9.0 GEOLOGY AND CONTAMINATED LAND

9.1 Introduction

9.1.1 Geology

9.1.2 Several site specific reports have been produced to assess the geology, mining and contamination issues at the site. These reports have been reviewed during the process of developing this Environmental Statement and are listed below.

- Desk Study, Initial Conceptual Site Model and Basis of Design for a Ground Investigation for Bilston Urban Village Preliminary Draft by Waterman Burrow Crocker, ref. 32161, dated June 2004
- Desk Study for Extended Plot A – Bilston Urban Village by Waterman Burrow Crocker, ref. 32161, dated April 2005
- Completion Report for Investigation and Stabilisation of Record Mineshafts at the Proposed Bilston Urban Village, Bilston, Wolverhampton, West Midlands by Johnson Poole & Bloomer, dated February 2005
- Ground Investigation Interpretative Report Ground Conditions & Outline Reclamation Strategy for Bilston Urban Village by Waterman Burrow Crocker, ref. 32161A, dated April 2005
- Ground Investigation Interpretative Report Geotechnical Assessment and Earthworks Design Strategy for Bilston Urban Village by Waterman Burrow Crocker, ref. 32161B, dated July 2005
- Ground Investigation Interpretative Report Contaminated Land Assessment and Remediation Strategy for Bilston Urban Village by Waterman Burrow Crocker, ref. 32161C, dated July 2005
- Ground Investigation Interpretative Report Mining Treatment Strategy for Bilston Urban Village by Waterman Burrow Crocker, ref. 32161D, dated July 200

9.1.3 There will be a separate full application for planning permission for the reclamation and remediation works on Plot A. The Plot A site boundary for the Planning Application should provide the necessary volume and storage area for material which is used for this works. There are 4 mineshafts south of the Dudley Street/Banksfield Diversion. These have been stabilised and material can be stored on top of them. However they will need to be capped before any future infrastructure construction works are completed in this area. Therefore it may be prudent to cap them as part of the works.

9.1.4 Waterman Burrow Crocker (now Waterman Civils) has produced two desk studies to identify the general conditions likely to be present at the site. The first desk study, reported in June 2004, was supplemented by an intrusive ground investigation by Waterman Burrow Crocker in 2004 to confirm the general ground conditions. The site was subsequently extended to include land to the west of Dudley Street and the High Street Link, referred to as extended Plot A in the second desk study.

9.1.5 The British Geological Survey (BGS) Dudley Solid and Drift Map (Sheet 167) and relevant maps from the BGS Technical Report WA/92/33 entitled "A geological background for planning and development in the 'Black Country' " indicate the site to be mostly underlain by Carboniferous Coal Measures. Two faults cross the site. Localised drift deposits are indicated to be present, generally in the centre and north of the site. However, due to the brownfield nature of the site, Made Ground is present across the site above the localised drift deposits and the Coal Measures. Many abandoned mine shafts and worked coal seams and ironstone bands are located within the site boundary.

9.1.6 A summary of the general ground conditions identified at the site is presented below and shown on Drawing No. 32161/200/03 Rev I1 'Geology of the Area (Solid and Drift)' presented in Appendix 9.1. It should be noted that the depths of each stratum differs across the site.

Methodology

9.1.7 Research and investigation has been carried out generally in accordance with BS5930: 1999 Code of Practice for Site Investigation and BS 10175: 2001 Code of Practice for the Investigation of Potentially Contaminated Sites. Geotechnical assessment is in accordance with standard practice with reference to Building Regulations Approved Document 'C' (Site Preparation and resistance to contaminants and moisture) and PPG 14 (Development on Unstable Land). Contaminated Land Risk Assessment is in accordance with PPG 23 (Planning and Pollution Control), the Environmental Protection Act (EPA) 1990, Environment Agency CLEA Guidance (Contaminated Land Exposure Assessment) and Environment Agency R&D Publication 20 (Methodology for the Derivation of Remedial Targets for Soil and Groundwater to Protect Water Resources.

9.1.8 Research and Investigation

9.2 Baseline Conditions

Hardstanding and buried structures

9.2.1 There is limited tarmac and concrete hardstanding on the site, restricted to the former Works (Metabrasive Ltd) in the west of the site, a car park and tennis courts belonging to Bilston High School in the north and paths and roads crossing the site.

9.2.2 Localised buried structures including cellars, buried walls and former foundations were encountered in the shallow Made Ground and are likely to relate to former factory foundations, furnace foundations and canal basins.

Made Ground

9.2.3 The site is underlain by up to 16.4m of Made Ground, which generally comprises two layers, Granular Made Ground and Cohesive Made Ground. Locally however, in an area of former unlicensed tipping adjacent to Carder Crescent, limited deposits of old Refuse have been encountered.

9.2.4 **Granular Made Ground:** Locally there is an upper layer of granular Made Ground, present in discrete areas across the site, consisting of broken concrete and brick demolition waste. This layer is generally <2m thick. The main layer of Granular Made Ground comprises loose dark grey and black sand, gravel and occasionally cobbles and boulder size brick, clinker, ash and slag with some concrete, mudstone and sandstone which includes occasional clayey pockets with rare pockets of “foul lime”. These deposits are considered to be Foundry Waste originating from the former ironworks and furnaces located across the site.

9.2.5 **Cohesive Made Ground:** The Cohesive Made Ground generally forms a layer beneath the Granular Made Ground across the majority of the site. However, locally these deposits are found at ground level. These deposits are shown to be generally between <1m and 11m thick and comprise dark brown grey sandy slightly gravely clay with a variable mixture of mudstone, sandstone, siltstone, coal, clinker, ash and slag gravel and cobbles. These deposits are considered to be colliery spoil resulting from the disposal of waste from the surrounding former collieries.

9.2.6 **Refuse:** Refuse-type materials comprise a variable grey black slightly clayey sand and gravel mixture of brick, clinker, ash and slag with some to occasional concrete, metal, pottery, plastic, newspaper, leather, glass, and asbestos sheet have been encountered to the north of Carder Crescent and between Carder Crescent and

Bilston High School playing fields. These deposits have been found near surface and have recorded thicknesses generally between <1m and 9.0m.

Drift Deposits

9.2.7 Locally, alluvial deposits relating to former stream alignments and former pond features have been identified on the site, comprising black organic sandy silts and clays generally between <1m and 1.5m thick.

In isolated locations, particularly toward the northern part of the site, there is evidence of glacial deposits comprising glacially reworked Coal Measures strata, recorded as light grey mottled orange brown sandy gravelly clay between <1m and 1.5m thick.

Solid Deposits

9.2.8 The Carboniferous Coal Measures generally comprise mudstone, siltstone, sandstone, ironstone and coal seams together with numerous significant voids and broken ground relating to former mine workings at depth. Close to sub crop, these strata are weathered to a light grey clay with occasional coal fragments, weathering to very weak mudstone at depth. A thin veneer of weathered Coal Measures has been identified across the site between <1m and 4.5m thick.

9.2.9 The published geology and evidence from the ground investigation indicates that the Coal Measures strata generally dip gently down to the south. There is a syncline fold axis running north west – south east through the site, resulting in this dip varying from south west in the east of the site to south east in the west of the site. The Coal Measures strata are affected by two faults, the Lanesfield Fault and Coseley - Wednesbury Fault, that cross the south western part of the site.

Groundwater

9.2.10 Perched water appears to be localised in pockets within the less permeable Cohesive Made Ground and in natural troughs at the surface of the weathered Coal Measures. There appears to be some localised hydraulic connection within each ponded area.

9.2.11 Deep groundwater is present within the Coal Measures strata. The average level of the local groundwater table is considered to be approximately 122m AOD. However, this is subject to natural fluctuations and will also possibly be affected by drawdown from periodic but significant local off-site abstractions by British Waterways, who use the groundwater to provide water for the region's canal network.

Faults

9.2.12 The Lanesfield Fault runs approximately west to east across the south western portion of the site and down-throws the Coal Measures strata by 64m to the south. Therefore, all coal and ironstone seams to the south of the fault will be 64m further below ground level than those to the north.

9.2.13 The Coseley - Wednesbury Fault runs approximately west to south east across the extreme south west of the site and down-throws the Coal Measures strata by 9m to the south. This suggests that the Etruria Formation will be present to the south of the fault overlying the Coal Measures, with the productive seams at considerable depth.

Mining

9.2.14. There is evidence that mining in the Bilston area dates back to the 14th century. However, it was during the 18th and 19th century and particularly during the industrial revolution that extensive mining of the coal and ironstone seams beneath the site was undertaken. It is understood that in this area nine coal seams and three ironstone bands were worked at varying depths between about 10m and over 100m bgl.

There are approximately 108 recorded potential mine shafts on or close to the site. Some of these have recently been treated by Forkers Limited but about 21 remain to be investigated.

9.3 Contaminated Land

Site History

9.3.1 The desk studies identify that the following former uses have been located across the site, as shown on Drawing No. 32161/200/17 Rev I1 'Potential Hazard Plan from Previous Land Use' (Appendix 9.2) and 32161/200/41 Rev A 'Extended Plot A Potential Hazard Plan' included within Appendix 9.3

- Collieries and associated mineshafts
- Refuse tip
- Iron and steel works
- Canal basins
- Railway lines / station / sidings
- Scrapyard

- Concrete works
- Metabrasive Limited (manufactured grinding discs and metal shot)
- Gasometer
- Refuse and spoil heaps
- Schools and associated playing fields
- Church and associated graveyard
- Windmill

9.3.2 Historically mining was the earliest industrial process carried out on the site. Consequently the majority of the deeper Made Ground, placed first on large parts of the site, is colliery spoil, which is generally cohesive in nature but also includes natural soil discarded from the mining and shaft sinking operations. Often these deposits appear to be located close to shafts. It should be appreciated that mining operations were undertaken over a long period of time, concurrent with later industry that occupied parts of the site and therefore mixed deposition of made ground materials has occurred.

9.3.3 A large area of the site was later occupied by a number of Furnaces (foundries) and Iron Works, which utilised the coal and ironstone mined from the local area. The historical plans suggest that stockpiles of raw product together with waste deposits from these industries would have been moved by small railways and / or conveyors. The coal and foundry products are likely to have been transported by canal and later railways to off-site destinations, with the by-products being deposited in heaps in adjacent areas of the site.

9.3.4 Mixing of deposits is likely to have occurred later when the Made Ground was moved and levelled to form plateaus for development or to form embankments, such as for the railway, and during more contemporary construction works such as the installation of the culvert and sewer that run at significant depth through the centre of the entire site.

9.3.5 The historical context of the placing of the Made Ground deposits suggest that these materials were not carefully selected and compacted and they are therefore highly variable in consistency.

Contaminated Soils and Groundwater

9.3.6 The ground investigation carried out by Waterman Burrow Crocker in 2004 identified several sources of potential soil contamination within each type of Made Ground. No sources of potential soil contamination were identified in the natural

strata. Potential sources of groundwater contamination were identified in both the perched and deep groundwater. It should be noted that the ground investigation in 2004 did not include the scrapyard, which was inaccessible at that time, or land to the west of Dudley Street and the High Street Link, which was incorporated into the site in 2005. As such, in the following section, the location of the source of contamination is separated into the “whole site”, the “main site” and the “scrapyard”. The “whole site” comprises the “main site” (which includes the land to the west of Dudley Street and the High Street Link) together with the “scrapyard” whereas the “main site” excludes the “scrapyard”. The potential impacts of this contamination on human health, flora and controlled waters are discussed in the following section.

Ground Gas

9.3.7 There is no evidence of putrescible materials that may produce combustible gas within the shallow soils below the site. Results of long term gas monitoring of borehole standpipes indicate elevated concentrations of carbon dioxide and occasional depleted oxygen concentrations. Combustible gas has not been detected.

Japanese Knotweed

9.3.8 Stands of Japanese Knotweed have been identified across the site by Faulks Perry Culley and Rech. Treatment of the Japanese Knotweed has been undertaken under the supervision of Faulks Perry Culley and Rech. Reference should be made to Section 6 Ecology and Nature Conservation in this report for details on the location and current status of the Japanese Knotweed.

It should be noted that prior to any works on the site, including remediation and earthworks, consultation with an ecologist will be necessary to prevent spreading of this extremely invasive and destructive plant.

9.4 Assessments of Impacts

Contamination

9.4.1 UK legislation on contaminated land is covered mainly by Part IIA of the Environmental Protection Act (EPA) 1990. The statutory guidance details how the regime under Part IIA will operate and, describes the risk assessment methodology in terms of 'significant pollutants' and ‘significant pollutant linkages’ within a source-pathway-receptor model of the site. This endorses the principle of a ‘suitable for use’ approach. The model comprises:

- the principal pollutant hazards associated with the site (the sources);
- the principal receptors at risk from the identified hazards; and
- the existence, or absence, of plausible pathways which may exist between the identified hazards and receptors.

9.4.2 All three elements of a significant pollutant linkage, i.e. the source-pathway-receptor model, must be present for land to be classified as 'contaminated'. In addition, significant harm being caused to the environment or humans (or a possibility of significant harm occurring) or pollution of controlled waters is being, or is likely to be, caused. Remediation may then be required depending on the proposed end use.

9.4.3 A preliminary qualitative contaminated land risk assessment for the site, based on the information available to date and on CIRIA C552, BS10175 and EA (CLEA) is presented below:

Source	**Pathway**	**Receptor**	**Risk**
Petroleum hydrocarbon compounds and associated carcinogenic volatile organic compounds within Made Ground on the main site	Inhalation of vapour	Site workers and public during works	**Low**
		End Users	**Low**
	Ingestion via direct contact	Site workers and public during works	**Low**
		End Users	**Low**
	Migration in solution by groundwater flow	Surface water drainage	**Negligible**
		Minor Aquifer (Coal Measures)	**None**
Petroleum hydrocarbon compounds and associated carcinogenic volatile organic compounds within Made Ground on the scrapyard	Inhalation of vapour	Site workers and public during works	**High**
		End Users	**Low**
	Ingestion via direct contact	Site workers during works	**High**
		End Users	**Moderate**
	Migration in solution	Surface water drainage	**Low**

Source	Pathway	Receptor	Risk
	by groundwater flow	Minor Aquifer (Coal Measures)	**Low**
	Downward migration via mineshafts	Minor Aquifer (Coal Measures)	**Low**
Asbestos within Made Ground on the main site	Inhalation of fugitive dust	Site workers and public during works	**Moderate**
		End Users	**Low**
Asbestos within Made Ground on the scrapyard	Inhalation of fugitive dust	Site workers and public during works	**High**
		End Users	**Low**
Toxic heavy metals within Made Ground on the whole site	Inhalation of fugitive dust	Site workers and public during works	**Low**
		End Users	**Low**
	Ingestion via direct contact	Site workers and public during works	**Low**
		End Users	**Moderate**
	Migration in solution by groundwater flow	Surface water drainage	**Low**
		Aquifer	**None**
Phytotoxic & ecotoxic metals within Made Ground on the whole site	Plant uptake	Garden and landscape planting	**Low**
	Migration in solution by groundwater flow	Surface water drainage	**Negligible**
		Aquifer	**None**
Corrosive contaminants in the soil and / or groundwater on the whole site	Direct contact or movement of mobile soluble contaminants within the groundwater	Foundations and in-ground structures and buildings	**Moderate**
		Services	**Moderate**
Combustible material on the whole site	In-ground fire	All	**Low**

Source	Pathway	Receptor	Risk
Ground Gas from Made Ground on the whole site	Migration into excavations	Site Workers	**Moderate**
	Migration into building	End Users	**Low**

9.4.4 There is evidence of potential contaminants, including petroleum hydrocarbons, asbestos and metals, within the Made Ground across the site. It should be noted that the elements of the risk assessment above relating to the scrapyard has been based on visual inspection only, since access for intrusive ground investigation works is not currently available. These potential risks on the scrapyard will be reassessed following clearance and ground investigation.

9.4.5 Risk to Human Health is considered to be moderate to low, except in the scrapyard where preliminary assessment suggests a potentially high risk.

9.4.6 Risk to garden and landscape planting is considered to be low.

Risk to Controlled Waters is considered to be low to none, taking into account the solid bedrock strata below the site being classified by the Environment Agency as a Minor Aquifer and the site not lying within a Groundwater Source Protection Zone.

9.5 Spoil Mounds

9.5.1 The soil mounds present a topographic and engineering constraint to the proposed development. Reprofiling, redistribution or removal of this material will be required to allow development to proceed. It is uneconomic and incompatible with the philosophy of sustainable development to remove these materials from site. Since the spoil heaps are artificial creations, their removal should have negligible geomorphological impact.

9.6 Mineshafts

9.6.1 108 No. potential mine shafts have been identified from mining records and old plans on the site.

9.6.2 North of the Lanesfield Fault and between the Lanesfield Fault and the Coseley – Wednesbury Fault numerous mineshafts are present. The assessed risk is detailed in the table below.

Condition Identified	**Potential Hazard to Development**	**Risk**
Untreated Mineshafts	Collapse / settlement of loose infill	**High**
Partially Treated Mineshafts	Settlement of temporary ‘grout’ cap	**Moderate**

9.6.3 To the south of the Coseley - Wednesbury Fault a few mineshafts are present. The assessed risk is detailed in the table below.

Condition Identified	Potential Hazard to Development	Risk
Untreated Mineshafts	Collapse / settlement of loose infill	**High**
Partially Treated Mineshafts	Settlement of temporary 'grout' cap	**Moderate / low**

9.6.4 An initial phase of mineshaft stabilisation was undertaken by Forkers Limited during Spring/Summer 2004. This work comprised the location, infilling and 'grout-capping' of easily accessible shafts on the site. Untreated mineshaft locations that could not be readily accessed were not located or treated in this operation. Partially treated mineshafts pose a risk of settlement of the temporary 'grout' cap. The location of all the recorded mineshafts and their status are identified on Drawing Number 32161/200/36 Rev I2 'Shaft Positions' included within Appendix 9.4.

9.6.5 The shaft stabilisation works suggest that the shafts are generally about 2m diameter and between 50m and 200m deep. Shafts pose a risk of subsidence and potential collapse due to the presence of loose infill and voids resulting from abandonment after cessation of mining activities.

9.7 Mineworkings

9.7.1 North of the Lanesfield Fault partially collapsed mineworkings, including open voids, were identified during the ground investigation in 2004 at shallow depth. The assessed risk is detailed in the table below.

Condition Identified	Potential Hazard to Development	Risk
Voids in shallow coal seams	Crown hole below building	**High / Moderate**
	Crown hole below roads and car park	**Moderate / Low**
Broken ground in shallow coal seams	Localised settlement below building	**Moderate**
	Localised settlement to roads and car park	**Low**
Workings in deeper seams (assumed)	Small settlement below building	**Low**
	Small settlement to roads and car park	**Negligible**

9.7.2 Between the Lanesfield Fault and the Coseley – Wednesbury Fault some workings were identified during the ground investigation in 2004 at depth. The assessed risk is detailed in the table below.

Condition Identified	**Potential Hazard to Development**	**Risk**
Voids in shallow coal seams	Crown hole below building	**Very Low**
	Crown hole below roads and car park	**Low**
Broken ground in shallow coal seams	Localised settlement below building	**Very Low**
	Localised settlement to roads and car park	**Low**
Workings in deeper seams (assumed)	Small settlement below building	**Negligible**
	Small settlement to roads and car park	**Negligible**

9.7.3 South of the Coseley-Wednesbury Fault some workings were identified during the ground investigation in 2004 at depth. The assessed risk is detailed in the table below.

Condition Identified	**Potential Hazard to Development**	**Risk**
Voids in shallow coal seams	Crown hole below building	**Very Low**
	Crown hole below roads and car park	**Very Low**
Broken ground in shallow coal seams	Localised settlement below building	**Very Low**
	Localised settlement to roads and car park	**Negligible**
Workings in deeper seams (assumed)	Small settlement below building	**Negligible**
	Small settlement to roads and car park	**Negligible**

9.7.4 Worked coal seams were identified during the ground investigation in 2004 below the entire site. The potential risk of subsidence associated with these workings is shown on Drawing Number 32161/200/09 Rev I2 'Potential Mining Subsidence Risk' presented in Appendix 9.5. The zones of risk highlighted are related to the proximity of the Staffordshire Thick Coal Seam and other potentially worked seams to the site surface. The boundaries of the zones are defined by the faults and the associated risk of subsidence reduces progressively to the south west as the Staffordshire Thick Coal is downthrown by each fault. The depth to broken ground within the Coal Measures is shown on a cross section on Drawing 32161/200/25 Rev I2 'Section C-C1' presented in Appendix 9.6. The line of cross section is shown on Drawing Number 32161/200/09 Rev I2 'Potential Mining Subsidence Risk'.

9.7.5 Investigations to date suggest that the deep Coal Measures are not generating significant levels of mine gas and therefore are not considered to pose a significant risk to development. However the development proposals should take into account that the greatest risk of mine gas after the mineshafts and mineworkings have been treated is along fault lines.

9.7.6 There is considered to be a low risk of subterranean fires from unworked or part worked coal seams that can potentially cause settlement, heat damage to structures, foundations and services and the production of toxic gas.

9.8 Unconsolidated and Heterogeneous Fill

9.8.1 The Made Ground deposits across the site are of variable depths, highly variable in density and appear to be generally unconsolidated. Its unconsolidated nature is likely to result in settlement over time, particularly where the ground is loaded with structures as part of the redevelopment of the site. The variability of depth and composition of the fill, as shown on Drawing 32161/200/25 Rev I2 'Section C-C1' presented in Figure 9.6, is considered likely to cause differential settlement across the site. Settlement and particularly differential settlement is likely to cause damage to foundations, ground floor slabs and superstructures. Roads and services may also be affected.

9.8.2 There is considered to be a low risk of physical contamination in the shallow Made Ground associated with former cellars, buried walls and foundations.

9.8.3 There is considered to be a low risk of subterranean fires from coal and coal dust within Made Ground that can potentially cause settlement, heat damage to structures, foundations and services and the production of toxic gas.

9.9 Slag

9.9.1 A mix of metaliferous slags has been identified in past and recent ground investigations across the site. Such materials may have the potential to expand under specific conditions and could cause damage to buildings, roads and other structures. Testing carried out during the ground investigation in 2004 on a limited number of samples of granular Made Ground suggests that there is a low risk of damage from expansion.

9.10 Japanese Knotweed

9.10.1 There is considered to be a high risk of damage to buildings, roads, hardstanding and services if Japanese Knotweed is present and not treated on the site, due to its vigorous and invasive growth, even through tarmac and concrete.

9.10.2 Additionally, its presence will have a significant impact on the phasing and carrying out of the earthworks and construction operations at the site.

9.11 Mitigation Proposal

9.11.1 It is proposed that various works will be undertaken as part of the reclamation scheme to mitigate the potential impacts identified above.

Contamination

9.11.2 Given the former industrial activities carried out on site, the Made Ground contains limited concentrations of usual contaminants of concern.

9.11.3 Potential pollutant linkages have been identified and in order to remove the risk to human health, garden and landscape planting and controlled waters, some remediation will be required. The remediation strategy is likely to comprise:

- Sustainable redevelopment by minimisation of off-site disposal thus reducing lorry movements and hence secondary pollution.
- Use of on-site remediation techniques such as; bioremediation, soil fixing, thermal disorption, soil washing and others in high risk areas.
- Use of barriers and pathway breaks such as; cover layers, break layers and appropriate construction in medium risk areas.
- Use of reduced infiltration by capping, hardstanding and sealed drainage and surface water features, not allowing soakaway drainage systems to be utilised.
- Use of suitably resilient plants within the landscaping and planting schemes that will tolerate the existing conditions present at the site.

9.11.4 The choice of remediation techniques and target concentrations will be determined using a risk assessment approach, taking into account the end uses and locally sensitive receptors and will require approval by the Local Authority and the Environment Agency before reclamation works commence.

9.11.5 Appropriate health and safety measures will be required during reclamation and construction to protect the health of site workers.

Remediation Mitigation

9.11.6 Remediation works will be required where it is found necessary to mitigate against potential impacts. The methodology selected will be subject to the requirements of CLR 11 and approvals from both the Environment Agency and Local Authority Environmental Health Officer, following detailed investigation and risk assessment.

9.11.7 Impacts from remediation works will take the form of odour from exposed contaminants, noise from plant movement and dust from soils; these are addressed elsewhere within appropriate sections of this statement. All works will be carried out in accordance with the agreed Remediation Strategy and Implementation Plan. These documents will address risks arising from access to pathways and impacts to receptors both during and after construction work.

9.11.8 Where practicable on site remediation methods will be used to minimise off site vehicle movements. The use of bio-remediation is possible for the soils contaminated with petroleum hydrocarbons. This will results in the excavation of soils, stockpiling, rotavating and returning the treated soils into the ground. This process will generally take 16 to 20 weeks at each location where remediation is required.

9.11.9 Remediation works will be carried out in accordance with BS10175 'Investigation of contaminated soils' and CIRIA Special Publication 109 'Remedial Treatment of Contaminated Land'.

9.11.10 Due to contamination on the site, building design should incorporate a suitable concrete design mix to protect in-ground concrete. It is recommended that all in ground concrete be designed and specified as Design Class DC- 4 with ACEC Site Classification of AC-4 as a minimum.

9.11.11 Significant levels of carbon dioxide were locally encountered during the ground investigation in 2004, suggesting a current requirement for Characteristic Situation 2 gas protection measures within the proposed buildings. It is also recommended that monitoring and interpretation of ground gases continues:-

- During the design period to provide further data for the detailed design.
- During construction for health and safety reasons and to identify any trends or changes resulting from the works.

- Post reclamation strategy since ground gases may increase / decrease with reclamation work and time.

Spoil Mounds

9.11.12 Due to the undulating topography of the site, there is a requirement to undertake earthworks to form a suitable land profile for infrastructure and drainage and to provide suitable flat plateaus for subsequent development.

9.11.13 The earthworks strategy will include:

- Cut and fill balance using 3-D digital terrain modelling.
- Suitably sized plateaus to allow flexibility in final plot layout.
- Treatment of on-site materials by sorting, crushing and screening to render them acceptable.
- Ground improvement of marginal materials which are to be left in place using; vibro, dynamic compaction etc.
- Protection of the temporary plateaus surface to reduce dust and silt-laden runoff.
- Reuse and retention of stripped topsoil in open space areas.

9.11.14 The final chosen technique will need to consider constraints that include the surrounding land users (noise, vibration) and the presence of services such as the deep culvert (vibrations).

Crushing & Screening

9.11.15 Earthworks design will consider the environmental impacts and will where practicable utilise methods which minimise impacts from noise and vehicle movements. The location of crushing facilities will be selected to minimise noise and vibration into adjacent residential areas. On site crushing and reuse of materials on site will minimise vehicle movements off site.

9.11.16 Crushed and sorted materials will then be used to cover areas to prevent dust generation in the period of time prior to development. The crushed materials will be rolled with a vibratory roller to ensure that materials are compacted to form a smooth surface.

9.11.17 The timescale for this work will be subject to the amounts of material and the size of crushing plant. The plant selection will be subject to the guidelines set out with respect to noise transmission. Where necessary noise barriers will be provided to meet the guidelines, monitoring will be carried out to ensure compliance.

9.11.18 That earthworks are not undertaken until all mineshafts have been treated and until the Japanese Knotweed has been treated or a strategy for dealing with the Japanese Knotweed has been adopted.

9.11.19 Cut areas should be improved by use of rapid impact compaction or Vibrocompaction, dependent upon depth of Made Ground present beneath the site and the sensitivity of the proposed end use.

9.11.20 Fill areas should be improved by use of rapid impact compaction or Vibrocompaction, dependent upon depth of Made Ground present beneath the site and the sensitivity of the proposed end use prior to commencement of filling operations.

9.11.21 Fill materials should be screened (where required), placed and compacted to Highways Agency Method Specification 2 utilising standard heavy compaction plant and techniques. It is recommended that Lime / cement stabilisation may be considered to improve wet materials and to seal final surfaces to reduce the risk of contaminated fugitive dust being generated whilst the site awaits future development.

Mineshafts and Mineworkings

9.11.22 As indicated by Drawing No. 32161/200/09 Rev I2 it is considered that a majority of the site is at risk from subsidence as a result of the former mining activities. In addition, there are approximately 100 recorded or suspected mineshafts present on or close to the site, a majority of which have recently been stabilised and temporarily capped. However several remain untreated.

Soil Treatment

9.11.23 The construction process for lime/ cement stabilisation will be achieved by keeping the materials in a sealed environment prior to use, spreading the materials on the surface and immediately mixing the lime/ cement into the soils using a rotavator. The surface is then rolled to consolidate the material and provide a seal against rain.

9.11.24 The improvement of soils will be carried out in accordance with the guidelines presented in CIRIA C572 ‘Treated Ground Engineering Properties and Performance’, 2002. Lime/ cement stabilisation will be carried out in accordance with the Dept. of Transport (2000) HA 74/00; ‘Treatment of fill and capping materials with either lime, cement or both’.

9.11.25 The mining treatment strategy will include:-

- Locating and filling of the remaining untreated shafts on the site.
- Consolidation of shallow mine workings using drilling and grouting techniques within the zone of influence of the building footprint.
- Inclusion of geogrid reinforcement within the sub-base construction of external roads and car parks.
- Permanent capping of all treated shafts.

Unconsolidated and Heterogeneous Fill

9.11.26 Due to the variable nature and depth of the fill and its variable density, possible solutions for supporting the foundation, substructure and floor slabs of the proposed development are:

- Ground improvement of the Made Ground and appropriate shallow foundations.
- Deep pad/pier foundations into the underlying natural strata.
- Provision of additional substructure, or lowering site levels, with foundations in the underlying natural strata.
- Engineering compaction and / or cement / lime stabilisation of near surface Made Ground combined with the use of raft foundations.

Mine Treatment

9.11.27 The works will require the drilling of holes using a rotary drilling rig, after which grout will be pumped into the ground until refusal. This will require the storage of cement and pulverised fuel ash (PFA) on site prior to use. Impacts from the works will be generally low and be of short duration. However, the issue of dust from the PFA will be addressed by keeping storage areas away from public areas and preventing dust by minimising on site storage and covering storage piles. The mine workings treatment will be designed to minimise any impact on the mass groundwater permeability of the underlying strata.

9.11.28 Grouting works will be carried out in accordance with the guidelines presented within CIRIA SP34 ‘Construction over abandoned mine workings’ 1984 and in general compliance with CIRIA Report C514 ‘Grouting for Ground Engineering’, 2000.

9.11.29 Despite the requirement to treat the shallow mine workings, the use of piled foundations would be precluded due to the potential for residual ground movements to reduce pile capacity.

9.11.30 The possibility of local hardspots associated with buried walls, foundations etc within the shallow Made Ground should be considered during the foundation design.

9.11.31 The viability and suitability of the above options depend upon the final adopted reclamation strategy and the final development levels in relation to appropriate founding strata.

9.11.32 It should be noted that specific foundation load / settlement analysis and detailed geotechnical and foundation design still has to be undertaken and finalised during the final design process.

9.11.33 It is recommended that beneath infrastructure roads, the soils are improved by the excavation, screening, placement and compaction of a minimum depth of 1m and the incorporation of geogrids and / or the use of lime / cement stabilisation.

9.11.34 The design of services entering the proposed structure should include flexible but robust connections between the structure and external areas. These should be capable of compensating for movement and settlement of the surrounding ground.

Slag

9.11.35 Slags expand in the presence of groundwater. At the site, perched groundwater appears to be only limited and localised. It is recommended that soakaways are precluded from use at the site as they may increase the chance of causing an expansive reaction to occur.

Japanese Knotweed

9.11.36 To prevent potential spreading of Japanese Knotweed, a minimum stand-off of 7m for plant trafficking or excavations is required from identified stands and shoots. An ecologist must be employed to identify, delineate, advise and approve of working methods in the vicinity of the Japanese Knotweed.

9.11.37 It is recommended that groundworks for the development are not undertaken until treatment of the Japanese Knotweed is complete or an alternative approved

strategy incorporating the stand-off and working methods has been developed and agreed.

Conclusion

9.38 The former industrial activities on the site have resulted in a number of different materials underling the site. Man-made materials deposited by the former mining activity lie on top of localised river deposits, glacial clays and rock. The rock underlies the whole site and consists of layers of mudstones, sandstones and siltstones with coal and ironstone seams throughout. Many boreholes and trial pits have been dug at the site to investigate the soil and rock, and to determine what needs to be done to the ground to make it suitable for development.

Some contamination was found in the man-made soils and in the water within the soil and rock. These will be remediated safely by treating on site, where possible, at an early stage of construction, which would mean that the site is safe to develop while minimising removal of material from site. Man-made soils will be reprofiled to form flat space for the development.

Many mine shafts on the site have already been treated by infilling and capping. However the remainder of the mine shafts will be treated to make sure the site is safe for development. In addition, some of the old mine workings below the site have potential to cause damaging subsidence. These workings will be treated as part of the construction.

Gases from man-made soils and coal seams are a potential hazard and will need to be assessed after remediation of the soils and treatment of the mineshafts and mine workings to ensure that subsequent development is safe. Japanese Knotweed, an invasive plant, is on the site and will be treated at the start of the construction works.