12. LAND CONDITIONS

12.1 Introduction

12.1.1 This chapter examines the ground conditions on site with respect to its geological and contamination status. The chapter addresses issues arising from potential contamination and/or geotechnical concerns and asses the impacts of these on potential receptors associated with the proposed development during construction activity and during operation of the site. The potential for adverse ground conditions at the site are associated with the following:

- Past underground and possible unidentified shallow mining beneath the site.
- Made ground materials potentially present in the northern half of the site (hereafter referred to as Phase 2 and 3 of the proposed development).

12.1.2 In particular this section includes;

- A description of the drift and solid geology.
- An evaluation of potential impacts from past mining activities with regard to land contamination and mining gases upon site contractors and eventual users.
- An evaluation of potential impacts from past landfill activities in respect of landfill gases upon those same receptors.
- An evaluation of potential impacts from this development on the surrounding environment in terms of possible contaminant migration.
- Proposed mitigation measures to avoid or reduce identified impacts on the surrounding environment and site users.

12.2 Policy Context

National Policy

12.2.1 Planning permission for this proposed development has already been granted. The planning conditions are in the process of being discharged. Conditions 26, 27 and 28 require investigation of ground conditions and submission of a remediation strategy. (See Appendix 1.1)

12.2.2 Investigation works to discharge these conditions have been carried out by Dunelm Geotechnical & Environmental (see Appendices 12.1, 12.2, and 12.3) and Wardell Armstrong LLP. The results of the investigations are summarised in this section of the ES.

12.2.3 National contaminated land policy and legislation is covered by two separate but complimentary systems, namely:

- Part IIA of the Environmental Protection Act 1990, its accompanying Regulations and Statutory Guidance
- Planning Policy Statement 23 (PPS23) – Planning and Pollution Control.

12.2.4 Under Part IIA, Local Authorities have the responsibility for the regulation of contaminated land within their catchment area. The definition of contaminated land for the purposes of Part IIA is as follows:

"any land which appears to the local authority in whose area it is situated to be in such a condition, by reason of substances in, on, or under the land that significant harm is being caused or there is a significant possibility of such harm being caused, or pollution of controlled waters is being, or is likely to be caused."

12.2.5 Part IIA assesses the risk from contamination using the concept of sources, pathways and receptors of pollution. If all three components are present there is said to be a pollutant linkage. Pollutant linkages are examined in terms of impact upon the receptors, assessing whether an "unacceptable risk" to that receptor is present. If the risk is found to be unacceptable then a *significant* pollutant linkage (SPL) exists.

12.2.6 The collection of all relevant potential pollutant linkages for a particular site can be grouped together to form what is known as a conceptual site model (CSM). The CSM is therefore a model of all the potential pollutant linkages on site which could lead to significant harm being caused to sensitive receptors.

12.2.7 The local authority's function under Part IIA is twofold; firstly to identify contaminated land and secondly to enforce any required remediation of that land. The Part IIA regime is implemented as policy to address the legacy of land contamination left following historical land uses and pollution incidents. The site at Coaley Lane does not fall under the Part IIA regime as there have been no historical industrial activities on site and no pollution incidents recorded.

12.2.8 PPS23 addresses potential land contamination as a material consideration for the purposes of planning. This policy advises that where land contamination may exist, development of that land could provide an opportunity to remediate the contamination. There is also provision in the policy which recognizes that, though a particular site may not be classified as contaminated under the Part IIA regime in terms of its current use, an unacceptable risk to receptors may be created through the implementation of development works and disturbance of the land.

12.2.9 For example, concentrations of pollutants may present an unacceptable risk should that site be redeveloped for a more sensitive land use. Disturbing materials on site as part of earthworks for redevelopment, may introduce new pathways for pollutants present to impact on sensitive receptors.

12.2.10 Therefore, as part of the planning process under PPS23, any potential developer of a site is responsible for ensuring that it is safe and suitable for that proposed development, i.e. that the site is "*fit for* purpose", or can be made so by remedial works. The developer must satisfy the local planning authority (LPA) that this is the case by means of a phased risk assessment.

12.2.11 The risk assessment process is operated on similar principles to Part IIA for the assessment of contamination in terms of examining potential pollutant linkages, the only difference being that a wider range of (i.e. future) pathways and receptors must be considered.

12.2.12 The minimum acceptable level of risk assessment to be submitted with a planning application is usually a report on the results of a desk study and site walkover. Further qualitative and quantitative risk assessment, plus the generation of remediation objectives may also be required depending on the findings of the preliminary phases of risk assessment.

Local Planning Policy

12.2.13 In the Sunderland City Council Unitary Development Plan Policy EN14 requires applicants to carry out investigations to determine ground conditions contamination or potential instability. It also requires remedial or precautionary measures to be carried out.

12.3 Methodology

12.3.1 This assessment has been carried out following current guidance on contaminated land and is consistent with the procedures detailed in both Part IIA of the EPA (1990) and PPS23. The potential environmental impacts of the proposed development arising as a consequence of geology and ground conditions have been examined in accordance with the source-pathway receptor principle of pollutant linkages.

12.3.2 This methodology section will summarise Phase I and Phase II site investigations separately.

Phase I Site Investigation

12.3.3 A Preliminary Geoenvironmental Appraisal was completed in June 2006, by Dunelm Geotechnical & Environmental (Appendix 12.1), following a site walkover survey on

30th May 2006. The results of which were used to define a preliminary conceptual site model (CSM) for the site. The preliminary CSM was then utilised in the design of a site investigation for both geotechnical and environmental purposes.

12.3.4 The site investigation was conducted in July 2006 and comprised elements of mini rig percussion boreholing, trial pitting, topsoil and subsoil sampling, gas and groundwater monitoring. The site investigation locations are shown on Dunelm Drawing D1122/02, in Appendix 12.2. The area designated for Phases 2 and 3 of the development was not comprehensively sampled due to dense woodland; neither the mini rig nor digger was able to gain access to this area. Therefore, several samples were taken from the periphery of Phase 2 and 3 lands. A total of 8 test pits were excavated in the area designated for Phase 1 of the development and 6 boreholes sunk in the area designated for Phases 2 and 3.

12.3.5 Soil samples were taken at trial pit and/or borehole locations and the subsequent scheduling of required laboratory analyses was determined based on the potential pollutant linkages identified in the preliminary CSM.

12.3.6 The results of the site investigation and laboratory analyses were assessed in a qualitative manner.

12.3.7 The concentrations of pollutants present within soil samples were assessed against CLEA Soil Guideline Values (SGV) for residential land use.

12.3.8 No surface water or groundwater samples were taken during the site investigation. The nearest surface water course is approximately 300 m south west of the site (Envirocheck Report, Preliminary Geoenvironmental Appraisal, Dunelm 2006, Appendix 12.1). No groundwater was detected at the time of the investigation.

12.3.9 The baseline environmental conditions are therefore described with reference to the following sources of information:

- The Preliminary Geoenvironmental Appraisal (Dunelm, June 2006) Appendix 12.1
- The Geoenvironmental Appraisal (Dunelm, July 2006) Appendix 12.2

12.3.10 The reports by Dunelm include information relating to the;

- Envirocheck report including historic plans
- Site inspection
- British Geological Survey (BGS) published geological plans
- Coal mining search report

- Findings of the site investigation including laboratory analysis results.

Phase II Site Investigation

12.3.11 A further site investigation was designed by Wardell-Armstrong LLP and carried out by Dunelm in 2008. This investigated the areas of phases 2 and 3 that had not been investigated previously. This Phase II Site Investigation was designed in accordance with BS10175:2001 *Investigation of Potentially Contaminated Site: Code of Practice.* Samples were taken at each junction of a 45 m grid (Drawing NT10128/004, Appendix 12.4). A total of 25 hand prepared trial pits were excavated to a depth of around 0.6 m, with made ground (MG) and natural ground (NG) samples taken from each site. In the first instance only the MG samples were sent for analysis. Results from these analyses indicated that there would be no need to analyse the NG samples.

12.3.12 The objectives of this secondary investigation were to:

- Determine the depth and nature of MG within Phase 2 and 3 land areas;
- Collect and analyse representative samples from this previously untested area;
- Ascertain the degree and extent of any contamination detected; and
- Investigate the potential for landfill gas generation and emanation from within the MG.

12.3.13 A Factual Report (D1957) of the Phase II Site Investigation was prepared by Dunelm and is presented in Appendix 12.5 of this Environmental Statement. It details the site investigation methodology, the suite of analyses performed and includes trial pit logs and chemical data from the analyses.

Significance Criteria

12.3.14 No standard regulatory criteria are available for assessing the significance of potential effects arising from land contamination or geotechnical issues. The significance of an effect has therefore been determined from criteria developed from expert knowledge and best practice techniques.

12.3.15 The significance of an effect is assessed by taking into account the magnitude of its impact on the affected receptor and the sensitivity of the affected receptor.

12.3.16 The following categories are used in determining the impact magnitude upon any given receptor:

- Substantial – substantial alteration to the condition of the receptor such that there would be a fundamental change following development.

- Moderate – alteration to the condition of the receptor such that there would be a readily apparent change following development.
- Minor - alteration to the condition of the receptor such that there would be perceptible change following development.
- Negligible - alteration to the condition of the receptor such that there would be no discernible change following development.

12.3.17 The sensitivity of a receptor is generally determined on the basis of the following categories:

- High – the receptor has little ability to tolerate change due to the source of an impact before the effect of that impact is realised.
- Moderate - the receptor has a moderate ability to tolerate change due to the source of an impact before the effect of that impact is realised.
- Low - the receptor is reasonably tolerant of change due to the source of an impact before the effect of that impact is realised.

12.3.18 Within the CLEA model for the assessment of contaminated land, the sensitivity of the human health receptor is dependent upon the exposure pathway to a particular contaminant which, for the end user, is dependent on the proposed end usage of the development.

12.3.19 The significance of an environmental impact due to geology and ground conditions at the site has been determined using the following matrix:

Table 12.1
Impact Significance Matrix

	Sensitivity		
Magnitude	**High**	**Moderate**	**Low**
Substantial	Major	Major-Moderate	Moderate-Minor
Moderate	Major-Moderate	Moderate	Minor
Minor	Moderate-Minor	Minor	Minor-Negligible
Negligible	Negligible	Negligible	Negligible

12.3.20 The significance of an environmental impact has been defined as follows:

- Major: impact of an acute hazard upon human health likely to result in significant harm, impact of a hazard upon future building materials likely to result in serious structural harm within the short term.
- Moderate – impact of a chronic hazard upon human health likely to result in significant harm, impact of a hazard upon future building materials likely to result in structural harm within the longer term.
- Minor – impact of a hazard on future building materials likely to result in superficial damage or remedial action being necessary a substantial time after construction.
- Negligible – undefined, not realised in this assessment.

12.4 Baseline conditions

Current Land Use

12.4.1 The site use is currently agricultural land in the Phase 1 area (southern half) of the site, and young, broadleaved woodland in the Phase 2 and 3 area (northern half) of the site. The proposed development on the site would include a sports pavilion, car and coach park, plus 20 junior football pitches, 2 senior pitches and 2 mixed-use games areas.

Historical Land Use

12.4.2 A review of historic County Series, Ordnance Survey and Raster Mapping plans has been undertaken, a summary of the findings is presented in Table 12.2.

Table 12.2
Historical Land Use

Data Source	Dates Covered	Remarks
Durham Series Plans (1:10,560 and 1:2,500)	1857 – 1895	The site appears as agricultural land. There are no developments on site at this time. Approximately 75 m to the west of the site boundary was the Mary Pit and old shaft; approximately 100 m west from the southern corner of the site was Betty Pit with its spoil and reservoir. Jane Pit was located approximately 210 m from the western-most corner of the site and Margaret Pit around 120 m north of the site. Coaly Lane runs parallel to the southern boundary of the site, while the Lambton Railway passes adjacent to the eastern boundary. There is a small pond and associated surface water course in the south of the site: surface water runs from northeast to southwest. Within 1 km of the site boundary were Bourn Moor Colliery, Painshaw Foundry and the small villages of Philadelphia and Newbottle.
Durham Series Plans (1:10,560 and 1:2,500)	1896-1898	The Northern Hospital for Infectious Diseases has been built, around 63 m from the western boundary. Betty Pit has closed. No other significant changes to site or surroundings.
Durham Series Plans (1:10,560 and 1:2,500)	1920 - 1921	No change to the site. Residential development at southern corner of the site and further development of surrounding villages/towns.
Durham & OS Series Plans (1:2,500)	1940 - 1959	The only change is the closing of the Mary Pit.
OS Plans (1:10,000 and 1:2,500)	1967 - 1978	No change to the site. The Northern Hospital for Infectious Diseases has closed, been demolished and new residential buildings erected. Margaret Pit has closed. A large spoil tip has emerged approximately 250 m west of the site.
OS Plans (1:10,000 and 1:2,500)	1981 - 1989	Lambton Railway which ran adjacent to the eastern boundary has been taken up. An electricity sub station is located around 180 m north of the northern corner of the site.
OS Plans (1:10,000 and 1:2,500)	1991- 2004	On site a broadleaved woodland has been planted in the northern half of the site. Newbottle has expanded considerably with significant development along the eastern boundary of the site. The electricity sub station has been removed.

12.4.3 The Envirocheck report (Preliminary Geoenvironmental Appraisal, Dunelm, June 2006, Appendix 12.1) states that there are possibly 4 LA recorded landfill sites within 1000 m of the site, with one landfill registered as being on the site. Sunderland City Council was contacted with regard to further information concerning this landfill site, but was unable to give any details. The precise location, size and content is unknown.

Geological Setting

Superficial and Drift Deposits

12.4.4 Superficial deposits across the development area were found to comprise a thin layer (up to 20 cm) of loamy topsoil in the southern half of the site (as demarcated by the footpath which passes east/west through the site) and made ground plus topsoil in

the northern half of the site. The drift deposits underlying the topsoil/made ground layers were found to comprise sandy gravelly CLAYS on investigation. BGS Drift maps indicate that the drift deposits consist of laminated clays and boulder clay.

Solid Geology

12.4.5 Baseline geological information was gathered from British Geological Survey (BGS) 1:50,000 (sheet 21) and 1:10,000 (NZ35 SW) Solid and Drift Maps and supplemented by the appropriate geological memoirs.

12.4.6 The solid geology comprises a combination of Middle Coal Measures and Sandstone, shales and mudstones.

Made Ground

12.4.7 The made ground typically lies at a depth of between 0.2 - 0.6 m, overlying the sandy gravelly CLAYS of the subsoil. The historical maps of the Envirocheck Report, dating back to the mid-late 1800s show there to be no development on the site. However, there were three coal mines to the western side of the site, all less than 300 m distant. It is possible that colliery spoil and/or ash from the nearby collieries and Lambton coke works could have been deposited on the site.

Former mining

12.4.8 Nine worked coal seams have been recorded beneath the site, of which the shallowest was recorded at 118 mbgl. There may be unrecorded shallow workings beneath the site, according to the coal mining report appended to the Preliminary Geoenvironmental Appraisal by Dunelm (Appendix 12.1).

12.4.9 Dunelm make the recommendation that rotary drilling should be carried out on site in order to confirm the potential for shallow unrecorded mine workings in the Ryhope Little and or Ryhope Five Quarter coal seams, which underlie the site.

12.4.10 There are no recorded shafts or adits within 20 m of the site boundary, or within the site itself. The coal mining report concludes that though old workings are present in the general area, any settlement is likely to have taken place already. However, they also recommend that full and proper site investigations be carried out in view of the variable depths of the old workings across the site.

12.5 Assessment

Phase I Site Investigation

12.5.1 Sampling and laboratory analysis of topsoil and made ground for the assessment of the presence and concentrations of potentially present pollutants was conducted by Dunelm.

12.5.2 A total of 8 test pits (TP) and 6 bore holes (BH) were excavated on site. The TPs were located in the Phase 1 area, while the BHs were positioned around the edges (just beyond the boundary) of the Phase 2 and 3 area of the site. Different techniques were employed in light of the relative inaccessibility of the woodland in the northern half of the site.

12.5.3 Monitoring wells for gas and groundwater were installed in BHs 1, 4 and 6.

12.5.4 The details of the ground conditions can be found in Appendix B of the Geoenvironmental Appraisal by Dunelm (Appendix 12.2).

Potential contamination

12.5.5 A summary of the analytical data (extracted from Geoenvironmental Appraisal, Appendix 12.2) from soil and made ground samples are given in Tables 12.3 and 12.4.

Table 12.3
Analytical data for the topsoil samples

Determinand	No.of samples	SGV conc. (mg kg^{-1})	Sample conc. (mg kg^{-1})	Samples > SGV
pH	5	5	5.5 – 8.1	0
Arsenic	5	20	14	0
Cadmium	5	1	<0.2	0
Chromium (Tot)	5	130	24	0
Lead	5	450	185	0
Mercury	5	8	<0.1	0
Selenium	5	35	<0.3	0
Boron (water sol)	5	3	2.5	0
Copper	5	130	48	0
Nickel	5	50	24	0
Zinc	5	300	132	0

Table 12.4
Analytical data for Made Ground samples

Determinand	No.of samples	SGV conc. (mg kg^{-1})	Sample conc. (mg kg^{-1})	Samples > SGV
pH	3	5	6.2 – 8.3	0
Arsenic	3	20	62	2
Cadmium	3	1	<0.2	0
Chromium (Tot)	3	130	21	0
Lead	3	450	151	0
Mercury	3	8	0.2	0
Selenium	3	35	<0.3	0
Boron (water sol)	3	3	2.9	0
Copper	3	130	161	1
Nickel	3	50	69	ng
Zinc	3	300	204	0

Note: Cadmium SGV concentration based on pH 6 soil. Increased pH raises Cadmium concentration.
Ng denotes not given in the report by Dunelm.

12.5.6 Calorific value of made ground was tested and found to be in the range of 8002 – 8890 MJ kg^{-1}, indicating the potentially combustible nature of the material.

12.5.7 Maximum soluble sulphate concentration was 180 mg L^{-1}.

Phase II Site Investigation

12.5.8 Sampling and laboratory analysis of MG samples for the assessment of the presence and concentrations of potentially present pollutants was conducted by Dunelm. The raw data can be viewed in Appendix 12.5.

12.5.9 The schedule of analyses on each MG sample comprised, a standard contaminated land suite (metals and inorganics) and PAH speciation (16 EPA PAH); four samples were also analysed for PCB, Dioxin and Furan contamination (samples 8, 10, 18 and 20).

12.5.10 A total of 25 hand excavated trial pits were positioned in the woodland area according to a 45 m grid (Drawing NT10128/004, Appendix 12.4). The depth and nature of the strata were recorded in trial pit logs (Appendix 12.5) and disturbed samples collected for analysis.

Potential Contamination

12.5.11 A summary of the chemical data for each sample site is shown in Table 12.5

Table 12.5
Analytical data for Made Ground samples

Determinand	No.of samples	SGV conc. (mg kg^{-1})	Max sample conc. (mg kg^{-1})	Samples > SGV
pH	25	-	5.8 – 7.9	0
Arsenic	25	20	17	0
Cadmium	25	30	1	0
Chromium (Tot)	25	200	26	0
Lead	25	450	410	0
Mercury	25	15	0.5	0
Selenium	25	260	0.4	0
Boron (water sol)	25	3	1.4	0
Copper	25	2080	89	0
Nickel	25	75	32	0
Zinc	25	8250	460	0
Total PAH	25		7.8	1

Note: Cadmium SGV concentration based on pH 6 soil. Increased pH raises Cadmium concentration. PAHs all below DL (< 5 mg/kg) except sample HA5.

12.5.12 Chemical data for metals, inorganics, PCBs and furans (the latter two sets of data can be viewed in Appendix 12.5) show that there are no elevated concentrations of these elements/compounds. Concentrations of metals and inorganics fall within their SGVs as specified for the criterion *residential land with no plant uptake* and as such do not pose a risk to human health. In contrast with the Geoenvironmental Appraisal (Dunelm, Appendix 12.2), this criterion was chosen to describe the behaviour of contaminants on site as it represents the closest example, out of the various criteria, to eventual site conditions; there will be grassed areas, but no (edible) planting. Any significant pollutant linkage would be most likely to occur through dermal contact with soil from the grassed pitches and (possibly) soil ingestion.

12.5.13 Total PAH was shown to have concentrations which were only just above detection limits at sample site HA5 (Drawing NT10128/004, Appendix 12.4); total PAHs at the other 24 sample sites were below detection limits. Benzo(a)pyrene (B(a)P), which is the most toxic PAH was detected in concentrations well below its General Assessment Criteria (GAC) value (Table 12.6)

12.5.14 The only MG sample to give total PAH above the detection limit was that from trial pit HA5. The total PAH concentration was 7.8 mg kg^{-1}, of which B(a)P constituted 0.2 mg kg^{-1}. There is a paucity of toxicological information and resulting soil guidance values for most of the PAH group, only B(a)P and naphthalene have been studied for their toxicology, though no SGVs have been published. Since B(a)P is the most toxic of the PAH group and naphthalene the most mobile, they are generally used as markers for assessing the behaviour and hence risk to human health posed by total PAH concentrations in the soil. In order to assess B(a)P and naphthalene, [1]GAC

[1] Nathanial, C.P., McCaffrey, C., Ashmore, M., Cheng, Y., Gillet, A., Hooker, P., and Ogden, R.C. 2007.*Generic Assessment Criteria for Human Health Risk Assessment.* Land Quality Press, Nottingham. ISBN 0-9547474-3-7.

have been derived for both PAH compounds. Comparison between observed concentrations and GAC values is given in Table 12.6.

Table 12.6
Observed and GAC values for PAH in HA5

PAH	Observed concentration (mg kg^{-1})	GAC concentration (mg kg^{-1})
Benzo(a)pyrene	0.2	1.30 @ 1% SOM 1.31 @ 2.5 % SOM 1.32 @ 5% SOM
Naphthalene	<0.1	6.94 @ 1% SOM 17.1 @ 2.5 % SOM 33.7 @ 5% SOM

Notes: GAC values for *Residential without plant uptake.*
%SOM not known for the samples.

12.5.15 %SOM (soil organic matter) is unknown for the sample, but even when the worst case scenario is applied, the actual values are well within the GAC values. This fact, coupled with the finding that HA5 was the only sample to exhibit a very slightly elevated total PAH concentration across the Phase 2 and 3 area means that overall, across the site, the risk to human health is very low from PAH compounds.

12.5.16 Dioxins and furans were tested for in four of the MG samples (HA8, HA10, HA18 and HA20). These particular sites were chosen as they will be located beneath various pitches and as such will be regularly used by children/adults. The decision to carry out these tests was based on the historical presence of an electricity sub station north of the site and the presence of ash in some of the samples taken during the Phase I Site Investigation; the ash may have been coal derived or incinerator derived. Although no ash material was encountered during the Phase II Site Investigation, given the historical proximity of the former Lambton gasworks and coke works, spoil heaps, railway lines and residential coal burning, plus the proposed end use of the site, a cautious approach was adopted.

12.5.17 Results of the dioxin/furan analyses are summarised in Table 12.7. Dioxins/furans are ubiquitous environmental contaminants, present in soils, food, air etc, hence there are always “natural” background concentrations of these groups of compounds present [dioxins and furans do not occur naturally, but are anthropogenic]. Most of us will have some level of these compounds sequestered into our fatty tissues and/or livers. Because dioxins/furans occur as groups of individual congeners, in which certain forms are more toxic than others (TCDD >>> toxic than OCDD), a weighting system is applied to the concentrations of individual congeners which reflects their relative toxicities. By multiplying the concentration of a congener by its Toxic Equivalent Factor (TEF), a Toxic Equivalent Value (TEQ) can be derived – a ‘weighted’ concentration. Summation of all TEQs in a group of dioxins/furans gives the total dioxin/furan TEQ concentration and hence toxicity for that sample.

Table 12.7					
Sample	**Dioxin TEQ1 (ng kg^{-1})**	**Dioxin TEQ2 (ng kg^{-1})**	**Furan TEQ1 (ng kg^{-1})**	**Furan TEQ2 (ng kg^{-1})**	**Total TEQ Dioxins+Furans (ng kg^{-1})**
HA8	3.0	3.0	6.2	6.2	9.2
HA10	3.4	2.6	6.2	6.2	9.6 – 8.8
HA18	4.5	1.4	7.7	7.7	12.2 – 9.1
HA20	2.9	2.4	5.7	5.7	8.6 – 8.1
Notes: TEQ1 where concentration of non-detected congeners at DL TEQ2 where concentration of non-detected congeners at zero Total D+F concentrations lie within the range given (TEQ1 + TEQ2 = Total TEQ)					

12.5.18 The levels of dioxins/furans in these samples are within what are considered to be natural soil background levels[2,3]. There are no screening/trigger/threshold values for these compounds under UK guidance as yet. However, in a paper by Caserini *et al.* (2004), screening/trigger values from New Zealand, Germany and the US were used to assess the potential risk to human health of residential soils sampled in that study. The most conservative of these guidance values used came from the US; 39 ng kg^{-1} (TCDD) from the offices of the USEPA and 50 ng TEQ kg^{-1} from the US Agency for Toxic Substances and Disease Registry. It could be argued that UK soils may differ significantly from US soils. However, the US is a large country with many soil types, yet the USEPA uses its one screening value to assess all soils. The Total TEQ values for Coaley Lane samples fall well within the USEPA screening value and as such is considered to present a negligible risk to human health; no further investigation is warranted.

12.5.19 The toxicological report for dioxins/furans quotes a Tolerable Daily Soil Intake (TDSI) of 0.4 pg kg^{-1} bw day^{-1}, which equates to a Mean Daily Intake (MDI) of 28 pg day^{-1} for an adult of 70 kg. In order to exceed this TDSI, approximately 2 g of soil would need to be ingested during the presence of the end user on site (using a maximum soil TEQ of 12.2 ng kg^{-1}, Table 12.6). The MDI is the mean intake of substance measured over a very long period. Obviously, there will be variations about this mean value on a daily basis. The total oral TDI is 2 pg kg^{-1} bw day^{-1}, which includes soil intake plus other sources ingested. It can be argued therefore that there is some flexibility for intake on a daily basis and the likelihood of an end user ingesting 2 g of soil at every visit is unlikely.

12.5.20 As the concentrations of dioxins/furans appear to be fairly consistent in the four samples tested, it might be reasonable to assume that similar concentrations are present across the site as a whole.

[2] UK Quality Ash Association, 2002. *Statement on Dioxin Levels in Furnace Bottom Ash and Pulverised Fuel Ash from Coal Burning Power Stations.* Web access.

[3] Caserini S., Cernuschi S., Giugliano M., Grosso M., Lonati G. and Mattaini P. 2004. Air and soil dioxin levels at three sites in Italy in proximity to MSW incineration plants, *Chemosphere,* **54** (9), p.1279-1287.

Geotechnical-based Impacts

12.5.21 The topography of the site would necessitate some re-grading to achieve a level platform prior to construction works.

12.5.22 The underlying drift deposits, below near surface mad ground, comprise firm to stiff CLAYS, which should provide an adequate foundation material for standard strip footings. A Design Sulphate Class DS-1 has been recommended for sub surface concrete foundations.

12.5.23 The site is underlain by a number of shallow coal seam horizons, with the potential for unrecorded old mine workings. Instability of roof strata associated with such workings could have the potential for the formation of crown hole type collapse features at surface, with a consequent threat to any built structures at surface.

Contamination-based Impacts

12.5.24 The main potential contamination-related impacts are presented in Table 12.8 in the form of potential pollutant linkages, comprising a source, pathway and receptor.

Table 12.8
Potential Pollutant Linkages

Source	Pathways	Receptor
Slightly elevated PAH concentrations within the made ground at sample site HA5.	Ingestion; Inhalation; Dermal Contact.	Human Health (current/future site users).
Background soil dioxin and furan concentrations	Ingestion; Dermal Contact.	Human Health (current/future site users).

12.5.25 Gas measurements were taken (Phase I SI) from BHs 1, 4 and 6, in the Phase 2 and 3 areas of the site. No methane was detected and carbon dioxide levels were very low (a few % v/v). It can be concluded from the results that neither the suspected landfill, nor the potential presence of mine voids beneath the site are active in terms of methane generation.

Geotechnical-based Impacts

12.5.26 Should the pavilion be developed over substantial made ground materials without adequate foundations, or above old shallow mine workings without pre-treatment through drilling and pressure grouting, the potential magnitude of impact could be **substantial**.

Magnitude of Contamination-based Impacts

12.5.27 There is a slightly elevated PAH concentration at HA5, though the concentration of B(a)P is very low and well within its GAC value. PAHs, of which B(a)P is the most toxic, are known to be carcinogens. There is no threshold value for B(a)P below

which no harm can be caused. Instead, there is a concentration of B(a)P below which it is considered to pose a negligible risk to human health. The concentration of B(a)P in sample HA5 is low, however, other PAHs in the sample are more concentrated e.g. benzo(b)fluoranthene at 1.7 mg kg^{-1}. When considering the toxicity of PAHs it is important to look at B(a)P, but also at the total PAH, as the toxicity of individual PAHs can be cumulative. There are very few toxicological reports for individual PAHs (only two exist at this time; B(a)P and naphthalene). However, the total PAH concentration at HA5 is only just above detection limits, and is not considered to pose a significant risk to human health; this is especially so as there will be a clean layer applied to the site, effectively removing the pathway between the source and the receptor. The magnitude of the impact is considered to be **negligible**.

12.5.28 The magnitude of the risk to human health posed by background levels of dioxins and furans is also considered to be **negligible**. There are no acute toxicity effects associated with short term exposure to background concentrations. It is also unlikely that grams-worth of soil will be ingested at any one time, or at every time. The application of the clean layer will also remove the pathway of contaminant transport.

12.5.29 Slightly elevated concentrations of arsenic, copper and nickel determined from the Phase I Site Investigation are not considered further since the sample sites lay without the [Phase 2 and 3] site boundary. No elevated metal concentrations were detected in any of the samples from the Phase II Site Investigation.

Assessment of Impact Significance

Geotechnical-based Impacts

12.5.30 The structural harm to buildings resulting from inadequate foundations or the presence of shallow mine workings is considered to be **moderate**. The impact significance from the presence of poor founding conditions or shallow mine workings is therefore **major – moderate** if not mitigated**.**

Contamination-based Impacts

12.5.31 The possibility of significant harm being caused to human health as a result of the slightly elevated PAH concentration at HA5 is considered to be **negligible**.

12.5.32 The possibility of significant harm being caused to human health as a result of background concentrations of dioxins and furans across the site is considered to be **negligible** for end users and **negligible** for site workers if good working practices are adopted (such as hand washing and boot washing to remove mud).

12.6 Mitigation Measures

Mitigation of Geotechnical-based Impacts

12.6.1 The established methodology for investigating and stabilising shallow mine workings has been developed in coal mining areas. One such method of stabilising shallow mine workings is by a process of drilling and pressure grouting. The technique involves drilling boreholes on a closely spaced grid pattern and injecting a cement grout into the old workings, thus in filling the voids and preventing the potential for mine collapse. The method of grout stabilisation is well established in coal mining areas for residential and light commercial type development.

12.6.2 The drilling and grouting technique is usually recommended where shallow mine workings are present at a depth of less than 10 times ratio to rockhead. The drilling and grouting technique however, becomes unsuitable where the depth of workings is less than 5 to 6 metres below surface and where there are substantial areas of collapsed and broken ground up to ground level. In such circumstances the excavation and re-compaction of material is recommended.

12.6.3 Notwithstanding the above, the risk of shallow old mine workings being present below the site is considered small.

12.6.4 The presence of near surface made ground affecting foundations can be mitigated by founding through this material into more competent in situ clay deposits. The presence of more substantial made ground materials can be mitigated by trench foot foundations or by excavation and re-compaction of these materials.

Mitigation of Contamination-based Impacts

12.6.5 Mitigation of several of the potential contamination-based impacts identified within the proceeding sections can be developed at the detailed design stage of the proposed redevelopment. These impacts can be mitigated in terms of the contaminated land assessment regime by removal of the source, pathway or receptor. Without any of these three components, the relevant pollutant linkage is broken and by definition there is no risk to the receptor in question. Appendix 12.6 is the revised remediation strategy produced by Wardell Armstrong, based on the initial remediation strategy produced by Dunelm for the planning application, but taking into account the additional site investigation and testing carried out in March 2008.

12.6.6 The potential impact to future site users from PAH and/or dioxins and furans within the made ground in the Phase 2 and 3 areas of the site could be mitigated by removal of either the pollutant source or pathway. Given the possible volume of potentially contaminated soils within this area, it is considered that the most feasible option would be to remove the pollutant pathway. This could be achieved by

importing clean cover material (such as topsoil, if required) or using clean material form elsewhere on site to form the uppermost development surface for the proposed playing fields. The construction of the car and coach parking areas, plus the pavilion, would automatically introduce a layer of hard standing between the source and receptor. The CLEA residential without plant uptake land use scenario considers the risk to future site users from potential contaminants through exposure pathways including ingestion and dermal contact with soil. It is considered that as part of normal proposed site usage, the future site user would not be exposed to any soil materials below a nominal depth. It is anticipated that some degree of cut and fill earthworks would be required in this area to create a level development platform, placement of this clean cover layer will be incorporated into the earthworks design.

12.7 Cumulative Impacts

12.7.1 No significant cumulative impacts arising as a consequence of geology and ground conditions are anticipated through the proposed redevelopment of the site.

12.8 Residual Impacts

12.8.1 Mitigation of all of the identified potential impacts arising as a consequence of geology and ground conditions at the site would be able to be planned for at the detailed design stage of the proposed redevelopment, and implemented as part of the site redevelopment works.

12.8.2 Implementation of the proposed mitigation measures would therefore negate the possibility of any residual impacts related to the identified current potential impacts.

12.9 Conclusion

12.9.1 Conditions 26, 27 and 28 require investigation of ground conditions and submission of a remediation strategy. (See Appendix 1.1). These conditions therefore guarantee that there would be no significant adverse impact on ground water or human health during construction activity and during operation of the site development.

12.9.2 A desk study, site walkover survey and subsequent site investigations have been undertaken to identify and assess the potential impacts of geological and ground conditions at the site on the proposed development.

12.9.3 Potential geotechnical and contamination-based impacts have been examined with potential pollutant linkages assessed using the CLEA model.

12.9.4 Potentially significant impacts to human health and future building materials have been identified as a result of abandoned deep and possibly shallow mine workings,

potentially uncompacted made ground materials, one slightly elevated total PAH concentration and background levels of dioxins and furans within made ground materials.

12.9.5 Mitigation measures have been proposed to address these potentially significant impacts. These include investigation and pressure grouting of old mineworkings should they be present, founding through or alternatively excavation and re-compaction of made ground materials and utilisation of hardstanding and clean cover layers.

12.9.6 Implementation of the proposed mitigation measures would negate the possibility of any residual impacts at the site from the identified current potential impacts arising from geological and ground conditions at the site.