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Studies and Work to Support Crawley Borough Council and Horsham District Council Preferred Option Joint Area Action Plan

Appraisal of Landfill Studies & Remediation Plan

Prepared for:

Crawley Borough Council and Horsham District Council

Prepared by:

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Studies and Work to Support Crawley Borough Council and Horsham District Council Preferred Option Joint Area Action Plan

Appraisal of Landfill Studies and Remediation Plan

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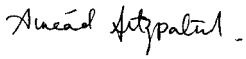
Prepared by	Sinead Fitzpatrick		11/7/07	Senior Environmental Consultant
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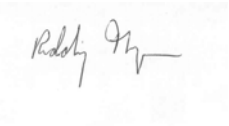
Approved by	Redding Thompson		11/7/07	Principal in Charge

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EXECUTIVE SUMMARY

This report was prepared by URS Corporation Limited (URS) for Crawley Borough Council and Horsham District Council to provide an appraisal of environmental site investigations completed at Bewbush Landfill, Bewbush, Crawley, West Sussex (the site).

Bewbush Landfill is an inert landfill (approximately 36 hectares infilled) located in the 'Search Area' for a new strategic housing scheme, as detailed in the West Sussex Structure Plan.

Since 2002, site investigations at the Bewbush Landfill were completed by SLR Consulting Limited (SLR) on behalf of Crest Nicholson in order to obtain surrender of the Waste Management Licence (WML), in terms of agricultural land use, following the landfill's closure in May 2006.

OBJECTIVES

In order for the Councils to understand the implications of developing the landfill site (particularly with regard to residential development), they required an appraisal of the landfill studies and a feasibility assessment for developing at this location. Therefore, the objective of this report was to provide an appraisal of the investigation works completed at the landfill and to assess the viability of remediation works proposed for the site.

The scope of work included a review of the landfill studies, a data gap analysis and a remediation methodology viability assessment.

REVIEW OF LANDFILL STUDIES

In terms of document review the environmental sensitivity of the site setting and potentially contaminative uses of the site and surrounding area were assessed. Using this information a Preliminary Conceptual Site Model (CSM) was developed by URS, to understand the potential risks posed to sensitive receptors, by potential contamination from the site.

DATA GAP ANALYSIS

Based on the preliminary CSM a data gap analysis of the available data was completed to determine if sufficient investigation works were carried out to assess the risk to future residents and Bewbush Brook, and to support the recommended remediation works for the site.

Data from two phases of investigation completed at the site (2002 and 2004) were provided to URS for review.

In terms of the soil investigation, the sampling density was less than that recommended in recognised guidance.

Groundwater monitoring wells were generally concentrated in the northeast portion of the landfill. This is not considered to represent reasonable coverage for the general assessment of groundwater quality at the site.

Bi-monthly sampling of surface water in Bewbush Brook was completed at four sample locations since 2002, which is considered appropriate given the size and location of the brook. However, URS

understands that no contact has been made to date with the Environment Agency (EA) regarding the regional importance of this surface water feature and also its environmental sensitivity.

A total of fourteen gas monitoring wells were installed as part of the investigation. However, the wells were generally concentrated in the northeast portion of the landfill.

Laboratory Analysis

Soil samples were analysed for metals, sulphate, cyanide, phenols and limited organic analysis (speciated polycyclic aromatic hydrocarbon (PAH) and extractable petroleum hydrocarbon (EPH)). Groundwater was analysed for metals, inorganics and, similarly limited organics. Surface water was analysed for metals and inorganics; no organic analyses was completed.

The required speciation of component total petroleum hydrocarbon (TPH) fractions and PAH compounds was not available to satisfactorily assess potential risks.

Assessment

The quantitative risk assessment completed as part of the SLR assessment is considered limited and inappropriate for fulfilling objectives more recently established by for Crawley Borough Council and Horsham District Council.

Proposed Additional Investigation

Since the commencement of this assessment, SLR has indicated their proposed plans for additional assessment at the site. These include additional trial pitting (174), boreholes (nine), gas monitoring probes (ten) and an additional surface water sampling location, which they propose to complete in late 2007 (the first phase has recently been completed).

SLR reported that these investigations will examine soil conditions from a land quality perspective, subject to confirmation of the development layout and ground profile as part of the master plan for the site. URS propose that the investigations should also be used to address data gaps identified in this report.

GENERIC QUANITATIVE RISK ASSESSMENT

URS completed a generic quantitative risk assessment (GQRA) of soil, groundwater and surface water at the site, using data provided by SLR (2002 and 2004 investigations).

From the findings of the GQRA, the following summarises the potential contamination present on the site.

- Exceedance of the adopted soil human health screening criteria was observed for EPH, PAHs and limited metals at the site, which indicates a potential risk to future site users. In terms of a risk to controlled water from soils, given the groundwater concentrations observed, it is likely that soils are acting as a potential source of impact to groundwater at the site;

- Groundwater results were above the adopted human health and controlled waters screening criteria for EPH, PAH, metals and some inorganics, representing a potential source of contamination to Bewbush Brook. The presence of petroleum hydrocarbon at elevated concentrations also represents a potential risk to future site users via outdoor/indoor inhalation of vapours;

- Exceedance of the adopted controlled waters screening criteria was observed for metals and inorganics in the surface water samples, indicating a potential for the migration of contamination off-site; and

- Concentrations and flow rates of methane and carbon dioxide assessed indicated that further ground gas risk assessment and/or possible remedial mitigation measures are required.

Recommendations

- Additional trial pit and groundwater/gas wells should be installed, particularly in the central and north western portions of the site;

- Sufficient speciated TPH and PAH data should be collected from site soil, groundwater and surface;

- Completion of a GQRA of data collected and Detailed Quantitative Risk Assessment (DQRA), if required;

- Contact should be made with the EA regarding the regional importance of this brook and also its environmental sensitivity; and

- Further ground gas risk assessment and/or possible remedial mitigation measures should be completed before the site would be considered suitable for low rise residential development.

REMEDIATION METHODOLOGY VIABILITY ASSESSMENT

The SLR landfill studies have been completed in terms of surrendering the WML. Therefore, only limited remediation proposals were provided. However, SLR has indicated that they are considering two potential remedial options for the site, which include source removal and elimination of the potential contaminant pathways.

Viability Assessment - Remedial Option 1

- SLR has indicated that fill will be excavated from areas of the site that contain concentrations of wood, timber and Alluvium above 5%, to address methane production in this fill material. Details on post remedial gas monitoring in areas excavated would be required to confirm methane concentrations are reduced to an acceptable level;

- SLR has recommended the installation of a gas protection membranes, in order to mitigate against any residual gas risks and this is considered appropriate;

- To address the risk posed to human health SLR has recommended the placement of suitable subsoil and 'clean' topsoils in garden areas; and

- SLR has recommended the installation of a drainage system to capture and treat leachate from the site, for the duration of the development works, in order to protect water quality in Bewbush Brook. Details are required on the measures proposed to protect water quality in the brook during the operational phase of the development is required.

Provided the additional investigations are completed (including data gaps as identified by URS) and the comments above are taken into consideration, source area removal would be considered a viable remedial option for the site. In the experience of URS source, removal is a very common and effective remedial option for addressing contaminated soil at a site.

Viability Assessment - Remedial Option 2

- To address the risk posed to human health SLR has recommended the placement of suitable subsoil and 'clean' topsoils in garden areas;

- SLR recommends diversion of Bewbush Brook into a purpose built clay-lined channel with appropriate landscaping and ecological restoration. Depending on the properties and construction of this channel it could have the potential to address impact from groundwater at the site to the brook, however, this would need to be completed with consultation with the EA; and

- SLR recommends the installation of suitably engineered gas impermeable membranes and passive venting systems across parts of the site that would be used for built development (i.e. excluding areas of open space). It should be noted a membrane would not be considered suitable to address certain areas of the site given the current level of assessment and further ground gas risk assessment and/or possible source removal would be required.

Provided the additional investigations are completed (including data gaps as identified by URS) and the comments above are taken into consideration, pathway elimination would be considered a viable remedial option for the site.

Assessment of Preferred Option for the JAAP

It was envisaged that this report would facilitate the identification of a development area to support the authorities in progressing site-specific proposals in the Preferred Options JAAP and to provide a clearer understanding of the constraints and opportunities for the identified 'developable' area. However, initial review of the SLR reports indicated that their objective was not full assessment of the site under Part IIA[1] and the Town and Country Planning Act[2] requirements. This was brought to the attention of Crawley Borough Council and Horsham District Council and URS was requested to

[1] Part IIA of the Environmental Protection Act, HMSO, DEFRA, 1990.

[2] The Town and Country Planning Act, ODPM, 1990.

assess the data more fully in terms of the risk in advancing the site as a Preferred Option for the Joint Area Action Plan (JAAP).

At this stage of the assessment it is difficult to recommend the site as a Preferred Option for the JAAP, given that a full evidence base and detailed remediation plan is not yet available. In terms of the risk associated with advancing this area as a Preferred Option (without having a full evidence base that remediation is reasonably achievable) URS would consider this an overall medium risk. This is based on the following observations and assumptions:

- The investigation completed at the site to date does not assess the site in terms of its future development, however, SLR has acknowledged that delineation and remediation planning have not yet been completed to the level of detail required to support a planning application as this work will be conducted once the final footprint, layout and phasing of the development has been completed. SLR has indicated that once detailed development plans for the site are confirmed, an investigation strategy and phased remediation plan will be developed in consultation with local regulators and the EA;

- The exploratory investigations completed to date have not indicated significant contamination in terms of soil. In terms of groundwater, elevated petroleum hydrocarbon, metal and inorganics contamination has been identified. Elevated methane concentrations have also been identified at the site. However, provided the additional investigation are completed at the site and URS' comments in this report are taken into consideration, the remedial options identified by SLR are considered viable; and

- The schedule proposed to complete further investigation and remediation at the site is considered reasonable. With regard to Waste Management Licence surrender, the EA[3] are satisfied with SLR's proactive approach to-date and do not envisage any major difficulties in achieving this within the proposed time-scale.

[3] Telecom with Ms. Katherine Manson (EA Officer) 7 March and 11 April 2007.

1. INTRODUCTION

The adopted West Sussex Structure Plan (2005) identifies the western side of Crawley to accommodate a Strategic Development Location of up to 2,500 dwellings and associated uses and infrastructure. The area of study covers a broad strip of land that arcs around the West and North West of Crawley, see Figure 1.1. This area of study is directly adjacent to Crawley Borough Council's boundary but lies predominantly within Horsham District Council's administrative area. As a consequence, the two Councils have been working together formally on formulating an Evidence Base for the identification of the precise location and form of the Strategic Development Location, which will be set in a Joint Area Action Plan.

The authorities' approach to the Strategic Development Location is set out in their respective Core Strategies[4], which includes a commitment to producing a Joint Area Action Plan for the Strategic Development Location. The Joint Area Action Plan will become a Development Plan Document to be adopted as part of the suite of documents that make up the Local Development Framework for each Council. The steps towards adoption of the Joint Area Action Plan as a Development Plan Document are outlined in Table 1.1.

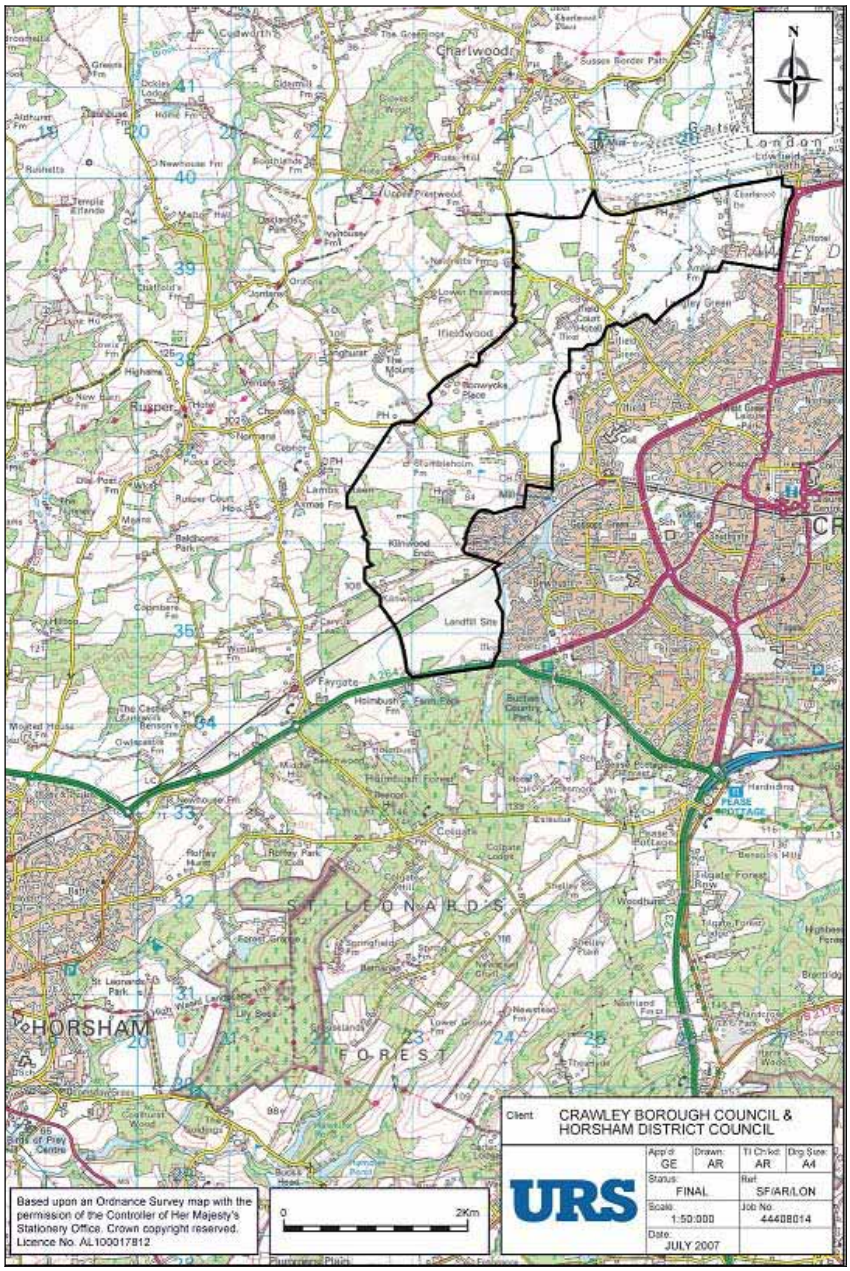
Table 1.1 Timetable for the Joint Area Action Plan for the West & North West of Crawley

Timescale	Key Stage
Oct-Nov 2006	Publication of Issues & Options Paper
Nov 2006	Workshops with Stakeholders
Sept-Oct 2007	Publication and formal consultation on 'Preferred Options' Joint Area Action Plan for the West & North West of Crawley
Apr-May 2008	Submission to Secretary of State of Joint Area Action Plan for the West & North West of Crawley
Dec-Jan 2008/09	Public Examination into Joint Area Action Plan (DPD) for the West & North West of Crawley
July 2009	Adoption of Joint Area Action Plan (DPD) to incorporate Inspector's comments

Source: Horsham District Council & Crawley Borough Council, 2007

[4] Horsham District Council's Core Strategy was adopted by the Council in Feb 2007. Crawley Borough Council's Core Strategy has undergone an examination and awaits the Planning Inspector's report into its soundness (due at the end of July, 2007)

Figure 1.1: The Area of Study for the West and North West of Crawley Joint Area Action Plan



Source: URS derived from Horsham District Council & Crawley Borough Council

The Joint Area Action Plan Issues & Options Paper (2006) outlines the issues and opportunities associated with development to the West and North West of Crawley. The report identifies the areas of research needed to produce a robust and credible evidence base for the Preferred Options Joint Area Action Plan. URS Corporation Ltd. (URS) has been commissioned by both Horsham District Council and Crawley Borough Council to produce work and studies for a number of elements informing the evidence base:

- Appraisal of Remediation and Landfill Studies;
- Appraisal of Transport Studies;
- Employment Provision;
- Neighbourhood Assessment; and
- Development Viability

This study is therefore one of five distinct but integrated research studies undertaken by URS that also form part of a wider body of work being undertaken simultaneously by both Councils and their respective consultants to inform the Joint Area Action Plan Preferred Options.

1.1. Appraisal of Remediation and Landfill Studies

URS is pleased to present Crawley Borough Council and Horsham District Council with this appraisal of environmental site investigations completed at Bewbush Landfill, Bewbush, Crawley, West Sussex (the site) (Figure 1, Volume II of report).

Bewbush Landfill is an inert landfill (approximately 36 hectares infilled) located in the Area of Study, as detailed in the previous section.

Site investigations at the Bewbush Landfill site were completed by SLR Consulting Limited (SLR) on behalf of Crest Nicholson in order to obtain surrender of the Waste Management Licence (WML), in terms of agricultural land use, following the landfill's closure in May 2006.

The investigations have been undertaken in phases as detailed below:

- Preliminary Environmental Review, August 2002;
- Risk Based Monitoring Review, April 2003;
- Preliminary Completion Report, 2005;
- Closure Plan, October 2006; and
- Summary Report, February 2007.

1.2. Objectives

In order for the Councils to understand the implications of developing the landfill site (particularly with regard to residential development), they required an appraisal of the landfill studies and a feasibility assessment for developing at this location. Therefore, the objective of this report was to provide an appraisal of the investigation works completed

at the landfill site and assess potential environmental data gaps and describe potential environmental issues.

The objective of the work was also to assess the viability of remediation works proposed for the site.

It was envisaged that this report would facilitate the identification of a development area to support the authorities in progressing site-specific proposals in the Preferred Options JAAP and to provide a clearer understanding of the constraints and opportunities for the identified 'developable' area.

2. SCOPE OF WORK

2.1. Review of Landfill Studies

In terms of document review the following information was evaluated:

- The environmental sensitivity of the site setting in terms of the geology, hydrogeology, hydrology, nearby land uses and the presence of nearby sensitive receptors;
- Potentially contaminative uses of the site and surrounding area as shown on the available historical maps/photographs etc.; and
- Preliminary Conceptual Site Model (CSM), as developed by URS.

2.2. Data Gap Analysis

Based on the preliminary CSM a data gap analysis of the available data was completed to determine if sufficient investigation works have been carried out to assess the risk to human health (practically in relation to future residential users) and controlled waters receptors, and to support the recommended remediation works for the site. This included the following:

- Appraisal of site investigations completed;
- Assessment of potential environmental data gaps and potential environmental issues; and
- Based on data provided, completion of a Generic Quantitative Risk Assessment (GQRA) to assess the risk present to human health and controlled waters from the site.

2.3. Remediation Methodology Viability Assessment

It was originally proposed to complete a viability assessment of the proposed remediation methodology, which would take consideration of the following:

- Conceptual Site Model (CSM);
- Remedial options review and the selected option;
- Effectiveness of remedial option in terms of addressing potential risks to human health and controlled waters,
- Performance criteria for remediation;
- In-process and post remediation groundwater monitoring programme;

- Permitting requirements; and
- Validation process.

However, as detailed in Section 1, the SLR landfill studies have been completed in terms of surrendering the WML. Therefore, only limited details on remediation proposals have been provided and a master plan indicating the proposed site layout is not yet available.

SLR has indicated they are considering two potential remedial options for the site, which have been assessed in terms of viability in Section 6. This section also assesses the risk of identifying the Bewbush Landfill site as a 'developable' site within the preferred option JAAP, given the stage of the investigation.

3. REVIEW OF LANDFILL STUDIES

Reports completed by SLR have included:

- Preliminary Environmental Review, August 2002;
- Risk Based Monitoring Review, April 2003;[5]
- Preliminary Completion Report, 2005;[6]
- Closure Plan, October 2006; and
- Summary Report, February 2007.

Following request from URS the following additional information was provided for review:

- Boreholes and trial pit logs from the 2004 investigation;
- Laboratory data for the 2002 and 2004 investigations;
- Gas monitoring data for the period 2004 to 2007;
- Groundwater data for the period 2002 to 2004; and
- SLR letter dated 23 April 2007 outlining their proposed additional investigation and proposed remediation strategy options.

3.1. Environmental Sensitivity

The following assessment of environmental sensitivity is based on information provided in the SLR reports and URS in-house data (geology, hydrogeology maps etc.).

3.1.1. Site Setting

Bewbush Landfill is located on the western boundary of the town of Crawley, in a predominantly agricultural area. Approximately 36 hectares of site has been infilled (Figure 1). To the south lie the A264 and Holmbush Potteries Industrial Estate. The Horsham-Crawley rail link is located to the north. Further north agricultural land and woodlands are present. The Bewbush neighbourhood of Crawley is located to the east and northeast of the site. Agricultural land lies to the west.

[5] This was not provided to URS for review, as it remains in draft format according to SLR. However, the groundwater data contained in the report has been provided.

[6] This was not provided to URS for review. SLR has indicated the information is contained within the Summary Report.

3.1.2. Geology

Made Ground

The 2002 and 2004 site investigations indicated that Made Ground (infilled area) extends to depths of between 0.35 m and 12 m below ground level. The Made Ground generally consisted of silts and clays with occasional wood, timber, textiles, plastic, metals and porcelain present.

Drift

Drift geology at the site consists of sands and gravels and Alluvium. Alluvium has been recorded in the vicinity of Bewbush Brook (located in the north portion of the site). An outcrop of River Gravels (1st and 2nd Terraces of the River Mole) have been recorded in the eastern portion of the site.[6] The thickness of these lithologies is not known.

Solid

The geological map for the site indicates that Weald Clay underlies the majority of the site.[7] Weald Clay consists of Shales and Mudstones and contains horizons of nodular Ironstone, Limestone and Sandstone. The geological map indicates the thickness of Weald Clay as up to 330 m. The thickness of this lithology at the site is not known, as investigation locations were terminated when clay was encountered. The maximum depth of Weald Clay encountered at the site was 9.5 m below ground level (BH5). The maximum thickness encountered was 3.5 m (BH2).

The map indicates that Horsham Stone (thinly bedded calcareous sandstone) outcrops in the northern part of the site (north of Bewbush Brook), parallel to the railway line. However, trial pit and borehole logs for the site do not indicate that Horsham Stone was encountered in this area (trial pits or boreholes generally terminated in Made Ground or clay at this location). The geological map indicates that the Horsham Stone (if present) dips in a northern direction (beyond the site boundary), therefore, it would not be present beneath of the site, south of the brook.

3.1.3. Hydrogeology

The Weald Clay is classified as a non-aquifer due to its low permeability and minor quantities of groundwater.

Groundwater monitoring completed at the site indicates groundwater is present within the fill material (likely perched). The water table is at a higher elevation than Bewbush Brook indicating the inferred groundwater flow direction is north, towards the brook.

SLR reported that there are no licensed groundwater abstractions within 1 km of the site.

3.1.4. Hydrology

SLR reported that several ponds acting as settlement lagoons and surface water ditches are present at the site. It is understood that these drain into Bewbush Brook via a culvert.

[7] Geological Map 1:50,000 scale for Horsham, Sheet No. 302, Solid and Drift Edition.

Bewbush Brook is located in the northern portion of the landfill. The brook is channelled through the landfill and flows from west to east. It is not known if the brook is clay lined. It reportedly flows into Ifield Mill Pond to the north east of the site. This flows into Ifield Mill Stream and then Ifield Brook, which discharges into the River Mole, located 6 km from the site.

Historically a mill pond was located in the northeast portion of the site. It is likely to have been created by the impoundment of Bewbush Brook. The location is currently infilled.

The current EA river quality data for the River Mole (2003 - 2005) classifies the river as B in terms of chemical and biological parameters (A as being very good, down to F, for poor quality). It also is considered Grade 2 in terms of nitrates and Grade 5 in terms of phosphates (Grade 1 indicating a very low presence of nutrients, up to Grade 6, indicating a very high presence of nutrients).[8] There was no river quality data for Bewbush Brook, Ifield Mill Stream and Ifield Brook.

The EA has conducted an assessment of the potential impact/vulnerability of water bodies and their risk of failing to achieve the objectives of the Water Framework Directive in 2015. The results of the assessments are displayed through maps that give an indication of which water bodies are at risk. Ifield Mill Stream, Ifield Brook and the River Mole have been classified as high risk by the EA in terms of meeting the Water Framework Directive. However, it should be noted that these assessments do not reflect the quality or status of a water body at the moment, and being 'at risk' does not mean that a water body has already failed its objectives, only that it might do so.[9]

3.1.5. Site History

Landfilling commenced at the site in 1977 and continued until May 2006. Solid waste accepted included class 4 I *construction waste*; 4 IV *waste arising from construction or maintenance of highways*; and Class 5 XIX *excavated materials in their natural state*. Municipal waste was not accepted at the site.

A summary of land use is provided in the Table 3.1.

[8] http://www.environment-agency.gov.uk/maps/info/river/ (accessed 4/5/07)
[9] http://www.environment-agency.gov.uk/subjects/waterquality/?lang=_e (accessed 16/4/07)

Table 3.1: Land Use History

Date	Description
1879	The site appears to be used for agricultural purposes with Bewbush Pond located in the north portion of the site. Surrounding land use comprises agricultural land with scattered woods. Scattered residential and industrial properties include Bewbush Mill northeast of the site; Manor House southeast of the site; the Brick, Tile and Pottery Works; and Hopper Farm, located to the southwest of the site
1899	Site appears unchanged. Minor changes to Bewbush Mill (disused)
1913	Site appears unchanged
1938-1946	Site appears unchanged (western portion of the site is not provided in these maps)
1963-1968	Bewbush Pond appears vegetated. A large residential development is present to the northeast of the site
1978-1979	Bewbush Pond is no longer present, however, Bewbush Brook is indicated transecting the north portion of the site. Drains are located on the north of the site connecting to Bewbush Brook. The large residential development to the northeast of the site and the pottery to the southwest of the site have expanded
1992	The residential development has extended southwards towards the A264
1999-2000	The north of the site appears to be infilled. An industrial estate is indicated to the south (east of the pottery works)

SLR reported that, with the exception of historical bell pits in the eastern portion of the site and recent clay borrow pit excavations within the southern portion of the site, there was no record of excavation/quarrying within the site.

3.2. Preliminary Conceptual Site Model

3.2.1. Introduction

Using the information outlined in the above section a Conceptual Site Model (CSM) was developed to understand the potential risks posed to sensitive receptors, by potential contamination from the site. Its purpose was to identify the following:

- Sources of contamination associated with the site;
- Potential receptors susceptible to adverse effects that may arise from impact; and
- Migration and exposure pathways through which receptors may be exposed to impact.

A potential risk can only be present if a complete source-pathway-receptor chain is present. This is known as a *complete pollutant linkage*. The following section outlines the potential sources, pathways and receptors arising on the site and summarises the complete pollutant linkages that are present as a result. The CSM for the site has been constructed assuming a low density residential (gardens) land-use for the site.

3.2.2. Sources of Contamination

Potential sources of contamination from the site include the following:

- Potential soil, soil gas and groundwater contamination associated with waste material landfilled at the site.

3.2.3. Receptors of Contamination

The site specific receptors have been identified based on the expected future land-use as well as the environmental setting of the site. Potential receptors are as follows:

- Future on-site residents (human health receptor): In accordance with current UK guidance contained within R&D Publication CLR10,[10] the critical receptor for low density residential exposure is assumed to be a female child aged 0-6 years;
- Bewbush Brook (controlled waters receptor): As discussed in Section 3.1.4 Bewbush Brook is located in the northern portion of the landfill and is the nearest surface water body. This discharges to Ifield Mill Stream, which has been classified as high risk by the EA in terms of meeting the Water Framework Directive; and
- Aquifer (controlled waters receptor): A potential receptor of contamination is an aquifer underlying a site. However, the Weald Clay is classified as a non-aquifer and there are reportedly no licensed groundwater abstractions with 1 km of the site. Therefore, this is not considered a controlled waters receptor of contamination. Horsham Stone, is indicated on the geological maps as outcroping in the northern portion of the site. The geological map indicates that the Horsham Stone (if present) dips in a northern direction (beyond the site boundary), therefore, it would not be present beneath of the site, south of the brook. The Horsham Stone could potentially be water bearing, however, trial pit and borehole logs for the site indicate that the Horsham Stone was not

[10] DEFRA, (2002-2004) Contaminated Land Research (CLR) Reports 7-11 ICRCL Guidance Note 59/83 (2nd edition).

encountered and trial pits or boreholes generally terminated in Made Ground or clay at these locations. Therefore, this is not considered a controlled waters receptor at the site.

3.2.4. Pathways

The evaluation of exposure pathways for controlled waters receptors requires an understanding of the geological and hydrogeological characteristics beneath the site. The potential controlled waters exposure pathways are summarised in Table 3.2 below, and are based on the geology, hydrogeology and other site information described in Section 3.1 of this report.

Table 3.2: Site Specific Exposure Pathways (Controlled Waters)

Controlled Waters Exposure Pathway	Controlled Waters Receptor
Leaching and downward vertical migration to groundwater of potential contaminants from continuing or residual soil sources via infiltration	✓
Vertical migration of groundwater through the Weald Clay (not considered a receptor as classified as a non-aquifer as detailed in Section 3.3.2)	×
Horizontal migration of groundwater through the waste material to Bewbush Brook as base flow	✓

✓ *Pathway present* × *Pathway absent*

Human health exposure pathways are dependent on land end use. As such, the human health exposure pathways that must be considered for low density residential land use according to the UK guidance set out in R&D Publications CLR10 are listed below in Table 3.3.

Table 3.3: Site Specific Exposure Pathways (Human Health)

Human Health Exposure Pathway	Future Occupants of the Site
Direct soil and dust ingestion	✓
Consumption of vegetables	✓
Soil attached to vegetables	✓
Indoor dermal soil and dust contact	✓
Outdoor dermal soil and dust contact	✓
Indoor inhalation of fugitive dust	✓
Outdoor inhalation of fugitive dust	✓
Indoor inhalation of vapours (from soil and groundwater)	✓
Outdoor inhalation of vapours (from soil and groundwater	✓

✓ *Pathway present* × *Pathway absent*

3.2.5. Complete Pollutant Linkages

Following the evaluation of potential contaminant sources, human and environmental receptors, and exposure pathways, the expected completed pollutant linkages associated with the site are summarised in Table 3.4:

Table 3.4: Summary of Complete Pollutant Linkages

Receptor	Medium/ Source	Pathway														
		1) Direct soil and dust ingestion	2) Consumption of vegetables	3) Soil attached to vegetables	4) Indoor dermal contact	5) Outdoor dermal contact	6) Indoor inhalation of fugitive dust	7) Outdoor inhalation of fugitive dust	8) Ingestion of groundwater	9)Dermal contact with groundwater	10) Indoor inhalation of vapours	11) Outdoor inhalation of vapours	12) Leaching from unsaturated zone	13) Vertical groundwater migration	14) Horizontal groundwater migration	15) Direct migration to groundwater via site drainage
Future On-site Resident	Soils	✓	✓	✓	✓	✓	✓	✓			✓	✓				
	Groundwater										✓	✓				
Surface Water (Bewbush Brook)	Soils												✓			
	Groundwater														✓	✓
Groundwater (Horsham Stone)	Soils															
	Groundwater															
✓ *Pathway Present* × *Blank if Absent*																

Therefore, the complete pollution linkage table indicates a potential risk, through the various pathways as outlined above, to the following receptors:

- Future on-site residents; and
- Bewbush Brook.

4. DATA GAP ANALYSIS

As discussed in Section 1.1, the SLR investigations completed to date were conducted to assist in surrendering of the WML, rather than for the assessment of potential risk from the site in terms of future residential land use. However, the following data gap analysis has been completed based on the *complete pollution linkages* identified in the preliminary CSM, which indicates a potential risk, through various pathways, to future on-site residents and Bewbush Brook.

4.1. Soil and Groundwater Investigation

Data from two phases of investigation completed at the site (2002 and 2004) have been provided to URS for review.

2002

As the landfill was still operational, the 2002 investigation concentrated on the northern portion of the landfill and comprised the following:

- Thirty three trial pits (TP1 – TP33) were excavated. Thirty of the trial pits were excavated within the infilled area and three were excavated east of the infilled area, but within the WML. No soil samples were collected for analysis (it is understood that trial pitting was completed to investigate ground gas concentrations (see Section 4.2) and to provide a visual assessment of waste material deposited at the site);
- Eight groundwater wells (BH1 to BH8) were installed and eight groundwater samples were collected for analysis.[11] Eight soil samples were collected for analysis from BH1 (2.5 m – 3.0 m and 4.0 m), BH3 (1.0 m and 5.0 m), BH6 (3.5 m, 5.5 m and 7.0 m) and BH7 (2.0 m);
- Four surface water samples were collected. SW1 was collected from a tributary ditch, which drains to Bewbush Brook from the materials recycling facility, west of the infilled area. SW2 was collected from the brook upstream of the site, SW3 was collected from the brook in the centre of the site, and SW4 was collected from the brook on the downstream site boundary; and
- Soil, groundwater and surface water samples were analysed for metals, inorganics, solvent extractable matter and phenols.

See Figure 2 for sample locations.

[11] Groundwater monitoring has been completed at these wells on a monthly or quarterly basis from 2002 to 2007.

2004

The 2004 investigation comprised the following:

- Fifty three trial pits (TP101 – TP153) were excavated. Twenty six were located within the infilled area (TP128 – TP153); seven were located in an area used as a recycling depot, east of the infilled area but within the WML area (TP121 to TP127); and ten were located within a field west of the WML area (TP101 to TP120);[12]
- Forty five soil samples were collected for analysis;
- Twelve grab groundwater samples were collected from certain trial pits. It is noted that according to BS10175:2001 (Investigation of potentially contaminated site – Code of Practice) water samples collected from trial pits at the time of excavation are unlikely to provide a reliable representation of groundwater quality due to the ground disturbance affecting the composition of the water. However, the results can provide preliminary information, which can assist in the design of a subsequent groundwater monitoring programme;
- Ten boreholes were advanced (BH9 - BH19), however, only six were converted to groundwater monitoring wells (BH9, BH11, BH15, BH17, BH18 and BH19);[13]
- Up to four groundwater monitoring rounds were completed during 2004. According to SLR (letter dated 23 April, 2007) monitoring ceased at these wells in 2004 as they were lost or damaged);
- Eight soil samples were collected for analysis from BH10 (0.9 m and 2.7 m), BH11 (1.4 m), BH12 (2.5 m), BH13 (1.8 m), BH15 (2.9 m – 3.0 m), BH17 (4.5 m) and BH18 (3.0 m);
- Surface water sampling was completed at SW1 to SW4; and
- Soil, groundwater and surface water samples were analysed for metals, inorganics, phenols, total Polycyclic Aromatic Hydrocarbons (PAH) and limited Extractable Petroleum Hydrocarbons (EPH) and speciated PAHs (soils and groundwater only).[14]

See Figure 2 for sample locations.

[12] According to SLR this is outside the WML, but was infilled under a verbal agreement with the EA.

[13] According to SLR, monitoring wells were not installed in these boreholes as they were considered to duplicate existing monitoring points adjacent to Bewbush Brook.

[14] Ten of the soil samples were only submitted for inorganic analysis - ammoniacal nitrogen, chloride, magnesium, nitrite, soluble sulphate and total sulphur.

4.1.1. Soil Sample Density

For the 2002 and 2004 investigations, in total 64 investigation locations were completed within the infilled area (an area of 36 hectares) and 42 soil samples were collected for analysis. This equates to an average sampling density of one analysed sample per 8,500 m^2, or a sample grid with a 93 m centre.

This sampling density is less than that recommended in BS10175:2001 (Investigation of potentially contaminated site – Code of Practice), which recommends 50 m to 100 m centres for exploratory investigations but 20 m to 25 m centres for main site investigations. Furthermore, it recommends that a greater sample density (10 m centres) could be considered where a high level of confidence is required for the outcome of the assessment, (i.e. in the case of residential development).

Generally less than one sample was collected per investigation location. URS would recommend a minimum of two samples (shallow and deep soil) per investigation location should be collected for analysis to provide vertical profile of contamination.

4.1.2. Groundwater Well Density

A total of fourteen groundwater monitoring wells were installed as part of the investigation and groundwater monitoring has been completed at BH1 to BH8 on a monthly or quarterly basis since 2002. However, the wells are generally concentrated in the northeast portion of the landfill (a limited number of wells were installed in the southern portion possibly due to this area being infilled up until May 2006).

This is not considered to represent reasonable coverage for the general assessment of groundwater quality at the site, given that the groundwater beneath the site is likely to provide base flow to Bewbush Brook.

4.1.3. Surface Water Sample Density

Bi-monthly sampling of surface water in Bewbush Brook has been completed at four sample locations since 2002, which is considered appropriate given the size and location of the brook. However, URS understands that no contact has been made to date with the Environment Agency regarding the regional importance of this surface water feature and also its environmental sensitivity. This should be completed given that it discharges to Ifield Mill Stream, which has been classified as high risk by the EA in terms of meeting the Water Framework Directive.

Please note that URS understands that as of the date of this report SLR propose to complete additional investigations as detailed in Section 4.4.

4.1.4. Laboratory Analytical Quality

Soil samples were analysed for metals, sulphate, cyanide, phenols and limited organic analysis (speciated PAH and EPH was analysed on four samples only). Groundwater was analysed for metals, inorganics and, similarly limited organics (organic analysis was conducted on groundwater samples collected from trial pits only). Surface water was

analysed for metals and inorganics, no organic analyses was completed. URS consider that insufficient samples were scheduled for organic analysis (PAH and petroleum hydrocarbon (TPH)).

Where EPH and total PAH analysis was completed, a basic analytical technique was used that does not provide the required speciation of component total petroleum hydrocarbon (TPH) fractions and PAH compounds to satisfactorily assess potential risks. For the assessment of TPH contamination against appropriate generic assessment criteria, recent regulatory guidance requires collection of speciated data that will provide information regarding the component fractions and compounds. For the assessment of potential risk due to PAH, an indication of the concentration of specific individual PAH compounds is required.[15]

The type of metal and inorganic chemical analyses completed is considered to be acceptable for the assessment against generic appropriate screening criteria. However, certain metal analysis was not completed in all water samples, such as arsenic, mercury and boron, that could be potential contaminants of concern associated with the waste material.

4.1.5. Assessment of Analytical Results

Once the potential for significant risk has been identified at a site (in terms of the identification of *complete pollutant linkages*), a quantitative assessment of these risks is required. The first stage of quantitative assessment is generic quantitative risk assessment (GQRA), which involves the comparison of site chemical data (soil, groundwater and surface water analytical results) with generic assessment criteria (GAC). GAC may be chosen based on the intended land-use and are designed to identify contaminants that could pose a potential risk to future site users and other sensitive environmental receptors. Exceedance of GAC does not necessarily mean that a risk exists; rather, they are an indication that a more detailed level of assessment is required.

The GQRA completed as part of the SLR assessments is considered limited. For the 2002 investigation no assessment criteria were used to screen soil or water data. It was stated that the fill material was uncontaminated, however, the basis of this assessment was not given.

For the 2004 investigation, soil analytical results were compared to UK Soil Guideline Values (SGVs)[16], which indicated a cadmium exceedance at the site. The SGVs are considered appropriate for the assessment of human health risk, however, currently there

[15] In order to assess potential risks from hydrocarbon contamination, an understanding of the carbon banding and aliphatic/aromatic split of the component compounds is required. This follows recent UK guidance on the assessment of hydrocarbon risks (EA Science Report P5-080/TR3).

[16] UK Soil Guideline Values published by DEFRA and the EA and developed using the Contaminated Land Exposure Assessment (CLEA) model.

are only ten SGVs,[17] and therefore a full assessment of potential contaminants of concern cannot be completed using SGVs alone. URS compare data against SGVs, Generic Acceptance Criteria developed in house in accordance with the methodology outlined by CLEA in EA/DEFRA R&D Publications CLR7-10 and against criteria from other countries, (as detailed in 5.1.1).

SLR compared groundwater and surface water analytical results against UK Drinking Water Standards, which indicated numerous exceedance of ammoniacal nitrogen, metals and sulphate in groundwater. However, given that the controlled waters receptor is a surface water body (Bewbush Stream), environmental quality standards (EQSs), where available, would be considered more appropriate.

In order to assess the potential risk to sensitive receptors, which were identified in the preliminary CSM, URS has completed a GQRA using data provided by SLR, as detailed in Section 5.

4.2. Gas Investigation

2002

As discussed in Section 4.1, 30 trial pits were excavated within the infilled area during the 2002 investigation. Piezometers were installed in each of the backfilled trial pits to provide gas monitoring data. The eight groundwater wells installed (BH1 to BH8) were also completed as gas wells.[18]

2004

The 2004 investigation comprised the following:

- Ten boreholes were advanced (BH9 - BH19), however, only six were converted to gas monitoring wells (BH9, BH11, BH15, BH17, BH18 and BH19) (as four were considered to duplicate existing monitoring points adjacent to Bewbush Brook);
- Up to two gas monitoring rounds were completed at these wells during 2004 (according to SLR monitoring ceased at these wells in 2004 as they were lost or damaged); and
- A survey of soil gas surface emissions (walk-over survey) and flux box survey was also completed in 2004.

[17] Arsenic, cadmium, chromium, lead, inorganic mercury, nickel, selenium, phenol, ethylbenzene and toluene.

[18] Gas monitoring has been completed at BH1 to BH8 from 2002 to 2007.

4.2.1. Ground Gas Sampling Density

Piezometers were installed in the thirty trial pits excavated during 2002, however, in accordance with current guidance,[19] standpipes in trial pits are not recommended for ground gas investigations (backfill material may allow venting). This technique can be used to provide an indication of the presence and concentration of ground gas but cannot prove its absence.

A total of fourteen gas monitoring wells were installed as part of the investigation. However, the wells are generally concentrated in the northeast portion of the landfill (a limited number of wells were installed in the southern portion possibly due to this area being infilled up until May 2006).

Monitoring has been completed at BH1 to BH8 on a monthly or quarterly basis since 2002, which has provided a good range of gas concentrations and flow rates. However, only two monitoring events were completed at the remaining six boreholes as the wells were lost or damaged. This is not considered acceptable to assess the effects of varying metrological conditions, which can affect the rate of gas production at a site. At least six gas monitoring rounds are recommended over a period of three months.[19]

A flux box survey was also completed in 2004. This gives good indication of rates of gas emission at ground surface, which can be related directly to volumes that could accrue in buildings (to be used in a more site specific risk assessment).

Please note that URS understands that as of the date of this report SLR proposes to complete additional ground gas investigation as detailed in Section 4.4.

4.2.2. Gas Assessment

The 2002 report refers to methane rich soils, possibly associated with wood and organic matter in the area of the old mill pond, located in the northern portion of the site. However, no ground gas data was provided in the report.

Landfill gas concentrations have been provided in the Summary Report but are not compared to industry guidance/screening criteria. The report indicates that the relatively high concentrations of methane present correspond to the footprint of Bewbush Brook, which is likely, due to high organic material being present in this area. However, elevated methane concentrations have also been detected in wells outside this area (BH3, BH5, BH7 and BH8).

In order to assess the potential risk to sensitive receptors URS has completed a generic ground gas assessment as detailed in Section 5.

[19] Guidance on Evaluation of Development Proposals on Sites Where Methane And Carbon Dioxide Are Present, Report Edition No. 04, NHBC and RSK Group Plc., March 2007.

4.3. Geotechnical

A review of the geotechnical assessment was not part of this scope of work, however, as geotechnical assessments were provided in the SLR Summary and Closure reports, a brief review of these sections is given below.

Preliminary foundation recommendations provided in the Summary Report for the landfill include ground improvement with stone columns for housing foundations and surcharge of other areas (roads, drains, etc) to provide compatibility of settlements.

Based on the general geotechnical characteristics of the site, the preliminary recommendations provided in the Summary Report appear reasonable, subject to removal of any non-inert material.

URS are aware of two sites in the UK where stone column ground improvement techniques have recently been implemented on landfill areas. However, its application is relatively new and requires detailed investigation and analysis to address all the geotechnical issues. The report includes sufficient information to provide desk study/preliminary recommendations. However, for final foundation designs, further geotechnical intrusive works and testing would be required.

Further geotechnical investigations and analysis are recommended to include the following:

- Soil strength and stiffness parameters;
- Bearing capacities, pre ground improvement settlements analysis and earth pressure coefficients;
- Dewatering measures or leachate control measures for excavations;
- Stone column detailed design (layout, length and diameter);
- Consolidation analysis (Time vs Settlements curves) and recommendations on best alternatives for surcharge including fill specifications and extent of loaded area; and
- Post ground improvement settlement analysis.

Typical parameters have been assumed for the stability risk assessments. These parameters will need to be confirmed once soil strength parameters have been determined.

4.4. Proposed Additional Investigation

Since the commencement of this assessment SLR has provided a letter (dated 23 April 2007) indicating their proposed plans for additional assessment at the site, which they propose to complete in late 2007 (the first phase has recently been completed).

Figure 6 provides indicative locations of additional trial pitting (174), boreholes (nine), gas monitoring probes (ten) and an additional surface water sampling location.

SLR reported that these investigations will examine soil conditions from a land quality perspective, subject to confirmation of the development layout and ground profile as part of the master plan for the site. URS propose that the investigations should also be used to address data gaps identified in this Section of the report.

5. GENERIC QUANITATIVE RISK ASSESSMENT

In order to assess the potential risk to sensitive receptors, which were identified in the preliminary CSM (Section 3.2), URS has completed a generic quantitative risk assessment of soil, groundwater and surface water at the site, using data provided by SLR (2002 and 2004 investigations).

5.1. Generic Screening Approach

This section presents the methodology of the Generic Assessment. A risk-based approach in accordance with Part IIA guidance[20] has been adopted for the assessment of data from the site. The data have been screened against criteria considered appropriate given the planned end use of the site (residential) and within the context of the site environmental setting, in order to assess the significance of identified contamination (if present).

Contaminant concentrations in soil and groundwater at the site were deemed 'potentially significant' where they exceeded the 'generic' values. These values are used for initial screening of contaminant concentrations for the purpose of providing an initial indication of contamination at a site and evaluating the compounds that should proceed to a detailed assessment. As such, it should be noted that generic exceedances are not an indication of the requirement for remediation but rather, an indication of the need for further assessment. Additionally, where further risk assessment is considered necessary, use of more site specific information in the assessment can often lead to the conclusion that the observed concentrations are present at levels which represent an acceptable level of risk, considering the actual or proposed end use of a site (although each site assessment does have to be considered on an individual basis).

For the purposes of this report, a preliminary assessment of the potential risks arising from identified contamination has been carried out by comparing the concentrations recorded in soil and groundwater against appropriate guideline values. Given the environmental setting of the site, the following receptors have been identified: Bewbush Brook (controlled waters receptor) and future residents (human health receptor). The generic guideline values used are described below and are based on the UK guidance residential land-use scenario.

The assessments of risks described herein focus on the long-term exposure to human health and the environment and an evaluation of chronic exposure. Short term acute exposure during construction works are outside the scope of this report and should be addressed using site and method specific assessment and mitigation measures in accordance with prevailing legislation and guidance.

[20] Part IIA of the Environmental Protection Act, HMSO, DEFRA, (1990).

In terms of ground gas risk assessment, given that the proposed future use of the site is residential, a recent document commissioned by the National House-Building Council (NHBC)[21] was used to assess ground gas concentrations.

In order to remove uncertainty from ground gas risk assessment, the authors of the NHBC document have taken account of existing publications on ground gas and derived a series of 'Traffic Lights' that can be applied to the assessment of ground gas for low rise residential development.[22]

Two other research projects on ground gas are currently being completed by the Construction Industry Research and Information Association (CIRIA) and Environment Industries Commission (EIC). These organisations have been consulted during the preparation of the NHBC document in order that results are generally consistent and conflicting advice has not been produced.

5.1.1. Generic Guideline Values for Human Health

Soil data has been compared against generic screening criteria taken from the following sources in order of preference:

- UK SGVs – UK Soil Guideline Values published by DEFRA and the EA and developed using the Contaminated Land Exposure Assessment (CLEA) model;
- URS GACs – URS Generic Acceptance Criteria developed by URS in accordance with the methodology outlined by CLEA in EA/DEFRA R&D Publications CLR7-10; and
- Other criteria from national and international organisations including VROM (2000)[23] and US EPA (2001, 2004a and 2004b).[24]

The criteria from international organisations have no legal status in the UK. However, as they have been derived using risk assessment techniques, they are considered to be acceptable as an initial screen at sites such as this (and their use is considered consistent with current guidance).

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[21] Guidance on Evaluation of Development Proposals on Sites Where Methane and Carbon Dioxide are Present, Report Edition No. 04, NHBC and RSK Group Plc., March 2007.

[22] As the master plan for the development is not yet complete, to provide a conservative assessment, low-rise residential properties are assumed (a non-flat/apartment development consisting of one to three storeys in height with domestic gardens).

[23] VROM (2000) Circular on target values and intervention values for soil remediation, VROM, The Hague, The Netherlands.

[24] *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*, Peer Review Draft, OSWER 9355.4-24, US EPA (2001). *Risk-Based Concentration Table*, Memo of 19th October 2004, from Jennifer Hubbard, Toxicologist, US EPA Region 3, US EPA (2004a). *User's Guide and Background Technical Document for US EPA Region 9's Preliminary Remediation Goals (PRG) Table*, October 2004 Update, US EPA (2004b).

In terms of controlled waters, leaching and downward vertical migration to groundwater of potential contaminants from soil sources via infiltration is considered a potential pathway, however, this is assessed in terms of groundwater data.

5.1.2. Generic Guideline Values for Controlled Waters

Groundwater data has been compared against generic criteria taken from the following sources, in accordance with guidance in EA R&D Publication 20, and in order of preference:

- Environmental Quality Standards (EQS's);
- UK drinking water standards taken from the Water Supply (Water Quality) Regulations 2000 and, as necessary, the Water Supply (Water Quality) Regulations 1989;
- World Health Organisation (WHO) Guidelines for Drinking Water Quality; and
- US EPA Region 9 tap water preliminary remediation goals.

It is noted that the most appropriate controlled waters screening criteria is dependent on the critical receptor. The site has a sensitive surface water receptor in the form of Bewbush Brook located in the northern portion of the north of the site, for which the EQS screening criteria are appropriate.

5.1.3. Ground Gas Assessment

As detailed in the NHBC document, the 'Traffic Light' assessment includes Typical Maximum Concentrations (TMC), which provide initial screening, and risk-based Gas Screening Values (GSVs) for consideration when TMC are exceeded. It is recommended that calculations should be for both methane and carbon dioxide and the worst case adopted in order to establish the appropriate protection measures.

It should be noted that the GSVs are based on a number of assumptions regarding proposed structures. When a master plan of the proposed development is complete the structures should be assessed, and if they differs significantly (e.g. deeper sub-floor void, increased ventilation etc.), site-specific GSV should be derived.

5.2. Analytical Results and Generic Screen

The laboratory analytical results have been screened against generic assessment criteria as described above. The following section describes the distribution of identified contamination across the site, including its significance in terms of the adopted screening criteria.

5.2.1. Soil Results

The analytical results for soils are presented in Table 1. Figure 3 provides an illustration GQRA screening criteria exceedance in soils at the site.

Extractable Petroleum Hydrocarbons

As the EPH analysis completed does not provide the required speciation of component TPH fractions to satisfactorily assess potential risk, the TPH fraction with the most conservative GAC was used to assess EPH concentrations in soils at the site.

EPH concentrations in all four samples analysed were observed to exceed the human health screening criteria. The highest concentration (685 mg/kg) was observed in soils at TP128 (1.4 m). No contamination observations were noted in the trial pit log for TP128, however, water seepage was observed at this depth. A slight diesel odour was noted in TP121 (1.5 m), which had the second highest EPH concentration (480 mg/kg).

Polycyclic Aromatic Hydrocarbons

PAHs were detected in all four samples analysed. Fluoranthene, benz(a)nthracene and benzo(a)pyrene exceeded the human health screening criteria at TP128 (1.4 m) (Figure 3). PAH concentrations in the other three samples were less their relevant human health screening criteria.

Thirty nine samples were analysed for Total PAHs. However, as this does not provide the required speciation of PAH compounds the assessment of potential risks could not be completed using this data.

Metals

The majority of the 48 samples analysed for metals had concentrations less than the human health screening criteria. The exception to this was TP117 (3.5 m), which had a nickel concentration (75 mg/kg) greater than the SGV of 50 mg/kg and BH15 (2.9 m – 3 m), which had a cadmium concentration (2 mg/kg) greater than the SGV of 1 mg/kg.

pH

Soil pH on site ranged from slightly acidic to slightly basic (4.91– 10.59). The lowest soil pH was observed in the sample from TP111 (3.0 m), while the highest was observed in the sample from TP127 (1.0 m). Although there is no criterion available for soil pH these results indicate a potential presence of acidic/basic contamination, which could result in the mobilisation of metals from soils to groundwater at the site.

5.2.2. Groundwater Results

The analytical results for groundwater are presented in Table 2. Figure 4 provides an illustration of GQRA screening criteria exceedance in groundwater at the site.

Extractable Petroleum Hydrocarbons

Similar to the soil analysis, the EPH analysis completed for groundwater does not provide the required speciation of component TPH fractions to satisfactorily assess potential risk, therefore, the TPH fraction with the most conservative GAC was used to assess EPH concentrations in groundwater at the site.

EPH analysis was only conducted on water samples collected from 12 trial pits (grab samples).[25] EPH concentrations were above the laboratory method detection limit in all samples analysed. Concentrations ranged from 0.25 mg/l (TP145) to 48.4 mg/l (TP130). Concentrations, in all samples analysed, were also above the adopted human health and controlled waters screening criteria.

Polycyclic Aromatic Hydrocarbons

Speciated PAH analysis was only conducted on water samples collected from 12 trial pits (grab samples). With the exception of TP123, concentrations of certain individual PAHs (Table 5.1 below) were above the adopted controlled waters screening criteria. Concentrations were less than the adopted human health screening criteria.

Table 5.1: PAH Exceedance

Parameter	Sample Location
Naphthalene	TP127
Fluoranthene	TP107, TP116, TP127, TP130, TP131, TP134, TP137 and TP145
Benz(a)anthracene	TP107, TP127, TP129, TP130, TP134, TP137 and TP145
Benzo(a)pyrene	TP107, TP127, TP129, TP131, TP134, TP137, TP139 and TP145
Dibenzo(a,h)anthracene	TP107, TP127, TP134, TP137 and TP145

Phenols

Phenol analysis was only conducted on water samples collected from the 12 trial pits. With the exception of TP107 and TP116, phenol concentrations were less than the adopted controlled waters and human health screening criteria in all samples analysed. Phenol concentrations detected in TP107 (2 μg/l) and TP116 (2.5 μg/l) were greater than the adopted controlled waters screening criteria of 0.5 μg/l.

[25] TP107, TP116, TP123, TP127, TP129, TP130, TP131, TP134, TP135, TP137, TP139 and TP145.

Metals and Inorganic

For metal and inorganics, data was provided from bi-monthly or quarterly monitoring completed from 2002 to 2004 at BH1 – BH8; one to four monitoring rounds completed at BH9, BH11, BH15, BH17, BH18, and BH19; and results from the grab sampling of the 12 trial pits (the analytical results are presented in Table 2). Exceedance of the adopted controlled waters and human health screening criteria for metals and inorganics were observed over the sample period as detailed in Table 5.2 below.

Table 5.2: Metal and Inorganic Exceedance

Parameter	Sample Location
Arsenic (only analysed in the trial pit grab samples)	TP107 (CW and HH), TP129 (HH), TP130 (HH), TP131 (HH), TP134 (HH), TP139 (HH)
Boron (only analysed in the trial pit grab samples)	TP107 (CW and HH), TP129, TP130, TP131, TP134 (HH), TP137 (CW and HH)
Cadmium	BH2 to BH4 (CW and HH), BH7 (CW and HH), BH15 (CW and HH), BH17 (CW and HH),
Chromium	BH3, BH4 and BH6 (HH), BH7 (CW and HH), BH15 (HH), BH17 (CW and HH), BH19 (HH)
Copper	BH8, BH9, BH17, BH18 (CW).
Iron	BH1 - BH8, BH9, BH11, BH15, BH17, BH18, BH19 (CW and HH)
Lead	BH1 to BH4 (CW and HH), BH5 (HH), BH6 and BH7 (CW and HH), BH8 (HH), BH9, BH11, BH15, BH17, BH18 (CW and HH), BH19 (HH)
Magnesium	BH2, BH4, BH5, BH7, BH8, BH17 (HH, no CW criteria)
Manganese (not analysed in the trial pit grab samples)	BH1 to BH8, BH9, BH11, BH15, BH17, BH18, BH19 (HH, no CW criteria)
Nickel	BH1 to BH3 (HH), BH4 (CW and HH), BH6 (HH), BH7 (CW and HH), BH8 (HH), BH9 (CW and HH), BH11 (HH), BH15, BH17 (CW and HH), BH18, BH19, TP127 (HH),
Selenium (only analysed in the trial pit grab samples)	TP107 TP129, TP134 (HH, no CW criteria)
Zinc	BH2 (CW and HH), BH3, BH4, BH6 (HH), BH7 (CW and HH), BH9 (HH), BH15 (CW and HH), BH17, BH18 (HH)
Ammoniacal nitrogen	BH1 to BH8, BH9, BH11, BH15, BH17 (CW and HH), BH18, BH19 (HH), TP107 TP116, TP123, TP127, TP129, TP130, TP131, TP134, TP135, TP137 (CW and HH)
Calcium (not analysed in the trial pit grab samples)	BH2, BH3, BH4, BH5, BH6, BH7, BH8, BH9, BH11, BH15, BH17 (HH, no CW criteria)
Chloride (not analysed in the trial pit grab samples)	BH1, BH5, BH6, BH7, BH8 (CW and HH)
Potassium (not analysed in the trial pit grab samples)	BH2, BH4, BH5, BH6, BH7, BH8, BH15, BH18 (HH, no CW criteria)
Sodium (not analysed in the trial pit grab samples)	BH5, BH7, BH8, BH18 (CW and HH)
Sulphate	BH2, BH4, BH5, BH7, BH8, BH11, BH17, BH18, TP107, TP123, TP127, TP131, TP135, TP137 (HH, no CW criteria)

CW = Controlled Waters, HH = Human Health

5.2.3. Surface Water Results

The analytical results for surface water are presented in Table 2. Figure 4 provides an illustration of GQRA screening criteria exceedance in surface water samples. The results represent the maximum concentration detected during the monitoring completed in 2002 to 2004. No EPH, PAH or phenol analysis was completed.

Metals and Inorganics

Cadmium concentrations were greater than the adopted controlled waters screening criteria of 0.01 mg/l at SW1 (0.04 mg/l), SW2 (0.03 mg/l) and SW3 (0.01 mg/l). Concentrations were less than the laboratory detection limit and screening criteria at SW4 (<0.005), the down gradient sample location.

Iron concentrations exceeded the adopted controlled waters screening criteria of 1 mg/l at all sample locations - SW1 (541 mg/l), SW2 (636 mg/l), SW3 (85.3 mg/l) and SW4 (51.7 mg/l).

Lead concentrations were greater than the adopted controlled waters screening criteria (0.25 mg/l) at SW1 (0.75 mg/l) and SW2 (0.43 mg/l). Concentrations were less than the screening criteria at SW3 (0.04 mg/l) and SW4 (0.02 mg/l).

There is no EQS for manganese, however, concentrations ranged from 149 mg/l (SW2) to 498 mg/l (SW4) and exceeded the Drinking Water Standard (0.05 mg/l) in all four samples.

Nickel concentrations exceeded the adopted controlled waters screening criteria of 0.2 mg/l at all sample locations - SW1 (0.42 mg/l), SW2 (0.44 mg/l), SW3 (2.3 mg/l) and SW4 (0.39 mg/l).

Exceedance of the adopted controlled waters screening criteria of 0.03 mg/l for ammoniacal nitrogen was observed at SW1 (3.9 mg/l), SW2 (1.1 mg/l), SW3 (4.4 mg/l) and SW4 (7.5 mg/l).

There is no EQS for potassium, however, concentrations ranged from 7.9 mg/l (SW3) to 886 mg/l (SW4) and exceeded the Drinking Water Standard (12 mg/l) in two samples (SW1 and SW4).

Exceedance of the adopted controlled waters screening criteria of 170 mg/l for sodium was observed at SW4 with a concentration of 3,820 mg/l.

There is no EQS for sulphate, however, concentrations ranged from 121 mg/l (SW3) to 276 mg/l (SW1) and exceeded the Drinking Water Standard (250 mg/l) in one sample (SW1).

5.2.4. Ground Gas Results

SLR has provided gas monitoring data from 2002 to 2007, which includes concentrations (Table 4) and flow rates of methane and carbon dioxide. These have been assessed

against the Typical Maximum Concentration (TMC) and Gas Soil Value (GSV) as detailed in Table 5.3 below, to determine the classification of the site in terms of ground gas risk.

Table 5.3: Gas Risk Assessment

Traffic Light Classification	Methane (CH_4)		Carbon Dioxide (CO_2)	
	Typical Maximum Concentrations (% v/v)	Gas Soil Value (l/hr)	Typical Maximum Concentrations (% v/v)	Gas Soil Value (l/hr)
Green				
	1	**0.13**	5	**0.78**
Amber 1				
	5	**0.63**	10	**1.60**
Amber 2				
	20	**1.60**	30	**3.10**
Red				

Taken from: *Guidance on Evaluation of Development Proposals on Sites Where Methane And Carbon Dioxide Are Present, Report Edition No. 04, NHBC and RSK Group Plc., March 2007.*

Based on the above table the gas protection measure recommended for low rise residential development is provided in Table 5.4 below.

Table 5.4: Ground Gas Protection Measures Required

Traffic Light	Ground Gas Protection Measures Required
Green	Ground gas protection measures are not required
Amber 1	Low-level ground gas protection measures are required, using a membrane and ventilated sub-floor void that creates a permeability contrast to limit the ingress of gas into buildings. Gas protection measures are to be installed as prescribed in BRE 414. Ventilation of the sub-floor void should be designed to provide a minimum of one complete volume change per 24 hours
Amber 2	High-level ground gas protection measures are required, creating a permeability contrast to prevent ingress of gas into buildings. Gas protection measures are to be installed as prescribed in BRE 414. **Membrane used should always be fitted by a specialist contractor and should be fully certified.** As with Amber 1, ventilation of the sub-floor void should be designed to provide a minimum of one complete volume change per 24 hours
Red	Standard residential housing is not normally acceptable without further ground gas risk assessment and/or possible remedial mitigation measures to reduce/remove the source of the ground gas. In certain circumstances, active protection method could be applied, but only when there is a legal agreement assuring the management and maintenance of the system for the life of the property

Taken from: *Guidance on Evaluation of Development Proposals on Sites Where Methane And Carbon Dioxide Are Present, Report Edition No. 04, NHBC and RSK Group Plc., March 2007.*

Assessment of both CH_4 and CO_2 has been completed, however, as discussed in Section 5.1.3, the worst-case classification should be adopted in order to establish the appropriate protection measures. This is driven by CH_4 concentrations at the site, which is discussed below.

BH1

Using the 'Traffic Light' classification as detailed in Table 5.3, the TMC at BH1 would indicate this area of the site as Red.

Taking consideration of the worst-case flow rate (5.3 l/hr) and maximum CH_4 concentration detected (40.4%) the Gas Soil Value (GSV) is 2.1 l/hr, therefore, this area of the site is also characterised as Red in terms of the GSV, (i.e. standard residential housing is not normally acceptable without further ground gas risk assessment and/or possible remedial mitigation measures to remove source).

BH2

At BH2, the TCM would indicate this area of the site as Red. Taking consideration of the worst-case flow rate (5.4 l/hr) and maximum CH_4 concentration detected (67.6%) the GSV is 3.7 l/hr, therefore, this area of the site is also characterised as Red.

BH3

At BH3, the TCM indicates this area of the site as Red. Taking consideration of the worst-case flow rate (5.4 l/hr) and maximum CH_4 concentration detected (91.3%) the GSV is 4.9 l/hr, therefore, this area of the site is also characterised as Red.

BH4

Based on the TCM this area of the site would be characterised as Amber 1. Taking consideration of the worst-case flow rate (5.5 l/hr) and maximum CH_4 concentration detected (3.5%) the GSV is 0.19 l/hr, therefore, this area of the site is also characterised as Amber 1, (i.e. low-level ground gas protection measures are required).

BH5

Based on the TCM this area of the site would be characterised as Red. However, the worst-case flow rate (5.4 l/hr) and maximum CH_4 concentration detected (20.9%) indicates a GSV of 1.1 l/hr, therefore, this area of the site is characterised as Amber 2, (i.e. high-level ground gas protection measures are required). It should be noted that according to the NHBC report as the maximum CH_4 concentration was above 20%, consideration should be given as to whether this area should be characterised as Red. However, as a robust assessment has been completed (data collected from 2002 to 2006), the characterisation of Amber 2 is considered appropriate.

BH6

At BH6, the TCM indicates this area of the site as Red. Taking consideration of the worst-case flow rate (6.3 l/hr) and maximum CH_4 concentration detected (98%) the GSV is 6.2 l/hr, therefore, this area of the site is also characterised as Red.

BH7

Based on the TCM this area of the site would be characterised as Red. Taking consideration of the worst-case flow rate (5.4 l/hr) and maximum CH_4 concentration detected (36.3%) the GSV is 2 l/hr, therefore, this area of the site is also characterised as Red.

BH8

At BH8, the TCM indicates this area of the site as Red. Taking consideration of the worst-case flow rate (5.3 l/hr) and maximum CH_4 concentration detected (83%) the GSV is 4.3 l/hr, therefore, this area of the site is also characterised as Red.

It should be noted that for the following six wells only two monitoring events were completed, as the wells were lost or damaged. To provide a robust assessment of flow rates and gas concentrations during different metrological conditions, this number of monitoring rounds is not considered to be sufficient. However, the results are discussed below as they may indicate potential ground gas present (but do not confirm its absence in these areas).

BH9, BH11, BH18 and BH19

Based on the TCM the monitoring data from BH9, BH11, BH18 and BH19 characterise these areas as Green for CH_4. Taking consideration of the worst-case flow rate and maximum CH_4 concentrations, these areas of the site are also characterised as Green (i.e. ground gas protection measures are not required). However, as discussed above further monitoring is required to confirm this.

BH15

At BH15, the TCM indicates this area of the site as Red. Taking consideration of the worst-case flow rate (5 l/hr) and maximum CH_4 concentration detected (21%) the GSV is 1.1 l/hr, therefore, this area of the site is characterised as Amber 2, (i.e. further ground gas risk assessment and/or possible remedial mitigation measures required to remove source). However, as discussed above, as the maximum CH_4 concentration is above 20%, consideration should be given as to whether this area should be characterised as Red. Therefore, as only two monitoring rounds have been completed at this well, the characterisation of Red is considered appropriate.

BH17

Based on the TCM this area of the site would be characterised as Amber 1. Taking consideration of the worst-case flow rate (4.9 l/hr) and maximum CH_4 concentration detected (3.8%) the GSV is 0.19 l/hr, therefore, this area of the site is also characterised

as Amber 1, (i.e. low-level ground gas protection measures are required). However, further monitoring is required to confirm this.

Figure 5 provides an illustration of Typical Maximum Concentrations on site and associated Traffic Light Classification.

5.3. Conclusions

From the findings of the GQRA, the following summarises the potential contamination present on the site.

5.3.1. Soil Contamination

Exceedance of the adopted human health screening criteria was observed for EPH, PAHs and limited metals at the site. This indicates a potential risk to future site users from the following pathways:

- Direct soil and dust ingestion;
- Consumption of vegetables;
- Soil attached to vegetables;
- Indoor dermal soil and dust contact/outdoor dermal soil and dust contact;
- Outdoor/indoor inhalation of fugitive dust; and
- Outdoor/indoor inhalation of vapours.

In terms of a risk to controlled water from soils, given the groundwater concentrations observed as detailed below, it is likely that soils are acting as a potential source of impact to groundwater at the site.

5.3.2. Groundwater Contamination

Groundwater results were above the adopted human health and controlled waters screening criteria for EPH, PAH, metals and some inorganics. According to the SLR Summary Report based on the groundwater elevations the inferred flow direction is towards Bewbush Brook, therefore, a source of contamination is potentially migrating to the brook. The presence of petroleum hydrocarbon at elevated concentrations also represents a potential risk to future site users via outdoor/indoor inhalation of vapours.

5.3.3. Surface Water Contamination

Exceedance of the adopted controlled waters screening criteria was observed for metals and inorganics in the surface water samples. For the majority of parameters, concentrations in the down stream sample generally decreased (when compared to the up stream samples). However, ammoniacal nitrogen, iron, manganese, potassium,

selenium and sodium exceed the screening criteria in this down stream sample indicating a potential for the migration of contamination off-site.

5.3.4. Ground Gas Contamination

Concentrations and flow rates of methane and carbon dioxide assessed against the TMC and GSV indicate that 50% of sample locations are characterised as Red, (i.e. further ground gas risk assessment and/or possible remedial mitigation measures required). Approximately 30% of sample locations were classified as Green (i.e. ground gas protection measures are not required). However, only two monitoring events were completed at these wells, which is not considered to be sufficient to confirm the absence of ground gas.

5.4. Recommedations

- Additional trial pit and groundwater/gas wells should be installed, particularly in the central and north western portions of the site;
- In order to assess potential risks to future site users and nearby environmental receptors (e.g. Bewbush Brook), it is considered that sufficient speciated TPH and PAH data should be collected from site soil, groundwater and surface water;
- Completion of a GQRA of data collected and Detailed Quantitative Risk Assessment (DQRA), if required;
- URS understand that no contact has been made to date with the Environment Agency regarding the regional importance of this brook and also its environmental sensitivity. Therefore, this should be completed in conjunction with additional investigations or remediation plans for the site;
- In terms of ground gas, given the number of areas classified as Red within the site, further ground gas risk assessment and/or possible remedial mitigation measures should be completed in these areas before they would be considered suitable for low rise residential development; and
- While not part of this scope of work, future consideration should be given to the aggresivity of the soil and groundwater towards any buried concrete that may form part of the proposed development. Soil and groundwater pH, sulphate and chloride test results should be considered against criteria presented in BRE Special Digest 1, in order to assess the Aggressive Chemical Environment for Concrete (ACEC) Class of the ground.

6. REMEDIATION METHODOLOGY VIABILITY ASSESSMENT

As detailed in Section 1, the SLR landfill studies have been completed in terms of surrendering the WML. Therefore, only limited remediation proposals were provided in the Summary Report (such as source removal, gas membrane installation and removal of "hot-spots" of hydrocarbon contamination).

URS agreed with the principle of these remedial measures but further investigation and remediation details were required to provide a robust assessment. This was indicated at the Stakeholders meeting on 12 April 2007.

Following the Stakeholders meeting, in the letter provided to URS (letter dated 23 April 2007) SLR acknowledged that at this stage of their investigation, delineation and remediation planning have not yet been completed to the level of detail required to support a planning application, as this work will be conducted once the final footprint, layout and phasing of the development has been completed.

SLR also has indicated that once detailed development plans for the site are confirmed, an investigation strategy and phased remediation plan will be developed in consultation with local regulators.

SLR indicated in their letter that they are considering two potential remedial options for the site, which include source removal and elimination of the potential contaminant pathways. These are presented in the following section and assessed in terms of viability in Section 6.2.

6.1. SLR Proposed Remedial Strategy

Consistent with URS's findings as detailed in Section 5.3, SLR have identified the key pollutant linkages at the site as follows:

- Potential high risks posed by methane to future residential buildings and occupants;
- Potential medium risks posed by shallow soil contaminants[26] to future residential occupants; and
- Potential high risks (during development) posed by leachate to Bewbush Brook.[27]

[26] URS would also consider that shallow groundwater could present a potential risk to site users via a vapour pathway, as well as the soil pathways.
[27] URS would also consider this a potential risk when the site is developed if the source of contamination has not been removed.

6.1.1. Proposed Remedial Plan

To date, SLR has not developed a detailed remediation strategy for the site as confirmation of the final development footprint, layout and landform is required. Furthermore in order to confirm the scope of remedial works, SLR agrees that further investigation of the site is required (as detailed in Section 4.3.1).

In terms of remediation SLR is considering two potential remedial options - source removal and elimination of the potential contaminant pathway. The remedial option will depend upon whether or not the final site landform and development requires removal of soil materials to facilitate development. If significant site remodelling and earth moving is required then the removal of some or all of the source contamination may be the most appropriate option. However, if it is determined that ground levels will not be reduced then they will consider the most appropriate option is to eliminate the potential pathways by which contamination could migrate to sensitive receptors.

SLR considers that the final remediation solution may incorporate elements of both strategies.

6.1.2. Remedial Option 1 - Source Removal

SLR reported that the ground profile may be affected by the need to minimise energy requirements at the site and to limit the visual impact of the development, therefore it is unlikely that the current site profile will be that of the development. If significant site remodelling is required, then remedial works will follow a source removal strategy and focus on:

- Excavation of fill from the areas of the site that contain wood, timber and Alluvium greater than 5%;
- The installation, as a precautionary measure, of a gas protection membranes in order to mitigate against any residual gas risks (only at properties constructed on the areas that have been subject to landfilling);
- Placement of suitable subsoil and ‘clean’ topsoils in garden areas; and
- The installation of a drainage system to capture and treat leachate, for the duration of the development works, that could potentially be encountered during soil movements in order to protect water quality in Bewbush Brook.

6.1.3. Remedial Option 2 - Eliminating Contaminant Pathways

SLR reported that if the final landform does not necessitate significant remodeling, then remedial works to eliminate the pathways between potentially contaminated soils and gases, and identified receptors, may be the most appropriate remediation strategy. At this stage it is described in outline only, but it would focus on:

- Installation of suitably engineered gas impermeable membranes and passive venting systems across parts of the site that would be used for built

development (i.e. excluding areas of open space). The membrane would be placed at least 1m below ground level and locally deeper for service trenches. Passive venting systems would include sub-floor vents and a network of gas collection pipework connected to above ground passive vent systems designed to visually integrate with street works infrastructure;

- Placement of suitable subsoil and 'clean' topsoils in garden areas; and
- Diversion of Bewbush Brook into a purpose built clay-lined channel with appropriate landscaping and ecological restoration.

6.2. Viability Assessment

6.2.1. Remedial Option 1

Provided the additional investigations are completed (including data gaps as identified by URS in Section 4) and the comments below are taken into consideration, source area removal would be considered a viable remedial option for the site. In the experience of URS source, removal is a very common and effective remedial option for addressing contaminated soil at a site.

In terms of the details provided by SLR on the source removal remedial strategy, URS has the following comments:

- SLR has indicated that fill will be excavated from areas of the site that contain concentrations of wood, timber and Alluvium greater than 5%, (i.e. to address methane production in this fill material). However, details on post remedial gas monitoring in areas excavated would be required to confirm that the removal of 95% of wood, timber and Alluvium from these areas, would reduce methane to an acceptable level;
- SLR has recommended the installation of a gas protection membranes in order to mitigate against any residual gas risks, as a precautionary measure, following source removal. This is considered appropriate given the historical use of the site and the potential human health vapour risk from soil and groundwater (following excavation and further gas assessment, the appropriate level of gas protection membrane can be confirmed);
- To address the risk posed to human health SLR has recommended the placement of suitable subsoil and 'clean' topsoils in garden areas. This is considered appropriate to address the human health risk to future site users from direct contact associated pathways. However, it should be noted that prior to the implementation of a remedial plan a detailed quantitative risk assessment (DQRA) could be completed as part of the further investigation. As discussed in Section 5.1 generic exceedance are not an indication of the requirement for remediation but rather, an indication of the need for further assessment; and

- SLR has recommended the installation of a drainage system to capture and treat leachate from the site, for the duration of the development works, in order to protect water quality in Bewbush Brook. However, details are required on the measures proposed to protect water quality in the brook during the operational phase of the development, given the elevated petroleum hydrocarbons, metals and inorganics identified in groundwater at the site (and that the brook discharges to Ifield Mill Stream, which has been classified as high risk by the EA in terms of meeting the Water Framework Directive).

6.2.2. Remedial Option 2

Provided the additional investigations are completed (including data gaps as identified by URS in Section 4) and the comments below are taken into consideration, pathway elimination would be considered a viable remedial option for the site.

In terms of the details provided by SLR on the pathway elimination remedial strategy, URS has the following comments:

- To address the risk posed to human health SLR has recommended the placement of suitable subsoil and 'clean' topsoils in garden areas. This is considered appropriate to address the human health risk to future site users as discussed in the previous section;

- SLR recommends diversion of Bewbush Brook into a purpose built clay-lined channel with appropriate landscaping and ecological restoration. Depending on the properties and construction of this channel it could have the potential to address impact from groundwater at the site to the brook, however, this would need to be completed with consultation with the EA; and

- SLR recommends the installation of suitably engineered gas impermeable membranes and passive venting systems across parts of the site that would be used for built development (i.e. excluding areas of open space). This would address the risk to site users from ground gas. As the membrane would be placed at least 1 m below ground level and locally deeper for service trenches, it would need to be demonstrated that soil above the membrane did not have the capacity to produce methane and carbon dioxide above the appropriate screening levels (using recent NHBC guidance).

It should be noted that as the GQRA has identified areas of the site as Red, in terms of ground gas, a membrane would not be considered suitable to address these areas given the current level of assessment (further ground gas risk assessment and/or possible source removal would be required). It should also be noted that according to the NHBC report, development at a site where ground gas has been identified is likely to influence the ground gas regime. The use of piled or strip foundations may create preferential migration pathways or obstacles to divert migration of gas. Areas developed with hardstanding or buildings may potentially affect ground gas movement in the subsurface. Therefore, suitable gas protection measures need to be designed so that they can

address increases in ground gas concentrations and more importantly ground gas flow rates.

The above remedial strategies are considered preliminary remedial options. Accordingly, once a detailed remediation strategy and master plan is provided this should be assessed in terms of the following:

- Update Conceptual Site Model (CSM);
- Remedial options review and the selected option;
- Effectiveness of remedial option in terms of addressing potential risks to human health and controlled waters,
- Performance criteria for remediation;
- In-process and post remediation groundwater monitoring programme;
- Permitting requirements; and
- Validation process.

6.2.3. Proposed Development Schedule

SLR reported that the current proposed development schedule allows for submission of an application for the surrender of the Waste Management Licence (WML) to the EA in early 2008. At this stage at least two years post closure monitoring data has been collected (minimum required by the EA). SLR anticipates that the negotiation of the licence surrender will take between four and six months (i.e. the surrender is anticipated autumn 2008). Following consultation with the EA,[28] URS would consider this a reasonable timeframe for surrender of the WML.

According to SLR the commencement of the development in the strategic area will be governed predominantly by the timetable for the JAAP process, which they understand will lead to adoption of the JAAP by mid 2009. Therefore it is unlikely that development of the sites within the JAAP study area will commence before 2010, (i.e. after the expected date of the surrender of the WML). According to SLR the initial development could concentrate on the land outside the landfill footprint, east of the infilled area, on the western outskirts of the existing Bewbush neighbourhood. This area is approximately 15 hectare and although it lies within the WML area it has not been subjected to infilling and therefore, is likely to be suitable for development following surrender of the WML.

SLR has indicated that remediation of the site is expected to take a period of up to two years. However, they anticipate that it could be completed over a phased programme, therefore certain areas would be made available for development before all of the remedial works were completed. Based on the current data, URS would consider this a reasonable timeframe for remediation of the site.

SLR has also indicated that early development could also take place to the west of the landfill area, however, as discussed in Section 4.1, investigation to west of the landfill was completed in 2004[29] (TP101 to TP120) and trial pit logs indicated the presence of fill material. Furthermore, soils and ground water concentrations were above GQRA screening criteria. Therefore, additional investigation and or remediation would be required before development, however, this would not be constrained by surrendering of the WML.

6.3. Assessment of Preferred Option for the JAAP

It was envisaged that this report would facilitate the identification of a development area to support the authorities in progressing site-specific proposals in the Preferred Options JAAP and to provide a clearer understanding of the constraints and opportunities for the identified 'developable' area. However, initial review of the SLR reports indicated that their objective was not full assessment of the site under Part IIA[30] and the Town and Country Planning Act[31] requirements. This was brought to the attention of Crawley Borough Council and Horsham District Council and URS was requested to assess the data more fully in terms of the risk in advancing the site as a Preferred Option for the Joint Area Action Plan (JAAP).

At this stage of the assessment it is difficult to recommend the site as a Preferred Option for the Joint Area Action Plan (JAAP), given that a full evidence base and detailed remediation plan is not yet available. In terms of the risk associated with advancing this area as a Preferred Option for the JAAP (without having a full evidence base that remediation is achievable), URS would consider this an overall medium risk. This is based on the following observations and assumptions:

- The investigation completed at the site to date does not assess the site in terms of its future development, however, SLR has acknowledged that delineation and remediation planning have not yet been completed to the level of detail required to support a planning application as this work will be conducted once the final footprint, layout and phasing of the development has been completed. SLR has indicated that once detailed development plans for the site are confirmed, an investigation strategy and phased remediation plan will be developed in consultation with local regulators and the EA;

[28] Telecom with Ms. Katherine Manson (EA Officer) 7 March and 11 April 2007.

[29] According to SLR (telecom 27/4/07) this area is outside the Waste Management Licence but was reported infilled following verbal permission from the EA.

[30] Part IIA of the Environmental Protection Act, HMSO, DEFRA, 1990.

[31] The Town and Country Planning Act, ODPM, 1990.

- The exploratory investigations completed to date have not indicated significant contamination in terms of soil. In terms of groundwater, elevated petroleum hydrocarbon, metal and inorganics contamination has been identified. Elevated methane concentrations have also been identified at the site. However, provided the additional investigation are completed at the site and URS's comments in this report are taken into consideration, the remedial options identified by SLR are considered viable; and

- The schedule proposed to complete further investigation and remediation at the site is considered reasonable. With regard to Waste Management Licence surrender, the EA[32] are satisfied with SLR's proactive approach to-date and do not envisage any major difficulties in achieving this within the proposed time-scale.

[32] Telecom with Ms. Katherine Manson (EA Officer) 7 March and 11 April 2007.