Contaminated Land
Air Quality
Environmental Audit

Partnership No: OC 300776

Heyford Park
Dorchester Living: Phase 10
Development for Residential-led Uses

REMEDIATION STRATEGY

For: Dorchester Living

September 2022

R1742d-R04-v1

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HEYFORD PARK, DORCHESTER PHASE 10

REMEDIATION STRATEGY

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DRAWINGS

1. Introduction

1.1. Dorchester Living (DL) intends to submit a planning application for the residential redevelopment of an area referred to as Phase 10 within the former RAF / USAF Upper Heyford Airbase. The proposed development is understood to consist of 140 dwellings with private gardens and areas of public open space. DL has instructed Smith Grant LLP (SGP) to produce a revised Remediation Strategy for the preparatory works and construction-stage of the development.

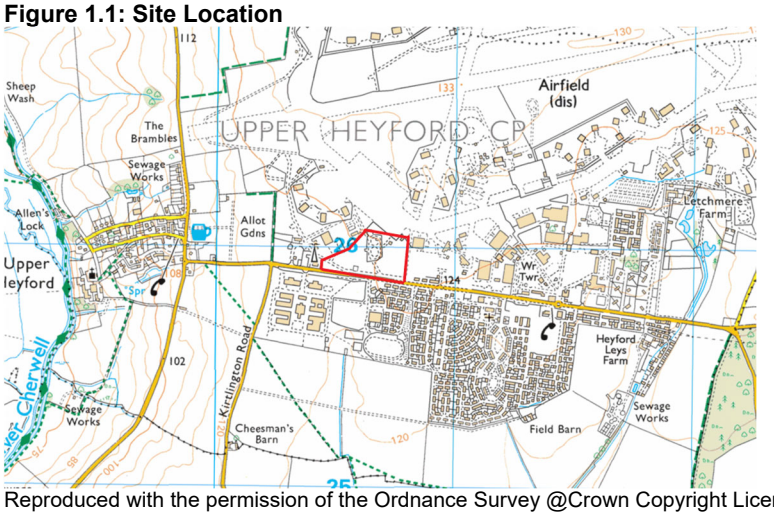
1.2. A Remediation Statement which covers Phase 10 and other development phases has been produced by Hydrock (ref. HPW-HYD-PX-REM-RP-GE-P1-S2; April 2017), however it was decided that a revised Strategy should be produced to align remedial and verification works to the approved SGP Strategy which covered the neighbouring NSA area (R1742-R01-v1; May 2014) under Planning Consent 10/1642/OUT for consistency and to also take into account the supplementary investigation works completed by Jomas in 2022.

1.3. The site currently comprises of the southwestern portion of the former Upper Heyford Airbase, later developed and used by the United States Airforce. Phase 10 is located to the north of Camp Road and is occupied by a series of Petroleum Oil Lubricant (POL) tanks which served the airfield to the north.

Table 1.1: Site details

Address	Upper Heyford, Camp Road, Oxfordshire
National Grid Reference	450640 225957
Local Authority	Cherwell District Council (CDC)
Site Area	51,573m^2
Current Site Use	Open ground with decommissioned POL tanks (POL 2A-2M & POL 21A-21C)
Proposed Use	140 residential dwellings with associated works including infrastructure, landscaping and public open space
Planning Consent	TBC

Figure 1.1: Site Location



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1.4. The assessment methodology in the production of this Remediation Strategy follows the framework described in the EA 'Land Contamination: Risk Management' (LCRM), comprising an options appraisal to evaluate and identify feasible remediation options, specification of appropriate techniques, and an implementation programme and verification plan.

1.5. It is understood that the initial site investigation reporting (ref. HPW-HYD-MS-ZZ-RP-G-0001) and Remediation Method Statement (ref. HPW-HYD-PX-REM-RP-GE-3000-P1-S2) produced by Hydrock in February and April 2017 and the supplementary site investigation conducted by Jomas in 2022 (ref. P4280J2513/SC) have not yet been submitted to CDC. For the purposes of producing this revised Remediation Strategy, it is assumed that the regulators will approve the findings, conclusions and recommendations made within these reports.

1.6. SGP produced a Remediation Strategy which covered the wider NSA area to the immediate east and was based on the findings and assessment of works undertaken by Waterman which covered the NSA, this included devising site-specific remedial targets for hydrocarbon hotspots. Given that similar conditions and potential contamination sources have been identified on Phase 10 with those within the NSA, it is considered appropriate to produce a revised Strategy to bring inline remedial works to be consistent with those of the wider NSA. This is also consistent with the approach adopted for Phase 9, located to the immediate south of the site beyond Camp Road.

2. Information Sources

2.1. Previous reports

2.1.1. The principal sources of information consulted in the preparation of this report include:

Table 2.1: Information Sources

Report	Factual Information
Vertase POL System – Clean and Make Safe, Upper Heyford, Oxfordshire: De-commissioning Method Statement (August 2011) Ref. 1246DOR	Method statement for the decommissioning of the POL system which enters from the south of the site and extends north. Includes a plan showing the route of the POL.
Vertase POL System – Clean and Make Safe, Upper Heyford, Oxfordshire: Contract Completion Report (February 2012) Ref. 1246DOR	Completion information on the decommissioning of the POL system included the confirmed routes of the pipeline network (Appendix B) and detail on the infilling of tanks and pipework
Watermans Controlled Waters Detailed Quantitative Risk Assessment (July 2012) Ref. EED10658-14-1.7_FA	Assessment of groundwater contamination risks across NSA, remediation options, objectives and production and remedial target values.
Smith Grant LLP New Settlement Area – Remediation Strategy (May 2014) Ref. R1742-R01-v3	Revised remedial Strategy to cover NSA superseding the approved Watermans Strategy and adopted verification criteria.
Hydrock Desk Study & Ground Investigation – Western Development, Phase 9, 10, 16 and 16A (February 2017)	Desk Study review comprising site setting and description, historical review, geology and hydrogeology & preliminary conceptual site model. Intrusive investigation consisting of 9 trial-pits to a max depth of 2.9m bgl, 6 cable percussion boreholes with groundwater/gas installations. Collection of 10 soil samples and 6 groundwater samples and 3 rounds of gas monitoring. Revised conceptual site model and outline remedial recommendations.
Hydrock Remediation Method Statement Phases 9, 10, 15, 16 & 16A (April 2017) Ref. HPW-HYD-PX-REM-RP-GE-3000-P1-S2	Remediation Strategy including demolition, enablement and construction phases with supervision, verification and reporting. Report includes areas of identified visual / olfactory contamination (potential hotspots) and reference to remedial criteria for hydrocarbon hotspot remediation.

Jomas Geo-Environmental & Geotechnical Assessment Ground Investigation Report for Phase 10 Ref. P4280J2513/SC	Site investigation covering both the existing area covered by Hydrock and the area to the north following extension of the Phase 10 boundary. Intrusive investigation consisted of 5 window sampler boreholes to 3.8m bgl, 9 rotary boreholes to 8m bgl, 20 trial-pits to 3m bgl and installation of 13 monitoring wells. Collection and submission of soil samples for heavy metals (25), PAHs (30), hydrocarbons (16), asbestos (18), VOCs (13) and PCBs (2). Two rounds of groundwater monitoring from newly installed wells (JBH1-JBH9 & JWS2-JWS3) and existing Hydrock wells BH05 and BH10-BH14) with samples submitted for heavy metals, PAHs and hydrocarbons. Three rounds of ground gas monitoring with ground gas risk assessment and generic human health and controlled risk assessment with updated conceptual site model and outline remedial recommendations

2.2. Investigation Coverage

2.2.1. The total of the 48 entries across the site (~51,573 m^2) is roughly equivalent to an average of 1 entry per 1,074m^2 or an approximate 33m grid spacing across the site. Entries from both investigations included targeted entries, specifically around POL21, the decommissioned fuel line and AST / Valve Pit in the south, and non-targeted entries over the remainder of the site to provide good spatial coverage. A limited number of entries targeted within the POL2 area, although entries surrounding this location were undertaken.

2.2.2. The site investigations completed are considered to cumulatively provide a good assessment of ground conditions at the site appropriate to its development history and anticipated ground conditions. On this basis, it is concluded that although localised sources could have been missed and some areas (specifically within the POL2 area) were not included, the investigations have been sufficient to develop an appropriate Remediation Strategy.

2.3. Use of Information in Strategy Development

2.4. The Site Characterisation and Risk Assessment outcomes from the available Information Sources are briefly summarised and used to define appropriate and proportionate Remediation Objectives to allow safe redevelopment for its intended use, remove risks of unacceptable pollution, manage residual risks where these exist and bring in line remedial works to that implemented within the wider NSA. An assessment of viable, and then feasible Remediation Options is provided, the preferred approaches selected and a decision of the techniques to be adopted is arrived at before Implementation and Verification Plans are provided.

3. Site Characterisation, Risk Assessment & Remediation Objectives

3.1. Historical Development and Potentially Contaminative Land Use

3.1.1. A review of the historical development of the site is made within the Hydrock Desk Study and Ground Investigation Report (ref. HPW-HYD-MS-ZZ-RP-G-0001) and Jomas Site Investigation Report (ref. P4280J2513). The site was occupied by agricultural farmland (1875-1880) until 1916-1918 when the Upper Heyford airbase was constructed and used by the Royal Flying Corps (later merging with the Royal Naval Air Service in 1918 to become the Royal Air Force). The Royal Air Force (RAF) took over control of the airbase until 1950 when the United States Air Force took over the site until its closure in 1994.

3.1.2. Limited historical mapping coverage was available due to national security of the site, however mapping from 1974-75 shows tanks present in the south, it is understood that these relate to the existing brick structure present today which are referred to by Jomas as ASTs. Mapping from 2002 shows the raised mounds associated with POL2 and POL21 although it is considered these features were present from a much earlier date but were omitted from mapping for reasons of security. The site has undergone little change with the POL tanks remaining to the present day, however they have been subject to decommissioning works.

3.1.3. Details of the POL tanks are provided within the Vertase reporting which confirms that the POL is the collective term for all tanks and pipework and associated infrastructure which have a unique reference number as to whether they are above ground storage tanks (AST) or underground storage tanks (USTs). The POL system was a supply pipe present on the Upper Heyford Flying Field and consisted of above and below ground infrastructure of pipework, pumps, valves and storage tanks to transport aviation fuel around the airbase. The POL system was previously connected to the National Fuel Pipeline (NFP) which entered the site in the south and transported fuel across the Airfield into a number of tanks (POLs).

3.1.4. There are two POLs located on the site which are all underground tanks; POL2 in the centre which is a collection of 12 tanks (referred to as POL 2A – POL 2L) and POL21 a cluster of 3 tanks (POL 21A – POL 21C) in the south / southeast. A summary of information on the POLs is presented below:

Table 3.1 Summary of Phase 10 POL

POL	Tanks	Volume (m^3)
POL2 (Type 4)	POL2 – 2A	188
	POL2 – 2B	188
	POL2 – 2C	188
	POL2 – 2D	188
	POL2 – 2E	188

	POL2 – 2F	188
	POL2 – 2G	188
	POL2 – 2H	188
	POL2 – 2I	188
	POL2 – 2J	188
	POL2 – 2K	188
	POL2 – 2L	188
POL21 (Type 1)	POL21 – 21A	736
	POL21 – 21B	736
	POLD21 – 21C	1,453

3.1.5. The fuel pipeline which supplied the POLs is present across the site, initially entering from the southern boundary before forming a "T-junction" with one line extending west and the other continuing east to POL2 and POL21 before continuing off-site to the north and northeast. The point in which the pipe becomes a "T-Junction" is mapped as a tank, however Vertase refer to this as a valve pit, reference as a AST / Valve Pit is made throughout this report to this feature. The approximate route of the pipeline and the location of the POL is presented in Drawing D02.

Figure 1. Phase 10 photos from Hydrock Ground Investigation Report

Photos of Tanks on southern boundary where fuel pipeline entered the site and formed a "T-junction"

POL21 within earth embankment

POL Decommissioning Works (Vertase)

3.1.6. Decommissioning works of the POL system, including the fuel pipeline, were undertaken by Vertase as documented in their De-commissioning Method Statement (ref 1246DOR). Following the disconnection of the POL system from the National Fuel Pipeline (NFP) the fuel pipe across the site was emptied, foam filled and cut in several locations but remains in the ground. Decommissioning works of the POL tanks and pipes are summarised by Vertase as follows:

- *Removal of any product and water*
- *Remove residual water, product and sludge from the bottom of the tank*
- *Clean the tank as necessary of residual fuel with contaminated washings sent to the on-site water treatment plant*
- *Undertake final inspection of tanks and confirm gas free status*

3.1.7. Following the decommissioning works the tanks were infilled with a Pulverised Fuel Ash (PVA) / Ordinary Portland Cement (OPC) mix. The levelling of filling was dependent on the category of tank. Type 1 tanks (POL21) were partially filled whilst all remaining tanks were fully filled. The decommissioning process was also subject to verification testing and monitoring undertaken by Watermans, which included the installation of monitoring of groundwater boreholes around the POLs, however a copy of any report relating to this monitoring has not been made available for review.

3.1.8. Release of fuels associated with the POL system including fuel pipeline may have historically occurred particularly if failure of the integrity of the tanks and / or pipeline historically occurred. The Groundsure Report provided within the Hydrock report did not identify any pollution incidents within Phase 10.

3.2. Present Land Condition

3.2.1. Descriptions are based on observations made within the reviewed reports and examination of more recent mapping and aerial photographs.

Table 3.1: Land Condition Summary

Site Description	The site currently comprises of four distinct areas which are summarised as follows: Northeast: Open landscaped area with grass cover Southeast: Raised landscaped mounds which house POL21. Mounds raise to approximately 8.21m above ground level (according to Vertase records) North: Roadway in a figure of eight with two islands housing POL2 West: open landscapes area with grass cover and small wooded area. Brick structure (AST / Valve Pit) along the southern boundary, historically mapped as tanks at the point in which the former fuel pipeline entered the site.
Access	The site is currently accessed off Camp Road to the west and through a gated security entrance
Boundaries/Adjoining Land Uses	**North:** open boundary onto airfield **East:** existing residential development (Bovis Phase 3) **South:** Chain-linked fence and hedgerow onto Camp Road **West:** open boundary onto former airfield with buildings used for commercial use
Services / Wayleaves	Service information has not been obtained as part of this report; however, it is considered likely that services are present which may include electric around the former POLs. A decommissioned fuel pipeline which traverses the site (see Drawing D02) is present and whilst cleaned and foam filled by Vertase still remains on the site.

	Records obtained from BGS for a trial-pit (TP7) in the northeast of the site excavated in 1989 recorded that a disused asbestos water main was encountered at a depth of 0.8m bgl. The orientation and extent of this is unknown. In a separate trial-pit log from this general area of the site (TP8) a cable was encountered and damaged at a depth of 0.75m bgl). A metal pipe was encountered at 0.9m in TP6, it is assumed that this relates to the fuel pipeline which is located in this part of the site.
Surfaces / Vegetation / Structures	The site is mainly covered by grass with exception of the area around POL2 where hardstanding is present. POL21 is located beneath a vegetated earth mound, the depth of soil cover over this area is unknown.

3.2.2. There are no landfills or COMAH registered sites within 250m of the site. The site is not located within an area which could be impacted by Coal Mining Areas and is not within an area affected by Radon areas with the potential to impact the site.

3.3. Geology

3.3.1. Ground conditions reported during the investigations were consistent with the mapped geology and developed history of the site, as summarised below.

Made Ground

3.3.2. Made ground was reported within all of the Hydrock entries and typically consisted of a firm gravelly sandy clay with frequent rootlets. Gravel was fine to coarse subrounded to subangular limestone. Anthropogenic inclusions were limited to brick (TP127, TP128, TP129) and plastic (TP128) only. No inclusions of ash, clinker, slag or organic soils were reported.

3.3.3. Jomas reported made ground within 18 entries (JWS1-JWS5, JBH1, JBH3, JBH4, JBH7, JTP1, JTP5, JTP7, JTP8, JTP14, JTP16, STP1, JSTP2 and JSTP2A) consisting of a clayey gravely sandy with gravel of coarse angular limestone. Inclusions of asphalt, brick with occasional concrete and flint, and rare glass timber and ceramic fragments. Neither site investigation reported the presence of ash, clinker, slag or organic soils.

3.3.4. Depths of made ground ranged between 0.1m (Hydrock TP109) to a maximum of 1.9m bgl (Jomas JSTP2). Nominally the thickness of made ground was <0.5m thick, however deeper deposits >1m were reported within TP131 (1.2m), JBH4 (1.2m), JBH7 (1m), JTP1 (1.6m), JTP5 (1.1m), JTP7 (1.6m), JTP14 (1.5m), JTP16 (1.6m), JSTP1 (1.5m), JSTP2A (1.7m), JSTP2 (1.9m).

3.3.5. The ground conditions are consistent with those encountered across the wider Heyford Park development with a surface layer of reworked natural strata with occasional inclusions of red brick although deeper deposits (i.e., >1m) have been recorded within Phase 10 compared to elsewhere. This may be associated with historical works to excavate the fuel pipelines and POLs.

Topsoil

3.3.6. Topsoil was not recorded within the Hydrock entries, however given the grass cover across the majority of the site, it is considered likely that the reported made ground (0.1 – 0.3m) which was recorded as a gravelly sandy clay most probably relates to topsoil.

3.3.7. Jomas differentiated between the topsoil and made ground and reported topsoil in 17 entries, describing it as a dark brown clayey gravelly sand with angular to sub-angular limestone. Entries and the thickness of topsoil reported are as follows: JBH2 (0.4m), JBH5 (0.1m), JBH6 (0.1m), JBH8 (0.2m), JBH9 (0.1m), JTP2 (0.4m), JTP3 (0.4m), JTP5 (0.1m), JTP6 (0.6m), JTP8 (0.2m), JTP10 (0.6m), JTP11 (0.3m), JTP12 (0.5m), JTP13 (0.2m), JTP15 (0.5m), JSTP3 (0.3m), JSTP4 (0.3m).

Natural Strata

3.3.8. Natural strata were encountered within all entries directly below made ground and/or topsoil consisting of a subangular to angular limestone gravel (weathered Great Oolite Group bedrock) with bands of a sandy gravelly clay.

3.3.9. Penetration of the limestone bedrock within trial-pits was not possible and resulted in refusal in all instances. Boreholes drilled by rotary methods (Hydrock: BH05, BH10-BH13 and Jomas: JBH1-JBH9) extended into the limestone to a maximum depth of 8m bgl. Clay was reported beneath the limestone within BH05 (6.6-8.0m bgl).

3.3.10. Sand / sandstone was recorded by the drillers (Hydrock entries only) in BH10 beneath a layer a gravel and above limestone within BH10 (1.2-5.40m bgl), BH11 (0.7-5.30m bgl), BH12 (0.8-5.0m bgl), within BH13 the sand / sandstone was located between two horizons of limestone at 3.4-6.0m bgl.

3.3.11. The depth at which competent bedrock was encountered (either within borehole logs or at the point in which trial-pit refusal occurred) ranged between 0.7m in BH11 to 2.90m in TP109.

3.4. Hydrogeology and Hydrology

3.4.1. The Great Oolite Group is classed as a Principal Aquifer which is described as ‘geology with a high intergranular and/or fracture permeability, usually providing a high level of water storage and may support water supply/river baseflow on a strategic scale’. The site is not located within a Source Protection Zone.

3.4.2. Groundwater during the Hydrock intrusive investigation was limited to a moderate groundwater flow within TP109 at a depth of 2.6m bgl. A summary of the depth to groundwater during monitoring works is produced within the Jomas report (Table 4.3) which encountered groundwater from 1.12m bgl (JWS2) to 5.02m bgl (JBH6 and JBH13).

3.4.3. Gallos Brook, a tertiary river is present to the immediate south beyond Camp Road and within the Phase 9 development area. Historical mapping shows this as a surface watercourse, however more recent mapping shows the watercourse no longer present suggesting it has been culverted. Historical mapping does not show that the watercourse extended onto the site, and it is assumed the source is a spring located along Camp Road.

3.4.4. Groundwater movement beneath the site is likely to be significant with groundwater flow direction as confirmed by Watermans (ref. EED10658-109-R-14.1.7.FA) to the southeast. Waterman's, who undertook a detailed assessment on the site hydrogeology, report that the NSA can be described as a two-aquifer system separated by a mudstone/siltstone layer of significantly lower permeability although there is evidence of some leakage between the aquifers.

3.4.5. Site drainage is considered to predominantly be infiltration and sub-surface flow within the bedrock aquifer within areas absent from hardstanding. Waterman's report that the NSA is drained by Gallos Brook which ultimately discharges into the river Cherwell. Monitoring undertaken by Waterman in Gallos Brook (June 2011 – August 2011) recorded TPH concentrations between <0.01 and 0.03 mg/l.

3.5. Soil Contamination

3.5.1. Visual or olfactory evidence of contamination during the site investigations as reported within the logs is as follows:

Hydrock

- TP109 – Slight hydrocarbon odour and sheen observed within groundwater ingress into the trial-pit

Jomas

- JBH4 – Black staining with hydrocarbon odour reported in cohesive deposits of weathered bedrock at 1.2-2.0m bgl
- JTP10 – Black staining with hydrocarbon odour reported in granular deposits of weathered bedrock at 1.5-1.7m bgl. Groundwater seepage at 2m did not display visual / olfactory evidence of contamination
- JSTP1 – Black staining with slight hydrocarbon odour reported within the made ground at 1.4-1.5m bgl
- JSTP2 – Black staining with no odours within made ground at 0.9-1.1m bgl

3.5.2. BGS trial-pits logs which have been reviewed for an investigation in 1989 in the northeast of the site have also been reviewed. Whilst no visual or olfactory evidence of contamination were reported, an asbestos pipe in TP7 at 0.8m bgl.

3.5.3. No waste materials have been reported as being present within the shallow ground, similarly no inclusions of significant degradable organic material have been encountered.

3.5.4. A comprehensive testing suite has been completed on the soil present which is appropriate for the site characterisation. No significant exceedances were reported when compared to Generic Assessment Criteria (GACs) for a residential land use (with plant uptake) with the following exceedances reported:

PAHs

3.5.5. Low-level exceedances of the GACs were reported for PAHs within TP128 (0.1m bgl), JWS1 (0.1m bgl), JBH2 (0.25m bgl), JBH3 (0.25m bgl) and JTP8 (0.5m bgl). Exceedances were limited shallow soils and whilst no discussion is made on the probable source of the PAHs, it is most likely to be attributed to the minor inclusions of asphalt which have been recorded.

Hydrocarbons

3.5.6. Hydrocarbon exceedances were limited to 2 locations, JBH3 (0.25m bgl) and JBH4 (1.5m bgl) with exceedances of the Aromatic C16-C21 and Aromatic C21-C35 fractions. Exceedances were minor with a maximum concentration of 880 mg/kg for the C16-C21 fraction compared to the GAC of 260 mg/kg and 1,300 mg/kg for the C21-C35 fraction with a GAC of 1,100 mg/kg.

Asbestos

3.5.7. Incidences of asbestos were limited to a single location, JTP8 at 0.5m bgl within the made ground where loose fibres of chrysotile and amosite were reported. Following identification, quantification was undertaken which confirmed a fibre mass below detection limits (<0.001%).

3.5.8. Concentrations of heavy metals, VOCs and PCBs were present below their respective GACs in all instances with VOCs and PCBs reported below analytical detection limits.

3.5.9. The findings are consistent with those reported within the wider NSA to the east and Phase 9 to the south, particularly regarding the occasional minor elevated PAHs within made ground soils where anthropogenic inclusions generally appear absent or limited. Previous minor PAH exceedances have been attributed to inclusions of overlying / nearby hardstanding resulting in some cross-contamination during sampling which has been confirmed using source-identification (ratio cross-plot) techniques.

3.5.10. Entries targeted the surrounding area of POL21 with no impacted soils encountered although due to the extent of the overlaying mounds and it is acknowledged that impacted soils directly around the tanks could exist. Similarly, entries around POL2 were limited and there is potential for impacted soils within this location.

3.5.11. A large number of entries were present around the fuel pipeline, particularly within the Jomas investigation which did not encounter impacted ground, however multiple pipelines cross the site

and the presence of locally impacted soils associated with the decommissioned fuel line cannot be ruled out.

3.5.12. Two locations reported elevated TPHCWG concentrations, one (JBH4) was adjacent to the ASTs / Valve Pit along the southern boundary whilst the other (JBH3) located in the east was not near to the POLs or fuel pipeline with no obvious source identified with Jomas concluding this was most likely attributed to the presence of asphalt fragments.

3.6. Groundwater Contamination

3.6.1. Groundwater samples were collected by Hydrock during a single round of monitoring within boreholes BH05, BH10, BH11, BH12, BH13 and BH14). Minor exceedances of heavy metals (copper, manganese, nickel and zinc), however these were not indicative of any pollution risk.

3.6.2. Hydrocarbons were below detection limits within BH13, whilst elevated concentrations were reported within the remaining boreholes. A summary of the maximum concentrations is as follows:

- BH05: Ali C12-C16 – 1,600 µg/l
- BH10: Ali C8-C10 – 3,800 µg/l
- BH11: Ali C12-C16 – 790 µg/l
- BH12: Ali C12-C16 – 1,800 µg/l and Aro C10-C12 & C12-C16: 1,600 µg/l
- BH14: Ali C12-C16 – 1,500 µg/l

3.6.3. Concentrations of VOCs and SVOCs (excluding PAHs) were below analytical detection limits within all samples except for BH12 which recorded the presence of:

- Isopropylbenzene (27.8 µg/l)
- N-propylbenzene (27.8 µg/l)
- 1,3,5 – trimethylbenzene (33.4 µg/l)
- 1,2,4,-trimethylbenzene (86.5 µg/l)
- Sec-butylbenzene (22.1 µg/l)
- 2-methylnaphthalene (37 µg/l)

3.6.4. Jomas carried out two rounds of monitoring within both their newly installed wells (JBH1-JBH9 and JWS2-JWS3) and within the existing Hydrock wells (BH05 and BH10-BH14). Minor exceedances of heavy metals (copper and to a lesser extent lead and nickel) were reported which is consistent with that reported by Hydrock. Exceedances of total cyanide were also reported within JBH7, JBH8, JBH9 and BH11, however further assessment undertaken by Jomas concluded there was no risk from the reported copper and cyanide concentrations within the groundwater.

3.6.5. Hydrocarbon concentrations reported above the WHO drinking water guideline values were reported as follows:

- JBH6 – Ali C10-C12 – 730 µg/l
  Ali C12-C16 – 580 µg/
  Aro C10-C12 – 390 µg/l and 390 µg/l
  Aro C12-C16 – 350 µg/l and 190 µg/l

- JBH4 - Aro C10-C12 – 210 µg/l and 200 µg/l
  Aro C12-C16 – 200 µg/l and 280 µg/l

- BH10 - Aro C10-C12 – 140 µg/l and 96 µg/l
  Aro C12-C16 – 120 µg/l and 93 µg/l

3.6.6. JBH6 and JBH4 are located either side of POL21 whilst JBH4 is adjacent to the ASTs on the southern boundary. Exceedances were generally minor when compared to the WHO drinking water limits and were highly localised with elevated concentrations not reported within downgradient boreholes. It is also observed that hydrocarbon concentrations within BH10 have substantially decreased since the original Hydrock reporting (Ali C8-C10 – 3,800 µg/l) compared to that by Jomas (Ali C8-C10) where concentrations were below detection limits (<1 µg/l). Jomas concluded that locations where hydrocarbon exceedances were reported were highly localised with no evidence of off-site migration of impacted groundwater.

3.6.7. Samples were also submitted for VOC analysis by Jomas with concentrations reported below analytical detection limits.

3.6.8. Hydrock's assessment concluded that the recorded groundwater contamination on Phase 10 does not represent a significant risk of pollution to the groundwater beneath the site but that existing fuel stores (tanks / pipelines) and impacted soils should be removed which again is in line with the recommendations outlined by Watermans and the approved remedial approach adopted within the wider NSA. This is in agreement with the overall conclusion made by Jomas.

3.7. Ground Gas Contamination

3.7.1. No significant sources of hazardous ground gas have been identified on the site or surrounding area with no significant depths of made ground soils encountered and so Hydrock undertook 3 rounds of gas monitoring. Jomas also undertook 3 rounds of monitoring both within the existing Hydrock boreholes but also their newly installed wells.

3.7.2. Low-level methane (<1%) was generally recorded with Hydrock reporting concentrations below the gas analyser's detection limit (<0.01% v/v) whilst Jomas typically recorded concentrations 0.0-

<0.3% v/v. Two boreholes over the total monitoring period recorded methane above 1%, Hydrock within BH10 between 1.5-1.7% v/v and Jomas in JBH4 (1.2-1.5% v/v).

3.7.3. Elevated concentrations of carbon dioxide (i.e., >5%) were limited to Jomas entries JBH3 (4.1-5.7% v/v), JBH4 (1.6-9.3% v/v), JBH7 (6.8-7.9% v/v) and BH05 (3.1-7.3% v/v). No significantly elevated peak flows were recorded with Jomas reporting a maximum peak flow of 0.2-0.3 l/hr.

3.7.4. Jomas concluded that based on the calculated GSVs and in consideration of the conceptual site model, the site is classified as Characteristic Situation 1 (CS1) and that no formal gas protection measures are considered necessary.

3.7.5. Screening of the well headspace with a PID to detect the presence of VOCs recorded some elevated readings. Locations where this exceeded 50 ppm were JWS5 (75 ppm), JBH2 (65 ppm), JBH3 (166 ppm), JBH4 (565 ppm), JBH6 (264 ppm), BH10 (73 ppm) and BH13 (112 ppm).

3.7.6. As part of the vapour risk assessment, Jomas compared groundwater hydrocarbon concentrations to the SoBRA GAC_{gwvap}[1] concentrations to assess whether hydrocarbon concentrations within the groundwater could pose a risk from vapour generation and migration into future dwellings. A single exceedance was reported for the Aliphatic C10-C12 hydrocarbons within JBH6 with a concentration of 730 µg/l compared to the criterion of 37 µg/l.

3.7.7. The assessment concluded that a widespread vapour risk is therefore considered unlikely to be present across the site but a localised risk around JBH6 cannot be ruled out. Recommendations were made for further investigation around JBH6, and vapour protection measures may be considered necessary within the vicinity of JBH6 depending on the outcome of further assessment. The assessment largely focussed on vapour risks from groundwater concentrations and did not take into account the elevated PID readings recorded within boreholes.

3.8. Risk Assessment

3.8.1. The potential contamination sources identified during the investigations which could impose constraints on the proposed redevelopment of the site for residential uses are:

- Possible Asbestos pipe in the northeast of the site (BGS TP7 – 0.8m bgl)
- Decommissioned fuel tanks and pipework associated with POL2 and POL21 where there is potential for residual hydrocarbon impacted soils associated with historical leaks and spills
- Decommissioned POL pipeline which crosses the site from west to north-east where there is potential for residual hydrocarbon impacted soils associated with historical leaks and spills (non-identified to date)
- AST / Valve Pit along the southern boundary where elevated TPHCWG within the soils have been reported within JBH4

[1] Society of Brownfield Risk Assessment (SoBRA). Development of Generic Assessment Criteria for Assessing Vapour Risks to Human Health from Volatile Contaminants in Groundwater (February 2017).

- Occasional PAH exceedances within the made ground soils and trace asbestos fibres (JTP8 only)
- Potential vapour migration risk from areas of former fuel storage / transmission where leaks / spills have occurred and from localised impacted groundwater within JBH6.

3.8.2. The potential risks identified will be managed to break potential pollution linkages and allow development of the site for residential use without harm to human health and the environment. Each of the potential contaminant linkages identified in the Waterman conceptual site model and risk assessment (Waterman Controlled Waters DQRA, ref. EED10658-R-109_14.1.7_FA, May 2012 and Preliminary Generic Quantitative Environmental Risk Assessment, ref. EED10658-R-13.2.2_FA, May 2012), Hydrock Desk Study and Ground Investigation, ref. HPW-HYD-MS-ZZ-RP-G-0001, February 2017) and Jomas Geo-Environmental and Geotechnical Assessment (Ground Investigation) Report (ref. P4280J2513/SC) will be addressed for the Remediation Strategy to be considered appropriate for the site and to allow construction to commence.

3.8.3. Concentrations of contaminants were compared to current assessment criteria derived for the protection of human health; initial screening levels were adopted from published generic assessment criteria for a residential land use. The exceedances of soils were limited to 5 minor localised exceedances of PAHs and 2 localised exceedances of heavy-end hydrocarbons, all exceedances have been attributed to the minor inclusions of asphalt within the made ground. Trace asbestos fibres have been reported within the made ground within a single location, however this may be associated with background levels rather than impacted soils. A historical BGS log has recorded the presence of an asbestos water pipe in the northeast. It is uncertain whether this is still present and further investigation works during the preparatory works will be required to ascertain its presence and if identified its removal.

3.8.4. Generally, descriptions of made ground consist of natural reworked soils with inclusions of brick and occasional asphalt fragments which overall make a very small proportion of the soils. No inclusions of ash, clinker or slag have been reported and the description of made ground is typical to that within the wider Heyford Development site. Given the absence of significant anthropogenic inclusions and generally localised minor exceedances, retention of reworked natural made round soils for retention in garden areas may be acceptable providing further testing demonstrates compliance with residential soils. Similarly, if localised exceedances are reported then recommendations for a garden cover system will be made. This approach would be in line with that adopted under the approved Strategy for the NSA to the east and the Phase 9 area to the south where formation testing of soils has been carried out to determine compliance.

3.8.5. The other exposure pathway with the potential to affect human health is the volatilisation, migration and indoor inhalation of volatile hydrocarbons associated with historical fuel spills or leaks (if present) associated with USTs, ASTs / valve pit, pipelines and identified hotspots. Additional assessments will be undertaken during tanks, pipeline and hotspot investigation/remediation to

confirm whether this pathway requires source remediation and/or building vapour protection. Jomas has reported the presence of hydrocarbon concentrations within the groundwater at JBH6 in excess of $GAC_{gwvap,}$ and also reported elevated PID readings within boreholes across the site.

3.8.6. The risk from migration of other hazardous soil gasses (methane and carbon dioxide) appears to be generally low following further assessment undertaken by Jomas with the main risk associated with vapour generation / migration where such fuel hotspots exist.

3.8.7. On-site groundwater impacts are not considered to be significant on the monitoring evidence. Hydrocarbon exceedances within the groundwater appear to be highly localised and were limited to 3 boreholes during the most recent monitoring by Jomas, however no exceedances were reported within downgradient wells which suggest highly localised impacted areas. The USTs (POL2 and POL21), fuel pipeline and valve-pit (referred by Jomas as ASTs) have been subject to decommissioning through emptying and full or partial filling and verification reporting by Vertase and so significant fuel reservoirs are unlikely to exist, however the potential for localised fuel impacted soils at the base and sides of the tanks / pipeline and valve pits is possible and care should be undertaken during the removal of such infrastructure to confirm this.

3.8.8. The Remediation Strategy assumes controlled demolition of all buildings (which are limited to POL2 and POL21) preceded by appropriate asbestos surveys and stripping by specialist contractors. Vertase reported that during tank access works, most tank lids were sealed with either a cork or asbestos gasket and where asbestos gaskets were present and required removal to facilitate the works they were removed under controlled conditions by suitably qualified persons. There is potential that asbestos gaskets which did not require removal to gain access may remain, these should be surveyed and removed by a specialist contractor prior to demolition works taking place. Similarly, historical records refer to the presence of an asbestos water pipe in the northeast (BGS TP7). Further investigation works will be required to ascertain if the pipe remains and if identified it will be subject to removal by a specialist contractor. The removal of ACM will be fully contained and monitored and be subject to completion on a contractors Method Statement; thus, remediation works only need to consider the methods of handling and monitoring retained hard materials that are to be recovered for use as aggregates within the work.

3.8.9. The Remediation works will also prepare the site for the proposed redevelopment. This entails modifying ground levels, improvement of the engineering properties of the ground by removing obstructions to foundations and services, and removal or treatment of deleterious materials, provision of supporting structures and suitable founding surfaces for infrastructure.

3.8.10. An assessment of the ground conditions, to determine their potential to impact concrete has been carried out by Jomas and recommended a classification of Design Sulphate DS-1 and Aggressive Chemical Environments for Concrete of AC-1.

3.8.11. A water pipeline risk assessment (PRAS) has not been undertaken to date, however Jomas have provided a preliminary screening for water pipe materials based on total VOC, BTEX, phenols and hydrocarbon concentrations by comparing to the PE thresholds. They reported 3 exceedances of hydrocarbons above PE thresholds at JBH3, JBH4 and JTP8 and recommended possible solutions including diversion of pipes, localised remediation and embedding the pipe in a sufficient thickness of clean granular material.

3.9. Conceptual Site Model

3.9.1. The conceptual site model is summarised below:

Table 3.2: Summary of Pollutant Linkages under development and residential use

receptors	pathways	contaminant sources
Human health (future residents) (transient risks to construction workers addressed under HSWA 1974 / COSSH)	Consumption of contaminated vegetables	Occasional elevated hydrocarbons and PAHs within made ground soils. Potential for naturally elevated concentrations of arsenic and vanadium associated with bedrock deposits. Possible localised hydrocarbon contamination associated with POL2, POL21, AST / Valve-Pit and decommissioned fuel pipeline. Hydrocarbon indicators (visual/olfactory) reported in JBH4, JTP10, JSTP1 and JSTP2. Possible asbestos water pipe in the northeast
	Soil and dust ingestion	
	Inhalation of dust	
	Dermal uptake	
	Vapour ingress into buildings from hydrocarbon hotspots	Hydrocarbon indicators (visual/olfactory) reported in JBH4, JTP10, JSTP1 and JSTP2. Potential localised hydrocarbon contamination associated with POL2, POL21, AST / Valve-Pit and decommission fuel pipe. Localised impacted groundwater with JBH6. Elevated PID readings in JBH2, JB3, JBH4, JBH6, JWS5, BH10 and BH13.
Built development (and by extension future residents)	Contact with aggressive soil or groundwater	Recommendation for concrete classification has been made, potential requirement for the use of barrier pipe due to the reported presence of elevated organic contaminants which could permeate water supply pipes.
	Ingress of hazardous ground gas into poorly ventilated spaces and build up to harmful or flammable concentrations	No sources of ground gas have been identified. Total of 6 rounds of gas monitoring have been undertaken. Slightly elevated methane (>1%) reported in 2 boreholes and carbon dioxide (>5%) in 4 boreholes. Further assessment

		concluded classification of the site as CIRIA CS1.
	Ingress of vapours into poorly ventilated spaces and build up to harmful or flammable concentrations	Hydrocarbon indicators (visual/olfactory) reported in JBH4, JTP10, JSTP1 and JSTP2. Potential localised hydrocarbon contamination associated with POL2, POL21, AST / Valve-Pit and decommission fuel pipe. Localised impacted groundwater with JBH6. Elevated PID readings in JBH2, JB3, JBH4, JBH6, JWS5, BH10 and BH13.
Controlled waters	Migration via permeable stratum or preferential flow pathways to nearby surface watercourse. Underlying bedrock aquifer a Principal Aquifer although no groundwater abstractions reported within 1km.	Localised hydrocarbon groundwater reported; however, contamination does not present in downgradient wells suggesting limited impact. POLs, AST / valve-pit and fuel line have been decommissioned with fuel removal and partial infilling so on-going fuel sources unlikely to be present. Potential for localised impacted soils at both features.

3.10. Remediation Objectives

3.10.1. The key remediation objectives are to:

- Create a significant betterment of the groundwater environment thereby protecting groundwater quality at and beyond the site boundary;
- Remove / remediate significant pollution sources such as hydrocarbon hotspots, if present, that pose a risk to man and the environment, to the extent feasible;
- Break significant or potentially significant future pollutant linkages resulting from the change of land use, in particular related to shallow garden soils and human exposure;
- Respond appropriately to contingencies in particularly the discovery of previously undisclosed contamination;
- Remove development constraints and prepare the site physically to enable residential development with associated infrastructure;
- Manage all emissions to air and water to protect surface waters and groundwater and the atmosphere during the remediation works;
- Provide appropriate additional protection measures where necessary, to be implemented during construction, including building gas barriers, water mains protection and garden / open space soil quality and thickness.

3.10.2. The potential risks identified will be managed to break any potential pollution linkages and allow development of the site for its intended residential use without harm to human health, property and the environment. Each of the potential contaminant linkages identified in the Jomas site conceptual model and risk assessment (Ground Investigation Report, ref. P4280J2513/SC) and Watermans

conceptual site model (Waterman "Controlled Waters Detailed Quantitative Risk Assessment", ref: EED10658-R-109_14.1.7_FA, July 2012; and "Preliminary Generic Quantitative Environmental Risk Assessment", ref: EED10658-R-13.2.2_FA, May 2012) will be addressed for the Remediation Strategy to be considered appropriate for the site and to allow construction to commence.

3.10.3. During the remediation works various contaminated materials may be exposed. Therefore, mitigation to prevent exposure of site workers, and site visitors to harmful or nuisance substance is a requirement of the Remediation Strategy. Similarly, the works must not cause pollution of water by discharge of silt or other materials to the surface water or groundwater receptors linked to the site.

3.10.4. Risks to human health associated with potential contamination by asbestos, metals, PAHs and non-volatile hydrocarbons can be managed by isolation of affected soils from future residents and, to a lesser extent, maintenance workers (whose exposure is likely to be limited). It is assumed that these substances could be present in the made ground across the site. Natural undisturbed soils are likely to be exposed following the removal of surface hardstanding / structures; other areas will be covered by permanent hardstanding or buildings to provide physical isolation of any residual contamination. Specific measures to isolate human from direct exposure to such contaminated is only required in areas where gardens or soft landscaping is proposed and where significant levels of contamination are present.

3.10.5. The other exposure pathway with the potential to affect human health is the volatilisation migration and indoor inhalation of volatile hydrocarbons associated with historical fuel spills or leaks (if present) and localised impacted groundwater; additional assessments through soils sampling will be undertaken during tank and pipeline with post-remediation vapour monitoring to assess whether installation of vapour protection measures is required.

3.10.6. The risk from migration of other hazardous soil gasses (methane and carbon dioxide) appears to be low following further assessment undertaken by Jomas with no off-site sources identified and the only one site source being associated with the degradation of hydrocarbons.

3.10.7. The potential for exposure of concrete to aggressive ground conditions and water supply pipes to damaging substances is considered to be low, however localised areas of hydrocarbon impacted soils above PE thresholds have been reported and further locations may exist. Remedial works to remove fuel impacted soils down to bedrock will form a remedial requirement and so the requirement for protective water supply pipes may be required and may be subject to further assessment during or following remediation works.

3.10.8. Off-site groundwater impacts are not considered to be significant on present monitoring evidence and the monitoring data does not suggest there is significantly impacted groundwater beneath the site with monitoring taken around all of the identified former fuel storage areas. Localised impacted groundwater has been reported; however, such concentrations are not repeated within

downgradient wells. Comparison of monitoring data undertaken by Hydrock and more recently by Jomas in the same wells have demonstrated a significant reduction in concentrations suggesting degradation of fuel concentrations is on-going. The former fuel pipeline, POLs and AST / valve-pit have been subject to decommissioning works and infilling by Vertase and so it is not considered to support a reservoir of fuel. As a priority, works associated with tank and pipework removal must not cause the release of any polluting substances to controlled waters, either via sub-surface or overland flows.

3.10.9. The Remediation Strategy assumes controlled demolition of all structures (limited to the POLs) preceded by appropriate asbestos surveys and stripping by specialist contractors. These workers will be fully contained and monitored; thus, remediation works only need to consider the methods of handing and monitoring retained hard materials that are to be recovered for use as aggregate within the works.

3.10.10. The Remediation works will also prepare the site for the proposed redevelopment. These entails modifying ground levels, improvement of the engineering properties of the ground by removing obstructions to foundations and services, and removal or treatment of deleterious materials, provision of supporting structures and suitable founding surfaces for infrastructure.

3.10.11. A watching brief should be maintained during all the required preparatory earthworks and excavations for uncharacterised sources of contamination. However, there are specific requirements in relation to enquiries regarding existing POLs, AST / valve-pit and fuel pipelines and scheduled inspections of local ground conditions to confirm the absence of associated contamination or deleterious conditions, and to delineate for removal if these are encountered.

3.11. Remediation Criteria

Shallow Soils & Site-Won Material

3.11.1. Remediation Criteria are site specific objectives and that have been determined through quantitative or qualitative risk assessment. The Risk Assessment completed by Hydrock and Jomas has relied on the use of Generic Assessment Criteria (GACs) for residential land use to compare against concentrations of common industrial and urban contaminants. This is considered a reasonable and proportionate means of assessing the limited risks posed by ground contamination on the site.

3.11.2. The criteria selected are protective of human health when applied to shallow soils in a model residential garden, with sensitive (child) receptors and high exposure frequencies and durations assumed for a conservative approach. While exceedances of the GACs may indicate a significant risk, it is also acceptable to undertake further testing, statistical analysis of the results and / or more

detailed risk assessment in this eventuality. If failures for the residential criteria occur, then the impacted materials could be utilised in less sensitive areas such as Public Open Space (POS).

3.11.3. The criteria will be applied to shallow soils, defined as those which will be in the upper 600mm of garden surfaces following completion of the development, with a shallower depth of 300mm suitable for managed POS areas and landscaping where penetration below the surface layer is less likely and can be controlled. They can be applied to other deeper soils but are unnecessarily conservative for these and would only be used as a screening criterion for this purpose

3.11.4. The Remediation criteria for the site are summarised in the tables below:

Table 3.3 Shallow (Garden) Soils Compliance Criteria

Contaminant	Residential Use Screening criteria (mg/kg unless stated)
Asbestos	**<0.001%** by mass (LOD)
Arsenic**	**37** LQM/CIEH S4UL
Cadmium	**11** LQM/CIEH S4UL
Chromium (total)	**910** LQM/CIEH S4UL
Hexavalent Chromium	**6** LQM/CIEH S4UL
Copper	**2,400** LQM/CIEH S4UL
Lead	**200** (C4SL)
Mercury	**40** LQM/CIEH S4UL
Nickel	**180** LQM/CIEH S4UL
Vanadium**	**410** LQM/CIEH S4UL
Zinc	**3,700** LQM/CIEH S4UL
Naphthalene	**2.3** LQM/CIEH S4UL
Acenaphthylene	**170** LQM/CIEH S4UL
Acenaphthene	**210** LQM/CIEH S4UL
Fluorene	**170** LQM/CIEH S4UL
Phenanthrene	**95** LQM/CIEH S4UL
Fluoranthene	**2400** LQM/CIEH S4UL
Anthracene	**280** LQM/CIEH S4UL
Pyrene	**620** LQM/CIEH S4UL
Benzo(a)anthracene	**7.2** LQM/CIEH S4UL
Chrysene	**15** LQM/CIEH S4UL
Benzo(b)fluoranthene	**2.6** LQM/CIEH S4UL
Benzo(k)fluoranthene	**77** LQM/CIEH S4UL
Benzo(a)pyrene	**2.2** LQM/CIEH S4UL
Indeno(123cd)pyrene	**27** LQM/CIEH S4UL
Dibenzo(ah)anthracene	**0.24** LQM/CIEH S4UL
Benzo(ghi)perylene	**320** LQM/CIEH S4UL
Aliphatic C5-C6	**42** LQM / CIEH S4UL
Aliphatic C6-C8	**100** LQM / CIEH S4UL
Aliphatic C8-C10	**27**LQM / CIEH S4UL
Aliphatic C10-C12	**130**LQM / CIEH S4UL
Aliphatic C12-C16	**1100** LQM / CIEH S4UL
Aliphatic C16-C21	**65,000** LQM / CIEH S4UL
Aliphatic C21-C35	**65,000** LQM / CIEH S4UL

Contaminant	Residential Use Screening criteria (mg/kg unless stated)
Aromatic C5-C6	**70** LQM / CIEH S4UL
Aromatic C6-C8	**130** LQM / CIEH S4UL
Aromatic C8-C10	**34** LQM / CIEH S4UL
Aromatic C10-C12	**74** LQM / CIEH S4UL
Aromatic C12-C16	**140** LQM / CIEH S4UL
Aromatic C16-C21	**260** LQM / CIEH S4UL
Aromatic C21-C35	**1100** LQM / CIEH S4UL
Benzene	**0.08** LQM / CIEH S4UL
Toluene	**130** LQM / CIEH S4UL
Ethyl-benzene	**47** LQM / CIEH S4UL
m/p-xylene	**56** LQM / CIEH S4UL
o-xylene	**60** LQM / CIEH S4UL

S4UL: Generic assessment criteria published by Chartered Institute of Environmental Health and Land Quality Management Ltd S4UL, residential land use scenario;

C4SL: Category 4 Screening Levels published by CL: AIRE 'residential land use with plant uptake'

** Naturally elevated concentrations may be present and could require further risk assessment

Hydrocarbon Hotspots

3.11.5. Site-specific remediation criteria for the verification of hydrocarbon contamination removal designed to be protective of controlled waters outside the site have been produced by Watermans ('Controlled Waters Detailed Quantitative Risk Assessment, ref. EED10658-14.1.7_FA) for the adjacent NSA area (immediate east of the site). This criterion was adopted within remedial works within the main extent of the NSA and Phase 9 area to the south and to be consistent with the remedial approach is to be adopted within Phase 10.

3.11.6. The criteria are organised in two tiers according to the distance of hotspots from the southern / south-eastern (downgradient) boundary of the site.

Table 3.4 Screening Criteria, Hydrocarbon hotspots dependent on distance from the southern / south-eastern site boundary (from Waterman Tables B2 and B3)

Petroleum Hydrocarbon Fraction	Target Concentration 0-250m (mg/kg)	Target Concentration >250m (mg/kg)
Aliphatic C8-C10	80	240
Aliphatic C10-C12	1000	1000
Aliphatic C12-C16	1000	1000
Aliphatic C16-C21	1000	1000
Aliphatic C21-C35	1000	1000
Aromatic C10-C12	7	23
Aromatic C12-C16	120	1000
Aromatic C16-C21	440	1000
Aromatic C21-C35	1000	1000

Soil VOC Vapours

3.11.7. Post-Remediation VOC monitoring is recommended across the site where elevated PID readings have been reported within existing monitoring wells as well as JBH6 where groundwater

concentrations exceeded the $GAC_{gwvoc.}$ Monitoring will be undertaken site-wide on a nominal 50m grid spacing but will target locations of former bulk fuel storage (POLs and AST / Valve-Pit) and locations where elevated vapours have been recorded previously.

3.11.8. The methodology for deriving assessment screening criteria for health impacts from VOCs at the receptor is set out in Appendix 9 of the VOC handbook[2]. Tolerable Daily Soil Intake values or Index Doses (for non-carcinogens and carcinogens respectively) are multiplied by the body weight (13.3 kg) and divided by the inhalation rate (8.8 m^3/day) of a child receptor as defined in the most recent published UK guidance (DEFRA C4SL). Most of the substances under consideration have toxicological inhalation data published in the "LQM/CIEH S4ULs for Human Health Risk Assessment" (S4UL) - *Copyright Land Quality Management Limited reproduced with Permission* or CL:AIRE "Soil Generic Assessment Criteria for Human Health Risk Assessment". The exception is benzene for which an air quality standard is available (5 µg/m^3).

3.11.9. The assessment criteria are highly conservative, as they assume long-term, constant exposure of residents over 24 hr periods, 365 days a year and a continuous source which does not diminish over time, with no attenuation by construction barriers, dispersion, dilution or biodegradation.

3.11.10. The Tier 1 screening criteria are presented in Table 4.5 below. Exceedance of the criteria in soil vapours will trigger the requirement for the installation of VOC protection measures within overlying plots.

Table 3.5. Tier 1 Assessment Criteria for Soil-Vapour Concentrations

Substance	Inhalation Health Critical Value (µg kg^{-1}.bw.day^{-1})	Assessment Criteria (µg m^{-3})
Benzene	1.4 (S4UL)	5
Toluene	1400 (S4UL)	2,116
Ethylbenzene	74.3 (S4UL)	112
m/p-xylene	60 (S4UL)	91
o-xylene	60 (S4UL)	91
Aliphatic Hydrocarbons (C4-C6)	5000 (S4UL)	7,557
Aliphatic Hydrocarbons (C6-C8)	5000 (S4UL)	7,557
Aliphatic Hydrocarbons (C8-C10)	290 (S4UL)	438
Aliphatic Hydrocarbons (C10-C12)	290 (S4UL)	438
Aromatic Hydrocarbons (C5-C7)	1400 (S4UL)	2,116
Aromatic Hydrocarbons (C7-C8)	1400 (S4UL)	2,116
Aromatic Hydrocarbons (C8-C10)	60 (S4UL)	91
Aromatic Hydrocarbons (C10-C12)	60 (S4UL)	91

[2] CIRIA C682: The VOCs Handbook: Investigating, assessing and managing risks from inhalation of VOCs at land affected by contamination 2009

4. Options Appraisal

4.1. Options Appraisal Objectives

4.1.1. The objectives of the Options Appraisal are therefore to determine the most appropriate means of meeting the above Remediation Objectives and Criteria, taking into consideration project and site-specific considerations including:

- Physical site constraints (boundaries, groundwater levels, available space);
- Costs;
- Programme (Duration);
- Sustainability (use of resources);
- Environmental Impact (pollution, nuisance);
- Health and Safety requirements;
- Geotechnical Requirements & Development Design;
- Regulatory controls -Permitting and Waste;

4.1.2. Physical site clearance, demolition and earthworks will be carried out in accordance with the earthworks design specifications and are not considered further. However, the chosen remedial techniques must not impede the works to physically prepare the site or unduly compromise the stability of the ground in respect of the design of foundations, pavements, and infrastructure.

4.1.3. One of the main constraints in selecting an appropriate remediation technique can be programme duration. Lengthy post-remediation monitoring to demonstrate the adequacy of the remediation techniques to achieve the objectives is undesirable. Also, given an approximate earthworks balance (no net surplus or deficiency in fill materials), it is important that the volume of any excavated materials that cannot be returned to the earthwork's operation is minimised, and that as far as possible, excavated materials can ultimately be retained, subject to their contamination status and geotechnical suitability.

4.1.4. Several potential methods could be considered to meet the site remediation objectives and criteria; however, these will vary in their impacts and requirements as well as their effectiveness. The objective of the Options Appraisal is to assess what remedial techniques might be effective, then to balance the advantages and disadvantages of each and arrive at the most appropriate method or combination.

4.2. Viable Technical Approaches

4.2.1. The identified pollutant linkage that requires addressing as the primary objective of the task is limited to the sporadic and occasional exceedances of residential soil criteria in made ground and topsoil, and potential hydrocarbon hotspots. These materials have been identified on the site and new receptors will be introduced following development. There is therefore a viable pollutant

source, sensitive receptor, and linkages between these at the site. Remediation measures could be targeted to any of these three elements to reduce risk to acceptable levels.

4.2.2. Modification of receptor behaviour would not normally be considered for a new development. For example, the planned dwellings have private gardens and areas of adjoining open space for reasons of amenity and marketing. As the properties may be sold freehold with permitted development rights, it is considered that the preferred approach should protect the future residents from unacceptable exposure during whatever activities can be reasonably envisaged over the design life of the development.

4.2.3. Based on the above considerations, managing the sources and / or exposure pathways is confirmed as the most appropriate means of managing risks to the future residents in the long-term. Source reduction may be appropriate for some, specific circumstances, for example asbestos containing materials or hydrocarbon impacted soils if these are identified, and can be achieved through a number of means, the simplest is to remove the contamination from the site to be dealt with elsewhere. Other methods generally utilise chemical or biological processes which destroy the contaminants or achieve a reduction in the amount of effective contaminant mass through removal of mobile phase contaminants only or fixing these within the soil matrix.

4.2.4. However, for the most part, as impacted soils do not appear to present a pollution risk and the types and concentrations of contaminants anticipated are of low mobility in the environment, retaining the impacted materials on site and severing the exposure linkage by ensuring isolation from contact with the future residents would appear to provide a sure and robust means of reducing risks.

4.2.5. There is, however, potential for fuel contamination hotspots associated with former fuel storage tanks and fuel pipelines on the site and so methods to deal with any such contamination if encountered are required to develop a robust Remediation Strategy.

4.3. Feasible Remediation Options & Feasibility Screening

4.3.1. Based on existing information gained from the intrusive investigations and risk assessment, a variety of techniques could be applied to manage the potential or confirmed sources. The general classifications of technique which could be considered viable in the context of the development and the requirement to manage the identified pollution linkage under consideration are listed below:

- Isolation of the materials through reduction of infiltration or in-ground barriers to achieve *Engineered Encapsulation*;
- *Excavation and Disposal* of contaminated soils off-site;
- Excavation and *Ex-Situ Treatment* by physical, chemical, or biological means to reduce concentrations, replacement once Remediation Criteria are achieved;

- Application of similar chemical, biological or physical process to the contaminant mass while still in the ground, or *In-Situ Treatment* to reduce concentrations sufficiently to achieve Remediation Criteria;
- Use of chemical / physical treatments to reduce the mobilisation of the contaminants from the impacted material matrix by *Solidification and Stabilisation* – may be achieved In-situ or Ex-situ.

4.3.2. Several different techniques could be used for the above methods giving a wide range of options, these are explored further below with the costs / benefits and advantages / disadvantages of each and a separate assessment of the possibility of combinations of options. Each of the various classes of remediation that could be applied to the potential or confirmed sources has relative advantages and disadvantages, some of which allow early exclusion from the feasibility.

Table 4.1: Feasibility Screening Assessment

Method Class	Advantages / Merits	Disadvantages / Limitations	Feasible?
Isolation / Encapsulation	Avoids generation of wastes, and large-scale earthworks / vehicle movements / import materials. Short term programme constructing engineered barriers. Allows for the retention of impacted bedrock if it cannot be readily excavated.	May require additional earthworks to achieve isolation by moving materials to less sensitive areas, Requirement to source clean cover materials, requirement to maintain barriers or design so would not be compromised during site operations.	Yes
Excavation and disposal	Fast and can be achieved using traditional plant to shallow water table / bedrock and verified simply with on-site monitoring equipment (PID) and comparison residual soil concentrations to Remediation Criteria; Allows physical preparation of site through removal of structures to be completed at the same time.	Excessive cost if large volumes or hazardous waste classification. Large number of lorry movements and use of resources (landfill space and replacement fill). Possible release emissions and associate health / nuisance odour risks during disturbance. Not feasible to remove shallow impacted bedrock.	Yes (shallow soils only)
Excavation and Ex-Situ Treatment : Destructive Techniques	All advantages of excavation and disposal (above) without generation of excessive wastes. Wide range of techniques applicable.	Inorganic and recalcitrant organic contaminants less amenable to biodegradation. Different techniques have different costs and timescales: faster techniques generally more expensive. Possible emissions and associate health / nuisance odour risks during disturbance.	Yes (Hydrocarbons only)
In-Situ Treatment	Avoids generation of wastes, and large-scale earthworks. Wide range of techniques applicable.	Significant uncertainty in terms of programme length and cost. Long-term monitoring programme to demonstrate no	No

Method Class	Advantages / Merits	Disadvantages / Limitations	Feasible?
		rebound effect conflicts with programme constraints Currently distribution of contamination is uncertain and further investigation required to fix design parameters.	
Stabilisation / Solidification	All advantages of Excavation and Disposal without generation of excessive wastes. Fast; materials can be processed in short timescales and binder curing completed to allow fast recovery of fill. Cost effective depending on amount and type of binders used. Can produce geotechnically suitable fill materials which are of lowered permeability, giving treated materials intrinsic properties with some of the advantages of encapsulation.	Uncertainty with respect to leaching properties of contaminants under consideration; may require special binders/ additives increasing costs. Limited track record in UK context Possible release of emissions and associate health / nuisance odour risks during disturbance. Requirement of treatment trials to demonstrate remedial targets can be achieved. Limited success in reducing volatile compounds	Yes

4.3.3. The ground on the site locally contains concentrations of contaminants, that in the absence of mitigation, could pose an unacceptable risk to the human health of future site users if present in garden soils and where residents may be exposed by inhalation of harmful vapours. The “do nothing’ option, containing no specific measures to remediation ground contamination or deal with further mobile substances, is therefore inappropriate and not acceptable.

4.3.4. A Strategy involving removal of all contaminated soils for off-site treatment or disposal has the benefit of remaining all potential contamination sources. However, much of the soils present on the site is unlikely to pose an unacceptable risk to human health or controlled waters. This option would require the use of significant resources in the form of replacement fill material and landfill space, and large additional lorry movement numbers, and is therefore regarded as unsustainable both economically and environmentally.

4.3.5. Risks to future site users from direct exposure to any residual contaminated soils can be managed by the use of a barrier system. Use of a suitable thickness of clean cover material over the site surface in areas where residual contaminants will remain and where human exposure could occur following remediation would provide physical isolation and break the relevant pollutant linkages. Minor risks to site users from tainting of water supplies could be managed by the use of high specification pollution resistant materials. Similarly, post-remediation vapour monitoring will be undertaken to establish whether a residual vapour risk remains. Any such vapours are likely to be associated with either localised impacted groundwater or impacted bedrock where removal is not

feasible. If elevated concentrations are reported, they can be safely mitigated through the installation of barrier measures in the form of VOC membranes within overlying dwellings.

4.3.6. Hydrocarbon contamination in the areas where potential sources of these substances were identified has only been confirmed in a few locations, and the results of the additional inspection and validation works proposed will be used to confirm any contamination by these substances. Depending on the volumes of impacted materials, off-site disposal may be considered a desirable option. However, if more significant volumes are encountered, ex-situ treatment through monitored natural attenuation, enhanced biodegradation or stabilisation may be considered to be more appropriate. This would require temporary relocation of impacted soils to a quarantine / soils treatment area, where risks of emissions to the environment can be managed, and adoption of well-established techniques to aerate the soils and allow indigenous biota to degrade substances such as oil and fuels. The efficiency of such works in determining the reuse of the treated soils on the site would be subject to achieving the remedial targets produced by Watermans and agreed with the Environment Agency (Table 3.4).

4.3.7. If significant amounts of asbestos containing materials are encountered, these can also be isolated, but the locations and depth will require further consideration to avoid the exposure of future construction and maintenance workers during the construction and operational phases of the development.

4.4. Decision

4.4.1. Most materials can be left in-situ or relocated around the site to meet the earthworks requirements without constraint. Inspection and / or testing of soils to remain at shallow depth, i.e.at remediation formation level, and of topsoil to be used as a growing medium in gardens and soft landscaped areas, will provide surety that no unacceptable materials have been placed in these sensitive areas or advised where garden soil cover system may be required over formation soils.

4.4.2. No identified hotspots have been identified to date, however descriptions of soils with black staining and hydrocarbon odours (TP109, JBH4, JTP10, JSTP1 and JSTP2) warrants further investigation concurrently with the preparatory works. Similarly, the removal of POL2, POL21, the AST / valve pit and former fuel pipeline is also required. Hydrocarbon hotspots would be subject to verification testing in accordance with the approved criteria produced by Watermans to verify the efficiency of remedial works. Any hydrocarbon impacted soils would be removed down to bedrock with the preferred remedial technique dependent on the overall volume of removed materials.

4.4.3. Post-remediation vapour monitoring is proposed across the site to confirm that a residual vapour risk does not remain. Currently this is based on a 50m spacing and will target areas where elevated PID readings have been reported within boreholes and the areas where bulk fuel storage has historically taken place (POLs and AST / valve pit). If additional hotspot areas where residual elevated soils concentrations remain or where impacted bedrock is encountered and cannot be removed, additional vapour monitoring wells may be required to adequately assess such areas.

4.4.4. Risks to human health would then be limited to exposure of construction and future maintenance workers. The reduced exposure durations and frequencies negate these for the most part, provided normal occupational hygiene and environmental management practices are adopted. The possible exception is asbestos for which special workplace exposure controls are required, however to date only a trace (<0.001%) of fibres have been reported within a single sample of the made ground and may be associated with background concentrations. Further testing of formation soils will be undertaken as part of the verification works which will include asbestos testing to further characterise the site soils. A possible asbestos water pipe may be present in the northeast of the site according to historical BGS trial-pit logs. Further investigation will be required to confirm whether this pipe remains and if encountered this would be subject to removal. There is also potential that ACM may be present within the POLs associated with gaskets, some of which were removed by Vertase as party of their decommissioning works. The POLs will be subject to an asbestos survey prior to demolition with removal of any ACM if encountered by a specialist sub-contractor prior to demolition works commencing.

4.4.5. For buildings and foundations, appropriate concrete classification should be specified, and advice sought regarding materials for water supply pipes. Given the apparent minimal risks from ground gas following further assessment by Jomas, gas protection measures are not required within the proposed dwellings, however the requirement for vapour protection measures (see 4.4.3) would be subject to the findings following remedial works and if necessary further assessment through post-remediation vapour monitoring.

5. Implementation Plan

5.1. Preferred Approach

5.1.1. Prior to the commencement of preparatory works, the existing monitoring wells should be decommissioned in accordance with Environment Agency Guidance[3]. The preferred method would be to infill with hydrated bentonite pellets. Decommissioning of the existing wells should only be completed once regulatory approval of the previous assessments have been received. In the absence of a regulatory response prior to the commencement of works, the boreholes should be located and secured with fencing to avoid destruction until such a time when regulatory approval is received.

5.1.2. Based on the above assessment it is envisaged that preparatory works will commence with the stripping of turf / topsoil from across the site and stockpiling. Stripped topsoil will be formed into several stockpiles for testing to demonstrate compliance. If the material from these areas is not suitable for use in private gardens it may still be acceptable for use in Public Open Space or landscaping providing it is compliant with the appropriate assessment criteria for its intended use. Soils recovered from around the POLs and AST / valve-pit will be stockpiled separately from that from the wider site areas due to the higher likelihood that fuel contamination may be present.

5.1.3. Following the stripping of topsoil, demolition works of the POLs and AST / Valve Pit will be carried out. Removal works are likely to be completed over several stages due to the size of the structures with the final stage relating to the breaking out and removal of the bases. Removal of the decommissioned fuel line which intersects these locations will also be undertaken with removal of the fuel line across the entirety of the site.

5.1.4. Excavations to recover materials and structures which are constraints to construction would form the next logical step, with removal or road surfacing and stockpiling separately to stone sub-base. Where concrete structures are present these can be broken out and crushed to form additional for recovered aggregates materials if volumes make this an economical alternative to disposal off-site. Resultant aggregate product will require testing for asbestos to demonstrate compliance with the required specifications for recovery. If required, unacceptably contaminated materials should be removed down to bedrock with verification samples collected from the base and sides of the remediation excavation to verify the efficiency of the remedial works. Removed arisings should be located within a temporary quarantine area pending either waste classification for disposal or ex-situ treatment.

5.1.5. The removal of the POLs and AST / Valve Pit, areas of previously reported visual / olfactory hydrocarbon indicators (TP109, JBH4, JTP10, JSTP1 and JSTP2) and possible asbestos water pipe (TP7) should all be subject to further investigation. If required, unacceptably contaminated

[3] Environment Agency. Decommissioning redundant boreholes and wells (1996)

materials should be removed down to bedrock with verification samples collected from the base and sides of the remediation excavation to verify the efficiency of the remedial works. Removed arisings should be located within a temporary quarantine area pending either waste classification for disposal or ex-situ treatment.

5.1.6. Further investigation of the decommissioned fuel line is not proposed based on the sufficient coverage by existing entries, however if impacted soils are encountered during pipe removal, then dedicated inspections / full-time attendance by the appointed consultant will be implemented.

5.1.7. Those areas requiring dedicated investigation / inspection and/or remediation are indicated on Drawing D04. Outside of these areas, regrading of the site to achieve the planned remediation formation can be carried out without constraint. A watching brief should be maintained by operatives and supervisors in case any currently uncharacterised areas need addition to the prescribed list where inspections and remediation excavations are recommended. Areas of heterogenous fills, soils emitting odours or the presence of high proportions of wastes, staining, sheens, drunks, tanks or other containers, or suspected ACM will trigger inspection by a specialist in land contamination, sampling, analysis and assessment.

5.1.8. Inspection of formation level following preparatory earthworks to confirm whether the shallow soils are suitable for retention within garden areas should be carried out with formation sampling completed across the site. Any significant inclusions of asphalt should be removed where it is feasible to do so.

5.1.9. Post-remediation vapour monitoring will form the final element of remedial verification works with monitoring probes installed on a 50m grid across the site (see Drawing D05). Entries will target existing locations where elevated PID readings within monitoring wells (JBH2, JB3, JBH4, JBH6, JWS5, BH10, BH13), where elevated groundwater vapour concentrations were recorded (JBH6) and the remediated areas of POL2, POL21 and AST / Valve Pit.

5.1.10. The preferred option for managing soil contamination within the site therefore involves elements of all previously described techniques. This will entail:

- Decommission existing boreholes
- Limited trial trenching and inspection of locations where visual / olfactory contamination reported previously (TP109, JBH4, JTP10, JSTP1 and JSTP2)
- Trenching within location of BGS TP7 (northeast) to identify if asbestos water pipe is present;
- Demolition and removal of POLs, AST / Valve Pit and fuel pipeline
- removal of un-treatable contaminated / deleterious materials (e.g. organic wastes, asbestos products or heavy hydrocarbon contamination) for off-site treatment / disposal;
- Soil / vegetation strip and recovery with testing to determine likely potential for reuse within the development as a growing medium to garden or landscape areas;
- Regrading of the site to appropriate design formation levels;

- In-situ formation testing across the site to assess the suitability for retention within garden areas or the requirement for 600mm clean cover soils for gardens and 300mm cover in landscape areas where exceedances present.
- VOC monitoring on 50m grid spacing across the site with locations to target areas where elevated PID readings reported in boreholes, areas of historical bulk fuel storage, location where elevated groundwater vapour concentrations reported and areas where residual contamination (e.g., impacted bedrock encountered).

5.2. General Approach: Preparatory Remediation Earthworks

5.2.1. The general approach to site preparatory / remediation works is described below:

Site security and supervision	The site will be securely fenced throughout the works and appropriate security provided; a full-time site manager representing the Principal Contractor will attend site during the works and welfare facilities for staff / visitors will be provided.
Access	Access will be formed off Camp Road to the south
Dedicated Inspections	Further inspections will be directed by the Environmental Consultant in the areas where visual / olfactory fuel contamination has been reported (Hydrock -TP109, Jomas - JBH4, JTP10, JSTP1 and JSTP2) and within the area of BGS TP7 where a suspected asbestos water pipe was reported at 0.8m bgl. Full time attendance will be required during the breaking out and removal of the base of the POLs and AST / Valve-Pit. It is recommended that these works are all undertaken at an early stage. General inspections of ground conditions during site turnover and construction excavations by operatives and supervisors for heterogeneous or unusual conditions is required. Inspection during removal of the decommissioned fuel line will also be undertaken, however if contamination around the fuel line is encountered then this will be treated as a hotspot area and attendance will increase to full time. Unless specific contamination indicators are encountered, the only further sampling and analysis will be on formation soils following the completion of preparatory works to determine the suitability for retention as shallow garden soils, testing of recovered or imported topsoil intended for use in a growing medium, and any additional recovered aggregates
Ecological clearance	SGP are not aware of a detailed ecological survey having taken place, a separate method statement will be required for management of any invasive or protected species.
Vegetation strip	The vegetation strip will remove vegetation / turf to nominal 50mm depth, recovery of topsoil where present and stockpiling pending removal for reuse or disposal. Soils recovered from around the POLs and around the AST / valve pit will be stockpiled separately from those of the wider site.

Asbestos clearance	The POLs will be subject to an asbestos survey prior to demolition. Any asbestos cement sheet or insulation board fragments / lagging / pipe gaskets will be removed by hand during systematic surveys by the specialist sub-contractor using suitably trained staff and in accordance with the contractor's method statements; asbestos will be double-bagged and placed in secure temporary storage (hazardous waste skips) pending off-site disposal; site staff will be trained in asbestos recognition and may hand pick further bonded asbestos where observed during the earthworks; in the event of significant unexpected deposits of asbestos containing materials being encountered then the specialist sub-contractor will revisit the site to carry out decontamination.
Demolition/Obstructions Breaking out paved surfaces, foundations, and sub-structures	Existing concrete slabs, tarmac roads, relict foundations, manholes and other sub-structures will be grubbed out by hydraulic excavator; all hard materials will be crushed and stockpiled for re-use by the contractor or developers; crushing and screening plant will be operated under a valid permit with appropriate controls over noise and dust, and will be located at least 100m from existing housing; hard materials stockpiles will be inspected for potential asbestos-containing materials before crushing, with any suspect materials being removed for disposal.
Soils stripping, handling and stockpiling	Soils will be carefully stripped by hydraulic excavator in panels to facilitate inspection of the exposed surfaces by the Site Engineer or Environmental Consultant; the Environmental Consultant will carry out appropriate further investigations / sampling in the event that suspect and unexpected contamination is discovered; stripping will progress down to the undisturbed natural subsoil surface or bedrock; internal site haulage will be by articulated dump truck; stockpiles will be placed in locations to be agreed with the developers, to be a maximum 5m in height and shaped to a smooth profile; stockpiles will be segregated to facilitate materials management and tracking.
Treatment of storage tanks and pipes, contents, and associated contamination	The existing tanks and fuel pipeline have been subject to emptying and partial / full filling as part of decommissioning works by Vertase. However, in the event that residual product is encountered the tank contents will be sampled and, where liquids are present, will be drained to tanker for subsequent treatment and disposal; tanks will be degassed prior to removal; any linking pipework will be similarly drained with collection of any contents and stripped out; the Environmental Consultant will inspect the excavations and advise upon the removal of unacceptable contamination and collect validation samples from the stripped surfaces prior to controlled filling
Vapour Monitoring	Vapour monitoring probes will be installed across the site on a nominal 50m grid spacing (see Drawing D05) following the completion of preparatory works.

Earthworks completion	On completion of the remediation works, the site will be re-graded to -200mm, with deep excavations for POLs / pipeline etc. backfilled with suitable material. Stockpiles of topsoil and recovered aggregate will be handed over to the respective developer. Further inspection and targeted sampling of the formation soils will allow the determination on whether the soils are suitable for retention within garden areas or whether gardens should be left low (-600mm) to allow the placement of a clean cover system to isolate impacted materials from residents. Post-Remediation vapour monitoring will allow a final assessment and recommendation to be made as to whether VOC protection measures are required to be installed within Plots.

5.3. Identified Contamination Hotspots

5.3.1. Investigation within the locations where visual / olfactory contamination indicators were reported (Hydrock – TP109 & Jomas – JBH4, JTP10, JSTP1 and JSTP2) and the possible location of a buried asbestos pipe (BGS TP7) should be completed at an early stage by an appropriately qualified contaminated land specialist and comprise of excavations within each area to inspect for the presence of contamination and if encountered delineation and removal. If contamination indicators are encountered, soil samples of impacted materials will be collected and submitted for an appropriate suite of analysis. Hydrocarbon contamination would be subject to testing in accordance with the remedial criteria produced by Watermans (see Table 3.4).

5.4. Decommissioned Fuel Pipeline

5.4.1. Generally, a good spread of investigation entries is located within close proximity of the decommissioned fuel line, the exception being around POL2, however this area will be subject to further inspection and remedial works during the removal of POL2. As such, further investigations along the decommissioned fuel pipeline route are not considered necessary. The pipeline will be subject to removal although full time attendance by a consultant is not considered necessary unless contamination indicators are encountered. A watching brief should be maintained by the contractor during the removal of the pipeline for any impacted soils. Inspection of the works will form part of the general weekly site visits by the appointed consultant; however, this will be increased to full-time attendance in the event that contamination indicators are encountered during their assessment and if necessary, remediation.

5.4.2. If impacted ground surrounding the pipeline is encountered, the remediation contractor will notify the Environmental Consultant who will attend site. Delineation of the extent of the contamination will then be carried out and remediated and validated as per the Section 5.5 below.

5.5. Fuel Tanks and Pipelines

5.5.1. A sequential approach will be taken to dealing with tank and pipeline contents prior to physical removal of the structures and backfilling of UST voids. This will entail:

- Inspection and survey, including monitoring of VOCs using PID and sampling contents;

- Emptying contents using a vacuum tanker for free liquids (if remnants present following decommissioning works); where possible, free product and contaminated water will be separated for treatment or recovery / disposal; sludges will be removed when safe access can be gained (probably following tank demolition);

- Following further vapour checks and venting, tanks will be removed or broken out using hydraulic breakers and metals shears as necessary, particular care will be taken to pump out any liquids retained in the tank surrounds to avoid release into the ground;

- Pipelines will be temporarily sealed pending draining / purging of any liquid contents;

- The Environmental Consultant will attend all tank (POL2, POL21 and AST / Valve Pit) removals and will advise on the requirements to remove residual contamination from the tank surrounds and will observe and record the works and collect validation samples to the extent possible, noting that entry to the voids will not be permitted on safety grounds, and that sampling from intact bedrock surfaces will not be undertaken.

- Following removal of the tank and its surrounds, samples of the surrounding soils (if any) will be obtained in order to visually assess the presence of hydrocarbon contamination; all significant hydrocarbon contamination in soils as determined by the Environmental Consultant on the basis of appearance or odour will be stripped back to a maximum vertical depth below ground level of 3m and laterally until the edges of the contaminated zone are judged to have been reached; validation samples will be taken from these surfaces as described in Section 6;

- In the event that validation samples from the extents of the excavation exceed the validation criteria (Table 3.4) then the results will be subject to further risk assessment and/or further excavation and validation will be undertaken, with the process repeated until the agreed completion criteria are achieved.

5.5.2. If hydrocarbon contamination is found in additional investigations or during tank / pipeline removals, specific measures to reduce or remove sources of contaminants will be implemented entailing the chasing out of impacted soils using a PID and visual inspection up to either site boundaries, retained buildings, services or intact bedrock. Impacted soils will be removed to a secure stockpile placed in a bunded area on an impermeable membrane liner or suitable impermeable paved surface; the stockpile will be sheeted to minimise leachate generation. The volume of material to be treated and/or disposed of will be minimised by segregation of contaminated and non-contaminated materials where possible. The sidewalls and bases of excavations where

contaminated materials are removed will be sampled to verify that contamination has been reduced as far as practicable or to acceptable concentrations.

5.5.3. The extent to which hydrocarbon-contaminated soil will be generated remains unknown at this time, and therefore details of any planned ex-situ treatment cannot be finalised. Where the volume of spoil is less than 1,000m^3 then the options to remove the spoil off-site, or treat the spoil on-site to achieve target concentrations meeting the Waterman's Criteria (Table 3.2) remain open. In the even that a greater volume of spoil is generated then a decision will be made as to an appropriate ex-situ treatment. Any such treatment works would be undertaken by a specialist sub-contractor with works carried out under an Environmental Permit with site-specific deployment details. If ex-situ treatment (e.g. bioremediation) is undertaken, then a detailed Method Statement will be issued for regulatory approval prior to commencement; this will detail the treatment location, methods of screening, mixing and handling the waste, containment and environmental protection measures, including runoff, leachate, dust and odour controls, and anticipated treatment programme and closure procedures for the treatment zone.

5.5.4. If asbestos fibre is detected in quantifiable amount (>0.001%) in fills, then this material will be excluded from use in soil cover and will be placed at depths over 1m below ground level within excavations (primarily with tank / pipeline backfill) subject to suitability. Locations of such fill will be agreed with the Developer, so as to avoid future disturbance during subsequent construction activities. The provision will not apply to hazardous levels of unbonded asbestos (>0.1%) which will be removed for disposal off-site.

5.5.5. The natural underlying deposits are unlikely to be contaminated by organic substances outside potential hydrocarbon hotspots, and in areas where the natural strata (including reworked natural strata) are exposed at the formation surface following level works, then the surfaces will be inspected for evidence of contamination. The Developer will be responsible for validating the natural soils and provided any additional topsoil needed as a growing medium for plants in gardens and landscaping.

5.5.6. It is noted that the site lies within or adjacent to the "ironstone domain" as described in DEFRA Technical Guidance Sheet TGS01 "Arsenic", July 2012, the site lies within 1km of mapped outcrops of ironstones within the Jurassic sedimentary rocks. Within the ironstone domain, the natural background concentrations of arsenic is reported to be 220 mg/kg which exceeds the Table 3.3 for garden cover soils. Where natural mineralisation is present in the bedrock and rock-derived soils in excess of the criteria then further consideration and with assessment, possibly including bioavailability testing may be carried out to determine acceptability of the cover soils.

5.6. Materials Management

5.6.1. Assuming an earthworks balance can be achieved and that development levels do not necessitate significant regrading, and the recovery of soils or other materials which would otherwise be wastes is not intended, the proposed preparatory works would not require a Materials Management Plan

(MMP) as set out under the Definition of Waste: The Development Industry Code of Practice (CoP) for use on the site of origin. If the contamination status of soils necessitates their relocation to manage risks is it likely an MMP will be required.

5.6.2. The site operations will be carried out to ensure that any contaminated materials / runoff or discharge do not affect clean areas of the site or surroundings. In particular, soils and materials from any hydrocarbon remediation excavations will be segregated and placed inside lined bunds where appropriate.

5.6.3. Contaminated water will be removed from tanks or other containments by vacuum tanker for off-site treatment. In the event that temporary dewatering of excavations is required then the necessary monitoring, risk assessment and regulatory permits will be obtained.

5.6.4. Most topsoil on the site is likely to be suitable for reuse in gardens subject to careful segregation, handing, quarantine and verification testing. If moderate exceedances of Remediation Criteria are noted these could still be used in less sensitive areas or be subject to further assessment. Verification testing of recovered topsoil will be required outside the baseball pitch area. Stockpiles of materials intended for re-use should be battered to prevent saturation.

5.6.5. In the event that surplus arisings requiring removal from the site comprising made ground are generated, or materials other than natural soils or recovered aggregate need to be removed, then these will be waste materials requiring disposal at a suitably permitted facility and retention of transfer documentation. Similarly, waste transfer notes for other materials removed from the site should be retained. Clean, uncontaminated soils could be transferred off the site within an MMP for the receiving site.

5.7. Unexpected Contamination

5.7.1. If previously uncharacterised materials or contamination sources (i.e., buried wastes) are identified during the works, then these will be investigated by the Environmental Consultant. The Local Authority Contaminated Land Officer will be notified immediately in writing following any such discovery and a decision as to whether the contamination can be remediated under the existing Strategy made. If necessary, an addendum or revised Strategy will be produced.

5.7.2. It is anticipated that immobile (low volatility / solubility) contaminants similar to the types described in the site characterisation would be retained below the proposed barrier system in garden areas and that other contaminants including asbestos hazardous waste, volatile or liquid hydrocarbons, drums, tanks or pipes will be excavated and removed from the site for waste treatment or disposal.

5.7.3. There is a very small potential for the presence of unexploded arms ordnance within the site, although nothing has been found during the current ground investigations. The Remediation Contractor is alerted to the potential for the presence of buried ordnance and will undertake all

necessary health and safety measures and make contingency arrangements for quarantining areas where suspect items are disclosed pending attendance by the appropriate services.

5.8. Construction materials

5.8.1. On the basis of the information to date, the use of protected water mains is unlikely, however a final recommendation should be made following the completion of remediation earthworks including the remediation of any fuel tanks and pipelines. A water pipeline risk assessment may be required by the Utility Provider which should use post-remediation data where available. Requirements for concrete specification (DS1-AC1) are as specified within the Hydrock and Jomas Ground Investigation report subject to any further testing which may be completed.

5.9. Construction Stage Mitigation Measures

5.9.1. The area requiring a clean soil cover system for garden areas is yet to be confirmed and is subject to the formation testing across the site following regrade, however based on current information by Jomas, localised areas of the site may require a soil cover system although this is not anticipated to be a side-wide requirement. A final recommendation of the requirement and locations for a soil cover system will be made within the forthcoming completion reports.

5.9.2. The standing recommendation for the provision of gas protection measures in accordance with CIRIA CS1 / NHBC Green classification within all plots and buildings is considered appropriate based on the assessments undertaken to date, however further investigation / assessment is required with regards to the risks from VOCs within localised areas of the site.

5.9.3. Post-Remediation vapour monitoring will be carried completed on a nominal 50m grid spacing across the site, with entries targeting locations of previous elevated PID readings, location of GW_{vapour} criteria exceedance and locations where bulk fuel storage historically occurred (POLs and AST / Valve Pit). Current proposed monitoring locations are provided in Drawing D05, however additional monitoring locations may be required should additional hotspot areas or locations where impacted bedrock which cannot readily be removed be identified during the preparatory works. The assessment will allow comparison of volatile hydrocarbon concentrations to derived inhalation criteria with exceedances either requiring further detailed quantitative risk assessment or recommendations for the installation of VOC protection measures within dwellings.

5.10. Health and Safety Roles / Responsibilities

5.10.1. The Principal Contractor under the Construction Design and Management Regulations 2015 (CDM2015) will be responsible for managing health and safety during the remediation / preparation works and for producing any risk assessments and method statements required.

5.10.2. SGP's responsibilities as 'Designer' under CDM 2015 are to eliminate, reduce or control foreseeable risks that may arise during construction, maintenance or use and to provide information to other members of the project team to assist them in fulfilling their duties. The recommendations

in this report should be considered by the 'Client' and/or 'Principal Designer', and Principal Contractor, and included in the Health and Safety File for the site.

5.10.3. Protection of site workers, local residents and visitors during the remediation works can be achieved by the adoption of appropriate health and safety practices, environmental management, and site security. All site workers will be given a comprehensive health and safety induction and required to use appropriate personal protective equipment.

5.11. Environmental Management Issues

5.11.1. The scope of remediation works is unlikely to have a significant impact upon the nearby housing and environment provided that due care is taken to control dust, odour, noise, and vibration, and to prevent surface runoff onto roads, into drains and in particular the surface watercourse Gallos Brook which is culverted to the immediate south of the site. Noise emissions will be managed through the observation of approved working hours and use of appropriate plant.

5.11.2. Appropriate dust suppression measures will be deployed for crushing plant and earthworks during dry periods. Dust will be routinely monitored visually, and if unacceptable emissions beyond the site boundaries are noted then the element of the works contributing to this will be halted until appropriate mitigation (damping down, road sweeper, etc) can be deployed.

5.11.3. No discharges of dewatering or surface runoff to surface waters is permitted, however uncontaminated or marginally contaminated water may be discharged to foul sewer in agreement with the utility provider. Regular inspections of the drains which discharge into Gallos Brook off the southern boundary must be undertaken to allow appropriate mitigation measures to deployed in the event that silt runoff or other pollutants enter the watercourses as a result of the works.

5.11.4. If on-site storage and treatment of hydrocarbon-impacted soils is carried out, it is expected that polluted leachate will be generated; this will be contained by means of impermeable liners to the treatment area and may either be recirculated to the soils under treatment as part of the process or removed for separate treatment / disposal in accordance with the general requirements for contaminated liquids.

5.11.5. Plant fuel and lubricant storage will take place using suitable containers, bunds, and secured filling points. An oil spill kit and adsorbent materials to manage any accidental release of liquid pollutants will be provided. Suitable sealed skips and containers will be used for the temporary storage of small quantities of asbestos or other hazardous wastes, if encountered.

5.12. Programme and Phasing

5.12.1. The area consists of a single parcel of land with demolition and preparatory earthworks to be completed in advance of any construction activities. It is anticipated that remediation earthworks will be completed and reported in a single phase, although this is subject to development proposals.

5.12.2. A separate, construction-stage verification report for the site may be required if further sampling / assessment confirms that a soil cover system and / or VOC protection measures are required within selected plots. A final recommendation of these will be made in the completion reporting

6. Inspection and Verification Plan

6.1. General Site Inspections

6.1.1. The remediation earthworks should be carried out under the supervision of an appropriately qualified and experienced site manager. If unexpected ground conditions and potential indicators of significant ground contamination are encountered, then works in that area should cease until specialist advice can be sought.

6.1.2. Weekly inspections of the site and exposed soils and made ground are to be undertaken by an independent consultant to assess whether currently uncharacterised contamination or pollution sources exist on the site and to carry out formation sampling / sample recovered soils to determine suitability for reuse.

6.1.3. Full-time attendance by the appointed consultant will be required during the removal of the POLs (limited to works at and below ground level), the AST / Valve-Pit in the south and any contamination hotspots encountered to allow the recording of remedial works and the collection of appropriate validation samples. If previously unexpected contamination or contamination associated with the fuel pipeline is encountered during preparatory works, consultant attendance will increase to full time during these works.

6.1.4. During construction, a full-time site manager will be required to supervise the implementation of the remaining mitigation measures and arrange verification testing and inspections by the independent consultant as required.

6.2. Targeted Additional Investigation

6.2.1. Additional investigation / assessment is required in several specific areas including:

- BGS TP7 – suspected Asbestos pipe
- Hydrock TP109 & Jomas JBH4, JSTP1 and JSTP2 where visual / olfactory contamination reported
- POL2 & POL21
- AST / Valve Pit

6.2.2. It is intended that these inspections and investigations will largely be carried out contemporaneously with the demolition and remediation works but that these investigations / assessments will be completed at an early stage.

6.3. Verification Testing

Hydrocarbon Hotspots

6.3.1. Stripped surfaces within any hydrocarbon hotspot area following removal of unacceptable contamination will be validated by visual inspection and PID screening to provide assessment of the efficiency of the works; additional soil samples will be collected for laboratory analysis. A minimum of 3 entries / samples will be taken where validation is required following any stripping of contaminated soils; for larger areas where more than 3 samples will be collected, the testing rate will be 1 composite sample per 15m^2 of exposed surface. Composite samples will comprise 5 representative sub-samples collected by the Environmental Consultant.

6.3.2. Screening criteria for hydrocarbon hotspots (see Table 3.4) will be adopted to determine any requirement for additional excavation or risk assessment, although intact rock surfaces where contamination is apparent will be assessed and recorded but not excavated. Where the screening criteria are exceeded then the specified depth of clean soil cover, post-remediation vapour monitoring or precautionary VOC protection measures will be deployed as appropriate following any additional source removal or remediation.

6.3.3. A record of descriptions, supplemented by photographic records, of the exposed strata in all areas where natural soils are present will be maintained by the Environmental Consultant. The national grid coordinates and level of all sampling points will be recorded.

Site Generated / Imported Aggregate

6.3.4. If any demolition arisings from the existing buildings, broken out hardstanding or removed oversized obstructions are intended to be crushed and recovered these should be stockpiled separately. The feedstock should be inspected by an appropriately trained operative and an asbestos screen on the final product at an appropriate frequency will be required. Depending on the volume generated, a sampling rate of 1 sample per 500m^3 is required with samples submitted for an asbestos screen, the chemical testing of aggregate is not required.

6.3.5. Any suspected Asbestos containing material will undergo sampling and bulk asbestos identification, the surrounding soil matrix will undergo soils asbestos identification and full quantification to provide information for assessing the type of work being undertaken in respect of the Control of Asbestos Regulations and determine where and how the material can be safely retained or whether disposal is required.

6.3.6. Widely accepted threshold values are currently unavailable for asbestos in soils or reclaimed materials but incidences over the common quantification threshold of 0.001% will require further assessment to determine the suitability of processed materials for retention within the development.

Formation Soils

6.3.7. The remediation contractor is contracted to leave the general site surfaces within redevelopment zones stripped of topsoil, at 200mm below existing ground levels. For the purposes of validation of the general development zones, this means that a 400 mm depth of subsoil will be left which would form part of the full 600 mm of garden soil cover after replacement of garden topsoil; the 600m depth is assumed as the soil mixing zone for human health risk assessment under the residential land-use scenario. Taking a nominal soil screening test frequency of 1 sample per 500m^3, the residual 400mm depth equates to 1 sample per 1,250m^2 plan area of development, or an approximate 35m grid spacing of sample points which will be used for validation, with samples collected from the upper 400mm of the soil profile. Samples will be submitted for the garden cover soils test suite in Table 3.3.

Site-Won Topsoil

6.3.8. Topsoil recovered during the site strip will be tested for the same contamination suite to that of the formation soils (see Table 3.3) at an initial screening frequency of 1 sample per 500m^3. Samples will be submitted to a laboratory with MCERTS accreditation as available.

Post-Remediation Vapour Monitoring

6.3.9. Following the completion of remediation earthworks, VOC monitoring will be required across the site to provide targeted (areas of elevated PID readings within existing boreholes, areas of bulk fuel storage, area where groundwater concentration exceeded $GAC_{gwvapour}$, and areas where residual impacted bedrock are present) and non-targeted coverage. Currently proposed locations based this coverage are reproduced in Drawing D05; however, this may be subject to change depending on the findings during the preparatory works. The VOC monitoring will utilise shallow soil probes with response zones at 1m below ground level, install and constructed as per British Standard BS8576:2013[4] (Section 10.2.3) where feasible to do so.

6.3.10. Diffusion tubes with appropriate adsorption media for the volatile hydrocarbon fractions (C5-C12 + BTEX) will deployed for a suitable duration so that detection limits below the respective criteria in Table 3.5 are achieved. Comparison of concentrations to derived inhalation criteria (Table 3.5) will be made and where exceedances are reported, further detailed quantitative risk assessment and / or recommendations for the installation of VOC protection measures will be made.

6.4. Remediation / Preparatory Earthworks Completion Reporting

6.4.1. A report detailing the works carried out and the results of the validation / verification testing will be prepared by an Independent Consultant and submitted to the Local Authority for approval upon completion of the relevant phase of works. The report will include a full description of the works carried out, findings of all validation and verification testing, any photographic records, and details of wastes removed, and any fills imported. The report will also confirm the construction – stage recommendations with respect to vapour protection and soil cover systems, specifically. whether

[4] BS8576:2016: Guidance on investigations for ground gas – Permanent gases and Volatile Organic Compounds (VOCs)

these are still considered valid or whether conditions have been encountered during the works and inspections whereby these may be required.

6.5. Developer Stage Remediation Verification

Gas / Vapour Protection

6.5.1. On present information the site is classed as CIRIA CS1 / NHBC Green, meaning that no special precautions against ground gases are required.

6.5.2. Further assessment will be undertaken following the completion of preparatory works to establish whether VOC protection measures are required, and recommendations will be made within the Completion Reporting.

Garden and Landscaping Cover Soils

6.5.3. The developer is responsible for placing and validating the full thickness of cover soils as necessary to achieve finished levels which may incorporate the reduced level surfaces handed over by the remediation contractor following completion of their works. These finished levels will be subject to the Developer's respective engineering designs. The cover soils will either be obtained from stockpiled site-stripped soils, be generated during the process of the development, or will be imported from off-site sources by the Developer.

6.5.4. The Developer will be responsible for managing soil stockpiles and completed areas of soil cover so as to avoid cross-contamination of clean materials.

6.5.5. The general Developer responsibilities will be as follows:

- in areas where natural uncontaminated soils are present following the site re-grade, clean topsoil may be required as a growing medium of nominal 150-200 mm depth, but there will be no requirement for a full 600mm of placed soil cover;

- provision of 600mm of clean soil cover within garden areas, with a reduced thickness of 300mm in landscape areas, where the underlying soil contains one or more concentrations of substances in excess of contamination targets set out in Table 3.3;

- site-won materials to be used as the garden/landscape clean soil cover must be suitable for use and validated to comply with contamination targets set out in Table 3.3 at the rate of 1 sample per 500m^3, and validated for depth on the basis of 1 entry per 3 plots for gardens, or the equivalent of a 50m grid in POS / landscaping areas;

- imported soils used for cover purposes are to comply with contamination targets set out in Table 3.3 validated at a rate of 1 sample per 250m^3 with a minimum of 3 samples per source;

- potential cross-contamination of clean natural soils or cover soils due to secondary excavations for foundations construction or trenching must be avoided, with appropriate replacement or disposal of arisings.

7. Conclusions and Recommendations

7.1. Conclusions

7.1.1. The site is generally of moderate risk from significant land contamination associated with the former military use of the site where bulk fuel stores and transport has historically taken place. Whilst significant contamination has not been encountered to date, it is recognised that there is potential for localised hotspots attributed to bulk fuel storage on the site.

7.1.2. Several potential hydrocarbon hotspots have been identified where visual or olfactory records of fuel impacted soils have been recorded (TP109, JBH4, JSTP1 and JSTP2) and further investigation / inspection as considered necessary at these locations to assess whether remediation is required. Such dedicated inspections also extend to the two sets of decommissioned POLs (POL2 and POL21) on the site and an AST / Valve-Pit which will be subject to removal as part of the preparatory works.

7.1.3. A historical trial-pit entry (TP7) from intrusive works in 1987 in the northeast of the site reported the presence of an asbestos water pipe at 0.8m. Further investigation is required within this area to assess whether the pipe remains and if identified and confirmed as redundant then it will be removed.

7.1.4. As part of the POL tanks, a former fuel pipelines crosses the site, this has also been subject to decommissioning works and the previous intrusive investigation has provided good spatial coverage around the pipeline route with no significant contamination encountered. The pipeline will be subject to removal as part of the preparatory works, however further investigations are not proposed unless significant ground contamination is encountered during pipe removal.

7.1.5. Groundwater monitoring has been undertaken most recently by Jomas in 2022 with two rounds of monitoring completed. The results show minor elevated hydrocarbons within several boreholes; however, the concentrations are highly localised with elevated concentrations not reported within downgradient wells. The removal of residual fuel sources including the POLs, pipework and any impacted soils is considered to provide an overall betterment of groundwater quality within these localised areas.

7.1.6. Gas monitoring has been undertaken and concluded that there is no risk from carbon dioxide or methane and that the site is characterised as CIRIA CS1 meaning that gas protection measures are not required. Elevated PID readings have been reported within several boreholes across the site most likely attributed to residual fuel impacted soils which will be subject to further investigation / remediation whilst a single exceedance of the $GAC_{gwvapour}$ was reported within JBH6. It is concluded that whilst remedial works to remove residual fuel sources will take place as part of works under this Strategy, post-remediation vapour monitoring will be undertaken to provide assess

whether a residual vapour risk remains and provide suitable recommendations of the installation of vapour protection measures if determined necessary.

7.1.7. The proposed management and programme for remediation and verification / validation testing regime will demonstrate that the proposed remedial works have been carried out and the site made suitable for the proposed development, subject to the execution of the additional requirements on the developers set out below.

7.1.8. Remedial works and their verification are consistent with those in the approved Strategy for the neighbouring NSA and Phase 9 area where similar ground conditions and contaminants were encountered.

7.2. Recommendations

7.2.1. The further recommended environmental investigation and verification measures to be adopted are summarised as follows:

Table 7.1 Summary of investigation / verification works

Remediation Stage 1 (Preparatory earthworks)	
1. further investigations / dedicated inspections	Potential Hydrocarbon Hotspot Areas: • Hydrock Entry: TP109 • Jomas Entries: JBH4, JSTP1 and JSTP2 • POL2 and POL21 • AST / Valve Pit Potential Asbestos Hotspot Areas: • BGS TP7 All to be inspected during remediation excavations. Requirements for post-remediation vapour monitoring to be assessed following completion of investigation, remediation and verification.
2. stockpile testing	• recovered / imported aggregate – testing for asbestos at 1/500m^3 • recovered topsoil – screening tests for soil contaminants (Table 3.3) at 1/500m^3
3. regular inspections and site attendance	Weekly site visits by Environmental Consultant during earthworks operations as required for the duration of the remedial earthworks programme. Full-time attendance for POL2, POL21, AST/Valve Pit removal and hotspot remediation and validation.
4. response to unexpected conditions / occurrences	SGP available to attend site and investigate any occurrences at short notice; the Local Authority will be advised as soon as possible in event of discovery of new contamination

5. formation testing	In-situ formation testing of the top 400mm of natural or reworked natural soils on a nominal 35m grid spacing across the site with samples submitted for the test suite as per Table 3.3
6. post-remediation vapour monitoring	Installation of vapour monitoring probes on 50m spacing to include non-targeted entries to provide good spatial coverage and targeted within areas of former POLs / AST / Valve-Pit, areas where fuel impacted soils removed and areas where impacted bedrock remains. Soil-Vapour monitoring of aliphatic and aromatic C4-C12 + BTEX hydrocarbons and comparison to criteria as per Table 3.5
7. reporting	SGP will produce phased earthworks remediation completion reports
Remediation Stage 2 (Development Phase)	
8.cover soil verification	Contamination testing will be carried out for placed site-won cover soils at rates of 1 sample / 500m^3 (site won) or 1 per 250m^3 (import) with a minimum of 3 samples per single source. Depth of soil cover will be dependent on the results of formation sampling. Where a full 600mm garden (300m landscape) cover system is required, this will be verified using test pits at 1 per 3 plots, or a 50m grid over POS; inspection and testing certification will be provided on plots as they are completed, copied to NHBC and the Local Authority
9.vapour protection inspection	If vapour protection measures are required, independent inspection in line with current guidance to inspect the installed membrane and provision of inspection certificates on a plot-by-plot basis will be completed and issued to NHBC and the Local Authority. If vapour protection measures are required these and the level of verification will be agreed with by the Local Authority in advance of installation.
10.water mains risk assessment	The developer will undertake a standard water supply pipe risk assessment for the utility provider as required, utilising post-remediation data where possible.

7.2.2. With the adoption of the above normal practices for Brownfield development, and on the information available to it, SGP considers that the site can be safely and economically redeveloped, and the existing environmental liabilities managed.

7.3. Limitations

7.3.1. This report has been prepared by SGP for the sole and exclusive use of Dorchester Living. All reasonable skill, care and diligence has been exercised within the budget available, and in accordance with the technical requirements of the brief. Notwithstanding the efforts made by the professional team in undertaking the assessment and preparing this report, it is possible that other ground conditions and contamination as yet undetected may exist. Reliance on the findings of this report must therefore be limited accordingly. Such reliance must be based on the whole report and not on extracts which may lead to incomplete or incorrect conclusions when taken out of context.

7.3.2. The factual information and recommendations for foundations measures has been largely informed by information prepared by third parties and provided to SGP. The recommendations contained within this report have been made in good faith, based on the totality of the information provided to SGP, however SGP accepts no responsibility or liability for errors or omissions caused by

information which has been withheld, or where errors or omissions within previous reporting have led to false or unreliable conclusions by others relating to the contamination status of the site

7.3.3. SGP reserves the right to alter any of the foregoing information in the event of new information being disclosed or provided and in the light of changes to legislation, guidelines, and responses by the statutory and regulatory authorities.

DRAWING

Phase 10 Boundary

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LLP

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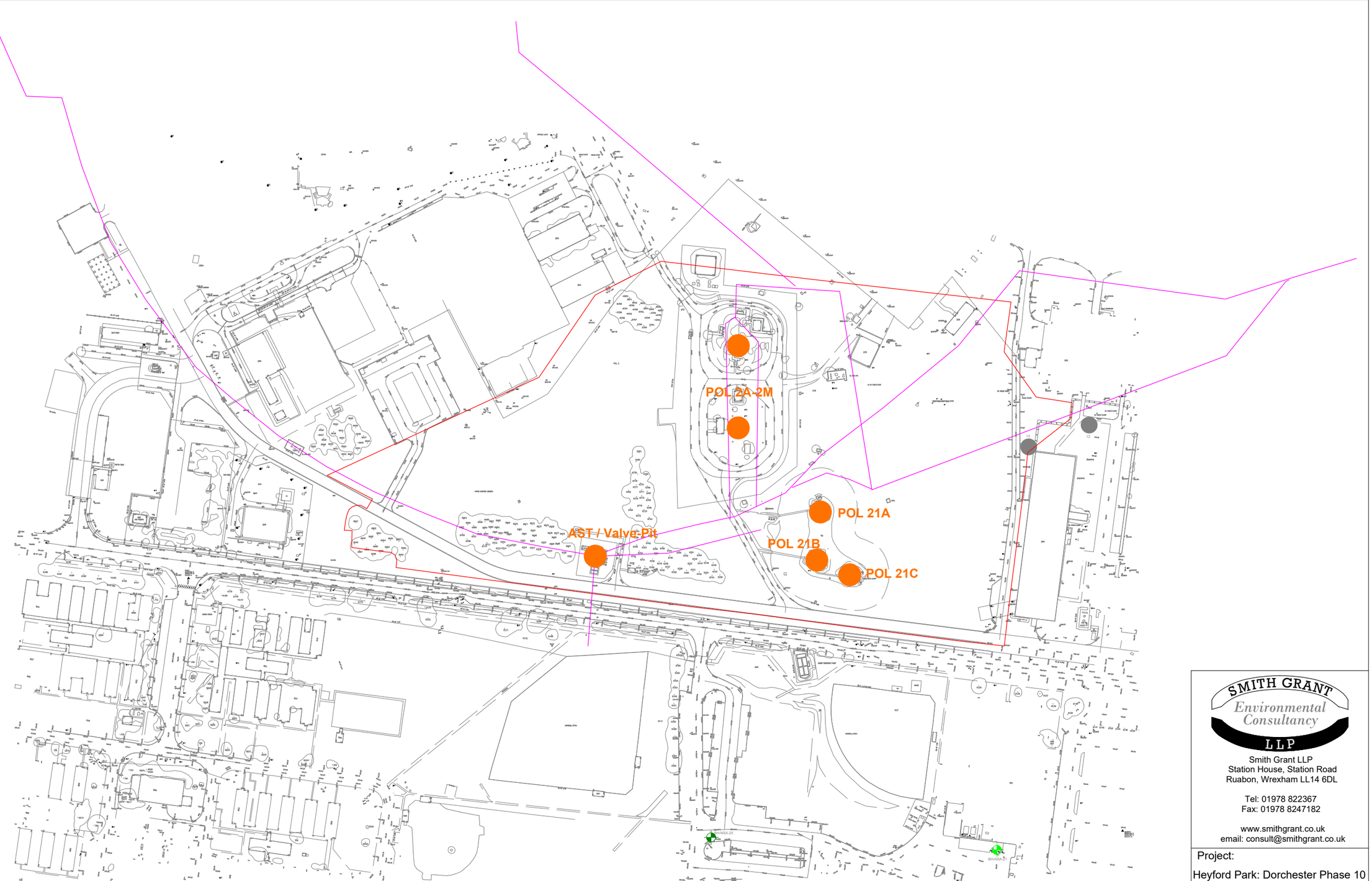
Project: Heyford Park: Dorchester Phase 10	
Drawing: Site Location & Boundary	
Drawn: DW	Checked: SM
Date: 13.09.22	Scale: 1:2,000 @ A3
Job No: R1742d	Drg No: R04-D01



Approx Route of POL Pipeline (Vertase)

POL Tank

Phase 10 Boundary

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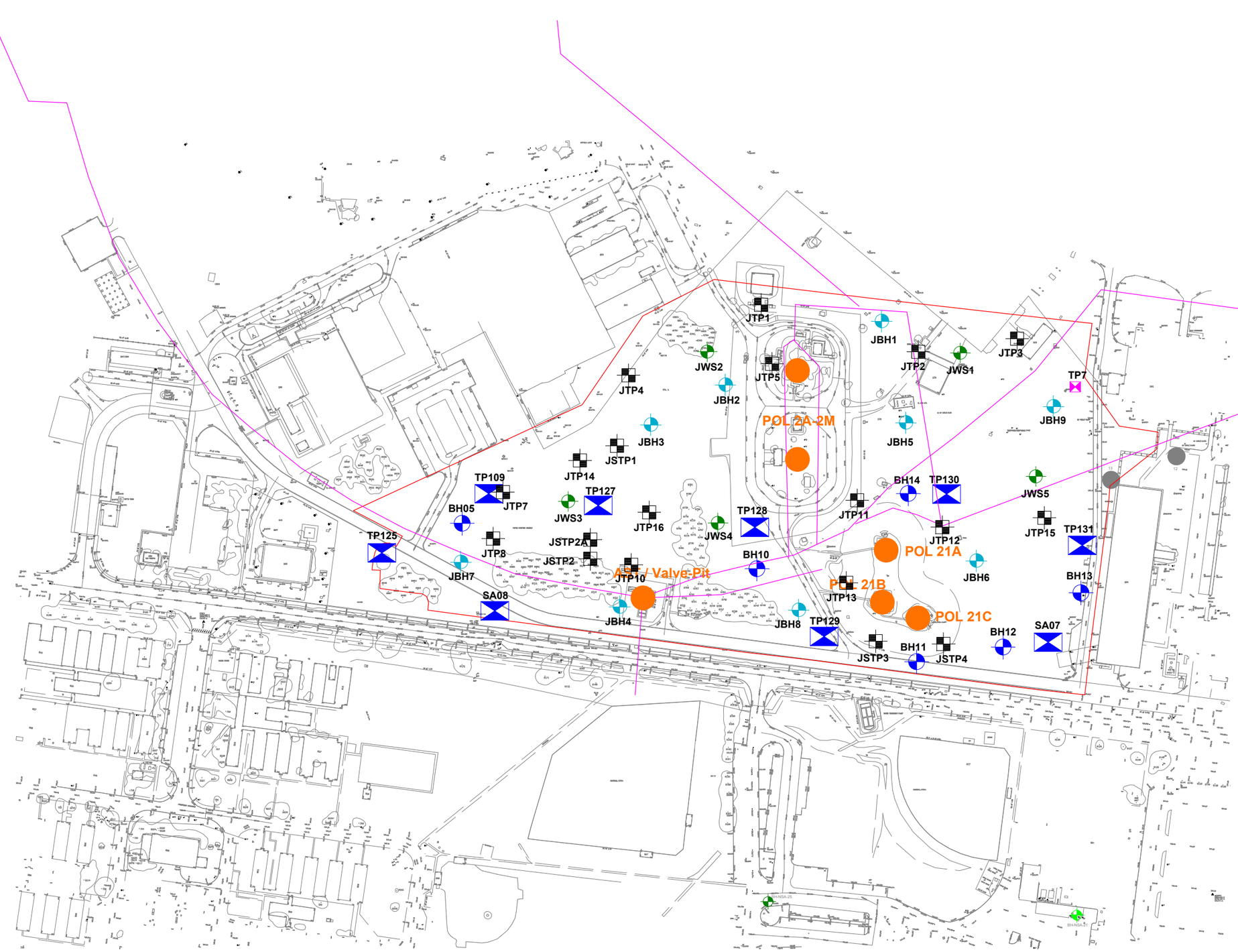
Project: Heyford Park: Dorchester Phase 10	
Drawing: POL & Fuel Pipe Location	
Drawn: DW	Checked: SM
Date: 13.09.22	Scale: 1:2,000 @ A3
Job No: R1742d	Drg No: R04-D02



Phase 10 Boundary

Hydrock Trial-Pit (2016)

Hydrock Borehole (2016)

Jomas Window Sampler Borehole (2022)

Jomas Rotary Borehole (2022)

Jomas Trial-Pit (2022)

BGS Trial-Pit (1987) - Location Approximate

POL Tank

Approx Route of POL Pipeline (Vertase)

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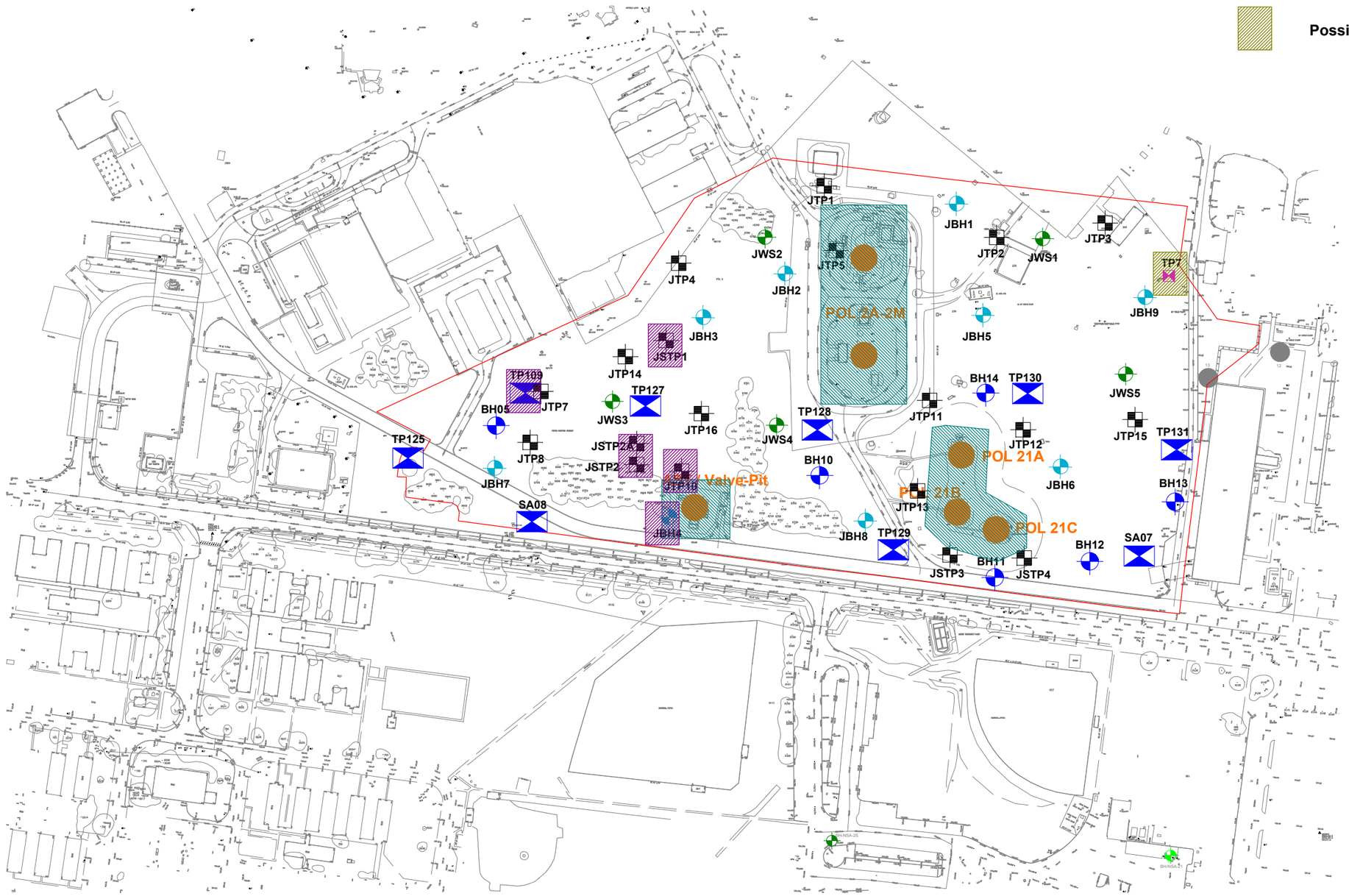
Project: Heyford Park: Dorchester Phase 10	
Drawing: Previous SI Locations	
Drawn: DW	Checked: SM
Date: 13.09.22	Scale: 1:2,000 @ A3
Job No: R1742d	Drg No: R04-D03



Phase 10 Boundary

Hydrock Trial-Pit (2016)

Hydrock Borehole (2016)

Jomas Window Sampler Borehole (2022)

Jomas Rotary Borehole (2022)

Jomas Trial-Pit (2022)

BGS Trial-Pit (1987) - Location Approximate

POL Tank

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Project:
Heyford Park: Dorchester Phase 10

Drawing:
Dedicated Inspection / Investigation Areas

Drawn: DW	Checked: SM
Date: 13.09.22	Scale: 1:2,000 @ A3
Job No: R1742d	Drg No: R04-D04

Phase 10 Boundary

POL Tank

VOC Vapour Monitoring (50m grid spacing)

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Project: Heyford Park: Dorchester Phase 10	
Drawing: Proposed Vapour Monitoring	
Drawn: DW	Checked: SM
Date: 13.09.22	Scale: 1:2,000 @ A3
Job No: R1742d	Drg No: R04-D05