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Dear Eric

## **ORIEL PROJECT: REVIEW OF EXISTING GROUND GAS MONITORING RESULTS**

### **Introduction**

Monitoring of ground gas has been undertaken by Geotechnical Engineering Limited (GEL) during June 2021 across the site at 4 St Pancras Way, St Pancras Hospital, London, NE1 0PE. The results are presented in AECOM Geotechnical and Geo-environmental Interpretative Report (ref. 60588325-ACM-HGT-Z\_Z\_Z\_Z-RP-GIR-0001), dated September 2021. The report concluded that the site should be classified as a CIRIA Characteristic Situation 2 (CS2). Whilst not specifically detailed within the AECOM report, a CS2 situation normally requires the installation of gas protection measures.

A review of the existing ground gas monitoring data contained within the AECOM Report has been undertaken for the site by CampbellReith, to determine whether gas protection measures are actually required, and / or whether additional gas monitoring would be beneficial. Following consultation with the Contaminated Land Officer (CLO) at London Borough of Camden, an additional two rounds of monitoring have been undertaken during December 2022 by Harrison Group Environmental Ltd (HGEL). The results of the GEL and HGEL ground gas monitoring are summarised herein.

In addition, a review of the site's Environmental setting has been undertaken with reference to the AECOM Phase 1 Geotechnical and Geo-environmental Desk Study Report (ref. ORL-INF-XX-XX-RP-PL-260-Phase 1\_Geotechnical and Geo-environmental Desk Study Report), dated October 2020.

### **Site Setting**

The site is located within St Pancras Hospital, London. It is currently occupied by six buildings which form part of the wider St Pancras Hospital estate. It is proposed to demolish the existing buildings and construct a single building between seven and ten storeys in height, with a lower ground floor and basement beneath. Anticipated uses are to comprise clinical, research and educational, and will include an accident and emergency department, outpatients, operating theatres, research areas, café and retail areas, facilities management, office and plant space. Investigations undertaken by AECOM in 2021 confirm that the site is underlain by generally clayey Made Ground to a maximum depth of 3.60m bgl (+17.95m AOD) with the London Clay proven to depths between 22.70 and 25.65m bgl (-2.75 and -3.20m AOD). This was underlain by the Lambeth Group, the base of which was not proven. Whilst not encountered during the investigations the Thanet Sand and White Chalk Subgroup are anticipated at depth.

## **Ground Gas Monitoring**

Six no. boreholes (BH01, BH02, BH04, WS01, WS02 and WS04) were installed with ground gas monitoring wells. BH01, WS01, WS02 and WS04 had response zones in both the Made Ground and the underlying natural strata (London Clay). BH02 and BH04 were installed in the Made Ground only. BH01, BH02 and BH04 were also installed with monitoring wells for monitoring groundwater levels in the Lambeth Group and deeper London Clay, as such, data from these installations will not be included in this ground gas risk assessment.

Six visits to monitor ground gas were undertaken by GEL between the 13<sup>th</sup> May and the 14<sup>th</sup> June 2021. Data indicating the atmospheric pressure in the three days prior to the monitoring visits was not provided by GEL and it is unknown whether monitoring was undertaken following / during periods of falling atmospheric pressure.

An additional two rounds of monitoring were carried out by HGEL on 2<sup>nd</sup> and 9<sup>th</sup> December 2022. Both rounds were undertaken during periods of falling atmospheric pressure.

The notable results, where carbon dioxide exceeded 1.5%, methane 1% and/or oxygen fell below 18% are summarised in Table 1 below. Also included are concentrations of volatile organic compounds (VOCs).

**Table 1: Summary Gas Concentrations and Flow Rates**

Borehole	Date	Gas Concentration (%)			VOC (ppm)	Steady Flow Rate (l/hr)
		CO <sub>2</sub>	CH <sub>4</sub>	O <sub>2</sub>		
<b>Geotechnical Engineering Ltd, 2021</b>						
BH01	13/05/2021	-	-	-	1.2*	0.0
WS02		2.1	-	17.5	5.0*	0.0
WS04		-	-	17.9	0.2*	0.0
BH01	19/05/2021	-	-	10.7	59.4**	0.0
BH02		-	-	-	3.4**	0.0
BH04		-	-	17.9	6.3**	0.0
WS01		-	-	-	0.2**	0.0
WS02		8.2	-	8.7	6.8**	0.0
BH01	27/05/2021	1.7	-	8.4	-	0.0
BH02		-	-	17.3	-	0.0
BH04		-	-	12.9	-	0.0
WS02		6.2	-	12.9	-	0.0
BH01	01/06/2021	2.1	-	7.5	1.5*	0.0
BH02		-	-	17.6	-	0.0
BH04		-	-	16.0	0.2*	0.0
WS04		-	-	-	0.8*	0.0
BH01	07/06/2021	2.4	-	8.6	-	0.0
BH02		-	-	17.4	-	0.0
BH04		1.5	-	15.2	-	0.0
WS02		4.8	-	14.9	-	0.0
WS04		-	-	17.9	-	0.0

Borehole	Date	Gas Concentration (%)			VOC (ppm)	Steady Flow Rate (l/hr)
		CO <sub>2</sub>	CH <sub>4</sub>	O <sub>2</sub>		
BH01	14/06/2021	2.8	-	6.9	-	0.0
BH02		-	-	17.3	-	0.0
BH04		-	-	15.0	-	0.0
WS02		8.5	-	10.5	-	0.0
WS04		-	-	17.7	-	0.0
<b>Harrison Group Environmental Ltd, 2022</b>						
BH01	02/12/2022	2.9	-	0.1	9.6**	0.0
BH02		2.5	-	10.5	4.4**	0.1
BH04		2.4	-	9.9	6.9**	0.0
WS01		-	-	-	4.6**	0.0
WS02		5.5	-	11.7	5.3	0.0
WS04		-	-	-	3.9**	0.0
BH01	09/12/2022	2.6	-	5.4	2.4**	0.0
BH04		2.3	-	14.3	0.8	0.0
WS02		4.4	-	15.6	0.7**	0.0
WS04		2.2	-	-	0.8	0.0

\*Assumed steady state concentration. \*\*Concentration not stabilised

#### Geotechnical Engineering Ltd Ground Gas Monitoring, 2021

Detectable concentrations of methane were not encountered during any of the monitoring rounds.

Elevated concentrations of carbon dioxide were encountered in BH01 and WS02 on several dates during the monitoring rounds carried out by Geotechnical Engineering Ltd. The maximum concentrations encountered were 2.8% v/v and 8.5% v/v respectively on the 14<sup>th</sup> June 2021. A single nominally elevated carbon dioxide concentration of 1.5% v/v was encountered in BH04 during the monitoring visit on 7<sup>th</sup> June 2021. These concentrations were noted by AECOM as being compatible with microbial activity rather than being generated from Made Ground materials.

Depressed oxygen concentrations were encountered in several locations during all monitoring visits. Oxygen concentrations in BH02 and WS04 were only marginally depressed and were not associated with elevated concentrations of carbon dioxide and as such, are not considered significant. Depressed oxygen concentrations in BH04 ranged from 17.9% v/v to 12.9% v/v and are likely associated with the presence of nominal carbon dioxide concentrations at this location. Again, this is not considered to be significant. The depressed oxygen concentrations in WS02 which ranged from 8.7% to 17.5%, were generally mirrored by elevated concentrations of carbon dioxide which ranged from 8.5% v/v to 2.1% v/v.

Concentrations of carbon monoxide and hydrogen sulphide were not recorded above the instrumentation detection limit during any of the monitoring visits.

Nominal concentrations of VOCs were encountered in several locations during the first two monitoring visits. Concentrations ranged from 0.2 to 6.8ppm except for BH01 where a maximum concentration of 65.7ppm was recorded. It should be noted that this concentration had not fully stabilised, and the final recorded concentration was 59.4ppm although it is likely this would have decreased if monitoring had continued. VOC concentrations were

not detected during the third visit and only nominal VOC concentrations were detected during the fourth monitoring visit, with a maximum concentration of 1.5ppm recorded in BH01. VOC concentrations were not detected during the final two monitoring visits. Reference to the exploratory hole logs do not indicate the presence of a significant source of VOCs at the site. As such the identified concentrations are not considered to be significant.

Positive peak flow rates of 54.0 l/hr and 73.9 l/hr were recorded in BH04 on 27<sup>th</sup> May 2021 and WS02 on 19<sup>th</sup> May 2021 respectively. A peak flow rate of 6.4 l/hr was also recorded in BH01 on 1<sup>st</sup> June. Reference to the AECOM ground investigation report and monitoring records contained within, indicate that these flow rates were instantaneous and dissipated quickly and are indicative of the borehole equilibrating to atmospheric pressure during the monitoring period rather than indicating the presence of a significant ground gas source. Flow rates were otherwise not recorded above the instrument detection limit. In addition, carbon dioxide and methane were not encountered within BH04 on the 27<sup>th</sup> May and as such, it is considered very unlikely that the flow is indicative of a ground gas source.

#### Harrison Group Environmental Ground Gas Monitoring, December 2022

Detectable concentrations of methane were not encountered during either of the monitoring visits.

Elevated carbon dioxide concentrations were encountered in BH01, BH04 and WS02 during both monitoring visits, and in BH02 and WS04 on the 2<sup>nd</sup> December and 9<sup>th</sup> December 2021 respectively. Concentrations ranged from 2.2% v/v in WS04 (9<sup>th</sup> December) to 5.5% v/v in WS02 (2<sup>nd</sup> December). Despite the falling atmospheric pressure the maximum concentration of carbon dioxide did not exceed those recorded by GEL in 2021.

Depressed oxygen concentrations were encountered in BH01, BH04 and WS02 during both monitoring visits and in BH02 during the monitoring visit of 2<sup>nd</sup> December. The lowest concentration encountered was 0.1% v/v at BH01 on 9<sup>th</sup> December. Depressed oxygen concentrations were generally associated with the presence of nominal concentrations of carbon dioxide and is therefore not considered to be significant.

Detectable, steady state concentrations of hydrogen sulphide and carbon monoxide were not encountered during either monitoring visit.

Nominal concentrations of VOCs were encountered in all locations during both monitoring visits. Generally, concentrations were higher during the monitoring round on 2<sup>nd</sup> December, ranging from 9.6ppm in BH01 to 3.9ppm in WS04 whilst concentrations ranged from 2.4ppm in BH01 to 0.7ppm in WS02 during the monitoring round on 9<sup>th</sup> December. It should be noted that most of the concentrations had not been allowed to stabilise and were still decreasing when the monitoring was completed. Given the nominal nature of the detected concentrations, VOC concentrations are not considered to be significant.

Detectable flow rates were not recorded except within BH02 during the monitoring round of 2<sup>nd</sup> December, where a nominal flow rate of 0.1l/hr was encountered.

## Discussion

Based upon the information presented above and a review of desk study information contained within the AECOM Phase 1 Geotechnical and Geo-environmental Desk Study Report, an assessment has been made of the requirements for gas protection that consider sources of gas generation, potential exposure routes and applicable, representative gas flows and concentrations. This is summarised below:

- **Potential on-site source of generation.** Carbon dioxide generation is suggested from areas of nominal infilling / Made Ground.
- **Potential off-site source of generation.** Any Made Ground and infilled areas local to the site, although there are no records of significant infilling in the surrounding area.
- **Representative concentrations and gas flows.** The highest steady state carbon dioxide concentration of 8.5% v/v and a gas flow rate of 0.1 l/hr will be applied during calculation of the gas screening value (GSV).
- **Exposure routes.** Gas at the site primarily presents a concern following ingress into confined spaces both during and after construction.

The GSV has been calculated using the worst case, representative gas concentration recorded within WS02. Table 8.5 of CIRIA C655 indicates that that GSV values of less than 0.07 l/hr are typical of Characteristic Situation 1. Comparison with the worst case GSV calculated (0.0085 l/hr) indicates the site should be classified as a CIRIA Characteristic Situation 1. It is however acknowledged that CIRIA C665: Assessing Risks Posed by Hazardous Ground Gases to Buildings, recommends that where concentrations of carbon dioxide in excess of 5% v/v are encountered, consideration should be given to the classification of the site as a CIRIA Characteristic Situation 2.

Reference to the AECOM Geotechnical and Geo-environmental Interpretative Report indicates that no significant sources of ground gas have been encountered at the site or in the surrounding area to date. Specifically, the AECOM report did not identify any landfilling operations at the site or its immediate vicinity. In addition, the nearest potentially infilled feature was located 380m east of the site, associated with unknown filled ground, dated circa 1920. Given the distance to this feature and approximate date of filling, it is not considered to present a source of ground gas to the site. Notwithstanding this, given the absence of significant granular deposits and the underlying cohesive geology of the London Clay, it is considered very unlikely that a ground gas migration pathway from an offsite source would exist.

The average depth of the Made Ground encountered at the site is 2.0m bgl with the maximum being 3.60m bgl in WS05. Aside from observations of rare fragments of wood in WS03, partially decomposed wood in WS04 and rare rootlets in WS05, the exploratory hole logs do not indicate the presence of significant organic material. In addition, total organic carbon (TOC) testing on eleven samples of Made Ground across the site indicated an average concentration of 0.62%, with the maximum of 1.3% encountered in WS01. Reference to BS8576:2013 (figure 6) indicates that Made Ground with a TOC concentration of less than 6% and natural strata with a low degradable organic content have a low – very low potential for ground gas generation. This is supported by generally negligible flow rates encountered during monitoring.

With respect to WS02 where the highest carbon dioxide concentrations were generally recorded, the exploratory hole log for this location indicates that the monitoring well was installed with a response zone almost entirely in the London Clay (with the top 0.2m at the base of the Made Ground). Total organic carbon was 0.2% for two samples collected at 1.00-1.10m bgl and 2.60m bgl (within the Made Ground and London Clay respectively) indicating a very low ground gas generation potential. Both monitoring visits in December 2022 were undertaken during periods of falling atmospheric pressure. Falling pressure can cause increases in ground gas emission rates. Concentrations of carbon dioxide in WS02 were comparable or less than those recorded during the monitoring undertaken in 2021 indicating that significant ground gas concentrations were not being generated during these periods of falling pressure.

It should also be noted that excavations and foundation works to accommodate the proposed basement construction will extend to a maximum depth of +15.375m AOD. As such, the excavation will likely result in the removal of the majority of Made Ground soils, and therefore, any source of ground gas will be mostly removed.

### **Conclusions**

The marginally elevated carbon dioxide concentrations encountered in WS02 during monitoring undertaken by GEL in 2021 and HGEL in 2022 are not considered to be associated with significant gas generation at the site or in the surrounding area. The concentrations encountered are likely associated with microbial activity occurring at this location.

A CIRIA Characteristic Situation 1 is therefore considered appropriate for the site and gas protection measures are not considered to be necessary.

It is recommended that this letter is submitted to the Contaminated Land Officer at the Local Planning Authority for their review and approval.

We trust the summary above fulfils your current requirements. Should you have any queries, please do not hesitate to contact the undersigned.

Yours sincerely



**BRANDON REILLY**

For and on behalf of **CAMPBELL REITH HILL LLP**

Encs. HGEL Ground Gas Monitoring Records dated 2<sup>nd</sup> and 9<sup>th</sup> December 2022

## LIMITATIONS

1. This report provides available factual data for the site obtained only from the sources described in the text and related to the site on the basis of the location information provided by the client.
2. Where any data or information supplied by the client or other external source, including that from previous studies, has been used, it has been assumed that the information is correct. No responsibility can be accepted by CampbellReith for inaccuracies within this data or information. In relation to historic maps the accuracy of maps cannot be guaranteed and it should be recognised that different conditions on site may have existed between and subsequent to the various map surveys.
3. This report is limited to those aspects of historical land use and enquiries related to environmental matters reported on and no liability is accepted for any other aspects. The opinions expressed cannot be absolute due to the limit of time and resources implicit within the agreed brief and the possibility of unrecorded previous uses of the site and adjacent land.
4. The material encountered and samples obtained during on-site investigations represent only a small proportion of the materials present on the site. There may be other conditions prevailing at the site which have not been revealed and which have therefore not been taken into account in this report. These risks can be minimised and reduced by additional investigations. If significant variations become evident, additional specialist advice should be sought to assess the implications of these few findings.
5. The generalised soil conditions described in the text are intended to convey trends in subsurface conditions. The boundaries between strata are approximate and have been developed on interpretations of the exploration locations and samples collected.
6. Water level and gas readings have been taken at times and under conditions stated on the exploration logs. It must be noted that fluctuations in the level of groundwater or gas may occur due to a variety of factors which may differ from those prevailing at the time the measurements were taken.
7. Please note that CampbellReith cannot accept any liability for observations or opinions expressed regarding the absence or presence of asbestos or on any product or waste that may contain asbestos. We recommend that an asbestos specialist, with appropriate professional indemnity insurance, is employed directly by the client in every case where asbestos may be present on the site or within the buildings or installations. Any comments made in this report with respect to asbestos, or asbestos containing materials, are only included to assist the client with the initial appraisal of the project and should not be relied upon in any way.
8. The findings and opinions expressed are relevant to those dates of the reported site work and should not be relied upon to represent conditions at substantially later dates.
9. This report is produced solely for the benefit of the client, and no liability is accepted for any reliance placed upon it by any other party unless specifically agreed in writing.