Heyford Park – Western Development, Phase 9, 10, 16 and 16A

Desk Study and
Ground Investigation

Draft Report for

DORCHESTER
LIVING

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Appendices

Executive Summary and Conceptual Site Model

SITE INFORMATION AND SETTING	
Report Purpose	Phase 1 and 2 desk study, ground investigation and risk assessment.
Client	Dorchester Living
Site Name and Location	Heyford Park – Western Development, Phase 9, 10, 16 and 16A
Proposed Development	Residential housing, with associated gardens, infrastructure and Public Open Space
PHASE 1 (DESK STUDY + WALK - OVER)	
Current Land Use and Description	Phase 9 is currently an abandoned school and associated buildings and infrastructure. The school is associated with the former Upper Heyford air base. Phase 10 is currently open ground and infrastructure situated to the south of the main former Upper Heyford air base site. Phase 10 includes three large above ground fuel tank, known as POL 21. Phases 16 and 16 A are arable fields. Phase 16A has a public footpath which trends diagonally across from the north west boundary with Kirtlington Road to the southern boundary. This footpath continues off-site through the field to the south of Phase 16A.
Site History	The earliest historical map (1875) shows the site as open fields. The first indication of the Upper Heyford air base is shown on the 1954 1:10,560 historical map. However, research has indicated that the surrounding land has had a military use from as early as 1916. From 1916 - 1918 the Upper Heyford air base was used by the Royal Flying Corps, which was merged with the Royal Naval Air Service in 1918 to become the RAF, at which point they the RAF took over control of the air base. The United States Air Force took over the running of the air base from 1950; it was then in use until it closed in 1994.
Unexploded Ordnance	Since the site is adjacent to a former military facility a specialist UXO Desk Top Study has been commissioned. This confirms that there is a low UXO risk at the site.
Geology	The available geological sources indicate the site to be underlain by the Great Oolite Group.
Mining or Mineral Extraction	The site is not within an area of recorded mining. The environmental data report and review of historical maps indicate quarry workings adjacent to the southern boundary of Phase 16. The environmental data report notes ‘surface mineworkings’ for limestone. In addition the environmental data report indicates a small ground workings associated with a ‘Refuse Heap’ 220m to the west of the site and ‘limestone abstraction’ 426m to the east of the site.
Hydrogeology	The Great Oolite Group is classified by the Environment Agency as a Principal aquifer. The site is not within a groundwater source protection zone (SPZ). The Preliminary Generic Quantitative Environmental Risk Assessment for the wider Heyford Park development, undertaken by Waterman Energy, Environment and Design Ltd (Ref: EED10658 - 13.2.2_FA), has confirmed the presence of underground and above ground storage tanks and confirmed the presence of locally impacted groundwater quality. The Waterman report assessed the quality of the groundwater impact in relation to the new settlement area. The Waterman report also indicates that groundwater quality across much of the site remains relatively good. It is understood that removal of the POL system is a condition of the planning permission (Ref: APP/C3105/A/08/2080594, dated 27th October 2010).
Hydrology	Gallos Brook (a Tertiary River) runs between Phases 16 and 16A. There is evidence that it used to extend north, thorough Phase 9 and the former sports fields, towards Camp Road. There is also

<table>
<tr><td></td><td>evidence from service plans that it has been culverted between Camp Road and the North of Phase 16 and 16A. However, this has not been proved.
There is an Unnamed Secondary River indicated in the Environment Agency records along the eastern boundary of Phase 16. This river was not visible during the siteworks and is potentially culverted.</td></tr>
<tr><td>Flood Risk</td><td>The site is in Flood Zone 1.</td></tr>
<tr><td colspan="2">PHASE 2 – GROUND INVESTIGATION</td></tr>
<tr><td>Hydrock Site Works</td><td>The Hydrock ground investigation comprised:
<u>Phase 9</u>
• 4 cable percussive borehole to 8.0m below ground level (bgl) with installation of groundwater/ground gas monitoring wells;
• 29 trial pits to a maximum depth of 2.75m bgl;
• 3 infiltration rate tests;
• chemical testing of soils and waters;
• geotechnical testing of soils; and
• groundwater and ground gas monitoring.
The trial pits were located on an approximate 50m spacing, subject to access, but no formal grid pattern was used. Trial pits were also targeted around fuel tanks present on site.
<u>Phase 10</u>
• 6 cable percussive borehole to 8.0m bgl with installation of groundwater/ground gas monitoring wells;
• 9 trial pits to a maximum depth of 2.90m bgl;
• 2 infiltration rate tests;
• chemical testing of soils and waters;
• geotechnical testing of soils; and
• groundwater and ground gas monitoring.
The trial pits were located to target POL 21 and other fuel tanks as well as providing good spatial coverage of the rest of Phase 10.
<u>Phase 16</u>
• 2 cable percussive borehole to 8.0m bgl with installation of groundwater/ground gas monitoring wells;
• 28 trial pits to a maximum depth of 1.80m bgl;
• 3 infiltration rate tests;
• chemical testing of soils and waters;
• geotechnical testing of soils; and
• groundwater and ground gas monitoring.
The trial pits were located on a 50m spacing depending on access, but no formal grid pattern was used.
<u>Phase 16A</u>
• 2 cable percussive borehole to 8.0m bgl with installation of groundwater/ground gas monitoring wells;
• 28 trial pits to a maximum depth of 3.0m bgl;
• chemical testing of soils, waters;
• geotechnical testing of soils; and
• groundwater and ground gas monitoring.
The trial pits were located on a 50m spacing depending on access, but no formal grid pattern was used.
The rotary open hole boreholes were located to target the southern and western boundary of the development and POL21 in Phase 10.</td></tr>
<tr><td>Ground Conditions</td><td>• Topsoil – encountered across the whole of Phase 16 and 16A as well as parts of Phase 9, to depths of between 0.15m bgl and 0.30m bgl. In Phase 9 the topsoil is generally associated with</td></tr>
</table>

Encountered	landscaped areas. • Made Ground – encountered across the whole of Phase 10, generally to depths of between 0.15m bgl to 0.30m bgl as well as parts of Phase 9. Some areas of deeper made ground were encountered in the northeast (1.3m bgl) and southeast (1.6m bgl) of Phase 9 and in the central north (0.8m bgl) and east (1.2m bgl). • Made Ground in Phase 9 consisted of brown gravelly sands and clays with limestone, brick, concrete, tile and wood fragments and clayey limestone gravels with occasional concrete, hardcore and other man - made constituents (metal rods, land drains). • Made Ground in Phase 10 consisted of brown gravelly sands and clays with limestone and occasional brick and plastic fragments. • Great Oolite Group – encountered across all phases below either the Made Ground or topsoil. The Great Oolite Group was encountered to a maximum depth of >8.00m bgl. The Great Oolite Group was encountered as fine and coarse soils of weathered limestone and with depth more intact limestone strata was encountered. The limestone was encountered below the clay and gravel. • Black staining and tar odours were recorded in TP101, TP102 and TP104, all located in Phase 9. No other visual or olfactory evidence of gross contamination was recorded.
Groundwater	Groundwater was encountered during the fieldwork in TP109 at 2.60m bgl (Phase 10), TP123 at 1.80m bgl and TP124 at 3.00m bgl (Phase 16A, close to Gallos Brook) only. Post fieldwork groundwater monitoring shows levels generally around 2.00m to 3.50m bgl across much of the site. However, groundwater is recorded at 7.00m and 6.00m bgl in boreholes BH01 and BH02 respectively, and 1.50 and 1.00m bgl in boreholes BH05 and BH09 respectively. A slight hydrocarbon odour and a sheen on the groundwater were recorded in TP109 (Phase 10). The Preliminary Generic Quantitative Environmental Risk Assessment for the wider Heyford Park development, undertaken by Waterman, has confirmed the presence of underground and above ground storage tanks and confirmed the presence of locally impacted groundwater quality.
GEO - ENVIRONMENTAL ASSESSMENT AND CONCLUSIONS	
Conclusions of Contamination Generic Risk Assessment (All Data)	**Human health:** Pervasive PAH, TPH and VOC in Made Ground in Phase 9 and 10. **Plant growth:** No risk identified to Phase 9, 10, 16 and 16A. **Controlled Waters:** No risk identified to controlled waters (subject to regulatory approval). **Ground gases or vapours:** Phase 9, 16 & 16A For Phases 9, 16 and 16A the ground gas regime at the site is provisionally classified as Characteristic Situation 1 (Situation A) and Green (Situation B). However, given the potential for petroleum hydrocarbon impacted groundwater present below the site, consideration should be given for the installation of ground gas and odour mitigation measures. For Phase 10 the ground gas regime at the site is provisionally classified as Characteristic Situation 2 (Situation A) and Amber 1 (Situation B). Ground gas and odour mitigation measures for Phase 10 are presented in Section 6.6.4. **Radon:** The site is in a Radon Affected Area (1 - 3% of existing homes affected). At this concentration, radon protection is not required for Phase 9, 10, 16 and 16A based on current guidance. However, given the potential for the Northampton Sand Formation (a known radon generating stratum) to underlie the site at shallow depth, it is recommended that a bespoke BGS radon report is obtained. **Water Supply Pipes:** • Phase 16 and Phase 16A are greenfield and the assessment has indicated no exceedance of the threshold values standard pipework should be suitable for this part of the site. • Phase 9 and Phase 10 are brownfield and organic contamination (PAH and petroleum hydrocarbons) have been identified in exceedance of the threshold values. On this basis, barrier pipe is required. Confirmation of these conclusions should be sought from the water supply company at the earliest

	opportunity.
Proposed Mitigation Measures	<u>Phases 16 and 16a</u> No remedial measures (other than possible radon protection, dependant on the findings of the Site Specific Radon Assessment). However, given the potential for petroleum hydrocarbon impacted groundwater present below the site, consideration should be given for the installation of ground gas and odour mitigation measures. <u>Phases 9 and 10</u> The most suitable form of remediation to protect site users would be the installation of a cover system for gardens and public open spaces. A 600mm thick cover over an orange (or similar bright colour) bonded combined geotextile and geogrid, such as TX - G 160, to create a combined warning, separation and 'hard to dig' layer is recommended in gardens, and 450mm in public open spaces. A minimum of 150 mm of topsoil is recommended to provide a growing medium for new planting. The 'hotspots' of hydrocarbon contamination noted in TP102 and TP104 should be delineated and selectively excavated. The use of barrier pipe for potable water supplies is recommended for Phase 9 and 10. It is assumed that the redevelopment works will include removal of the former fuel tanks (in Phase 9 and 10). Any associated free phase hydrocarbons or petroleum hydrocarbon impacted soils around and below the tanks should also be removed. Validation testing of the sides and base of any resultant excavation should also be undertaken. Controlled decommissioning, decontamination and demolition of site buildings and ancillary structures such as tanks and the existing drainage system should be undertaken by suitably qualified and licensed Contractors in accordance with appropriate regulations. Ground gas mitigation measures will be required for Phase 10. These are presented in Section 6.6.4. Given the potential for petroleum hydrocarbon impacted groundwater present below Phase 9, consideration should be given for the installation of ground gas and odour mitigation measures.
GEOTECHNICAL CONCLUSIONS	
Obstructions	A concrete slab was encountered in the base of trial pit TP107 (Phase 9), at a depth of 1.1m bgl. Intact limestone is present at shallow depth across the site.
Groundworks and Earthworks	Excavation to proposed founding depth generally should be readily achievable with standard excavation plant. However, heavy duty excavation plant or even breaking equipment may be required to excavate the limestone, for example, if required for drainage etc. Water seepages into excavations are likely to be adequately controlled by sump pumping. Excavated natural soils should be reusable as a General Fill subject to suitable classification testing.
Foundations	Strip/trench fill foundations at a minimum depth of between 0.90m bgl and 1.90m bgl. An allowable net bearing pressure of 100kN/m^2 should be available on the natural soils, and at least 250kN/m^2 on the natural rock quality strata, keeping total and differential settlement within acceptable limits.
Ground Floor Slabs	Ground bearing.
Road Pavement Design (CBR)	<2.5% on Made Ground. 3% on natural fine soils. 5% on natural coarse soils.
Soakaways	The infiltration test results indicate that soakaways may be possible. However, because of the relatively slow infiltration rates in places, this will depend on the available storage capacity. Further, fully BRE365 compliant infiltration testing is required followed by detailed drainage design by a specialist to determine if soakaway drainage is possible.
Buried Concrete	Design Sulfate Class - DS-1 and ACEC Class AC-1. Equivalent to Design Chemical Class DC-1 for a 50 year design life.

Waste Management	Based on the HazWasteOnline™ output, it is considered that soils from Phase 10 are likely for the most part to be classified as non-hazardous. However, it is possible that some petroleum hydrocarbon impacted soils will be encountered, for example during the removal of fuel storage tanks, which may be hazardous for waste disposal purposes. It is considered likely that soils from the hotspots of petroleum hydrocarbons (including any contaminated soils encountered during the removal of fuel storage tanks) in Phase 9, will be classified as hazardous for waste disposal purposes. However, once these have been removed as part of the site preparation/remedial works, it is considered likely that the remaining soils will be classified as non-hazardous. All natural material (Great Oolite Group) from Phase 16 and 16A is considered to be inert. This should be confirmed by undertaking a visual and olfactory assessment at the time of excavation. Prior to disposal, the characteristics of any excavated soils will need classification in consultation with landfill sites and waste disposal contractors. Waste Acceptance Criteria (WAC) Testing on the actual soil arisings, which will constitute the waste, will be required.
FUTURE CONSIDERATIONS	
Uncertainties and Limitations	Large parts of Phase 9 were inaccessible at the time of the investigation due to existing buildings and infrastructure, and material/soil storage for the larger Heyford Park development. It was not possible to excavate close to any of the buried tanks in Phases 9 and 10 due to buried services. Some areas of Phase 10 were inaccessible at the time of the investigation due to stands of large trees and buried services.
Further Work	The following further works will be required: • Removal of all underground and above ground storage tanks. • Removal of any impacted soils and groundwater associated with the fuel storage tanks, including validation sampling and testing. • Infiltration rate testing in accordance with BRE365 followed by detailed drainage design by a specialist , if soakaway drainage is being considered. • Discussions with service providers regarding the materials suitable for pipework etc. • Discussions with regulatory bodies regarding the conclusions of this report. • Foundation depth in relation to trees assessment, following a tree survey to BS 5837:2012. • An asbestos survey of the former buildings and other structures on Phase 9 and Phase 10 (if not already undertaken).

This Executive Summary forms part of Hydrock Consultants Limited report number HPW - HYD - MS - ZZ - RP - G - 0001 (Issue 1) and should not be used as a separate document.

1.0 INTRODUCTION

1.1 Terms of Reference

In October 2016, Hydrock Consultants Limited (Hydrock) was commissioned by Dorchester Living (HS - 1999/00139) to undertake a desk study and initial ground investigation at Phases 9, 10, 16 and 16A of the Heyford Park development, Camp Road, Upper Heyford, Bicester, Oxfordshire, OX25 5TB

The site covers an area of approximately 32 hectares, divided into four Phases as shown in Table 2.2. It comprises an abandoned/derelict school associated with the former Upper Heyford air base (Phase 9); an area of open ground and infrastructure, including three large above ground fuel tanks, known as POL 21, to the south of the former air base site (Phase 10) and two arable fields (Phases 16 and 16A).

The proposed development is understood to comprise residential housing with associated gardens, infrastructure and areas of public open space.

A site location plan (Drawing HPW - HYD - MS - ZZ - DR - GE - 0001) is presented in Appendix A.

1.2 Objectives

The objectives of this investigation are to assess the ground and groundwater conditions to provide initial geotechnical design recommendations and to carry out a risk assessment of potential chemical contaminants to establish 'suitability for use' under the current planning regime.

1.3 Scope

The scope of work for this commission comprises:

- a desk study and site walk - over reconnaissance to determine the nature of the site and its surroundings including current and former land uses, geology, hydrogeology, hydrology and geo - environmental data;
- an initial ground investigation including trial pitting, rotary drilling, gas and groundwater monitoring, laboratory chemical and geotechnical testing; and
- reporting on findings of the desk study, ground investigation, geo - environmental assessment of the site conditions and geotechnical interpretation of the ground and groundwater conditions.

See Appendix H for detailed reporting methodology.

1.4 Provided Information

Hydrock has been provided with the following by Dorchester Living, for use in the preparation of this report:

- Waterman Energy, Environment and Design Ltd. May 2012. 'Preliminary Generic Quantitative Environmental Risk Assessment'. Ref: EED10658 - 13.2.2_FA.

  This report covers the wider Heyford Park development including Phase 9 and Phase 10, but not Phase 16 or 16A.
- Dorchester Holdings. 16th February 2012. 'Layout Plan and Indicative Location of Buried Services'. Drawing E10658 - 109 - Issue A02
- Cube Surveys. 2nd August 2016. 'Layout Plan and Utility Survey'. Drawing CUB - RBS - DL - 004.
- Cube Surveys. 7th October 2016. 'Layout Plan and Utility Survey'. Drawing CUB - RBS - DL - 005.
- Cube Surveys. 10th October 2016. 'Layout Plan and Utility Survey'. Drawing CUB - RBS - DL - 006.

1.5 Approach

The work has been carried out in general accordance with recognised best practice as detailed in guidance documents such as the CLR 11 M*odel Procedures* (Environment Agency 2004), the AGS (2006) *Good Practice Guidelines for Site Investigations*, BS 5930:2015 and BS 10175:2011+A1:2013. The technical details of the approach and the methodologies adopted are given in Appendix H.

A recognised phased approach has been followed, starting with a desk study and walkover to produce a preliminary assessment of the site conditions and the important factors that require further investigation to reduce uncertainty.

Phase 2 comprises intrusive investigation work and testing. The factual data from Phases 1 and 2 are used to develop a conceptual site model (CSM). This comprises a ground model (of the physical conditions) and an exposure model (of the possible contaminant linkages). The CSM forms the basis for a number of risk assessments in accordance with current guidelines. Professional judgement is then used to evaluate the findings of the risk assessments and to provide recommendations for the project.

By convention, the geo - environmental and the geotechnical aspects are discussed in separate sections, but in instances where interaction is required to produce a holistic design, this is discussed at the end of the geotechnical recommendations section.

Remaining uncertainties and recommendations for further work are listed at the end of the report.

2.0 PRELIMINARY INVESTIGATION (PHASE 1 STUDY)

A number of desk study sources have been used to assemble the following information, including a proprietary environmental data report, obtained for the site (dated 26th October 2016), which is presented in Appendix D.

Hydrock has also been provided with a Preliminary Generic Quantitative Environmental Risk Assessment for the wider Heyford Park development, undertaken by Waterman Energy, Environment and Design Ltd (Ref: EED10658 - 13.2.2_FA). This report includes Phases 9 and 10, but not Phases 16 and Phase 16A.

2.1 Site Referencing

The site is referenced in Table 2.1.

Table 2.1: Site Referencing Information

Item	Brief Description
Site name	Heyford Park – Western Developments, Phase 9, 10, 16 and 16A
Site location and grid reference	Phase 9 and 10 are accessed from Camp Road. Phase 16 and 16A are accessed via a track from Kirtlington Road. The post code for the centre of the site (Phase 9) is OX25 5AB. The National Grid Reference for the centre of the site is 450385E, 225734N.

A site location plan is provided in Appendix A (Drawing HPW - HYD - P15 - ZZ - DR - GE - 0001).

2.2 Site Description and Walk - Over Survey

A walkover survey was undertaken on 2nd November 2016 to visually assess potential hazards and receptors. A basic site description is presented in Table 2.2 and selected walkover photographs are presented in Appendix B.

Table 2.2: Site Description

Item	Brief Description
Site access	Phase 9 and 10 are accessed from Camp Road. Phase 16 and 16A are accessed via a track from Kirtlington Road.
Site area	Phase 9: Approximately 11.5 ha. Phase 10: Approximately 3.8 ha. Phase 16: Approximately 8.2 ha. Phase 16A: Approximately 8.7 ha.
Elevation, topography and any geomorphic features	Phase 9 is generally flat lying. Phase 10 is flat lying with the exception of three large, connected, above ground fuel tanks (known as POL21). These cover a surface area of approximately 3,270 m^2 and are approximately 7m in height. Phase 16 and Phase 16A are generally level. However, they slope gently towards a stream and ditch, which separate the two phases.

Item	Brief Description
Present land use	Phase 9 is an abandoned school, with associated buildings and infrastructure, formerly associated with the former Upper Heyford air base. Phase 10 is currently open ground and infrastructure situated to the south of the main former air base site and includes three large above ground fuel tank, known as POL 21. Phases 16 and 16 A are arable fields. A public footpath which crosses Phase 16A diagonally from the northwestern boundary with Kirtlington Road, to the southern boundary.
Vegetation	Phase 9: There are numerous trees and large shrubs across the area. Most notably around the northern parts of the site, where there are areas of landscaping; along the northern boundary with Camp road where there is a hedge and large mature trees; and around the former school buildings. In addition the areas of soft standing are very overgrown with shrubs, brambles and long grass. The western boundary of Phase 9 (which bounds Kirtlington Road) is a mature hedge. Phase 10: There is a hedge present along the whole southern boundary of Phase 10 with Camp Road, and a number of large mature trees across the site. Phase 16 and 16A: The western boundary of Phase 16 (which bounds Kirtlington Road) is a mature hedge. Along the eastern boundary of Phase 16A (which bounds Tait Drive) there are trees, just beyond the site boundary. Between Phased 16 and 16A there is a mature hedge which runs along the edge of the stream.
General site sensitivity	The site includes commercial, industrial and former military land, and arable farmland. Gallos Brook flows between Phases 16 and 16A. It is understood that this stream is culverted through the northeastern part of Phase 9.
Site boundaries and surrounding land	Phase 9 is bounded to the north by a chain link fence and hedge, along Camp Road and to the north east by temporary fencing along Izzard Road, with a flat area (understood to be the site of a future sports field) beyond. It is bounded to the west by a mature hedge at the edge of Kirtlington Road, and to the south by a chain link fence, and some shrubs, with Phases 16 and 16A beyond. The eastern site boundary is the eastern side of Homestead Road. To the south east the site is bounded by a fence which separates the site from a school sports field. Phase 10 is part of the southern part of the former air base site. It is bounded to the south by a chain link fence and mature hedge along Camp Road and to the east by temporary fencing with a partially completed residential housing development beyond. There are commercial and industrial buildings to the north and west, as well as former buildings and infrastructure associated with the former air base. The northern and western site boundaries are not physically marked. Phase 16 is bounded to the north by a chain link fence and occasional mature shrubs, with Phase 9 and the school sports field beyond. Gallos Brook and a mature hedge form the western boundary, with Phase 16A beyond. The southern boundary is a track with arable fields beyond. The eastern boundary is a chain link fence with Tait Drive and existing residential dwellings, beyond. Phase 16A is bounded to the north by a chain link fence and occasional mature shrubs, with Phase 9 and the school sports field beyond. Gallos Brook and a mature hedge form the eastern boundary, with Phase 16 beyond. The site is bounded to the west by a mature hedge, with Kirtlington Road beyond. The southern boundary is a track with arable fields beyond.

2.3 Site History

A study of historical Ordnance Survey maps (presented in Appendix C) has been undertaken to identify former land uses at the site and surrounding areas which may have geotechnical or geo - environmental implications for the proposed development. The rsults are summarised in Table 2.3.

Note that it is common for military sites not to be shown on Ordnance Survey maps and so details of sites with military or security significance may not be picked up in this review.

Table 2.3: Key Features from Historical Mapping

Map Edition and Scale	Key Features on Site	Key Features off Site
1875: 1:2,500 1875 - 1880: 1:10,560	The site is open fields, with Camp Road and Kirtlington Road shown in their current positions (althopugh unnamed). A stream/drainage channel (later identified as Gallos Brook) flows north - south through Phase 9 and between Phases 16 and 16A.	The village of Upper Heyford is seen to the west of the site. A quarry is noted adjacent to the southern boundary of Phase 16A, with a second approximately 200m to the east of the site, on the southern side of Camp Road. There is a wood to the east of the site, with a third quarry to the southeast of it, and a well to the southwest.
1875: 1:2,500 1919 - 1923: 1:10,560	No significant change.	The quarry adjacent to the southern boundary of Phase 16A is now slightly larger in size. A large allotment is now noted adjacent to the north west boundary of the Phase 9.
1954 1:10,560	*This map is blank around the site and the present day location of the Upper Heyford air base. This area is marked as 'Airfield'.*	
1965: 1:10,560	Infrastructure associated with the Upper Heyford airfield cover Phases 9 and 10. There is no significant change to Phases 16 and 16A.	Upper Heyford airfield is now shown to the north and east of the site. A 'Works', which looks to be a sewage treatment facility, is shown to the east. A quarry is noted to the north of Phase 9 (west of Phase 10)
1974 - 1975: 1:2,500 1979 - 1981 1:10,000	Phase 9 is now shown as Upper Heyford American Elementary School. The site layout is as seen today. Tanks are noted to southeast of Phase 9. There is a raised/covered feature noted in the south of Phase 9, to the south of the boiler house. This is not labelled but could possibly be a covered, above - ground reservoir, or an air raid shelter. The stream/drainage channel is referred to as a 'Pipeline'. Further infrastructure associated with the airfield, is shown across Phase 10. The tanks to the south of Phase 10 are shown in the location of present day tanks.	More buildings and infrastructure are noted to the north and east of the site, associated with the air base. The area adjacent to the eastern boundary of Phase 9 is shown as sports facilities, associated with the Upper Heyford air base. Tanks are present adjacent to the northern boundary of Phase 9 (west of phase 10) and adjacent to the north-eastern boundary of phase 9 (south of Phase 10). The quarry adjacent to the southern boundary of Phase 16A is no longer noted on the maps. Camp Road is now named.

Map Edition and Scale	Key Features on Site	Key Features off Site
	Phase 16 and 16A – no change.	
1992 1:10,000	No significant change.	No significant change.
1994 1:10,000	The raised/covered feature to the south of Phase 9 is no longer shown.	No significant change.
2002 1:10,000	POL 21 A, B and C are now shown.	No significant change.
2014 1:10,000	No significant change.	No significant change.

While not shown on the historical maps, research has indicated that the surrounding land has had a military use from as early as 1916, when it was used by the Royal Flying Corps. From 1918 the Royal Flying Corps was merged with the Royal Naval Air Service to become the RAF, at which point the RAF took over control of the site air base.

The United States Air Force took over the running of the air base from 1950 until it was closed in 1994.

2.4 Unexploded Ordnance/Bombs

In general accordance with CIRIA Report C681 (Stone *et al* 2009) non-specialist UXO screening exercise has been carried out for the site. Screening against the Zetica regional bomb risk map (Oxfordshire) indicates the site to be in an area where the bomb risk is low.

As the site is adjacent to a former military facility, a specialist UXO Desk Top Study has been commissioned (presented in Appendix D), which confirms that the UXO risk at the site is low.

2.5 Geology

The general geology of the site area is shown on the 1:50,000 geological map of Chipping Norton (Sheet 218) to be Jurassic Great Oolite Group strata. These are described as limestone interbedded with mudstones and clay; weathering to clay, sand and gravels.

2.6 Mining or Mineral Extraction

The site is not within an area of recorded mining. However, the historical maps and environmental data report show a number of quarry workings/excavations close to the site. These are detailed below:

- Unspecified Quarry and infilled land, located to the south of the site, adjacent to the southern boundary of Phase 16A.
- Refuse Heap, 220m to the west of the site.
- Limestone abstraction, 426m to the east of the site.

2.7 Hydrogeology

The Great Oolite Group is designated on the Environment Agency interactive aquifer designation map as a Principal aquifer. These are described as 'geology of high intergranular and/or fracture permeability, usually providing a high level of water storage and may support water supply/river base flow on a strategic scale'.

Given the interbedded nature of the Great Oolite Group it is likely that groundwater will be encountered within the limestone deposits, but not in the mudstone or clay layers.

It is possible that the groundwater will be in hydraulic continuity with the surface water bodies.

The site is not within a within a groundwater Source Protection Zone (SPZ). However, there is one licensed groundwater abstraction within 1km of the site. This is located 510m to the west. and is for drinking, cooking, sanitary, washing – household, general farming and domestic. However, it is marked as 'historical' suggesting it is no longer in use.

The site is covered by soils of high leaching potential.

2.8 Hydrology and Flooding

The surface water features in the vicinity of the site are listed in Table 2.4 and, where appropriate, are marked on the Site Zonation Plan in Appendix A.

Table 2.4: Surface Water Features

Feature	Location Relative to Site
Gallos Brook, Tertiary River	On site, between Phases 16 and 16A There is historical evidence that Gallos Brook extended north thorough Phase 9 and the former sports fields towards Camp Road. There is also evidence from service plans that Gallos Brook has been culverted between Camp Road and the North of Phase 16 and 16A.
Unnamed Secondary River – This is not visible on site and is potentially culverted.	Along the eastern boundary of Phase 16

There are no licensed surface water abstractions within 1km of the site.

Given the gentle slope between Phase 16 and Phase 16A, which fall towards Gallos Brook, and given the expected ground conditions of the Great Oolite Group it is likely that surface water will both drain into the ground and run off into the brook.

Given the expected ground conditions it is possible that the groundwater is in hydraulic continuity with Gallos Brook, situated between Phase 16 and Phase 16A.

The desk study information indicates the proposed development is in Flood Zone 1 (with a low probability of flooding).

The environmental data report indicates a low risk of groundwater flooding.

No further consideration of flood risk is undertaken in this report. Specialist flood risk advice should be sought with regards to drainage and flooding.

2.9 Waste Management and Hazardous Substances

The environmental data report indicates no waste management sites recorded within 250m of the site. However, a historical refuse heap, dated 1880 is shown 220m to the west of the site on the historical OS mapping. Furthermore, the environmental data report has highlighted historical quarry workings adjacent to the southern boundary of Phase 16A. These quarry workings are not visible and it is assumed that they have been backfilled.

There are no records relating to the storage of radioactive materials within 1km of the site.

There are no records of prosecutions relating to authorised processes in the vicinity of the site.

There is a Current COMAH Site 448m to the east of the site, registered to Heyford Park Management Company Limited, Southern Bomb Store. There is also a historical COMAH site 343m south of the site, registered to Black Cat Fireworks Ltd. The Health and Safety Executive produces risk maps incorporating inner, middle and outer zones (HSE Consultation Zones), the size of which will vary depending on the nature of the site and the perceived hazard. Depending on the sensitivity of the development, the HSE will advise against granting planning permission for developments within particular zones. This advice is only provided to Local Planning Authorities (LPA) via the PADHI+ software decision support tool (planning advice for developments near hazardous installations). PADHI can be used to obtain HSE's advice on pre-planning enquiries (PPEs) in a similar way as formal consultations on planning applications, provided sufficient information is available. Hydrock recommends the LPA is contacted at the earliest opportunity.

There are a number of industrial processes operating in the surrounding area. However, as long as these have been operated in accordance with any applicable licence, no impact on the site is envisaged.

2.10 Previous Evidence of Known Contamination Events

The environmental data report indicates no known pollution incidents within 500m of the site.

The Preliminary Generic Quantitative Environmental Risk Assessment for the wider Heyford Park development, undertaken by Waterman Energy, Environment and Design Ltd (Ref: EED10658 - 13.2.2_FA), has confirmed the presence of underground and above ground storage tanks and confirmed the presence of locally impacted groundwater quality. The Waterman report assessed the quality of the groundwater impact in relation to the new settlement area. The Waterman report also indicates that groundwater quality across much of the site remains relatively good. It is understood that the Waterman report gained sign off from the relevant regulatory bodies. It is also understood that removal of the POL system is a condition of the planning permission (Ref: APP/C3105/A/08/2080594, dated 27th October 2010).

The Waterman report also states that Made Ground is present across much of the wider Heyford Park development, but analysis of soil samples indicates that inorganic and organic contamination was associated with the Made Ground, but the underlying natural material was not significantly impacted.

2.11 Natural Soil Chemistry

Information contained within the environmental data report (presented in Appendix D) gives indicative natural concentration values (estimated) for the natural soils at the site for a selection of Contaminants of Potential Concern (CoPC). These have been reproduced in Table 2.5.

Table 2.5: Natural Soil Chemistry (mg/kg)

Element	Arsenic	Cadmium	Chromium	Lead	Nickel
Concentration (mg/kg)	15 - 25	<1.8	60 - 90	<100	15 - 30

2.12 Radon

The environmental data report indicates that the site is in a Radon Affected Area where recorded radon levels in 1 - 3% of homes are above the action level. However, given the close proximity of the site to outcropping Northampton Sand Formation (a known radon generating strata) and therefore the likelihood of Northampton Sand Formation strata underlying the site at shallow depth, it is recommended that a bespoke BGS radon report be obtained to confirm if protection is recommended.

3.0 PRELIMINARY CONCEPTUAL SITE MODEL

3.1 Physical Setting

The preliminary ground model of the site is the basis of the understanding of the ground conditions that will inform the geo - environmental exposure model and the geotechnical hazard assessment.

3.1.1 Location and Site History

The site is situated on the western side of the former Upper Heyford air base. Phase 9 consists of abandoned school buildings and infrastructure associated with the air base. Phase 10 comprises buildings and infrastructure (including three large above ground fuel tanks known as POL 21) associated with the former air base. Phase 16 and 16A are currently arable fields located to the south east of the former air base.

Research has indicated that the surrounding land has had a military use (air base) from 1918 until it was closed in 1994.

3.1.2 Landscape and Topography

The site is relatively flat lying, with the exception of Phase 10, which is dominated by the above ground, soil covered POL 21. This a fuel storage area approximately 3,270m^2 in area and approximately 7m in height. Phase 16 and Phase 16A slope gently towards the stream, which separates the two phases.

3.1.3 Geology

Phases 9 and 10 are likely to be underlain by either a thin layer of Topsoil or Made Ground, over granular or cohesive material (weathered limestone), over a substantial thickness of limestone interbedded with mudstones and clay, weathering to clay, sand and gravels.

Made Ground is likely to be present in Phases 9 and 10, due to historical and current development.

3.1.4 Hydrology and Drainage

The primary natural drainage features is Gallos Brook, which runs between Phases 16 and 16A. Phase 16 and Phase 16A both slope gently down toward this stream.

There are no licensed surface water abstractions within 1km of the site.

3.1.5 Hydrogeology

The Great Oolite Group is classed by the Environment Agency as a Principal Aquifer. However, the site is not within a source protection zone. Groundwater may be in hydraulic continuity with the surface water.

3.2 Geo-environmental Exposure Model

The preliminary exposure model is used for geo - environmental hazard identification and establishing potential contaminant linkages based on the contaminant - pathway - receptor approach.

3.2.1 Potential Contaminants

For the purpose of this assessment the potential contaminants have been separated according to whether they are likely to have originated from on-site or off-site sources.

Potential On-Site Sources of Contamination

- Made Ground possibly including metals, metalloids, asbestos, PAH and petroleum hydrocarbons.
- Hydrocarbon fuels and lubricants associated with the fuel storage tanks and former land use.
- VOCs and SVOCs associated with the former land use.
- Ethylene glycol – potentially used as a de-icer on Phase 10, which forms part of the main former air base.

The Preliminary Generic Quantitative Environmental Risk Assessment for the wider Heyford Park development, undertaken by Waterman, has confirmed the presence of underground and above ground storage tanks and confirmed the presence of locally impacted groundwater quality.

Potential Off-Site Sources of Contamination

- Hydrocarbons fuels and lubricants associated with the POLs and other fuel storage tanks.
- Quarry backfill adjacent to the southern boundary of Phase 16A possibly including metals, metalloids, asbestos, PAH and petroleum hydrocarbons.
- Ground gas from nearby backfilled quarries.
- Ethylene glycol – potentially used as a de-icer on the air base runway and associated infrastructure.

The Preliminary Generic Quantitative Environmental Risk Assessment for the wider Heyford Park development, undertaken by Waterman, has confirmed the presence of underground and above ground storage tanks and confirmed the presence of locally impacted groundwater quality.

3.2.2 Potential Receptors

The following potential receptors have been identified.

- Humans (neighbours, site end users).
- Development end use (buildings, utilities and landscaping).
- Groundwater: Principal aquifer status of the Great Oolite Group.
- Surface water: Gallos Brook.

It should be noted that health and safety risks to site contractors and maintenance workers have not been assessed during these works and will need to be considered separately.

3.2.3 Potential Pathways

The following potential pathways have been identified.

- Humans: ingestion, skin contact, inhalation of dust and indoor air.
- Buildings: methane ingress via permeable soils and/or construction gaps.
- Plant life: root uptake.
- Underlying groundwater: migration of contaminants into the Great Oolite Group strata.
- Surface water: overland flow.
- Surface water: base flow from groundwater.

3.3 Geotechnical Hazard Identification

Potential geotechnical hazards based on the expected ground conditions are listed below.

- Uncontrolled Made Ground – excessive settlement (creep and inundation settlement or differential settlement) of foundations, roads, and infrastructure elements.
- Low strength, compressible ground – excessive settlement of foundations, roads, and infrastructure elements.
- Attack of buried concrete by aggressive ground conditions – the development site may contain unknown Made Ground and potentially sulfate bearing soils.
- Shrinkage/swelling of clay – settlement/heave of foundations when located within the influence of trees and vegetation.

4.0 GROUND INVESTIGATION

4.1 Investigation Rationale

The ground investigation rationale is based on the findings of Hydrock's preliminary risk assessment for Phase 9, 10, 16 and 16A as well as the findings of the Preliminary Generic Quantitative Environmental Risk Assessment for the wider Heyford Park development, undertaken by Waterman Energy, Environment and Design Ltd (Ref: EED10658 - 13.2.2_FA).

The ground investigation rational is summarised in Table 4.1.

Table 4.1: Investigation Rationale

Exploratory Holes	Purpose
Phase 9	
Trail Pits TP01 to TP15, TP101 to TP108 and TP132 to TP134	To assess shallow ground conditions. To allow collection of samples for contamination analysis. To allow collection of samples for geotechnical testing. Nominal 50m spacing depending on access, but no formal grid pattern. Targeted around fuel tanks in the centre of the site.
Rotary Open Hole boreholes BH01 to BH04	To allow for the installation of groundwater and ground gas monitoring wells. To allow collection of groundwater samples for contamination analysis. Locations selected to target southern and western boundary of the Heyford Park development.
Soil Infiltration Test SA04 to SA06	To assess shallow ground conditions. To provide information to assist in the design of the drainage strategy. To assess shallow ground conditions. To allow collection of samples for contamination analysis. To allow collection of samples for geotechnical testing.
Phase 10	
Trail Pits TP109 and TP126 to TP131	To assess shallow ground conditions. To allow collection of samples for contamination analysis. To allow collection of samples for geotechnical testing. TP 128, TP129, TP130, TP131 and SA07 targeted around POL 21 and TP109, TP127 and SA08 to give good spatial coverage.
Rotary Open Hole boreholes BH05 and BH10 to BH14	To allow for the installation of groundwater and ground gas monitoring wells. To allow collection of groundwater samples for contamination analysis. Locations selected to target POL 21 (BH10, BH11, BH12, BH13 and BH14) and western boundary of the Heyford Park development (BH05).
Soil Infiltration Test SA07 to SA08	To assess shallow ground conditions. To provide information to assist in the design of the drainage strategy. To assess shallow ground conditions. To allow collection of samples for contamination analysis. To allow collection of samples for geotechnical testing.
Phase 16	

Exploratory Holes	Purpose
Trail Pits TP144 to TP152 and TP154 to TP169	To assess shallow ground conditions. To allow collection of samples for contamination analysis. To allow collection of samples for geotechnical testing. Nominal 50m spacing depending on access, but no formal grid pattern.
Rotary Open Hole boreholes BH08 and BH09	To allow for the installation of groundwater and ground gas monitoring wells. To allow collection of groundwater samples for contamination analysis. Locations selected to target southern boundary of the Heyford Park development.
Soil Infiltration Test SA01 to SA03	To assess shallow ground conditions. To provide information to assist in the design of the drainage strategy. To assess shallow ground conditions. To allow collection of samples for contamination analysis. To allow collection of samples for geotechnical testing.
Phase 16A	
Trail Pits TP16 to TP26, TP110 to TP125 and TP153	To assess shallow ground conditions. To allow collection of samples for contamination analysis. To allow collection of samples for geotechnical testing. Nominal 50m spacing depending on access, but no formal grid pattern.
Rotary Open Hole boreholes BH06 and BH07	To allow for the installation of groundwater and ground gas monitoring wells. To allow collection of groundwater samples for contamination analysis. Locations selected to target southern and western boundary of the Heyford Park development.

4.2 Ground Gas Regime

There are several backfilled quarries close to the site and underground fuel tanks on site, all of which are potential gas/vapour sources.

It is assumed that the buried tanks will be removed from site prior to redevelopment and so should not present a risk to site users.

It is judged from the available evidence that the gas generation potential at the site is low. Therefore, three gas monitoring visits were carried out over two months. The results are presented in Appendix G and discussed further in Section 4.7 and 6.6.

4.3 Site Works

The fieldwork took place between 2nd and 14th November 2016 and is summarised in Table 4.2. The approximate site investigation locations (surveyed in using a tape measure from landmarks) are shown on the Ground Investigation Plan in Appendix E.

The logs, including details of ground conditions, soil sampling, *in situ* testing and any installations, are presented in Appendix E.

The weather conditions during the fieldwork and for the previous week were mainly dry with some light rainy conditions during the site works.

Table 4.2: Summary of Site Works

Activity	Method	No.	Depth Range	*In Situ* Tests	Notes (e.g. Installations)
Boreholes	Rotary open hole	14	8m bgl	-	Locations selected to target southern and western boundary of the Heyford Park development and POL 21. 63mm HDPE wells with gas taps in all holes.
Trial pits	Machine (wheeled backhoe excavator)	94	1.8 – 3.0m bgl	-	-
Infiltration Testing	Hydrock in-house testing within trial pits	8	1.5 – 2.1m bgl	Infiltration tests	

4.3.1 Sampling Strategy and Protocols

The trial pits were in the most part set out on an approximate 50m grid and then moved slightly dependent on access conditions. In some instances the trial pits were located to target certain potential contaminant sources, for example the buried tanks associated with the boiler house in Phase 9.

The rotary open holes were drilled to allow for the installation of groundwater monitoring installations. Rotary holes in Phase 9 were located to assess the groundwater conditions at the southern and western extents of the larger Heyford Park development. Rotary holes in Phase 10 were undertaken to both assess the groundwater conditions at the western extent of the larger Heyford Park development as well as to target POL 21. Rotary holes in Phase 16 and 16A were undertaken assess the groundwater conditions at the southern and western extents of the larger Heyford Park development.

Samples were taken stored and transported in general accordance with BS 10175:2011+A1:2013.

4.3.2 Geo-environmental Monitoring

Groundwater and gas monitoring boreholes have been monitored on three occasions to date. The results are presented in Appendix G. On one of these visits the boreholes were monitored for the presence and thickness of oil/hydrocarbons.

4.4 Laboratory Testing

4.4.1 Geo-environmental Laboratory Analyses

The geo-environmental analyses undertaken on soils are summarised in Table 4.3 and the chemical test certificates are provided in Appendix I. Where possible, UKAS accredited procedures have been used.

Table 4.3: Summary of Sample Numbers for Geo-environmental Analyses of Soils

Determinand Suite (see Appendix H for Details of Suites)	Made Ground	Topsoil	Great Oolite Group
Hydrock default suite of determinands for solids	22	19	3
Total petroleum hydrocarbons by GC-FID (Hydrock Level 2 suite)	23	19	7
Benzene, toluene, ethylbenzene and xylene (BTEX) by GC-MS)	23	19	7
Volatile organic compounds (VOC target list plus TIC by GC-MS	7	5	-
Semi-volatile organic compounds (SVOC target list plus TIC by GC-MS)	7	5	-

The geo - environmental analyses undertaken on samples of groundwater and surface water are summarised in Table 4.4.

Table 4.4: Summary of Sample Numbers for Geo - environmental Analyses of Waters

Determinand Suite (see Appendix H for Details of Suites)	Groundwater	Surface Water
Gropundwater		
Hydrock default suite of determinands for waters	13	-
Total petroleum hydrocarbons by GC - FID (Hydrock Level 2 suite)	13	-
Benzene, toluene, ethylbenzene and xylene (BTEX) by GC - MS)	13	-
Volatile organic compounds (VOC target list plus TIC by GC - MS	5	-
Semi - volatile organic compounds (SVOC target list plus TIC by GC - MS)	5	-
Ethylene Glycol	6	-
Surface water (Gallos Brook)		
Hydrock default suite of determinands for waters	-	2
Total petroleum hydrocarbons by GC-FID (Hydrock Level 2 suite)	-	2
Benzene, toluene, ethylbenzene and xylene (BTEX) by GC-MS)	-	2

4.5 Geotechnical Testing

The tests undertaken are summarised in Table 4.5 and the geotechnical test certificates are provided in Appendix F. Where possible, UKAS accredited procedures have been used.

Table 4.5: Summary of Sample Numbers for Geotechnical Tests

Test	Made Ground	Topsoil	Great Oolite Group
Natural moisture content	3	-	28

Test	Made Ground	Topsoil	Great Oolite Group
Atterberg limits determination (definitive)	2	-	24
Particle size distribution (Wet Sieve)	3	-	28
Sulfate and aggressive chemical environment classification for buried concrete classification (full BRE SD1 suite)	2	6	21

4.6 Constraints and Limitations

The following restrictions limited the access for the intrusive investigation:

- Existing buildings (Phase 9).
- Material storage (Phase 9).
- Stockpiles of soil and crushed concrete (in the south of Phase 9).
- Existing tanks and buried services (Phases 9 and 10).
- Existing vegetation (Phases 9 and 10).

5.0 GROUND INVESTIGATION RECORDS AND DATA

5.1 Physical Ground Conditions

5.1.1 Introduction

The following presents a summary of the properties of the ground and groundwater conditions encountered, based on field observations, interpretation of the field data and laboratory test results, taking into account drilling, excavation and sampling methods, transport, handling and specimen preparation.

All relevant data from the Hydrock investigation detailed in Section 4.0 are used from this point forward. Derived[1] geotechnical parameters are presented also.

For the purposes of property designation, soils are divided into fine soils (clays and silts) and coarse soils (sands, gravels, cobbles and boulders) in accordance with BS 5930.

Soil plasticity class for fine soils is based on the classification system of BS 5930, adopting modified plasticity index values (based on percentage passing 425 µm sieve). Volume change potential of fine soils on change of moisture content has been assessed using guidance provided in NHBC Standards.

5.1.2 Summary of Strata Encountered

Details are provided in the logs in Appendix E, a summary is presented in Table 5.1 and the individual strata are described in the sections below.

Table 5.1: Strata Encountered

Stratum	Brief Description	Depth to Top (m bgl)	Depth to Base (m bgl)	Thickness (m)
Phase 9				
Topsoil	Brown sandy gravelly clay or clayey gravelly sand. Gravel was fine to coarse angular to sub-rounded limestone.	0.00	0.15 – 0.30	0.15 – 0.30
Made Ground	Surfacing including asphalt and concrete. Brown gravelly sands and clays with limestone, brick, concrete, tile and wood fragments. Clayey limestone gravels with occasional concrete, hardcore and other man-made constituents (metal rods, land drains).	0.00	0.05 – 1.60	0.05 – 1.60

[1] **Derived values** of geotechnical parameters and/or coefficients are obtained from test results, by theory, correlation or empiricism in line with BS EN 1997-2:2007, Section 1.6.

Stratum	Brief Description	Depth to Top (m bgl)	Depth to Base (m bgl)	Thickness (m)
Great Oolite Group	Brown sandy gravelly clay with occasional limestone cobbles. Gravel is fine to coarse angular to subrounded limestone. Light grey and brown fine to coarse angular to subrounded gravel of limestone with occasional cobbles of limestone. Yellow brown clayey sand with occasional limestone gravel. Light grey or light brown limestone recovered as gravel and cobble sized fragments in a matrix of clayey sand or sandy clay.	0.05 – 1.60	>8.00 (base not proven)	>7.95 (thickness not proven)
Phase 10				
Made Ground	Brown gravelly sands and clays with limestone and occasionally brick fragments and plastic fragments.	0.00	0.10 – 1.20	0.10 – 1.20
Great Oolite Group	Brown and yellow brown sandy gravelly clay with occasional limestone cobbles. Gravel is fine to coarse angular to subrounded limestone. Light grey and brown fine to coarse angular to subrounded gravel of limestone with occasional cobbles of limestone. Light brown silty sand. Light orange brown gravelly clayey silt. Gravel is fine subangular limestone. Light grey or light brown limestone recovered as gravel and cobble sized fragments in a matrix of clayey sand or sandy clay.	0.10 – 1.20	>8.00 (base not proven)	>7.90 (thickness not proven)
Phase 16				
Topsoil	Brown sandy gravelly clay or clayey gravelly sand. Gravel was fine to coarse angular to sub-rounded limestone.	0.00	0.20 – 0.30	0.20 – 0.30
Great Oolite Group	Brown, yellow brown and orange brown sandy gravelly clays with occasional limestone cobbles. Gravel is fine to coarse angular to subrounded limestone. Light brown clayey sandy fine to coarse angular to subrounded gravel of limestone. Light grey or light brown limestone recovered as gravel and cobble sized fragments in a matrix of clayey sand or sandy clay.	0.20 – 0.30	>8.00 (base not proven)	>7.80 (thickness not proven)
Phase 16A				
Topsoil	Brown sandy gravelly clay or clayey gravelly sand. Gravel is fine to coarse angular to subrounded limestone.	0.00	0.20 – 0.40	0.20 – 0.40

Stratum	Brief Description	Depth to Top (m bgl)	Depth to Base (m bgl)	Thickness (m)
Great Oolite Group	Light brown, light grey and orange brown sandy gravelly clays. Gravel is fine to coarse angular to subrounded limestone. Brown and yellow brown clayey sandy fine to coarse angular to subrounded gravel of limestone with occasional cobbles of limestone. Brown clayey gravelly sand. Gravel is fine to coarse angular to subrounded limestone. Light grey or light brown limestone recovered as gravel and cobble sized fragments in a matrix of clayey sand or sandy clay.	0.20 – 0.40	>8.00 (base not proven)	>7.80 (thickness not proven)

5.1.3 Topsoil

For the purposes of this report, topsoil is defined as the upper layer of an *in situ* soil profile, usually darker in colour and more fertile than the layer below (subsoil), and which is a product of natural chemical, physical, biological and environmental processes, but does not imply compliance with BS 3882:2015.

Topsoil was encountered on Phase 9, particularly associated with the western and north central parts of the site where soft standing and trees and shrubs are present. Topsoil was also encountered occasionally around the middle of the site associated with areas of grass between buildings. Topsoil was also encountered across the whole of Phase 16 and 16A.

Topsoil was encountered as brown sandy gravelly clay or clayey gravelly sand. Gravel is fine to coarse angular to sub-rounded limestone.

In TP19 in Phase 16A a small amount of glass was found in the topsoil, but this is considered to be associated with the agricultural use of this part of the site.

5.1.4 Made Ground

Made Ground was encountered across much of Phase 9, in particularly associated with the abandoned school buildings in the centre of the site; much of the eastern area of Phase 9, and the whole of Phase 10.

It was generally recorded to depths of approximately 0.15 – 0.30m bgl. However, deeper Made ground was noted in TP132 (1.30m bgl - in the northeast of Phase 9) , TP105 (1.60m bgl - in southeast of Phase 9), TP127 (0.80m bgl - in the central north of Phase 10), and TP131 (1.20m bgl - in the east of Phase 10).

Generally, there are three main types of Made Ground:

- surfacing including asphalt and concrete (Phase 9 only);
- Brown gravelly sands and clays with limestone, brick, concrete, tile and wood fragments; and

- Clayey limestone gravels with occasional concrete, hardcore and other man-made constituents (metal rods, land drains) (Phase 9 only).

The Made Ground is inherently variable and as such representative values of geotechnical properties are impracticable to determine.

5.1.5 Great Oolite Group

Great Oolite Group was encountered underlying the Made Ground or topsoil across the whole site, as brown sandy gravelly clay, or light grey and brown clayey sandy fine to coarse angular to subrounded gravel of limestone with occasional cobbles of limestone. These soils grade with depth into more intact limestone strata.

Natural moisture contents in the fine units of these materials range from 10% to 25%, and modified plasticity indices range from 5.8% to 32%. On this basis these soils are classified as ranging from low, intermediate and high plasticity (CL/CI/CH and ML/MI/MH soils) and non-shrinkable to medium volume change potential.

The PSD analyses indicate slightly clayey and sandy gravel sized lithorelicts of limestone, with a moderate cobble content. The majority of the lithorelicts are coarse gravel sized.

5.2 Obstructions

A number of trial pits encountered obstructions during excavation as summarised in Table 5.2. In addition, all the trial pits and boreholes were terminated on rock-quality strata.

Table 5.2: Obstructions Encountered During Hydrock Investigations

Exploratory Hole	Depth	Description	Stratum
TP08 (Phase 9)	1.3m bgl	Buried service encountered in base of trial pit.	Great Oolite Group/Made Ground
TP107 (Phase 9)	1.1m bgl	Possible concrete slab in base of trial pit.	Made Ground

5.3 Visual and Olfactory Evidence of Contamination

Visual and olfactory evidence of contamination was noted in a number of trial pits and is summarised in Table 5.3.

Table 5.3: Visual and Olfactory Evidence of Contamination

Exploratory Hole	Depth	Description	Stratum
TP101 (Phase 9)	0.0 – 0.2m bgl	Slight tar odour	Made Ground
TP102 (Phase 9)	0.3 – 0.5m bgl	Black staining and tar odour	Made Ground
TP104 (Phase 9)	0.03 – 0.2m bgl	Black staining and tar odour	Made Ground
TP104 (Phase 9)	0.2 – 0.8m bgl	Some black staining and tar odour	Great Oolite Group
TP109 (Phase 10)	2.7 – 2.9m bgl	Slight hydrocarbon odour and sheen on groundwater	Great Oolite Group

5.4 Sulfate Content

In accordance with BRE (Special Digest 1), the Design Sulfate (DS) classification and the Aggressive Chemical Environment for Concrete (ACEC) classification are presented in Table 5.4. The assessment summary sheets are presented in Appendix F.

Table 5.4: Aggressive Chemical Environment Concrete Classification

Stratum	No. Tests	DS	ACEC
Made Ground	1	DS-1	AC-1
Topsoil	2	DS-1	AC-1
Great Oolite Group	7	DS-1	AC-1

5.5 Groundwater

5.5.1 Groundwater Levels

Groundwater strikes encountered during the investigation and subsequent monitoring are summarised in Table 5.5.

Table 5.5: Groundwater Data

<table>
<tr><th rowspan="2">Stratum</th><th rowspan="2">Date Range</th><th rowspan="2">Exploratory Hole</th><th>Fieldwork</th><th>Post-Fieldwork Monitoring</th></tr>
<tr><th>Depth Groundwater Encountered (m bgl)</th><th>Depth to Groundwater (Range) (m bgl)</th></tr>
<tr><td colspan="5">Phase 9</td></tr>
<tr><td rowspan="4">Great Oolite Group</td><td rowspan="4">23/11/16 – 19/12/16</td><td>BH01</td><td rowspan="4">Not possible to monitor due to drilling technique</td><td>7.23 – 7.37</td></tr>
<tr><td>BH02</td><td>5.70 – 6.41</td></tr>
<tr><td>BH03</td><td>2.49 – 2.81</td></tr>
<tr><td>BH04</td><td>2.97 – 3.25</td></tr>
<tr><td colspan="5">Phase 10</td></tr>
<tr><td rowspan="7">Great Oolite Group</td><td rowspan="6">23/11/16 – 19/12/16</td><td>BH05</td><td rowspan="6">Not possible to monitor due to drilling technique</td><td>1.69 – 1.97</td></tr>
<tr><td>BH10</td><td>2.50 – 2.95</td></tr>
<tr><td>BH11</td><td>2.56 – 3.07</td></tr>
<tr><td>BH12</td><td>3.39 – 3.74</td></tr>
<tr><td>BH13</td><td>2.98 – 3.71</td></tr>
<tr><td>BH14</td><td>2.80 – 3.26</td></tr>
<tr><td>03/11/16</td><td>TP109</td><td>2.60</td><td>-</td></tr>
</table>

Stratum	Date Range	Exploratory Hole	Fieldwork	Post-Fieldwork Monitoring
			Depth Groundwater Encountered (m bgl)	Depth to Groundwater (Range) (m bgl)
Phase 16				
Great Oolite Group	23/11/16 – 19/12/16	BH08	Not possible to monitor due to drilling technique	2.02 – 2.58
		BH09		1.02 – 1.12
Phase 16A				
Great Oolite Group	23/11/16 – 19/12/16	BH06	Not possible to monitor due to drilling technique	Dry on all three monitoring visits
		BH07		6.71 – 6.74
	07/11/16	TP123	1.80	-
		TP124	Seepage at 3.00	-

On the third post-fieldwork monitoring visit (dated 19.12.16) the boreholes were monitored for light non-aqueous phase liquids (LNAPL), but none were detected.

5.5.2 Infiltration Tests

The results of the infiltration testing undertaken are summarised in Table 5.6 and the results sheets are presented in Appendix F. All testing was carried out in accordance with Hydrock's 1-day assessment methodology. This is in general accordance with BRE Digest 365 (BRE 2007) where infiltration rates allow three test runs during a working day (or where there is no infiltration), but where low infiltration rates were encountered the available time may not have been sufficient to fully comply with the BRE test method.

Where less than three tests were possible in a particular location the results provided should be considered indicative only and should not be used for design purposes. Further discussion concerning the suitability of infiltration testing at the site is provided in Section 7.7.

Table 5.6: Infiltration Test Results

Stratum	Trial Pit no.	Depth	Infiltration Rate (m/s)		
			Test 1	Test 2	Test 3
Phase 9					
Great Oolite Group	SA04	1.55m bgl	8.00×10^{-5}	6.86×10^{-5}	-
	SA06	1.60m bgl	1.18×10^{-5}	1.23×10^{-5}	-
	SA06	1.70m bgl	3.88×10^{-4}	3.82×10^{-4}	3.28×10^{-4}
Phase 10					
	SA07	1.50m bgl	9.22×10^{-5}	3.78×10^{-5}	5.52×10^{-5}

Stratum	Trial Pit no.	Depth	Infiltration Rate (m/s)		
			Test 1	Test 2	Test 3
	SA08	2.10m bgl	Did not pass 25%	-	-
Phase 16					
Great Oolite Group	SA01	1.10m bgl	4.64×10^{-5}	4.24×10^{-5}	3.74×10^{-5}
	SA02	1.30m bgl	2.80×10^{-4}	2.29×10^{-4}	1.76×10^{-4}
	SA03	1.50m bgl	2.61×10^{-5}	2.59×10^{-5}	4.57×10^{-5}

5.6 Geo-Environmental Results

The chemical test results for soil, leachate and groundwater are presented in Appendix I, which also includes summary tables of the data.

5.7 Ground Gases (Carbon Dioxide and Methane)

Records from the gas monitoring boreholes are presented in Appendix G and summarised in Table 5.7. Three monitoring visits have been undertaken, as part of the current commission.

Table 5.7: Range of Ground Gas Data

Methane (%)	Carbon Dioxide (%)	Oxygen (%)	Flow Rate (l/hr)
0.0 – 1.7	0.6 – 4.9	10.1 – 20.5	<0.01

5.8 Updated Ground Model

The preliminary conceptual site model initially developed from the desk study and walk-over survey (Section 3.0) has been confirmed using the findings of the ground investigation.

The ground investigation has confirmed ground conditions below the site comprise:

- Topsoil – encountered across the whole of Phase 16 and 16A as well as parts of Phase 9, generally associated with landscaped areas.
- Made Ground – encountered across the whole of Phase 10 as well as parts of Phase 9. Deep Made Ground was encountered in the south east (1.6m bgl) and north east (1.30m bgl) of Phase 9. Made Ground consisted of brown gravelly sands and clays with limestone, brick, concrete, tile and wood fragments or clayey limestone gravels with occasional concrete, hardcore and other man-made constituents (metal rods, land drains).
- Great Oolite Group – encountered across all phases below either the Made Ground or topsoil. The Great Oolite Group was encountered to a maximum depth of >8.00m bgl. The Great Oolite Group was encountered as fine and coarse soils of weathered limestone, grading with depth into more intact limestone strata.

Black staining and tar odours were recorded in TP101, TP102 and TP104, all located in Phase 9. No other visual or olfactory evidence of gross soil contamination was recorded.

Contamination was recorded in TP109 (Phase 10) as a slight hydrocarbon odour and a sheen on the groundwater.

During the fieldwork groundwater was only encountered in one trial pits from Phase 10 (TP109 at 2.60m bgl) and two trial pits from Phase 16A (TP123 at 1.80m bgl and TP124 at 3.00m bgl), the latter being in close proximity to Gallos Brook.

Post fieldwork groundwater monitoring indicates that the groundwater is generally around 2.0m to 3.5m bgl across much of the site. However, in boreholes BH01 and BH02 it is recorded at approximately 7m and 6m bgl respectively, and in boreholes BH05 and BH09 at approximately 1.5m and 1.0m bgl respectively.

6.0 GEO-ENVIRONMENTAL ASSESSMENT

6.1 Approach

A number of generic risk assessments have been undertaken in accordance with the principles of CLR 11 (Environment Agency 2004) using the CSM that has been updated following the ground investigation. Firstly, the risks associated with the identified potential contaminant linkages have been estimated using standardised methods (typically involving comparison of site data with published 'screening values'. Secondly, where screening values are exceeded, the risks are evaluated in an authoritative review of the findings with other pertinent information to determine if exceedance may be acceptable in the particular circumstances. For details please refer to Appendix H.

In cases where unacceptable risks are indicated, mitigation measures such as more advanced stages of risk assessment or remediation are proposed in Section 6.9.

6.2 Updated Exposure Model

Following the site investigation, no sources, pathways or receptors have been removed from, or added to, the exposure model.

Generic risk assessment is undertaken in Section 6.0, with reference to the updated ground model and updated exposure model reported above.

6.3 Human Health Risk Assessment

This is a Tier 2 assessment using soil-screening values for the CLEA land use scenario residential with plant uptake.

The soil screening values used are generic assessment criteria (GAC) and results are presented in Appendix I. Note that the Category 4 Screening Levels (C4SL) for lead have been used as there are no recognised GACs and the use of the term 'GAC' in this report includes these.

Statistical testing is used where data sets are suitable. For data sets with low sample numbers and/or a non-random spatial distribution (e.g. where sampling is targeted at specific areas) individual sample test results are compared directly with the screening values.

It should be noted that the phrase 'further assessment required' is used to denote soil concentrations that are equal to, or exceed, a GAC. This does not necessarily mean that the soil is 'contaminated' or not fit for use.

6.3.1 Risk Estimation (With Statistical Testing)

The 'averaging areas' used in this report are based on the conceptual model and the proposed development and are summarised as:

- Phase 9 and 10 Made Ground – screened for Hydrock Default Suite, TPH, VOCs, SVOCs, BTEX and MTBE; and

- Natural soils from Phase 16 and 16A – Screened for Hydrock Default Suite, TPH, BTEX and MTBE.

The data set for each chemical determinand has been assessed for the presence of potential outliers (based on the conceptual model).

Petroleum hydrocarbons (aromatics within the >EC10 - EC35 range) are recorded at concentrations above the GAC in two samples of Made Ground from Phase 9 (TP102 and TP104). The recorded concentrations of some of these hydrocarbon species are statistical outliers. However, it is considered that these results represent two hotspots of hydrocarbon contamination rather than being indicative of widespread (pervasive) hydrocarbon contamination across the site.

In line with the guidance provided by the CIEH (May 2008) the 95th upper confidence level on the true mean (US_{95}) has been calculated from the sample data. Data have been assessed using the one-sample t-test or the one-sided Chebychev Theorem, as appropriate to the distribution and number of samples.

Phase 9 and 10 - Made Ground

Based on a US_{95} exceedance of the GAC, the pervasive chemicals of potential concern, which require further assessment, are summarised in Table 6.1.

Table 6.1: Pervasive Chemicals of Potential Concern for Which Further Assessment is Required (Human Health)

Chemical of Potential Concern	Generic Criterion (mg/kg)	Basis for Generic Criterion	No. Samples	Min. (mg/kg)	Max. (mg/kg)	US_{95} (mg/kg)	No. Samples Exceeding Generic Criterion
Benz(a)anthracene	6.7	GAC	24	0.1	170	43.154	4
Benzo(a)pyrene	1.5	GAC	24	0.1	140	36.246	8
Benzo(b)fluoranthene	9.4	GAC	24	0.1	120	32.080	4
Benzo(k)fluoranthene	14	GAC	24	0.1	110	28.213	4
Chrysene	11	GAC	24	0.05	110	29.610	4
Dibenz(a,h)anthracene	1.3	GAC	24	0.1	11	3.028	4
Indeno(1,2,3,cd)pyrene	5.5	GAC	24	0.1	50	13.51379	4
Naphthalene	5.2	GAC	24	0.05	180	40.310	1
1,2,4-Trimethylbenzene	1.4	GAC	8	1	4.6	3.412	1

Phase 16 and 16A - Natural Soils

There are no substances for which the US_{95} exceeds the GAC and it is concluded that no further assessment is required.

6.3.2 Risk Estimation (Without Statistical Testing)

Where statistical analysis has not been undertaken, the individual analytical results for the following contaminants have been compared with the relevant GACs.

Asbestos

No asbestos was encountered in samples screened for asbestos in either the Made Ground or natural soils.

Volatile Organic Substances (VOC) and Semi-Volatile Organic Substances (SVOC)

No VOC or SVOC were recorded above the detection limit of the laboratory equipment in samples of natural soil from Phase 16 and 16A.

6.3.3 Risk Evaluation

The screening exercise has identified PAH, TPH and VOC in soils from Phase 9 and Phase 10, for which the US_{95} exceeds the GAC. The concentrations recorded are considered to represent an unacceptable risk, which requires mitigation for the proposed residential use.

6.4 Plant Life Risk Assessment

6.4.1 Risk Estimation

Priority phytotoxic chemical concentrations have been screened against published values to determine the likely risk to plant growth and the findings presented in Appendix I. As with human health, statistical testing is used where data sets are suitable, otherwise individual sample test results are compared directly with the screening values.

There are no substances for which the US_{95} exceeds the GAC, and it is concluded that no further assessment of the risk to plant life is required.

6.5 Pollution of Controlled Waters Risk Assessment

6.5.1 Risk Estimation

The risks to groundwater and surface water from contaminants on site have been assessed according to the Environment Agency (2006) Remedial Targets Methodology (RTM).

Under the European Water Framework Directive (2000/60/EC) pollutants from contaminated land sites are considered as passive inputs. Inputs to surface waters and inputs of non-hazardous pollutants to groundwater and are regulated under the Agency's 'limit' pollution objective. As such, site contaminant loadings are compared with relevant threshold values (Water Quality Targets) which are linked to the conceptual site model. Acceptable WQT are defined for protection of human health (based on Drinking Water Standards (DWS)) and for protection of aquatic ecosystems (Environmental Quality Standards (EQS)).

The approach for hazardous substances in groundwater is to use the 'prevent' pollution objective. Acceptable WQT are listed by UKTAG (November 2013, amended January 2014) and are minimum reporting values (MRV), referred to in this report as HAZ-MRV.

For the purposes of this report, the site data are compared with the various targets as set out according to the Hydrock scenarios in Table 6.2 (see Appendix H for details), on the basis of the following:

- Phase 9 and 10 are part of the former Upper Heyford air base, on which large quantities of fuel are known to have been stored and used.
- Phase 16 and 16A are adjacent to the former Upper Heyford air base, on which large quantities of fuel are known to have been stored and used.
- The groundwater around the former Upper Heyford air base is known (from previous investigations) to contain petroleum hydrocarbons.
- The groundwater below the current area of investigation may be in hydraulic continuity with groundwater below the wider air base site and with Gallos Brook, between Phase 16 and 16A.
- Groundwater has been recorded at relatively shallow depths.

Table 6.2: Summary of Water Quality Risk Assessment Protocol

Hydrock Scenario	Water Body Receptors	Secondary Receptors	Example Contaminant Linkages	RTM Level and Data Used	Water Quality Targets
B	Groundwater. Surface water.	Aquatic ecosystem.	Contaminants from site leach or seep into groundwater body and this feeds surface water by base flow. The surface water may be an aquatic ecosystem.	RTM Level 2 - Groundwater.	EQS (inland) HAZ-MRV
Notes: Some EQS are water hardness dependent. This is measured either in the receiving water or in groundwater (if it is part of the pathway), or is estimated from national maps. Inland waters EQS applicable to freshwater, other waters EQS applicable to marine or transitional waters. Where both DWS and EQS are applicable, it is assumed that the EQS is for inland waters. This table and the results of the assessment are considered as a first screening for potential risks of pollution of Controlled Waters. More specific requirements may be stipulated by the relevant Agency. The only groundwater abstraction point within 1km of the site is marked as 'historical' and as such this is not considered to be a receptor. Therefore, no assessment of substances have been made against the drinking water standards.					

The results of the Remedial Targets Methodology assessment are presented in Appendix I and are summarised in Table 6.3.

There are no WQT for petroleum hydrocarbons in water. However, because of the sensitivity of the water environment to petroleum hydrocarbons, an initial screening exercise is also included in Table 6.3 irrespective of the assessment scenarios stated in Table 6.2.

It should be noted that in some instances the reporting limit (or detection limit) quoted by the laboratory may be greater than the WQT that it is being assessed against. As the current exercise is an initial screening assessment, further assessment of these elements has not been undertaken.

Table 6.3: Chemicals of Potential Concern for Which Further Assessment is Required (Controlled Waters)

Chemical of Potential Concern	Water Quality Target (ug/l)	Basis for Water Quality Target	No. Samples	Min. (ug/l)	Max. (ug/l)	No. Samples Exceeding Target
Groundwater						
Cadmium	0.25	EQS	13	0.02	0.28	1
Cobalt	3	EQS	13	0.4	5	2
Copper	1	EQS	13	2	8.6	13
Manganese	123	EQS	13	8	360	5
Nickle	4	EQS	13	0.9	18	10
Lead	1.2	EQS	13	0.2	2.9	1
Zinc	10.9	EQS	13	1.8	140	4
Anthracene	0.1	EQS	13	0.01	2.22	1
Benzo(a)pyrene	0.00017	EQS	13	0.01	0.33	1
Fluoranthene	0.0063	EQS	13	0.01	1.64	2
Naphthalene	2	EQS	13	0.01	9.11	2
Ali >EC6 - EC8	10	Water Supply Regulations 1989 and the Private Water Supply Regulations 1991(withdrawn).	13	10	480	3
Ali >EC8 - EC10	10		13	10	12,000	5
Ali >EC10 - EC12	10		13	10	40,000	7
Ali >EC12 - EC16	10		13	10	83,000	7
Ali >EC16 - EC35	10		13	10	15,000	2
Aro >EC7 - EC8	10		13	10	26	2
Aro >EC8 - EC10	10		13	10	610	1
Aro >EC10 - EC12	10		13	10	1,600	1
Aro > EC12 - EC16	10		13	10	1,600	2
Aro >EC16 - EC21	10		13	10	12	1
Surface Water						
Copper	1	EQS	2	5.1	5.9	2
Note: the maximum recorded value is compared with the water quality target.						

Chemical of Potential Concern	Water Quality Target (ug/l)	Basis for Water Quality Target	No. Samples	Min. (ug/l)	Max. (ug/l)	No. Samples Exceeding Target
* The Water Supply Regulations 1989 and the Private Water Supply Regulations 1991 both contained a prescribed concentration of 10 µg/l for "dissolved or emulsified hydrocarbons (after extraction with petroleum ether); mineral oils". This was removed when these Regulations were updated in 2000 (consolidated 2007) and 2009, respectively. However 10 µg/l is used in this report as an initial screening assessment as it is frequently the preferred approach of the Environment Agency.						

A number of other VOCs and SVOCs were also detected in the groundwater from samples tested from BH10 and BH12, located close to POL 21. However, there are no water quality targets available for these (see Table 6.4).

Table 6.4: Additional Substances Present in Groundwater

Chemical	Max. Conc. (ug/l)
Toluene (BH12, Phase 10)	12.2
Isopropylbenzene (BH12, Phase 10)	27.8
n-Propylbenzene (BH12, Phase 10)	29.9
1,3,5-Trimethylbenzene (BH12, Phase 10)	33.4
1,2,4-Trimethylbenzene (BH12, Phase 10)	86.5
sec-Butylbenzene (BH12, Phase 10)	22.1
p-Isopropyltoluene (BH12, Phase 10)	15.2
2-Methylnaphthalene (BH12, Phase 10)	37
Acenaphthylene (BH12, Phase 10)	0.36
Acenaphthene (BH12, Phase 10)	0.60
Fluorene (BH10 and BH12, Phase 10)	0.43
Phenanthrene (BH10, Phase 10)	0.18
Pyrene (BH10, Phase 10)	0.20

A review of the groundwater data had been undertaken against the groundwater data presented in the Waterman's Preliminary Generic Quantitative Environmental Risk Assessment for the wider Heyford Park development (Ref: EED10658 - 13.2.2_FA). Concentrations of petroleum hydrocarbons recorded on Phase 9 and 10 were not recorded significantly higher than those recorded and presented in the Waterman report. It should be noted that petroleum hydrocarbons were not recorded in boreholes from Phase 16 and 16A, which form the south-eastern boundary of the wider Heyford Park development. This is considered in line with the findings of the Waterman report where low to negligible concentrations of petroleum hydrocarbons were present at the southern boundary of the wider site.

6.5.2 Risk Evaluation

Groundwater

The Environment Agency is aware of the poor groundwater quality (due to the presence of petroleum hydrocarbons) below the air base to the north of the site. Elevated concentrations of metals and PAH (above the EQS) and petroleum hydrocarbons (above the DWS), have also been recorded during the current investigation. However, the closest groundwater receptor (abstraction) is more than 1km from the site and it is considered that dilution and dispersion effects would minimise the risk to any receptor that far from the site.

It is likely that the Environment Agency will consider any ongoing pollution of the groundwater to be unacceptable. As part of the development works, the likely source of the groundwater contamination, the existing fuel storage tanks will be removed, together any associated contaminated soils or water from the excavation. This should break the contamination linkage. However, further sampling and testing may be required following tank removal to confirm there is no ongoing contamination.

On the basis of the above, it is considered that, following removal of the tanks and any associated soils and waters from the excavation, the recorded groundwater contamination does not represent a significant risk of pollution to the groundwater below the site.

Surface Water

There are exceedances of the water quality targets for the groundwater, which it is considered, may feed into Gallos Brook. However, water from the brook has been analysed and while there are elevated concentrations of copper it is considered that this originates from the natural geology rather than artificial sources as no soil copper contamination has been identified.

Furthermore, the inland waters EQS for copper is based on the bioavailable fraction and because bioavailability has not been calculated for this metal the assessment is conservative, as it is based on the assumption of 100% bioavailability.

On this basis, these exceedances are not considered to represent a significant risk of pollution to surface waters.

It is recommended that the above conclusions be confirmed with the Environment Agency.

6.6 Ground Gases Risk Assessment

6.6.1 Assessment

The risks associated with the ground gases methane (CH_4) and carbon dioxide (CO_2) have been assessed using BS 8485:2015 and guidance from CIRIA Report 665 (Wilson *et al* 2007) and NHBC (Boyle and Witherington 2007). The development proposals require consideration of Situation A (all forms of development) and Situation B (low-rise housing with a vented sub-floor void).

The guidance requires the calculation of Gas Screening Values (GSV). For the purposes of the calculation, were the recorded gas flow rate is below the manufacturer's limit of detection for the instrument used, the detection limit has been adopted for the gas flow rate.

The monitoring strategy reported in Appendix G is considered suitable for assessment of ground gas risk at the site.

For Phases 9, 16 and 16A the typical worst case GSV have been calculated as <0.07 for both methane and carbon dioxide. Phase 9, 16 and 16A are therefore provisionally classified as Characteristic Situation 1 (Situation A) and Green (Situation B).

For Phase 10, the typical worst case GSV have been calculated as <0.07 for both methane and carbon dioxide. However, methane concentrations were noted above 1% on two visits. Phase 10 is therefore provisionally classified as Characteristic Situation 2 (Situation A) and Amber 1 (Situation B).

6.6.2 Radon

The environmental data report indicates that the site is in a Radon Affected Area where recorded radon levels in 1 - 3% of homes are above the action level. At this concentration, radon protection is not required for Phases 9, 10, 16 and 16A based on current guidance. However, given the close proximity of the site to outcropping Northampton Sand Formation (a potential radon generating strata) and therefore the likelihood of Northampton Sand Formation strata underlying the site at shallow depth, it is recommended that a bespoke BGS radon report be obtained to confirm if protection is recommended.

6.6.3 Volatile Organic Compounds

Where GACs were not available for VOCs then a screen has been undertaken comparing the concentrations against the Workplace Exposure Limits. No VOCs are recorded above the Workplace Long-term Exposure Limit (8-hr TWA reference period).

6.6.4 Gas Protection Measures

Phase 9, 16 and 16A

Given the potential for petroleum hydrocarbon impacted groundwater present below the site, consideration should be given for the installation of ground gas and odour mitigation measures.

Phase 10

Situation A

The design of gas protection measures according to BS 8485:2015 requires the building(s), or different parts thereof, to be categorized into one of four building types: Type A, Type B, Type C or Type D. This is because The construction and use of the building, together with the control of future structural changes to the building and its maintenance (the building's management) should be assessed, since potential risks posed by ground gases are strongly influenced by these factors.

For CS 2 (residential), CIRIA Report C665 (Wilson *et al* 2007) recommends:

- Reinforced concrete cast *in situ* floor slab (suspended, non-suspended or raft) with at least 1200g DPM and underfloor venting; or

- Beam and block or pre-cast concrete and 2000g DPM / reinforced gas membrane and underfloor venting.
- All joints and penetrations sealed.
- See also text following CIRIA Report 665 8.6 (Wilson *et al* 2007) which gives additional details.

For CS 2 (commercial/industrial), CIRIA Report C665 (Wilson *et al* 2007) recommends:

- Reinforced concrete cast *in situ* floor slab (suspended, non-suspended or raft) with at least 1200g DPM; or
- Beam and block or pre-cast concrete and 2000g DPM / reinforced gas membrane.
- Possibly underfloor venting or pressurisation in combination with the above depending on use.
- All joints and penetrations sealed.
- See also text following CIRIA Report 665 8.6 (Wilson *et al* 2007) which gives additional details.

BS 8485:2015, Table 3 indicates a score of 3.5 points for Type B buildings, 2.5 points for Type C buildings and 1.5 points for Type D buildings. A combination of two or more of the following three types of protection measures should be used to achieve that score: structural barrier, ventilation measures and gas resistant membrane. These will require detailed design and specification in accordance with BS 8485:2015. Note that if a membrane is installed it must be verified in accordance with CIRIA C735 (Mallet et al 2014) or it will score zero points and will not be deemed to afford any protection.

Situation B

For Amber 1 conditions, NHBC (Boyle and Witherington 2007) recommends:

- Low-level ground protection measures using a membrane and ventilated sub-floor void that creates a permeability contrast to limit the ingress of gas into buildings.
- Gas protection measures are to be installed as prescribed in BRE 414 (Johnson 2001).
- Ventilation of the sub-floor void should be designed to provide a minimum of one complete volume change per 24 hours.

In addition to the above odour mitigation measures should also be considered.

6.6.5 Ground Workers

It is noted that concentrations of carbon dioxide (an asphyxiant) in the soil exceed HSE Workplace Exposure Limits for personnel in the working environment of 1.5% for short-term (15 minutes) exposure and/or 0.5% for long-term exposure. Furthermore, soil concentrations of oxygen are below the HSE recommendations of 18%.

Whilst risks to construction workers are not generally discussed in this report, and soil gas concentrations are not necessarily reflected by those in the breathing zone, all contractors and maintenance workers should be made aware of the possible presence of carbon dioxide and should take all necessary health and safety precautions when working in trenches or confined spaces.

6.7 Water Pipelines

The current guidance on selection of materials for potable water supply pipes to be laid in contaminated land is contained in a document published jointly by Water UK and the Home Builders Federation (Water UK HBF (2014)). The protocols in that document are for guidance and are not subject to enforcement by Water UK or any agency, but have been adopted by Water UK and by HBF as best practice for their members. Accordingly this guidance is used in the following assessment. For further details see Appendix H.

A formal water pipe risk assessment is beyond the scope of this report, however, the findings of this investigation have been compared to the threshold values in Water UK Table 1 as far as is practicable to give an indication of the possible restrictions to the use of plastic pipes for water supply to the site.

Phase 16 and Phase 16A are greenfield and the investigation and assessment has indicated no exceedance of the threshold values. It is envisaged that standard pipework will be suitable for these parts of the site. However, this investigation was not designed specifically for water pipe runs and confirmation should be sought from the water supply company at the earliest opportunity.

Phase 9 and Phase 10 are brownfield and organic contamination (PAH and petroleum hydrocarbons) have been identified in exceedance of the threshold values and Hydrock believes barrier pipe is required. However, confirmation should be sought from the water supply company at the earliest opportunity.

6.8 Findings of the Generic Risk Assessments

The source-pathway-receptor contaminant linkages given in Table 6.5 are those which, following the risk evaluation process, require further consideration and are discussed further in Section 6.9.

Table 6.5: Final Conceptual Model and Residual Risks Following Risk Evaluation

Contaminant Linkage			Comments	
Sources	**Pathways**	**Receptors**	**General**	**Mitigation**
Petroleum hydrocarbons in the Made Ground in TP102 and TP104 (Phase 9).	Ingestion, inhalation or direct contact.	Human health.	Significant exceedance of the GACs.	Mitigation required.
Pervasive PAH in the Made Ground in Phases 9 and 10.	Ingestion, inhalation or direct contact.	Human health.	Significant exceedance of the GACs.	Mitigation required.

Contaminant Linkage			Comments	
Sources	**Pathways**	**Receptors**	**General**	**Mitigation**
Elevated concentrations of petroleum hydrocarbons (above the DWS) and metals and PAH (above the EQS) in the groundwater	Direct	Gallos Brook Drinking water abstraction	No evidence of connectivity to Gallos Brook. Abstraction is more than 1km from site.	None required (subject to regulatory confirmation)
Elevated concentrations of copper in the surface water from Gallos Brook.	Direct	Gallos Brook	Considered that elevated concentrations of Cu originates from the natural geology.	None required (subject to regulatory confirmation)
Elevated concentrations of ground gases (methane) in Phase 10.	Migration through soils or groundwater to indoor air.	End users of new buildings (asphyxiation or explosion). New buildings (damage by explosion).	Soils are permeable.	Characteristic Situation 2 / Amber 1

6.9 Mitigation Measures

The former fuel tanks across Phase 9 and 10, including POL21, together with any associated pipework, should be removed together with any petroleum hydrocarbon impacted soils or water around and below them.

The ‘hotspots’ of hydrocarbon contamination noted in TP102 and TP104 should be delineated and selectively excavated.

Observation of all excavations in Phase 9 and 10 should be carried out to check for any, as yet unidentified hotspots, of hydrocarbons, which should also be delineated and selectively excavated.

Validation testing of the sides and base of any excavation for tank or hydrocarbon removal should be undertaken.

Following the removal of the tanks and hydrocarbon hotspots, the most suitable form of remediation would be the installation of a cover system for all gardens and public open space in Phase 9 and 10. A cover system thickness of 600mm thick in gardens and 450 mm in public open space is recommended. This will sever the contaminant linkages at risk to human health and plant life. The cover should also be suitable to provide a growing medium for new planting and to this end a minimum of 150 mm of topsoil is recommended, over a sub-soil layer. The inclusion of an orange (or similar bright colour) bonded combined geotextile and geogrid, such as TX-G 160, to create a combined warning, separation and ‘hard to dig’ layer at the interface between the contaminated soils and the base of the cover system is recommended.

Service trenches in Phases 8 and 9 should be over excavated (widened) and filled with 'clean' backfill to minimise the risk of contact between future maintenance workers and potentially contaminated soils.

Barrier water supply pipes should be installed in Phase 9 and 10.

Whilst outside the scope of this report, it is recommended that, if not already done, an asbestos survey of the former buildings and other structures on Phase 9 and Phase 10 should be undertaken prior to demolition. If asbestos is encountered, removal work should be undertaken by a specialist Contractor in accordance with relevant legislation.

Gas protection measures in Phase 10 will be required.

6.10 Waste Management

Any material excavated on site may be classified as waste and it is the responsibility of the holder of a material to form their own view on whether or not it is waste. This includes determining when waste that has been treated in some way can cease to be classed as waste for a particular purpose. Further details are given in Appendix H.

If material is to be removed from the site (e.g. foundation arisings) the laboratory test results in Appendix I, should be presented to the proposed receiving landfill site (to aid Waste Characterisation), prior to export, to confirm that it is suitably licensed to accept them. Some additional testing may be necessary at the time of disposal for the receiving landfill to confirm the Waste Acceptance Criteria (WAC) are acceptable for it to receive the waste.

6.10.1 HazWasteOnline™ Assessment

In order to inform the waste characterisation process, Hydrock has undertaken a preliminary exercise using the proprietary web-based tool HazWasteOnline™, to characterise the soils encountered in the investigation. The results of the output are included in Appendix J.

Based on the HazWasteOnline™ output, it is considered that soils from Phase 10 are likely for the most part to be classified as non-hazardous. However, it is possible that some petroleum hydrocarbon impacted soils will be encountered, for example during the removal of fuel storage tanks, which may be hazardous for waste disposal purposes.

It is considered likely that soils from the hotspots of petroleum hydrocarbons (including any contaminated soils encountered during the removal of fuel storage tanks) in Phase 9, will be classified as hazardous for waste disposal purposes. However, once these have been removed as part of the site preparation/remedial works, it is considered likely that the remaining soils will be classified as non-hazardous.

All natural material (Great Oolite Group) from Phase 16 and 16A is considered to be inert. This should be confirmed by undertaking a visual and olfactory assessment at the time of excavation.

6.10.2 Waste Recommendations

Prior to disposal, the characteristics of any excavated soils will need classification in consultation with landfill sites and waste disposal contractors. Waste Acceptance Criteria (WAC) Testing on the actual soil arisings, which will constitute the waste, will be required.

6.10.3 Materials Management

Any material excavated on site may be classified as waste and it is the responsibility of the holder of a material to form their own view on whether or not it is waste. This includes determining when waste that has been treated in some way can cease to be classed as waste for a particular purpose.

If site-won material is to be reused on site, a Materials Management Plan will be required, signed off by a Qualified Person as defined in the ‘Development Industry Code of Practice’ (CL:AIRE, March 2011).

7.0 GEOTECHNICAL ASSESSMENT

7.1 Geotechnical Categorization of the Proposed Development

Eurocode 7, Section 2 advocates the use of geotechnical categorization of the proposed structures to establish the design requirements. For the purposes of this investigation, the proposed structures have been classed as Geotechnical Category 1.

7.2 Characteristic Design Values

The geotechnical parameters recommended for the design of Category 1 structures are given in Table 7.1.

Table 7.1: Characteristic Geotechnical Parameters

Parameter	Weathered Great Oolite Group (fine)	Weathered Great Oolite Group (coarse)	Intact Great Oolite Group (weak or stronger)
c_u (kPa)	60	-	-
c'(kPa)	-	-	30
ϕ' (°)	-	31	-

7.3 Groundwork

7.3.1 Site Preparation

A concrete slab was encountered in the base of trial pit TP107 (Phase 9), at a depth of 1.1m bgl. Further buried construction (old foundations, ground floor slabs and tanks) are also anticipated locally at least on Phase 10, and possibly also Phase 9. In addition, there are a number of services crossing the site. Intact limestone is also present at shallow depth across large areas of the site.

Removal of the buried construction should be undertaken ahead of the start of development works. Removal of the tanks should be undertaken as part of a controlled remediation programme.

Topsoil and unsuitable Made Ground should be removed from beneath all building and hardstanding areas.

7.3.2 Groundworks

Above the intact rock quality strata, conventional plant and equipment should be suitable for excavation. However, excavation through intact rock quality strata may require the use of heavy-duty excavation plant, ripping plant or the use of specialist breaking equipment.

The excavation faces were generally stable, but some minor collapse was noted in the Great Oolite Group strata below 1m bgl. On this basis, random and sudden falls from the faces of near vertically sided excavations put down at the site should be anticipated.

Temporary trench support, or battering of excavation sides, is likely to be required for all excavations that are to be left open for any length of time, and will definitely be required where man entry is required. Particular attention should be paid to excavation at, or close to, site boundaries and adjoining existing roads/structures, where collapse of excavation faces could have a disproportionate effect.

A risk assessment of the stability of any open excavation should be undertaken by a competent person and appropriate measures adopted to ensure safe working practise in and around open excavations. Further guidance on responsibilities and requirements for working near, and in, excavations can be obtained from the Construction Design and Management Regulations (2015).

Recorded groundwater levels are locally at least, shallow. Based on site observations, it is considered that sump pumping is likely to be sufficient to deal with anticipated flows. However, it should be recognised that groundwater levels will fluctuate seasonally and the timing of construction may dictate the extent of groundwater control required.

Any water pumped from excavations is likely to need to be passed via settlement tanks before being discharged to the sewer; discharge consents will also be required.

At this stage, Hydrock is not aware of proposals for regrading of the site. However, it may be necessary to consider reuse of existing soils as part of redevelopment proposals. Should earthworks be required, an earthworks specification will be necessary to ensure the appropriate management and reuse of the existing soils. Once site proposals have been further defined more specific consideration will need to be given to the reuse of materials and reference should be made back to this office if an earthworks specification is required. The earthworks may need to be undertaken under a Materials Management Plan

7.3.3 Earthworks/Reuse of Site-Won Materials

Spoil resulting from excavations within the areas of Made Ground, are considered likely to be unsuitable for reuse without grading and sorting to remove oversize or otherwise unsuitable material, and should be removed from site.

Arisings from excavation in the natural soils should be suitable for reuse as general fill subject to further testing and specification.

An initial assessment has been completed on the potential to reuse site-won materials as an engineered fill material, which indicates the soils that are likely to be reused, can be classified as follows:

- Heavily weathered Great Oolite Group soil - Class 2 cohesive (more than 15% passing the 63µm sieve) or Class 2 granular (less than 15% passing the 63µm sieve) - General Fill.
- Fractured slightly to moderately weathered Great Oolite Group – Class 1 granular - General Fill.

Where an increased end-performance of the material is required over and above those defined for General Fill materials additional testing and specification will be required, which is outside the scope of the current assessment.

Where it is proposed to reuse site won materials as an engineered fill, it will be necessary to develop an appropriate Site Specific Earthworks Specification as part of the GDR which can be adopted as part of the contract documentation. The basis for the Specification should be BS 6031:2009 and the latest version of the SHW, Series 600 Earthworks.

7.4 Foundations

The recommendations in this report follow NHBC Standards Chapter 4.2 (2016).

The Made Ground (encountered locally to depths of up to 1.60m bgl) and low strength natural fine soils are considered unsuitable in their present condition for use as founding soils on the basis of their relatively low strength and high compressibility and should be fully penetrated by all new foundations. Al foundations should be carried down to found a minimum of 300mm into the natural firm or stiffer natural clays, medium dense or denser ‘granular’ weathered limestone. Where intact limestone is encountered at founding depth, it should be proved to be intact and continuous and foundations cast on it.

The natural fine soils are shown by the results of the Atterberg limits testing to range from non-shrinkable to medium volume change potential. However, for purposes of foundation design it is recommended that a medium volume change potential be assumed.

On the basis of the above minimum founding depths of between 0.90m bgl and 1.90m bgl are recommended, in accordance with NHBC Standards.

If trees are to be removed, the roots should be grubbed out and foundations extended to below the zone of disturbance created by this activity.

The allowable bearing pressure for foundations takes into consideration the risk of shear failure of the ground (ultimate limit state) and acceptable limits of settlement (serviceability limit state).

The preliminary foundation designs in this section are based on the parameters given in Section 7.2.

As foundations will span founding materials of different stiffness mesh reinforcement should be placed at the top and bottom.

The depth of foundations should be designed, and the formations inspected by, a Geotechnical Engineer. Any sub-formation materials deemed as unsuitable such as soft or loose zones should be excavated and replaced with well compacted suitable granular fill or lean mix concrete.

Foundations in excess of 2.5m depth should be designed by an Engineer in accordance with the requirements of NHBC Standards.

Foundation excavations should be protected from water and inclement weather including frost and any water should be removed by pumping from a sump in the base of the excavation

7.4.1 Strip or Trench Fill Foundations

Traditional strip or trench fill foundations are considered suitable for the proposed development.

Based on the design soil parameters provided in earlier sections of this report, as a guide, an allowable net bearing pressure of 100kN/m^2 should be available for a strip or trench fill foundation. This value should result in total settlements of not more than 20mm for foundations up to 1m wide, keeping differential settlements within acceptable limits.

Deepening of foundations within the influencing distance to trees should be undertaken in accordance with the requirements of NHBC Standards. However, the rock quality and predominantly granular, heavily weathered Great Oolite Group limestone strata are considered to be non-shrinkable and therefore deepening due to trees is not necessary for these soil types.

Excavation of trench fill foundations to depths in excess of 2.5m bgl is considered highly unlikely to be necessary, unlikely to be economical and likely to be impracticable to undertake. Care should be taken to ensure the verticality of deep, narrow foundations to prevent eccentric loading.

Should enlarging the foundations be considered (for example because loads are such that the quoted bearing pressure is inadequate based on the size of foundation identified) this will probably lead to increased settlements and the above recommendations should be reviewed.

7.4.2 Heave Protection

Deepening of foundations in accordance with NHBC Standards/BRE 298 will be required where foundations are within the zone of influence of existing, removed or proposed trees and proposed shrub planting on clay soils. For existing (and any known removed) trees this will require a tree survey to be undertaken by an arboriculturist in accordance with BS 5873:2012 which must include off-site trees that could have an effect on foundation design, in addition to trees on site. Where foundations are on clay soils within the influence of trees and are deeper than 1.5m bgl, a suitable compressible material or void former will be required.

Should foundations require deepening to greater than 2.5m bgl, they must be designed by an engineer, as specified in NHBC Technical Requirement R5.

7.5 Ground Floor Slabs

As highly variable soils are present across the site, including Made Ground to depths greater than 600mm and clays oils of medium volume change potential, in accordance with the requirements of NHBC Standards, suspended ground floors should be adopted for all plots.

7.6 Roads and Pavements

Based on the test results, it is considered likely an equilibrium CBR of 3% will be achievable over those areas of the site, where natural fine soils are present at formation level. Where entirely coarse soils are encountered, an equilibrium CBR of 5% should be achievable. For areas where Made Ground is encountered at formation level, an equilibrium CBR of 2.5% is recommended.

These values can be used for preliminary design, subject to *in situ* testing during construction.

Proof rolling of the formation level will be required and any loose or soft spots should be removed and replaced with an engineered fill, in accordance with a suitable Specification. The formation level will also need to be protected during inclement weather from deterioration; all slopes should be trimmed to falls to shed rainwater and the surface sealed to limit infiltration.

Prior to the placement of the founding materials and the construction of the road pavement, the sub-formation and formation will need to be inspected and checked in accordance with a suitable specification to ensure the ground conditions are as expected. All testing should be carried out in accordance with DMRB IAN 73/06 to confirm that the ground conditions at time of construction are consistent with the previous design parameters.

Where the CBR is found to be less than 2.5%, the sub-grade may be unsuitable for both the trafficking of site plant and as support for a permanent foundation, without improvement works being undertaken. Improvement works should be carried out in accordance with DMRB IAN 73/06 Rev 1 Chapter 5. In summary, consideration may be given to the following potential remedial techniques:

- excavation and reengineering or replacement of weaker soils;
- the inclusion of geosynthetic reinforcement within the unbound layers of the capping and sub-grade;
- where cohesive soils are present and they are deemed suitable for treatment with hydraulic binders, to employ modification and/or stabilisation techniques on the formation; and
- where granular soils are present, dewatering and re-engineering the formation.

7.7 Soakaways and Drainage

Indicative infiltration rates for the ground investigation are presented in Appendix F and are summarised in Table 7.2.

Table 7.2: Infiltration Testing Data

Area of the site	Stratum	Recorded Indicative Infiltration Rate (Range of Final Runs (m/s))	Comments
Phase 9	Great Oolite Group	3.28×10^{-4} to 1.23×10^{-5}	Test not fully BRE compliant.
Phase 10	Great Oolite Group	No result to 5.52×10^{-5}	Test not fully BRE compliant. Of the two test locations one did not pass the 25% infiltration point.
Phase 16	Great Oolite Group	1.76×10^{-4} to 3.74×10^{-5}	Test not fully BRE compliant.

The above data indicate that soakaways may be possible. However, because of the relatively slow infiltration rates in places, this will depend on the available storage capacity and size of the soakway. Further, fully BRE365 compliant infiltration testing is required followed by detailed drainage design by a specialist to determine if soakaway drainage is possible.

7.8 Buried Concrete

Based on guidelines provided in BRE Special Digest 1 (BRE 2005), the soils can be classified as Design Sulfate Class DS-1 and ACEC Class AC-1.

This equates to a Design Chemical Class DC-1 for a 50 year design life (see BS 8500-1:2006 for details).

8.0 UNCERTAINTIES AND LIMITATIONS

8.1 Site-Specific Comments

Demolition of the buildings in Phase 9 had not happened at the time of the investigation. In addition, this area was being used in part as a storage site for the larger Heyford Park development, with construction materials and stockpiles of demolition wastes and soil.

In addition, it was not possible to excavate close to any of the buried tanks in Phase 9, or close to either POL21 or the small above ground tank on Phase 10, due to the presence of underground services. In addition there were stands of large trees and a large number of buried services across Phase 10.

On the basis of the above, large parts of Phase 9 and 10 were not accessible, and therefore could not be investigated.

8.2 General Comments

This report details the findings of work carried out in November 2017. The report has been prepared by Hydrock on the basis of available information obtained during the study period. Although every reasonable effort has been made to gather all relevant information, all potential environmental constraints or liabilities associated with the site may not have been revealed.

The report has been prepared for the exclusive benefit of Dorchester Living and those parties designated by them for the purpose of providing geotechnical and geo-environmental recommendations for the site. The report contents should only be used in that context. Furthermore, new information, changed practices or new legislation may necessitate revised interpretation of the report after the date of its submission.

Hydrock has used reasonable skill, care and diligence in the design of the investigation of the site. The inherent variation of ground conditions allows only definition of the actual conditions at the locations and depths of trial pits and boreholes at the time of the investigation. At intermediate locations, conditions can only be inferred.

Groundwater findings described are only representative of the dates on which they were made and levels may vary.

Unless otherwise stated, the recommendations in this report assume that ground levels will remain as existing. If there is to be any reprofiling (e.g. to create development platforms or for flood alleviation) then the recommendations may not apply.

Information provided by third parties has been used in good faith and is taken at face value; however, Hydrock cannot guarantee its accuracy or completeness. It is assumed that previous reports provided have been assigned to the Client and can be relied upon. Should this not be the case Hydrock should be informed immediately as additional work may be required.

The work has been carried out in general accordance with recognised best practice. The various methodologies used are explained in Appendix H. Unless otherwise stated, no assessment has been made for the presence of radioactive substances or unexploded ordnance. Where the phrase 'suitable for use' is used in this report, it is in keeping with the terminology used in planning control and does not imply any specific warranty or guarantee offered by Hydrock.

The chemical analyses reported were scheduled for the purposes of risk assessment with respect to human health, plant life and controlled waters as discussed in the report. Whilst the results may be useful in applying the Hazardous Waste Assessment Methodology given in Environment Agency Technical Guidance WM3, they are not primarily intended for that purpose and additional analysis may be required should waste classification be required for consideration of off-site disposal of contaminated soils. Separate analyses will be required to meet the Waste Acceptance Criteria for specific landfill sites.

Unless otherwise stated, the chemical testing carried out for this report was not scoped to comply with the requirements of the water supply company and further work may be required.

The preliminary risk assessment process may identify potential risks to site demolition and redevelopment workers. However, consideration of occupational health and safety issues is beyond the scope of this report.

Please note that notwithstanding any site observations concerning the presence or otherwise of archaeological sites, asbestos-containing materials or invasive weeds such as Japanese knotweed, this report does not constitute a formal survey of these potential hazards.

Any site boundary line depicted on plans does not imply legal ownership of land.

9.0 RECOMMENDATIONS FOR FURTHER WORK

The following further works will be required:

- Removal of all underground and above ground storage tanks.
- Removal of hydrocarbon impacted hotspots.
- Removal of any impacted soils and water associated with the removal of fuel storage tanks, including validation sampling and testing.
- Infiltration rate testing in accordance with BRE365 followed by detailed drainage design by a specialist, if soakaway drainage is being considered.
- Discussions with service providers regarding the materials suitable for pipework etc.
- Discussions with regulatory bodies regarding the conclusions of this report.
- Foundation depth in relation to trees assessment, following a tree survey to BS 5837:2012.
- An asbestos survey of the former buildings and other structures on Phase 9 and Phase 10 (if not already undertaken).

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Appendix A

Drawings

Drawings included in this report:

HPW-HYD-MS-ZZ-DR-GE-0001 – Site Location Plan

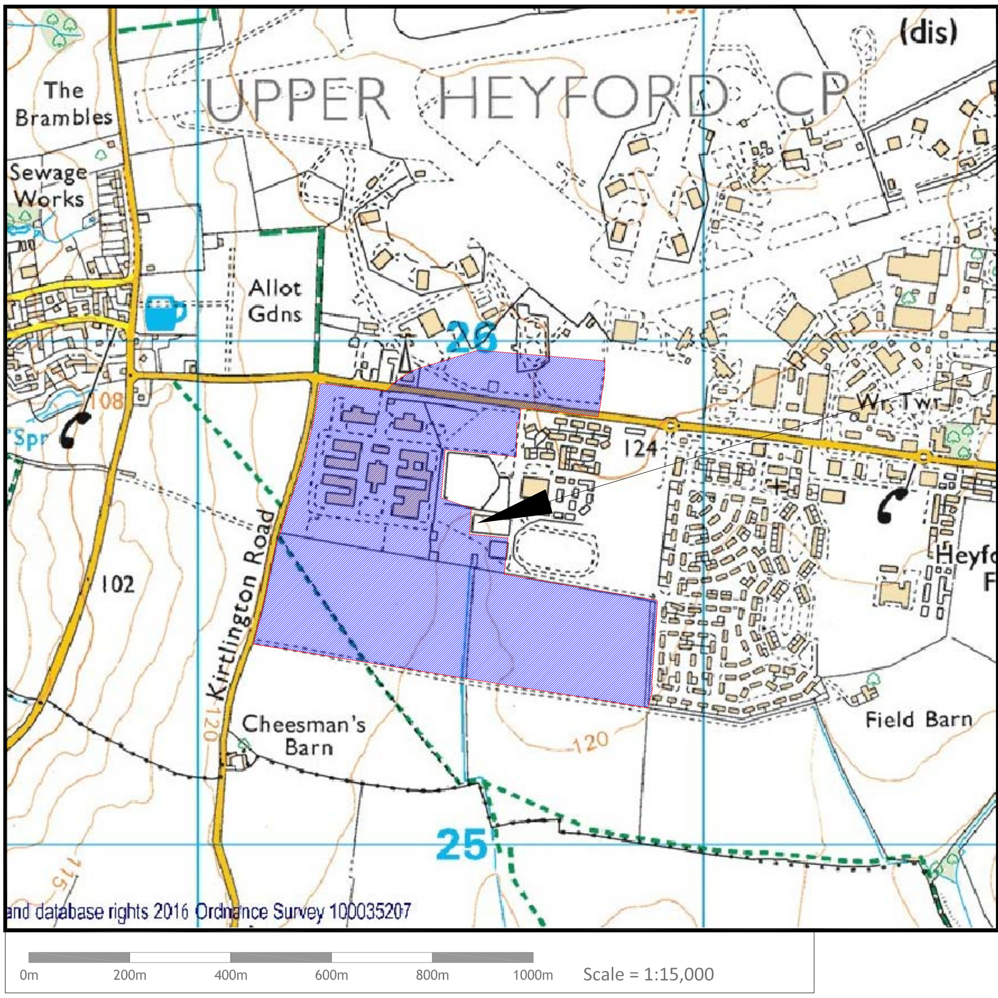
HPW-HYD-MS-ZZ-DR-GE-0002 – Site Walkover Plan

HPW-HYD-MS-ZZ-DR-GE-0001 – Exploratory Hole Plan

Notes:

1. Contains Ordnance Survey data © Crown copyright and database right 2015

THE SITE



THE SITE

Rev	Date	Description	By	Ckd

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DORCHESTER LIVING

Project Title:
HEYFORD PARK WESTERN DEVELOPMENT, Phase 9, 10, 16 & 16A

Drawing Title:
Site Location Plan

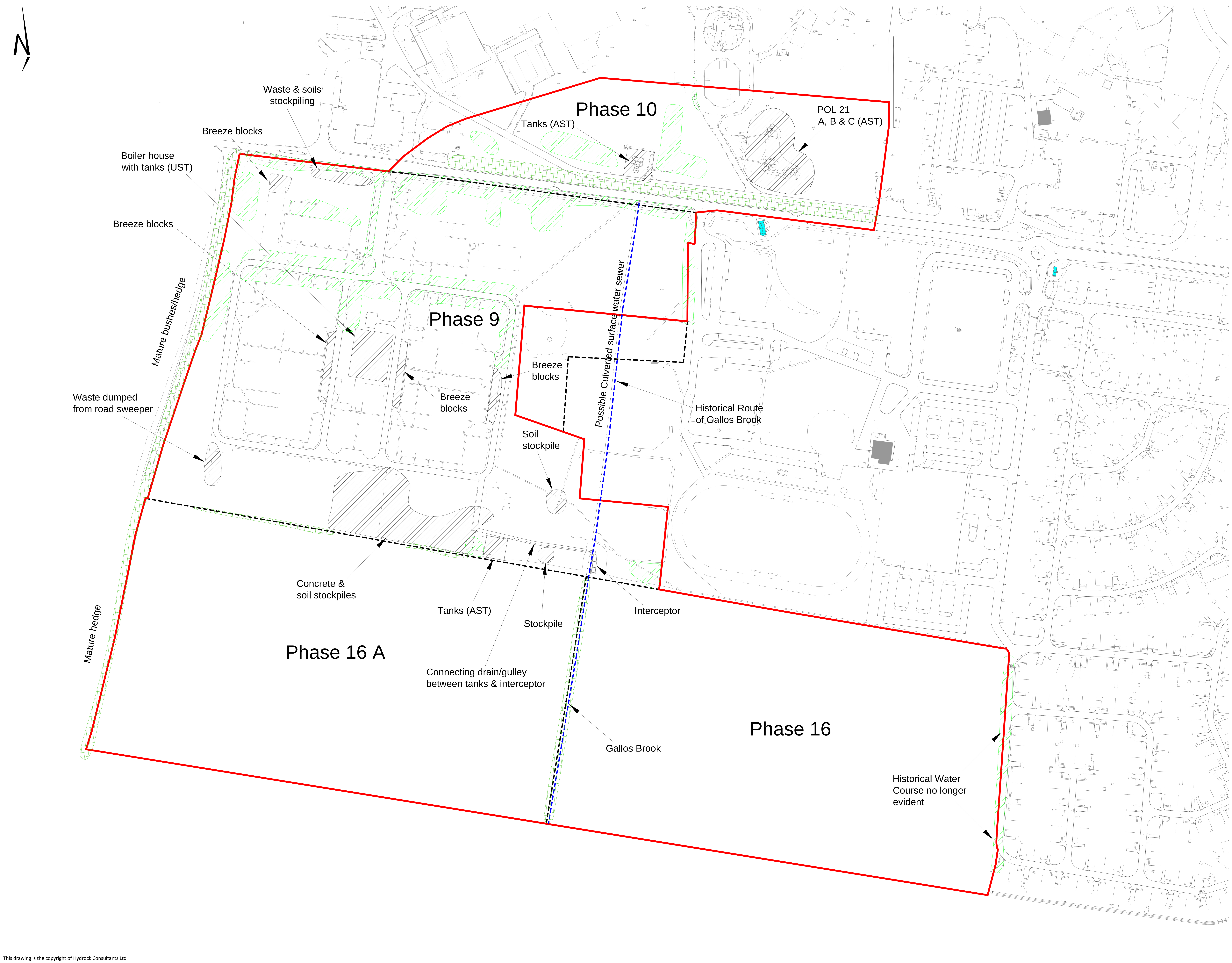
Reference:
HPW-HYD-MS-ZZ-DR-GE-0001

Hydrock Job No:
C-04583-C

Drawn	Checked	Scale @ A4	Date	Issue Date
SD	DM	See Drawing	07/12/16	07/12/16

Revision: P1.1

Status: S0



Notes:

1. All dimensions are to be checked on site before the commencement of works. Any discrepancies are to be reported to the Architect & Engineer for verification. Figured dimensions only are to be taken from this drawing.
2. This drawing is to be read in conjunction with all relevant Engineers' and Service Engineers' drawings and specifications.

Legend

- Site Boundary (approximate)
- Tree(s)
- Hedge(s)

Rev	Date	Description	By	Ckd

Architect :

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Client :

DORCHESTER LIVING

Project Title:

HEYFORD PARK WESTERN DEVELOPMENT, Phase 9, 10, 16 & 16A

Drawing Title:

Site Walkover Plan

Reference: HPW-HYD-MS-ZZ-DR-GE-0002

Hydrock Job No: C/04583

Drawn	Checked	Scale @ A1	Date	Issue Date
SD	DM	1:1500	06/12/16	06/12/16

Revision: P1.1 Status: S0

Notes:

1. All dimensions are to be checked on site before the commencement of works. Any discrepancies are to be reported to the Architect & Engineer for verification. Figured dimensions only are to be taken from this drawing.
2. This drawing is to be read in conjunction with all relevant Engineers' and Service Engineers' drawings and specifications.

Legend

- Site Boundary (approximate)
- TPXX Hydrock Trial Pit
- BHXX Hydrock Borehole

Rev	Date	Description	By	Ckd

Architect :

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Client :

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Project Title:

HEYFORD PARK WESTERN DEVELOPMENT, Phase 9, 10, 16 & 16A

Drawing Title:

Exploratory Hole Location Plan

Reference:

HPW-HYD-MS-ZZ-DR-GE-0003

Hydrock Job No: C/04583

Drawn	Checked	Scale @ A1	Date	Issue Date
SD	DM	1:1500	06/12/16	06/12/16

Revision: P1.1

Status: S0

Appendix B

Site Walkover Photographs

This appendix may not be included in the printed report to reduce the document size, but is included in the digital version.

Figure 1: Looking south towards entrance to Phase 9.

Figure 2: Looking west within entrance to Phase 9 showing restrictions to areas available for ground investigations works.

Figure 3: Looking west along the northern extents of Phase 9. No access into these areas for intrusive investigation due to trees and buried services.

Figure 4: Looking east along the northern extents of Phase 9. No access into these areas for intrusive investigation due to trees and buried services.

Figure 5: Looking east from Phase 9 at former school buildings.

Figure 6: Looking south from Phase 9. Note, boiler house to right of shot, stockpiles breeze blocks to left of shot and concrete stockpile in distance.

Figure 7: Looking east from Phase 9 towards the north-eastern part of Phase 9. Note, POL21 (located on Phase 10) can be seen in distance.

Figure 8: Looking south from Phase 9 along eastern boundary of the site. Note, stockpiled breeze blocks which restricted access for intrusive ground investigation.

Figure 9: Looking at former boiler house on Phase 9.

Figure 10: Looking southeast from Phase 9 towards south-eastern boundary of the phase. Note the concrete stockpile to right of shot.

Figure 11: Looking at tanks to the southeast of Phase 9. Note, Gallos Brook located top right of shot.

Figure 12: Looking at tanks in southeast of Phase 9. Note, tanks in the foreground and in the background of shot.

Figure 13: Looking within one of the former school classrooms.

Figure 14: Looking east from Phase 9 at soil and concrete stockpiles located in the south of Phase 9.

Figure 15: Looking at stockpiled material close to entrance to Phase 9.

Figure 16: Looking at above ground tanks in Phase 10.

Figure 17: Looking northwest from the centre of Phase 10.

Figure 18: Looking northeast towards POL 21.

Figure 19: Looking north towards POL 21.

Figure 20: Looking west from central southern part of Phase 10.

Figure 21: Looking west towards POL 21.

Figure 22: Looking towards the former Upper Heyford air base runways from the top of POL 21.

Figure 23: Looking northeast across Phase 16A. Note Phase 9 in distance.

Figure 24: Looking east across Phase 16A.

Figure 25: Looking east across Phase 16.

Figure 26: Looking north across Phase 16.

Figure 27: Looking west across Phase 16A (foreground) and Phase 16 (Background). Note, Gallos Brook separating the two phases.