollutant linkage may be present but the circumstances under which harm would occur are improbable.

		Potential Severity			
		Severe	**Medium**	**Mild**	**Minor**
Probability of risk	**High Likelihood**	Very high risk	High risk	Moderate risk	Moderate / low risk
	Likely	High risk	Moderate risk	Moderate / low risk	Low risk
	Low Likelihood	Moderate risk	Moderate / low risk	Low risk	Very low risk
	Unlikely	Moderate / low risk	Low risk	very low risk	Very low risk

APPENDIX D - HUMAN HEALTH ASSESSEMENT CRITERIA

HUMAN HEALTH ASSESSMENT CRITERIA

Context

Contaminated Land is defined under law through Part IIA of the Environmental Protection Act 1990, implemented through Section 57 of the Environment Act 1995 and associated guidance ("Part IIA"). These specify that a "suitable for use" approach is to be applied in the assessment of potentially contaminated land, implemented through a phased programme of site investigation and risk assessment appropriate to the site under consideration.

The assessment of potential risks posed by contaminated land is based upon the assessment of plausible contaminant source - pathway - receptor linkages ("pollutant linkages") for the current and/or proposed future use of the site. The process for the assessment of contaminated land adopted in this report is in line with guidance issued by the Environment Agency Land contamination risk management (LCRM) - GOV.UK (www.gov.uk)

Land contamination can harm:

- human health
- drinking water supplies, groundwater and surface water
- soils
- ecosystems including wildlife, animals and wetlands
- property

It can also affect the current and future land use. Dealing with land contamination helps make the environment clean and safe. Through regeneration it can:

- enhance the health and wellbeing of all
- add to the economic, ecological and amenity value of the area

Use land contamination risk management (LCRM) to:

- identify and assess if there is an unacceptable risk
- assess what remediation options are suitable to manage the risk
- plan and carry out remediation
- verify that remediation has worked

You can use LCRM in a range of regulatory and management contexts. For example, voluntary remediation, planning, assessing liabilities or under the Part 2A contaminated land regime. The Environment Agency expects you to follow LCRM if you are managing the risks from land contamination.

We support the use of the National Quality Mark Scheme (NQMS). You can use it for any type of land contamination report.

Using the NQMS:

- will make sure all legislative requirements and necessary standards related to managing land contamination are met
- can provide increased confidence by submitting reports of the quality we expect
- can result in cost and time savings by 'getting it right first time'

LCRM is made up of 4 guides.

1. LCRM: Before you start.
2. LCRM: Risk assessment.
3. LCRM: Options appraisal.
4. LCRM: Remediation and verification.

We use a staged risk based approach. There are 3 stages, and each stage is broken down into tiers or steps.

Stage 1: Risk assessment

You will use a tiered approach to risk assessment. The 3 tiers are:

1. Preliminary risk assessment.
2. Generic quantitative risk assessment.
3. Detailed quantitative risk assessment.

Stage 1 includes information for intrusive site investigations.

Stage 2: Options appraisal

There are 3 steps to follow.

1. Identify feasible remediation options.
2. Do a detailed evaluation of options.
3. Select the final remediation option.

Stage 3: Remediation and verification

There are 4 steps to follow.

1. Develop a remediation strategy.
2. Remediate.
3. Produce a verification report.
4. Do long term monitoring and maintenance, if required

You must always start with a preliminary risk assessment.

The risk assessment stage is an iterative process. You can do the 3 tiers in order or progress from a preliminary risk assessment to a detailed quantitative risk assessment. As part of a generic or detailed quantitative risk assessment you will need to collect detailed information about the site. This is usually through an intrusive site investigation.

Depending on the level of risk or regulatory requirements, you can proceed from a preliminary risk assessment to the options appraisal stage. If you proceed direct to the options appraisal stage, you still need to collect the detailed site investigation information required by the generic and detailed quantitative risk assessments. This is to confirm that your approach is viable and acceptable.

Following the risk assessment stage, if you conclude that the risks are acceptable, with agreement from the relevant regulator, you can end the process.

If there are unacceptable risks, then remediation or mitigation is required. Follow stages 2 and 3 in order.

In stage 2 options appraisal, you will:

- look at the most feasible options
- produce a shortlist of options
- use evaluation criteria to assess them
- select which ones are the most suitable to take forward to stage 3

In stage 3 remediation and verification, you will produce a remediation strategy, do the remediation and then produce a verification report.

You will decide at the options appraisal stage if long term monitoring and maintenance is the remediation option. You may need to do post-remediation monitoring for further verification.

The risk assessment and subsequent investigation, remediation and verification must address all potential sources of pollutants that may be present on the site (the “hazards”), all receptors that may be harmed by these (e.g., human health, controlled waters, ecological receptors) and the pathways by which the contamination may be transported from the contaminant source(s) to the receptor(s). This is defined within the conceptual model for the site, which represents the characteristics of the site in a form that shows the possible pollutant linkages. As further information becomes available (for example, through site investigation), so the conceptual model will be refined.

Remedial action can be specified at any phase within this assessment process to break the identified pollutant linkage in determining whether or not to undertake further assessment or to undertake remediation, the potential cost-savings arising from a more thorough assessment of the pollutant linkages and more tightly defined remedial strategy must be considered against the direct costs involved in the work and the time that this will take to execute and gain regulatory approval.

A different approach to the statistical appraisal of data is required depending on whether the assessment is being undertaken to assess land as Contaminated Land in accordance with the regulations or whether the assessment is to assess whether the site is suitable for new development in accordance with the Planning regime. The statistical approach to assessment is discussed further in CL:AIRE:2020 “Professional Guidance: Comparing Soil Contamination Data with a Critical Concentration”.

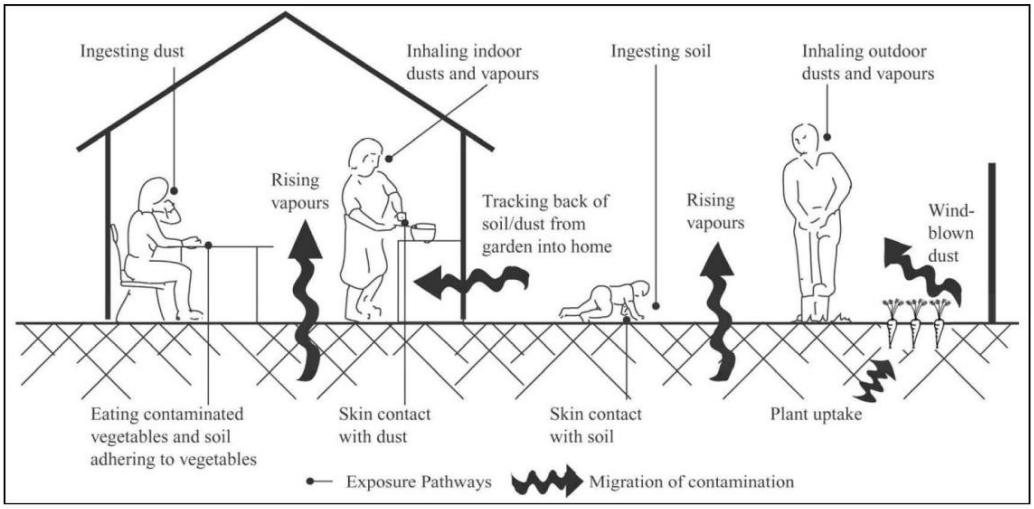
Some form of Detailed Quantitative Risk Assessment (DQRA) will be essential for those cases where appropriate GAC values cannot be established for the contaminant linkages under consideration.

Generic Assessment Criteria for Human Health Risk Assessment

In March 2002, the Department for Environment, Food and Rural Affairs (DEFRA) and the Environment Agency (EA) published the Contaminated Land Exposure Assessment (CLEA) Model and a series of related reports and guidance. These were designed to provide a scientifically based framework for the assessment of chronic risks to human health from contaminated land. The initial documents (CLR7 – 10) were withdrawn and replaced with revised guidance issued by the Environment Agency including:

- "Using Soil Guideline Values"; EA,2009; Land contamination: using soil guideline values (SGVs) - GOV.UK (www.gov.uk)
- "Human Health toxicology assessment of contaminants in soil" EA;, 2009; https://www.gov.uk/government/publications/human-health-toxicological-assessment-of-contaminants-in-soil
- "Update technical background to the CLEA model" 2009; https://www.gov.uk/government/publications/updated-technical-background-to-the-clea-model
- CLEA Software (Version1.05) Handbook 2015; https://www.gov.uk/government/publications/contaminated-land-exposure-assessment-clea-tool
- Compilation of Data for priority Organic Contaminants for Derivation of Soil Guideline Values; Science Report SC050021/SR7, 2008; and,
- "Professional Guidance: Comparing Soil Contamination Data with a Critical Concentration". CL:AIRE:2020 https://www.claire.co.uk/component/phocadownload/category/9-other-cl-aire-documents?download=745:2020-stats-guidance

The CLEA model and associated guidance was developed to calculate an estimated tolerable daily intake (TDI) of contaminants for site users given a set of 'typical' human health exposure pathways which are detailed in "SR3: Updated technical background to the CLEA model"



(Science Report SC050021/SR3, EA, 2009) and reproduced below.

Ingestion

- Outdoor soil;
- Indoor dust;
- Home grown produce;
- Soil attached to home grown produce.

Dermal Contact

- Outdoor soil;
- Indoor dust.

Inhalation

- Outdoor dust;
- Indoor dust;
- Outdoor vapour;
- Indoor vapour.

It should be noted that the CLEA model does not include an exhaustive list of potential exposure pathways, e.g. certain compounds can pass through plastic water pipes into drinking water supply.

The potential significance of each of the exposure pathways is dependent upon the type of land use and the nature of the contaminant being considered. The CLEA model considers principal 'default' land use scenarios and makes a series of assumptions with regards to building type (where applicable), identification of the critical human receptor group, exposure frequency and duration. The definitions of the principal land use types given in SR3 (EA, 2009) are:

Residential land use;

- A typical residential property consisting of a two-storey terraced house built on a ground-bearing slab of 0.15m thickness with a private garden consisting of lawn, flowerbeds, and a small fruit and vegetable patch. The occupants are assumed to be parents with young children, who make regular use of the garden. The critical receptor is a 0 – 6-year-old female.
- Active exposure pathways are ingestion of outdoor soil, ingestion of indoor dust, ingestion of home grown produce and soil adhering to home grown produce; direct dermal contact with outdoor soil and indoor dust; inhalation of outdoor dust and vapour and indoor dust and vapour

Allotments

- A plot of open space commonly made available by the Local Authority to tenants to grow fruit and vegetables for their own consumption. There are usually several plots to a site and the overall site area may cover more than one hectare. The tenants are assumed to be the parents or grandparents and that young children make occasional accompanied visits to the plots. The critical receptor is a 0 – 6-year-old female and there is no building present on Site.
- Active exposure pathways are ingestion of outdoor soil, ingestion of home grown produce and soil adhering to home grown produce; direct dermal contact with outdoor soil; inhalation of outdoor vapour.

Commercial and industrial land use.

- A typical commercial or light industrial property consisting of a three-story office building (pre-1970) with a ground bearing floor slab at which employees spend most time indoors and are involved in office based or related light physical work. The critical receptor is a working female adult aged 16 – 65 years.
- Active exposure pathway is ingestion of outdoor soil, ingestion of indoor dust; direct dermal contact with outdoor soil and indoor dust; inhalation of outdoor dust and vapour and inhalation of indoor dust and vapour.

Soil Guideline Values

Based on the assumption of each land use type, the EA and DEFRA developed and published Soil Guideline Value (SGV) using the CLEA model for a number of principal contaminants and 'default' end-use scenarios of residential, allotments and commercial/industrial use. The primary purpose of the SGVs is as trigger value for the tolerable daily intake (TDI), below which it can be assumed that the soil does not pose an unacceptable risk to the identified receptor. Where soils contamination is present above this level further assessment may be required. SGVs were developed for the following contaminants:

- Heavy metals and other inorganic compounds: arsenic, cadmium, chromium, cyanide, lead (now withdrawn), mercury, nickel and selenium.
- Benzene, ethylbenzene, toluene and xylenes.
- Phenol.
- Dioxins and dioxin-like polychlorinated biphenyls (PCBs)
- Polycyclic aromatic hydrocarbons (PAHs) – 11 substances

LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment

In addition, in 2009 CIEH through LQM and EIC published generic assessment criteria (GACs) for 82 substances including metals, petroleum hydrocarbons, PAHs and explosive substances for a variety of soil types and the three 'default' land uses – (residential, allotments and commercial end-uses) as described in SR3 (EA, 2009). These have been superseded as described below.

Category 4 Screening Values

In 2013 "SP1010: Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination" (CL:AIRE 2013) was issued which detailed findings of a research project undertaken by CL:AIRE to set out the framework by which potential Category 4 Screening Levels (pC4SL) may be derived for 6 contaminants of concern, Arsenic, Benzene, Benzo(a)pyrene, Cadmium, Chromium VI and Lead.

This was supplemented in 2014 by "SP1010: Development of Category 4 Screening Levels for the Assessment of Land Affected by Contamination – Policy Companion Document" (DEFRA, 2014). SP1010 proposed several updated toxicology information relating to contaminant behaviour updated assumptions relating to the modelling of human exposure to soil contaminants, derivation of separate C4SLs for residential with the consumption of home grown produce, residential without the consumption of home grown produce, and two new land uses: public open spaces near residential housing (POS resi) and public parks (POS park).

Public Open Space: Residential

- For public open space in close proximity to residential housing and the central green area around which houses are located, as on many housing estates from the 1930s to 1970s. It is also applicable for smaller areas commonly incorporated in newer developments as informal grassed areas or more formal landscaped areas with a mixture of open space and covered soil with planting. It is considered to be a generally grassed area up to 0.5ha with up to 50% bare soil. The land use is an important resource

for children and the area is near the homes. The critical receptor is a female child age >3 - <9 years old (CLEA age class 4 – 9) as younger children are unlikely to play outdoors unsupervised.

- Active exposure pathways are ingestion of outdoor soil, ingestion of indoor dust; direct dermal contact with outdoor soil and indoor soil derived dust; inhalation of outdoor and indoor dust and inhalation of outdoor vapour.

Public Open Space: Park

- A public park is defined as an area of open space provided for recreational use and usually owned and maintained by the Local Authority. It is anticipated the park could be used for a wide range of activities, including the following:
    - Family visits and picnics;
    - Children's play area;
    - Sporting activities such as football on an informal basis (i.e. not a dedicated sports pitch); and
    - Dog walking.
- The park is modelled as an area >0.5 ha of predominantly grasses open space with no more than 25% of exposed soil.
- The critical receptor is a female child with CLEA age classes 1 – 6.
- Active exposure pathway are: ingestion of outdoor soil; direct dermal contact with outdoor soil; inhalation of outdoor dust and inhalation of outdoor vapour.

Furthermore, the C4SLs are based on a different toxicological benchmark, the 'low level of toxicological concern' (LLTC). This difference in approach was adopted because the C4SLs were primarily intended for use under Part2A of the EPA 1990 to quickly screen out Category 4 sites where there is "*no risk or that the level of risk posed is low*". SGVs and LQM GACs are based on the more conservative 'minimal or tolerable level of risk' as defined in SR2 (EA, 2009) and were derived for assessment of contamination for the Planning process.

LQM/CIEH Suitable 4 Use Levels (S4ULs)

The publication of the C4SLs resulted in considerable and inconclusive debate about the applicability of the lower level of protection of the C4SL, which are underlain by the LLTC, outside of the Part 2A context for which they were derived. In 2014 LQM/CIEH presented a Suitable 4 Use Levels (S4ULs), which incorporate the updated assumption exposure derived for the production of the C4SLs but within the context of deriving screening criteria above which further assessment of the risks or remedial action may be needed. The S4ULs replace the 82 substances, species and fractions and congeners contained in the previous LQM/CIEH GACs issued in 2009. Additionally, following changes and new land uses proposed in the C4SL research project, S4ULs have also been derived for the majority of substances for which the EA derived SGVs in 2009 with the exception of lead (see below).

Lead

The C4SL for lead provides a technically robust and conservative assessment tool using significantly updated toxicological modelling than the withdrawn SGV and derived in line with current science of lead toxicology.

EIC/AGS/CL:AIRE Soil Generic Assessment Criteria (2010)

In some instances, EIC/AGC/CL:AIRE GACs for certain VOC / SVOC potential contaminants of concern have been used *in lieu* of available LQM / CIEH S4UL values.

Parameter	Residential with homegrown produce			Residential without homegrown produce			Allotment			Commercial / Industrial			Public Open Space near Residential			Public Open Space - Park			Source
	(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			
SOM	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	
Metals/metalloids																			
Arsenic	37			40			43			640			79			170			LQM (2014)
Beryllium	1.7			1.7			35			12			2.2			63			LQM (2014)
Boron	290			11000			45			240000			21000			46000			LQM (2014)
Cadmium	11			85			1.9			190			120			532			LQM (2014)
Chromium III	910			910			18000			8600			1500			33000			LQM (2014)
Chromium VI	6			6			1.8			33			7.7			220			LQM (2014)
Copper	2400			7100			520			68000			12000			44000			LQM (2014)
Lead	200			310			80			2330			630			1300			C4SL
Mercury (elemental)	1.2			1.2			21			58 (25.8)			16			30 (25.8)			LQM (2014)
Mercury (Inorganic)	40			56			19			1100			120			240			LQM (2014)
Methylmercury	11			15			6			320			40			68			LQM (2014)
Nickel	180			180			230			980			230			3400			LQM (2014)
Selenium	250			430			88			12000			1100			1800			LQM (2014)
Vanadium	410			1200			91			9000			2000			5000			LQM (2014)

Parameter	Residential with homegrown produce			Residential without homegrown produce			Allotment			Commercial / Industrial			Public Open Space near Residential			Public Open Space - Park			Source
	(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			
SOM	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	
Zinc	3700			40000			620			730000			81000			170000			LQM (2014)
Other																			
Total Sulphate	2,400			2,400			2,400			2,400			2,400			2,400			BRE (2005)
Water Soluble Sulphate (g/l)	0.5			0.5			0.5			0.5			0.5			0.5			BRE (2005)
PAHs																			
Acenaphthene	210	510	1100	3000 (57)	4700(141)	6000 (336)	34	85	200	84000 (57)	97000 (141)	100000	15000	15000	15000	29000	30000	30000	LQM (2014)
Acenaphthylene	170	420	920	2900 (86.1)	4600 (212)	6000 (506)	28	69	160	8300 (86.1)	97000 (212)	100000	15000	15000	15000	29000	30000	30000	LQM (2014)
Anthracene	2400	5400	11000	31000 (1.17)	35000	37000	380	950	2200	520000	540000	540000	74000	74000	74000	150000	150000	150000	LQM (2014)
Benzo(a)anthracene	7.2	11	13	11	14	15	2.9	6.5	13	170	170	180	29	29	29	49	56	62	LQM (2014)
Benzo(a)pyrene	2.2	2.7	3	3.2	3.2	3.2	0.97	2	3.5	35	35	36	5.7	5.7	5.7	11	12	13	LQM (2014)
Benzo(b)fluoranthene	2.6	3.3	3.7	3.9	4	4	0.99	2.1	3.9	44	44	45	7.1	7.1	7.1	13	15	16	LQM (2014)
Benzo(g,h,i)perylene	320	340	350	360	360	360	290	470	640	3900	4000	4000	640	640	640	1400	1500	1600	LQM (2014)
Benzo(k)fluoranthene	77	93	100	110	110	110	37	75	130	1200	1200	1200	190	190	190	370	410	440	LQM (2014)
Chrysene	15	22	27	30	31	32	4.1	9.4	19	350	350	350	57	57	57	93	110	120	LQM (2014)

Parameter	Residential with homegrown produce			Residential without homegrown produce			Allotment			Commercial / Industrial			Public Open Space near Residential			Public Open Space - Park			Source
	(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			
SOM	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	
Dibenz(a,h)anthracene	0.24	0.28	0.3	0.31	0.32	0.32	0.14	0.27	0.61	3.5	3.6	3.6	0.57	0.57	0.58	1.1	1.3	1.4	LQM (2014)
Fluoranthene	280	560	890	1500	1600	1600	52	130	290	23000	23000	23000	3100	3100	3100	63	6300	6400	LQM (2014)
Fluorene	170	400	860	2800 (30.9)	3800 (76.5)	4500 (183)	27	67	160	63000 (30.9)	68000	71000	9900	9900	9900	20000	20000	20000	LQM (2014)
Indeno(1,2,3-cd)pyrene	27	36	41	45	46	46	9.5	21	39	500	510	510	82	82	82	150	170	180	LQM (2014)
Naphthalene	2.3	5.6	13	2.3	5.6	13	4.1	10	24	190 (76.4)	460 (183)	1100 (432)	4900	4900	4900	1200 (76.4)	1900 (183)	3000	LQM (2014)
Phenanthrene	95	220	440	1300 (36)	1500	1500	15	38	90	22000	22000	23000	3100	3100	3100	6200	6200	6300	LQM (2014)
Pyrene	620	1200	2000	3700	3800	3800	110	270	620	54000	54000	54000	7400	7400	7400	15000	15000	15000	LQM (2014)
Coal Tar (BaP as surrogate marker)	0.79	0.98	1.1	1.2	1.2	1.2	0.32	0.67	1.2	15	15	15	2.2	2.2	2.2	4.4	4.7	4.8	LQM (2014)
BTEX and TPH																			
Benzene	0.087	0.17	0.37	0.38	0.7	1.4	0.017	0.034	0.075	27	47	90	72	72	73	90	100	110	LQM (2014)
Toluene	130	290	660	880 vap (869)	1900	3900	22	51	120	56000 vap (869)	110000 vap (1920)	180000 vap (4360)	56000	56000	56000	87000 vap (869)	95000 vap (1920)	100000 vap (4360)	LQM (2014)
Ethylbenzene	47	110	260	83	190	440	16	39	91	5700 vap (518)	13000 vap (1220)	27000 vap (2840)	24000	24000	25000	17000 vap (518)	22000 vap (1220)	27000 vap (2840)	LQM (2014)
Xylene - o	60	140	330	88	210	480	28	67	160	6600 (478)	15000 (1120)	33000 (2620)	41000	42000	43000	17000 (478)	24000 (1120)	33000 (2620)	LQM (2014)

Parameter	Residential with homegrown produce			Residential without homegrown produce			Allotment			Commercial / Industrial			Public Open Space near Residential			Public Open Space - Park			Source
	(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			
SOM	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	
Xylene - m	59	140	320	82	190	450	31	74	170	6200 (625)	14000 (1470)	31000 (3460)	41000	42000	43000	17000 (625)	24000 (1470)	32000 (3460)	LQM (2014)
Xylene - p	56	130	310	79	180	430	29	69	160	5900 (576)	14000 (1350)	30000 (3170)	41000	42000	43000	17000 (576)	23000 (1350)	31000 (3170)	LQM (2014)
Aliphatic EC 5-6	42	78	160	42	78	160	730	1700	3900	3200 (304)	5900 (558)	12000 (1150)	570000 (304)	590000	600000	95000 (304)	130000 (558)	180000 (1150)	LQM (2014)
Aliphatic EC >6-8	100	230	530	100	230	530	2300	5600	13000	7800 (144)	17000 (322)	40000 (736)	600000	610000	620000	150000 (144)	220000 (322)	320000 (736)	LQM (2014)
Aliphatic EC >8-10	27	65	150	27	65	150	320	770	1700	2000 (78)	4800 (190)	11000 (451)	13000	13000	13000	14000 (78)	18000 (190)	21000 (451)	LQM (2014)
Aliphatic EC >10-12	130 (48)	330 (118)	760 (283)	130 (48)	330 (118)	760 (283)	2200	4400	7300	9700 (48)	23000 (118)	47000 (283)	13000	13000	13000	21000 (48)	23000 (118)	24000(283)	LQM (2014)
Aliphatic EC >12-16	1100 (24)	2400 (59)	4300 (142)	1100 (24)	2400 (59)	4300 (142)	11000	13000	13000	59000 (24)	82000 (59)	90000 (142)	13000	13000	13000	25000 (24)	25000 (59)	26000 (142)	LQM (2014)
Aliphatic EC >16-35	65000 (8.48)	92000 (21)	110000	65000 (8.48)	92000 (21)	110000	260000	270000	270000	1600000	1700000	1800000	250000	250000	250000	450000	480000	490000	LQM (2014)
Aliphatic EC >35-44	65000 (8.48)	92000 (21)	110000	65000 (8.48)	92000 (21)	110000	260000	270000	270000	1600000	1700000	1800000	250000	250000	250000	450000	480000	490000	LQM (2014)
Aromatic EC 5-7	70	140	300	370	690	1400	13	27	57	26000 (1220)	46000 (2260)	86000 (4710)	56000	56000	56000	76000 (1220)	84000 (2260)	92000 (4710)	LQM (2014)
Aromatic EC >7-8	130	290	660	860	1800	3900	22	51	120	56000 (869)	110000 (1920)	180000 (4360)	56000	56000	56000	87000 (869)	95000 (1920)	100000 (4360)	LQM (2014)
Aromatic EC >8-10	34	83	190	47	110	270	8.6	21	51	3500 (613)	8100 (1500)	17000 (3580)	5000	5000	5000	7200 (613)	8500 (1500)	9300 (3580)	LQM (2014)
Aromatic EC >10-12	74	180	380	250	590	1200	13	31	74	16000 (364)	28000 (899)	34000 (2150)	5000	5000	5000	9200 (364)	9700 (899)	10000	LQM (2014)

Parameter	Residential with homegrown produce			Residential without homegrown produce			Allotment			Commercial / Industrial			Public Open Space near Residential			Public Open Space - Park			Source
	(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			
SOM	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	
Aromatic EC >12-16	140	330	660	1800	2300 (419)	2500	23	27	130	36000 (169)	37000	38000	5100	5100	5000	10000	10000	10000	LQM (2014)
Aromatic EC >16-21	260	540	930	1900	1900	1900	46	110	260	28000	28000	28000	3800	3800	3800	7600	7700	7800	LQM (2014)
Aromatic EC >21-35	1100	1500	1700	1900	1900	1900	370	820	1600	28000	28000	28000	3800	3800	3800	7800	7800	7900	LQM (2014)
Aromatic EC >35-44	1100	1500	1700	1900	1900	1900	370	820	1600	28000	28000	28000	3800	3800	3800	7800	7800	7900	LQM (2014)
Aromatic EC >44-75	1600	1800	1900	1900	1900	1900	1200	2100	3000	28000	28000	28000	3800	3800	3800	7800	7800	7900	LQM (2014)
VOCs																			
1,2-dichloroethane (1,2-DCA)	0.0071	0.011	0.019	0.0092	0.013	0.023	0.0046	0.0083	0.016	0.67	0.97	1.7	29	29	29	21	24	28	LQM (2014)
1,1,1-trichloroethane	8.8	18	39	9	18	40	48	110	240	660	1300	3000	140000	140000	140000	57000 (1425)	76000 (2915)	100000 (6392)	LQM (2014)
1,1,2,2,tetrachloroethane	1.6	3.4	7.5	3.9	8	17	0.41	0.89	2	270	550	1100	1400	1400	1400	1800	2100	2300	LQM (2014)
tetrachloroethene	0.18	0.39	0.9	0.18	0.4	0.92	0.65	1.5	3.6	19	45	95	1400	1400	1400	810 (424)	1100 (951)	1500	LQM (2014)
tetrachloromethane (Carbon tetrachloride)	0.026	0.056	0.13	0.026	0.056	0.13	0.45	1	2.4	2.9	6.3	14	890	920	950	190	270	400	LQM (2014)
Trichloroethene	0.016	0.034	0.075	0.017	0.036	0.08	0.041	0.091	0.21	1.2	2.6	5.7	120	120	120	70	91	120	LQM (2014)
Trichloromethane (chloroform)	0.91	1.7	3.4	1.2	2.1	4.2	0.42	0.83	1.7	99	170	350	2500	2500	2500	2600	2800	3100	LQM (2014)

Parameter	Residential with homegrown produce			Residential without homegrown produce			Allotment			Commercial / Industrial			Public Open Space near Residential			Public Open Space - Park			Source
	(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			
SOM	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	
Chloroethene (Vinyl chloride)	0.00064	0.00087	0.0014	0.00077	0.001	0.0015	0.00055	0.001	0.0018	0.059	0.077	0.12	3.5	3.5	3.5	4.8	5	5.4	LQM (2014)
2,4,6 Trinitrotoluene (TNT)	1.6	3.7	8.1	65	66	66	0.24	0.58	1.4	1000	1000	1000	130	130	130	260	270	270	LQM (2014)
RDX	120	250	540	13000	13000	13000	17	38	85	210000	210000	210000	26000	26000	27000	49000 (18.7)	51000	53000	LQM (2014)
HMX	5.7	13	26	6700	6700	6700	0.86	1.9	3.9	110000	110000	110000	13000	13000	13000	23000 (0.35)	23000 (0.39)	24000 (0.48)	LQM (2014)
Aldrin	5.7	6.6	7.1	7.3	7.4	7.5	3.2	6.1	9.6	170	170	170	18	18	18	30	31	31	LQM (2014)
Dieldrin	0.97	2	3.5	7	7.3	7.4	0.17	0.41	0.96	170	170	170	18	18	18	30	30	31	LQM (2014)
Atrazine	3.3	7.6	17.4	610	620	620	0.5	1.2	2.7	9300	9400	9400	1200	1200	1200	2300	2400	2400	LQM (2014)
Dichlovos	0.032	0.066	0.014	6.4	6.5	6.6	0.0049	0.01	0.022	140	140	140	16	16	16	26	26	27	LQM (2014)
Alpha-Endosulfan	7.4	18	41	160 (0.003)	280 (0.007)	410 (0.016)	1.2	2.9	6.8	5600 (0.003)	7400 (0.007)	8400 (0.016)	1200	1200	1200	2400	2400	2500	LQM (2014)
alpha-Hexachlorocyclohexane	0.23	0.55	1.2	6.9	9.2	11	0.035	0.087	0.21	170	180	180	24	24	24	47	48	48	LQM (2014)
beta-hexachlorocyclohexanes	0.085	0.2	0.46	3.7	3.8	3.8	0.013	0.032	0.077	65	65	65	8.1	8.1	8.1	15	15	16	LQM (2014)
gamma-hexachlorocyclohexanes	0.06	0.14	0.33	2.9	3.3	3.5	0.0092	0.023	0.054	67	69	70	8.2	8.2	8.2	14	15	15	LQM (2014)

Parameter	Residential with homegrown produce			Residential without homegrown produce			Allotment			Commercial / Industrial			Public Open Space near Residential			Public Open Space - Park			Source
	(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			
SOM	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	
Chlorobenzene	0.46	1	2.4	0.46	1	2.4	5.9	14	32	56	130	290	11000	13000	14000	1300 (675)	2000 (1520)	2900	LQM (2014)
1,2-Dichlorobenzene	23	55	130	24	57	130	94	230	540	2000 (571)	4800 (1370)	11000 (3240)	90000	95000	98000	24000 (571)	36000 (1370)	51000 (3240)	LQM (2014)
1,3-Dichlorobenzene	0.4	1	2.3	0.44	1.1	2.5	0.25	0.6	1.5	30	73	170	300	300	300	390	440	470	LQM (2014)
1,4-Dichlorobenzene	61	150	350	61	150	350	15	37	88	4400 (224)	10000 (540)	25000 (1280)	17000	17000	17000	36000 (224)	36000 (540)	36000 (1280)	LQM (2014)
VOCs Continued																			
1,2,3-Trichlorobenzene	1.5	3.6	8.6	1.5	3.7	8.8	4.7	12	28	102	250	590	1800	1800	1800	770 (134)	1100 (330)	1600 (789)	LQM (2014)
1,2,4-Trichlorobenzene	2.6	6.4	15	2.6	6.4	15	55	140	320	220	530	1300	15000	17000	19000	1700 (318)	2600 (786)	4000 (1880)	LQM (2014)
1,3,5-Trichlorobenzene	0.33	0.81	1.9	0.33	0.81	1.9	4.7	12	28	23	55	130	1700	1700	1800	380 (36.7)	580 (90.8)	860 (217)	LQM (2014)
1,2,3,4-Tetrachlorobenzene	15	36	78	24	56	120	4.4	11	26	1700 (122)	3080 (304)	4400 (728)	830	830	830	1500 (122)	1600	1600	LQM (2014)
1,2,3,5-Tetrachlorobenzene	0.66	1.6	3.7	0.75	1.9	4.3	0.38	0.9	2.2	49 (39.4)	120 (98.1)	240 (235)	78	79	79	110 (39)	120	130	LQM (2014)
1,2,4,5-Tetrachlorobenzene	0.33	0.77	1.6	0.73	1.7	3.5	0.06	0.16	0.37	42 (19.7)	72 (49.1)	96	13	13	13	25	26	26	LQM (2014)
Pentachlorobenzene	5.8	12	22	19	30	38	1.2	3.1	7	640 (43)	770 (107)	830	100	100	100	190	190	190	LQM (2014)

Parameter	Residential with homegrown produce			Residential without homegrown produce			Allotment			Commercial / Industrial			Public Open Space near Residential			Public Open Space - Park			Source
	(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			
SOM	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	
Hexachlorobenzene	1.8 (0.2)	3.3 (0.5)	4.9	4.1 (0.2)	5.7 (0.5)	6.7 (1.2)	0.47	1.1	2.5	110 (0.2)	120	120	16	16	16	30	30	30	LQM (2014)
Phenol	280	550	1100	750	1300	2300	66	140	280	760 dir (31000)	1500 dir (35000)	3200 dir (37000)	760 dir (31000)	1500 dir (35000)	3200 dir (37000)	760 dir (31000)	1500 dir (35000)	3200 dir (37000)	LQM (2014)
Chlorophenols (excluding pentachlorophenol)	0.87 (g)	2	4.5	94	150	210	0.13 (g)	0.3	0.7	3500	4000	4300	620	620	620	1100	1100	1100	LQM (2014)
Pentachlorophenol	0.22	0.52	1.2	27 (16.4)	29	31	0.03	0.08	0.19	400	400	400	60	60	60	110	120	120	LQM (2014)
Carbon Disulphide	0.14	0.29	0.62	0.14	0.29	0.62	4.8	10	23	11	22	47	11000	11000	12000	1300	1900	2700	LQM (2014)
Hexachlorobutadiene	0.29	0.7	1.6	0.32	0.78	1.8	0.25	0.61	1.4	31	66	120	25	25	25	48	50	51	LQM (2014)

(g) derived based on 2,3,4,6-tetrachlorophenol; dir - based on a threshold protective of direct skin contact with phenol (guideline in brackets based on health effects following long term exposure provided for illustration only); (vap) calculated for vapour phase only. SOM – Soil Organic Matter; (4.5) solubility.

APPENDIX E - CONTROLLED WATERS RISK ASSESSMENT

CURRENT GUIDANCE FOR CONTROLLED WATERS RISK ASSESSMENT

Regulatory Context

Government policy is based upon a "suitable for use approach," which is relevant to both the current use of land and also to any proposed future use. When considering the current use of land, Part IIA of the Environment Protection Act 1990 (EPA 1990) provides the regulatory regime, which was introduced by Section 57 of the Environment Act 1995, which came into force in England on 1 April 2000. The main objective of introducing the Part IIA regime is to provide an improved system for the identification and remediation of land where contamination is causing unacceptable risks to human health, controlled waters or the wider environment given the current use and circumstances of the land. Part IIA provides a statutory definition of contaminated land under Section 78A(2) as:

> *"any land which appears to the Local Authority in whose area it is situated to be in such a condition, by reason of substances in, on, or under the land, that:*
>
> *(a) Significant harm is being caused or there is a significant possibility of such harm being caused; or*
>
> *(b) Pollution of controlled waters is being, or is likely to be, caused."*

Part IIA provides a statutory definition of the pollution of controlled waters under Section 78A(9) as:

> *"the entry into controlled waters of any poisonous, noxious or polluting matter or any solid waste matter"*

Controlled Waters are defined Section 104 of the Water Resources Act 1991. In summary, the comprise relevant territorial waters which extend seaward for three miles from the low-tide limit from which the territorial sea adjacent to England and Wales is measured.

The Environment Agency has powers under Part 7 of The Water Resources Act (1991) to take action to prevent or remedy the pollution of controlled waters, including circumstances where the pollution arises from contamination in the land. This is reinforced in The Contaminated Land (England) (Amendment) Regulations 2012 and Contaminated Land Statutory Guidance (DEFRA, 2012) which came into force in early April 2012.

Part IIA introduces the concept of a contaminant linkage; where for potential harm to exist there must be a connection between the source of the hazard and the receptor via a pathway. Risk assessment in contaminated land is therefore directed towards identifying the contaminants, pathways and receptors that can provide contaminant linkages. This is known as the contaminant-pathway-receptor link (CPR or contaminant linkage).

Part IIA places contaminated land responsibility as a part of the planning and redevelopment process, rather than Local Authority or Environment Agency directly, except in cases of very high pollution risk or where harm is occurring. In the planning process, guidance is provided by National Planning Policy Framework (NPPF) of March 2012. The NPPF requires that a site which has been developed shall not be capable of being determined "contaminated land" under Part IIA. Therefore, appropriate risk-based investigation is required to identify the contaminant linkages that can then be assessed, and then mitigated using methods that can be agreed with the planners.

Source Protection Zones

Source Protection Zones (SPZs) are defined by the Environment Agency (for England and Wales), SEPA (Scotland) and the Environment and Heritage Service (Northern Ireland) for groundwater sources such as wells, boreholes and springs that are used for public drinking water supply. The zones show the risk of contamination from activities that might cause groundwater pollution in the area. The size and shape of a zone depends upon subsurface conditions, how the groundwater is removed, and other environmental factors.

SPZs are classified into four categories:

- **Zone 1 (Inner protection zone).** Any pollution that can travel to the abstraction point within 50 days from any point within the zone is classified as being inside Zone 1. This applies at and below the groundwater table. This zone also has a minimum 50 m protection radius around the abstraction point. These criteria are designed to protect against the transmission of toxic chemicals and water-borne disease.
- **Zone 2 (Outer protection zone).** The outer zone covers pollution that takes up to 400 days to travel to the abstraction point, or 25% of the total catchment area, whichever area is the largest. This travel time is the minimum period over which the Environment Agency considers that pollutants need to be diluted, reduced in strength or delayed by the time they reach the abstraction point.
- **Zone 3 (Total catchment).** This is the total area needed to support removal of water from the abstraction point, and to support any discharge from this.
- **Zone of special interest.** This may occasionally be defined as a special case. This is usually where local conditions mean that industrial sites and other potential sources of contamination could affect the groundwater source, even though they are outside the normal catchment area.

Groundwater Vulnerability Assessments

From 1 April 2010 The Environment Agency Groundwater Protection Policy began to use aquifer designations which are consistent with the Water Framework Directive. These designations reflect the importance of aquifers in terms of groundwater as a resource (drinking water supply) but also their role in supporting surface water flows and wetland ecosystems.

The aquifer designation data is based on geological mapping provided by the British Geological Survey. It is updated regularly to reflect their ongoing programme of improvements to these maps. The maps are split into two different type of aquifer designation:

- Superficial (Drift) - permeable unconsolidated (loose) deposits. For example, sands and gravels.
- Bedrock -solid permeable formations e.g. sandstone, chalk and limestone.

The maps display the following aquifer designations:

Table 1. Aquifer Classification ("Geological Classification").

Classification	Definition
Principal Aquifers (Highly Permeable)	These are layers of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale. In most cases, principal aquifers are aquifers previously designated as major aquifer.
Secondary A Aquifers	Permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers.
Secondary B Aquifers	Predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers.
Secondary Undifferentiated Aquifers	This has been assigned in cases where it has not been possible to attribute either category A or B to a rock type. In most cases, this means that the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type.
Unproductive Strata	These are rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow.

Environment Agency Guidance

The Environment Agency's stance on groundwater resources is:

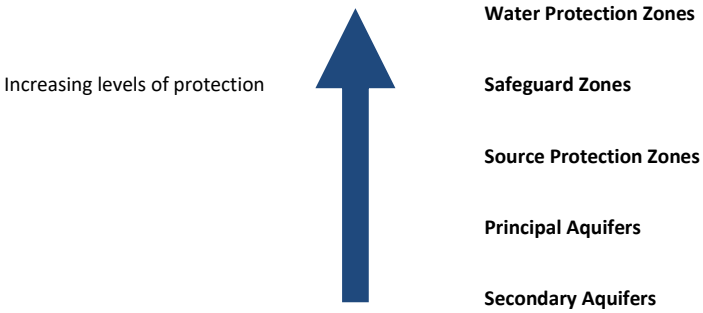
> *"to protect and manage groundwater resources for present and future generations in ways that are appropriate for the risks we identify"* (Groundwater Protection: Policy and Practice GP3, 2012).

At present, the legislation and guidance pertaining to the protection of controlled waters in the UK is complex; however, the core objectives seek to enforce the position given above.

In 1992, the National Rivers Authority published their Policy and Practice for the Protection of Groundwater (PPPG), this document introduced areas of focus for developments such as Source Protection Zones (SPZs) and Groundwater Vulnerability Maps. The Policy was revised in 1998, since which there have been substantial changes in legislation, driven by key European Directives relating to groundwater include the Groundwater Directive (80/68/EEC) and the Water Framework Directive (2000/60/EC). Aspects of these directives are controlled by primary UK legislation such as the Water Resources Act 1991 as amended by the Water Act 2003. Gaps in the 1998 PPPG that emerged as the result of further legislative changes were addressed in the Environment Agency Policy document Groundwater Protection: Policy and Practice (GP3), Version 1 of November 2012. The three main parts of GP3 were:

- Groundwater principals;
- Position statements and legislation; and
- Technical information.

The Environment Agency has a tiered risk based approach to drinking water protection as summarised below:



Controlled Waters Risk Assessment

A number of tools are available (as detailed in GP3) in order for a developer of a potentially contaminated site to fulfil their obligations under the legislation. A site assessment would be required in order to identify any potential risks to controlled waters and to derive suitable clean up criteria, if required, to ensure the protection of controlled waters.

There are three main stages to any risk assessment of controlled waters:

1. Risk Screening (devise Conceptual Site Model, making reference to groundwater vulnerability maps, site setting, controlled waters context etc)
2. Generic Risk Assessment (EA Remedial Targets Methodology Tier 1 / Comparison of groundwater data with relevant standards)
3. Detailed Quantitative Risk Assessment (Consideration of aquifer properties and site specific parameters, EA Remedial Targets Methodology Tiers 2 & 3)

Risk Screening

Here, the Conceptual Site Model (CSM) is a critical tool to assessing any potentially contaminated site. The information from a robust CSM can be used to establish any pathways or receptors that do not require further assessment at an early stage. For example, it may be possible to confirm the absence of a particular sensitive controlled water receptor (such as a surface water feature) within the vicinity of the Site thereby breaking the associated source-pathway-receptor pollutant linkage. Information from subsequent tiers of risk assessment, such as following intrusive investigations, are used to update the CSM accordingly.

Generic Risk Assessment - England and Wales

When undertaking the Generic Hydrogeological Risk Assessment (EA Remedial Targets Methodology Tier 1), comparison of chemical analytical results is made with those screening criteria.

In accordance with Part 2A of the Environmental Protection Act 1990, Tier Environmental has made regard to all of the Water Quality Standards (WQS) that are relevant to the specific site and a judgment has been made against the most stringent of those relevant standards:

- EQS Directive 2008/105/EC
- Priority Substances Directive 2013/39/EU
- Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015
- UK Drinking Water Standards (UK DWS)
- World Health Organisation (WHO Guidelines) for Drinking Water Quality
- Council Directive 98/83/EC on the quality of water intended for human consumption (Drinking water directive)

In some instances, the laboratory method detection limit is greater than the appropriate EQS/UKDWS value. In these instances, only measured concentrations in excess of the laboratory method detection limit have been considered likely to potentially represent a possible significant risk to controlled waters.

Please note that there is no quantitative criterion for total petroleum hydrocarbons (TPH), or speciated TPH fractions. Historically, standards provided for petroleum hydrocarbons ranges from 10µg/l (Private Water Supply Regulations 1991, removed from the 2009 regulations) to 50µg/l-1000µg/l (Surface Waters (Abstraction for Drinking Water) Regulations 1989) which related to the degree of treatment of water prior to use as drinking water. Over time, the legislative standards have been rescinded and no alternative standard provided, although the Environment Agency planned to release speciated TPH criteria (Fretwell et al., 2009).

In order to assess whether there is a potentially unacceptable risk of pollution of controlled waters, the results of the groundwater chemical analysis for TPH and BTEX were evaluated against Water Quality Standards (WQS) appropriate to the conceptual model for the site:

Table 2. Summary of Selected TPH and BTEX Water Quality Standards Selected for Tier 1 Screening

Determinand	Units	WQS Selected	Source of WQS
Aliphatics >C5-C6	µg/l	15000	Table 5.4 of CL:AIRE 2017#
Aliphatics >C6-C8	µg/l	15000	Table 5.4 of CL:AIRE 2017#
Aliphatics >C8-C10	µg/l	300	Table 5.4 of CL:AIRE 2017#
Aliphatics >C10-C12	µg/l	300	Table 5.4 of CL:AIRE 2017#
Aliphatics >C12-C16	µg/l	300	Table 5.4 of CL:AIRE 2017#
Aliphatics >C16-C21	µg/l	-	Table 5.4 of CL:AIRE 2017#
Aliphatics >C21-C35	µg/l	-	Table 5.4 of CL:AIRE 2017#
Aromatics >C5-EC7	µg/l	10	Table 5.4 of CL:AIRE 2017#
Aromatics >EC7-EC8	µg/l	700	Table 5.4 of CL:AIRE 2017#
Aromatics >EC8-EC10	µg/l	300	Table 5.4 of CL:AIRE 2017#
Aromatics >EC10-EC12	µg/l	100	Table 5.4 of CL:AIRE 2017#

Aromatics >EC12-EC16	µg/l	100	Table 5.4 of CL:AIRE 2017#
Aromatics >EC16-EC21	µg/l	90	Table 5.4 of CL:AIRE 2017#
Aromatics >EC21-EC35	µg/l	90	Table 5.4 of CL:AIRE 2017#
Benzene	µg/l	10	Priority Substance Water Framework Directive 2015 and Table 5.3 of CL:AIRE 2017#
Toluene	µg/l	74	Table 1 Water Framework Directive 2015 and Table 5.3 of CL:AIRE 2017#
Ethylbenzene	µg/l	20	R&D Technical Report P2-115/TR4, 2002
Total xylenes	µg/l	30	DoE (1997c) Hedgecott S. and Lewis S, An update on proposed environmental quality standards for xylenes in water, final report to the Department of the Environment. Report No. DoE 4273/1. Medmenham: WRc; and; Table 5.3 of CL:AIRE 2017#

Notes - # = CL:AIRE document 'Petroleum Hydrocarbons in Groundwater: Guidance on assessing petroleum hydrocarbons using existing hydrogeological risk assessment methodologies' (ISBN 978-1-905046-31-7, dated 2017),

Table 5.3 was referenced in the first instance from the CL:AIRE document 'Petroleum Hydrocarbons in Groundwater: Guidance on assessing petroleum hydrocarbons using existing hydrogeological risk assessment methodologies' (ISBN 978-1-905046-31-7, dated 2017), the to select appropriate Freshwater EQS values for benzene, toluene and total xylenes. The selected value for Ethylbenzene was derived from the proposed EQS value of 20µg/l from the Environment Agency R&D Technical Report P2-115/TR4, 2002. This represents a more conservative value than the 300µg/l value in Table 5.3.

With respect to speciated TPH CWG fractions, Table 5.3 states and refers the reader to 'See Table 5.4'. On this basis, Tier Environmental selected the World Health Organization (WHO) guide values for TPHCWG fractions in drinking water that are presented in Table 5.4 which may be considered appropriately protective of the controlled waters environment based on the conceptual site model.

Generic Risk Assessment is generally undertaken via comparison of reported leachate and/or groundwater concentrations against selected assessment criteria for the potential contaminants of concern identified for the Site from a preliminary desk based assessment.

The selected Generic Assessment Criteria (GAC) derived from a Water Quality Standard (WQS) for any specific substance may not necessarily be a simple number and can often be found to be expressed as:

- Annual mean concentration;
- Maximum allowable concentration;
- 95th percentile concentration for *n* samples;
- Total concentration;
- Dissolved concentration (applicable to filtered samples)

The values may sometimes be expressed for individual substances (e.g. arsenic or for groups of substances e.g. total xylenes or sums of certain PAHs).

Environmental Quality Standards (EQS) have been used where available for Priority Substances and Priority Hazardous Substances set at a European level:

- Priority Substances Directive 2013/39/EU;
- Amending 2008/105 and 2000/118/EC

In addition, EQS values derived for Specific Pollutants have been used as presented in The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015.

For assessing risks to potable water abstraction supplies, UK Drinking Water Standards presented in the Water Supply (Water Quality) Regulations 2000 (SI/2000/3184) (as amended) have been applied.

In selecting a GAC for a particular Site, Tier Environmental considers the following factors:

- Current use/function of the groundwater (e.g. drinking water, irrigation water, industrial use, base-flow to rivers and streams);
- Plausible, proposed or planned future uses of the water and nearby waters;
- Sensitivity of the critical receptor (e.g. human health, aquatic life); and,
- Requirements to trigger action under the legal context

In accordance with Part 2A:

> *"in deciding whether pollution of controlled waters is occurring, the assessor will have regard to all of the water quality standards that are relevant to the specific site and make a judgment against the most stringent of those relevant standards"*

Should the Level 1 or 2 assessments indicate threshold levels to be exceeded, then there are three alternative ways in which to proceed:

- To devise suitable remedial solutions;
- To carry out more investigation, sampling and analysis;
- To conduct a site-specific Detailed Quantitative Risk Assessment (DQRA) to whether or not the soil materials are suitable for their site-specific intended use or to devise a site-specific clean-up level.

Detailed Quantitative Risk Assessment (DQRA)

The decision to carry out a DQRA will be informed by the initial qualitative and generic assessment. The scope of any such assessment will be accurately defined by the outcomes of the former two stages. The robust CSM will be sufficiently refined by this stage that only certain contaminants of concern, certain pathways and certain receptors will require further assessment.

Additional site specific data is normally required for this stage of assessment, as explained above, more processes that are capable of affecting contaminant concentrations are considered (such as dilution and attenuation).

Remediation criteria derived will therefore be specific to each site and will be based on a detailed assessment of the potential impact at the identified receptor or compliance point. A greater level of confidence can be placed on the predicted impact on the compliance point following a DQRA.

Hazardous and Non Hazardous Substances

The Groundwater (England and Wales) Regulations 2009 control the disposal to the hydrogeological environment of potentially polluting substances which are divided into Hazardous Substances and Non-hazardous Contaminants (this roughly approximates to the former List 1 and List 2 substances).

Hazardous Substances are the most damaging and toxic and must be prevented from directly or indirectly entering the groundwater environment. Hazardous Substances include mineral oils and hydrocarbons, pesticides, biocides, herbicides, solvents and some metals. Discharge of Hazardous Substances to Controlled Waters must be prevented.

Non-hazardous Pollutants are any contaminants other than Hazardous Substances. Non-hazardous Pollutants are potentially toxic but are less harmful than Hazardous Substances, but their direct discharge to groundwater is generally not permitted and any indirect discharge to groundwater must be limited and be controlled by technical precautions in order to prevent pollution. Non-hazardous Pollutants include ammonia and nitrites, many metals and fluorides.

APPENDIX F - CHEMICAL TEST SAMPLING

Samples were selected by a representative of Tier Environmental during the site investigation works in accordance with the sampling approach described elsewhere in this report.

Samples for chemical analysis

All samples for chemical analysis were placed into clean new containers as summarised in Table 1. Unless explicitly stated elsewhere in this report, no preservatives were used to eliminate the risk that preservatives cause contaminant dissolution or analytical interference. Containers for VOC analysis were fully filled to exclude headspace.

Soil samples were dispensed as soon as possible after collection using reusable stainless steel spatulas, trowels or similar implements.

Ground water samples were collected from boreholes using single-use Teflon bailers or dedicated Waterra tubing with foot valves, except as otherwise noted within this report. Caution was taken to avoid excessive agitation during collection

New disposable gloves were used by the engineer for the collection of each sample.

Reusable equipment was washed down with distilled or deionised water between samples, except where tarry or similarly sticky materials were present. In such cases specific cleaning procedures were adopted as specifically described elsewhere in this report.

All sub-samples taken for chemical analysis were placed into refrigerators or cool boxes containing frozen ice packs immediately after aliquoting. All samples were transferred in cool boxes containing frozen ice packs to the relevant UKAS/MCERTS accredited laboratory as soon as possible. Recommended maximum holding times before analysis are summarised in Table 1.

Table 1. Sample containers and holding times.

Analysis	**Container/special requirements**	**Max. holding time at 4°C before analysis**
Soil and sediment samples		
VOCs	30-60 g brown or green glass jar with VOC-resistant cap and inert cap liner. Must be fully filled.	14 days
TPHCWG	30-60 g brown or green glass jar with VOC-resistant cap and inert cap liner **PLUS** 250-500 g brown or green glass jar with unwaxed cap liner.[1] The former must be fully filled.	14 days
All other organics	250-500 g brown or green glass jar with unwaxed cap liner.	7 days
Inorganics	Air-tight 0.5-2.0 kg plastic container (250-500 g brown or green glass jar may also be used).	14 days[2]
Water samples		
VOCs	40-50 ml glass vial with VOC resistant screw cap and inert liner. Must be fully filled.	14 days
TPHCWG	40-50 ml glass vial with VOC resistant screw cap and inert liner **PLUS** 500-1000 ml brown or green glass bottle with screw cap and unwaxed liner.[1] The former must be fully filled, the latter should be filled if possible.	14 days
All other organics	500-1000 ml brown or green glass bottle with screw cap. Fill if possible.	7 days
Inorganics	500-1000 ml translucent or opaque screw cap plastic *or* brown or green glass bottles. Fill if possible.	14 days[3]

1 The smaller vessel is used for analysis of the volatile components within the TPH mixture and the larger one is for the non-volatile components.

2 14 days is set as a reasonable limit for all routine analyses of soil for those inorganic components vulnerable to chemical and/or biological breakdown. Samples for sulphate analysis are vulnerable to biological sulphate-reduction but can be held for up to 28 days. For total metals, a holding period of up to 6 months is acceptable.

3 14 days applies for all routine analyses of most inorganic components that may be vulnerable to chemical and/or biological reactions. In the specific cases of sulphide, nitrite, nitrate and phosphate analyses, storage time must not exceed 48 hours. For total metals, a holding time of up to 6 months is acceptable.

Tier Environmental standard analytical suites

The analyses included with Tier Environmental's standard analytical suites for soil, soil leachate and water samples are presented in Table 2. Other individual analyses were specified as described within this report.

Table 2. Tier Environmental Standard Analytical Suites.

Parameter	**Sample type**					
	Soil		**Leachate[1]**		**Water**	
		LoD[2] (mg/kg or as stated)		**LoD (µg/l or as stated)**		**LoD (µg/l or as stated)**
Metals and metalloids						
Arsenic	✓	1	✓	10	✓	10
Cadmium	✓	1	✓	5	✓	5
Chromium	✓	1	✓	5	✓	5
Mercury	✓	1	✓	1	✓	1
Lead	✓	1	✓	4	✓	4
Selenium	✓	2	✓	10	✓	10
Copper	✓	1	✓	1	✓	1
Nickel	✓	1	✓	50	✓	50
Zinc	✓	1	✓	8	✓	8
Other inorganics						
Ammonia (as NH_4-N)					✓	15
Total sulphate	✓	100			✓	50 mg/l
Water-soluble sulphate	✓	0.1 g/l				
Hardness (as $CaCO_3$)					✓	1 mg/l
Organics						
Monohydric phenol	✓	1	✓	0.5	✓	0.5
Speciated PAHs (USEPA 16)	✓	0.1	✓	0.01	✓	0.01
Total Organic Carbon	✓	0.1 wt%				
Others						
Electrical conductivity					✓	NA
pH	✓	NA	✓	NA	✓	NA

NA - Not applicable

1 Leachate preparation according to NRA (1994), 10:1 liquid to solid ratio.

2 The table presents the desired limit of detection for the analysis. Higher LoDs may be reported on analytical data sheets due to interference between analytes within specific samples or if the laboratory needed to dilute samples to achieve results within the calibrated range for that instrument.

Analytical QA procedures

Introduction

Quality Assurance (QA) is a system of review and audit that assesses the effectiveness of that product and assures the producer and user that defined standards of quality have been met. If we consider site investigation and chemical analysis, QA is the management system that ensures these measures are in place and working as intended.

QA within the laboratory form part of relevant certification programmes (such as UKAS and MCERTS) and, indeed, will be undertaken in some form by any reputable analyst, whether for a certified technique or not. Laboratory QA/QC is beyond the control of Tier Environmental and will not be considered further in this document, although the relevant laboratory documentation can be obtained upon request. QA must also form part of the design and execution of a site investigation.

Two parameters often used to assess measurement quality objectives are bias and precision. Bias is a systematic deviation in the data. For example, a positive bias (concentrations higher than in reality) would be introduced if sampling bottles were a source of the analyte and this fact was unknown. Precision is the variation in the measurements around a central 'expected' value. This could be due both to real variability in the environmental medium being measured and random errors in the analytical process. Both precision and bias can be assessed by the use of appropriate blanks and replicates within the site investigation programme.

The objectives of the QA activities undertaken in this present site investigation were to recognise and quantify systematic bias within the analytical dataset and to obtain an indication of precision. In environmental samples, much of the observed variability is likely to result from heterogeneity in the sampled medium, particularly for soil and sediment samples.

Such QA practice within the sampling programme is required by current guidance (e.g., Environment Agency report P5-065/TR (2000); Environment Agency LFTGN02 (2002); BS 10175:2001).

Alternative QA procedures to the generic approach presented in this appendix may be specified for a project, provided case-specific justification is given.

QA checking procedure (data validation)

The responsible Engineer and Project Reviewer are required to undertake data validation and provide comment on data quality within the main body of the report(s) issued, when noteworthy matters arise. This QA checking should involve:

Confirming that data reported by the laboratory have achieved the standards specified by the certification scheme (MCERTS or UKAS). This will be indicated on the analytical certificates issued by the laboratory.

Checking that the limit of detection (LoD) and limit of quantification (LoQ) achieved by the laboratory for an individual analyte is appropriate for the purposes of the report. LoD and LoQ will vary dependent upon analyte concentrations, sample matrix properties and interference from co-contaminants.

A check that the reported range of concentrations are reasonable for the analyte. For example, the dissolved concentration of an analyte in a water sample should not exceed saturation. If it does, then this merits further consideration (e.g., was colloidal organic matter or other solid-phase material present or could there have been unobserved free-phase organic liquid?) and explicit comment. At its simplest, there may be a unit error.

Where analysis involves reporting of Tentatively Identified Compounds (TICs; normally by mass spectrometry), the reviewers should check that these might reasonably be expected at the site under consideration. The uncertainties in identification by MS mean that it is not uncommon that TICs are incorrectly assigned. In cases of doubt, the analytical laboratory can re-check the raw data and confirm.

A review of the analytical precision by comparing data obtained for duplicate samples. There is no absolute threshold - variability is entirely dependent upon the sample matrix and manner in which the contaminant has entered the sample. Variability that cannot reasonably be assigned to such factors (for example a very high apparent variability in data for sediment-free water samples) should be reviewed with the laboratory. Variability that is attributable to the sample matrix can nevertheless provide important pointers to improve understanding of contaminant transport pathways and the risks posed by pollutant linkages (e.g., soil heterogeneity, the association of contamination with particular soil fractions, the presence of residual NAPL within soil pores or the role of suspended sediments in contaminant transport).

Confirmation that no errors have been introduced by data transcription, unit conversion or corrections between preliminary and certificates issued by the laboratory. The reviewer should audit a proportion (typically 5-10%) of all data from the original (final) certificates of analysis through to the equivalent values in the report for those specific samples.

In is important to consult the analytical laboratory if apparent QA issues arise. Many apparent concerns can be adequately resolved on the basis of revisiting the raw analytical data or by obtaining a better understanding of the inherent limitations of the analysis for a particular matrix or sample type.

APPENDIX G - COMPLYING WITH CONTROL OF ASBESTOS REGULATIONS 2012

Complying with Control of Asbestos Regulations (CAR): Risk Assessments, Licensing and Training

This appendix outlines CAR risk assessments and where they should be applied in relation to assessing and remediating brownfield sites. The information below details the different classifications of work with asbestos under CAR, summarises the legal requirements for asbestos awareness training for all involved in the investigation and management of asbestos containing soil (ACS), and details the potential requirements for suitable proficiency training relating specifically to ACS.

CAR RISK ASSESSMENTS

A CAR Risk Assessment is required for any work which may expose employees to asbestos. It is recommended that a precautionary approach is adopted if there is any doubt about risks associated with asbestos.

There are three main activities for potential asbestos exposure during work on brownfield sites:

- Site reconnaissance visits;
- Site investigation works; and
- Site remediation.

CAR risk assessments are needed at each stage but may be incorporated during the site investigation stage into the overarching health and safety risk assessments.

The CAR risk assessment must:

- Identify the type of asbestos to which employees are liable to be exposed, where possible, or assume it is present in different forms;
- Determine the type and extent of exposures to asbestos that may occur during the work
- Identify the steps to be taken to prevent exposure or reduce it to the lowest level reasonably practicable; and,
- Consider the effects of control measures that have been or will be taken.

The CAR risk assessment should include any information used to inform the risk assessment such as asbestos reports or desk study information. In the event that this information is not available, the assessor should be assumed that all forms of asbestos may be present on Site.

For all investigation and remediation of ACSs, a detailed written work plan should he produced and followed as detailed on the HSE website and in the CAR.

The CAR risk assessments for specific investigations or remediation projects, will determine whether or not work is 'licensable work' (LW)**,** notifiable non-licensable work' (NNLW) or 'non-licensed work' (NLW). In addition, training requirements are also defined by the CAR risk assessment.

Some examples of control measures that apply during site reconnaissance, site investigation works, and site remediation are given below and should be applied depending on the asbestos risks identified for the Site at each stage of investigation:

- Avoiding stirring up dust;
- Cleaning footwear after site works;
- Removing and bagging any overalls for disposal/laundering;
- Respirators and hygiene facilities for high risk sites;
- Segregated welfare units;
- Wetting ground
- Minimising soil disturbances;
- Implementation or retention of capping/break layers;
- Implementation of awareness training;
- Air monitoring;
- Managing stockpiles;
- Area segregation;
- Wheel washing
- Road washing/cleaning

It is important to note that during Site reconnaissance visits, Site investigation works and Site remediation that asbestos should not be considered in isolation and control measures are likely to form part of a wider health and safety precautions.

Respiratory protective equipment (RPE)

RPE is the last line of defence and its requirement would be defined by the CAR risk assessment. HSE (2013b) advises that RPE should have an assigned protection factor of 20 or more for all work with asbestos. In certain instances, full face-piece, positive pressure respirators with a protection factor of 40 are necessary (to EN 12942:1998, TM3).

Suitable types of RPE for most ***short*** duration non-licensed asbestos work:

- Disposable respirator to standards EN149 (type FFP3) or EN1827 (type FMP3)
- Half mask respirator (to standard EN140) with P3 filter
- Semi-disposable respirator (to EN405) with P3 filter

These filters are not suitable for people with beards/stubble or for long or continuous use.

LICENSING

CAR defined certain types of activities involving asbestos as 'licensable work' (LW) or as 'notifiable non-licensable work' (NNLW). All other work would be 'non-licensable work' (NLW).

LW is defined as:

- work where exposure is not 'sporadic and low intensity'
- work where the risk assessment cannot demonstrate that the control limits (four hour and 10 minute limits) will not be exceeded
- work on asbestos coating
- work on AIB or insulation where risk assessment is either of first two points above or not of short duration (where short duration is defined for any work liable to disturb asbestos as taking less than two hours per week (including ancillary work) and no one person carries out that work for more than one hour').

NNLW includes work with:

- AIB or asbestos insulation of short duration that is not licensable
- fire-damaged asbestos cement or asbestos cement damaged so as to create significant dust and debris
- asbestos ropes, yarns, woven cloths in poor condition or handling cutting or breaking up the materials
- asbestos papers, felts and cardboard in poor condition, unencapsulated or not bound into another material.

Work with weathered asbestos cement, air monitoring and collecting samples of ACM in buildings would not normally be notifiable.

It is impossible to specify definitively what activities will and will not be licensable. This decision should be made as part of the CAR risk assessment. CAR is not primarily aimed at work with ACSs and there is little published information on airborne asbestos concentrations during work with ACSs. Nevertheless, CAR will require some remediation projects, and occasionally site investigations, to be LW. Investigations on other sites may involve NNLW. The decision as to whether work is LW or NNLW should be made during the CAR risk assessment by those in charge of the brownfield site investigations and remediation projects.

TRAINING REQUIREMENTS

Asbestos health and safety courses are offered by a number of providers in the UK. Training courses that include the problem of identifying ACMs in soil should be undertaken at regular intervals by those involved in the investigation, assessment and management of sites where ACs are known or suspected. It is the role of the employer to identify the level of training required for an employee based on their role, experience and duties. Reference to Regulation 10 of CAR should be referred to for more information on training requirements.

Recognising asbestos within soils is challenging due to the heterogeneity of such soils and the discolouration of asbestos by smeared soil. Specific training for ground workers should include understanding fibre release potential, potential control measures in the field, how to take representative ACSs safely, sample labelling and what analytical tests are available and when the y should be implemented.

Health and safety training required under CAR includes asbestos awareness, non-licensable work (including notifiable non-licensable work) and licensable work with asbestos.

In addition to health and safety training, some staff involved in the technical identification on site of ACMs, sampling and analysis may require technical proficiency training (competency training).

Training vs. Competence

HSE (2005) identifies that ‘training alone does not make people competent. Training must be consolidated by practical experience so that the person becomes confident, skilful and knowledgeable in practice on the job’. It is critical that ACS surveyors demonstrate competency with details of relevant field experience alongside training and examples of previous works/references.