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Combined Phase I and II land contamination risk assessment

A50 Dove Way

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Executive Summary

Amey's geo-environmental team have been commissioned to undertake a combined phase I and II land contamination risk assessment for the construction of a Household Waste Recycling Centre (HWRC) and associated access roads at Dove Way, Uttoxeter.

The site comprises open land with long grass, shrubs and other vegetation. The area has been identified as a historic refuse tip which operated between 1964 and 1978. Since its closure the site has appeared to have remained wholly undeveloped.

No information exists to suggest that tip was engineered (e.g. with basal liner or leachate or gas control systems). The wastes that are recorded to be deposited there are a combination of inert, industrial, commercial, household, industrial, and sewage liquids/sludge wastes.

The site is underlain by the bedrock geology of the Mercia Mudstone Group. The overlying superficial deposits comprise a variable thickness of alluvium together with glaciofluvial deposits (sand and gravel).

The River Tean is located approximately 150m north of the site and flows in an easterly direction. Groundwater flow in the superficial strata direction appears to be towards the river.

Investigations undertaken by Amey and BWB have recorded the presence of lead, PAH compounds, cyanide and asbestos in the wastes/made ground which extend to 4.0m depth. The presence of asbestos will require the finished scheme to incorporate measures to break the human uptake pathway and will be the subject of a separate remediation strategy report.

The levels of contamination in the made ground /wastes will render much of these as hazardous wastes, however, WAC testing shows that they may not be suitable for disposal to hazardous waste landfill without some form of treatment.

Some relatively minor contamination of on-site groundwater was recorded in previous investigations. However, risks to the aqueous environment will be reduced by the construction of the proposed scheme. Drainage waters from the proposed access road and HWRC will be positively drained to sewer network, no soakaways or sustainable urban drainage have been designed that drain into the fill or natural material at the site. The design scheme has incorporated lined swales which are also discharged into the local sewer network.

Further testing is however recommended to confirm gas regime and groundwater quality.

Materials re-use is planned and will follow the CLAIRE Definition of waste. A separate materials management plan will be produced in due course.

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1 Introduction

1.1 Scope and objectives of the report

The objective of this combined phase I and II land contamination risk assessment is to provide an assessment of potential contamination risks associated with the proposed development of a new Household Waste Recycling Centre and access road.

The assessment is undertaken by a review of a variety of data sources to ascertain the potential contamination sources, pathways and receptors in order to develop a conceptual site model (CSM) of the proposed development. The initial CSM has been used to develop a ground investigation to collect site specific information on the soil, soil gas and groundwater beneath the site. This data is used to assess the presence of potentially complete pollutant linkages that will require further work or remedial action. The report also provides comment on soil re-use and importation criteria.

The report is required to assist with the discharge of a planning condition relating to contaminated land and also to obtain Key Stage 2 Preliminary Certification from Highways England as the A518 and A50 are part of the strategic roads network.

1.2 Sources of information

The information for this assessment has been taken from a number of sources including:

- Published geological and hydrogeological maps
- Environment Agency website
- British Geological Survey (BGS) Geoindex website
- Highways Agency Geotechnical Management Database (HAGDMS)
- Historical land use maps
- Coal Authority Gazetteer
- Landmark Data (BWB Appendix)
- BWB Consulting LTD for East Staffordshire Borough Council; Phase II Factual Report; The Dove Way (Areas A & B), Uttoxeter, Reference NTE285/03/v1 (August 2010 [1])
- Ground Investigation information collected by Amey Consulting GI between the 9th and 11th September 2015 [2].

1.3 Legislation and regulatory context

The primary regime for the management of contaminated land in the UK is Part 2A of the Environmental Protection Act 1990 Ref [3]. This regime is primarily concerned with identifying and dealing with the most significantly contaminated sites.

'Contaminated Land' is defined as land which appears to be in such a condition by reason of substances in, on or under the land that:

- significant harm is being caused or there is a significant possibility of such harm being caused, or
- Significant pollution of controlled waters is being caused, or there is significant possibility of such pollution likely being caused.

However, the majority of contamination assessment and remediation work in the UK is undertaken through the planning process during the development or redevelopment of sites, as is the case with the present site. Under the National Planning Policy Framework the presence of contamination will have material considerations on any planning application. Where a site is affected by contamination, responsibility for securing a safe development rests with the developer and/or landowner.

This report has been prepared in accordance with the over-arching framework guidance for the management of land contamination in the United Kingdom given in CLR11 (EA, 2004 [4]), as well as other technical guidance and best practice documents such as BS10175: Investigation of potentially contaminated sites - code of practice (BSI, 2013 [5]), Construction Industry Research and Information Association (CIRIA) C552 Contaminated land risk assessment – a guide to good practice (2001 [6]) and the Environment Agency's Groundwater protection: Principles and practice (GP3 [7]).

1.4 Proposed scheme

The proposed scheme forms part of the Staffordshire County Council (SCC) led 'A50 Project B' which is aimed at creating a new junction off the A518 The Dove Way. This will provide a 315m access road to land which will be developed for a Household Waste Recycling Centre (HWRC) and a commercial/industrial estate (see drawing ID-017-M5242 SK04 D02 Dove Way Option 2 and CDW8936-R01-00 CI0).

The development of the HWRC and proposed adjacent is phased Each phase will be covered by a separate planning application, with the present report relating specifically to phase one which consists of a proposed household waste recycling site (HWRC) and associated access road and spurs to the phase two development plot.

Details of the phase two development plot immediately to the west are yet to be fixed but it will comprise commercial units, associated parking and soft landscaping.

The proposed access road and spurs in phase one are to be constructed on low embankments with soft landscaping proposed on the side slopes. Some ground treatment via high energy impact compaction (Landpac), a form of dynamic compaction, is required and was ongoing at the time of writing.

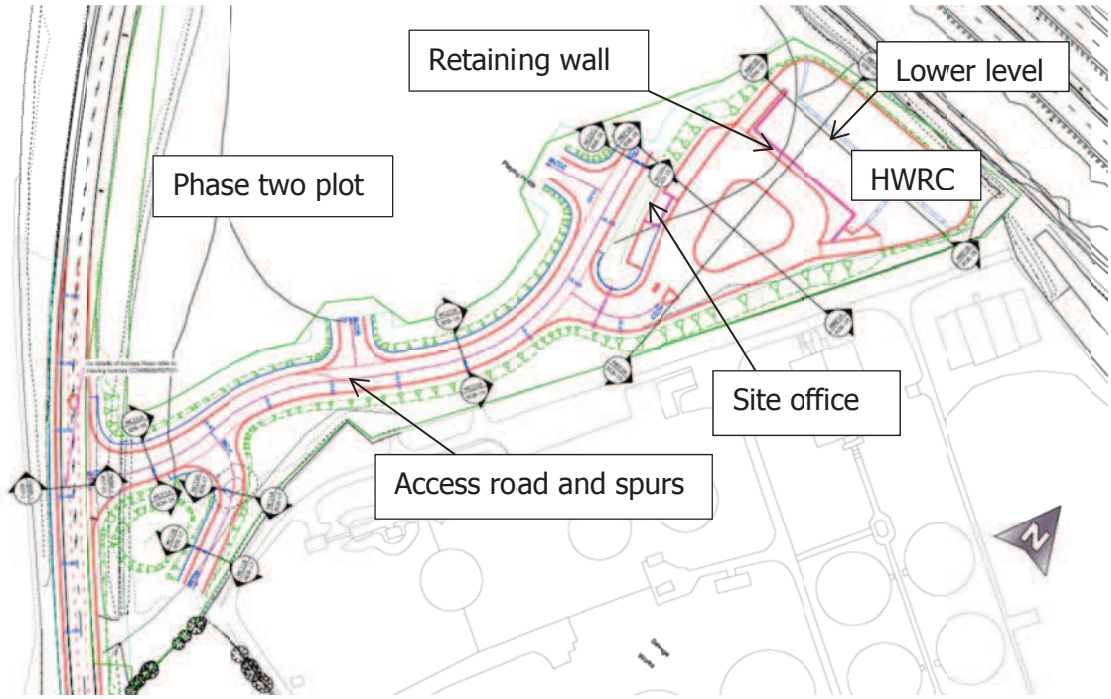
The proposed HWRC will comprise an area of impermeable hardstanding. Much of the site is to be built up using imported granular fill. The site is designed to be split level allowing for deposition of materials by site users into bins at the lower level. A 3m high retaining wall will separate the lower and upper levels as shown in Figure 1.1. The wall will comprise a modular block reinforced earth construction.

No permanent buildings are proposed although some temporary site buildings will be placed in the HWRC area to provide welfare facilities for site staff near the entrance of the HWRC. The site will have a potable water supply. Welfare facilities are located and shown on drawing CDW8936-PA-02.

All surface water drainage is to be lined including proposed swales that will drain into the local sewage network.

A scheme drawing is shown in Figure 1.1 and additional layouts and cross sections are presented in Appendix A.

Figure 1.1: Proposed site layout



Additional information and site overview is shown on drawing CDW8936-R01-00 CI0 'Location Plan and General Information' and CDW8936-R01-01 CI0 'General Arrangement'. The proposed works for the phase one plot including the Dove Way access road and HWRC is approximately 1.32 Hectares.

2 Desk study information

2.1 Topographical maps

The site is centred at OS Grid Reference SK 09262 34606 (409262E, 334606N) with the nearest approximate postcode of ST14 7FB. The site extents is shown in Figure 2.1.

The topography of the site is relatively flat and lies at approximately 80m above ordnance datum (AOD). There is a small drop of elevation of around 1.5m in the north western area of the site, and a small mound of approximately 2.0m in height is present close to the south eastern boundary of the site. The site slopes away steeply at its southern edge with a drop of approximately 3.0m.

Figure 2.1: Location of the proposed access route

(source: OS Map, Contains Ordnance Survey data © Crown copyright and database right 2016.)

2.2 Site description and walkover survey

A representative of the Amey Geotechnical team and an Amey Geo-Environmental Engineer undertook a site walkover visit on 7th July 2015.

The site occupies an irregular shaped plot of land to the east of the A518 in Uttoxeter and covers a plan area of approximately 1.2 hectares.

The majority of the site is covered in dense shoulder high vegetation, high grasses, nettles and shrubs. The walkover identified the presence of a drainage cover around the north western boundary of the site. There was a rough trodden path through the dense foliage were it was apparent dog walkers had been using the site. The path was around 5-10m from the edge of site boundary and followed the alignment of this boundary.

There was no visual or olfactory evidence of contamination at the surface of the site during the walkover.

Two areas (stands) of Japanese knotweed were identified and noted. Both of these occurred on the southern border of the site, approximately half way along the southern site boundary and to the south west near the proposed site access on to the A518. The area near the south western corner of the site had dense tree vegetation. The stands were reported to an Amey Ecologist and have since been removed.

The site is bounded by the west by the remainder of the former landfill, with the A518 embankment beyond; this rises 3-4m above the more or less flat site centre. At the south west corner of the site the A518 Carriageway is approximately at site level rising gradually to an underbridge which is situated in the north west of the site.

The site is bounded to the north by the A50 and the east and south east by a sewage treatment works.

A small mound of approximately 2.0m in height is present close to the south eastern boundary of the site near the proposed access onto the A518.

2.3 Geological maps and memoirs

Consultation of the BGS website [8], indicates that the bedrock geology of the area comprises the Mercia Mudstone Group as summarised in Table 2.1.

Table 2.1: Summary of bedrock geology

Age	Strata	Typical Description
Triassic	Mercia Mudstone Group	Red occasionally green/grey mudstones and subordinate siltstones

The available geological records indicate that superficial deposits are present across the site, and these are summarised in Table 2.2 below.

Table 2.2 Summary of superficial deposits

Age	Strata	Typical Description
-	Alluvium	Clay, Silt, Sand & Gravel
Mid Pleistocene	Glacio-Fluvial Deposits	Sand & Gravel

Although made ground is not specifically recorded by the BGS mapping, the site comprises a former landfill site and as such a cover of made ground will be present and has been recorded by investigations (refer to Section 5).

2.4 Hydrogeology

The Environment Agency (EA) [9] has designated aquifers in England in line with the Water Framework Directive (Europa, 2000 [10]). These designations reflect the importance of aquifers in terms of groundwater as a resource (drinking water supply) and also their role in supporting surface water flows and wetland ecosystems.

Both the alluvium and the glaciofluvial deposits indicated at the site are classified by the EA as Secondary 'A' aquifers. The underlying Mercia Mudstone Group is classified as a Secondary 'B' aquifer.

The EA definitions of the various types of aquifer are as follows:

- Secondary A – 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 the rivers. These are generally aquifers formerly classified as minor aquifers
- Secondary B – 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.

The site is not located in a source protection zone for groundwater abstraction.

2.5 Hydrology

The nearest body of water to the site is the River Tean, which runs roughly parallel to the A50 approximately 150m to the north of the site.

The Highways Agency Geotechnical Data Management System (HAGDMS [11]) shows that the area is susceptible to groundwater flooding, however the EA website identifies that the risk of flooding in the area is low to medium across the site location.

The EA website includes the following data on the River Tean.

- Ecological quality – moderate
- 2015 ecological quality prediction – moderate
- 2015 predicted chemical quality – good

2.6 Environmental designations

The Multi-Agency Geographic Information for the Countryside website (MAGIC [12]) has been searched to check for any environmental or statutory designations. The area is designated nitrate vulnerable for surface waters, and is located within a protected area for Grassland Assemblage for Farmland Birds, including the Curlew, Lapwing, and Yellow Wagtail.

The EA website [9] also identifies a number of current or former land uses that have the potential to impact upon land quality, including: a former gas works to the south of the site; the adjoining Pennycroft Sewage Works; and the site itself which is a former landfill.

There are no reported pollution incidents recorded by the EA at the site or in the surrounding area.

2.7 Additional environmental information

A number of data sources are interrogated as part of the Landmark report commissioned by BWB [13], including EA data, licensed waste sites and hazardous substance consents. Table 2.3 summarises this data.

Table 2.3: Summary of environmental data

Item	On site	0-250m	251-500m	501-1000m
Agency and Hydrological				
Discharge Consents	2	8	1	7
Local Authority Pollution Prevention and Controls	-	1	3	7
Local Authority Pollution Prevention and Control	-	-	-	1

Item	On site	0-250m	251-500m	501-1000m
Enforcements				
River Quality	1	-	-	2
River Quality Chemistry Sampling Points	-	-	-	1
Industrial Land Use				
Fuel Station Entries	-	-	3	2
Sensitive Land Use				
Nitrate Vulnerable Zones	1	-	-	-
Waste				
BGS Recorded Landfill Sites	1	-	-	-
Historic Landfill Sites	2	-	-	-
Licensed Waste Management Facilities	3	-	2	-

There are a number of designations listed for the site which include the known former use as landfill site. The wastes that are recorded to be deposited there are a combination of inert, industrial waste, commercial, household waste, and liquids/sludge [14].

A former discharge consent from Severn Trent Water is recorded 251-500m from the site. Three fuel stations are also recorded within 500m of the site with a further two within 1km.

2.8 Site history

A summary of the site history has been made by review of the historic mapping provided in the BWB report and is presented in Table 2.4.

Table 2.4: Summary of site history

Maps, dates and scale	Main on-site features	Main features in the vicinity of the site
1882, 1:2,500	Consists of various open fields. A track is present in the south.	Open fields. Staffordshire railway to the southwest. Leasows and Cottonmill Farm are shown 130m to the north, with a watercourse shown adjacent to both establishments.
1901, 1:2,500	No significant change.	A path is shown just west of the site.
1922, 1:2500	Sewage works have been built to the east. The sewage works "tanks" are present on the boundary of the site.	Sewage works just off the eastern boundary of the site contains four circular tanks in a square formation. A rectangular feature is shown 40m south of the sewage works. The watercourse is now labelled the River Tean.
1937, 1:2,500	No significant change.	Sewage works have been expanded to the southeast, with the addition of further tanks, and sludge beds. The rectangular feature has the symbol of a refuse heap and has been expanded north, towards the sewage works.
1964-1967, 1:2,500	The A50 is shown to have been constructed passing adjacent to the northern site boundary. Two refuse heaps are shown; the northern refuse heap appears to be connected to the sewage works.	Sewage works have been expanded again. The refuse heap to the south of the sewage works is no longer shown.
1978-1990, 1:2,500	Field boundaries removed. The two refuse heaps are no longer shown.	Sewage works expanded extensively.
1981 – 1983, 1:2,500	There is an undefined feature in the north of the site.	Railway to the southwest labelled as disused.
1994, 1:2,500	Open field area labelled as Playing Fields.	No significant change.
1997, 1:2,500	No significant change.	Railway replaced by a path.
1999, 1:2,500	The Dove Way cuts through part of the south of the site, running adjacent to the western boundary of the site before	The A50 has been expanded into a dual carriageway.

Maps, dates and scale	Main on-site features	Main features in the vicinity of the site
	bridging over the A50. A track runs through the north of the site, between the A50 and Dove Way.	

2.9 Regulatory consultation

Preliminary discussions were undertaken with the contaminated land specialist at the local authority in relation to contamination risks associated with the historical landfill site.

Consultation was also undertaken with the local contaminated land officer to determine whether any additional records or determinations had been made at this site. However no additional information was available. Email exchanges and telephone records are contained within Appendix F.

3 Preliminary contamination risk assessment

3.1 Potential sources and contaminants

Table 3.1 summarises the potential contaminants and sources highlighted by the desk study work.

Table 3.1: Potential contaminants and sources

Potential sources		Possible contaminants
On-site	Former railway line	Heavy metals and PAH in coal ash and clinker Petroleum hydrocarbons from lubricating oils and greases Asbestos from brake liners
	Historical landfill site/ Made Ground	Industrial waste Commercial waste Household waste Liquid/sludge/sewage → Various contaminants Inc. PAH, hydrocarbons, asbestos, heavy metals and pathogens Hazardous ground gases pose a risk (methane/carbon dioxide/carbon monoxide/hydrogen sulphide)
Off-site	Sewage Works	Sewage Sludge Heavy metals Inorganic compounds Industrial sludge to the south west
	A50	Possible elevated pH from surface runoff, and chloride where salt is used on the highway in winter
	Former Gas works	Former gas works to the south west of the site Organic compounds Glycols, petroleum, naphthas, acids and alkalis Cyanides

3.2 Potential pathways and receptors

With respect to the development proposals, key receptors which may be exposed to contamination during and after construction have been identified. The receptors and possible exposure pathways are shown in Table 3.2

Table 3.2: Receptors and exposure pathways

Receptors	Possible exposure pathways
Human health (future site users)	Ingestion, inhalation, dermal contact with soil, fugitive dust and vapours.
Human health (construction workers)	Ingestion, inhalation, dermal contact with soil, fugitive dust and vapours.
Controlled waters (surface waters)	Lateral and vertical migration of leachates, free-phase non-aqueous liquids and surface run-off.
Controlled waters (groundwater in Secondary A aquifer)	Lateral and vertical migration of leachates, free-phase non-aqueous liquids.
Flora & fauna (plants and animals)	Direct contact, root uptake and stomatal diffusion.
Built environment (structures / services)	Direct contact with soil and water contaminants.

3.3 Preliminary conceptual site model

In accordance with the guidelines set out in the Contaminated Land Report 11: Model Procedures for the management of Land Contamination (CLR11 [15]) a preliminary conceptual site model has been produced, which represents the understanding of the pollutant linkages assumed to exist on-site prior to undertaking intrusive investigations. Where doubt exists as to potential pollutant linkages, the precautionary principle is adopted and a linkage is assumed to exist until proven otherwise. The contamination sources, pathways and receptors identified on-site are shown in the conceptual site model (**Error! Reference source not found.**).

Table 3.3 : Preliminary conceptual site model

Receptors	Pathways	Heavy metals	Petroleum hydrocarbons	PAH	Asbestos	pH	Ground gas	VOC	SVOC	Japanese Knotweed
Human health (site users)	Inhalation	×	✓	✓	✓	×	✓	✓	✓	×
	Ingestion	✓	✓	✓	×	✓	×	✓	✓	×
	Dermal	✓	✓	✓	✓	✓	×	✓	✓	×
Human health (construction workers)	Inhalation	×	✓	✓	✓	×	✓	✓	✓	×
	Ingestion	✓	✓	✓	×	✓	×	✓	✓	×

Receptors	Pathways	Heavy metals	Petroleum hydrocarbons	PAH	Asbestos	pH	Ground gas	VOC	SVOC	Japanese Knotweed
	Dermal	✓	✓	✓	✓	✓	✓	✓	✓	×
Surface water	**Run-off, leaching of contaminants**	✓	✓	✓	×	✓	×	✓	✓	×
Groundwater	**Lateral and vertical migration of contaminants**	✓	✓	✓	×	✓	×	✓	✓	×
Flora and fauna	**Root uptake**	✓	✓	✓	×	✓	✓	✓	✓	×
	Direct contact	✓	✓	✓	×	✓	×	✓	✓	×
	Leaching	✓	✓	✓	×	✓	×	✓	✓	×
Built environment	**Direct contact**	×	✓	✓	×	✓	✓	✓	✓	✓
Notes: ✓ - indicates a pollutant linkage is suspected × - indicates a pollutant linkage is not suspected										

From a review of the conceptual site model it is judged the receptors requiring further consideration in the context of the site and proposed scheme are:

- surface water/ groundwater (drainage pathways, aquifers, River Tean)
- human health (construction workers and site end users)

4 Site investigation

4.1 Intrusive ground investigations

BWB Consulting was commissioned by Mr P.G. Somerfield on behalf of East Staffordshire Borough Council to carry out a Phase 2 Geo-environmental Assessment of two separate plots of land along Dove Way in 2011. Area A of the BWB report relates to the former landfill site of which the present scheme is located in the easternmost portion of.

The investigation carried out in Area A has therefore been considered for the purpose of this report.

A supplementary ground investigation was subsequently commissioned by Amey's geotechnical team between 9th and 11th September 2015. Works were undertaken by specialist ground investigation contractor White Young Green (WYG). The information obtained from this investigation is contained within Appendix B.

4.1.1 BWB Investigation

Overview

The ground investigation was carried out in the site area (and the wider phase two development plot) between 5th July 2010 and 8th July 2010 and comprised the following:

- 3 No. cable percussive boreholes up to a maximum depth of 11.0mbgl with all exploratory holes terminated within strata inferred to represent rock head based upon standard penetration test (SPT) results. In-situ geotechnical testing was carried out in the boreholes, comprising SPT.
- 15 No. mechanically excavated trial pits up to a depth of 4mbgl
- Installations comprising standpipes, gas taps and lockable covers in all cable percussive borehole locations.
- Collection of soil samples from borehole locations and logging of the soil strata encountered.

The locations of the exploratory holes and results of the BWB ground investigation are presented in The Dove Way (Areas A7B), Uttoxeter, Phase 2 Geo Environmental Assessment Report, August 2010 (NTE285/05/V1) Ref [13]. The results of the groundwater analysis have been extracted and are presented in Appendix B of the present report.

Chemical Analysis

- 30 No. samples tested for arsenic, barium, beryllium, water soluble boron, cadmium, chromium, copper, lead, mercury, nickel, selenium, vanadium, zinc, water soluble sulphate (2:1 extract), total phenols, total cyanide, free cyanide, complex cyanide, fraction of organic carbon, pH, polycyclic aromatic hydrocarbons (PAH) (United States Environment Protection Agency priority 16 compounds) and Total Petroleum Hydrocarbons (TPH) C6-C40 with TPH column clean up.
- A total of 12 samples tested for TPH speciated to the UK Criteria Working Group (CWG) aliphatic and aromatic compounds
- Two samples tested for volatile organic compounds (VOC)
- An asbestos screen in six samples
- Leachate derived from soil samples was analysed from 12 samples. The suite of analytical testing undertaken comprised: arsenic, barium, beryllium, dissolved boron, cadmium, chromium, copper, lead, mercury, nickel, selenium, vanadium, zinc, sulphate, total cyanide and pH.
- Three samples of groundwater for arsenic, barium, beryllium, dissolved boron, cadmium, chromium, copper, lead, mercury, nickel, selenium, vanadium, zinc, sulphate, total cyanide, BTEX, MTBE, TPH, PAH and pH.

4.1.2 Amey Ground Investigation

The ground investigation was carried out between 9th September 2015 and 11th September 2015 and comprised the following:

- 4 No. cable percussive boreholes to a maximum depth of 10.5mbgl (boreholes were terminated in the Mercia Mudstone bedrock).
- 11 No. window sample boreholes to a maximum depth of 5.0mbgl.

  22 No. hand dug trial pits up to a maximum depth of 0.4mbgl.

Given the lack of point sources of contamination identified by the desk study work, the investigation comprised a spread of untargeted sampling points across the site.

Selected soil samples from the ground investigations works were scheduled for contamination testing including the following contaminants:

- Metals (As, Cd, Cr, Cu, Hg, Ni, Pb, Se, Zn)

- Boron (water soluble)
- Chromium (hexavalent)
- pH value
- Cyanide (free)
- Water Soluble Sulphate as SO4
- Speciated PAHs (US EPA 16 priority pollutants)
- Extractable petroleum hydrocarbons (EPH, C8-C40, with carbon banding)
- Extractable petroleum hydrocarbons (with Aliphatic Aromatic Spilt) BTEX
- Fraction of organic carbon
- Asbestos

Six samples of made ground were also analysed for their leachable proportion of the following contaminants:

- Metals (As, Cd, Cr, Cu, Hg, Ni, Pb, Se, Zn)
- Boron (water soluble)
- Chromium (hexavalent)
- pH value
- Cyanide (free)
- Water Soluble Sulphate as SO4
- Speciated PAHs (US EPA 16 priority pollutants)
- Extractable petroleum hydrocarbons (EPH, C8-C40, with carbon banding)
- BTEX
- Fraction of organic carbon

5 Ground summary

5.1 Stratigraphy

The available exploratory holes information has been reviewed to indicate the geological sequence at the site. A plan showing the locations of all available exploratory holes is presented in drawing CDW8936-GE-001, included in Appendix B.

A summary of the strata encountered is presented in Table 5.1. The information summarised is extracted from the ground investigation completed by BWB Consulting. The base of each stratum isn't always proven due to termination of boreholes before reaching the end of the strata.

Table 5.1: Ground Summary

Strata		Elevation (mAOD)	Typical Thickness (m)	Typical Description
Topsoil		80.94 to 79.54	0.10 – 0.60	Brown gravelly SAND with abundant rootlets overlain by long grass. Gravel is fine to medium rounded quartzite, with occasional chert and limestone.
Made Ground	**Cohesive**	80.98 to 75.03	0.30 – 4.0	Brown / grey, soft to stiff sandy gravelly CLAY, clayey SAND & GRAVEL, containing cobbles, brick, landfill waste of plastic bags, metal wire, glass, paper, cement, wood, shoes, bones (occasional) and rounded to angular quartz.
	Granular	80.68 to 77.42	0.10 – 2.6	Brown and grey, ashy loose soil, GRAVEL and SAND. Gravel is of angular to sub-round cobbles, brick, rubble and quartz, containing landfill waste of plastic bags, metal wire, glass, paper, cement, wood, shoes, and bones (occasional) and sub-round quartz.
	Intermixed	80.15 to 77.98	1.30 – 1.70	Brown grey ashy gravelly SAND and CLAY in a matrix with frequent glass, bottles, plastics, metal fragments, wood, textile and pottery.
Alluvium		80.30 to 75.82	0.20 – 1.90	Orange brown mottled grey, soft to firm slightly gravelly, slightly sandy CLAY. Gravel is of sub round to round quartz. Contains

Strata	Elevation (mAOD)	Typical Thickness (m)	Typical Description
			organic matter and roots.
Glaciofluvial deposits	78.60 to 69.74	5.00 – 8.40	Medium dense, grey and brown fine to coarse grained SAND and sub-rounded to rounded quartz GRAVEL with occasional cobble.
Mercia Mudstone	72.50 to 69.74	Not proven	Red brown, moderately weak MUDSTONE.

As shown in Table 5.1, topsoil is present across the majority of the site ranging between thicknesses of 0.1-0.6m. The topsoil is underlain by made ground which consists heavily of landfill waste. This comprises a mixture of materials included soils and construction wastes as well as items such as plastic, metals, glass, paper, clothing and rare fragments of bones.

The maximum thickness of made ground/landfill wastes was proven within Amey investigations was 3.0m. The site ground levels indicate that this was achieved through land raising rather than purely excavation. There is no evidence to suggest that an engineered cap was placed on the site following waste deposition. No engineered geological barrier was identified either lining or capping the waste mass.

The made ground is underlain by alluvium with thicknesses ranging between 0.20m to 1.90m. This is then underlain by glaciofluvial deposits which predominantly comprise sands and gravels and in turn the weathered and moderately weak Mercia Mudstone bedrock.

5.2 Groundwater

There are two known groundwater bodies within the site; the secondary A Aquifer within the glaciofluvial deposits, and another secondary aquifer within the Mercia Mudstone Group which were identified in section 2.2. In order to monitor the groundwater quality and levels standpipe installations were constructed in three of the boreholes by BWB.

Water strikes were noted in a number of boreholes during the additional GI conducted by Amey Consulting in 2015; the depths of these water strikes are summarised in Table 5.2. No permanent monitoring wells were installed.

Table 5.2: Summary of groundwater strikes (Amey)

Borehole ID	Depth Groundwater Encountered Strike 1		Depth Groundwater Encountered Strike 2		Depth of water after 20min observation	
	Water Level (mbgl)	Water Level (mAOD)	Water Level (mbgl)	Water Level (mAOD)	Water Level (mbgl)	Water Level (mAOD)
BHA	3.50	76.74	8.20	72.04	N/A	N/A
BHB	3.00	77.00	N/A		2.70	77.30
BHC	6.00	74.35			4.00	76.35
BHD	5.50	74.63			4.60	75.53
P-WS-1	2.40	77.82			N/A	
P-WS-2	4.00	76.46				
WS2	3.20	77.21				
WS4	4.26	75.89			3.83	76.34
WS6	3.50	-			N/A	N/A

As part of the BWB investigation, groundwater monitoring was undertaken on the subject site on three occasions. BH2 and BH3 are located within the subject site whilst BH1 is located to the east. The data is summarised in Table 5.3.

Table 5.3: Summary of groundwater elevations from BWB investigation

	Groundwater elevation (mAOD)		
Borehole no	Date: 15/07/2010	Date: 22/07/2010	Date: 05/08/2010
BH1	76.25	76.13	76.13
BH2	76.23	76.10	76.12
BH3	76.38	NR	76.26

Where sufficient data is available to triangulate flow direction, the monitoring shows that groundwater flow beneath the site was in a north-north-easterly direction at the time of monitoring.

Additional groundwater monitoring is proposed and is discussed within Section 9.2.3

6 Generic quantitative risk assessment

6.1 Methodology

6.1.1 Overview

To provide an initial assessment of the potential for significant contamination to exist on the site, Amey has undertaken a screening assessment of the reported analytical data against generic assessment criteria (GAC) derived to protect human health.

This screening approach is consistent with the Stage 2 (generic quantitative) risk assessment approach contained in the CLR11 'model procedures' framework guidance for the investigation of potentially contaminated land [15]. This will identify if there are any potentially unacceptable risks to receptors based on the initial conceptual site model described in Section 5 and therefore a need to undertake additional site specific risk assessment or undertake remedial action.

The following paragraphs detail the methodologies and relevant generic information adopted for the risk assessments.

6.1.2 Human health risk assessment

The results of the laboratory analysis of samples taken during the Amey investigation were compared with Category 4 Screening Levels (C4SLs) for light industrial/commercial land use produced by the CLA:iRE on behalf of the Department for Environment, Food and Rural Affairs Ref [16].

Published C4SLs are currently limited to the following common contaminants: *Arsenic, Cadmium, Chromium (VI), Lead, Benzo(a)pyrene, Benzene.*

Where published C4SL were not available, the LQM/CIEH Suitable 4 Use Levels (S4ULs) or *ATRISK*^{soil} database of soil screening values [17] were used.

Both these data sets (LQM/CIEH S4UL and *ATRISK*^{soil}) represent generic assessment criteria (GAC) developed under the current UK approach to risk assessment. They are fully compliant with the parameters specified in the Environment Agency's scientific report series of guidance documents (EA, 2009a – d, [18] [19] [20] [21]) and associated guidance.

GAC derived using the revised Environment Agency protocols represent 'trigger values' that may indicate if concentrations of contaminants encountered in the ground represent a significant possibility of significant harm (SPOSH) to human health. Where soil concentrations encountered are below the GAC and where the land-use scenario is representative of, or conservative for, the site being investigated, it can be assumed that it is unlikely that SPOSH exists and that remedial intervention would not be required to render a site fit-for-purpose.

The ground conditions encountered typically represent both cohesive and granular materials (generally sand and gravelly clay).

The average soil organic matter (SOM) measured for the site was a relatively high 4.48%; therefore screening values for soils with a 6% SOM content were used where applicable.

The risk to human health from asbestos fibres was assessed using the precautionary principle that any detectable asbestos may pose a risk, a simple presence or absence in samples has therefore been applied to initial assessment of human health risk from asbestos fibres.

6.1.3 Controlled waters risk assessment

The preliminary conceptual site model given in section 5 identifies controlled waters as a receptor of lateral and vertical migration of leachates, free-phase non-aqueous liquids and surface run-off.

An assessment of the risk to groundwater was carried out in line with the Environment Agency's Groundwater Protection document GP3 [7].

GP3 sets out the Environment Agency's aims and objectives for groundwater in terms of protecting its quality and quantity in consideration of the Water Framework Directive. GP3 also introduces basic concepts and the principles of management, monitoring and risk assessment that are used in the protection of groundwater. It also describes the technical tools used by groundwater specialists and the legal framework we all need to operate within.

In line with GP3, the assessment of risk to groundwater has been undertaken using the EA's remedial targets methodology (RTM). The methodology is based on a tiered risk assessment, with the level of analysis and detail increasing at each stage.

A level 1 assessment was undertaken for soils – this assesses the concentration of contaminants in the soil pore water with the soil zone as the compliance point. This has been achieved by undertaking laboratory analysis of the samples of soil eluate (leachate). When comparing soil leachability values, these values are not affected by physicochemical parameters or attenuation in the aquifer and therefore the environmental standards can be used as conservative screening levels for the risk to groundwater.

A level 2 assessment of groundwater data was undertaken in accordance with the RTM methodology. A level 2 assessment compares recorded contaminant concentrations in groundwater beneath the site directly with a target concentration, in this case the environmental standards presented in the following sections and Appendix D.

The Water Framework Directive (2000/60/EC) and the Groundwater Directive on the Protection of Groundwater against Pollution and Deterioration (2006/118/EC) classifies groundwater pollutants into two lists:

- Hazardous substances (H) are the most toxic and must be prevented from entering groundwater.
- Non-hazardous pollutants (NH) are less toxic but could be harmful to groundwater, and the entry of these substances into groundwater must be limited.

Under an Environmental Permit, a hazardous substance is considered to be non-compliant if a concentration exceeding the EA's Minimum Reporting Value (MRV) or, where there is no published MRV the laboratory Method Detection Limit (MDL), is found in groundwater. Non-hazardous pollutants can be discharged to groundwater under an Environmental Permit, but must not cause pollution. The concentration level that is considered to cause pollution depends on the use of the receptor.

However, GP3 states that diffuse inputs form historic land contamination are not considered to be an 'activity' requiring an Environmental Permit, and the use of environmental screening criteria for both categories of pollutants has been undertaken.

The site is not within a groundwater drinking water safeguard zone or a source protection zone for potable water supply. The bedrock and superficial deposits are secondary aquifers and neither are abstracted for supply, although they may supply base flow to the River Tean to the north. In consideration of these factors, in the first instance, inland water Environmental Quality Standards (EQS) as given by UK Technical Advisory Group (UKTAG) on the Water Framework Directive [22] have been used in the assessment of risk. Where there are no published EQS values reference has also been made to the UK drinking water standards.

The assessment criteria used for this site are presented in Appendix C and are also contained on summary tables within the following section.

6.2 Human health risk assessment

The measured concentrations of contaminants in up to 54 soil samples (comprising 40 made ground and 14 natural ground samples) taken during the Amey investigation have been compared with the generic assessment criteria (GAC) discussed in Section 6.1.2. The following sections identify any elevated determinands and their locations. Comments on the findings of the earlier investigation undertaken by BWB are also given where relevant.

(a) Inorganic contaminants

A selection of soil samples were scheduled for heavy metals/semi-metals, boron and cyanide analysis, the results of which are summarised in Table 6.1. Where contaminants were encountered above the screening values a statistical test has been applied to the data (see Appendix H for further guidance).

Table 6.1: Inorganic contaminants summary

Determinand	No. Samples	Source of GAC	GAC (mg/kg)	Min. Conc. (mg/kg)	Max. Conc. (mg/kg)	UCL (mg/kg)	Number of Exceedances
SO_4 (acid sol)	23	S4UL	20000	261.00	19200.00	-	0
Boron (water soluble)	42	S4UL	240000	1.00	62.00	-	0
Antimony	19	Atkins Atrisk values	4830	1.00	47.00	-	0
Arsenic	43	S4UL	640	1.70	164.40	-	0
Cadmium	44	C4SL	410	0.10	9.36	-	0
Chromium	44	C4SL	8600	29.90	321.10	-	0

Determinand	No. Samples	Source of GAC	GAC (mg/kg)	Min. Conc. (mg/kg)	Max. Conc. (mg/kg)	UCL (mg/kg)	Number of Exceedances
Copper	43	S4UL	68000	1.00	1937.00	-	0
Lead	43	C4SL	1330	5.00	4381.00	1097	3
Mercury	43	S4UL	120	0.10	13.74	-	0
Molybdenum	19	Atkins Atrisk values	17700	1.10	24.10	-	0
Nickel	43	S4UL	980	13.20	130.30	-	0
Selenium	34	S4UL	12000	1.00	3.00	-	0
Zinc	44	S4UL	730000	28.00	10350.00	-	0
Barium	19	Atkins Atrisk values	22100	89.30	939.00	-	0
Beryllium	30	S4UL	12	0.50	11.40	-	0

Three samples of made ground, namely: TP18 (0.7m), TP01 (1.5m) and TP05 (2.5m) recorded concentrations of lead above the GAC. The statistical mean for the lead concentration (upper confidence limit) is below the assessment criteria. Each of the samples is classified by the maximum value test as outliers and thus lead contamination may be regarded as existing as discrete contamination hotspots rather than being widespread.

None of the samples analysed by BWB as part of their previous investigation at the site exceeded the GAC.

(b) Organic contaminants

A range of samples were also analysed for organic contaminants including total phenols, PAH, TPH, cyanide and PCB. The results were compared against the chosen GAC.

Polycyclic aromatic hydrocarbons

Table 6.2 summaries the polycyclic aromatic hydrocarbon data from the laboratory analyses on the soil samples.

Table 6.2: Summary of polycyclic aromatic hydrocarbon in soils

Determinand	No. samples tested	Source of screening criteria	Screening criteria (mg/kg)	Min. Conc. (mg/kg)	Max. Conc. (mg/kg)	UCL (mg/kg)	Number of Exceedances
Naphthalene	49	S4UL	1100	0.04	36.30	-	0
Acenaphthylene	49	S4UL	100000	0.03	0.44	-	0
Acenaphthene	49	S4UL	100000	0.05	21.81	-	0

Determinand	No. samples tested	Source of screening criteria	Screening criteria (mg/kg)	Min. Conc. (mg/kg)	Max. Conc. (mg/kg)	UCL (mg/kg)	Number of Exceedances
Fluorene	49	S4UL	71000	0.04	18.60	-	0
Phenanthrene	49	S4UL	23000	0.03	225.00	-	0
Anthracene	49	S4UL	54000	0.04	34.80	-	0
Fluoranthene	49	S4UL	23000	0.03	200.00	-	0
Pyrene	49	S4UL	54000	0.03	192.00	-	0
Benzo[a]anthracene	49	S4UL	180	0.06	75.60	-	0
Chrysene	49	S4UL	350	0.02	78.50	-	0
Benzo[b]fluoranthene	49	S4UL	45	0.05	68.70	9.2	1
Benzo[k]fluoranthene	49	S4UL	1200	0.02	18.00	-	0
Benzo[a]pyrene	49	S4UL	36	0.04	52.60	7.0	1
Indeno[1,2,3-cd]pyrene	49	S4UL	510	0.04	23.00	-	0
Dibenzo[a,h]anthracene	49	S4UL	6.3	0.04	5.82	-	0
Benzo[g,h,i]perylene	49	S4UL	4000	0.04	21.90	-	0

A sample of made ground taken from TP20 at 0.7m depth recorded concentrations of benzo[b]flouroanthene and benzo[a]pyrene above the respective GAC for these compounds.

The statistical mean for these particular compounds is well below the assessment criteria. Both compounds were recorded as outliers using the maximum value test and may therefore be regarded as discrete 'hotspots'.

Detectable concentrations of 'total PAH' were identified within the BWB in 2010. Concentrations ranging from 7.61mg/kg to 140mg/kg were recorded. The PAH testing was not speciated to USEPA 16 and thus no comparison with current GAC can be made.

Total Petroleum Hydrocarbons

Petroleum hydrocarbon analysis was scheduled on a total of 41 samples of soils/wastes. Testing included three different suites, firstly a total test with no breakdown of the hydrocarbon type, secondly a simple 'banded TPH' according to carbon ranges (on eleven of the samples) and thirdly, testing speciated to TPH Criteria Working Group (TPHCWG) specification on 19 further samples – this last suite includes a further breakdown into aliphatic/aromatic hydrocarbons. Additionally, samples were analysed for the BTEX compounds, and compound methyl tertiary butyl ether (MTBE). The results are summarised in Table 6.3 and Table 6.4.

Table 6.3: Summary of MTBE and BTEX contaminants in soils

Determinand	No. Samples	Source	Assess-ment criteria (µg/kg)	Min. Conc. (µg/kg)	Max. Conc. (µg/kg)	Number of Exceedances
MTBE	32	EICCLAIRE	24000	1.00	20.00	0
Benzene	33	S4UL	90	0.01	10.00	0
Toluene	33	S4UL	110000	0.01	13.00	0
Ethylbenzene	32	S4UL	13000	0.01	10.00	0
m and p-Xylene	33	S4UL	14000	0.01	31.00	0
o-Xylene	33	S4UL	15000	0.01	10.00	0

Table 6.4: Summary of petroleum hydrocarbon contaminants in soils

Determinand	No. Samples	Source	Assess-ment criteria (mg/kg)	Min. Conc. (mg/kg)	Max. Conc. (mg/kg)	Location of maximum	Number of Exceedances
TPH >C10-C40	41	NV	NV	52.0	5200	TP27 at 2.5m	NA
Aliphatics >C8 - C10	19	S4UL	11000	0.10	4.0	TP18 at 0.7m	0
Aromatics >C8 - C10	19	S4UL	17000	0.10	4.0	TP18 at 0.7m	0
Aliphatics >C10 - C12	19	S4UL	47000	0.20	101	PWS04 at 2.0m	0
Aromatics >C10 - C12	19	S4UL	34000	0.20	94.9	TP20 at 0.7m	0
Aliphatics >C12 - C16	19	S4UL	90000	4.00	46.0	PWS04 at 2.0m	0
Aromatics >C12 - C16	19	S4UL	38000	4.00	120.0	TP20 at 0.7m	0
Aliphatics >C16 - C21	19	S4UL	180000	4.00	47.4	TP20 at 0.7m	0
Aromatics >C16 - C21	19	S4UL	28000	4.00	957	TP20 at 0.7m	0
Aliphatics >C21 - C35	19	S4UL	180000	7.00	717	TP29 at 1.5m	0
Aromatics >C21 - C35	19	S4UL	28000	7.00	2250	TP20 at 0.7m	0
>C8 - C10	11	S4UL (aliphatics)	11000	2.00	3.8	TP27 at 2.5m	0
>C10 - C12	11	S4UL (aliphatics)	47000	2.00	79.7	TP27 at 2.5m	0
>C12 - C16	11	S4UL (aliphatics)	38000	2.00	894	TP27 at 2.5m	0
>C16 - C21	11	S4UL	28000	2.00	595	TP27 at	0

Determinand	No. Samples	Source	Assess-ment criteria (mg/kg)	Min. Conc. (mg/kg)	Max. Conc. (mg/kg)	Location of maximum	Number of Exceedances
		(aliphatics)				2.5m	
>C21 - C35	11	S4UL (aliphatics)	28000	11.10	2930	TP27 at 2.5m	0

No elevated concentrations of petroleum hydrocarbons were found above the screening values for the protection of human health in the completed scheme. It is however noted that eight samples were identified to be impacted by heavier range hydrocarbons and recorded concentrations above 1000mg/kg (i.e. the level that would render them as hazardous wastes - see Section 8).

Cyanide

44 samples were tested for cyanide. One sample from TP20 at 0.7m recorded cyanide at 36mg/kg which exceeded the Atkins Atrisk screening value of 34mg/kg. This sample is a statistical outlier (contamination hotspot) and thus not representative of the soil mass as a whole.

Phenols

None of the 28 samples that were tested for phenols exceeded the GAC.

Poly Chlorinated Bi-phenyls

Seven of the 20 samples tested for poly chlorinated bi-phenyls (PCB) recorded detectable values of at least two PCB compounds, the most common being PCB138.

Elevated concentrations were on average 30µg/kg, with a maximum of 132µg/kg. There are no published UK screening criteria for the PCBs recorded, however the concentrations may be regarded as being very low and of no significant risk to end users.

Asbestos

In total 35 samples of made ground were tested for the presence of asbestos. Asbestos was recorded as being detectable in six of the samples, namely: BHA at 1.20mbgl, BHC at 1.20mbgl, P-WS04 at 2.00mbgl, WS5 at 1.20mbgl, TP03 at 0.4m, TP7 at 0.5m. A sample of suspected asbestos containing material from a service excavation was also analysed and tested positive for asbestos (labelled ACM at PIT).

The type and concentrations of asbestos are summarised in Table 6.5 below.

Table 6.5: Asbestos results

Sample	Depth (mbgl)	Mass of Dry Sample (g)	Asbestos Containing Material	Asbestos Screen	Asbestos Level	Asbestos Gravimetric Quantification (ACMs)
BHA	1.20	42.1	Fibre Bundles	Chrysotile	Quantifiable	-
BHC	1.20	38.2	Fibre Bundles	Chrysotile	Quantifiable	<0.001 (mass %)
P-WS04	2.00	44.3	Fibre Bundles	Chrysotile	Quantifiable	<0.001 (mass %)
WS5	1.20	37.3	Free Fibre	Chrysotile	Quantifiable	<0.001 (mass %)
ACM	PIT	79.6	Cement	Chrysotile	Quantifiable	15.000 (mass %)
TP03.1	0.40	-	Bound insulation Board	Chrysotile Amosite	Quantifiable	<0.001 (mass %)
TP07	1.50	-	-	Amosite	-	-

Four of the samples were recorded to contain asbestos as free fibres, one as insulation board and one as cement (the ACM PIT sample). Quantification of the asbestos in these samples recorded concentrations of lower than 0.001% asbestos by dry weight in the soil samples and insulation board and 15% in the cement.

Even though less than 0.001% asbestos was identified by the quantification analysis, there could still be risk from respirable fibres release. Even at the levels recorded, depending upon site conditions (soil type, moisture content and wind) and disturbance, concentrations could exceed the occupational control limit of 0.1f/ml [23]. Further discussion on risks from asbestos is given in Section 7.5

6.3 Risks to controlled waters

The preliminary conceptual site model given in Section 3.3 identified that soils at the site might pose a risk to groundwater and to surface water receptors via leaching and subsequent vertical/lateral migration within the groundwater flow path.

An assessment of leachable fraction of contaminants in soils was undertaken as part of the Amey investigation. Historical data on groundwater contamination beneath site contained in the BWB report has also been summarised to provide preliminary information on risks to controlled waters. Boreholes BH2 and BH3 of the BWB investigation are located within the proposed HWRC/access road and BH1 is located to the north west in the proposed commercial development area (phase two). The locations are shown within Appendix A Figures and Drawings, labelled BWB Exploratory hole location plan.

The results of the Level 1 assessment of comparing soil leachate concentrations against available GAC and Level 2 screening of groundwater samples are presented in the following sections.

6.3.1 Leachable contamination quality

Inorganic contaminants

Leachate extracts prepared from six samples of made ground were analysed for a range of inorganic contaminants. A summary of the results is presented in Table 6.6.

Table 6.6: Leachable inorganic contaminants

Contaminant	Units	No. of samples	Min	Max	GAC (ug/l)	Number exceeding	Location of exceedances
Antimony	µg/l	6	2	4	nv	-	
Arsenic	µg/l	6	2.5	2.6	50 (EQS)	0	
Barium	µg/l	6	3	103	100 (DWS)	0	
Cadmium	µg/l	6	0.5	0.5	0.08 (EQS)	6#	All
Chromium	µg/l	6	1.5	6.4	3.4 (EQS)	1	TP2 at 0.1m
Copper	µg/l	6	7	43	1 (EQS)	6#	All
Lead	µg/l	6	5	6	7.2 (EQS)	0	
Mercury	µg/l	6	1	1	0.05 (EQS)	6#	All
Molybdenum	µg/l	6	3	8	nv	-	
Nickel	µg/l	6	2	5	20 (DWS)	0	
Selenium	µg/l	6	3	3	10 (DWS)	0	
Zinc	µg/l	6	4	12	8 (EQS)	0	

Notes:

EQS – environmental quality standards
DWS – UK drinking water standards
Detection limit is greater than assessment criteria

Discounting the determinants where the detection limit is greater than the assessment criteria, a slightly elevated concentration of chromium was identified in the sample taken from TP2 at 0.1-0.4m depth. Further analysis of groundwater using lower detection limits will be required to better assesses risks from other metals. Recommendations are detailed within section 9.2.3.

Organic contaminants

Selected samples were also analysed for their concentration of leachable organic contaminants including total phenols, TPH, and PAH. The results of the assessment for organic contaminants is summarised in Table 6.7.

Table 6.7: Leachable organic contaminants

Contaminant	Units	No. of samples	Min	Max	GAC	Number exceeding	Location of maximum
Polycyclic aromatic hydrocarbons							
PAH (total of 4) • Benzo(b)fluoranthene • Benzo(k)fluoranthene • Indeno(123cd)pyrene • Benzo(ghi)perylene	µg/l	3	<0.04	1.94	0.1 (DWS)	3[#]	All but only WS3 at 1.2m recorded detectable concentrations
Acenaphthene	µg/l	3	0.01	0.04	n/a	-	
Acenaphthylene	µg/l	3	0.01	0.06	-	-	
Anthracene	µg/l	3	0.01	0.1	0.4 (EQS)		
Benzo(a)anthracene	µg/l	3	0.01	0.37	-	-	
Benzo(a)pyrene	µg/l	3	0.01	0.79	0.027 (EQS MAC)	3[#]	
Chrysene	µg/l	3	0.01	0.72	-	-	
Dibenzo(ah)anthracene	µg/l	3	0.01	0.45	-	-	
Fluoranthene	µg/l	3	0.01	0.28	-	-	
Fluorene	µg/l	3	0.01	0.46	-	-	
Naphthalene	µg/l	3	0.01	0.09	10 (EQS)	0	
Phenanthrene	µg/l	3	0.01	0.67	-	-	
Pyrene	µg/l	3	0.01	0.03	-	-	
Petroleum hydrocarbons							
EPH >C10-C12	µg/l	6	0.01	<10	10 (DWS*)	0	
EPH >C12-C16	µg/l	6	0.1	<10	10 (DWS*)	0	
EPH >C16-C21	µg/l	6	10	<10	10 (DWS*)	0	
EPH >C21-C28	µg/l	6	0.3	<10	10 (DWS*)	0	
EPH >C28-C35	µg/l	6	3	<10	10 (DWS*)	0	
EPH >C35-C40	µg/l	6	3.06	453.42	10 (DWS*)	1	TP2 0.1-0.4m
EPH >C40-C44	µg/l	6	10	4533.8	10 (DWS*)	2	TP2 0.1-0.4m
GRO (>C5-C10)	µg/l	6	6	<100	10 (DWS*)	2[#]	
Other contaminants							

Contaminant	Units	No. of samples	Min	Max	GAC	Number exceeding	Location of maximum
Total monohydric phenols	mg/l	6	<0.01	9	0.007 (EQS AA)	6#	

Notes: EQS Environmental Quality Standards
EQS AA Environmental Quality Standards Annual Average
DWS UK Drinking Water Standards
EPH – extractable petroleum hydrocarbons
GRO – Gasoline range organics
* Oils/hydrocarbons value now revoked
# Detection limit is greater than assessment criteria

The testing to date recorded locally elevated - but generally low - concentrations of mobile PAHs. Significantly elevated concentrations of mobile heavy distillate range petroleum hydrocarbons of 4533 µg/l was recorded in the sample taken from TP2 at 0.1m to 0.4m depth. This coincides with some elevated TPH found in soils at this location. Elevated levels of leachable phenols above the detection limit were also encountered in four of the six samples tested.

6.3.2 Groundwater quality

Inorganic contaminants

A summary of the results of the analysis of inorganic contaminants in groundwater as assessed by BWB on a single occasion is presented in Table 6.8.

Table 6.8: Inorganic contaminants in groundwater

Contaminant	Units	No. of samples	BH1	BH2	BH3	GAC	Number exceeding
Ammoniacal nitrogen	mg/l	3	0.266	17.5	23.1	3 (EQS)	2
Arsenic	µg/l	3	1.68	2.68	1.12	50 (EQS)	0
Barium	µg/l	3	<0.01	<0.01	<0.01	700 (DWS)	0
Beryllium	µg/l	3	11.6	17	12.4	nv	-
Boron	µg/l	3	0.423	1.03	1.3	1000 (DWS)	0
Cadmium	µg/l	3	2.14	4.28	4.2	0.08 (EQS)	3
Chromium	µg/l	3	230	413	51.3	50 (DWS)	3
Copper	µg/l	3	0.266	17.5	23.1	1 (EQS)	3
Lead	µg/l	3	<0.07	<0.07	<0.07	7.2 (EQS)	0
Mercury	µg/l	3	0.128	0.119	<0.1	0.05 (EQS)	3#
Nickel	µg/l	3	6.52	13.6	12.9	20 (DWS)	0
Selenium	µg/l	3	1.68	2.68	1.12	10 (DWS)	0
Vanadium	µg/l	3	0.027	0.05	<0.02	nv	-
Zinc	µg/l	3	<0.01	<0.01	<0.01	8 (EQS)	0
Sulphate	mg/l	3	11.6	17	12.4	nv	-

Notes: EQS – environmental quality standards
DWS – UK drinking water standards
NV – No relevant value

Detection limit is greater than assessment criteria

The testing undertaken by BWB shows some elevated concentrations of metals cadmium, chromium and copper above the chosen assessment criteria in shallow groundwater in and around the site.

Organic contaminants

Samples of groundwater retrieved from the monitoring boreholes installed by BWB were also analysed for organic contaminants on a single occasion. The results of the analyses are summarised in Table 6.9 below.

Table 6.9: Organic contaminants in groundwater

Contaminant	Units	No. of samples	BH1	BH2	BH3	GAC	Number exceeding
Cyanide (total)	µg/l	3	<0.05	<0.05	<0.05	50 (DWS)	0
Total monohydric phenols	µg/l	3	<0.015	<0.015	<0.015	7.7 (EQS)	0
Benzene	µg/l	3	<7	<7	<7	1	0
Ethylbenzene	µg/l	3	<5	<5	<5	300	0
Toluene	µg/l	3	<4	<4	<4	700	0
m,p,o-xylene	µg/l	3	<10	<10	<10	500	0
TPH	µg/l	3	<10	<10	<10	10 (DWS)	0
MTBE	µg/l	3	<10	<10	<10	nv	-
Total PAH (sum of four)	µg/l	3	<0.117	<0.08	<0.08	0.1 (DWS)	0
Benzo(a)pyrene	µg/l	3	0.03	<0.009	<0.009	0.027 (EQS MAC)	1
Benzo(b)fluoranthene	µg/l	3	0.04	<0.023	<0.023	0.017 (EQS MAC)	3#
Benzo(k)fluoranthene	µg/l	3	<0.027	<0.027	<0.027	0.017 (EQS MAC)	3#
Benzo(g,h,i)-perylene	µg/l	3	0.03	<0.016	<0.016	8.2×10^{-4}	3#

Notes: EQS – environmental quality standards
EQS MAC – maximum allowable concentration
Detection limit is greater than assessment criteria

The analysis recorded no detectable petroleum hydrocarbons, BTEX, MTBE, phenols or cyanide. Detectable but only very low concentrations of PAH compounds were recorded.

6.4 Ground gas risk assessment

An assessment of the ground gas regime beneath the site was undertaken by BWB in 2010 [13]. This comprised four readings of ground gas in thee standpipes located within the former landfill site (two within the present site and one in the phase two development plot). No further data has been collected by Amey, although it is proposed that some additional monitoring will be undertaken following the completion of ground treatment.

The BWB report calculates a gas screening value in accordance with CIRIA C665 [24]. The maximum concentrations and flow rates recorded during the monitoring undertaken to date have been used to assess the potential ground gas risk at the site:

- Gas Flow: 1.3l/hr (measured at location BH2 on 5th August 2010);
- Carbon Dioxide: 17.2% v/v (measured at location BH3 on 5th August 2010);
- Methane: 0.2% v/v (measured at location BH3 on 15th July 2010).

A gas screening value was calculated using the concentration and emission rate of gas from the ground. For this area a GSV of 0.224l/hr was calculated by BWB. This value falls into characteristic situation 2 of the CIRIA C665 [24].

We note that the boreholes on the proposed HWRC site were screened through much of the made ground and may not be wholly representative of the principal gas generation source. We also note that the number of gas monitoring rounds is below the suggested minimum number of rounds and monitoring period suggested by both CIRIA C665 and BS8576.

Whilst the proposed development is of very low sensitivity as no permanent structures are currently proposed, it would be prudent to more fully assess gas risks, particularly in view of the wider development in Phase II and the potential for services acting as preferential pathways for gas transmission.

Further discussion on the risks posed by elevated ground gases in the context of the proposed scheme are presented in Section 7.5.

7 Overall phase II contamination assessment

7.1 Introduction

The following section summarises the main contaminants found during the investigation and presents a revised conceptual site model based on the findings of the investigation and in consideration of the proposed development. Where necessary the revised conceptual site model is used to undertake a risk assessment which seeks to identify any unacceptable risks and consequently the need for any further action which may comprise further testing, detailed quantitative risk assessment or remedial action as necessary.

7.2 Sources of contamination

7.2.1 Soils/solid wastes

Significant widespread contamination of the on-site soils/landfill wastes with chemical contaminants in the context of risks to human health has generally not been recorded by the two phases of investigation. Only localised elevated concentrations of PAH, lead and cyanide were recorded.

Some asbestos and asbestos containing materials have also been found at discrete locations and it is likely that asbestos containing wastes occur throughout the site.

It should be noted that much of the wastes were non-soil related e.g. bone, plastic, domestic wastes and are not suitable for laboratory testing for contamination purposes.

Low but detectable levels of mobile contaminants, including chromium, petroleum hydrocarbons and to a lesser extent PAH have been recorded in the limited number of samples tested for leachable contaminants.

In view of the uncapped nature of the site and the large amount of time since deposition of wastes, the majority of leachable contamination should have already been mobilised.

7.2.2 Groundwater

Analysis of groundwater beneath the site undertaken by BWB in 2010 recorded elevated concentrations of the metals cadmium, chromium and copper as well as marginally elevated PAH and locally elevated ammoniacal nitrogen.

Further data collection on groundwater regime and quality is recommended to confirm and expand upon the findings of this earlier work. The scope of suggested works is discussed in section 9.2.3

7.2.3 Soil gas

The site is a former landfill site and as such may be regarded as a significant source of hazardous ground gases. The deposition of wastes was completed during the period 1960s to 1980s, and, as such, the principal phase of methane generation will be substantially complete. A residual carbon dioxide production phase would still be expected and such gases have been recorded in on-site monitoring wells.

Additional rounds of monitoring are to be undertaken post ground treatment to confirm findings of the earlier work.

7.3 Pathways for contamination

The following are potential pathways which could lead to receptor exposure:

- Human uptake pathways - the inhalation of asbestos dusts and gases/vapours
- Leaching of contaminated soils into groundwater
- Horizontal and vertical migration of contaminated groundwater/liquids through permeable strata
- Gas migration through permeable strata or conduits into confined spaces at potentially asphyxiant concentrations
- Direct contact (e.g. with construction materials)

7.4 Potential human and environmental receptors

The following are potential receptors of contamination:

- Construction workers involved in site works such as remediation, groundworks, demolition and construction works.
- Future end users within the completed scheme
- Adjacent site users within the surrounding industrial/commercial areas
- Groundwater
- Surface water (River Tean) and dependent ecological receptors
- Construction materials (e.g. buried concrete, buildings and water supply pipes)
- Temporary site buildings.

7.5 Revised conceptual site model and risk evaluation

The risk assessment approach has been designed to be consistent with CLR11. The aim of the preliminary risk assessment is to identify if there are any potentially unacceptable risks to receptors based on the initial conceptual site model described previously.

The approach therefore aims to identify whether additional site specific risk assessment or remedial action is likely to be required to enable the proposed scheme to proceed. The following sections detail the methodologies and relevant generic information adopted for the risk assessments.

The risk evaluation / assessment has been derived from the guidance given in CIRIA C552: *Contaminated Land Risk Assessment – A Guide to Good Practice* [6]. The description of the risk assessment methodology adopted is given in Appendix D, but a brief summary is presented below.

The assessment considers only the plausible pollutant linkages as identified in the refined conceptual site model presented in Table 7.1. For each possible active pollution linkage (source-pathway-receptor) identified, the potential risk can be evaluated, based on the principle:

'***Risk = Probability of event occurring x consequence of event occurring***'.

The relationship is shown below in the following table:

		Consequence			
		Severe	**Medium**	**Mild**	**Minor**
Probability	**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**

The definitions of the risk categories identified in the above matrix are given in Appendix D together with the investigatory and remedial actions that are likely to be necessary in each case. The risk categories apply to each pollutant linkage, not just to each hazard or receptor.

The risk evaluation summary for the active pollutant linkages is given in Table 7.1 with further discussion on risks to receptors given after the table.

Table 7.1: Revised CSM and risk evaluation summary

Potential source	Potential receptor	Possible pathway	Probability	Severity of consequence	Risk classification and justification
Asbestos and hotspots of lead and PAH contamination in soils/wastes	Human health (site end users)	Inhalation, ingestion, direct contact	Likely	Medium	**Moderate risk**: Whilst the majority of the proposed site will be hard surfaced, there are some proposed soft landscaped areas which, without appropriate mitigation could pose a risk to end users.
	Human health (construction workers)	Inhalation, ingestion, direct contact	High likelihood	Medium	**High risk**: There are specific risks associated with construction workers and the identified asbestos contamination.
Mobile metals and hydrocarbons in soils/wastes	Off-site surface waters (River Tean)	Horizontal and vertical migration of contaminated groundwater/liquids through permeable strata	Low Likelihood	Mild	**Low risk**: The majority of leachable contaminants are likely to have already have been mobilised. The identified water course is some 200m to the north. The low levels of contaminants recorded by the investigation are likely to attenuate sufficiently in the aquifer to pose minimal risks to the river.
	Groundwater	Leaching of contaminants into the groundwater	Likely	Medium	**Moderate risk:** Some relatively minor impacts to the underlying groundwater have already been recorded. However, groundwater quality will need to be further assessed to both confirm findings of earlier work and to identify any changes in the quality before, during and after construction.

Potential source	Potential receptor	Possible pathway	Probability	Severity of consequence	Risk classification and justification
	Construction materials	Direct contact	Likely	Minor	**Low risk:** The built environment at the site is relatively insensitive and risks can be easily mitigated through correct concrete mix design and protection of water supply pipes.
Elevated metals, ammoniacal nitrogen and PAH in groundwater	Off-site surface waters (River Tean)	Horizontal and vertical migration of contaminated groundwater/liquids through permeable strata	Low likelihood	Medium	**Low risk**: The underlying groundwater at the site is recorded to be only slightly impacted by contamination form the historic site use as a landfill. However further assessment will need to be undertaken to confirm the findings of the earlier limited work.
Hazardous ground gases and vapours (principally carbon dioxide)	Human health (site end users)	Gas migration through permeable strata or service conduits into confined spaces at potentially asphyxiant concentrations.	Unlikely	Mild	**Very low risk**: There are no structures or confined spaces that would be open to end users. Any hazardous ground gases present would vent to atmosphere and quickly attenuate.
	Human health (construction workers)		Low likelihood	Severe	**Moderate risk**: There are some earthworks planned and utilities trenches could represent confined spaces where hazardous gases could accumulate. Risk can be easily mitigated by good working practices and adherence to confined space entry protocols where necessary.
	Construction materials (e.g. buried concrete, services and site buildings)		Unlikely	Severe	**Moderate/low risk**: There are no permanent structures at the site. The proposed site cabins are to be raised and there is only very limited opportunity for ground/structure interaction and build-up of gases.
	Adjacent site users/services		Unlikely	Severe	**Moderate /low risk**: Current information suggests that the gas generation potential is low and that methane production has finished. Further data is required to confirm this and to ensure that proposed new services do not act as a conduit for hazardous gases.

Human health – site end users (members of public and staff)

The two phases of investigation have recorded isolated levels of chemical contamination (lead, cyanide and PAH) above generic assessment criteria suitable for assessing the long term risks to human health in the proposed commercial/light industrial development. Concentrations of these contaminants in the soils/waste are, as a whole, below the assessment criteria. However, the presence of additional hotspots (or so far unidentified contaminants or wastes) cannot be ruled out considering the heterogeneity of the deposits.

There are also specific risks associated with the asbestos contamination at the site and these will need to be addressed during site re-development to ensure adequate protection for end users in the completed scheme. Risks will be negligible in much of the scheme due to the presence of hardstanding which will break the human uptake pathway. Buried asbestos left in-situ under areas of permanent hard-standing should be noted in the asbestos management plan for the site.

However, there are **moderate** risks to end users where asbestos impacted wastes are left exposed in areas of soft landscaping in the periphery of the scheme. In particular this risk would apply to the long term workforce who would have long exposure durations and may have direct contact with soils.

In order to mitigate these risks and break the uptake pathway, a cover of verifiably suitable soils and a geotextile membrane should be placed in all areas of soft landscaping to provide a cover to asbestos impacted soils/wastes. This should be agreed in principle with the local planning authority and specific details, such as type of membrane and minimum thickness of cover, should be presented in a remediation method statement.

In terms of risks to end users from landfill gases, there are no permanent buildings which would be open to end users. As such any hazardous ground gases present would vent to atmosphere and naturally attenuate. Risks associated with land gas in the completed scheme are therefore considered to be **very low**.

Human health – construction workers

For construction workers who have a greater potential for close contact with soils during redevelopment the risk is **high**, although it is expected that this could be significantly reduced by adopting appropriate PPE and site safety protocols.

At the time of writing, preliminary enabling works and additional sampling have been undertaken under the supervision and direction of DMW Environmental Ltd a specialist asbestos licensed contractor. This has included on-site monitoring and the use of appropriate PPE. No free fibres have been identified in quantifiable volumes in the additional materials tested so far. No detectable asbestos airborne fibres or asbestos personal air monitors were triggered during enabling works.

Any further proposed earthworks or other site preparation works taking place within or around the landfilled wastes will continue to employ the advice of a licensed asbestos contractor. Records of findings will be kept in the site health and safety file and verification report for the site.

Groundwater

The groundwater in the superficial deposits beneath the site comprises a secondary A aquifer and is not abstracted for supply. The aquifer potentially provides a source of base flow to the River Tean which lies to the north of the site.

Groundwater quality recorded by previous investigations show some elevated levels of heavy metals, ammoniacal nitrogen and PAH, although in consideration of the sites previous use as a landfill, groundwater quality is not grossly impacted. As some impacts have been recorded the risks to groundwater may be provisionally regarded as **moderate**.

Drainage waters from the proposed access road and HWRC will be connected to the sewer network, no soakaways or sustainable urban drainage have been designed that drain into the fill or natural material at the site. The scheme will incorporate lined swales which are discharged into the local sewer network.

Infiltration from precipitation will therefore effectively reduce completely across the site post construction as all of the site surface area will positively drained hard standing or lined swales. This will significantly reduce the volume of water entering the underlying soils/wastes and leaching of residual mobile contamination which in turn should have a beneficial impact on groundwater quality.

It is recommended that the further information on groundwater quality beneath the site is obtained to confirm and expand upon the findings of earlier works. Recommendations are given in 9.2.3.

Surface water

The River Tean is located some 150m to the north of the site and is assumed to be in hydraulic continuity with the superficial aquifer beneath the site. The groundwater flow direction beneath the site appears to be towards the river.

Groundwater beneath the site has been recorded to contain elevated levels of contaminants, although no gross contamination has been recorded. It is likely that attenuation of the contaminants within the aquifer between the source and the receptor would be sufficient to reduce risk to the watercourse and therefore the risks are likely to be **low.** In addition it is likely that risks to the watercourse from on-site contamination would reduce substantially following the construction of the scheme due to the capture and diversion of rainwater infiltration at the site.

On the basis of the current information it is therefore unlikely that any specific remedial action will be required to protect controlled waters, including the River Tean. The risks should however be confirmed following additional investigations into groundwater quality at the site.

Construction materials/ built environment

Risks to construction materials and the built environment form soil and groundwater contaminants are **low**. Risks to buried concrete for any foundations passing into the wastes or sulphate containing natural soils can be easily mitigated by testing and selection of buried concrete in accordance with BRE Specials Digest No. 1 - which is presented in the GIR/GDR [25] for the scheme.

In order to provide sufficient protection of water supply pipes, it will be necessary to follow the guidance given 'Pipe Materials Selection and Specification for use in Contaminated Land' [26]

Any portacabins proposed for the site should be placed on raised supports to allow free flow of air beneath structure and thus minimise the residual risks of land gas or vapour entry. The proposed layout is shown on drawing number CDW8936-PA-02.

Off-site receptors

Off-site receptors include adjacent land users and buildings. In terms of people it will be the potential for the disturbance and wind-blown dust pathway for asbestos that is of principal concern. Mitigation measures must therefore be included as part of the construction environmental management plan to minimise risks of off-site migration of dusts. The continued advice of a suitably qualified asbestos specialist will need to be ensured during construction works.

In terms of buildings and services the risk are associated with the transmission of landfill gases along any newly constructed service conduits. In view of the low gas flow rates and negligible methane concentrations, risks are judged to be low. This should be confirmed during additional investigations and the need for any further mitigation assessed at this time (e.g. the construction of intermittent clay stanks to reduce continual gas flow along service conduits).

8 Excavated materials management

8.1 Reuse of site-won materials

The current proposals included the re-use excavated made ground from the phase one under pile caps in the northern part of the site (the phase 2 development plot shown in drawing no. ID-017-M5242 SK04 D02 dove way option 2).

The re-use of excavated materials will follow the guidance given in the CL:AiRE Definition of waste: development industry code of practice (DoW CoP) CON-GE-BHAM-COSTCDM0015-002 [27] and a materials management plan is currently in progress.

It is intended to test and stockpile suitable material to be placed under pile caps and hard standing/building footprints in the proposed future development. The local authority have agreed in principle with the proposed re-use of soils in this manner.

We currently estimate that approximately 14,000 tonnes (9750m^3) Is to be stockpiled with respect to re-use subsequently further testing is planned. It is anticipated at 2500m^3 topsoil and 7500m^3 made ground will be suitable for re-use and 250m^3 unsuitable for re-use and require offsite disposal.

8.2 Criteria for testing of stockpiles for re-use

Sampling of stockpiles will be undertaken in accordance with ISO 10381-8:2006 Soil quality -- Sampling -- Part 8: Guidance on sampling of stockpiles'. Samples from different stockpiles should not be mixed. Stockpiled samples will be tested for a variety of determinants, similar to those outlined within section 4.1.2.

Re-use criteria should be agreed with local planning authority and presented in the remediation strategy report. It is provisionally advised that the C4SL and S4UL for light industrial/commercial land use are used for any areas in the upper 1m of the finished ground levels.

Less stringent criteria could be used in area of permanent hardstanding but will need to be agreed with the local planning authority prior to use.

8.3 Waste disposal

8.3.1 Excavated soils

To determine the potential waste class of excavated soils a waste categorisation exercise was undertaken.

Waste classification is a two stage process, with the first step comprising a hazard assessment of the soil quality data in line with the guidance set out in the Environment Agency waste classification technical guidance WM3 document [28]. Once the hazardous nature of the materials is known, the second step is to assess the potential performance of the materials in a landfill; this is undertaken by considering the results of waste acceptance criteria (WAC) testing.

Generally, wastes that are classified as hazardous will need to be deposited in a hazardous waste landfill or within a stable non-reactive hazardous waste cell in a non-hazardous waste landfill (depending on the WAC test results). Wastes that are shown not to be hazardous may either be deposited in a non-hazardous waste landfill (for which no WAC tests are required) or as inert waste (which would require confirmation of suitability for this particular waste stream through WAC testing).

Some materials may be automatically classified as inert wastes, and this includes soils and stones not from contaminated sites (this would apply only to uncontaminated natural soils).

8.3.2 Hazardous waste assessment

Soil quality data from the investigation was entered into a hazard assessment tool, *HazWasteOnline*. The tool uses the current EA WM3 [28] guidance to determine whether the substances contained in the soils tested exceed any risk phrases that would render the materials as 'hazardous' waste.

The tool includes a number of options for using the different valences (chemical species) or compounds that may be present, e.g. whether the chromium found is chromium III or the less common but more toxic chromium VI. Where options were available these were generally set at the default (worst case assessment) for the model in accordance with the guidance set out in WM3.

The exception to this was zinc, which was set to zinc sulphate rather than the worst case zinc chromate due to the fact that there was insufficient chromium recorded for this particular compound to exist in the samples tested.

It should be noted that hazardous waste guidance is revised at regular intervals and the results of the assessment could change with subsequent revisions.

The results of hazard assessment show that of the 49 samples entered into the tool, 12 were classified as hazardous wastes as shown inTable 8.1. The full hazard classification report can be viewed within Appendix I.

Table 8.1: Summary of Hazwaste online classification

Samples (depth mbgl)	Hazardous Properties	Properties Description
WS5.1 (1.2) WS6 (1.2) TP23 (0.70) TP29 (1.50)	HP 14	**HP 14: Ecotoxic** "waste which presents or may present immediate or delayed risks for one or more sectors of the environment" **R50/53** "Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment"
TP18 (0.70)	HP 7, HP 10, HP 14	**HP 7: Carcinogenic** "waste which induces cancer or increases its incidence" Risk Phrase: **Carc. 1B; H350** **HP 10: Toxic for reproduction** "waste which has adverse effects on sexual function and fertility in adult males and females, as well as developmental toxicity in the offspring" Risk Phrase: **Repr. 1A; H360Df** **HP 14: Ecotoxic** "waste which presents or may present immediate or delayed risks for one or more sectors of the environment" Risk Phrase: **R50/53**
TP01 (1.50) TP05 (2.50) TP07 (1.50) TP26 (3.00) TP27[1] (2.50) TP35 (1.00)	HP 7, HP 11	**HP 7: Carcinogenic** "waste which induces cancer or increases its incidence" Risk Phrase: **Carc. 1B; H350** **HP 11: Mutagenic** "waste which may cause a mutation, that is a permanent change in the amount or structure of the genetic material in a cell" Risk Phrase **Muta. 1B; H340**
TP20 (0.70)	HP 7, HP 11, HP 14	**HP 7: Carcinogenic** "waste which induces cancer or increases its incidence" Risk Phrase: **Carc. 1B; H350** **HP 11: Mutagenic** "waste which may cause a mutation, that is a permanent change in the amount or structure of the genetic material in a cell" Risk Phrase **Muta. 1B; H340** **HP 14: Ecotoxic** "waste which presents or may present immediate or delayed risks for one or more sectors of the environment" Risk Phrase: **R50/53**
PWS04 (2.0) PWS04[1] 4.2	Non-Hazardous	**None**

As is shown in the table, the made ground at the site at the site is variable in nature and a mixture of hazardous and non-hazardous wastes. The concentrations of hydrocarbons and heavy metals (lead, zinc and copper) are responsible for the hazardous classification.

It is therefore expected that the made ground will be classified as 17 05 03 unless some form of treatment can be undertaken to reduce the waste class.

8.3.3 Waste acceptance criteria testing

Eight samples of made ground were analysed for the WAC test suite.

The WAC test is primarily a compliance test for material being received at a landfill and further testing of waste streams will be required in due course. A summary of the testing is presented in Table 8.2.

Table 8.2: Summary of WAC testing

Sample ref	Suitable for inert	Suitable for SNRHW[1] in non-hazardous landfill	Suitable for hazardous waste
TP2 0.1-0.4	No	Yes	Yes
TP3.1 0.1-0.4	Yes	Yes	Yes
TP11 0.1-0.4	No	No	No
TP17 0.1-0.4	No	No	No
P-WS01 1.2	No	Yes	Yes
P-WS2 2.0	No	No	No
P-WS04 2.0	No	Possibly*	Possibly*
BHD 1.2	No	No	No

Notes: *TOC and LOI were unable to be determined at laboratory due to asbestos being detected within the sample. Results from similar strata and soil types indicate this sample may be not be suitable for SNRHW in non-hazardous landfill or Hazardous landfill due to high organic content. This will need to be confirmed if determined for offsite disposal.

[1] Stable Non-Reactive Hazardous Waste in Non-Hazardous Landfill.

8.3.4 Overall comment on waste classification and excavation of soils

Laboratory analyses and hazard assessment confirm that the made ground at the site is mixture of hazardous and non-hazardous wastes. This is to be expected given the site is a former landfill that has previously been used for the co-disposal of different waste streams.

Laboratory testing show that the majority of the samples fail the inert waste threshold and half fail the hazardous waste WAC. So whilst a proportion of the wastes will be suitable for disposal as non-hazardous wastes, some materials will therefore not be suitable for landfill disposal without some form of treatment.

All wastes will need to be treated by sorting, screening, etc. prior to disposal to reduce the volume of waste, as required by the Environment Agency.

Relevant chemical test data along with material descriptions and EWC codes will need to be provided to the proposed destination landfill and confirmation sought as to the final classification and cost associated with disposal.

8.4 Discovery strategy for unexpected contamination

Given the nature of the site and the likely heterogeneity of the wastes that has been deposits, the presence of previously unidentified contamination may exist between sample locations, and such areas could be encountered during excavation works.

The following procedure should be adopted at the construction phase to address this:

1. **Visual monitoring of excavation works** should be undertaken by the Contractor under the guidance of an environmental specialist and asbestos specialist to check for unexpected or unusual materials with a contaminative potential. Such material could consist of buried drums, tanks or containers, soil, groundwater or liquids with an unusual colour or odour, or other evidence of contamination.
2. **Halt work in affected area and consult an environmental specialist if such material is encountered -** work in that area will be stopped until the material has been properly identified and suitable precautions taken.
3. **Have the suspect material tested and characterised** - where safe and reasonable to do so, any suspected contaminated material should be left in-situ and subjected to testing by an environmental specialist.

4. **Assess options for dealing with the observed contamination**
   On the basis of the test results, the contamination must be appropriately dealt with in one of the following ways, in sequence:

   (i) additional risk assessment by an environmental specialist to determine whether the material poses any risk, and if it may be suitable for an alternative use on-site

   (ii) on-site treatment, subject to degree of contamination, available facilities, licences and space. Re-testing would be necessary before suitability for re-use could be confirmed

   (iii) the material may need to be removed for disposal or recycling off-site. This should be considered a last resort.

Regardless of which route above is taken, the Local Planning Authority must be consulted at the earliest stage, and all decision making and actions must be recorded in the site file.

9 Conclusions and recommendations

9.1 Conclusions

The subject site comprises part of a former landfill/land raise area that is proposed to be redeveloped for a new HWRC, associated access roads and soft landscaping.

Site investigation data has recorded the underlying stratigraphy at the site to comprise a cover of topsoil overlying a variable thickness of wastes extending to a maximum depth of 3.0m bgl. Natural strata comprising a discontinuous layer of alluvium overlying glaciofluvial deposits and in turn Mercia Mudstone is present beneath the site.

Groundwater has been recorded between 4.2m and 5.6m below ground level in previous investigations (within the glaciofluvial deposits). Groundwater flow direction appears to be in a north-north easterly direction towards the River Tean.

Analysis of a number of samples of made ground soils/wastes from the site has recorded levels of chemical contamination to be generally below the generic screening values appropriate for the assessment of long term risks to human health, although some isolated hotspots of lead, PAH and cyanide have been identified.

Asbestos fibres (chrysotile) were recorded in samples analysed for their presence. Given the nature of the wastes, additional asbestos containing materials and asbestos as free fibres must be considered to be present throughout the waste mass. Some mitigation from asbestos fibres will be required during construction and in the completed scheme.

The levels of contamination recorded in the made ground /wastes will render much of these as hazardous wastes, however, WAC testing shows that they may not be suitable for disposal to hazardous waste landfill without some form of treatment.

Some mobile (leachable) metals and hydrocarbons of soils/wastes were recorded through leachability testing.

Groundwater analysis has not recorded gross contamination although some elevated concentrations of metals, ammoniacal nitrogen and PAH were recorded above the chosen screening values (Environmental Quality Standards and Drinking Water Standards). Further analysis will be required to confirm and expand on the findings of the earlier work to more fully assess risks to both groundwater and off-site surface water.

However, risks to the aqueous environment will be lowered by the construction of the proposed scheme. Drainage waters from the proposed access road and HWRC will be positively drained to sewer network, no soakaways or sustainable urban drainage have been designed that drain into the fill or natural material at the site. The design scheme has incorporated lined swales which are also discharged into the local sewer network.

Infiltration and leaching of residual contaminants will reduce substantially, which in turn should have a beneficial impact on groundwater quality. Risks to the underlying aquifer and nearby River Tean are judged to be moderate and low respectively. It is considered unlikely that any specific remedial measures will be required for protection of water resources, although this will be confirmed during additional investigations.

Gas monitoring undertaken by BWB Consulting at the site in 2010 recorded moderately elevated concentrations of carbon dioxide but very low concentrations of methane. Additional gas monitoring is proposed as part of additional investigations proposed in February 2016. However in view of the proposed development which is of very low sensitivity to land gas, risks in the completed scheme are judged to be low.

The development of the site requires some ground treatment to improve the formation soils. At the time of writing this had been completed under the guidance of asbestos specialists.

9.2 Recommendations

9.2.1 Protection of human health during construction

Site investigations have recorded the presence of locally elevated concentrations of lead, PAH and cyanide, as well as asbestos as loose fibres and as ACM, in wastes beneath the site. Asbestos is considered to be the principal contamination risk to human health at the site.

As such, all earthworks should be competed under the guidance of an asbestos specialist and in consideration of the Control of Asbestos Regulations [28] and the guidance given in CIRIA C733: Asbestos in made ground [29].

9.2.2 Long term protection of site end users in the completed scheme

The investigations to date have recorded soils at the site to have been locally impacted with PAH, lead, cyanide and more widespread contamination with asbestos as ACM and free fibres.

The construction of permanent areas of hardstanding and roadways will break the human uptake (inhalation) pathway in much of the completed scheme. However in order to ensure that this pathway is effectively broken in proposed soft landscaping area, the provision of cover soils in such areas will be required.

It therefore provisionally proposed that a geo-membrane marker layer and a minimum of 500mm cover of suitable fill is placed in all soft landscaping areas. The existence of asbestos impacted soils and ACM at depth should be recorded in the health and safety file and in the asbestos register for the site.

9.2.3 Groundwater monitoring

The investigation by BWB in 2010 recorded some contamination of on-site groundwater by several contaminants above environmental screening criteria. Only a single sample of groundwater was taken from two boreholes on the subject site.

In order to provide up to date and repeatable data on the groundwater quality beneath the site it is recommended that three monitoring wells are installed within the subject site. Wells should be constructed to a depth of 7m and monitor groundwater solely in the glacial-fluvial deposits. The response zones of the wells should not cross strata boundaries and act as potential pathways for contamination into the underlying aquifer.

It is recommended that these wells are monitored using an interface meter to determine the presence of non-aqueous phase liquids. They should be sampled on at least three occasions and tested for the following contaminants.

- Heavy metals and semi-metals
- Polycyclic aromatic hydrocarbons
- Total petroleum hydrocarbons speciated to TPHCWG specification
- Volatile and semi-volatile organic compounds
- Poly-chlorinated biphenyls
- Ammoniacal nitrogen
- pH , nitrate, manganese IV, iron III, sulphate

9.2.4 Ground gas recommendations

The ground gas assessment undertaken to date supports the hypothesis that the methane generation potential of the site is essentially complete. However given the uncertainty surrounding the placement of the response zones of the combined gas/groundwater monitoring wells previously installed, it is recommended that four dedicated gas monitoring wells are installed within the area of thickest waste deposits, including at least one in the location of the planned HWRC welfare facilities.

9.2.5 Documentation

The results of the additional data collection should be reported in a revised or addendum risk assessment report, including, where necessary, a detailed quantitative risk assessment for controlled waters. The report should be presented to the local planning authority for their comment.

Any unacceptable risks that require remedial action should then be presented a remediation strategy report (following an appropriate options appraisal exercise). The report should be approved by the local planning authority contaminated land officer prior to undertaking the work.

A separate materials management plan will be produced in order to support the re-use of suitable materials within the phase 2 development plot as part of the CLAIRE: Definition of waste voluntary code of practice [27].

References

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