Comments on the report entitled 'Pepper street Development – Initial Comments on Ground Investigation' prepared by Dr Bernard Besly.

1. Dr Susan Digges la Touche is a Chartered Geologist and geoscience professional with approximately 20 years of experience in consulting and research for consulting, public sector and academic bodies. I have a first degree in Geology with honours, a Master's degree in Mineral Exploration and Mining Geology and a PhD in Earth Sciences (Hydrogeology). I have been working in the area of Contaminated Land and Environmental Protection since 1997 and have held posts including Project Hydrogeologist at URS, Principal Hydrogeologist at MWH and Senior Geoscientist at Golder Associates (UK). Whilst working in the area of Environmental Protection at Birmingham City Council I dealt with a number of successful prosecutions under the Environmental Protection Act and acted as an expert witness on behalf of the Council for environmental issues including contaminated land and noise. In my capacity as contaminated land professional I have been retained by Keele Parish Council to provide a verification of a report entitled 'Pepper street Development – Initial Comments on Ground Investigation' prepared by Dr Bernard Besly. I will therefore make reference to this report and provide additional comments as appropriate.

2. In verifying Dr Besly's report the following resources have been utilised:

    - Betts Geo-Environmental Land off Pepper Street Desk Study Jan 2013 12HDS002/DS. Referred to as Betts DS)
    - Betts Geo-Environmental Land off Pepper street Keele Sept 2013 Report 12HDS002/GI (referred to as Betts GI)
    - Betts Ground Investigation Report for Garage Area, Pepper street Keele Sept 2013 Report 12HDS002/GI (referred to as Betts GI)
    - Guidance on Evaluation of Development Proposals on Sites Where Methane and Carbon Dioxide are Present', Report Edition No.04 March 2007 NHBC – designed for use with low rise residential properties
    - Guidance for the Safe Development of Housing on Land Affected by Contamination R&D Publication 66: 2008 Volume 1, http://www.environment-agency.gov.uk/static/documents/Leisure/SR-DPUB66-e-e.pdf
    - USGS Fact Sheet 2009–3084; Emissions from Coal Fires and Their Impact on the Environment, Allan Kolker, Mark Engle, Glenn Stracher, James Hower, Anupma Prakash, Lawrence Radke, Arnout ter Schure, and Ed Heffern
    - ICRCL Guidance Note 61/84, Notes on the fire hazards of contaminated land
    - An extract from Bernard Besly's PhD thesis entitled The sedimentology and stratigraphy of Red Beds in the Westphalian A to C of Central England, 1983, University of Keele pp. 221-222 and Fig. 174
    - Environmental Permitting Guidance Water Groundwater Activities, For the Environmental Permitting (England and Wales) Regulations 2010;

http://www.environment-agency.gov.uk/static/documents/Business/ep-groundwater-activities.pdf

3. Following a brief discussion of the background and history of the site Dr Besly comments that the historical account given in Betts GI fails to identify the presence of a large former clay to the south of the tilery (referred to by him and hereafter as the "1877 clay pit"). This was intersected in BH7, where the made ground is present to a depth of 12.5m, and the excavation ceased upon intersecting a sandstone bed of 1.7m thickness. This is important due to the potentially unidentified fill in the made ground (the pit) and because the sandstone has not been identified as a pathway for both gaseous and liquid contaminants. Accordingly, it forms an important component of the site conceptual model (CSM) and will be further discussed below.

4. Dr Besly also notes that significant concentrations of methane are present in boreholes WS2 and WS3. In addition to these high methane concentrations, some moderate flows (a flow of 15.5 l/hr in was recorded in WS11) also occur. Although Betts DS mentions a number of potential sources for ground gas within the site, including fill, mine workings, landfill gas and other sources such as the former Tilery, timber yard and clay pit, the GI report does not identify either the source of the gas or pathways. An identification of the gas by means of gas chromatograph, GC-MS of trace organic compounds or carbon ratio by mass spectrometry, amongst other methods could have been used in order to clarify the source of the gas. Indeed, Dr Besly's report states that:
"*The occurrence of these anomalous flows can be related to the presence of permeable sandstones in the lower part of the Etruria Formation. These are known from field mapping carried out in connection with evaluation of clay potential of the Field Site in the 1980's, which have not been recognised in the present ground investigation study ……. It appears possible that migration of gas may occur in solution in groundwater within such sandstone bodies, rather than by simple diffusion through soil.*"

5. This suggestion by Dr Besly could explain why the high methane concentrations on the 1st March and 26th March coincide with the borehole being 'damp' rather 'dry', although high readings were also obtained on the 15th March and 26th April whilst the borehole was 'dry'. In particular, a soluble methane assessment may have aided in the interpretation of the data and clarification of the conceptual model. Currently Dr Besly's belief cannot be confirmed or refuted, as there is no data.

6. Dr Besly also states that:*"….. the remediation measures proposed to protect against gas migration may be inadequate, and the area of the site potentially affected by such gas migration is uncertain, since it is constrained by the correct mapping of the NNW - SSE fault….."*. Indeed, the presence of any gas control measures should be such that the source pathway is removed; without establishing the applicable pathway and, indeed, the source; it cannot be ascertained that the suggested measures will be effective for the purpose of controlling gas ingress.

7. A final Conceptual Site Model (CSM) is presented in section 14.2 of Betts GI; it is broadly generic; merely stating that, 'gas protection is required'. In line with relevant guidance

an initial conceptual site model (ICSM) should have been developed, followed by its development into the working and final conceptual site model. The development of a CSM should include, in addition to the receptor(s), the source of the ground gas, means of migration, potential pathways and site influences both natural and anthropogenic, the meterological conditions, geology and hydrogeology of the site and any details of surface effects, slope, vegetation, etc. (NHBC 2007). Betts do not appear to present any rationale for the design of their monitoring scheme, with respect to the gas source or geology and whether they anticipate lateral or vertical flow. This is rather surprising when the number of potential sources of ground gas is considered. Furthermore, the same publication emphasises that:

"It is of vital importance that the Conceptual Site Model is capable of predicting the worst- case temporal conditions that the site may experience, so that these can then be used in the ground gas risk assessment …... This is essential, and cannot be stressed enough, as the ground gas protection measures installed must be capable of coping with this event".

8. Environmental conditions have the potential to affect ground gas migration and impact upon the reliability of the data set to represent the gassing regime and may include: meteorological conditions, geology, presence of development and vegetation. Low barometric pressure will cause ground gas to expand and emission rates to increase, whilst rising barometric pressure will cause gas to flow into the ground, thereby lowering ground gas concentrations. Barometric pressure will also influence the solubility of gas, with high pressures increasing the solubility and lower pressures causing gases to be released from water. Precipitation may also have a significant impact upon ground gas concentrations, with high levels of rainfall causing the groundwater table to rise, leading to a corresponding increase in the release of gases to the atmosphere. Precipitation can also cause gases to be trapped within the ground, particularly within a clay rich soil.

9. Although barometric data, weather and depth to water have been recorded for up to 12 monitoring rounds, from March to August 2013, there has been no attempt to correlate these data with pressure changes or rainfall, nor is there any discussion regarding whether this represents the 'worst case' temporal range.

10. With respect to the mine tip Betts GI states that data regarding this site was obtained from a Report by White Young Green consulting for Staffordshire County Council and Newcastle Under Lyme Borough Council reference A042825 (instructed January 2012). The purpose of the report was to discuss and assess the risk of the underground fire at the tip to the north of the site, assess its impact upon public health and provide a potential remediation solution. I have seen the conclusions and recommendations of this report, although not the full report. WYG noted that the tip was, "*clearly on fire {as} evidenced from a site inspection and has been burning for at least 2 years*". They suggested that, "*there is little opportunity for isolating areas of the tip by cut off trenches and little scope for suppression of the fire by blanketing*" and recommended that the mine tip area be 'made safe', carefully monitored and allowed to burn itself

out. As additional land is now available, Betts (2013) contained the recommendation that the spoil tip may be remediated by digging it out, spreading it upon the nearby (newly acquired) field and quenching it.

11. It is apparent that Bassy Mine workings were encountered within boreholes 1 and 3 and that these, together with the BGS mapping, suggest old mine workings to underlie the tip. Accordingly, there are a number of considerations that should be assessed prior to any remedial works:
    - Exposing underground coal and or waste coal piles is likely to lead to the oxidation of coal and pyrite in the coal, which produces CO2 and heat, sulphate and potentially sulphuric acid;
    - It is possible that, due to the lower temperature required for coal combustion at depth, spontaneous combustion of coal within a seam can occur;
    - Where exposed at a surface, coal beds can spontaneously combust or be ignited by the tip fire at ground surface;
    - Material laid on the field surface and quenched is likely to result in the emission of pollutants such as CO, CO2, nitrogen oxides, particulate matter, sulphur dioxide, toxic organic compounds, and potentially toxic trace elements, such as arsenic, Hg, and selenium (USGS Fact Sheet 2009–3084; Emissions from Coal Fires and Their Impact on the Environment);
    - Mineral condensates formed from gaseous emissions around vents during an underground fire and as mineral-encrusted surfaces following burning of materials at the surface may also contaminate nearby water bodies, whilst water used for quenching the fire is considered to have the potential to impact controlled waters.

12. With respect to paragraph 11 above, the act of extinguishing burning tip material may potentially result in the discharge of potentially hazardous substances to controlled waters and may therefore require a permit . The discharge of fire water, infiltrating the soil of the field is likely to represent an indirect discharge, whilst the presence of potentially toxic trace elements in that water is likely to meet the definition of a 'hazardous substance' as defined in article 2(29) of the Water Framework Directive.

13. In addition to contamination issues it should be appreciated that the stability of any site that has been on fire should be regarded as suspect, due to the formation of cavities under the ground which could potentially collapse (ICRCL, 1986).

14. In connection with the Field area (section 7 of Dr Besly's report) it is apparent that the proposals fail to consider pollution management issues including compounds generated during the combustion activity, the management of the effluent and the emissions generated. Material that has been quenched is still potentially flammable unless it is completely combusted. It is therefore apparent that the material must be very carefully burned on the site; with the potential to give rise to further ignition of flammable materials and noxious emissions; or must be transported off site (for off-site incineration) with the risks and additional costs entailed by this process.

15. In his discussion regarding the Landfill area (Section 8) Dr Besly considers that, "*Although the Landfill Site is likely to house the largest concentration of hazardous materials in the vicinity of the proposed development, the ground investigation studies include only slight consideration of this….. in view of the potential of this site to act as a source of significant contaminants …. and in view of the suitability or otherwise of the Landfill Site for its proposed amenity end use*". In view of the age of the landfill which is believed to be in filled between 1971 and 1992, it is likely to contain a range of industrial and domestic waste and be unlined. It is also not disputed that the Etruria Marl does contain beds of sandstone; these can be seen in borings in the Walleys Quarry site; borehole records that are freely available within the public domain on the BGS borehole records site. These sandstone beds are also logged to contain joints and fissures; discontinuities that are likely to permit a more rapid transmission of gases and potentially contaminative fluids than intergranular flow alone would provide.

16. Further investigation of the landfill is clearly warranted in order to assess the extent to which the unlined and potentially poorly capped construction may provide a source and a pathway for various contaminants to impact upon the surrounding development and upon any user of the proposed amenity space.

17. Government policy for dealing with past land contamination focuses on taking action where there are "unacceptable risks to human health and the environment" in relation to the use of the land and environmental setting. In planning and development control, as in this case, the aim is to ensure that there are no unacceptable risks to relevant receptors, taking into account the use of the land and appreciating that: "*The question of whether an intake or exposure is unacceptable is independent of the number of people who might experience or be affected by that intake or exposure.*" (DEFRA Circular 01/2006).

18. With this in mind, elevated concentrations of contaminants within the top 0.4m of the proposed amenity space would be considered as posing potentially unacceptable risks to human health whilst contamination below 0.4m depth may not pose an unacceptable risk to human health due to the lack of a pathway between the source and the receptor. However, should the landfill become eroded, further material at depth would start to become exposed; and the material would need to be assessed further.

19. Landfill capping of that era may often be of a variable thickness and quality, due to being sourced locally in most cases. It would therefore appear prudent that an additional intrusive investigation should be undertaken in order to clarify the thickness of the capping and the presence of any contamination within 0.4m of the ground surface.

20. Asbestos was detected at WS201 (0.2m depth) and WS202 (0.1m depth) in the area of the garage site. The asbestos was present as loose fibres of chrysotile and is thus likely to be in a respirable form. It would appear from the laboratory certificates that *only these locations were tested for the garage site*. A further summary Table is present in the garage site investigation report which suggests that additional locations were

tested; this appears to be incorrect. It is recommended that the presence or absence of asbestos at other locations is determined or the whole area is considered to contain loose fibres of asbestos in the near surface.

21. A positive identification of chrysotile asbestos fibres at TP14 should be regarded with caution as this location is within the area of the 1877 clay pit in filling. Thus the asbestos may not reflect construction waste but may indicate the presence of loose asbestos fibre screenings deposited within the waste of the pit. Loose fibre screenings are likely to be highly respirable and highlight the importance of understanding the content of the pit and its position within the site.

22. To conclude, the ground investigation carried out by Betts (2013) is considered insufficiently complete to support that the development of the site. Many of these omissions relate to an insufficient consideration of the geology and hydrogeology within a CSM, whilst others relate to an incomplete assessment of risks and potential hazards, particularly in relation to the treatment of the burning mine tip and the landfill and gas migration. I believe that Dr Besly has summarised the pertinent issues comprehensively and am grateful for his presentation of the geological issues which are easily corroborated with the borehole logs.

23. Accordingly, it is considered that the contaminated land investigations carried out by Betts do not present an adequate assessment of risks to the proposed end-users of the development and do not contain enough information to determine whether the proposed development of land off Pepper Lane may be undertaken to a satisfactory and safe manner.

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