COMPREHENSIVE VAPOUR MONITORING EVENT

Shell Camden Town

10 July 2018

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EXECUTIVE SUMMARY

AECOM Infrastructure and Environment UK Limited undertook a Comprehensive Vapour Monitoring Event (VME) of Shell Camden Town, 109-113 York Way, Camden Town, London, N7 9QE. This report has been collated to support Shell UK Oil Products Limited (Shell) with its environmental asset management activities.

The site is currently an active petrol filling station located in a predominantly residential area. There are four (4) active tanks with seven (7) compartments in use at the site. There is not known to have been any previous remediation.

The geology beneath the site comprises made ground to a maximum depth of 1.3 metres (m) below ground level (bgl), underlain by bedrock geology of the London Clay Formation (Unproductive Strata)proven to a maximum thickness of 4.2 m bgl below the site. The London Clay Formation is anticipated to be 60-100m thick. There are no superficial deposits at the site.

The nearest surface water feature to the site is a pond located 660m south of the site.

A survey of all wells was completed on 27th March 2017 using photo-ionisation detector (PID) only. One (1) Vapour Monitoring Event (VME) of two (2) vapour monitoring wells was undertaken at the site in July 2017 and one VME of one (1) vapour monitoring well was undertaken in September 2017. The monitoring indicated:

- Perched water was encountered in on site monitoring wells at depths between 0.58m to 1.33m bgl. Given the significant variability in groundwater elevations, it is considered that the water is perched and discontinuous, therefore it was not possible to define a flow direction. LNAPL was not identified in any of the wells.

A Stage 2 risk assessment was performed on the data collected during the vapour monitoring event of MW4 and MW105 to assess potential risks to human health. Based on the soil vapour analytical data collected from MW4, no COPC exceeded the HDR or CPU GAC, therefore it is considered unlikely that COPC pose an unacceptable risk.

A helium leak test was conducted on MW105 in September 2017, the results of which indicate that there was unacceptable ingress of ambient air, therefore analytical data from that well were discarded and instead a semi-quantitative assessment of risks was made based on the PID data. An assessment of COPC concentration trends in each well over this and previous rounds concluded that there is no evidence for an increase in the vapour source.

Additional lines of evidence indicate that vapour intrusion risks from MW105 are acceptable, including correction of COPC concentrations measured by laboratory analysis in July 2017 by the leakage rate measured in September 2017, the PID readings measured during three VMEs in 2017, the vapour source is in dissolved phase and therefore considered to be a ‘weak’ source with limited potential for vapour intrusion and the presence of perched water fills permeable horizons, preventing them from being available for vapour transport.

1. INTRODUCTION

AECOM was requested by Shell UK Oil Products (Shell) to undertake a Comprehensive Vapour Monitoring Event (VME) at Shell Camden Town located at 109-113 York Way, Camden Town, London, N7 9QE (hereafter referred to as "the site").

Table A – Site Information	
Site Name	Shell Camden Town
Site Operation	The site is currently an active petroleum filling station.
GSAP ID Number	12038454
Site Address	The site is located at 109-113 York Way, Camden Town, London, N7 9QE (**Figure 1)**.
Grid Reference (easting and northing)	529970 (E), 184710 (N)
Reported Site Area	Approximately 1,100 square metres (m^2)
Freehold/Leasehold	Freehold. AECOM understands that the site is owned by Shell.

1.1 Objectives

This report has been collated to support Shell with its environmental asset management activities.

The objective of the Comprehensive VME detailed herein was to refine the preliminary Conceptual Site Model (CSM) for the site developed in the URS CESA (Ref. 6).

1.2 Scope of Work

- Completion of one vapour survey (PhotoIonisation Detector [PID] readings) of all the accessible wells present at the site.
- Completion of one VME of two (2) vapour monitoring wells and one VME of one (1) vapour monitoring well.
- Assessment of the magnitude, type and extent of chemicals of potential concern (COPC) present through the performance of laboratory and/or on-site analysis of soil vapour for various chemical indicators associated with operation as a petrol filling station.
- Screening of analytical results against appropriate Generic Assessment Criteria (GAC) to determine the requirement for a Detailed Quantitative Risk Assessment (DQRA).
- Completion and submission of this Comprehensive VME Report.

1.3 Sustainability

In implementing the scope of works outlined above, AECOM made the following considerations of sustainability:

- Field work was staffed from local AECOM office to reduce travel impact.
- Deliverables were submitted electronically.

2. BACKGROUND INFORMATION AND PRELIMARY RISK ASSESSMENT

2.1 Background Information

A summary of the information about the site setting, site use and development is provided in Tables B, C and D below. Full details are provided in the Phase 1 (Ref 5).

Table B – Environmental Setting	
Surrounding Land Use	North: The site is immediately bound by residential dwellings with gardens with a school approximately 40 beyond. Residential properties with basements are located adjacent to the site to the northwest. South: Residential properties with basements bound the site to the south. East: The site is immediately bound by York Way, with residential properties located approximately 50m beyond. West: The site is immediately bound by Camden Park Road, with residential properties with basements approximately 50m beyond.
Elevation	The site is located at an approximate elevation of 49m Above Ordnance Datum (AOD).
Topography	The topography of the surrounding area generally slopes downwards toward south to southwest.
Surface Water Features	The nearest surface water feature is a pond located 660m south of the site. The Grand Union Canal is located approximately 850m south west of the site at its nearest pint. There are no reported surface water abstractions located within 1 kilometre (km) of the site.
Geology	The site is surfaced with hardstanding (primarily brick paviour or concrete), which is underlain by made ground. The made ground generally comprises sandy gravel/ gravelly sand (maximum thickness of 1.3m) underlain by gravelly clay (maximum thickness greater than 1.25m). Available British Geological Survey (BGS) geological maps indicate that there are no superficial deposits beneath the site. The solid geology underlying the site is indicated to be the London Clay Formation. This was confirmed during the Arcadis 2002 site investigation (Ref. 1) when it was proven to be at least 4.2m thick and comprised clay and gravelly clay. No sand or gravel horizons were reported at depth. It is anticipated that the London Clay is 60-100m thick beneath the site. The Woolwich and Reading Beds Formation, Thanet Formation and Upper Chalk Formation are indicated to be present beneath the London Clay.
Hydrogeology	The Environment Agency (EA) classifies the London Clay as Unproductive Strata.

Table B – Environmental Setting	
Groundwater Abstractions and SPZs	Three (3) groundwater abstractions are reported to be located within 1km of the site, all of which belong to Hanson Quarry Products Europe Ltd. These are all for general use relating to "Secondary Category (High Loss)" and are located 648m south of the site. The London Borough of Camden does not hold any information regarding private groundwater abstractions. The site is not located within an EA defined source protection zone (SPZ).
Potential Vapour Receptors	USEPA Guidance (Ref. 11) has been used to determine potential vapour intrusion receptors that require assessment. The site shop has been assessed primarily as a vapour receptor for potential acute risks, however chronic risks to site workers have also been considered. Although there is extensive and continuous hardstanding present between the site and receptors, oxygen levels within the monitoring wells indicated that there was oxygen recharge to the subsurface, and therefore this has not been identified as a precluding factor. Receptors that have been PVI screened in for further assessment because they are the nearest receptors within 10m, they include: • Residents in adjacent residential properties to the north, northwest and south. • Basements of the properties adjacent to the northwest and south. Receptors greater than 10m from the site have not been assessed because there are other receptors nearer the site, therefore, any assessment protective of those will also be protective of receptors further away.

Table C – Site use and Development		
Current Use	The site is currently used as a petrol filling station located in a predominantly residential area. There are four (4) active tanks with seven (7) compartments at the site.	
Site History	The site has been operated as a garage from c. 1977 when the original tanks were installed. These tanks were decommissioned and slurry filled in 1988 and a replacement tank farm installed. Reports of hydrocarbon vapours were recorded within the site shop and / or neighbouring properties in the early 1990s, 2005 and 2015.	
Dates of accidental release or known source of COPC	**1990s**	Information provided in the PO report presented within the URS Phase 1 report (Ref. 5) indicates that strong odours were reported by a neighbouring property on multiple occasions in the early 1990s which were related to the interceptor. No further information was available.
	2002	Reports of petroleum vapours were reported in the site shop.
	2004	Additional reports of hydrocarbon vapours in the shop were reported in 2004.

Table C – Site use and Development		
	2015	Information provided by Shell indicates an integrity issue was identified on Pump 7/8 during proactive checks in July 2015. Upon further investigation, fuel was identified within the sump below the drip tray. Hydrocarbon odours were also reported by the shop staff emanating from a small electrical cupboard below the till area. Repairs were made to the pump, the hydrocarbons within the sump were removed and an electrical duct between the pump and the shop was foam filled to inhibit vapour migration.
Dates of closure, tank removal, soil removal etc	Information from the Petroleum Officer report presented in the URS Phase 1 report (Ref. 5) indicates that there are three (3) tanks with five (5) compartments which were decommissioned and slurry filled in c. 1988. The tanks remain in-situ in the northern part of the site under the northern fuelling area.	
Previous site investigations	**2002**	**Arcadis GMI, Tier 2 Environmental Assessment Report (Ref: 942720107) dated April 2002 (Ref. 1).** Detailed investigation in response to customer complaints of petroleum vapours in the site shop. Works included a site walkover, which identified elevated hydrocarbon vapours in the shop electrical cupboard and tank access chambers. The site walkover survey was followed by an environmental site investigation after the identification of a small integrity issue beneath a pump island. Initially screening indicated that shallow soils had been impacted with MTBE at concentrations above the Tier 1 Risk Based Screening Levels (RBSL) however further assessment indicated that results were below Tier 2 RBSL's and unacceptable risks were not present.
	2004	**Arcadis GMI, Incident Response Report (Ref: 942720203), dated November 2004 (Ref. 2).** Investigation due to reported presence of hydrocarbon vapours within the shop office and electrical cupboard. Report included collection of PID readings from the tank access chambers, shop and electrical cupboard with concentrations ranging between 38.2ppm (electrical cupboard) and 2,942ppm (tank chamber). Phase separated hydrocarbons (PSH) was indicated in two of the tank chambers and all chambers / manholes were observed to be flooded. Electrical and telecom pits were also inspected with PID readings between 339ppm and 774ppm.
	2005	**Arcadis GME Groundwater Monitoring Report (Ref: 942720302) dated by January 2005 (Ref. 3).** Details a groundwater monitoring visit which was conducted to obtain updated groundwater data, prior to the fuel line replacement and re-pump works. Concentrations of MTBE and Aliphatic Hydrocarbons (C_6-C_8) were detected in concentrations exceeding the Generic Screening Level (GSL).

Table C – Site use and Development		
	2005	**Arcadis GMI, Report on Fuel Line Replacement (Ref: 942720405), dated January 2005 (Ref. 4).** Details soil testing during the pump and fuel line replacement works. Elevated concentrations of hydrocarbons were identified in soil samples remaining on site that exceed the generic screening levels for human health and environmental receptors.
	2015	**URS, P1 Environmental Site Assessment (Ref: 46370434-001), dated September 2015 (Ref. 5).** A desk study, site walkover and survey of underground and above ground features and services on site were carried out following an integrity issue identified on Pump 7/8. A number of potential pollutant linkages relating to human health were identified in the preliminary conceptual model.
	2016	**URS, P2 Comprehensive Environmental Site Assessment (Ref: 46370434-002), dated January 2016 (Ref. 6)** A Stage 2 risk assessment was performed on the soil, vapour and potable water data collected during the investigation works to assess potential risks to human health only (on-site workers, off-site residents including those residing in buildings with basements). Due to the distance to the nearest surface water feature (660m from the site) and the presence of the >60m London Clay beneath the site (inhibiting downward migration), no potential complete pollutant linkages have been identified to controlled waters receptors. Based on the comparison of site data to GAC, no unacceptable risks were identified to human health receptors.
	2016	**AECOM, Comprehensive Vapour Monitoring Report (Ref: 46370434-003), dated March 2016 (Ref. 7)** A stage 2 risk assessment was performed on perched groundwater and vapour data collected during February 2016 to assess the potential risks to human health receptors (on-site workers, off-site residents including those in buildings with basements). Based on comparison of the site data to GAC, no unacceptable risks were identified to human health receptors.
Historical Remedial Activities	AECOM is not aware of any remedial works having been undertaken at the site.	

Table D – Summary of On-site Fuel Tank / Compartments							
Tank number or ID	**Tank 1**		**Tank 2**	**Tank 3**		**Tank 4**	
Compartment number or ID	**Compartment 1**	**Compartment 2**	**Compartment 3**	**Compartment 4**	**Compartment 5**	**Compartment 6**	**Compartment 7**
Tank type[1]	Single skin steel	Single skin steel	Single skin steel	Single skin steel	Double skin steel	Single skin steel	Single skin steel
Tank size (litres) [2]	22,010	22,010	22,010	22,010	22,010	22,010	22,010
Product stored[2]	V-Power Diesel	Unleaded	V- Power Unleaded	Unleaded	Unleaded	Diesel	Diesel
Status[2]	In use	In use	Out of Use*	In use	In use	In use	In use
Date of installation[3]	1988	1988	1988	1988	1988 (relined 2005)	1988	1988
Removal date or abandonment date	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Relative level (RL) of tank base	Assumed to be 4.5m bgl	Assumed to be 4.5m bgl	Assumed to be 4.5m bgl	Assumed to be 4.5m bgl	Assumed to be 4.5m bgl	Assumed to be 4.5m bgl	Assumed to be 4.5m bgl

NOTES:

1 - Based on information provided by Shell

2 - Tank gauge print out obtained 22 July 2015 during site walkover

3 - Petroleum Officer response dated 06 August 2015

2.2 Preliminary Conceptual Site Model

Following review of the available data regarding site history, environmental setting, and continued oil use, a preliminary conceptual site model (CSM) was developed, as presented in Table E below. For a risk from a given source to be considered plausible, a 'pathway' must be present by which COPC can reach a given receptor. Such complete Source ⇨ Pathway ⇨ Receptor (SPR) exposure mechanisms are commonly termed 'pollutant linkages'. The CSM illustrates the potentially viable source-pathway-receptor linkages which have been identified.

Table E – Preliminary Conceptual Site Model

Source	Pathway	Receptor
Human Health		
• Impacted soils • Soil vapour • Impacted groundwater	• Lateral and vertical vapour migration and subsequent inhalation.	• On-site shop staff and site users. • Off-site residents in adjacent residential properties to the north, north west and south (including basements of the property to the north west)
	• Particulate - Ingestion, inhalation, dermal contact, with soil particulates.	• Visiting contractors excavating ground.*

* Potential risks to visiting contractors undertaking intrusive works should be managed by appropriate PPE, risk assessment and method statements. Risks to visiting contractors excavating the ground have therefore not been further assessed.

3. FIELD WORK

3.1 Summary of Field Work

<table>
<tr><th colspan="2">Table F – Summary of Field Work</th></tr>
<tr><td>Date of Field Work</td><td>The vapour survey with PID only was undertaken on 27 March 2017.
The VME was undertaken on 13 July and 25 September 2017.</td></tr>
<tr><td>Site Activities</td><td>Field works included the following key tasks:
Groundwater gauging and vapour survey (with PID only) of all the ten (10) accessible monitoring wells on site in 27 March 2017.
Completion of ground gas monitoring of two (2) monitoring wells (MW105 and MW4) in July 2017.
Purging and vapour sample collection from two (2) monitoring wells (MW105 and MW4) in July 2017.
Completion of ground gas monitoring and helium leak test of one (1) monitoring well (MW105) in September 2017.
Purging and vapour sample collection from one (1) monitoring well (MW105) in September 2017.</td></tr>
<tr><td>Details of Existing Monitoring Well Network</td><td>Drilling locations were designed to evaluate the soil, soil vapour and / or groundwater conditions associated with the target locations described below. A borehole location plan is provided as Figure 2. A summary of the well installation details is presented in Table 1.
<table>
<tr><th>Borehole ID</th><th>Location</th><th>Monitoring Well Screening Depth (m bgl)</th><th>Monitoring Well Screening Strata</th></tr>
<tr><td>VP101</td><td>Between the northern tank farm & northern pump islands and the site shop.</td><td>0.5-1.0</td><td>Made Ground</td></tr>
<tr><td>VP102</td><td>Between the tank farms & pump islands and the site shop.</td><td>0.5-1.0</td><td>Made Ground</td></tr>
<tr><td>VP103</td><td>Along the southwestern boundary, protective of basements in residential properties 15m to the south west.
The base of screen was determined by the anticipated base of the neighbouring basement. The ceiling of the basement was noted approximately 1.0m above ground level. The screen was to extend below the base of the basement.</td><td>0.4-1.6</td><td>Deeper Made Ground</td></tr>
<tr><td>VP104</td><td>Along the northern boundary, protective of residential properties adjacent to the north, without basements.</td><td>0.5-1.0</td><td>Made Ground</td></tr>
<tr><td>VP105</td><td>In the southwest corner of the site, protective of residential</td><td>2.5-3.0</td><td>Deeper London Clay</td></tr>
</table></td></tr>
</table>

Table F – Summary of Field Work

		properties with basements to the south. *The base of screen was determined by the anticipated base of the neighbouring basement. The screen was to extend below the base of the basement.*		
	VP106	In the southwest corner of the site, protective of residential properties with basements to the south. *The base of screen was determined by the anticipated base of the neighbouring basement. The screen was to extend below the base of the basement.*	2.5-3.0	Deeper London Clay
	MW101 (formerly MW1)	Between western pump islands and the site shop.	0.5-1.0	Made Ground
	MW102 (formerly MW2)	Delineation well from northern pump islands to the south eastern corner of the site.	0.5-1.0	Made Ground
	MW105 (formerly MW5)	Along the northwestern site boundary, protective of residential properties with basements to the northwest.	2.4-3.0	Deeper London Clay
	MW4	Along the northwestern site boundary, protective of residential properties with basements to the northwest.	0.5-1.5	Shallow London Clay (sandy)
Surveying	The elevations of groundwater and vapour monitoring well standpipes on site were surveyed to National Grid coordinates and m AOD by Greenhatch Ltd, under the supervision of URS as part of the CESA.			
Groundwater gauging	Groundwater level gauging was undertaken on 27 March, 13 July and 25 September 2017. The depth to groundwater and light non aqueous phase liquids (LNAPL) (if present) was gauged using a portable oil / water interface probe. Groundwater gauging results are presented in **Table 1a** and **1b** in **Appendix A**. Groundwater sampling was not part of the scope of works.			
Potable water sampling	Potable water sampling was not part of the scope of works.			
PID monitoring only	PID monitoring only of all the wells was carried out on 27 March 2017. Monitoring results are presented in Table 1a in Appendix A.			

Table F – Summary of Field Work	
Ground gas monitoring	Ground gas monitoring of MW105 was conducted on 13 July and 25 September 2017 and of MW4 on 13 July 2017 using a portable infrared ground gas monitor. Monitoring results are presented in **Table 2** in **Appendix A**.
Soil vapour monitoring	Prior to soil vapour sample collection each well was purged of one (1) well pipe volume using an air pump to remove standing ambient air from the well. Leak checks were then completed to ensure that ambient air was not being drawn into the sample train. The vapour monitoring samples were then collected in absorbent tubes. During and after purging, measurements of Volatile Organic Compounds (VOCs) were taken using a photo ionisation detector (PID) equipped with a 10.6 electron-volt (eV) lamp. Vapour samples were recovered from vapour wells MW4 and MW105 using sorbent tubes and a low flow pump.
Helium Leak testing	Prior to the collection of the sample from MW105 in September 2017, a helium leak test was conducted to assess the integrity of the well seal and connectivity between soil gas within the well and the atmosphere. The results of the helium test indicated that helium leakage into the well was approximately 29% and as such the soil vapour sample was not scheduled for laboratory analysis because it exceeds the maximum 15% acceptable leakage as advised by ITRC.
Field quality control sampling	The following field quality control samples were collected as part of this CGVME: • Vapour: one (1) trip blank and one (1) equipment blank.

3.2 Field Screening Results / Observations

Table G – Field Screening	
Light Non-Aqueous Phase Liquid (LNAPL)	No measurable thickness of LNAPL was encountered in any of the monitoring wells on site.

3.3 Geological/Hydrogeological Information

Table H – Hydrogeological Information	
Depth to Groundwater	Groundwater was recorded within nine (9) monitoring wells (all wells with the exception of VP101), at depths ranging from 0.31m bgl to 1.33m bgl. Groundwater elevations ranged from 47.72m AOD to 48.90m AOD. Groundwater level data is presented in **Table 1a** and **Table 1b** in **Appendix A**.
Inferred Groundwater Flow	Given the significant variability in observed groundwater elevations, including between wells with similar screened sections, it has been concluded that the groundwater is perched and discontinuous, therefore, it is not possible to define a flow direction. Based on the elevation of the top of the London Clay, any flow would likely be towards the south west.

3.4 Analytical Schedules & QA/QC

<table>
<tr><th colspan="3">Table I – Analytical Information</th></tr>
<tr><td>Analytical Laboratory</td><td colspan="2">Vapour samples were analysed by ALS laboratories of Chester. The results are discussed in Section 4 and 5 and presented in Appendix B. Copies of laboratory certificates are presented in Appendix C.</td></tr>
<tr><td rowspan="5">Analytical Schedule</td><td colspan="2">The following schedule of analysis was completed, excluding QAQC samples. The COPC in bold are those identified by Shell as potential risk drivers from retail petroleum sites. The results and analytical methodology are presented in Appendix C.</td></tr>
<tr><th>Analysis</th><th>Number of Vapour Samples</th></tr>
<tr><td>Fuel Oxygenates (methyl tertiary butyl ether (MTBE), tert-butyl ethyl ether (ETBE), di-isopropyl ether (DIPE), tert butanol (TBA), tert-amyl methyl ether (TAME), Ethanol)</td><td>2</td></tr>
<tr><td>2-methylnaphthalene</td><td>2</td></tr>
<tr><td>n-hexane</td><td>2</td></tr>
<tr><td>Volatile Organic Compounds (VOC) and TPH (C6-12) including BTEX</td><td>2</td></tr>
<tr><td>Field and laboratory quality control sampling</td><td colspan="2">The analytical data have been reviewed for quality assurance and control purposes (QA/QC), the results of which are presented in Appendix C.
The surrogate data were reported within acceptable limits.
The laboratory blanks were within acceptable limits.
A number of COPC were detected in the equipment blank taken at the site. Of these BTEX compounds and n-Hexane were detected in the equipment blank at concentrations above of on the same order of magnitude as those detected within the vapour wells. The measured concentrations of the BTEX compounds and n-Hexane were below the GAC and therefore not considered to affect the assessment.
In general, the data are considered appropriate for reporting.</td></tr>
</table>

4. HUMAN HEALTH STAGE 2 GENERIC QUANTITATIVE RISK ASSESSMENT

4.1 Methodology

The risk based methodology adopted in this report is primarily based upon the UK Defra and EA "best practice" in regard to the assessment of contaminated land. The approach taken reflects that promoted in CLR11 (Ref. 9) and R&D Publication 66 (Ref. 10) and the supporting guidance referenced within them.

Soil vapour data have been screened against generic assessment criteria (GAC) protective of potential human health receptors.

The derivation of the GACs for organic compounds includes an element of receptor identification and vapour pathway assessment. The vapour pathways assume a distance of 0.5m from the source to the receptor, respectively, for soil vapour.

Notwithstanding the adopted methodology, for the assessment of potential receptors for petroleum vapour intrusion, assessment has also been completed in line with more recent guidance from the USEPA (USEPA, 2015. Ref. 13). Where receptors are PVI screened in for further assessment, the GAC are appropriate. Where receptors are PVI screened out, the contribution to risk from the vapour pathways assessed by the GAC can be disregarded.

However, where the USEPA guidance is not valid based on the presence of precluding factors (see Table B), receptors have been selected using distances to receptors set out in USEPA 2015 (Ref. 13). The GAC are appropriate for screening chemical data.

The site shop has been included within the assessment, although it is recognised that risks to petrol filling station workers from petroleum products are controlled primarily through health and safety systems.

Gas risk assessment has been carried out following guidance in B8485 (Ref. 14) which sets out an empirical semi-quantitative approach for deriving Gas Screening Values based on gas monitoring measurements to select a Characteristic Situation which informs the scope of gas protection measures that could be required, if any.

4.2 Generic Assessment Criteria (GAC) – Vapours

The Stage 2 Generic Assessment Criteria (GAC) for vapours were derived using the LQM/CIEH S4UL methodology, protective of:

- Off-site residents (in adjacent residential properties to the north, north west and south including those with basements (north west and south of the site) using a high density residential (HDR) end use scenario.
- On-site workers (including Shell shop staff and site users) using a continued petroleum use (CPU) end use scenario.

As noted in Table B, residential properties within 10m of the site have been screened in for assessment with GAC using the USEPA methodology, and the site shop has been assessed for chronic risks also. No precluding factors were identified.

Assumptions within the derivation of the GAC and their applicability to the site are set out in Table K. Comparison of soil vapour analytical results to Stage 2 GAC is provided in **Appendix B** and GAC exceedances are summarised in Table K.

Table J – assumptions within the GAC and applicability to the site				
	GAC	**Assumption**	**Applicable at site**	**Likely to over or under simulate risks**
Active Pathways	High Density Residential	Only vapour pathways are viable. No exposure to soils via direct contact pathways including dermal contact and dust inhalation/ingestion as the receptor is off-site	The receptors are off-site and would not have direct contact with the on-site soils.	GAC are applicable to offsite houses, however may overestimate the risk as it assumes that the same concentrations found on-site are present off-site.
	CPU	Only vapour pathways are viable. No exposure to soils via direct contact pathways including dermal contact and dust inhalation/ingestion as the site is fully covered in hardstanding/building footprint and/or managed landscape	The site surface is covered in 100% hardstanding	GAC applicable to site shop.
Model Parameters all CLEA defaults except those listed below	All landuses - Vapour	'Soil vapour to indoor air' factor for volatile compounds set to zero	Soil vapour data collected from wells with top of screen is between 0.5m and 2.4m bgl.	GAC may overestimate risks
	All landuses - vapour	Vapours assumed to migrate from a source 0.5m deep.	Appropriate for site shop. Likely to be appropriate for houses including their basements as known sources are at least 0.5m laterally from the basement walls.	GAC are applicable
	All landuses - vapour	For volatile compounds it is assumed that vapour ingress is via a 2mm crack between concrete floor slab and walls.	Site shop likely to have a ground bearing slab. Off-site houses have basements and are likely to have suspended wooden floors.	GAC applicable for site shop, but may underestimate risks to adjacent off-site houses.
	CPU - vapour	Building size set to 14m x 6.5m x 2.4m high representative of a small site shop	Site shop is smaller.	GAC may underestimate risks due to less dilution of soil air in building than assumed by GAC

4.3 Analytical Results GAC Screening

Comparison of soil vapour analytical results to Stage 2 GAC is provided in **Appendix C** and GAC exceedances are summarised in the table below:

Table K – GAC and TPH Hazard Index Exceedances in MW4

Receptor Type	Screening Criteria	Media	Benzene	TEX	GRO C6-C12	MTBE	Other Oxygenates	n-hexane	Other VOCs (vapour)	Naphthalene	2-methyl naphthalene
Human Health	CPU	Soil Vapour	×	×	×	×	×	×	×	×	×
	HDR	Soil Vapour	×	×	×	×	×	×	×	×	×

Notes: ✓= Measured in excess of GAC

× = Not measured in excess of GAC

n/a = not applicable

4.4 Discussion of Key Exceedances of Human Health GAC – MW4

4.4.1 Human Health - HDR

Based on the soil vapour data collected, no COPC exceeded the HDR GAC, therefore it is considered unlikely that COPC pose an unacceptable risk.

4.4.2 Human Health – CPU

Based on the soil vapour data collected, no COPC exceeded the CPU GAC, therefore it is considered unlikely that COPC pose an unacceptable risk.

4.5 Discussion of Results – MW105

4.5.1 Helium Testing and Implications for Data Interpretation

Due concerns that the oxygen concentration recorded in MW105 during the July 2017 VME indicated ingress of ambient air, during the September 2017 VME a leak test was conducted using helium. As a result of the helium test, AECOM considers the rate of leakage through the well head of 29% exceeded the maximum acceptable leakage rate advised by ITRC of 15% and therefore the July 2017 laboratory results from MW105 have not been included within the GAC screen, nor was a sample collected during the September 2017 VME. It is noted however that the concentrations of all COPC reported in MW105 during the July 2017 VME were at least two orders of magnitude below their respective GAC. This suggests that if the leakage rate in July 2017 was the same as was measured in September 2017 then before dilution of the sample with 29% ambient air, the COPC concentrations are likely to have been at least an order of magnitude below GAC.

The leakage of ambient air into the sample train is probably due to the predominately cohesive soils in which the borehole is screened (clay) resulting in a greater vacuum in the sample train that the fittings could hold.

4.5.2 PID results

A semi-quantitative assessment of risk has been completed through use of the PID readings taken from the well during March, July and September 2017 VMEs:

Table L – PID Results, MW105	PID Results (ppmV)	
Monitoring Event	**Pre-purge**	**Post-purge**
March 2017	n/a*	0.6
July 2017	2.0	0.2
September 2017	2.0	0.2

NOTES FOR TABLE
*A gas tap had not been fitted during the first round therefore peak readings could not be measured. To obtain the steady reading a tap was fitted to the well and the well was purged.

It is acknowledged that the PID readings may also have been diluted, however the risk of dilution is lower for the pre-purge readings since there would have been less time for a vacuum to start forming within the well pipe. Therefore the pre-purge readings should give a reasonable estimate of conditions within the well.

Assuming that the results from the PID surveys comprise solely benzene (the compound usually used to assess risk on petroleum vapour intrusion sites [USEPA, 2015]), and applying 2.0 ppm to the USEPA online vapour unit convertor at 1 atmosphere of pressure and 12^0C soil temperature, (https://www3.epa.gov/ceampubl/learn2model/part-two/onsite/ia_unit_conversion.html) then the benzene concentration would be 6.7mg/m^3 which is a factor of approximately three greater than the HDR GAC of 2.4mg/m^3.

Based on data from both MW105 and the other monitoring wells on site during previous VMEs, benzene forms less than 2% of the total hydrocarbon vapour. 2% of the calculated benzene of 6.7 mg/m^3, results in a benzene concentration of 0.13 mg/m^3, which is over an order of magnitude below the GAC. The potential risk from benzene in vapour to the adjacent basement is therefore considered to be acceptable.

Another potential risk-driving compound on petroleum vapour intrusion sites is naphthalene (USEPA, 2015) due to its common occurrence and relatively low GAC, however it was not detected within the vapour at any of the vapour wells on site and therefore risks from naphthalene are considered to be acceptable.

4.5.3 Perched Water

It is also noted that perched water was encountered in the wells during both monitoring events. As emissions from dissolved sources are considered a weak source of vapours [USEPA, 2015], and no LNAPL (a strong source of vapours) was encountered in the monitoring wells and there were no other indications of residual phase NAPL, it is considered that there is a low risk of vapour intrusion into basements adjacent to the northwest of the site. Habitable basements will have been 'tanked' using low permeability materials to prevent damp ingress, which will also reduce the potential for vapour intrusion.

Finally, the perched water within the permeable horizons fills those horizons and prevents vapour migration through them by diffusion or advection, reducing the risk of vapour migration.

4.5.4 Summary of MW105 Assessment

The following lines of evidence indicate that vapour intrusion risks from MW105 are acceptable:

- Correction of COPC concentrations measured by laboratory analysis in July 2017 by the leakage rate measured in September 2017 indicates COPC concentrations would have been over an order of magnitude below GAC if leakage rates were similar.
- The PID readings measured during three VMEs in 2017 and converted to potential benzene concentrations support the above assessment.
- The vapour source is in dissolved phase and therefore considered to be a 'weak' source with limited potential for vapour intrusion.
- The presence of perched water fills permeable horizons, preventing them from being available for vapour transport.

Potential vapour intrusion risks from COPC at MW105 to both HDR and CPU receptors are considered to be acceptable.

4.6 Ground Gas

Ground gas monitoring results collected from MW4 and MW105 are presented in **Table 1** in **Appendix A,** and post purge results are summarised as follows:

Table M – Ground Gas Results

	Units	Minimum	Maximum	Comment
Methane	% v/v	<0.1	<0.1	-
Carbon dioxide	% v/v	<0.1	3.8	-
Oxygen	% v/v	16.4	20.5	'Shut-in' vacuum leak test passed.
Total ground gas flow rates	litres per hour (l/hr)	<0.1	<0.1	-
Atmospheric pressure	millibar (mBar)	1,016	1,018	-

Peak readings were similar to post purge results and have therefore not been separately assessed.

Calculated hazardous gas flow rates based on the maximum recorded flow and concentrations were <0.0001 litres per hour (l/hr) of methane and <0.0001 l/hr of carbon dioxide. The characteristic gas situation is classified as 1 for the site, with a risk classification of Very Low (i.e. less than 0.07 l/hr).

Guidance provided within BS8485 suggests that where concentrations of methane and carbon dioxide exceed 1% v/v and 5% v/v respectively then an increase to Characteristic Situation 2 should be considered, but this trigger has not been exceeded.

The characteristic gas situation is classified as 1 for the site, with a risk classification of Very Low. Ground gases have therefore not been considered further in the risk assessment for the site.

4.7 PID Survey readings

The PID vapour survey undertaken on the 27th March 2017 from all the ten (10) monitoring wells, reported elevated PID readings in one well, MW4 (423.5 parts per million [ppm]). The remaining PID readings were below 10ppm. MW4 passed subsequent leak tests and laboratory analysis showed that GAC were not exceeded, therefore the elevated PID reading is not considered indicative of potential unacceptable risks.

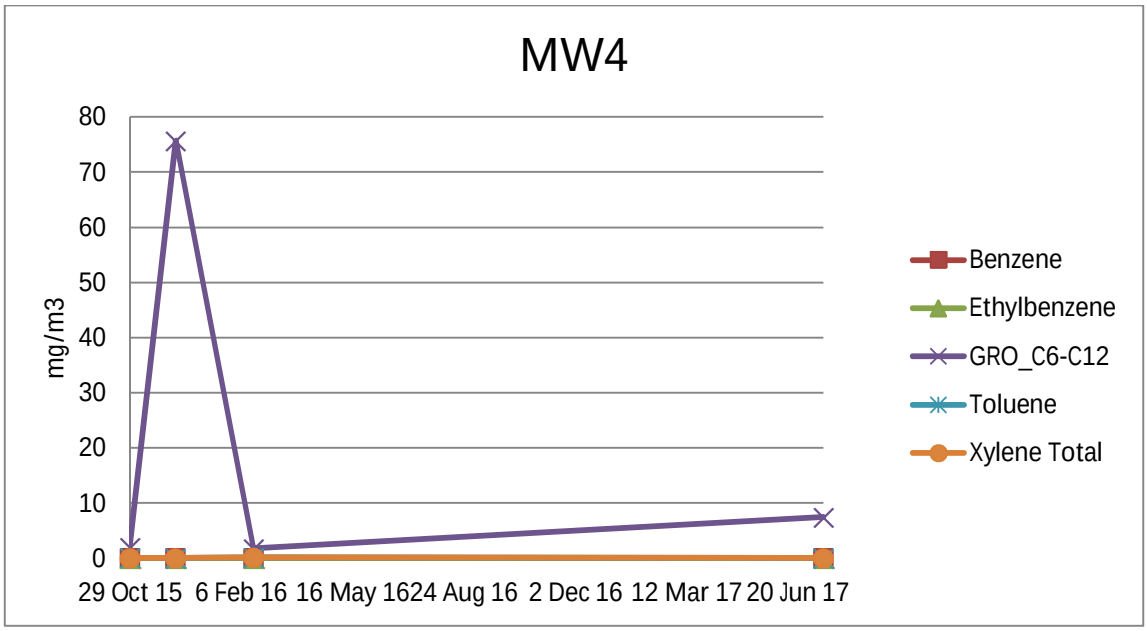
4.8 Summary

None of the COPC in the samples collected exceeded the HDR or CPU GAC and therefore, there is not a requirement for a Stage 3 assessment.

4.9 Vapour Trends

4.9.1 MW4 Trends

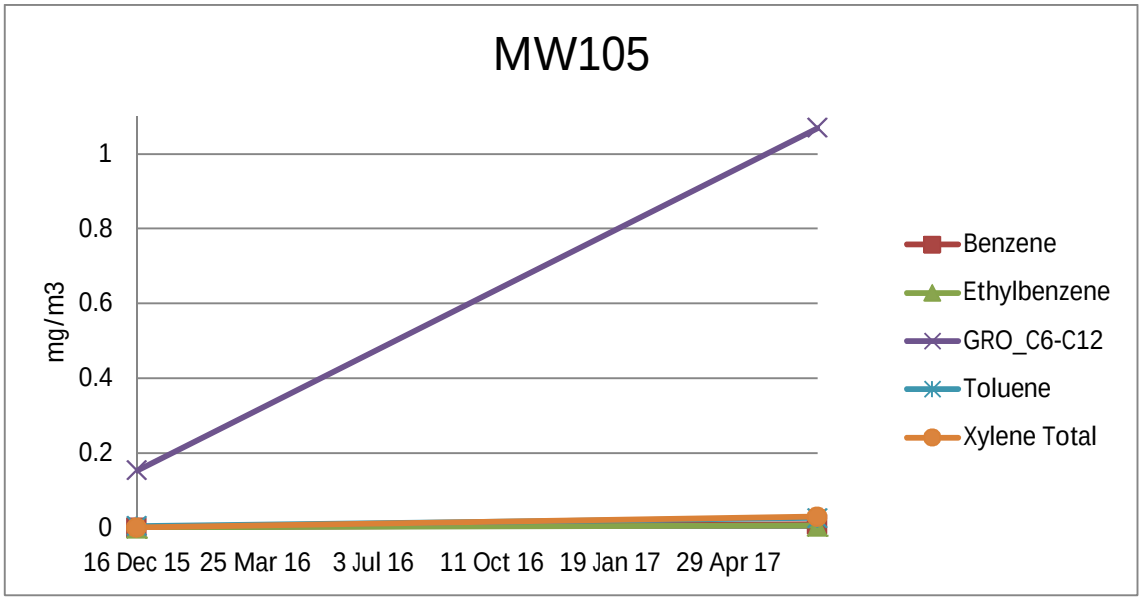
Graph 1: MW4 Trends



Concentrations of BTEX compounds in the vapour samples collected from MW4 have been relatively stable since the October 2015 monitoring round. Concentrations of GRO (C6-C12) in MW4 peaked in December 2015 at 75.7 mg/m^3 before falling to 1.73 mg/m^3 in the subsequent monitoring round (February 2016). In the July 2017 monitoring round GRO (C6-C12) concentrations increased slightly to 7.45 mg/m^3.

4.9.2 MW105 Trends

Graph 2: MW105 trends



Concentrations of BTEX compounds in the vapour samples collected from MW105 have been relatively stable since the previous monitoring round. There has been an increase in GRO (C6-C12) concentrations between the previous monitoring round (December 2015) and the most recent monitoring round. However, it is noteworthy that there have only been two monitoring events which assess the vapour from MW105.

4.9.3 Trend Summary

BTEX compounds have consistently remained at relatively low concentrations in MW105 and MW4, whereas GRO (C6-C12) concentrations have been shown to fluctuate in MW4. There is insufficient data to determine a trend in MW105, however there was an limited increase in GRO (C6-C12) between two rounds. The relatively low concentrations of BTEX compounds confirm that the GRO (C6-C12) bands are not dominated by BTEX compounds, and are more likely dominated by aliphatic TPH fractions which have greater vapour pressures.

Considering the relative locations of these wells to the potential sources (fuel island 7/8 where an integrity issue was reported, and locations of historical USTs), the data do not suggest an increase in the vapour source since MW4 is nearer to the source area.

5. CONCEPTUAL SITE MODEL

The Conceptual Site Model (CSM) presented here is based on the information provided in the historic reports prepared for the site, on observations made during the AECOM VME, and on the subsequent AECOM generic quantitative risk assessments.

The site is an active petrol filling station, and as such there is the potential of COPC to be present from accidental releases to ground from infrastructure. The VME has indicated that the COPC listed in **Sections 4** are present in the areas of the site which were investigated.

The potential pathways and receptors identified for assessment at Stage 2 are listed in **Table N** below.

5.1 Review of Potential Source-Pathway-Receptor Linkages

The following pollutant linkages were evaluated at Stage 2 given continued oil use. These are also detailed on **Figure 3**.

Table N – Human Health CSM

Source	Pathway	Receptor	Likelihood of Pollutant Linkage Presenting an Unacceptable Risk
• Impacted soils / soil vapour / perched groundwater	Lateral and vertical vapour migration and subsequent inhalation.	On-site shop staff, visiting staff and general public.	Unlikely: Based on Stage 2 assessment.
		Off-site residents in adjacent residential properties to the north, north west and south (including basements of the properties to the north west and south).	
	Particulate - Ingestion, inhalation, dermal contact with soil particulates.	Visiting on-site contractors excavating ground.	**Possible***

* Potential risks to visiting contractors undertaking intrusive works should be managed by appropriate PPE, risk assessment and method statements. Risks to visiting contractors excavating the ground were therefore not assessed within the scope of the DQRA.

6. CONCLUSIONS

The geology encountered consisted of made ground underlain by a solid geology of the London Clay Formation (Unproductive Strata); it is anticipated that the London Clay Formation is 60-100m thick. There are no superficial deposits at the site.

Perched water was encountered in on site monitoring wells at depths between 0.58m to 1.33m bgl. Given the significant variability in groundwater elevations, it is considered that the water is perched and discontinuous, therefore it was not possible to define a flow direction. LNAPL was not identified in any of the wells.

A Stage 2 risk assessment was performed on the data collected during the vapour monitoring event of MW4 and MW105 to assess potential risks to human health. No other potential complete pollutant linkages were identified during the URS CESA and therefore have not been assessed in this report. Based on the soil vapour data collected from MW4, no COPC exceeded the HDR or CPU GAC, therefore it is considered unlikely that COPC pose an unacceptable risk.

A helium leak test was conducted on MW105 in September 2017, the results of which indicate that there was unacceptable ingress of ambient air, therefore analytical data from that well were discarded and instead a semi-quantitative assessment of risks was made based on the PID data. An assessment of COPC concentration trends in each well over this and previous rounds concluded that there is no evidence for an increase in the vapour source.

Additional lines of evidence indicate that vapour intrusion risks from MW105 are acceptable, including correction of COPC concentrations measured by laboratory analysis in July 2017 by the leakage rate measured in September 2017, the PID readings measured during three VMEs in 2017, the vapour source is in dissolved phase and therefore considered to be a ‘weak’ source with limited potential for vapour intrusion and the presence of perched water fills permeable horizons, preventing them from being available for vapour transport.

7. REFERENCES

Ref. 1 Arcadis GMI, Tier 2 Environmental Assessment Report, Ref. 9427200107; April 2002.

Ref. 2 Arcadis GMI, Incident Response Report, Ref: 942720203, November 2004.

Ref. 3 Arcadis GMI, GME Groundwater Monitoring Report, Ref: 942720302; January 2005.

Ref. 4 Arcadis GMI, Report on Fuel Line Replacement, Ref: 942720405; January 2005.

Ref. 5 URS, P1 Environmental Site Assessment, Ref: 46370434-001; September 2015.

Ref. 6 URS, P2 Comprehensive Environmental Site Assessment, Ref: 46370434-002; January 2016.

Ref. 7 AECOM, Comprehensive Vapour Monitoring Report, Ref: 46370434-003; dated March 2016.

Ref. 8 CLR11 Model Procedures for the Management of Land Contamination

Ref. 9 Guidance for the Safe Development of Housing on Land Affected by Contamination, R&D Publication 66: 2008 (Volume 1), NHBC and the Environment Agency 2008.

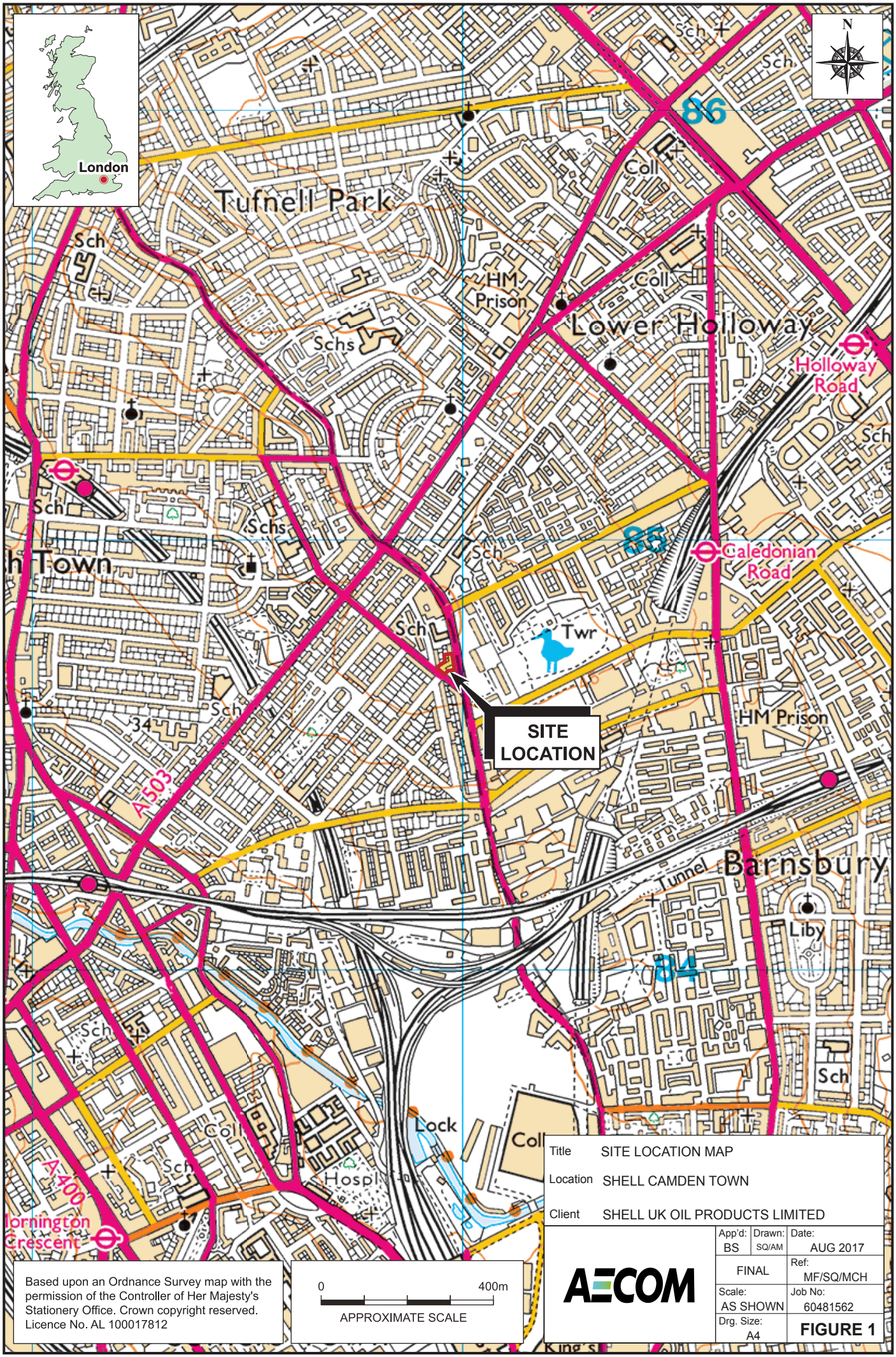
Ref. 10 LQM/CIEH S4UL methodology

Ref. 11 USEPA. Technical Guide For Addressing Petroleum Vapor Intrusion At Leaking Underground Storage Tank Sites. EPA 510-R-15-001. June 2015

Ref. 12 USEPA. OSWER Technical Guide For Assessing And Mitigating The Vapor Intrusion Pathway From Subsurface Vapor Sources To Indoor Air, Office of Solid Waste and Emergency Response, June 2015

Ref. 13 British Standard Institute. Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings. BS8485:2015. June 2015.

FIGURES



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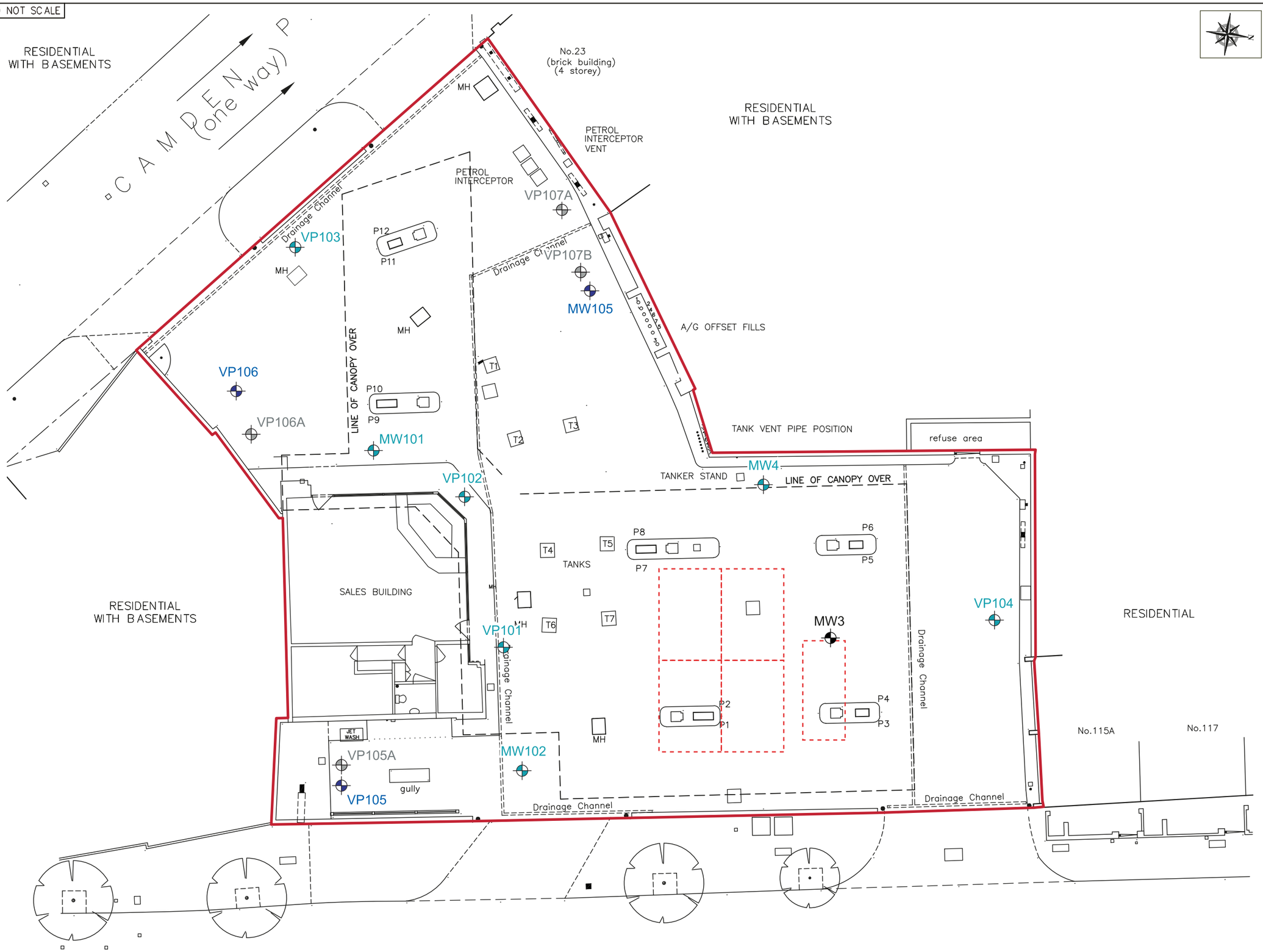
Title	SITE LOCATION MAP
Location	SHELL CAMDEN TOWN
Client	SHELL UK OIL PRODUCTS LIMITED

AECOM

App'd:	Drawn:	Date:
BS	SQ/AM	AUG 2017
FINAL		Ref: MF/SQ/MCH
Scale: AS SHOWN		Job No: 60481562
Drg. Size: A4		**FIGURE 1**

DO NOT SCALE



NOTES

- Site Boundary
- Shallow Vapour Monitoring Well
- Deep Vapour Monitoring Well
- Refusal Location
- Historical Well - Failed Seal Test (Not Sampled)
- Historical Tank Location

REV	DESCRIPTION	DRAWN	APPROVED	DATE

STATUS
FOR INFORMATION

CONSULTING ENGINEERS

AECOM

BRIDGEWATER HOUSE, WHITWORTH STREET, MANCHESTER, M1 6LT
TEL 0161-907-3500 FAX 0161-907-3501

CLIENT
SHELL UK OIL PRODUCTS LTD

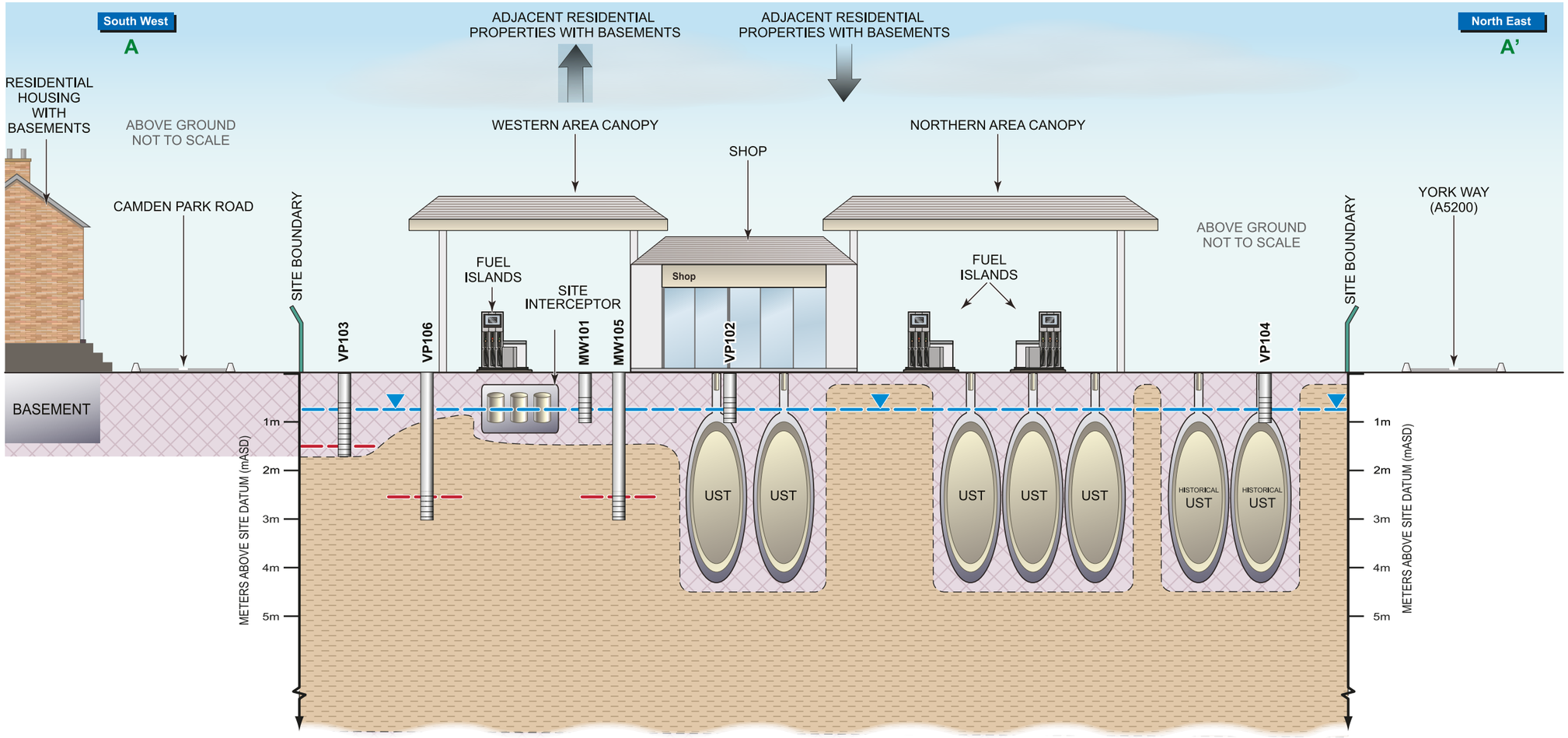
PROJECT
SHELL CAMDEN TOWN

DRAWING TITLE
Figure 2
Site Features Plan

DRAWN		CHECKED	APPROVED	DATE
SQ		BS	BS	AUG 2017

SCALE	DRG No.	REV.
As Shown	60481562	

DO NOT SCALE



AREA OF POTENTIAL CONCERN

On-site

Historical

- Historical use of the site as a petrol filling station since c.1972 (including three (3) former tanks / five (5) compartments – now abandoned).
- Made Ground associated with historical buildings on the site.

Current

- Operational underground storage tanks (four (4) tanks / seen (7) compartments) in the centre of the site.
- Accidental releases to ground from off-set fill points, located along the eastern site boundary.
- Accidental releases to ground from dispenser pumps: six (6) car fuel islands,
- Accidental releases from fuel lines present between the tanks, off-set fill points and fuel islands.
- The forecourt interceptor located in the northeastern part of the site and associated drainage lines.
- Made Ground.

Off-Site, Historical

- Former reservoir approximately 100m north of the site active – infilled from 1938.

CHEMICALS OF POTENTIAL CONCERN

Current Potential On-site Sources

- TPH - Petroleum hydrocarbons.
- BTEX- Benzene, toluene, ethylbenzene and xylenes.
- Petroleum Additives- Methyl tertiary butyl ether (MTBE), ethyl tertiary butyl ether (ETBE),tertiary amyl methyl ether (TAME), di-isopropyl ether (DIPE), and tertiary butyl alcohol (TBA).
- PAHs- Polycyclic aromatic hydrocarbons.
- Metals – arsenic, boron, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, selenium and zinc.
- 1,2-dichloroethane (EDC) and 1,2-dibromoethane (EDB) (lead scavengers).
- 2-methylnaphthalene and n-hexane.
- Landfill gases such as methane and carbon dioxide
- Lead scavengers
- Asbestos

POTENTIAL PATHWAYS

Human Health

- Vapours – Migration of vapours through made ground above ground buildings.
- Particulate – Ingestion, inhalation, dermal contact, with soil particulates.
- Permeation – Migration of hydrocarbon substances through plastic potable water supply pipes.
- Gases – Migration of landfill gases through the made ground to above ground buildings.

Controlled Waters

- Leaching – Migration of hydrocarbon substances from soils into perched and deeper groundwater.
- Migration of impacted shallow perched water to surface water.

POTENTIAL RECEPTORS

Human Health

- On-site shop staff.
- On-site general public and visiting staff (such as contractors, including those conducting excavation works).
- Off-site residents in the surrounding residential dwellings to the north, north west, south, south west (with basements to the northwest, south and south west).

Controlled Waters

- Deeper groundwater within Secondary and Principal Aquifers.
- Surface water (Pond 659m south and Grand Union Canal 850m southwest of the site).

POSSIBLE COMPLETE POLLUTANT LINKAGES

Human Health

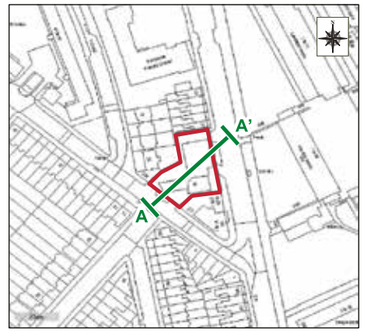
- None identified.

Controlled Waters

- None identified following P1ESA.

ORIGINAL DRAWING A3

NOTES



MADE GROUND

LONDON CLAY - UNPRODUCTIVE STRATA

PERCHED WATER (LEVEL VARIABLE ACROSS SITE 0.32mbgl TO 1.44mbgl OCTOBER & DECEMBER 2015)

ANTICIPATED LEVEL OF BASE OF ADJACENT BASEMENT

REV	DESCRIPTION	DRAWN	APPROVED	DATE

STATUS

PRELIMINARY

CONSULTING ENGINEERS

AECOM

BRIDGEWATER HOUSE, WHITWORTH STREET, MANCHESTER, M1 6LT
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CLIENT
SHELL UK OIL PRODUCTS LTD

PROJECT
Shell Camden Town

DRAWING TITLE
Figure 3
Conceptual Site Model

DRAWN		CHECKED	APPROVED	DATE
LCS		BS	BS	AUG 2017

SCALE	DRG No.	REV.
VERTICAL SCALE AS SHOWN	60481562	

APPENDIX A FIELD DATA TABLES

TABLE 1a
GROUNDWATER ELEVATIONS MEASUREMENTS

Site	Shell Camden Town
Sample Round	27 March 2017

Borehole	Ground elevation (m AOD)	Elevation of top of pipe (m AOD)	Top and base of screen (mbgl)		Base of drilled borehole (mbgl)	Top and base of screen (mAOD)		Base of borehole (mAOD)	Dip date	Depth to LNAPL (m below top pipe)	Depth to water (m below top pipe)	Depth to base (m below top pipe)	Difference from installed depth / silt thickness (m)	NAPL Surface Elevation (mAOD)	Groundwater elevation (m AOD)	PID	Comments
MW4	49.08	49.05	0.50	1.50	1.50	48.58	47.58	47.58	27/03/2017	-	1.33	1.83	-0.33	-	47.72	423.5	
MW101	48.98	48.86	0.50	1.00	2.00	48.48	47.98	46.98	27/03/2017	-	0.92	1.09	-0.09	-	47.94	0.5	
MW102	48.93	48.83	0.50	1.00	2.00	48.43	47.93	46.93	27/03/2017	-	0.32	1.00	0.01	-	48.51	3.4	
MW105	49.04	48.93	2.40	3.00	3.00	46.64	46.04	46.04	27/03/2017	-	0.58	2.91	0.09	-	48.35	0.6	
VP101	48.97	48.88	0.50	1.00	1.00	48.47	47.97	47.97	27/03/2017	-	DRY	0.60	0.41	-	DRY	0.4	
VP102	49.09	48.97	0.50	1.00	1.00	48.59	48.09	48.09	27/03/2017	-	0.76	0.80	0.20	-	48.22	0.3	
VP103	48.86	48.77	0.40	1.60	1.60	48.46	47.26	47.26	27/03/2017	-	0.41	1.28	0.33		48.36	0.1	
VP104	49.30	49.20	0.50	1.00	1.00	48.80	48.30	48.30	27/03/2017	-	0.74	0.86	0.14		48.46	2.0	
VP105	48.91	49.82	2.50	3.00	3.00	46.41	45.91	45.91	27/03/2017	-	0.93	2.82	0.18		48.90	1.1	
VP106	48.88	48.77	2.50	3.00	3.00	46.38	45.88	45.88	27/03/2017	-	0.80	2.91	0.10		47.97	0.3	

Legend

m bgl - metres below ground level
m AOD - metres Above Ordnance Datum

Notes

Boreholes were levelled to ordnance datum.

TABLE 1b
VAPOUR MONITORING

Site	Shell Camden Town
Sample Round	13 July and 25 September 2017

Sample Location	Sample Date	Depth to Base (m bgl)	Depth to Groundwater (m bgl)	Sample Tube ID	PID Reading (ppm)		Flow Pod (L/hr)	Barometric Pressure (mb)	Methane (CH_4) %LEL	Carbon Dioxide (CO_2) %v/v	Oxygen (O_2) % v/v	Methane Flow (l/hr)	Carbon Dioxide Flow (l/hr)
					Pre-purge	Post-purge	Peak		Peak	Peak	Peak		
MW4	13/07/2017	1.83	1.33	460	9.4	4.8	<0.1	1017	<0.1	3.7	16.4	0.0000	0.0000
MW105	13/07/2017	2.91	0.58	354	2	0.2	<0.1	1016	<0.1	<0.1	20.5	0.0000	0.0000
MW105	25/09/2017	2.92	0.92	223	2	0.2	<0.1	1018	<0.1	0.8	18.8	0.0000	0.0000

Legend:

ppm - parts per million
L/hr - litres per hour
LEL - lower explosive limit
-- - not encountered
mb - milliBar
m bgl - metres below ground level

CS: CIRIA Characteristic Situation. Volumetric flow rate of CH_4 or CO_2 (litre/hour):

CS1 (very low risk): <0.07l/hr (CH_4 <1% and/or CO_2 <5%).
CS2 (low risk): <0.7l/hr (CH4 >1% and/or CO2 >5%).

NHBC Traffic Light Classification

Green: CH_4< 1%, CH_4 flow rate< 0.16l/hr, CO_2 <5%, CO_2 flow rate <0.78l/hr
Amber 1: 1% <CH_4< 5%, 0.16l/hr <CH_4 flow rate< 0.63l/hr, 5% <CO_2< 10%, 0.7l/hr <CO_2 flow rate< 1.56l/hr
Amber 2: 5%< CH_4 <20%, 0.63l/hr <CH_4 flow rate <1.56l/hr, 10% <CO_2 <30%, 1.56l/hr <CO_2 flow rate <3.13l/hr

APPENDIX B STAGE 2 TABLES

Table 2
Analytical Results
GESS 2015
Shell UK Oil Products Ltd.

	Units	Method Detection Limit	2015 GAC - Continued Petroleum Use	2015 GAC - High Density Residential	**Location**	MW4	MW105*
					Date	13/07/2017	13/07/2017
BTEX							
Benzene	mg/m3		48[#1]	**2.4**[#2]		0.00255	0.0087
Toluene	mg/m3		50,000[#1]	**2,600**[#2]		0.00496	0.0261
Ethylbenzene	mg/m3		2,700[#1]	**140**[#2]		0.00102	0.00578
Xylene (m & p)	mg/m3					0.00383	0.021
Xylene (o)	mg/m3		2,200[#1]	**110**[#2]		0.00178	0.00814
Xylene Total	mg/m3		2,200[#1]	**110**[#2]		0.00561	0.02914
Oxygenates							
Diisopropyl Ether	mg/m3	0.005	4,300[#1]	**230**[#2]		<0.005	<0.005
Ethyl Tert Butyl Ether	mg/m3	0.005	20,000[#1]	**1,100**[#2]		<0.005	<0.005
Methyl Tert Butyl Ether	mg/m3	0.005	26,000[#1]	**1,300**[#2]		<0.005	<0.005
Tert Amyl Methyl Ether	mg/m3	0.005	2,000[#1]	**1,100**[#2]		<0.005	<0.005
n-Hexane	mg/m3		6,500[#1]	**330**[#2]		0.0252	0.0848
PAH							
Naphthalene	mg/m3	0.002	31[#1]	**1.4**[#2]		<0.002	<0.002
SVOC							
1-Methylnaphthalene	mg/m3	0.004	91[#1]	**5**[#2]		<0.004	<0.004
Gas VOC							
Decane	mg/m3					0.0243	0.0364
Dodecane	mg/m3	0.003				<0.003	<0.003
Octane	mg/m3	0.0025				<0.0025	0.0672
GRO C6-C12	mg/m3					7.45	1.07
Other							
1,2,3-trimethylbenzene	mg/m3	0.003				0.0126	<0.003

Comments
#1 URS derived GAC for petrol filling stations
#2 Derived GAC for petrol filling stations
GAC: Generic Assessment Criteria
(blank): No assessment criteria available
HH GAC calculated using CLEA methodology with C4SL exposure scenarios, specifically for petrol filling stations
HH GAC based on soil properties for 'CLEA sand' and 1% SOM (0.58% TOC)
Sat: Hazard quotient at vapour saturation < 1
*: MW105 results not compared to GAC

Key

XXX	Exceedance of 2015 GAC - Continued Petroleum Use
XXX	Exceedance of 2015 GAC - High Density Residential

APPENDIX C LABORATORY ANALYTICAL RESULTS CERTIFICATES

Unit 7-8 Hawarden Business Park
Manor Road (off Manor Lane)
Hawarden
Deeside
CH5 3US
Tel: (01244) 528700
Fax: (01244) 528701
email: hawardencustomerservices@alsglobal.com
Website: www.alsenvironmental.co.uk

AECOM
St. George's House
2nd Floor
5 St. George's Road
Wimbledon
Greater London
SW19 4DR

Attention: Marc Gath

CERTIFICATE OF ANALYSIS

Date:	24 July 2017
Customer:	H_URS_WIM
Sample Delivery Group (SDG):	170715-37
Your Reference:	60481562
Location:	Shell Camden Town
Report No:	417265

We received 4 samples on Saturday July 15, 2017 and 4 of these samples were scheduled for analysis which was completed on Monday July 24, 2017. Accredited laboratory tests are defined within the report, but opinions, interpretations and on-site data expressed herein are outside the scope of ISO 17025 accreditation.

Should this report require incorporation into client reports, it must be used in its entirety and not simply with the data sections alone.

Chemical testing (unless subcontracted) performed at ALS Environmental Hawarden (Method codes TM) or ALS Environmental Aberdeen (Method codes S).

Approved By:

Sonia McWhan

Operations Manager

CERTIFICATE OF ANALYSIS

SDG:	170715-37	**Client Reference:**	60481562	**Report Number:**	417265
Location:	Shell Camden Town	**Order Number:**	60481562	**Superseded Report:**	

Received Sample Overview

Lab Sample No(s)	Customer Sample Ref.	AGS Ref.	Depth (m)	Sampled Date
15844434	EQUIPMENT BLANK			13/07/2017
15844432	MW4			13/07/2017
15844431	MW105			13/07/2017
15844435	TRIP BLANK			13/07/2017

Maximum Sample/Coolbox Temperature (°C) : **18**

ISO5667-3 Water quality - Sampling - Part3 -
During Transportation samples shall be stored in a cooling device capable of maintaining a temperature of (5±3)°C.

ALS have data which show that a cool box with 4 frozen icepacks is capable of maintaining pre-chilled samples at a temperature of (5±3)°C for a period of up to 24hrs.

Only received samples which have had analysis scheduled will be shown on the following pages.

Validated

CERTIFICATE OF ANALYSIS

SDG:	170715-37	**Client Reference:**	60481562	**Report Number:**	417265
Location:	Shell Camden Town	**Order Number:**	60481562	**Superseded Report:**	

Results Legend

X **Test**

N **No Determination Possible**

Sample Types -
S - Soil/Solid
UNS - Unspecified Solid
GW - Ground Water
SW - Surface Water
LE - Land Leachate
PL - Prepared Leachate
PR - Process Water
SA - Saline Water
TE - Trade Effluent
TS - Treated Sewage
US - Untreated Sewage
RE - Recreational Water
DW - Drinking Water Non-regulatory
UNL - Unspecified Liquid
SL - Sludge
G - Gas
OTH - Other

Lab Sample No(s)	15844434	15844432	15844431	15844435
Customer Sample Reference	EQUIPMENT BLANK	MW4	MW105	TRIP BLANK
AGS Reference				
Depth (m)				
Container	TD tube	TD tube	TD tube	TD tube
Sample Type	G	G	G	G
UST Gases / All / NDPs: 0 Tests: 4	X	X	X	X

Validated

CERTIFICATE OF ANALYSIS

SDG:	170715-37	**Client Reference:**	60481562	**Report Number:**	417265
Location:	Shell Camden Town	**Order Number:**	60481562	**Superseded Report:**	

Results Legend	
#	ISO17025 accredited.
M	*m*CERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&+§@	Sample deviation (see appendix)

Component	LOD/Units	Method	Customer Sample Ref.	EQUIPMENT BLANK	MW4	MW105	TRIP BLANK		
			Depth (m)	.	.	.	.		
			Sample Type	Gas (G)	Gas (G)	Gas (G)	Gas (G)		
			Date Sampled	13/07/2017	13/07/2017	13/07/2017	13/07/2017		
			Sample Time	.	.	.	.		
			Date Received	15/07/2017	15/07/2017	15/07/2017	15/07/2017		
			SDG Ref	170715-37	170715-37	170715-37	170715-37		
			Lab Sample No.(s)	15844434	15844432	15844431	15844435		
			AGS Reference						
MTBE	ng	TM278					<10		
	ug/m³	TM278		<5	<5	<5			
Hexane	ng	TM278					16.2		
	ug/m³	TM278		17.9	25.2	84.8			
DIPE	ng	TM278					<10		
	ug/m³	TM278		<5	<5	<5			
ETBE	ng	TM278					<10		
	ug/m³	TM278		<5	<5	<5			
Benzene	ng	TM278					<5		
	ug/m³	TM278		13.5	2.55	8.7			
TAME	ng	TM278					<10		
	ug/m³	TM278		<5	<5	<5			
Toluene	ng	TM278					2.26		
	ug/m³	TM278		21	4.96	26.1			
Octane	ng	TM278					<5		
	ug/m³	TM278		<2.5	<2.5	67.2			
Ethylbenzene	ng	TM278					<2		
	ug/m³	TM278		2.59	1.02	5.78			
p/m-Xylene	ng	TM278					<3		
	ug/m³	TM278		7.98	3.83	21			
o-Xylene	ng	TM278					<2		
	ug/m³	TM278		2.56	1.78	8.14			
Decane	ng	TM278					<1.6		
	ug/m³	TM278		5.19	24.3	36.4			
1,2,3-Trimethylbenzene	ng	TM278					<6		
	ug/m³	TM278		<3	12.6	<3			
Dodecane	ng	TM278					<6		
	ug/m³	TM278		<3	<3	<3			
Naphthalene	ng	TM278					<4		
	ug/m³	TM278		<2	<2	<2			
1-Methylnaphthalene	ng	TM278					<8		
	ug/m³	TM278		<4	<4	<4			
GRO C6-C12	ng	TM278					<67		

Validated

CERTIFICATE OF ANALYSIS

SDG:	170715-37	**Client Reference:**	60481562	**Report Number:**	417265
Location:	Shell Camden Town	**Order Number:**	60481562	**Superseded Report:**	

Results Legend	
#	ISO17025 accredited.
M	*m*CERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&+§@	Sample deviation (see appendix)

Component	LOD/Units	Method	Customer Sample Ref.	EQUIPMENT BLANK	MW4	MW105	TRIP BLANK		
			Depth (m)	.	.	.	.		
			Sample Type	Gas (G)	Gas (G)	Gas (G)	Gas (G)		
			Date Sampled	13/07/2017	13/07/2017	13/07/2017	13/07/2017		
			Sample Time	.	.	.	.		
			Date Received	15/07/2017	15/07/2017	15/07/2017	15/07/2017		
			SDG Ref	170715-37	170715-37	170715-37	170715-37		
			Lab Sample No.(s)	15844434	15844432	15844431	15844435		
			AGS Reference						
GRO C6-C12	ug/m³	TM278		394	7450	1070			

CERTIFICATE OF ANALYSIS

SDG:	170715-37	**Client Reference:**	60481562	**Report Number:**	417265
Location:	Shell Camden Town	**Order Number:**	60481562	**Superseded Report:**	

Table of Results - Appendix

Method No	Reference	Description	Wet/Dry Sample [1]	Surrogate Corrected
TM278		Determination of Selective VOCs by TD-GC-MS		

[1] Applies to Solid samples only. DRY indicates samples have been dried at 35°C. NA = not applicable.

Chemical testing (unless subcontracted) performed at ALS Environmental Hawarden (Method codes TM) or ALS Environmental Aberdeen (Method codes S).

CERTIFICATE OF ANALYSIS

SDG:	170715-37	**Client Reference:**	60481562	**Report Number:**	417265
Location:	Shell Camden Town	**Order Number:**	60481562	**Superseded Report:**	

Test Completion Dates

Lab Sample No(s)	15844434	15844432	15844431	15844435
Customer Sample Ref.	EQUIPMENT BLANK	MW4	MW105	TRIP BLANK
AGS Ref.				
Depth				
Type	Gas (G)	Gas (G)	Gas (G)	Gas (G)
UST Gases	24-Jul-2017	24-Jul-2017	24-Jul-2017	24-Jul-2017

ASSOCIATED AQC DATA

UST Gases

Component	Method Code	QC 1551
1,2,3-Trimethylbenzene raw	TM278	**95.0** 84.74 : 112.58
1-Methylnaphthalene raw	TM278	**91.6** 78.86 : 115.19
Benzene raw	TM278	**96.0** 92.82 : 110.95
Decane raw	TM278	**94.2** 85.50 : 110.26
DIPE raw	TM278	**96.6** 94.35 : 110.60
Dodecane raw	TM278	**89.2** 81.10 : 122.27
ETBE raw	TM278	**94.8** 91.70 : 109.18
Ethylbenzene raw	TM278	**100.0** 91.02 : 114.09
GRO C6 - C12 raw	TM278	**111.5** 83.79 : 121.12
Hexane raw	TM278	**97.0** 88.35 : 119.04
MTBE raw	TM278	**97.0** 88.46 : 113.09
Naphthalene raw	TM278	**99.4** 84.94 : 110.28
Octane raw	TM278	**101.4** 91.30 : 115.61
o-Xylene raw	TM278	**97.8** 90.04 : 111.10
p/m-Xylene raw	TM278	**99.0** 90.00 : 114.30
TAME raw	TM278	**95.4** 86.79 : 115.90
Toluene raw	TM278	**100.8** 90.77 : 113.80

The above information details the reference name of the analytical quality control sample (AQC) that has been run with the samples contained in this report for the different methods of analysis.
The figure detailed is the percentage recovery result for the AQC.
The subscript numbers below are the percentage recovery lower control limit (LCL) and the upper control limit (UCL). The percentage recovery result for the AQC should be between these limits to be statistically in control.

Appendix

General

1. Results are expressed on a dry weight basis (dried at 35ºC) for all soil analyses except for the following: NRA and CEN Leach tests, flash point LOI, pH, ammonium as NH4 by the BRE method, VOC TICs and SVOC TICs.

2. Samples will be run in duplicate upon request, but an additional charge may be incurred.

3. If sufficient sample is received a sub sample will be retained free of charge for 30 days after analysis is completed (e-mailed) for all sample types unless the sample is destroyed on testing. The prepared soil sub sample that is analysed for asbestos will be retained for a period of 6 months after the analysis date. All bulk samples will be retained for a period of 6 months after the analysis date. All samples received and not scheduled will be disposed of one month after the date of receipt unless we are instructed to the contrary. Once the initial period has expired, a storage charge will be applied for each month or part thereof until the client cancels the request for sample storage. ALS reserve the right to charge for samples received and stored but not analysed.

4. With respect to turnaround, we will always endeavour to meet client requirements wherever possible, but turnaround times cannot be absolutely guaranteed due to so many variables beyond our control.

5. We take responsibility for any test performed by sub-contractors (marked with an asterisk). We endeavour to use UKAS/MCERTS Accredited Laboratories, who either complete a quality questionnaire or are audited by ourselves. For some determinands there are no UKAS/MCERTS Accredited Laboratories, in this instance a laboratory with a known track record will be utilised.

6. When requested, the individual sub sample scheduled will be analysed in house for the presence of asbestos fibres and asbestos containing material by our documented in house method TM048 based on HSG 248 (2005), which is accredited to ISO17025. If a specific asbestos fibre type is not found this will be reported as “Not detected”. If no asbestos fibre types are found all will be reported as “Not detected” and the sub sample analysed deemed to be clear of asbestos. If an asbestos fibre type is found it will be reported as detected (for each fibre type found). Testing can be carried out on asbestos positive samples, but, due to Health and Safety considerations, may be replaced by alternative tests or reported as No Determination Possible (NDP). The quantity of asbestos present is not determined unless specifically requested.

7. If no separate volatile sample is supplied by the client, or if a headspace or sediment is present in the volatile sample, the integrity of the data may be compromised. This will be flagged up as an invalid VOC on the test schedule and the result marked as deviating on the test certificate.

8. If appropriate preserved bottles are not received preservation will take place on receipt. However, the integrity of the data may be compromised.

9. NDP - No determination possible due to insufficient/unsuitable sample.

10. Metals in water are performed on a filtered sample, and therefore represent dissolved metals - total metals must be requested separately.

11. Results relate only to the items tested.

12. LoDs (Limit of Detection) for wet tests reported on a dry weight basis are not corrected for moisture content.

13. **Surrogate recoveries** - Surrogates are added to your sample to monitor recovery of the test requested. A % recovery is reported, results are not corrected for the recovery measured. Typical recoveries for organics tests are 70-130%, they are generally wider for volatiles analysis, 50-150%. Recoveries in soils are affected by organic rich or clay rich matrices. Waters can be affected by remediation fluids or high amounts of sediment. Test results are only ever reported if all of the associated quality checks pass; it is assumed that all recoveries outside of the values above are due to matrix affect.

14. **Product analyses** - Organic analyses on products can only be semi-quantitative due to the matrix effects and high dilution factors employed.

15. Phenols monohydric by HPLC include phenol, cresols (2-Methylphenol, 3-Methylphenol and 4-Methylphenol) and Xylenols (2,3 Dimethylphenol, 2,4 Dimethylphenol, 2,5 Dimethylphenol, 2,6 Dimethylphenol, 3,4 Dimethyphenol, 3,5 Dimethylphenol).

16. Total of 5 speciated phenols by HPLC includes Phenol, 2,3,5-Trimethyl Phenol, 2-Isopropylphenol, Cresols and Xylenols (as detailed in 15).

17. Stones/debris are not routinely removed. We always endeavour to take a representative sub sample from the received sample.

18. In certain circumstances the method detection limit may be elevated due to the sample being outside the calibration range. Other factors that may contribute to this include possible interferences. In both cases the sample would be diluted which would cause the method detection limit to be raised.

19. Mercury results quoted on soils will not include volatile mercury as the analysis is performed on a dried and crushed sample.

20. For leachate preparations other than Zero Headspace Extraction (ZHE) volatile loss may occur.

21. For the BSEN 12457-3 two batch process to allow the cumulative release to be calculated, the volume of the leachate produced is measured and filtered for all tests. We therefore cannot carry out any unfiltered analysis. The tests affected include volatiles GCFID/GCMS and all subcontracted analysis.

22. We are accredited to MCERTS for sand, clay and loam/topsoil, or any of these materials - whether these are derived from naturally occurring soil profiles, or from fill/made ground, as long as these materials constitute the major part of the sample. Other coarse granular material such as concrete, gravel and brick are not accredited if they comprise the major part of the sample.

23. Analysis and identification of specific compounds using GCFID is by retention time only, and we routinely calibrate and quantify for benzene, toluene, ethylbenzenes and xylenes (BTEX). For total volatiles in the C5-C12 range, the total area of the chromatogram is integrated and expressed as ug/kg or ug/l. Although this analysis is commonly used for the quantification of gasoline range organics (GRO), the system will also detect other compounds such as chlorinated solvents, and this may lead to a falsely high result with respect to hydrocarbons only. It is not possible to specifically identify these non-hydrocarbons, as standards are not routinely run for any other compounds, and for more definitive identification, volatiles by GCMS should be utilised.

24. **Tentatively Identified Compounds (TICs)** are non-target peaks in VOC and SVOC analysis. All non-target peaks detected with a concentration above the LoD are subjected to a mass spectral library search. Non-target peaks with a library search confidence of >75% are reported based on the best mass spectral library match. When a non-target peak with a library search confidence of <75% is detected it is reported as “mixed hydrocarbons”. Non-target compounds identified from the scan data are semi-quantified relative to one of the deuterated internal standards, under the same chromatographic conditions as the target compounds. This result is reported as a semi-quantitative value and reported as Tentatively Identified Compounds (TICs). TICs are outside the scope of UKAS accreditation and are not moisture corrected.

Sample Deviations

If a sample is classed as deviated then the associated results may be compromised.

1	**Container with Headspace provided for volatiles analysis**
2	**Incorrect container received**
3	**Deviation from method**
4	**Holding time exceeded before sample received**
5	**Samples exceeded holding time before presevation was performed**
§	**Sampled on date not provided**
♦	**Sample holding time exceeded in laboratory**
@	**Sample holding time exceeded due to sampled on date**
&	**Sample Holding Time exceeded - Late arrival of instructions.**

Asbestos

Identification of Asbestos in Bulk Materials & Soils

The results for identification of asbestos in bulk materials are obtained from supplied bulk materials which have been examined to determine the presence of asbestos fibres using ALS (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining, based on HSG 248 (2005).

The results for identification of asbestos in soils are obtained from a homogenised sub sample which has been examined to determine the presence of asbestos fibres using ALS (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining, based on HSG 248 (2005).

Asbestos Type	Common Name
Chrysotile	White Asbestos
Amosite	Brown Asbestos
Crocidolite	Blue Asbestos
Fibrous Actinolite	-
Fibrous Anthophyllite	-
Fibrous Tremolite	-

Visual Estimation Of Fibre Content

Estimation of fibre content is not permitted as part of our UKAS accredited test other than: - Trace - Where only one or two asbestos fibres were identified.

Further guidance on typical asbestos fibre content of manufactured products can be found in HSG 264.

The identification of asbestos containing materials and soils falls within our schedule of tests for which we hold UKAS accreditation, however opinions, interpretations and all other information contained in the report are outside the scope of UKAS accreditation.