



**Defence  
Infrastructure  
Organisation**

Future Defence Storage and Redistribution Programme,

## Redevelopment of MOD Bicester

# Graven Hill: Land Quality Assessments - Phase 1 and Phase 2

BIC/OPA/DOC/21

September 2011



# **Defence Estates**

## **Site D and Site E, DSDC Bicester**

Phase Two Land Quality Assessment  
DE Project No: 13104

Final Report

24 September 2010

Prepared by Entec UK Limited for the  
Ministry of Defence under commission  
FTS3/PTSELM/46



**DEFENCE ESTATES**  
Delivering Estate Solutions to Defence Needs



---

**Report for**

Jenny Robbins  
Environmental Manager  
DE Ops North PTS-ELMG  
Defence Estates  
Kingston Road  
Sutton Coldfield  
West Midlands B75 7RL


---

**Main Contributors**

Simon Howard  
Stephen Dooley  
James Ridehalgh  
Lewis Miffling

---

**Issued by**

  
.....  
Simon Howard

---

**Approved by**

  
.....  
Mike Sheard

---

**Entec UK Limited**

Canon Court  
Abbey Lawn  
Abbey Foregate  
Shrewsbury SY2 5DE  
England  
Tel: +44 (0) 1743 342000  
Fax: +44 (0) 1743 342010

## Defence Estates

### Site D and Site E, DSDC Bicester

Final Phase Two Land Quality Assessment  
Report

24 September 2010

Prepared by Entec UK Limited for the  
Ministry of Defence under commission  
FTS3/PTSELM/46

r:\data\mod projects\26999 dsc bicester lqa review\docs\final  
reports\ph2\d and e sites\m084i2.doc



Certificate No. FS 13881



Certificate No. EMS 69090

In accordance with an environmentally responsible approach,  
this document is printed on recycled paper produced from 100%  
post-consumer waste, or on ECF (elemental chlorine free) paper



**Document Revisions**

No.	Details	Date
1	Draft Phase Two LQA Report	31 August 2010
2	Final Phase Two LQA Report	24 September 2010

---

# Land Quality Statement for Site D and Site E, DSDC Bicester

---

## Introduction and Terms of Reference

Entec UK Ltd (Entec) was commissioned by Defence Estates (DE) to undertake a Phase Two Land Quality Assessment (LQA) of Site D and Site E, DSDC Bicester, Oxfordshire ('the site') on 28 June 2010. This commission was carried out under the interim contracting arrangement and FATS/3 framework between Entec and Defence Estates. The purpose of the assessment is to provide information on the site as well as any health and environmental risks that any potential contamination may present to existing site users and in changing the use of the land.

## Site Location and Description

The site is located approximately 1.5 km south-east of Bicester town centre, Oxfordshire. Site D and Site E are located to the immediate north-west and south-east of Graven Hill respectively, which is located at National Grid Reference (NGR) 458800 220500. Access to the site is made via a dedicated access road off a roundabout on the A41 to the immediate south of Bicester.

The site forms a continuous 'ring' of land surrounding St David's Barracks on Graven Hill that includes the former Operational Service Unit (OSU) and Bicester International Freight Terminal (BIFT) located to the immediate east of E Site. The site covers a total area of approximately 130 ha, with buildings, roads, railway lines and other hardstanding covering approximately 25% of the site area, with the balance as soft landscaping, fields and woodland.

## Site History

The entire DSDC Bicester site was built on agricultural land and woodland during the period 1941-1943 and was subsequently stocked with tanks, armoured cars, other vehicles and guns in preparation for the invasion of Europe in 1944. The site was used for the processing of return stores from the Second World War and for stores issue in 1949 for the Korean War. The entire DSDC Bicester site was redesignated as a Base Ordnance Depot (BOD) in the 1950, with the adjacent St David's Barracks constructed by 1956. By 1961 the whole site had been reorganised, with technical stores and Motor Transport (MT) units to other depots including BOD Donnington in Shropshire. BOD Bicester was established as the main UK depot for military clothing and general stores. By 1992, the whole site became known as the Defence Storage and Distribution Centre, Bicester.

## Environmental Setting and Site Sensitivity

The anticipated geological sequence consists of undivided Made Ground (in the north-west boundary of E Site) and Landscaped Ground (over the rest of the site) directly overlying solid geology consisting of the Peterborough Member (mudstone) of the Oxford Clay Formation. Beneath the Oxford Clay Formation, the Kellaways Sand and Kellaways Clay members of the Kellaways Formation both outcrop in the north-west of E Site.

The anticipated geological sequence consists of undivided Made Ground (in the north-west boundary of E Site) and Landscaped Ground (over the rest of the site) directly overlying solid geology consisting of the Peterborough Member (mudstone) of the Oxford Clay Formation. Beneath the Oxford Clay Formation, the Kellaways Sand and Kellaways Clay members of the Kellaways Formation both outcrop in the north-west of E Site. Almost the entire site is underlain by a Non-Aquifer (Negligibly Permeable), which appears to relate to the Oxford Clay Formation. Groundwater sensitivity has been assessed as **low**.

Precipitation from roofs and hardstanding areas drains to a network of surface water drainage ditches that drain the low-lying, poorly draining parts of the site. The closest surface water feature to the site is the Langford Brook, which enters the site at the extreme northern tip of Site E. The Langford Brook discharges into the River Ray approximately 3 km south-west of the site. There are records of one surface water abstraction license within 1 km of the site and thirty-three Licensed Discharge Consents within 500 m of the site, nineteen of which relate to permits that are now revoked. During a conversation with a representative of Kelda Water Services during preparation of the Phase One LQA, it was indicated that no discharge consents related to the site are still extant. Surface water sensitivity has been assessed as **moderate/high**.

There are records of three ESAs within 0.5 km of the site, which collectively form part of the Upper Thames Tributaries ESA. The closest of these areas is 16 m south-east of the site boundary. A SSSI, Arncott Bridge Meadows, is located 50 m to the north-east of the strip of land connecting D Site and DSDC Bicester C Site. The condition of this site is recorded as 'favourable'. In addition, the site falls within a Nitrate Vulnerable Zone (NVZ). Ecological sensitivity has been assessed as **moderate**.

### Sources of Potential Site Contamination

The following areas of potentially significant contamination risk were identified for further investigation, with reference to the Zones identified within the Phase Two LQA:

- D Site Zone 1: BIFT (fuel storage area with known spills);
- D Site Zone 2: Vicinity of buildings D2, D6, D9 and Maintenance Yard (fuel storage and workshops);
- D Site Zone 3: Area of Made Ground between buildings D6 and D9;
- E Site Zone 1: Rodney House / OSU (fuel storage areas with known spills);
- E Site Zone 2: Car park by E25 and building E10 (former fuel storage);
- E Site Zone 3: Building E14/E16 fuel tanks and building E20 (fuel storage and use);
- E Site Zone 4: E15 Tip Area.

In addition, the Environment Agency (EA) expressed concern over the potential for site contaminants to have migrated and impacted on the Kellaways Sands outcropping in the far north-west of the site. Consequently, three window sample locations were excavated in this area to assess the presence of contamination in the ground and groundwater in this area of the site, referred to in this report as E Site Zone 5.

## Site Works

To target the above identified sources of contamination, a detailed programme of site appraisal and intrusive investigation was undertaken. This included a radiological survey of targeted parts of the site along with boreholes, trial pits and hand dug pits.

## Contamination Findings and Environmental Risk Assessment

- Laboratory analysis of soil samples indicated the presence of organic and inorganic contaminants, particularly hydrocarbons including polycyclic aromatic hydrocarbons (PAHs) as well as metals/metalloids including selenium, arsenic, and within the E15 Tip Area, hexavalent chromium, copper, lead, mercury, nickel and zinc. This is indicative of there having been some impact by site activities, and largely corresponds with visual and olfactory evidence of contamination noted at a number of locations across the site;
- Asbestos was also identified, generally as chrysotile (white asbestos) in the form of cement board in a single soil sample from D Site Zone 2 and E Site Zone 3;
- Laboratory analysis of groundwater and surface water samples from across the site generally indicated widespread, but typically moderate, exceedances for ammoniacal nitrogen and sulphate, as well as generally limited exceedances for hydrocarbons including speciated PAHs, as well as metals and metalloids, including boron and selenium;
- The vast majority of the areas investigated displayed surface radioactivity readings at natural background activity levels of 90-200 cps. Three small areas of elevated radiological readings were identified, one within the BIFT and two within the E15 Tip Area. Based on the results of the radiological survey, all three areas identified as exhibiting elevated probe measurements were targeted for hand excavated exploratory holes. The results of the hand excavation revealed that the source of the elevated readings in the location within the BIFT was naturally occurring, as large granite cobbles. Within the E15 Tip Area, one hand pit encountered a layer of ashy material whilst the other revealed a small artefact (a damaged luminised dial). Only the luminised dial is likely to be classified as Low Level Waste (LLW);
- Soil gas, comprising volatile organic compounds, methane and carbon dioxide were generally recorded at low concentrations. The GSVs generally indicate a 'green' NHBC traffic light classification, meaning ground gas protection measures are not likely to be required. However, the carbon dioxide concentration of within D Site Zone 1 and E Site Zone 3 give rise to an 'Amber 1' classification, meaning low to moderate gas protection measures are likely to be required;
- The risks to current site users from contamination with all of the zones investigated are generally assessed as **low** to **moderate/low**. **Moderate/low** risks were associated with landfill gas in the E15 Tip Area;
- The risks to future residential site users from contamination with all of the zones investigated are generally assessed as **moderate/low**. However, **moderate** risks were identified from hydrocarbons, metals and asbestos within the E15 Tip Area;

- The risks to future commercial/industrial site users from contamination with all of the zones investigated are generally assessed as **low** to **moderate/low**. The **moderate/low** risks were assessed related to hydrocarbons, metals, asbestos and hydrocarbons, metals, asbestos and landfill gas in the E15 Tip Area;
- Overall risks to construction workers from the contamination identified in all of the zones investigated have been assessed as **low** to **moderate/low** based on the potential for exposure, particularly due to a range of contaminants in the E15 Tip Area. It should be noted that in close proximity to underground tanks and flow lines higher concentrations of hydrocarbons may be present than identified in this investigation. However, exposure times are likely to be short and exposure can be controlled by design considerations, environmental management during construction and suitable personal protective equipment. The risk to this receptor will be mitigated through use of appropriate PPE and control measures;
- The risks to neighbouring site users from contamination with all of the zones investigated are generally assessed as **low** to **moderate/low**. **Moderate/low** risks were assessed related to landfill gas in the E15 Tip Area;
- It is considered likely that the sulphate is naturally derived (e.g. gypsum crystals were noted within the clays on the borehole logs). Therefore, risks to groundwater from contamination present within the zones investigated have been assessed as **negligible**;
- With the possible exception of ammoniacal nitrogen and sulphate, there appears to be no consistent linkage between soil contamination and the minor groundwater exceedances. Therefore, risks to surface water from contamination present within the zones investigated have been assessed as **low** to **moderate**. **Moderate/low** risks were assessed related to former vehicle fuelling areas (D18 and E11), the E20 former fire training building, the E15 tip area, site-wide POL stores and Made Ground in the BIFT and between buildings D6 and D9. Risks associated with the E15 Tip Area were assessed as **moderate**;
- The risk to ecological receptors and vegetation is assessed as **negligible** to **low**. The risks to agricultural receptors have also been assessed as **negligible**;
- The potential presence of fuel contamination (especially heating oil) at the site from the areas investigated generally gives rise to **low** to **negligible** risks to buildings and buried services.

### Overall Land Quality and Suitability for Existing Use and Future Development

Based on findings of this risk-based Phase Two LQA, which targeted areas of potential contamination identified from the Entec Phase One LQA, the majority of the site (Site D and Site E) is considered suitable for current use with only a few localised occurrences of contamination identified.

The future use of Site E is likely to be a combination of residential (which will include garden areas), public open space and commercial/industrial use. The future use of D Site is likely to be similar to that of E Site.

Based on the results of the investigation, the site (Site D and Site E) is considered to be suitable for redevelopment for a residential (with gardens) end use and further commercial/industrial use which may include further development.

However, due to the limited nature and extent of the intrusive investigation and the potential for residual contamination to be present in and around existing (and in most cases still operational) infrastructure, it is possible that additional investigation will be required as part of the development process. Such investigation will be dependant upon the development design. Ground gas/vapours may also need to be considered if new residential or commercial/industrial developments are built on areas of localised hydrocarbon contamination but will again be dependant upon the development design.



# Contents

<b>1.</b>	<b>Introduction</b>	<b>1</b>
1.1	<b>Terms of Reference</b>	<b>1</b>
1.1.1	Aims and Methodology	1
1.1.2	Future Site Use	2
1.2	<b>Site Location</b>	<b>2</b>
1.3	<b>Site Information</b>	<b>2</b>
1.3.1	General	2
1.3.2	Site History	2
1.3.3	Land Use	2
1.3.4	Site Buildings and Activities	3
1.3.5	Evidence of Former Structures, Fill Material and/or Disturbed Ground	4
1.3.6	Site Boundaries	5
1.3.7	Tenant, Lodgers and Enclaves	6
1.3.8	Buried Services	6
1.3.9	Ordnance	7
1.3.10	Dstl Radiological Assessment	8
1.4	<b>Environmental Setting and Site Sensitivity</b>	<b>8</b>
1.4.1	Geology and Hydrogeology	8
1.4.2	Surface Water	9
1.4.3	Ecology	9
1.5	<b>Previous Entec Phase One LQA Assessment</b>	<b>9</b>
1.5.1	Summary of Potential On-site Sources of Contamination	9
1.5.2	Summary of Potential Off-Site Sources of Contamination	10
<b>2.</b>	<b>Sources of Information</b>	<b>11</b>
2.1	<b>General Information Sources</b>	<b>11</b>
<b>3.</b>	<b>Assessment Approach</b>	<b>13</b>
3.1	<b>Introduction</b>	<b>13</b>
3.2	<b>Definition of Contaminated Land</b>	<b>13</b>
3.3	<b>Assessment Framework - Chemical Contaminants</b>	<b>14</b>
3.4	<b>Assessment Framework - Radioactive Contaminants</b>	<b>15</b>



3.4.1	Background	15
<b>4.</b>	<b>Initial Conceptual Site Model and Preliminary Risk Assessment</b>	<b>17</b>
4.1	Introduction	17
4.2	Initial Conceptual Site Model	17
4.2.1	Receptors and Pathways	17
4.3	Preliminary Risk Assessment Findings	18
4.3.1	Current Site Users	18
4.3.2	Construction and Maintenance Workers	18
4.3.3	Future Site Users (Residential, Commercial and Industrial)	19
4.3.4	Neighbouring Site Users	19
4.3.5	Groundwater	19
4.3.6	Surface Water (Site Drainage Ditches, Langford Brook)	20
4.3.7	Ecological Systems	20
4.3.8	Agriculture (Arable and Livestock)	20
4.3.9	Buildings and Buried Services	20
4.4	Summary of Potential Contamination	20
<b>5.</b>	<b>Site Investigation</b>	<b>23</b>
5.1	Objectives	23
5.2	Scope of Works	23
5.2.1	Variations to Original Scope	24
5.3	Non Intrusive Surveys	24
5.3.1	Radiological Walkover Survey	24
5.4	Intrusive Site Investigation	26
5.5	Chemical Sampling and Analysis	28
5.5.1	Soil Sampling	28
5.5.2	Soil Analysis	28
5.5.3	Groundwater Analysis	29
5.5.4	Surface Water Analysis	29
5.6	Gas and Vapour Screening	29
5.7	Standpipe Monitoring	29
5.8	Quality Assurance and Control	30
5.9	Health and Safety	30
5.9.1	CDM Regulations	30
5.9.2	Health and Safety Planning	30

<b>6.</b>	<b>Ground Conditions</b>	<b>31</b>
6.1	<b>Strata Encountered</b>	<b>31</b>
6.1.1	Site D: BIFT Area	31
6.1.2	Site D: Vicinity of Buildings D2/D6/D9 and Maintenance Yard	32
6.1.3	Site D: Area of Made Ground Between D6 and D9	32
6.1.4	Site E: Rodney House and the Ordnance Support Unit (OSU)	33
6.1.5	Site E: Car Park by E25 and Building E10 Area	33
6.1.6	Site E: Building E14/16 Fuel Tanks and Building E20	34
6.1.7	Site E: E15 Tip Area	35
6.1.8	Site E: Agricultural Land on North Western Boundary	35
6.2	<b>Visual and Olfactory Evidence of Contamination</b>	<b>35</b>
6.3	<b>In-Situ Vapour Monitoring</b>	<b>37</b>
6.4	<b>Radiological Monitoring</b>	<b>37</b>
6.5	<b>Groundwater</b>	<b>37</b>
6.6	<b>Gas and Vapour Monitoring</b>	<b>40</b>
6.7	<b>Summary of Ground Conditions</b>	<b>42</b>
<b>7.</b>	<b>Generic Quantitative Risk Assessment</b>	<b>43</b>
7.1	<b>Assessment Guidelines</b>	<b>43</b>
7.1.1	Human Health Guidelines	43
7.1.2	Controlled Waters Guidelines	45
7.1.3	Absence of Guidelines	45
7.1.4	Radiological Assessment Guidelines	46
7.1.5	Entec's Approach to Risk Assessment from Radioactivity	49
7.2	<b>Definition of Zones</b>	<b>50</b>
7.2.1	Zones and Averaging Areas (Chemical Analysis)	50
7.2.2	Assessment Zones	50
7.2.3	Statistical Assessment	51
7.3	<b>Comparison with Generic Assessment Criteria</b>	<b>51</b>
7.3.1	D Site Zone 1: BIFT	52
7.3.2	D Site Zone 2: Buildings D2, D6, D9 and Maintenance Yard	54
7.3.3	D Site Zone 3: Area of Made Ground between buildings D6 and D9	57
7.3.4	E Site Zone 1: Rodney House and OSU	59
7.3.5	E Site Zone 2: Car Park by E25 and Building E10	61
7.3.6	E Site Zone 3: Building E14/E16 Fuel Tanks and Building E20	63
7.3.7	E Site Zone 4: E15 Tip Area	66
7.3.8	E Site Zone 5: Agricultural Land on North-Western Boundary	69
7.3.9	Radiological Survey Results	71
7.3.10	Radiological Intrusive Investigation	73

<b>7.4</b>	<b>Conceptual Model</b>	<b>74</b>
7.4.1	Summary of Ground Conditions	74
7.4.2	Summary of Contaminants	75
7.4.3	Receptors and Pathways	78
<b>7.5</b>	<b>Risk Assessment</b>	<b>79</b>
7.5.1	Current Site Users (Commercial/ Industrial)	80
7.5.2	Future Site Users (Residential and Commercial/ Industrial)	81
7.5.3	Construction and Maintenance Workers	81
7.5.4	Neighbouring Site Users	81
7.5.5	Groundwater	81
7.5.6	Surface Water	82
7.5.7	Ecological Receptors	82
7.5.8	Agricultural Receptors (Arable and Livestock)	83
7.5.9	Buildings and Buried Services	83
<b>8.</b>	<b>Overall Land Quality and Suitability for Continued Use</b>	<b>85</b>
<b>8.1</b>	<b>Site Sensitivity</b>	<b>85</b>
<b>8.2</b>	<b>Overall Land Quality</b>	<b>85</b>
<b>8.3</b>	<b>Environmental Risks</b>	<b>86</b>
<b>8.4</b>	<b>Suitability of the Site for Continued Use</b>	<b>87</b>
<b>8.5</b>	<b>Suitability of the Site for Future Development</b>	<b>87</b>
Table 1.1	Site Buildings and Activities	3
Table 1.2	Site Former Structures, Fill Material and/or Disturbed Ground	5
Table 1.3	D Site Boundaries and Adjacent Land Uses	6
Table 1.4	E Site Boundaries and Adjacent Land Uses	6
Table 3.1	Tiered Framework	14
Table 4.1	Receptors and Pathways	17
Table 4.2	Definition of Risk Classification	18
Table 5.1	Outline of Works Undertaken	23
Table 5.2	Summary of Radiological Instrument Calibration Factors and Indicative Count Rates	25
Table 5.3	Intrusive Investigation Locations	26
Table 6.1	Geological Sequence Encountered During Investigation	31
Table 6.2	Groundwater Monitoring Summary	38
Table 6.3	Groundwater Visual and Olfactory Evidence of Contamination	40
Table 6.4	Vapour Monitoring Summary	41
Table 7.1	Ra-226 Disposal Criteria	48
Table 7.2	RadSurvey Calibration Data	49
Table 7.3	Ludlum 2" Calibration Data	49
Table 7.4	Assessment Zones	51
Table 7.5	Summary of Zone 1 Soil Exceedances Compared to GAC	52
Table 7.6	Summary of E Site Zone 3 Soil Exceedances Compared to GAC	64
Table 7.7	Summary of E Site Zone 4 Soil Exceedances from Made Ground Compared to GAC	66
Table 7.8	Radiological Survey: Probe Readings in Point Source Locations Site D	73
Table 7.9	Radiological Survey: Probe Readings in Point Source Locations Site E	73
Table 7.10	Intrusive Radiological Summary	74
Table 7.11	Updated Receptors and Pathways	78
Table 7.12	Risk Assessment Criteria	79
Table 7.13	Consequence Matrix	80

Figure 1	Site Location
Figure 2	Site Layout
Figure 3a	Radiological Survey Coverage Site D
Figure 3b	Radiological Survey Coverage Site E
Figure 4	Exploratory Hole Locations
Figure 5	Visual and Olfactory Evidence of Contamination
Figure 6	Site Zonation Plan
Figure 7a	Soil Exceedances of Generic Assessment Criteria (GAC)
Figure 7b	Ground and Surface Water Exceedances of Water Quality Targets (WQT)
Figure 8a	Radiological Survey Results Site D
Figure 8b	Location of Areas of Elevated Activity Site E
Figure 9	Indicative Exempt and Low Level Waste Site D
Figure 10	Conceptual Model

Annex A	Intrusive Hole Logs
Annex B	Gas Monitoring Tables
Annex C	Water Monitoring Data
Annex D	Screened Laboratory Data
Annex E	Laboratory Analysis Certificates
Annex F	Radiological Trial Pit Logs
Annex G	Environmental Risk Assessment Tables



---

## Glossary of Terms

---

ACM	-	Asbestos Containing Material
AOD	-	Above Ordnance Datum
AONB	-	Area of Outstanding Natural Beauty
AST	-	Above ground Storage Tanks
BFI	-	Bulk Fuel Installation
bgl	-	below ground level
BGS	-	British Geological Survey
BIFT	-	Bicester International Freight Terminal
BOD	-	Base Ordnance Depot
COD	-	Central Ordnance Depot
BTEX	-	Benzene, Toluene, Ethyl Benzene and Xylene
CLEA	-	Contaminated Land Exposure Assessment
DE	-	Defence Estates
DSDC	-	Defence Storage and Distribution Centre
Dstl	-	Defence Science and Technology Laboratory
Dstl ESD-		Dstl Environmental Service Department
DEFRA-		Department for Food and Rural Affairs
EA	-	Environment Agency
EPA	-	Environmental Protection Act 1990
ESA	-	Environmentally Sensitive Areas
GAC	-	Generic Assessment Criteria
GQA	-	General Quality Assessment (Surface Water)
GQRA	-	Generic Quantitative Risk Assessment
HPA	-	Health Protection Survey
LQA	-	Land Quality Assessment
ESA	-	Environmentally Sensitive Areas
MOD	-	Ministry of Defence
MT	-	Motor Transport

---

NGR	-	National Grid Reference
NNR	-	National Nature Reserves
NRPB	-	National Radiological Protection Board
NGR	-	National Grid Reference
OS	-	Ordnance Survey
OSU	-	Operational Service Unit
OWI	-	Oil Water Interceptor
PAH	-	Polycyclic Aromatic Hydrocarbons
POL	-	Petrol, Oil and Lubricants
Part 2A	-	Part 2A of the Environmental Protection Act (1990)
PCB	-	Polychlorinated Biphenyls
PPE	-	Personal Protective Equipment
RPC	-	Regional Prime Contractor
QRA	-	Quantitative Risk Assessment
SAC	-	Special Areas of Conservation
SPA	-	Special Protected Areas
SPZ	-	Source Protection Zone (groundwater)
SSSI	-	Site of Special Scientific Interest
TPH	-	Total Petroleum Hydrocarbons
VOC	-	Volatile Organic Compounds
UXO	-	Unexploded Ordnance
WWII	-	The Second World War

---

# 1. Introduction

---

## 1.1 Terms of Reference

Entec UK Ltd (Entec) was commissioned by Defence Estates (DE) to undertake a Phase Two Land Quality Assessment (LQA) of Site D and Site E, DSDC Bicester, Oxfordshire ('the site') on 28 June 2010. This commission was carried out under the interim contracting arrangement and FATS/3 framework between Entec and Defence Estates.

The purpose of the assessment is to provide information on the site as well as any health and environmental risks that any potential contamination may present to existing site users and in changing the use of the land.

### 1.1.1 Aims and Methodology

It is understood that the LQA is required to support disposal of the sites and redevelopment to a combination of residential, public open space and commercial/industrial uses. This investigation is designed to provide sufficient information to allow an estimate of the magnitude of potential issues.

The information obtained allows the site conceptual model to be refined and the environmental risk assessment to be reappraised based on the findings of this Phase Two investigation. This information is used to refine future potential management options and to identify where further investigation is required, if necessary.

To achieve this, the following methodology was adopted:

- Review of the May 2010 Entec Phase One LQA, including risk appraisal;
- Acquisition and review of buried service plans;
- A buried service clearance exercise, including identification of site drainage routes and fuel infrastructure;
- Non-intrusive investigation, consisting of radiological survey of targeted areas of the site to assess the potential presence of detectable radiological residues;
- Targeted intrusive investigation, consisting of progression of cable percussive and window sample boreholes, excavation of machine dug trial pits and hand dug pits;
- Gas and groundwater monitoring of installed boreholes;
- Surface water monitoring of the site-wide drainage ditch network; and
- Interpretation and reporting of analytical laboratory data.

The findings of this study are based on the information made available to Entec by MOD personnel at the time, together with information obtained from the intrusive investigation.



### **1.1.2 Future Site Use**

It is understood that the LQA is required to support disposal of the sites and redevelopment to a combination of residential with gardens, public open space and commercial/industrial use. For the purposes of the risk assessment, this report considers future use of the site for residential with plant uptake (i.e. residential with gardens) as well as commercial/industrial purposes.

## **1.2 Site Location**

The site is located approximately 1.5 km south-east of Bicester town centre, Oxfordshire. Site D and Site E are located to the immediate north-west and south-east of Graven Hill respectively, which is located at National Grid Reference (NGR) 458800 220500. Access to the site is made via a dedicated access road off a roundabout on the A41 to the immediate south of Bicester. The location of the site is shown in Figure 1.

## **1.3 Site Information**

### **1.3.1 General**

The site forms a continuous 'ring' of land surrounding St David's Barracks on Graven Hill that includes the former Operational Service Unit (OSU) and freight terminal (BIFT) located to the immediate east of E Site. The site covers a total area of approximately 130 ha, with buildings, roads, railway lines and other hardstanding covering approximately 25% of the site area, with the balance as soft landscaping, fields and woodland. A site layout plan is included as Figure 2.

### **1.3.2 Site History**

A detailed site history has been presented in the previous Phase One LQA. This is summarised below.

The entire DSDC Bicester site was built on agricultural land and woodland during the period 1941-1943 and was subsequently stocked with tanks, armoured cars, other vehicles and guns in preparation for the invasion of Europe in 1944. The site was used for the processing of return stores from WWII and for stores issue in 1949 for the Korean War. The entire DSDC Bicester site was redesignated as a Base Ordnance Depot (BOD) in the 1950s, with the adjacent St David's Barracks constructed by 1956. By 1961 the whole site had been reorganised, with technical stores and Motor Transport (MT) units to other depots including BOD Donnington in Shropshire. BOD Bicester was established as the main UK depot for military clothing and general stores. By 1992, the whole site became known as the Defence Storage and Distribution Centre, Bicester.

### **1.3.3 Land Use**

The site is understood to be a storage and distribution hub for a variety of military equipment, including clothes, rations, tents, packaging materials as well as general stores. According to available information (refer to Section 1.3.9 of this report), it is understood that the site has never been used to store explosive ordnance.

There is an extensive private railway network across the site which is connected to the national rail network via a spur off the Oxford-Bletchley main line. Fields are located in the far north-west of E Site which are used for rough agricultural grazing.

### 1.3.4 Site Buildings and Activities

With reference to Figure 2, Table 1.1 summarises the buildings/activities within each area of the site.

**Table 1.1 Site Buildings and Activities**

Building No.	Description and Activities
<b>D Site</b>	
D1, D2 and D4 to D9	General stores for items including military clothing, rucksacks, textiles, rations, reels of electrical cable and packaging materials. Adjacent to Building D4 are four uncovered engineers stores areas, used for the storage of runway bomb damage repair kits. Adjacent to building D2 is a series of six small single-storey brick buildings, three each on opposite sides of the building that appears to have been used for storage but is now generally empty.
D3	DSDA HRD (Learning and Development Centre), used as offices. Adjacent to building D3 is a series of four small single-storey brick buildings (two each on opposite sides of the building) that appear to have been used for storage but are now generally empty.
D10	Brick warehouse used for storage of packed quantities of hexamine solid fuel tablets and stoves.
D11	Former fire station of modern brick construction that is now used by the Railway Squadron Rail Troop for storage of railway locomotive spare parts, clothing and memorabilia.
D12 and adjacent shed/small brick building	Used by Barloworld Handling for maintenance and repair of forklift trucks.
D13	Small brick guard house and office.
D14	Brick building used for ad-hoc furniture and archive storage.
D15 and D16	Part of the recently installed site-wide sprinkler system plant.
Adjacent to D13	Small brick building opposite guardhouse (D13) that appears to be disused. Possible offices/welfare block.
D21	Single storey brick building that appears to be a former guardhouse.
D98	Corrugated iron rail wagon shed, used for storage of the Queen's Carriage.
D99	Two storey brick building used by the DSDA Rail and Container Service as offices/welfare.
<b>E Site</b>	
E1	The Defence Distribution Hub. To the west of E1 is a small empty brick building, the E1 paint store.
E2/E2G	Large warehouse building used by Kellogg, Brown & Root (KBR) for storage of temporary field hospitals and mortuaries. Associated generators are also stored within the building but no fuels, etc. E2G is a single storey brick forklift truck garage to the south-west of E2, used for parking and electrical charging of forklift trucks.
E3	Storage of a variety of packaging materials and dry batteries. A forklift truck garage is present to the immediate north of E3, used for parking and electrical charging of forklift trucks.
E4	Small empty brick building.

**Table 1.1 (continued) Site Buildings and Activities**

<b>Building No.</b>	<b>Description and Activities</b>
E5	Brick warehouse building occupied by European Freight Services Ltd, used for storage of packaged items for distribution.
E6	Occupied by PriDE, used for temporary storage of old computers and packaging materials prior to disposal.
E7/E7A	Small brick guard house and office.
E10	Part of the recently installed site-wide sprinkler system plant.
E14	Former (disused) boiler plant with large (30 m long) empty coal bunker and rail wagon shed to the immediate south.
E15	Large non-hazardous storage warehouse used for returned stores items from military operations and bases.
E15A	Single storey brick constructed offices, the 'Head Office Business Development and Contracts storage Business Stream Bicester Sites'.
E16	Rail and Container Service depot, with garages for the storage and servicing of site locomotives and rolling stock. To the immediate south-east is a former brick-built POL store.
E17	Large Rubb hangar used for storage of non-hazardous aircraft parts.
E20	Single storey partly collapsed derelict brick building, signposted as 'fire training area'. Former coal storage bunker at the rear of building.
E25	Single storey brick built DSDA office.
E31	Large half-round corrugated metal 'bolero' type building, which was locked at the time of the site visit. To north-east of E31 is a small brick single storey building, which is locked at appears disused.
E59	Single storey forklift truck garage, used for parking and electrical charging of forklift trucks adjacent to E5.
Water Tower	Large modern construction water tower situated in the vicinity of E6.
<b>OSU, including buildings S2, S3, S11 and S905</b>	A number of (now disused) Nissen hut-type buildings, smaller brick buildings and a large above ground probable water tank within a fenced compound.
<b>BIFT, including buildings 1, 2A, 2, 3 and 4</b>	A large concrete surfaced shipping container storage/handling area with a number of small buildings including offices and a workshop in the south-eastern corner. A POL point is also present in the north-west corner of the area.

### **1.3.5 Evidence of Former Structures, Fill Material and/or Disturbed Ground**

Evidence of several former structures, fill material and/or disturbed ground was noted during the Phase One LQA site walkover, and, with reference to historic maps and plans is summarised in the Table 1.2.

**Table 1.2 Site Former Structures, Fill Material and/or Disturbed Ground**

<b>Building No.</b>	<b>Description</b>
<b>D Site</b>	
North of D3	5 m x 3 m concrete plinth with a brick surround of a small probable former building.
Between D6 and D9	Large grassy mounded area. Anecdotal information from site staff says this is likely to be surplus inert fill material from trenching activities site-wide from when the sprinkler system was installed and/or site levelling activities.
Opposite D13	Small building marked on 1966 historical photographs which now appear to have now been demolished.
D18	A historic plan included in the 1998 Aspinwall Phase One LQA factual report, dated 10 June 1948 shows building D18 to the north-west of D9 and is marked as a filling station. Area is now a car park.
D32	The four uncovered engineer's stores adjacent to Building D4 show evidence of previous structures. These stores are shown on a historic plan included in the 1998 Aspinwall Phase One LQA factual report, dated 10 June 1948, as 'bolero' buildings D32.
D34/D35	To south-east of D7 are two areas of possibly demolished buildings, with hardstanding still present. A historic plan included in the 1998 Aspinwall Phase One LQA factual report, dated 10 June 1948 shows these two hardstanding areas as 'bolero' buildings D34 and D35. Small piles of brick and broken concrete, soil and railway sleepers were noted during the site walkover. A large 3 m high stone-soil bund on north-eastern side of one of these areas was also noted. The 1998 Aspinwall Phase One LQA factual report states that there was a major fire in D34 in 1965, resulting in the destruction of 1.75 million sandbags.
<b>E Site</b>	
E11	A historic plan included in the 1998 Aspinwall Phase One LQA factual report, dated 10 June 1948 shows building E11 to the north-east of E3 and is marked as a filling station. Area is now a car park (E25 Car Park).
North-west of E15/E17	Area to immediate north-west appears to be a former tipping area. The Aspinwalls Phase One LQA interpretative report says filling is old (pre 1980s). Area is now heavily overgrown, but concrete, leaf litter, wooden sleepers, plastics, steel pipes and rails, empty steel oil drums, corrugated metal sheeting, bricks, plastic crates and breeze blocks all visible at the surface. Area bisected by a drainage ditch, which appears clean. It appears that approximately 2 to 3 m of materials have been tipped in this area as a land raise.
South of E17	Wooded area to immediate south of E17 contains piles of overgrown timber sleepers.
E30-E32	Within the south-westernmost of the three hardstanding areas to the immediate west of E2 is evidence of demolished buildings, which are probable former rail sheds according to site staff. A historic plan included in the 1998 Aspinwall Phase One LQA factual report, dated 10 June 1948 shows these three hardstanding areas as bolero buildings E30, E31 and E32.
HQ7	A historic plan included in the 1998 Aspinwall Phase One LQA factual report, dated 10 June 1948 shows the 'HQ7 Transit Shed' in the vicinity of the current E15. It is possible that this designation may both refer to the building now known as E15.
<b>BIFT</b>	An area of infilled/raised ground, approximately 5 m x 50 m x 3 m high noted on the south-western boundary.

### 1.3.6 Site Boundaries

Land uses surrounding the site are summarised in the following tables (Table 1.3 and Table 1.4) below.

**Table 1.3 D Site Boundaries and Adjacent Land Uses**

Boundary	Adjacent Land Use	Nearby Land Use
North	Military (E Site and St David's Barracks)	Predominantly residential with some agricultural and commercial
East	Agricultural	Predominantly agricultural with some residential
South	Agricultural	Agricultural
West	Agricultural	Predominantly agricultural with a railway line

**Table 1.4 E Site Boundaries and Adjacent Land Uses**

Boundary	Adjacent Land Use	Nearby Land Use
North	A41 road, agricultural and residential	Predominantly residential with some commercial
East	Commercial/Industrial (Bicester International Freight Terminal)	Predominantly agricultural with some residential
South	Military (E Site and St David's Barracks)	Predominantly agricultural
West	Railway	Predominantly agricultural with sewage works

### 1.3.7 Tenant, Lodgers and Enclaves

A number of areas of the site are leased to businesses and individuals for a variety of uses. According to the 2008 site Estate Development Plan, these areas/buildings include Rodney House Sports Club (leased by MOD Sports & Social Club) and Building E2 (leased by Kellogg, Brown and Root) along with three areas of allotments, agricultural land and grazing leased by individuals.

### 1.3.8 Buried Services

Information on buried services on and in the vicinity of the site was obtained via site records held by the following:

- The Site Estate Authority Team (SEAT);
- The MOD site estate management contractor (PriDE) via SEAT; and
- The MOD site water service (Project Aquatrine) contractor, Kelda Water Services (Kelda).

Buried service plans were obtained as part of the intrusive works. Water mains, surface and foul drainage, electricity mains, mains gas and telecommunications plans were made available to Entec.

### 1.3.9 Ordnance

As part of the Phase One LQA, an Explosive Ordnance Threat Assessment (EOTA) was commissioned, which concluded as follows:

- DSDC Bicester has been a military depot for over 65 years. No evidence could be found to indicate that the purpose of the depot was ever for the storage of explosive ordnance. Nevertheless, as with all historic military facilities, there is always a residual risk of explosive ordnance contamination;
- During the war years, the facility would have been defended, and weaponry in the form of small arms and land service ammunition would have been stored and available for use. Furthermore, as a result of the military association with the area, it is likely that the land on and around the depot would have been utilised for ground training exercises historically;
- The 'house-keeping' of WWII facilities is known to have often been poor with unwanted and unused items of explosive ordnance frequently buried, burnt, lost or otherwise discarded within a facility perimeter. Given the available history of the site, the likelihood of this having occurred within the perimeter of DSDC Bicester is not considered high, but cannot be entirely discounted. It should be noted that several search and clear operations have been undertaken at several locations on the site by 33 Engineer Regiment (EOD) in the post-war period. Although nothing was found, the requirement for and completion of such operations at the cost of the MoD indicates that there was a credible perceived threat/possibility of explosive ordnance contamination being present. It should also be noted that only small sections of DSDC Bicester have been subject to such searches, those searches only providing 12.5% clearance;
- Research indicates that bombing density over the Bicester area was low. Very few references could be found to raids over the region despite there being a number of high profile RAF targets present. ARP records for Central Ordnance Depot (COD) Bicester could not be located (reports of bombing on military land were generally made by military personnel and kept separate from civilian records). It has therefore not been possible to confirm that the facility was not attacked. However, work on the construction of the depot did not commence until after the main period of bombing in this part of the UK; and
- The depot employed thousands of people and for the latter part of WWII at least, would have been manned twenty-four hours a day. It is considered very unlikely that evidence of unexploded ordnance would have been overlooked across the site subsequent to construction work beginning in June 1941. Prior to this date, the site comprised open, agricultural land on which it is conceivable that unexploded bombs could have been overlooked had they been dropped. However, given the low bombing density in this part of the county and lack of viable targets within the site area in 1940/early 1941, the likelihood of unexploded bombs having been dropped is considered minimal.

BACTEC recommended a number of risk mitigation measures to support intrusive investigation, including:

- Explosive Ordnance Safety and Awareness Briefings to all personnel conducting intrusive works; and
- The Provision of Unexploded Ordnance Site Safety Instructions.

These measures were adopted by Entec through provision and presentation of the Construction Phase Health & Safety Plan (Entec ref: 26999Q066i1).

### 1.3.10 Dstl Radiological Assessment

As part of the Phase One LQA, a desk study was commissioned through the Dstl Environmental Services Department (Dstl ESD). Dstl ESD conducted a search of records relating to any radiological contamination issues at the whole DSDC Bicester site.

Dstl ESD records show that a very large number of items of standard military equipment containing radioactive material have been stored at the DSDC Bicester site from at least 1994 to the present day; the site being a major distribution centre for the main storage facility at DSDC Donnington. These include various pieces of instrumentation and check sources containing the following radionuclides: tritium (H-3), nickel-63 (Ni-63), thorium-232 (Th-232), strontium-90 (Sr-90) chlorine-36 (Cl-36) and cobalt-57 (Co-57). In addition, an instrumentation dial from a Canberra (jet aircraft) cockpit containing radium-226 (Ra-226) has been stored on site since at least 1999.

The desk study concluded that the likelihood of contamination being present on other parts DSDC Bicester is deemed to be **moderate**. In particular, if any additional burning grounds, disposal areas or workshops are identified on the site, these should be subject to a radiological survey.

This Phase Two LQA included radiological survey of areas of the site suspected as having the potential for contamination by radiological materials.

## 1.4 Environmental Setting and Site Sensitivity

A full description of the site environmental setting is presented within the Phase One LQA. This is briefly summarised below, with reference to the assessed site sensitivity.

### 1.4.1 Geology and Hydrogeology

The anticipated geological sequence consists of undivided Made Ground (in the north-west boundary of E Site) and Landscaped Ground (over the rest of the site) directly overlying solid geology consisting of the Peterborough Member (mudstone) of the Oxford Clay Formation. Beneath the Oxford Clay Formation, the Kellaways Sand and Kellaways Clay members of the Kellaways Formation both outcrop in the north-west of E Site.

Almost the entire site is underlain by a Negligibly Permeable strata, which appears to relate to the Oxford Clay Formation. However, there are two discrete areas within the extreme south of D Site underlain by a Secondary Aquifer (High Leaching Potential), which is likely to be related to the alluvial deposits in these areas. In addition, the strip of land connecting D Site and DSDC Bicester C Site is also underlain in places by a Secondary Aquifer (both High and Low Leaching Potential). Beneath the Oxford Clay and Kellaways formations, the Cornbrash Formation is also classified as a Secondary Aquifer of Low Leaching Potential.

Groundwater levels are understood to have been recorded at approximately 30 m below ground level. The site does not fall within a groundwater Source Protection Zones (SPZ) and there are no SPZ marked within 1 km of the site.

<b>Groundwater Sensitivity: Low</b>
-------------------------------------

#### **1.4.2 Surface Water**

Precipitation from roofs and hardstanding areas drains to a network of surface water drainage ditches that drain the low-lying, poorly draining parts of the site. The closest surface water feature to the site is the Langford Brook, which enters the site at the extreme northern tip of Site E. The Langford Brook discharges into the River Ray approximately 3 km south-west of the site. There are records of one surface water abstraction license within 1 km of the site and thirty-three Licensed Discharge Consents within 500 m of the site, nineteen of which relate to permits that are now revoked. During a conversation with a representative of Kelda Water Services during preparation of the Entec Phase One LQA, it was indicated that no discharge consents related to the site are still extant.

<b>Surface Water Sensitivity: Moderate/High</b>
---

#### **1.4.3 Ecology**

There are records of three Environmentally Sensitive Areas (ESA) within 0.5 km of the site, which collectively form part of the Upper Thames Tributaries ESA. The closest of these areas is 16 m south-east of the site boundary. A Site of Special Scientific Interest (SSSI) (Arncott Bridge Meadows) is located 50 m to the north-east of the strip of land connecting D Site and DSDC Bicester C site. The condition of this site is recorded as 'favourable'. In addition, the site falls within a Nitrate Vulnerable Zone (NVZ).

<b>Ecological Sensitivity: Moderate</b>
---

## **1.5 Previous Entec Phase One LQA Assessment**

Two Phase One LQAs and a Phase Two LQA are known to have historically been undertaken for the sites and are reported within Section 1.8 of the Entec Phase One LQA Report (Ref: 26999rr028i2).

The summary of potential sources of contamination identified within the Entec Phase One LQA is presented below.

### **1.5.1 Summary of Potential On-site Sources of Contamination**

Following the assessment of historical and current activities, there are several potentially contaminative activities which have been identified on the site, namely:

- Former vehicle fuelling areas at E11 and D18 (particularly related to any former/current underground storage tanks within these areas);
- Former railway workshops within current buildings D6 and D9;
- Former fire training building E20 (particularly related to fuel storage and usage, along with the ad-hoc storage of containers of potential contaminants);



- Former waste tip near building E15;
- Railway lines (site-wide);
- POL stores and POL points (fuel tanks) (site-wide);
- Oil/water interceptors (site-wide);
- Made Ground at BIFT and between D6/D9; and
- Made Ground: stockpile(s) of ash ballast materials.

### **1.5.2 Summary of Potential Off-Site Sources of Contamination**

Following the assessment of historical and current activities, there are several potentially contaminative activities which have been identified off the site which may have an impact on the site, namely:

- Former rifle range;
- Sewage Treatment Works; and
- Military use (particularly the adjacent St David's Barracks).

---

## 2. Sources of Information

---

### 2.1 General Information Sources

Information for this study has been gained from previous investigation reports and general mapping sources as summarised below.

#### Public Domain and Non-MOD Sources:

- General mapping/plans: recent and historical;
- BGS Digital Geological mapping;
- Hydrogeology mapping and groundwater vulnerability mapping;
- emapsite™ GroundSure data search (GeoInsight and EnviroInsight reports, as well as historical mapping);
- Local Authority (Cherwell District Council) environmental data search;
- English Heritage (National Monuments Record) aerial photographs;
- *The Bicester Military Railway and the Army's Central Railway Workshops* by E R Lawton & Major M W Sackett, Oxford Publishing Company, 1992 ISBN 0-86093-467-4-5;
- Archaeology and cultural heritage references; and
- Multi-Agency Geographic Information for the Countryside (MAGIC) website [www.magic.gov.uk](http://www.magic.gov.uk).

#### Specialist Data Searches

- A search of records relating to any radiological contamination issues was requested from Dstl ESD as part of the site Phase One LQA; and
- An Explosive Ordnance Threat Assessment (EOTA) was commissioned through BACTEC as part of the Phase One LQA.

#### MOD Information Sources

- Plans provided by Defence Estates;
- Estate Development Plan (v1.1, 15 August 2008) provided by Defence Estates;
- Phase One and Phase Two LQA Reports undertaken by Aspinwall & Company (1998 and 2001);
- Draft Phase 1 LQA Report undertaken by DE&S ESG (February 2010);
- Anecdotal information from estates management personnel; and

- OS Tiles provided by DE Geographical Information Unit.

**Site Visit by Entec on 9 July 2010**

- Observations, notes and documents reviewed; and
- Visual assessment of the site and surrounding area.

**Initial Non-Intrusive Site Surveys commissioned by Entec**

- Service clearance exercise undertaken by on 9 and 12 July 2010; and
- Radiological walkover survey of the E15 Tip Area and areas of Made Ground at the BIFT and between buildings D6 and D9 undertaken between 8 and 16 July 2010.

**Main Intrusive Site Investigation Works and Monitoring**

- Undertaken by Entec between 12 July and 18 August 2010.

---

## 3. Assessment Approach

---

### 3.1 Introduction

The potential health and environmental risks associated with contaminants at the site have been assessed using a risk based framework established to support the implementation of the contaminated land regime in the UK.

The contaminated land regime is based on the 'suitable for use' approach to the assessment and remediation of contaminated land, which recognises that the risks presented by contamination vary according to the use of the land and other circumstances. In accordance with the DE LQA Directive, the assessment considers potential future use of the site along with current use and circumstances of the land.

### 3.2 Definition of Contaminated Land

The contaminated land regime is set out within Part 2A of the Environmental Protection Act (EPA), 1990. It was introduced in England in April 2000 by the Contaminated Land (England) Regulations 2000, updated in 2006. The regulations are in turn supported by Statutory Guidance issued by the Department for the Environment Food and Rural Affairs (Defra) in September 2006, Defra Circular 01/2006<sup>1</sup>.

Part 2A provides a statutory definition of 'Contaminated Land' and sets out the nature of liabilities that can be incurred by owners of contaminated land. According to the Act, as amended by the Water Act 2003, contaminated land is defined as:

*"land which appears to the local authority in whose area it is situated to be in such a condition, by reason of substances in, on, or under that land:*

- that significant harm is being caused, or there is significant possibility of such harm being caused; or*
- that pollution of controlled waters is being or is likely to be caused."*

Central to the regulatory system is a rigorous procedure of risk assessment which is used to determine the existence of 'contaminated land' according to the definition. Under the risk assessment procedure, for such harm to the non-aquatic environment or pollution of controlled waters to be possible, there must be a 'significant pollutant linkage'.

In February 2010, Defra announced its decision to review the Statutory Guidance which underpins the contaminated land regime under Part 2A of the Environmental Protection Act 1990 and consider where it could be amended to reflect experience in delivering the regime and developments in scientific understanding.

---

<sup>1</sup> Department for Environment Food and Rural Affairs. Environmental Protection Act 1990: Part 2A Contaminated Land. Defra Circular 01/2006. September 2006.

It is anticipated that formal consultations on proposals to amend the Statutory Guidance will be undertaken in mid to late 2010. Defra has stated that while this work proceeds, Local Authorities should continue to fulfil their legal duty to identify and deal with contaminated land.

For the purpose of assessment within this report the legislation as it currently stands has been considered. However, this appraisal may need to be re-assessed should there be changes in the Statutory Guidance.

### 3.3 Assessment Framework - Chemical Contaminants

There is a range of technical approaches to risk assessment of chemical contaminants, all of which broadly fit within a tiered approach. The tiered approach to assessing risks from land contamination is set out in the Defra and Environment Agency publication "Model Procedures for the Management of Land Contamination" CLR11.

Entec's approach to undertaking risk assessments is based on a tiered framework in accordance with CLR11, as outlined in Table 3.1.

**Table 3.1 Tiered Framework**

Tier 1: Preliminary Risk Assessment	<ul style="list-style-type: none"> <li>• Development of a conceptual model.</li> <li>• Preliminary Risk Assessment examining potential contaminants, pathways and receptors to identify the potential 'pollutant linkages'.</li> <li>• Identification of further risk assessment requirements.</li> </ul>
Tier 2: Generic Quantitative Risk Assessment (GQRA)	<ul style="list-style-type: none"> <li>• Screening of analytical results against generic assessment criteria (GAC) for soils and groundwater including Soil Guideline Values, Environmental Quality Standards, etc., to identify issues that require more detailed consideration.</li> <li>• Identification of further risk assessment or risk management requirements.</li> </ul>
Tier 3: Detailed Quantitative Risk Assessment (DQRA)	<ul style="list-style-type: none"> <li>• Refinement of site conceptual model which may require the collection of additional data.</li> <li>• Application of detailed quantitative risk assessment procedures in accordance with CLR Guidance to further assess potential pollutant linkages. <ul style="list-style-type: none"> <li>– With respect to human receptors this may involve assessment of site specific exposure scenarios taking into account toxicological properties of substances to derive site specific assessment criteria (SSAC).</li> <li>– With respect to controlled water receptors this may involve simple analytical calculations of groundwater and/or surface water flow and contaminant attenuation to derive remedial target concentrations.</li> </ul> </li> <li>• To undertake the assessment proprietary software such as RISC4, RBCA or RAM may be used.</li> <li>• Identification of further risk assessment or risk management requirements.</li> </ul>

The conceptual model is developed at the preliminary risk assessment tier and reviewed and refined during subsequent risk assessment tiers. The conceptual model represents the characteristics of this site and indicates the possible relations between **contaminants, pathways and receptors**, where:

- a **contaminant** is a substance which is present in, on, or under the land and has the potential to cause harm;
- a **receptor** is something which could be adversely affected by the contaminant, including human beings; and
- a **pathway** is a route or means by which a receptor could be exposed to, or affected by, a contaminant.

For a potential risk to exist with respect to a site, all three of the above elements must be present, and linked together so that a contaminant has been identified, a receptor is located on the site and there is an exposure pathway that links the contaminant to the receptor. The term **pollutant linkage** is thus used to describe a particular combination of contaminant-pathway-receptor relationship.

In general, the application of increased tiers of risk assessment should result in less conservative assessment criteria which in turn should reduce the need for costly remediation action.

This report presents a **Tier 2 Generic Quantitative Risk Assessment** in accordance with the DE Contaminated Land Management LQA Management Guide (PG01/07).

In accordance with DE Phase 2 LQA Directive, the potential environmental risks associated with the following land uses have been evaluated:

- Current land use (i.e. military use); and
- Future use, including residential with gardens, public open space and commercial/industrial.

## 3.4 Assessment Framework - Radioactive Contaminants

### 3.4.1 Background

Since August 2006, Part 2A has been extended to include radioactive contamination (Defra Circular 01/2006, superseding 02/2000). Local Authorities now have a duty to identify sites that are potentially contaminated with radioactive material by virtue of past operational activities. Former military sites that were operational during the first half of the 20<sup>th</sup> century are likely to be considered as possible candidates for inspection under Part 2A, because of the historic use of radioactive materials on these sites.

This extension of Part 2A applies only in respect to harm to human health, and not in respect of other receptors or pollution of controlled waters. Under Part 2A, land is determined as contaminated land by virtue of radioactivity if 'harm' is being caused, or there is a significant possibility of 'harm' being caused to existing site users, by ionising radiation.

The criteria for harm are based on 'intervention' scenarios; i.e. situations in which site users are currently being exposed, and the decision must be made whether an 'intervention' (i.e. remedial action) is necessary to reduce exposure levels. Lower dose thresholds apply for 'practices', which generally refer to consented radioactive discharges but also include redevelopment projects that result in a different exposure scenario, i.e. a change of land use. The dose received can be related to the activity concentration of contaminated soil using software published by

Defra (CLR15). Radioactive soil guideline values (RSGVs) can be established for different exposure scenarios using this software.

## 4. Initial Conceptual Site Model and Preliminary Risk Assessment

### 4.1 Introduction

The findings of the Entec Phase One LQA form the basis of the initial conceptual model and risk assessment. The subsequent Phase Two intrusive ground investigation was designed on the basis of this initial conceptual model. The data obtained from the investigation have been used to refine and update this conceptual model. The updated conceptual model for the site is presented in Section 7.4.

### 4.2 Initial Conceptual Site Model

The following section summarises the initial conceptual model, consisting of the preliminary identified sources, pathways and receptors relevant to the site.

The potential sources of contamination are summarised previously within Section 1.5.

#### 4.2.1 Receptors and Pathways

Potential receptors and pathways from identified sources to receptors are detailed in Table 4.1.

**Table 4.1 Receptors and Pathways**

Receptor	Pathway
Site Visitors/Users (Commercial/Industrial)	Dermal contact, direct contact, ingestion, inhalation
Construction and Maintenance Workers	Dermal contact, direct contact, ingestion, inhalation
Future Site Users (Commercial/Industrial)	Dermal contact, direct contact, ingestion, inhalation
Future Site Users (Residential)	Dermal contact, direct contact, ingestion, inhalation
Neighbouring Site Users	Dermal contact, direct contact, ingestion, inhalation
Groundwater (secondary aquifer and unproductive strata)	Leaching from soils, transport in groundwater, groundwater contamination
Surface Water (site drainage ditches, Langford Brook)	Leaching from soils, transport in groundwater, groundwater contamination, run-off
Ecological Receptors	Uptake, direct contact
Agricultural Receptors	Uptake, direct contact
Buildings and Buried Services (current and future)	Degradation (chemical attack), direct contact, vapour migration



## 4.3 Preliminary Risk Assessment Findings

The environmental risk assessment undertaken as part of the Phase One LQA comprised an analysis of potential pollutant linkages (contaminant-pathway-receptor) on the site. The risk assessment is presented in full in the Phase One LQA report.

The potential risks were evaluated using the following criteria:

- i) Potential consequence of pollutant linkage;
- ii) Likelihood of pollutant linkage; and
- iii) Risk classification.

The 'Risk Classification' is an overall assessment of the potential risk, which considers the likely effect on a given receptor, taking account the potential consequence of the pollutant linkage and the likelihood. The definition of the risk classifications is outlined in Table 4.2.

**Table 4.2 Definition of Risk Classification**

<b>Potential Significance</b>	
Very High Risk	Severe harm to a receptor may already be occurring OR a high likelihood that severe harm will arise to a receptor, unless immediate remedial works/mitigation measures are undertaken.
High Risk	Harm is likely to arise to a receptor, and is likely to be severe, unless appropriate remedial actions/mitigation measures are undertaken. Remedial works may be required in the short term, but likely to be required over the long term.
Moderate Risk	Possible that harm could arise to a receptor, but low likelihood that such harm would be severe. Harm is likely to be medium. Some remedial works may be required in the long term.
Low Risk	Possible that harm could arise to a receptor. Such harm would at worst normally be mild.
Negligible	Low likelihood that harm could arise to a receptor. Such harm unlikely to be any worse than mild.

The following summarises the findings of the risk assessment undertaken in the Phase One LQA. The implications of redevelopment of the site for residential and commercial/industrial end use have been briefly considered together with current site usage.

### 4.3.1 Current Site Users

The site is an operational facility which is secure. Access to the site area is restricted to MOD staff and visitors. The majority of the site is suitable for use by the current users. However, due to the long history and the type of activities undertaken at the site, numerous potential but generally localised sources have been identified and the risks identified for these sources are assessed as **moderate/low**.

### 4.3.2 Construction and Maintenance Workers

A pollutant linkage is created during redevelopment activities, as extensive ground disturbance or entry into confined spaces may take place. However, exposures may be controlled by

working methods and suitable personal protective equipment (PPE). The exposure pathways include dermal contact, ingestion and inhalation.

It is assumed that ground work would be the subject of a site specific health and safety assessment and appropriate measures would be taken for any redevelopment work at the site. The risks to ground workers during redevelopment are therefore considered generally to be **moderate** but covers the range **moderate/low** to **moderate**. The incorporation of appropriate Health and Safety protocols will likely reduce these risks.

The risks during demolition or intrusive work could be greater than this, depending on the potential extent and condition of localised asbestos and work close to any fuel leaks.

#### 4.3.3 Future Site Users (Residential, Commercial and Industrial)

The risk to future site users depends on the type of redevelopment. The future site use is currently not known. For the most sensitive potential end uses, namely residential with gardens the risk to site users in the areas of identified potential contamination is generally **moderate/low** but are covered by a breadth of risks in the range **moderate/low** to **moderate**, with the **moderate** risks being assessed for source areas including the former fuelling areas D18 and E11, former fire training building E20, former railway workshops, former waste tip near E15, current POL point/fuel tanks and areas of Made Ground at the BIFT and between D6/D9.

For potential commercial/industrial end users, the risk is slightly lower, due to the probable placement of hard surfaces and consequent reduced contact with soil, which would reduce/negate potential pathways for contaminant migration to identified, less sensitive receptors. The exposure frequency and duration to contaminants from outdoor air is also reduced for commercial/industrial workers. The risks presented to future commercial/ industrial end users have generally been assessed as **moderate/low**.

#### 4.3.4 Neighbouring Site Users

The site is bounded in the main by agricultural areas and St David's Barracks. Whilst there is some potential for contaminants to be present on site, the localised nature of much of the identified potential contamination and negligible permeability of the underlying strata means that it is less likely to migrate from the site, especially given the distances in most cases. Consequently, generally **moderate/low** and **low** risks are considered to be posed to this receptor.

#### 4.3.5 Groundwater

According to the Aquifer and Abstraction License Map provided in the EnviroInsight Report, almost the entire site is underlain by Negligibly Permeable strata, which appears to relate to the Oxford Clay Formation. However, there are two discrete areas within the extreme south of D Site underlain by a Secondary Aquifer (High Leaching Potential), which is likely to be related to the alluvial deposits in these areas. In addition, an area in the far north-west of E Site is shown to be directly underlain by a Secondary Aquifer. Consequently, there is a generally **negligible** risk for contaminant migration to groundwater, with a **moderate/low** risk associated with the suspected ash ballast stockpile to the south of D7, given that the stockpile is likely to be situated on a Secondary Aquifer.

#### 4.3.6 Surface Water (Site Drainage Ditches, Langford Brook)

Precipitation from roofs and hardstanding areas drains to a network of surface water drainage ditches that drain the low-lying, poorly draining parts of the site. The closest major surface water feature to the site is the Langford Brook, which enters the site at the extreme northern tip of Site E. Based on the nature of the drainage and outfalls present at the site, the risks to surface water have been assessed as generally **moderate** to **low** risks, with the highest risk associated with the waste tip near E15.

#### 4.3.7 Ecological Systems

There are records of three ESAs within 0.5 km of the site. These three areas are all part of the same ESA, the Upper Thames Tributaries. The closest of these areas is 16 m south-east of the site boundary. A SSSI (Arncott Bridge Meadows) is located 50 m to the north-east of the strip of land connecting D Site and DSDC Bicester C site. The condition of this site is recorded as 'favourable'. In addition, the site falls within a Nitrate Vulnerable Zone (NVZ). However, given the limited potential contamination identified on site and the dilution and attenuation of contaminants given the distance of most of the identified sources to potential receptors, the risk to ecological receptors and vegetation is assessed as generally **negligible** to **low**.

#### 4.3.8 Agriculture (Arable and Livestock)

Parts of the site are leased by DE for use as agricultural land, with further agricultural land to the east, south and west. These areas are mainly used for the grazing of livestock at the time of the site visit. However, given the nature and distance of these receptor areas from the potential sources of contamination and the negligible permeability of the underlying strata, risks to agricultural receptors have been assessed as **negligible** to **low**.

#### 4.3.9 Buildings and Buried Services

Risks to buildings and buried services may occur via direct contact, or vapour migration from contaminants in soils accumulating and potentially exploding. The potential presence of fuel contamination (especially heating oil) at the site generally gives rise to **moderate/low** to **negligible** risks.

### 4.4 Summary of Potential Contamination

The findings of the previous Phase One LQA and the further desk study information obtained as part of the updated Phase One LQA assessment were used to inform the scope of the Phase Two LQA. The full list of sources of potential contamination is presented within Section 1.5.

The principal health and environmental risks identified based on the initial conceptual model are summarised in the bulleted list below. The list includes all potential sources which were assessed as giving rise to a risk of **moderate** or higher. Where the only risk of greater than moderate for a source related to Humans (Construction and Maintenance Workers), these sources have not been investigated, as risks to this receptor may be mitigated by appropriate working methods and personal protective equipment (PPE). The sources that were identified for further investigation are as follows:

- Former vehicle fuelling areas at E11 and D18;

- Former railway workshops (current buildings D6 and D9);
- Former fire training area (building E20);
- Former waste tip near building E15;
- POL stores and POL points (fuel tanks) (site-wide); and
- Made Ground at BIFT and between D6/D9.

Surface water sampling to investigate the extensive surface water drainage system across Sites D and E was also performed to give a general indication of the surface water and land quality. Three additional boreholes were drilled in the north-west of Site E in order to fulfil a request for basic investigation of the Secondary Aquifer by the Environment Agency.



## 5. Site Investigation

### 5.1 Objectives

The Phase Two investigation was commissioned by DE based on the findings of the previous Phase One LQA. The investigation design was based on targeted characterisation of the potential contamination sources summarised in Section 1.3.11 of this report.

The objectives were satisfied by both non-intrusive and intrusive investigation along with sampling to obtain representative samples of soil, surface water and groundwater to characterise potential contaminants within targeted areas and to assess the associated risks to human health and the environment.

### 5.2 Scope of Works

The scope of works comprised some initial surface surveys, to inform and direct the subsequent intrusive works in the targeted areas. An outline of the works undertaken and their general order is summarised in Table 5.1.

**Table 5.1 Outline of Works Undertaken**

	Stage	Description
1	Confirmation of target areas	The general location and extent of identified target areas outlined by Entec based on the aerial extent identified in the previous Phase One LQA.
2	Radiological walkover survey	Walkover survey of targeted areas of the site with a radiation scintillation probe to review any detectable surface radiation. The survey data was used to manage potential health and safety issues, and to locate investigation positions to field anomalies.
3	Finalise ground investigation locations	On the basis of the Phase One LQA data and the radiological survey data, the investigation scope and locations were identified in the target areas; each located to investigate identified anomalies/buried objects/provide general ground coverage.
4	Locate positions in the field	Exploratory locations in the field were located either by reference to existing buildings and structures, or using a GPS unit.
5	Service clearance	Copies of available service utility plans were obtained from the Regional Prime Contractor (PriDE/Interserve) prior to undertaking the works. Prior to any excavation, the May Gurney and/or Entec engineer undertook service scanning and clearance of each location. Due to the absence of complete service plans, a specialist service clearance engineer (Site Vision Surveys Ltd) was utilised to clear services in all investigation areas of the site prior to the intrusive works.
6a	Intrusive site works	Up to three ground investigation teams were present on site progressing a combination of boreholes and trial pits.
6b	Radiological screening	Field radiological screening of exploratory locations and soil arisings was undertaken on areas identified as having a potential for containing buried radiological materials.
7	Laboratory analysis	Soil, groundwater and surface water samples were submitted for analysis for chemical contaminants.

### 5.2.1 Variations to Original Scope

Some variation to the original scope of works was undertaken, as a result of consultation with the Local Authority (Cherwell District Council) and the Environment Agency (EA) on the proposed scope of the intrusive investigation works and conditions encountered/identified in the field. These are outlined below:

#### Site D: Additional Investigation Locations Within the OSU

Investigation of the OSU area of Site D targeted former underground fuel storage tanks. As the precise location of the tanks could not be identified during the investigation, it was deemed prudent to excavate an additional window sample borehole (WSE27) to provide further coverage in the suspected vicinity of the buried tanks.

#### Site E: Investigation of the Agricultural Land on the North-western Site Boundary

The EA expressed concern over the potential for site contaminants to have migrated and impacted on the Kellaways Sands, a Secondary Aquifer outcropping in the far north-west of the site. Consequently, three window sample locations were excavated in this area to assess the presence of contamination in the ground and groundwater in this area of the site.

#### Site E: Investigation of the E15 Tip Area

Prior to the commencement of intrusive works on E Site, it was anticipated that the E15 Tip Area could be accessed by a wheeled excavator to progress approximately ten trial pits throughout the tip area. An initial walkover of the site prior to the commencement of the intrusive investigation identified that vegetation was much heavier across the area than that noted during the Phase One LQA (undertaken in winter), and a number of dormouse traps had been set up. It is understood that dormice can nest in heavy vegetation during the summer months.

Therefore, trial pitting within the E15 Tip Area could only be undertaken in two locations along the south-eastern boundary of the area, away from areas of heavy vegetation. In other areas of the tip, and where access and vegetation cover permitted, three hand dug pits and five window samples boreholes were progressed instead of the initially specified trial pits.

## 5.3 Non Intrusive Surveys

A non-intrusive radiological survey was undertaken ahead of the main intrusive works in a number of areas across Site D and Site E where information from the Phase One LQA identified the potential for radiological contamination to be present. The survey was undertaken to review the potential presence of detectable radiological residues at the near surface, as below.

### 5.3.1 Radiological Walkover Survey

#### RadSurvey 3" Probe

The RadSurvey instrument is a 3"x3" sodium iodide probe coupled with a Trimble GPS receiver and datalogger. Radioactivity measurements in 'counts per second' (cps) and GPS coordinates are recorded simultaneously every second. The instrument was operated in 'hand held' mode.

Where possible, a 100% walkover survey was conducted across the targeted areas of the site. Each area was surveyed in 2 m strips with the probe detectors held approximately 100 mm

above the ground surface. The surveyor walked at speeds of no more than 1 m/s and given that readings are taken every second, a measurement of radioactivity is recorded at one metre intervals on the ground. The RadSurvey instrument also has a spectrographic capability for identification of contaminating radioisotopes.

### **Ludlum 2" Probe**

The Ludlum 2241 digital ratemeter and 44-10 sodium iodide 2"x2" probe is a hand-held instrument providing measurements of radioactivity in cps where GPS satellite signals were obscured, particularly within the E15 Tip Area. In areas surveyed using the Ludlum probe, the locations of measurements above background levels were recorded manually.

Both instruments are calibrated to respond to radium-226 (the suspected contaminant) as shown in Table 5.2. The radiological monitoring instruments used have valid Health Protection Agency calibration certificates.

Radium-226 contaminated soil in the range  $>0.37\text{Bq/g}$  to  $<4.9\text{Bq/g}$  is currently exempt from the provisions of the Radioactive Substances Act 1993 (RSA93) and the Environmental Permitting Regulations 2010 (EPR10) by virtue of its compliance with 'The Radioactive Substances (Phosphatic Substances Rare Earths etc.) Exemption Order 1962'. This is currently referred to as "Exempt" material with material above  $4.9\text{Bq/g}$  regarded as Low Level Radioactive Waste (LLW). As part of the Environmental Permitting Regulations (EPR) programme which included incorporation of Radioactive Substances Regulation, the Exemption Orders which exempt activities meeting specified criteria from the need to hold a permit under RSA93 and EPR10 are being reviewed. Consideration will be given once the review has been completed as to whether a new schedule or schedules may be inserted into the EPRs, especially in relation to any revised exemptions. The main risks to DE from the review of the Exemption Orders is expected to originate from the possibility that, unlike the current circumstances, future exemption limits could be radionuclide-specific. The potential impacts could include the availability of landfill disposal routes changes in waste volumes and additional complexities to record keeping and monitoring.

**Table 5.2 Summary of Radiological Instrument Calibration Factors and Indicative Count Rates**

<b>Instrument</b>	<b>Calibration Factor (cps/Bqg<sup>-1</sup>)</b>	<b>Uncontaminated Background Count Rates (cps)</b>	<b>Indicative Probe Measurements for Exempt Waste Threshold: 0.37 Bq/g (cps)</b>	<b>Indicative Probe Measurements for Low Level Waste Threshold: 4.9 Bq/g (cps)</b>
RadSurvey Probe	1000	400	770	5300
Ludlum 2"	500	200	385	2650

Note: Calibration factor and count rates are for radium-226.

Natural background radioactivity is ubiquitous, and needs to be considered separately from 'contaminating' radioactivity arising from human actions. At the site, the average background measurement was 400 cps using the RadSurvey probe and 200 cps using the Ludlum 2" probe. The field results of the survey are presented in Section 7.3.9. The survey areas are shown on Figures 3a (Site D) and 3b (Site E).



### Survey Area Restrictions

Tarmac and concrete hardstanding will attenuate radioactivity present in the ground beneath and may itself also contain relatively high concentrations of naturally occurring radioactive material (NORM). For these reasons, monitoring of hard surfaced areas is unlikely to yield a reliable indication of the presence or absence of radioactive contamination. Therefore, the radiological survey focused on the unsurfaced areas of the site.

## 5.4 Intrusive Site Investigation

The intrusive ground works were carried out over a two week period from 12 to 23 July 2010. Entec designed and supervised the intrusive works. May Gurney was appointed as the subcontractor to undertake the intrusive ground investigation works.

Entec and May Gurney engineers supervised the fieldwork, logged ground conditions in all exploratory locations and obtained environmental samples as required. The target areas of concern outlined in the table below are identified on Figure 2, and the locations of all exploratory locations within each target area are outlined in detail in Figure 4.

Table 5.3 provides details of the initial specification for the intrusive investigation locations. The excavation logs are presented in Annex A.

**Table 5.3 Intrusive Investigation Locations**

Area/Building	Objective	Contaminants of Concern	Exploratory Locations
Site D: BIFT	Investigate potential leakage from USTs in fuel storage area and any associated hydrocarbon contamination from known spills.	Hydrocarbons	BHD01
		Metals and other inorganics	WSD14
		Solvents	WSD15
	Investigate the nature of deposited Made Ground material in the western BIFT Area.	Asbestos	TPD07
		Radiological materials	TPD08
			TPD09
Site D: Vicinity of buildings D2, D6, D9 and Maintenance Yard	Investigate potential leaks or spills from existing fuel storage tanks and/or associated pipework.	Hydrocarbons	WSD01
		Metals and other inorganics	WSD02
		Solvents	WSD03
	Investigate potential spills and disposal of contaminating materials outside workshop areas.	Asbestos	WSD04
			WSD05
			WSD06
			WSD07
			WSD08
			WSD09
			WSD10
			WSD11
			WSD12
			WSD13
			WSD16
			WSD17

**Table 5.3 (continued) Intrusive Investigation Locations**

Area/Building	Objective	Contaminants of Concern	Exploratory Locations
Site D: Area of Made Ground between buildings D6 and D9	Investigate the nature of known Made Ground material deposited in this area.	Hydrocarbons	TPD01
		Metals and other inorganics	TPD02
		Solvents	TPD03
		Asbestos	TPD04
			TPD05
			TPD06
Site E: Rodney House and OSU	Investigate potential leakage from fuel tanks in fuel storage areas and ground contamination from known spills.	Hydrocarbons	WSE15
		Metals and other inorganics	WSE16
			WSE17
			WSE18
			WSE27
			BHE01
Site E: Car Park by E25 and building E10	Investigation of potential hydrocarbon contamination in former vehicle fuelling areas and fuel storage areas.	Hydrocarbons	BHE02
		Metals and other inorganics	WSE01
		Solvents	WSE02
		Asbestos	WSE03
			WSE04
			WSE05
Site E: Building E14/16 fuel tanks and building E20	Investigate potential leakage in fuel storage areas and ground contamination from fire training activities.	Hydrocarbons	WSE06
		Metals and other inorganics	WSE07
		Solvents	WSE08
		Asbestos	WSE09
			WSE10
			WSE11
			WSE12
			WSE13
			WSE14
			WSE19
Site E: E15 Tip Area	Investigate the nature of known Made Ground material deposited in this area.	Hydrocarbons	WSE20
		Metals and other inorganics	WSE21
		Solvents	WSE22
		Asbestos	WSE23
		Radiological materials	TPE01
		Landfill Gas	TPE02
			HDPER01
			HDPER02
			WSE24
			WSE25
Site E: Agricultural Land on north-western site boundary	Investigate potential impact to underlying Secondary Aquifer.	Hydrocarbons	WSE26
		Metals and other inorganics	
		Solvents	

BH - Cable percussion Borehole; HP - Hand-Pit; TP - Trial Pit; WS - Window Sampler borehole.

\* Exploratory position progressed in reaction to conditions encountered in the field.

## 5.5 Chemical Sampling and Analysis

### 5.5.1 Soil Sampling

Soil samples were collected from excavations at changes in strata and/or 1 m depth intervals or less where appropriate.

For much of the site, the potential for contamination was likely to be attributable to surface residues from previous activities or buried materials/Made Ground. Consequently, for most exploratory locations, a shallow sample was taken, typically from between 0.10 to 0.50 metres below ground level (m bgl). Additional deeper samples were also taken to review the contamination profile with depth, particularly where any significant depth of Made Ground or infill material was identified.

Soil samples were taken using either a stainless steel trowel, which was cleaned between each use to avoid cross contamination, or by hand with a change of gloves between sampling. The samples were placed directly into containers provided by the laboratory.

### 5.5.2 Soil Analysis

Soil samples were scheduled and subsequently analysed in the laboratory for some or all of the following determinands depending on historical use and visual and olfactory observations:

- Metals: arsenic, boron, cadmium, chromium, hexavalent chromium, copper, lead, mercury, nickel, selenium and zinc;
- Organics: Total Petroleum Hydrocarbons Criteria Working Group (TPH-CWG), Total Petroleum Hydrocarbons (TPH) screen, polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCBs), benzene, toluene, ethylbenzene and xylene (BTEX) and semi-volatile and volatile organic compounds (SVOC) and (VOC); and
- Asbestos and other soil parameters including pH, ammoniacal nitrogen, soluble sulphate and soil organic matter.

Where hydrocarbons were identified as a target potential contaminant of concern in the Phase One LQA, selected samples of soil and groundwater were analysed using the TPH-CWG approach which divides the petroleum mixtures into fractions using the Equivalent Carbon (EC) number convention. EC numbers are used to normalise petroleum constituents by reference to their boiling point and the boiling point of equivalent n-alkanes where the number of carbon atoms is known. This allows EC numbers to be determined for constituents where only the boiling point is known. This convention is described fully in the TPH-CWG documents (*TPH-CWG 1997*).

In addition to dividing the petroleum mixtures by EC number, the TPH-CWG method also considers aliphatic and aromatic hydrocarbon fractions separately due to their differing behaviour in the environment and variation in toxicity. Thus, for the purposes of laboratory analysis and risk assessment, the TPH-CWG recommend that petroleum mixtures are considered in fourteen fractions which includes aliphatic and aromatic compounds with equivalent carbon numbers of up to 35. The UK approach considers a further three fractions to take account of aliphatic and aromatic compounds with equivalent carbon numbers of up to 70, although given the contaminants likely to be encountered during this investigation (petrol and

diesels), samples were submitted for speciated analysis of aromatic/aliphatic TPH-CWG bands with equivalent carbon numbers of up to 35.

### **5.5.3 Groundwater Analysis**

Groundwater was sampled from selected boreholes on either one or two occasions and subsequently analysed in the laboratory for some or all of the following determinands depending on historical use and visual and olfactory observations:

- Metals: arsenic, boron, cadmium, calcium, chromium, copper, lead, mercury, selenium and zinc;
- Organics: TPH-CWG or extractable petroleum hydrocarbons (EPH), PAHs, BTEX, VOCs, SVOCs; and
- Chloride, sulphate, ammoniacal nitrogen and pH.

### **5.5.4 Surface Water Analysis**

Surface water was sampled on three occasions and subsequently analysed in the laboratory for some or all of the following determinands depending on historical use and visual and olfactory observations:

- Metals: arsenic, boron, cadmium, calcium, chromium, copper, lead, mercury, selenium and zinc;
- Organics: TPH-CWG or EPH, PAHs, BTEX, VOCs, SVOCs; and
- Chloride, sulphate, ammoniacal nitrogen and pH.

## **5.6 Gas and Vapour Screening**

Headspace monitoring was undertaken on soil samples using a photo-ionisation detector (PID) to inform sample scheduling. The PID instrument was calibrated at the beginning of each day using isobutylene (100 ppm with 10.2eV lamp, span 9.8). PID headspace results are presented in Section 6.3 of this report, along with the exploratory hole logs included as Annex A.

## **5.7 Standpipe Monitoring**

An infra-red gas detector (Geotechnical Instruments GA2000 analox) was used on all occasions to monitor levels of methane, carbon dioxide and oxygen from completed standpipes on up to six occasions following completion of the site works. In addition to the gas detector, a PID (photo ionisation detector) was also used to qualitatively measure the concentration of VOCs. Measurements were also taken of the resting groundwater depth and the depth to the base of each installation. The monitoring data is presented in Section 6.6 of this report.

## 5.8 Quality Assurance and Control

The following section summarises the overall quality assurance and control applied during the intrusive investigation undertaken at the site. As demonstrated below, a quality chain exists from Entec through the various sub-contractors employed to complete the intrusive investigation and analytical work.

Entec operates a quality system registered under BS EN ISO 9001 (Certificate Registration No FS34171). Entec only employs contractors and other key suppliers from its 'approved supplier list', which is managed under Entec's Quality System. Subcontractors are managed following guidance under Entec's Quality System Procedure 'Management of Site Works Contractors'.

The works were supervised on a full time basis by Entec. During the fieldwork the following procedures were followed to ensure the accuracy of the sampling and minimise cross contamination:

- i) Samples were only handled using clean latex or nitrile rubber gloves;
- ii) Soil samples were collected in a manner to minimise disturbance; and
- iii) Samples were maintained at a low temperature and conveyed to the testing laboratory at the earliest opportunity.

Samples were sent to ALcontrol Laboratories (ALcontrol), a specialist subcontractor to Entec. ALcontrol is an MCERTS and UKAS accredited laboratory. All samples were sent by courier accompanied by full Chain of Custody documentation and unique identifiable labels. Samples on site were stored in cool boxes with refrigerant blocks and were located out of direct sunlight. Samples were couriered on a same day basis.

## 5.9 Health and Safety

### 5.9.1 CDM Regulations

Entec undertook the role of CDM Designer, however the construction works were not anticipated to be > 30 days in duration, nor > 500 person days and therefore not considered 'notifiable' in accordance with the Construction (Design and Management) Regulations 2007. CDM Coordinator and Principal Contractor roles were not required.

### 5.9.2 Health and Safety Planning

Given the potential risks to the health and safety of site workers, a detailed Health and Safety (H&S) risk assessment and review was undertaken. The findings of this review were presented within a detailed H&S Plan prepared by Entec (Entec ref: 26999Q066i1, dated July 2010) in advance of the site investigation works and sent to all contractors and DE.

Work instructions were compiled and presented to Entec site personnel and toolbox talks provided to all site personnel to ensure that the objectives, potential risks, and works protocol was communicated and fully understood.

The final Health and Safety file arising from this project will comprise this Phase Two LQA Report.

## 6. Ground Conditions

### 6.1 Strata Encountered

The geological sequence encountered across the site is summarised in Table 6.1.

**Table 6.1 Geological Sequence Encountered During Investigation**

Strata Constituents	Typical Thickness	Typical Depth	
		Top	Base
Topsoil (where present), typically comprising of brown sandy slightly gravely clay with rootlets.	0.00 m to 0.40 m	0.00 m bgl	0.40 m bgl
Made Ground (where present) varied in nature across the site areas and in relation to the areas targeted. In general, Made Ground encountered consisted of brown sandy gravely clay typically with brick and concrete. In some areas ash, asbestos containing materials (ACM) and glass were also encountered. Layers of black ash Made Ground were also encountered in WSE9 and WSE10 in the E14/E16 area and within TPE19 and TPE20 in the E15 Tip Area.	0.40 m to 3.50 m	0.00 m bgl	3.50 m bgl
Firm brown orange mottled and/or grey orange mottled sandy slightly gravely CLAY with occasional sand and fine gypsum crystal bands.	1.00 m to 2.50 m	0.50 m bgl	3.00 m bgl
Firm brown sandy CLAY with highly weathered yellow chalk laminations and gypsum crystal bands.	1.00 m to 1.50 m	2.00 m bgl	3.50 m bgl
Stiff grey laminated CLAY with shell fragments and occasional gypsum crystals.	Unknown	3.00 m bgl	Unproven

Exploratory excavation logs are presented as Annex A to this report. Ground conditions in each of the target areas are outlined in detail below:

#### 6.1.1 Site D: BIFT Area

A total of one cable percussion borehole, two window samples and four trial pits were progressed in this area as shown on Figure 4. Investigation of the BIFT area consisted of the investigation of two distinct areas. Two large stockpiles of Made Ground were located in the eastern area of the BIFT. The Made Ground stockpiles were investigated with the excavation of four trial pits. An area containing USTs was investigated with the borehole and two window samples. The encountered conditions are summarised below:

#### Stockpiled Made Ground

Several layers of Made Ground were encountered throughout the depth of the stockpiles excavated (max depth of 2.90 m, TPD08). In general the Made Ground consisted of sandy gravely clay. Gravel within the Made Ground consisted of cobbles of brick and concrete, tarmac and ash. A slight organic and/or hydrocarbon odour was also noted.

**General Made Ground: UST Area**

A layer of concrete and dolomite fill was encountered in the UST area from surface to approximately 0.50 m bgl. Underlying this layer, in BHD01, a layer of slightly gravelly clay (reworked natural) was encountered with a slight organic odour extending to 1.60 m bgl.

**Natural Ground: UST Area**

Natural Ground was encountered in all of the exploratory locations, and was consistent across the area.

This generally comprised upper layers of firm brown laminated clay extending to 3.50 to 4.00 m bgl. Occasional thin sand and gravel bands were encountered within these clay layers from 3.00 to 4.00 m bgl. A layer of stiff blue grey laminated clay with shell fragments was underlying the firm brown clay from 3.50 to 4.00 m bgl to the base of the excavations.

**6.1.2 Site D: Vicinity of Buildings D2/D6/D9 and Maintenance Yard**

A total of fifteen window samples were progressed in these areas of Site D as shown on Figure 4. The encountered conditions are summarised below:

**Topsoil**

Topsoil was encountered in approximately a third of the locations. Topsoil was generally stiff brown sandy gravelly clay with brick, concrete and limestone gravel up to 0.20 m thick.

**General Made Ground**

Made Ground, where encountered typically extended to approximately 0.40 to 0.60 m bgl, with a maximum depth of 1.00 m bgl encountered in WSD05. In general, the Made Ground consisted of firm brown sandy gravelly clay with brick, concrete, chert, ash and very occasional possible asbestos sheet fragments. In WSD5, a layer of soft green/grey slightly gravelly clay was encountered with a strong hydrocarbon odour between 0.40 to 1.00 m bgl.

**Natural Ground**

The underlying natural ground materials were very consistent across the site. Shallow strata typically consisted of bands of firm brown/orange mottled clay and firm brown laminated sandy gravelly clay to depths ranging from 2.00 to 3.50 m bgl. Occasional sand bands and gravel bands of fine gypsum crystals were encountered in these layers from 2.00 to 3.50 m bgl. These layers of brown clay were underlain by firm to stiff grey laminated clay with shell fragments and gypsum crystals. This grey clay layer was encountered typically from 2.60 to 4.50 m bgl.

**6.1.3 Site D: Area of Made Ground Between D6 and D9**

Made Ground materials are stockpiled in this area of the site. The investigation area was separated into two stockpiles of Made Ground by a railway siding passing through the central area of the stockpiles. A total of six trial pits were excavated in this area, with three trial pits in each of the stockpiles, to assess the nature and depth of the Made Ground material, as shown on Figure 4. The encountered conditions are as follows:

### **Made Ground**

Trial pits TPD01 to TPD03 were excavated in the eastern Made Ground stockpile. Made Ground in this area extended to depth of between 1.10 to 1.30 m bgl and several layers of stiff yellow brown and brown grey clay with limestone gravel.

Trial pits TPD04 to TPD06 were excavated in the western Made Ground stockpile. Made Ground in this area was present to a greater depth, extending to between 2.80 and 3.60 m bgl. The Made Ground in this area was consistent with the eastern area and generally consisted of several layers of stiff clay with limestone gravel and occasional rootlets. A slight organic odour was noted in TPD05 and TPD06 in the Made Ground between 2.00 and 3.00 m bgl.

### **Natural Ground**

Made Ground in the eastern investigation area was underlain by layers of natural stiff grey brown and green grey mottled clay with occasional iron staining.

Made Ground in the western investigation area was underlain by a layer of grey brown silty sandy clay with rootlets, suspected buried topsoil, from approximately 3.00 to 3.50 m bgl. This layer was in turn underlain by stiff green grey clay with occasional rootlets and a light organic odour.

#### **6.1.4 Site E: Rodney House and the Ordnance Support Unit (OSU)**

A total of two cable percussion boreholes and five window samples were progressed in these areas, as shown on Figure 4. The encountered conditions are as follows.

### **Made Ground**

A shallow surface layer of Made Ground was encountered in all exploratory hole locations excavated across these areas of the site. A black plastic pipe was encountered in WSE16 at 0.7 m bgl. Made Ground extended from ground level to a maximum depth of 0.80 m bgl and in the majority of locations consisted of reworked natural material consisting of brown slightly sandy slightly gravelly clay with occasional concrete, brick, tarmac, limestone and chalk gravel.

### **Natural Ground**

Deeper strata generally comprised firm brown grey-orange mottled clay with occasional sand and fine gypsum gravel bands to approximately 3.00 to 3.50 m bgl. A soft grey/black sandy silty clay band with an organic odour was present underlying the Made Ground in WSE17 from 0.45 to 0.80 m bgl.

A further layer of stiff grey-brown laminated clay with shell fragments was encountered from approximately 3.00 m bgl to the termination depths of each of the exploratory holes.

#### **6.1.5 Site E: Car Park by E25 and Building E10 Area**

A total of four window samples were progressed in these areas as shown on Figure 4. The encountered conditions are summarised below.

### **Topsoil**

A thin layer of stiff brown sandy topsoil with rootlets was encountered to a depth of 0.20 m bgl in the E25 car park area overlying natural ground layers.



A thin layer of Made Ground topsoil was also encountered in WSE03 and WSE04, investigating the building E10 area from surface to 0.20 m bgl, consisting of stiff brown sandy slightly gravely clay with gravel of brick, concrete and wood.

#### **Made Ground**

A thin layer of Made Ground underlying the topsoil was encountered in WSE03 and WSE04, investigating the building E10 area. The Made Ground extended from 0.20 to 0.40 m bgl and consisted of brown sandy slightly gravely clay with brick, ash, sandstone and concrete gravels.

#### **Natural Ground**

Layers of natural strata were encountered underlying the topsoil throughout the depth of the window samples excavated in E25 car park area. Several layers of firm brown orange-grey mottled sandy clay with fine gypsum crystals and weathered chalk laminations were encountered from approximately 0.20 to 3.50 m bgl. A layer of firm to stiff grey laminated clay with occasional gypsum crystals was encountered underlying these clay layers and extending to the termination depth of the window samples.

Made Ground in the E10 area was underlain by natural clay bands. A layer of firm brown orange grey mottled sandy clay was encountered from approximately 0.40 to 1.50 m bgl. This in turn was underlain by firm grey orange mottled slightly sandy clay to 2.50 m bgl, with sand bands present from 2.40 to 2.50 m bgl. A further clay layer was encountered underlying the sand bands and consisting of firm brown laminated clay with highly weathered chalk laminations. This layer was present to the base of the excavations at 4.00 m bgl.

### **6.1.6 Site E: Building E14/16 Fuel Tanks and Building E20**

A total of ten window samples were progressed in this area as shown on Figure 4. The encountered conditions are summarised below:

#### **Made Ground**

Made Ground was encountered in all investigation locations throughout this area of the site. In general this consisted of a single layer extending to approximately 0.50 m bgl. The Made Ground consisted of brown sandy gravely clay with brick and concrete and occasional ash and potential ACM. However, a second layer of black ash Made Ground with slight hydrocarbon odour was encountered within WSE09 and WSE10 extending from 0.35 m bgl to a maximum depth of 1.10 m bgl.

#### **Natural Ground**

In general, most excavations were found to contain largely similar natural soils. Typically Made Ground was underlain by a series of three to four clay bands. The upper layer of clay consisted of typically firm grey orange mottled sandy clay ranging from 0.20 to 1.70 m bgl. This layer was underlain by brown orange mottled sandy clay with occasional sand bands between 1.50 to 3.30 m bgl, which in turn was underlain by firm brown laminated clay with occasional yellow weathered chalk lamination and fine gypsum crystals. From approximately 3.10 to 3.50 m bgl, a final stiff grey laminated clay with shell fragments was encountered extending to the base of the exploratory hole locations.

### **6.1.7 Site E: E15 Tip Area**

A total of two trial pits, five window samples and three hand dug pits were progressed in this area, as shown on Figure 4. The encountered conditions are summarised as follows.

#### **Made Ground**

Due to this area being former tip, varying Made Ground was encountered throughout the area. Made Ground varied in depth from 0.70 m bgl in TPE01 to 3.50 m bgl in WSE19. In general the Made Ground consisted of layers of brown sandy gravelly clay with large volumes of brick and concrete and occasional glass, ash and possible ACM. Distinct burnt ash layers were encountered in WSE19 from 0.55 to 0.80 m bgl and WSE21 from 0.80 to 0.95 m bgl. The layer in WSE19 consisted of numerous military cap badges and buttons from jackets.

#### **Natural Ground**

Natural ground was encountered underlying the Made Ground in most locations. A layer of sand or very sandy clay was encountered underlying the Made Ground in WSE20 and WS2E21 at depths of 3.40 to 4.80 m bgl and 1.00 to 1.90 m bgl respectively. Made Ground or sand layers were typically underlain by firm brown clay with yellow highly weathered chalk laminations, which in turn was underlain by stiff grey laminated clay.

### **6.1.8 Site E: Agricultural Land on North Western Boundary**

A total of three window samples were progressed in this area as shown on Figure 4 to assess the potential impacts of site activities to the boundary area of the site. No Made Ground was encountered. The encountered conditions are summarised below.

#### **Topsoil**

A thin 0.10 to 0.20 m layer of dark brown sandy topsoil with rootlets was encountered in all three window sample locations.

#### **Natural Ground**

Natural strata in this area were similar to the clays encountered in all other areas across the sites. A layer of stiff sandy orange mottled clay was encountered overlying firm grey orange mottled sandy clay to approximately 1.70 m bgl. From approximately 1.50 to 2.60 m bgl, a layer of firm brown clay with brown organic and yellow highly weathered possible chalk was present. This in turn was underlain by firm grey blue sandy laminated clay with occasional gypsum crystals which was typically the base layer of the excavations in other areas of Sites D and E. In this area of the site, the grey clay was underlain by a layer of soft to firm grey blue sand, extending from a depth of 4.30 to 4.70 m bgl.

## **6.2 Visual and Olfactory Evidence of Contamination**

In the majority of areas across the site, evidence of man-made disturbance and the presence of Made Ground have identified the potential for contamination to be present. In the majority of investigation areas, the Made Ground contained demolition-type rubble consisting of concrete and brick. In some areas, potential ACM was also encountered and several discrete layers of ash and evidence of burning.

In summary, the following key areas of potential contamination were identified in the field:

- Site D BIFT: thick layers of a Made Ground material were identified within the stockpiled areas. Much of the Made Ground contained 'inert' materials (rubble, glass, etc.) but layers of ash were also encountered within these stockpiles, alongside layers of clayey Made Ground with associated organic odours and occasional potential ACM (sheeting) identified;
- Site D building D2/D6/D9/Maintenance Yard areas: where Made Ground was encountered, much of it contained 'inert' materials (brick, concrete, etc.). Black pockets of organic matter were encountered in WSD05 and a slight hydrocarbon odour was noted. Possible ACM was noted within WSD03 and the presence of chrysotile asbestos was confirmed in laboratory analysis. The presence of small quantities of ash and coal gravel was also noted in window samples WSD09 to WSD16. Possible ACM was also noted in Made Ground from WSD17;
- Site D area of Made Ground between D6 and D9: little evidence of potential contamination was observed in this area. The Made Ground material appears to be mainly reworked natural clay from other areas of the site stockpiled in this area. A slight organic odour was noted in some of the clay layers within the stockpiles;
- Site E Rodney House and the OSU: very little evidence of potential contamination was observed in this area. A thin layer of Made Ground was present in all exploratory holes but only 'inert' materials (brick and concrete) were observed in these layers. A slight organic odour was noted in a clay layer underlying the Made Ground in WSE17 (0.45 to 0.80 m bgl);
- Site E car park by building E25 and building E10: no Made Ground material or evidence of contamination was noted in the investigation of the car park area by E25. Shallow Made Ground was encountered in the exploratory holes excavated by building E10. Ash material was noted in the Made Ground within WSE4;
- Site E building E14/E16 fuel tanks and building E20: shallow Made Ground was encountered in all locations around building E20 but little evidence of contamination was observed within these layers. Black staining was noted within WSE08 in the initial clay layer underlying the Made Ground material at 0.70 m bgl. In the E14/E16 fuel tanks area, a layer of black sandy ash and gravel was encountered in WSE09 and WSE10 from 0.50 to 1.10 m bgl. A slight hydrocarbon odour was also noted within these layers. Within WSE11 to WSE14, the Made Ground was noted to contain small amounts of ash material and ACM;
- Site E building E15 Tip Area: variable Made Ground was identified across this area. Much of the Made Ground consisted of 'inert' materials (brick and concrete) but burnt ash, clinker and possible ACM were also encountered;
- Site E agricultural land on the north western boundary: no Made Ground or evidence of contamination was observed in this area.

Figure 5 summarises the visual and olfactory evidence of contamination across the Site.

### **6.3 In-Situ Vapour Monitoring**

Soil samples were screened for VOCs using a PID. It should be noted that measuring VOCs using a PID is only a qualitative screen; it is not uncommon for a PID to produce erroneous results so a degree of caution should be made in not to over-interpret results. For Sites D and E only a single soil sample returned a positive result for the presence of VOCs. A Made Ground sample from WSD5 (0.60 to 0.70 m bgl) recorded a peak VOC reading of 8.3 parts per million (ppm) and an average of 7.5 ppm. A hydrocarbon odour was noted in the ground investigation log indicating the potential presence of contamination.

### **6.4 Radiological Monitoring**

A hand-held scintillation detector (Ludlum model 2241-3) was used to survey arisings excavated from the trial pits, window samples and hand dug pit during the intrusive ground works in the E15 Tip Area. Arisings rates in counts per second (cps) in the trial pits and window samples in the E15 Tip Area ranged between 90 cps and 200 cps across the site. These levels are not considered to represent a significant radiological risk or a matter for regulatory concern within the areas surveyed.

### **6.5 Groundwater**

Groundwater was sampled from selected boreholes on either one or two occasions and groundwater depth was measured on up to six occasions between 21 July 2010 and 18 August 2010. A summary of groundwater depth monitoring data is provided within Table 6.2. Groundwater monitoring data is included as Annex C.

**Table 6.2 Groundwater Monitoring Summary**

Borehole	Depth to Groundwater											
	21/07/10	21/07/10	23/07/10	23/07/10	29/07/10	29/07/10	04/08/10	04/08/10	13/08/10	13/08/10	18/08/10	18/08/10
	m bgl	m AOD	m bgl	m AOD	m bgl	m AOD	m bgl	m AOD	m bgl	m AOD	m bgl	m AOD
BHD01	0.80	70.73	0.81	70.72	0.85	70.68	0.84	70.69	0.82	70.71	0.84	70.69
WSD02	3.33	62.99	2.84	63.48	1.94	64.38	0.73	65.59	0.92	65.40	0.80	65.52
WSD03	0.82	70.53	0.37	70.98	0.72	70.63	0.59	70.76	0.67	70.68	0.60	70.75
WSD05	-	-	0.77	70.62	0.74	70.65	0.66	70.73	0.67	70.72	0.63	70.76
WSD07	1.23	69.53	1.25	69.51	1.31	69.45	1.30	69.46	1.22	69.54	1.21	69.55
WSD09	2.03	71.14	2.05	71.12	2.10	71.07	2.05	71.12	2.10	71.07	2.06	71.11
WSD10	1.14	70.59	1.26	70.47	1.27	70.46	1.23	70.50	1.30	70.43	1.17	70.56
WSD12	1.69	70.39	1.77	70.31	1.80	70.28	1.73	70.35	1.73	70.35	1.66	70.42
WSD14	0.65	70.76	0.70	70.71	0.78	70.63	0.74	70.67	0.72	70.69	0.70	70.71
WSD15	0.28	71.15	0.50	70.93	0.50	70.93	0.51	70.92	0.54	70.89	0.49	70.94
BHE01	5.36	65.60	5.36	65.60	-	-	4.40	66.56	3.87	67.09	3.62	67.34
BHE02	1.46	69.36	1.56	69.26	-	-	1.61	69.21	1.55	69.27	1.46	69.36
WSE02	-	-	Dry	Dry	Dry	Dry	2.31	67.05	2.26	67.10	2.23	67.13
WSE04	-	-	-	-	1.91	69.62	1.60	69.93	1.46	70.07	1.38	70.15
WSE08	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	1.03	67.97	0.55	68.45
WSE09	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry

Table 6.2 (continued) Groundwater Monitoring Summary

Borehole	Depth to Groundwater											
	21/07/10	21/07/10	23/07/10	23/07/10	29/07/10	29/07/10	04/08/10	04/08/10	13/08/10	13/08/10	18/08/10	18/08/10
	m bgl	m AOD	m bgl	m AOD	m bgl	m AOD	m bgl	m AOD	m bgl	m AOD	m bgl	m AOD
WSE10	1.71	66.62	1.70	66.63	1.74	66.59	1.73	66.60	1.70	66.63	1.66	66.67
WSE17	0.52	66.92	0.58	66.86	0.74	66.70	0.79	66.65	0.65	66.79	0.56	66.88
WSE19	Dry	Dry	Dry	Dry	-	-	Dry	Dry	Dry	Dry	Dry	Dry
WSE21	-	-	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
WSE22	-	-	-	-	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
WSE23	-	-	-	-	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
WSE24	-	-	-	-	-	-	1.81	64.89	1.85	64.85	1.82	64.88
WSE25	-	-	-	-	1.26	64.96	1.17	65.05	1.19	65.03	1.18	65.04
WSE26	-	-	-	-	0.93	64.58	0.94	64.57	0.93	64.58	0.91	64.60

- No data available. Boreholes WSE21-WSE26 were not able to be monitored on 21 and 23 July 2010 as they had either not been drilled at this time or were being allowed to stabilise post installation. Boreholes E1, E2 and WSE19 were not able to be accessed on 29 July 2010 as the OSU compound was locked and the key was not available. Borehole WSE24 could not be found on 29 July 2010 but was subsequently located during later monitoring rounds.

Groundwater samples were taken from WSD03, WSD07, WSD09, WSD10, BHD01, WSE10, WSE17, WSE24, WSE25, WSE26 and BHE02 between 4 and 13 August 2010. A follow up groundwater monitoring round was carried out on WSD09, BHD01, WSE10, WSE17, WSE26 and BHE02 on 18 August 2010.

Visual or olfactory evidence of contamination encountered within groundwater samples is presented on Table 6.3.

**Table 6.3 Groundwater Visual and Olfactory Evidence of Contamination**

<b>Location</b>	<b>Visual or Olfactory Evidence of Contamination</b>
WSE17	Hydrocarbon odour.
BHE02	Slight sheen on water.
BHD01	Water foamy, green colour with reduced surface tension.
WSD03	Water foamy, green colour with reduced surface tension.
WSD09	Water foamy, green colour with reduced surface tension.

## 6.6 Gas and Vapour Monitoring

Gas and vapour monitoring was undertaken following drilling works on six occasions between 21 July 2010 and 18 August 2010. All of the boreholes and window samples installed (fifteen on E site and ten on D site) during the site investigation were monitored for the following:

- VOCs;
- Flow rate;
- Methane;
- Carbon dioxide;
- Oxygen; and
- Atmospheric Pressure.

The VOC results of greater than 1.0 ppm are presented in Table 6.4. The results represent the peak levels recorded at each monitoring installation. The atmospheric pressure recorded during the monitoring rounds varied between 995 and 1012 millibars (mb). The monitoring rounds on the 21 and 29 July, as well as 13 August 2010, were undertaken during periods of generally falling atmospheric pressure. The full monitoring results and the Gas Screening Values (GSV) are provided as Annex B to this report. Further commentary on ground gas is provided in Section 7.3.

**Table 6.4 Vapour Monitoring Summary**

Location	Date	VOC (ppm)	Location	Date	VOC (ppm)	Location	Date	VOC (ppm)
BHE01	21/07/2010	6.5	WSD05	13/08/2010	3.8	WSD12	23/07/2010	0.0
BHE01	23/07/2010	17.8	WSD05	18/08/2010	0.0	WSD12	13/08/2010	14.0
BHE01	29/07/2010	-	WSE10	21/07/2010	11.9	WSD12	18/08/2010	1.8
BHE01	04/08/2010	-	WSE10	23/07/2010	0.0	WSD14	21/07/2010	0.0
BHE01	13/08/2010	0.9	WSE10	29/07/2010	20.2	WSD14	23/07/2010	17.5
BHE01	18/08/2010	0.8	WSE10	04/08/2010	0.0	WSD14	29/07/2010	0.0
BHE02	21/07/2010	1.2	WSE10	13/08/2010	1.7	WSD14	04/08/2010	-
BHE02	23/07/2010	5.1	WSE10	18/08/2010	0.0	WSD14	13/08/2010	0.2
BHE02	29/07/2010	-	WSE17	21/07/2010	0.0	WSD14	18/08/2010	0.0
BHE02	04/08/2010	-	WSE17	23/07/2010	17.1	WSD15	21/07/2010	0.0
BHE02	13/08/2010	0.0	WSE17	29/07/2010	6.2	WSD15	23/07/2010	30.6
BHE02	18/08/2010	0.0	WSE17	04/08/2010	-	WSD15	29/07/2010	0
BHD01	21/07/2010	2	WSE17	13/08/2010	2.9	WSD15	04/08/2010	-
BHD01	23/07/2010	6.2	WSE17	18/08/2010	1.2	WSD15	13/08/2010	0.2
BHD01	29/07/2010	0.0	WSD07	21/07/2010	6.4	WSD15	18/08/2010	0.0
BHD01	04/08/2010	-	WSD07	23/07/2010	0.0	WSE25	21/07/2010	-
BHD01	13/08/2010	3.7	WSD07	29/07/2010	0.0	WSE25	23/07/2010	-
BHD01	18/08/2010	0.0	WSD07	04/08/2010	-	WSE25	29/07/2010	20.1
WSD02	21/07/2010	0.0	WSD07	13/08/2010	2.9	WSE25	04/08/2010	0.0
WSD02	23/07/2010	19.2	WSD07	18/08/2010	0.0	WSE25	13/08/2010	2.5
WSD02	29/07/2010	0.0	WSD09	21/07/2010	0.0	WSE25	18/08/2010	0.0
WSD02	04/08/2010	-	WSD09	23/07/2010	20.7			
WSD02	13/08/2010	0.7	WSD09	29/07/2010	0.0			
WSD02	18/08/2010	0.0	WSD09	04/08/2010	-			
WSD03	21/07/2010	10.1	WSD09	13/08/2010	6.4			
WSD03	23/07/2010	0.0	WSD09	18/08/2010	0.4			
WSD03	29/07/2010	0.6	WSD10	21/07/2010	11.9			
WSD03	04/08/2010	-	WSD10	23/07/2010	12.5			
WSD03	13/08/2010	3.3	WSD10	29/07/2010	0.0			
WSD03	18/08/2010	0.0	WSD10	04/08/2010	-			
WSD05	21/07/2010	-	WSD10	13/08/2010	1.4			
WSD05	23/07/2010	7.1	WSD10	18/08/2010	0.0			
WSD05	29/07/2010	0.0	WSD12	21/07/2010	1.4			



## **6.7 Summary of Ground Conditions**

### **General Ground Conditions**

In summary, general ground conditions comprised Made Ground (where present) and/or topsoil, overlying several clay strata, which are likely to be representative of the Oxford Clay Formation. On the north western boundary of Site E, natural sand and clay was encountered, which is likely to be representative of the Kellaways Sands and Kellaways Clays.

Clay strata encountered across the site were generally consistent, with firm brown orange mottled and brown grey mottled clay layers with occasional sand and gravel bands of fine gypsum crystals encountered at shallow depths. These layers were underlain by a firm brown laminated clay layer typically with highly weathered yellow chalk veins and fine gypsum crystals. The underlying clay layer in all areas of the site was stiff grey laminated clay with shell fragments and occasional gypsum crystals. The sand layer in the north western boundary of Site E comprised soft to firm blue grey clayey sand.

### **Made Ground and Evidence of Contamination**

Variable Made Ground is present within almost all of the areas investigated across the site, with the exception of the area investigated along the north-western boundary of Site E. In the majority of areas, Made Ground consisted of clay with 'inert' materials (such as brick and concrete) and little evidence of contamination was noted. No gross contamination was noted in any areas of the site, although evidence of burnt materials and ash layers were noted in the Made Ground within the BIFT area, E15 Tip Area and the building E14/E16 area. Possible ACMs were also noted in a number of locations across the site.

---

## 7. Generic Quantitative Risk Assessment

---

### 7.1 Assessment Guidelines

As part of a Tier 2 risk assessment, chemical analysis data for soils and groundwater are compared with generic assessment criteria (GAC), for determinands where values are available, in order to identify contaminants of concern and determine whether further assessment of risks is required. The assessment criteria used depends upon the source media (soil, groundwater or other measure) and the receptor under consideration.

#### 7.1.1 Human Health Guidelines

In order to provide an assessment of risks to humans presented by any contaminants identified within the surface soils and vapours at the site a human health Generic Quantitative Risk Assessment (GQRA) has been undertaken. The GQRA involves comparing contaminant concentrations observed at the site with appropriate GAC. As noted above, a GQRA forms Tier 2 of the tiered approach to assessing risks from land contamination as set out in the Defra and Environment Agency publication "Model Procedures for the Management of Land Contamination" (*Defra/EA 2004a*) CLR11.

To perform a GQRA, contaminant concentrations in soil have been compared with relevant GAC. These GAC consist of:

- EA/Defra Soil Guideline Values (SGVs);
- Entec-derived GAC;
- Chartered Institute of Environmental Health/LQM (CIEH/LQM) GAC; and
- The Environmental Industries Commission/Association of Geotechnical and Geoenvironmental Specialists/CL:AIRE (EIC/AGS/CL:AIRE) GAC for the assessment of risks to human health.

These GAC have been derived by Entec, Defra and the Environment Agency, the Chartered Institute of Environmental Health/LQM and EIC/AGS/CL:AIRE for selected substances in soils using the 'Contaminated Land Exposure Assessment' (CLEA) model.

SGVs were first published by Defra/Environment Agency in 2002. In 2008 these were withdrawn and a revised methodology for SGV derivation published (EA, 2009c). To date updated SGVs have been published for eleven contaminants (benzene, toluene, ethylbenzene and xylene, selenium, mercury, arsenic, nickel, phenol, cadmium and dioxins, furans and dioxin-like PCBs). Where published we have used revised SGVs, in absence of updated SGVs we have used previously published SGVs.

SGVs are generic values for specific land-uses derived by Defra and the Environment Agency and calculated using the CLEA model.

The SGVs are presently published for the following land use:

- Residential with consumption of home-grown produce;
- Allotments; and
- Commercial (formerly commercial/ industrial).

For the purposes of this assessment, GAC have been selected based on residential with consumption of home-grown produce, as the most sensitive potential future end use.

The SGVs are derived for particular soil conditions, and therefore the specific values used have been selected based on soil organic matter content of the soil where appropriate. It should be noted that the updated SGVs have been derived using a sandy loam soil with 6% soil organic matter (SOM). For Made Ground materials such as those often encountered at contaminated land sites the soil organic matter content is generally lower than 6%. Entec has therefore derived GAC for soil containing 1% and 3% SOM, which can be used as an alternative to the Environment Agency updated SGVs.

Soil Organic Matter (SOM) was analysed as part of the site investigation. The laboratory analysis recorded values ranging between 1.68 and 60.5% within the Made Ground, and between 0.876 to 9.69% in natural ground, across the site. The single result of 60.5% SOM in a shallow sample from E Site (window sample WSE9, 0.4 to 0.5 m bgl) is likely to be anomalous as the borehole log does not indicate any highly organic strata (e.g. peat) or visual/olfactory evidence of any particularly heavy organic contamination at this depth. If the single result of 60.5% SOM is disregarded, the range of SOM recorded across the site in Made Ground is 1.68 to 21%.

As a result of the size of the site, the discrete locations of most zones and the variability in SOM, screening values for both Made Ground and natural strata have been chosen using the appropriate conservative (e.g. lowest) SOM value for that particular zone and strata. Site zones are defined in Section 7.2 of this report.

In summary, the GQRA has been undertaken using the following assessment criteria, in order of availability:

- Defra/EA SGVs (2009);
- Entec derived GAC for 1%, 3% or 6% SOM (as appropriate) based on SGVs for a residential with plant uptake (i.e. consumption of home-grown produce) land use;
- CIEH/LQM GAC for 1%, 3% or 6% SOM (as appropriate) for a residential with plant uptake land use;
- EIC/AGS/CL:AIRE GAC for 1%, 3% or 6% SOM for a residential with plant uptake land use; and
- Previously published CLEA SGV for residential with plant uptake land use (lead only).

### **Contaminants within Gas**

The gas monitoring data has been assessed using CIRIA document C665 '*Assessing risks posed by hazardous ground gases to buildings*'. This method uses both gas concentrations and

borehole flow rates to define a Gas Screening Value and Characteristic Situation. As the Site may be used for residential development, the calculations are based on 'Situation B - Low Rise Housing with gardens' and reference is made to the National House Building Council (NHBC) 'Traffic Light' classification instead of the Characteristic Situation classification.

### **Contaminants within Groundwater**

Volatile compounds present within groundwater may potentially present a risk to site users via volatilisation of vapours from groundwater and subsequent inhalation. Therefore, any potentially volatile contaminants noted as being present within groundwater at elevated concentrations, i.e. above Method Detection Limit (MDL), have been considered as presenting a potential risk to human health and have been considered further.

### **7.1.2 Controlled Waters Guidelines**

There are currently no published UK guideline values for soils derived to be protective of controlled waters. However, identified contaminant concentrations in groundwater or surface water have been assessed using the following Water Quality Targets (WQTs).

### **Environmental Quality Standards**

Environmental Quality Standards (EQS) have been derived by the Environment Agency for the protection of surface water quality in England and Wales. These values have been used for assessment of groundwater. Where an EQS value does not exist the appropriate Drinking Water Standard (DWS) value has been used.

Some EQS values are dependent on water hardness. Given that the water hardness measured in water samples from the site is generally around (or in excess) of 200 mgCaCO<sub>3</sub>/l, the highest EQS values have been used where applicable.

The absence of an applicable EQS or DWS for TPH is covered by Section 7.1.3 below.

### **Drinking Water Standards**

UK DWS are set out in the Water Quality (Water Supply) Regulations, 2000. These values have been used for assessment of groundwater where an EQS value does not exist.

Where there are no applicable EQS or DWS, the MDL has been used.

### **7.1.3 Absence of Guidelines**

The site investigation employed a targeted approach and scheduled analysis of determinands based on the contaminants likely to be associated with each particular source area. For a number of the determinands scheduled, in particular chlorinated solvents and other volatile and semi volatile compounds, there are no authoritative generic assessment criteria with which to assess potential risks to human health or the environment. Therefore, where these contaminants have been detected, they have been considered further at the risk evaluation stage. Where VOCs or SVOCs have been detected, consideration has also been given to associated compounds that may also be present at concentrations below the detection limit but which may be sufficient to present a risk to receptors.

TPH no longer has an EQS or drinking water standard following the replacement of the Private Water Supply Regulations 1991 with the Private Water Supply Regulations 2009, which came

into force in January 2010. In the absence of any threshold value with a statutory basis it is more appropriate to evaluate the risk on the basis of marker and indicative compounds, such as BTEX compounds and PAHs.

#### 7.1.4 Radiological Assessment Guidelines

The extension of Part 2A to include radioactivity applies only in respect to harm of human health, and not in respect of other receptors or pollution of controlled waters.

The criteria for harm are when long-term exposure gives rise to doses that exceed one or more of the following:

- An effective dose of 3 millisieverts per annum (mSv/a);
- An equivalent dose to the lens of the eye of 15 mSv/a; or
- An equivalent dose to the skin of 50 mSv/a.

These doses are based on so-called 'intervention' scenarios; i.e. situations in which site users are currently being exposed, and the decision must be made whether an 'intervention' (i.e. remedial action) is necessary to reduce exposure levels. Lower dose thresholds apply for 'practices', which generally refer to consented radioactive discharges but also include redevelopment projects that result in a different exposure scenario, i.e. a change of land use.

The results of the radiological survey undertaken on this site can offer more certainty as to whether or not it is likely to be considered by the local authority in respect of Part 2A inspection, and ultimately the likelihood of it being determined as radioactively contaminated land. However, the final decision rests with the local authority:

- In the case of DSDC Bicester, where radium-226 is expected to be the predominant contaminating isotope, the Radioactive Soil Guideline Value (RSGV) applicable to commercial use, and therefore the most appropriate for current use, would be 5 Bq/g, assuming a uniform distribution of radioactivity. For comparison, the RSGV for radium-226 applicable to the most sensitive end-use scenario (residential with gardens) would be 1 Bq/g;
- If a change of use were proposed, the planning regime would take precedence over Part 2A and RSGVs would not apply. The introduction of new exposure pathways would require risk assessment, and if remediation were deemed necessary the clean-up threshold provided by the Health Protection Agency would be applied. For the purposes of this report, the end use for the site (Residential with areas of Commercial/Industrial use) identified in the Defence Estate Phase Two LQA Directive has been assessed. Furthermore, the radiological contamination has been assessed under EPR10 and the remaining relevant provisions of RSA93 with respect to 'practices' situations.

#### Radioactively Contaminated Land Exposure Assessment (RCLEA) Model

The Radioactively Contaminated Land Exposure Assessment (RCLEA) model is Defra's recommended approach for the assessment of a site under the Part 2A regime for managing contaminated land. It complements the Contaminated Land Exposure Assessment (CLEA) approach for assessing non-radioactive contamination and is designed to support decision making under the extended regime. The methodology is based on a set of mathematical models

and data that calculate radiation doses from radionuclides in soil. These have been implemented as a software application in Microsoft Excel®, published by Defra as CLR 15, which is accompanied by a summary methodology (CLR 13) and a detailed technical report (CLR 14).

Using measured concentrations of radionuclides, RCLEA calculates potential doses for comparison with regulatory criteria. It can also be used to calculate ‘Guideline Values’ in terms of radionuclide concentrations if reliable measurements are not yet available. In addition to specifying radionuclides present (and concentrations, if known), initial generic calculations provide the user with four basic options to select from:

- Reference land uses (consistent with CLEA), including residential (with or without home-grown vegetables), allotments and commercial/industrial use;
- Building type (timber framed or brick);
- Age (adult, infant or child); and
- Sex (male or female).

The RCLEA model is based on a probability of significant harm arising from ionising radiation, in relation to dose rate thresholds measured in millisieverts per year (mSv/a). The lowest threshold for ‘intervention’ embodied in the model is an effective dose rate of 3 mSv/a. An intervention is defined as an activity intended to reduce the exposure of an individual who is at risk from existing radioactivity. It is assumed that no remedial action would be justified if the effective dose rate were lower than this. Lower dose limits (lower by a factor of 10) are applicable to ‘practices’, e.g. radioactive discharges. Remediation of a site prior to a change of use would be classed as a ‘practice’.

Dose rate is related to activity concentration but is dependent on a number of contingent factors such as the distribution of sources in the ground. RCLEA assumes a homogeneous source over a depth of 1 m and a surface spread of at least 10 m. RCLEA is not intended to apply to sites containing discrete point sources, but can be adapted to ‘patchy’ contamination by application of an averaging factor.

RCLEA can be used to generate generic guideline values for individual radionuclides. CLR 13 includes a table of generic guideline values, which for radium-226, are as follows:

- For residential land-use scenarios - 1 Bq/g; and
- For commercial or industrial land-use scenarios - 5 Bq/g.

On the majority of former MOD sites, radium-226 is the sole contaminating isotope. It is noted that the activity of its stable decay products are included in the guideline values.

### **Health Protection Agency Recommendation**

- The Health Protection Agency recommends a maximum annual dose to members of the general public of 300 µSv. For sites contaminated with radium-226, this is equivalent to a maximum activity concentration of 0.34 Bq/g in soils. This is the most stringent activity concentration and has therefore been used to assess radioactive materials at the site.

## Waste Disposal of Radioactive Waste

The primary legislative instruments regulating the disposal of radioactively contaminated waste are the Radioactive Substances Regulations of EPR10 and the remaining provisions of RSA93. The disposal criteria for radium-226 contaminated soils based on RSA93 are shown in Table 7.1.

**Table 7.1 Ra-226 Disposal Criteria**

Activity Concentration	Description	Classification
<0.37 Bq/g	Under 'The Radioactive Substances Act 1993' such material is not regarded as radioactive for the purposes of statutory control and is considered to pose no risk. This material can be left in situ.	Free Release
>0.37 <4.9 Bq/g	Contaminated soil in this range is exempt from the controls in 'The Radioactive Substances Act 1993' by virtue of its compliance with 'The Radioactive Substances (Phosphatic Substances Rare Earths etc) Exemption Order 1962'. Such material is generally disposed of to landfill under normal duty of care arrangements. (Note: whilst some volume averaging may be acceptable in this category disposal of discrete sources would generally have to be isolated and removed)*.	'Exempt Waste'
>4.9 Bq/g	Material above this concentration is regarded as Low Level Radioactive Waste (LLW). Some landfills are currently going through the permit process in order that they can accept solid low and very low level radioactive waste. The average activity (specific) concentration of waste to be disposed to permitted landfill is likely to be limited to a total of 200 Bq/g for all radionuclides with half lives greater than 3 months.  Higher activity waste would be dispatched to Low Level Waste Repository (LLWR) at Drigg in Cumbria for disposal under a permit issued by the Environment Agency. The upper activity concentrations for such disposals is 4000 Bq/g for alpha activity and 12 000 Bq/g for beta/gamma activity. For radium and daughters in equilibrium this would equate to a radium 226 concentration of 2000 Bq/g.	LLW

\* Exemption Orders which exempt activities meeting specified criteria from the need to hold a permit under RSA93 and EPR10 are being reviewed. The review may result in future exemption limit being radionuclide-specific. The potential impacts could include changes in waste volumes (and hence cost of management and disposal) and additional complexities relating to record keeping and monitoring.

For a 3"x3" probe, a reading of 1000 cps (above background levels) equates to an average activity concentration of 1 Bq/g. An activity concentration of 0.37 Bq/g (Exempt waste threshold) therefore equates to a RadSurvey probe reading of 370 cps above background levels. An activity concentration of 4.9 Bq/g (LLW threshold) therefore equates to a RadSurvey probe reading of 4900 cps above background levels. Table 7.2 provides the RadSurvey instrument calibration data.

**Table 7.2 RadSurvey Calibration Data**

<b>Classification</b>	<b>Average Site Background Level (cps)</b>	<b>Equivalent RadSurvey Probe Reading Above Background Levels for Classification</b>	<b>Total Probe Reading for Classification (Equivalent+Background)</b>
Exempt Waste	400	370	770
LLW	400	4900	5300

For a 2"x2" probe, a reading of 500 cps (above background levels) equates to an average activity concentration of 1 Bq/g. An activity concentration of 0.37 Bq/g (Exempt waste threshold) therefore equates to a Ludlum 2" probe reading of 185 cps above background levels. An activity concentration of 4.9 Bq/g (LLW threshold) therefore equates to a Ludlum 2" probe reading of 2450 cps above background levels. Table 7.3 provides the Ludlum 2" instrument calibration data.

**Table 7.3 Ludlum 2" Calibration Data**

<b>Classification</b>	<b>Average Site Background Level (cps)</b>	<b>Equivalent Ludlum 2" Probe Reading Above Background Levels for Classification</b>	<b>Total Probe Reading for Classification (Equivalent +Background)</b>
Exempt Waste	200	185	385
LLW	200	2450	2650

In accordance with the Radioactive Substances Regulations of EPR10 and the remaining provisions of RSA93, the results of the radiological investigation have been considered against a threshold guidance level of 0.37 Bq/g radium-226 for exempt waste and 4.9 Bq/g radium-226 for Low Level Waste.

### **7.1.5 Entec's Approach to Risk Assessment from Radioactivity**

Entec's approach to assessing risks to human health from radioactive contamination is as follows:

#### **RCLEA and Part 2A**

To assess the risks to current site users in the context of EPA Part 2A, using the RCLEA model and the generic guideline values for radium-226 provided in CLR 13, as follows:

- For commercial or industrial land-use scenario - 5 Bq/g;
- For residential land-use scenarios - 1 Bq/g.

This will allow an assessment of whether the land could potentially be regarded as 'radioactively contaminated land' (under Part 2A), in the current use and circumstances of the land.



It should be noted that a residential land-use has been assumed for the purpose of this assessment.

## **Dose Exposure Scenarios**

### *Current Site Users*

To further assess the risks to current site users by considering a number of viable exposure scenarios relevant to the current use of the site, the dose rate that site users could conceivably receive (under each of the scenarios considered) compared with the Health Protection Agency recommended maximum annual dose of 300  $\mu$ Sv.

### *Future Site Users*

To assess the risks to future site users (residential and commercial) considering the following:

A threshold level of 0.34 Bq/g radium-226 in soils, derived for a residential end use, being the activity concentration equivalent to the Health Protection Agency recommended maximum dose to members of the general public of 300  $\mu$ Sv/annum.

## **Radioactive Substances Regulations of EPR10 and the remaining provisions of RSA93**

The statutory requirement for the control of radioactive material under these regulations is assessed, where the threshold for radium-contaminated material to be considered radioactive is 0.37 Bq/g above background. This legislative tool is used to regulate the accumulation and disposal of radioactive material but would also be used to regulate any change of use.

## **7.2 Definition of Zones**

### **7.2.1 Zones and Averaging Areas (Chemical Analysis)**

The CLR guidance promotes the concept of considering a site in terms of zones and averaging areas, when assessing site investigation data. In the first instance, the site should be zoned into areas of similar historical activity and material type. The objective of this is to divide the site and its materials into data sets with similar physical and contamination characteristics that can be represented by a single representative concentration. When assessing the data, consideration must also be given to the areas to which a receptor may be exposed, termed an averaging area. Averaging areas are determined based on current or proposed land use.

### **7.2.2 Assessment Zones**

The assessment has considered the following zones of similar historical activity and broadly similar Made Ground/natural material type. This division is based on the sources identified during the previous LQAs undertaken on the site and the physical conditions identified during the site investigation. It should be noted that in some cases a zone may comprise a number of sources located at discrete locations across the site, such as historical fuel tanks. For the purpose of simplicity and clarity within this report, such sources of similar historical activity have been considered together. The assessment zones used in this risk assessment are shown on Figure 6 and in Table 7.4 below.

**Table 7.4 Assessment Zones**

Zone Number	Description	Number of Samples		
		Soil	Groundwater	Surface Water (3 Sampling Rounds)
D Site				
1	BIFT (fuel storage area with known spills)	9x Made Ground, 4x Natural	2	-
2	Vicinity of buildings D2, D6, D9 and Maintenance Yard (fuel storage and workshops)	9x Made Ground, 12x Natural	5	2 per round
3	Area of Made Ground between buildings D6 and D9	7x Made Ground, 2x Natural	-	1 (on last sampling round)
E Site				
1	Rodney House / OSU (fuel storage areas with known spills)	5x Made Ground, 6x Natural	4	1 per round
2	Car park by E25 and building E10 (former fuel storage )	6x Natural	-	1 per round
3	Building E14/E16 fuel tanks and building E20 (fuel storage and use)	8x Made Ground, 7x Natural	2	-
4	E15 Tip Area	9x Made Ground, 3x Natural	-	1 (on last sampling round)
5	Agricultural land on north-western site boundary	5x Natural	4	-

### 7.2.3 Statistical Assessment

The site investigation works undertaken provided a relatively targeted dataset for all of the zones set out in Table 7.4. Therefore, a full statistical assessment of the data set has not been undertaken. However, where exceedences of the GAC used in these zones have been recorded, the calculated sample mean has been compared to the GAC.

## 7.3 Comparison with Generic Assessment Criteria

Observed soil concentrations have been compared to the GAC discussed above for residential with plant uptake end use, based on the most sensitive likely future use of the investigated areas of the site. The comparison is presented below. Results for all zones compared with relevant screening criteria are provided in Annex D. Laboratory data is presented as Annex E, and all soil/water exceedences of the GAC/WQT used are shown on Figures 7a and 7b respectively.

The results of the comparison of the site investigation data have been used to refine the conceptual model which is set out in Section 7.4. The risks associated with each of the pollutant linkages identified in the previous Phase One LQA report have been assessed, updated and presented in Section 4.3.

### 7.3.1 D Site Zone 1: BIFT

A total of thirteen soil samples (four of natural ground and nine of Made Ground) and two groundwater samples were scheduled for laboratory analysis from this zone. The samples targeted the locations of the following:

- The BIFT POL area, where there are records of previous fuel spillage; and
- Two areas of Made Ground directly to the north-west and south-west of the BIFT POL area.

### Soils Analysis

A summary of the soil exceedance data compared with residential with plant uptake screening criteria is provided in Table 7.5.

**Table 7.5 Summary of Zone 1 Soil Exceedances Compared to GAC**

Analyte	No of Samples Tested	Conc. Range (mg/kg)	Screening Criteria	Screening Value (mg/kg)	Samples Exceeding	Location and Depth (where GAC available)
Carbon Disulphide	1	0.289 mg/kg	Entec GAC (Res. With plant uptake)	0.24 mg/kg	1	0.289 mg/kg BHD01 3.6-3.8 m bgl (natural ground)

The pH values in D Site Zone 1 varied between 7.67 and 9.06 in the Made Ground (average of 8.20) and between 5.91 and 8.13 within the natural ground (average of 6.91).

Asbestos was not identified in any of the three samples screened for asbestos within this zone.

### *Metal and Inorganic Contaminants*

- No metal/metallloid concentrations exceeding the relevant screening criteria were recorded in this zone;
- Ammoniacal nitrogen analysis was undertaken on nine Made Ground and four natural samples from this zone, of which five Made Ground and two natural samples were above the MDL of 15 mg/kg. The highest result (171 mg/kg) was recorded in a natural sample from WSD14 (0.45-0.55 m bgl); and
- Water soluble sulphate analysis was undertaken on nine Made Ground and four natural samples from this zone, all of which were above the MDL of 0.003 g/l. The highest result was 1.69 g/l in a natural sample from WSD14 (3.00-3.20 m bgl).

### **Organic Contaminants**

- None of the concentrations of the individual TPH fractions exceeded the relevant Entec/LQM GAC for residential with plant uptake land use for the seven samples analysed;
- The highest TPH fraction (aromatic hydrocarbons C21-C40) concentration was recorded in a sample of Made Ground from WSD15 at 0.40-0.50 m bgl (545 mg/kg). One or more of the heavier range TPH bands (>C12) were detected at concentrations above the MDL in all of the Made Ground and natural samples analysed;
- One sample of natural ground was submitted for speciated PAH analysis. None of the individual PAH species exceeded the Entec GAC used;
- One sample of natural ground was submitted for SVOC (including PAH) and VOC analysis. This sample (BHD01 3.60-3.80 m) recorded a very slight exceedance of the Entec GAC for carbon disulphide (0.24 mg/kg) of 0.289 mg/kg. Given the limited exceedance of carbon disulphide noted in a deep natural ground soil sample, as well as the likely future commercial/industrial use of D Site, we have not considered this contaminant further; and
- Benzene, toluene, ethylbenzene and xylenes (BTEX), along with Methyl Tertiary Butyl Ether (MTBE) was not detected in the natural ground sample above the respective MDL.

### **Ground Gas and Vapours**

Screening of soil samples with a PID prior to dispatch to laboratories did not indicate the presence of VOCs.

Gas and vapour monitoring of the three installations present in this zone was carried out on six occasions. VOC concentrations were recorded at concentrations ranging between 0.2 and 30.6 ppm. The highest concentration (30.6 ppm) was recorded in WSD15 on 23 July 2010 with an atmospheric pressure of 1009 mb.

Methane was not detected in any of the installations within this zone. Carbon dioxide was detected at concentrations ranging between 0.2% and 5.2% v/v in BHD01, 0.1% and 0.5% v/v in WSD15 and at 0.1% in WSD14. The highest concentration of 5.2% v/v was recorded in BHD01 on 4 August 2010 with an atmospheric pressure of 1003 mb. Oxygen levels were generally indicative of normal atmospheric conditions.

The GSVs generally indicate a 'green' NHBC traffic light classification, meaning ground gas protection measures as not likely to be required. However, the carbon dioxide concentration of 5.2% in BHD01 give rise to an 'Amber 1' classification, meaning low to moderate gas protection measures are likely to be required.

### **Groundwater Analysis**

Groundwater was sampled from one of the boreholes in this zone (BHD01) on two occasions (5 and 18 August 2010).

The pH value recorded in this zone was recorded between 7.63 and 7.99 (average 7.81) indicating slightly alkaline groundwater conditions.

### ***Metal and Inorganic Contaminants***

- There were no exceedences of the WQTs used for metals in the samples obtained from this zone, with the exception of boron and selenium, which were detected at concentrations of 2.08 and 0.0107 mg/l respectively in the samples from 18 August 2010, both very slightly exceeding the EQS and DWS WQTs respectively;
- Ammonical nitrogen was detected at a concentration of 1.83 mg/l in the groundwater samples obtained, which exceeds the conservative DWS WQT of 0.5 mg/l; and
- Sulphate was detected at a concentration of 2,140 mg/l in the groundwater samples obtained, which exceeds the EQS WQT of 400 mg/l.

### ***Organic Contaminants***

- BTEX and MTBE, along with banded petroleum hydrocarbons were not detected above the individual MDL for the sample obtained from this zone; and
- PAH species, including fluorene, phenanthrene, pyrene, benzo(b)fluoranthene and benzo(k)fluoranthene were all detected at concentrations very slightly in excess of the conservative DWS WQT (0.1 µg/l). Benzo(a)pyrene was also detected at concentrations of up to 0.125 µg/l, which exceeds the conservative DWS WQT of 0.01 µg/l.

### **Surface Water Analysis**

No surface water samples were obtained from this zone, as there are no suitable drainage ditches.

### **7.3.2 D Site Zone 2: Buildings D2, D6, D9 and Maintenance Yard**

A total of twenty soil samples (twelve of natural ground and eight of Made Ground), four groundwater and six surface water samples were scheduled for laboratory analysis from this zone. The samples targeted the locations of:

- Building D2: fuel storage;
- Buildings D6 and D9: former railway workshops and fuel storage; and
- Maintenance Yard: workshops and fuel storage.

### **Soils Analysis**

The pH values in D Site Zone 2 varied between 6.54 and 8.32 in the Made Ground (average of 7.76) and between 5.16 and 8.13 within the natural ground (average of 6.30).

Asbestos was detected in one of the three samples submitted for screening as chrysotile (white asbestos). This was a Made Ground sample from WSD03 at 0.10 to 0.20 m bgl.

### ***Metal and Inorganic Contaminants***

- No metal/metalloid concentrations exceeding the relevant screening criteria were recorded in this zone, with the exception of arsenic, that was detected at a concentration of 32.5 mg/kg in WSD09 (3.80 to 4.00 m bgl), which very slightly exceeds the SGV of 32.0 mg/kg;
- Ammoniacal nitrogen analysis was undertaken on eight Made Ground and twelve natural samples from this zone, of which none of the Made Ground and three natural samples were above the MDL of 15 mg/kg. The highest result (114 mg/kg) was recorded in a natural sample from WSD16 (0.50-0.70 m bgl); and
- Water soluble sulphate analysis was undertaken on eight Made Ground and twelve natural samples from this zone, all of which were above the MDL of 0.003 g/l. The highest result was 1.8 g/l in a natural sample from WSD12 (1.50-1.70 m bgl).

### ***Organic Contaminants***

- None of the concentrations of the individual TPH fractions exceeded the relevant Entec/LQM GAC for residential with plant uptake land use for the nine samples analysed;
- The highest TPH fraction (aromatic hydrocarbons C21-C40) concentration was recorded in a sample of Made Ground from WSD1 at 0.00-0.20 m bgl (491 mg/kg). One or more of the heavier range TPH bands (>C16) were detected at concentrations above the MDL in all of the Made Ground and four of the natural samples analysed;
- One sample of Made Ground and two samples of natural ground was submitted for speciated PAH analysis. None of the individual PAH species exceeded the LQM GAC used;
- One sample of Made Ground and two samples of natural ground were submitted for SVOC (including PAH) and VOC analysis. No SVOC and VOCs were detected at concentrations above the GAC used. However, trace concentrations of certain compounds were detected in the Made Ground, e.g. 2,4-dinitrotoluene (0.184 mg/kg) in WSD05; and
- BTEX, along with MTBE was not detected in the one Made Ground and two natural ground samples above the respective MDL.

### ***Ground Gas and Vapours***

Screening of soil samples prior to dispatch to laboratories indicated the presence of volatile organic compounds within the soil matrix in one of the samples (WSD05) from this zone.

Gas monitoring of the seven installations present in this zone was carried out on six occasions. VOC concentrations were recorded in all boreholes at concentrations ranging between 0.1 and 20.7 ppm. The highest concentration of 20.7 ppm was recorded in WSD09 on 23 July 2010 with an atmospheric pressure of 1010 mb.

Methane was not detected in any of the installations within this zone. Carbon dioxide was detected at concentrations of up to 1.7% v/v, although only WSD02 and WSD10 recorded

carbon dioxide concentrations over 1.0% v/v. The highest concentration of 1.7% v/v was recorded in WSD10 on 13 August 2010 with an atmospheric pressure of 1006 mb. This concentration of carbon dioxide is not considered to be significant. Oxygen levels were generally indicative of normal atmospheric conditions.

The GSVs generally indicate a 'green' NHBC traffic light classification, meaning ground gas protection measures as not likely to be required.

### **Groundwater Analysis**

Groundwater was sampled from four of the boreholes in this zone (WSD03, WSD07, WSD09 and WS10). All of the above locations were sampled on a single occasion, with the exception of WSD09, which was sampled on two occasions.

The pH value recorded in this zone was between 7.67 and 7.57, with a mean of 7.05 indicating generally neutral groundwater conditions.

### ***Metal and Inorganic Contaminants***

- There were no exceedences of the WQTs used for metals in the samples obtained from this zone, with the exception of selenium in the sample from WSD10 taken on 5 August 2010. This selenium concentration (11.3 µg/l) very slightly exceeds the DWS WQT for selenium (10 µg/l);
- Ammonical nitrogen was detected at a concentration of up to 3.16 mg/l, exceeding the conservative DWS WQT of 0.5 mg/l in three of the samples (WSD03 and WSD09 twice) obtained; and
- Sulphate was detected at a concentration of up to 2150 mg/l (WSD10, 18 August 2010), exceeding the EQS WQT of 400 mg/l in all of the samples obtained.

### ***Organic Contaminants***

- BTEX and MTBE, along with speciated PAHs were generally not detected above the individual MDL in the samples obtained from this zone. In the absence of an applicable EQS or DWS marker compounds for fuels (such as BTEX) or compounds indicative of a particular fraction (naphthalene for aromatic >EC10-EC12), may be used for comment. Comparison to naphthalene EQS is however highly conservative as this would assume that the total show for aliphatic and aromatic fractions is firstly all aromatic and secondly that all of that fraction is accounted for by naphthalene which is unlikely. As such, it is noted that all Extractable Petroleum Hydrocarbon (EPH) bands >C10 were detected at concentrations in excess of the conservative EQS for naphthalene used in both samples from WSD09 within this zone.. The highest exceedance was in the >C16-C21 band at 0.114 mg/l, compared to the EQS for naphthalene of 0.01 mg/l.

### **Surface Water Analysis**

Surface water was sampled in two locations within this zone (SWD06 and SWD09) on three occasions (21 and 29 July 2010, as well as 4 August 2010 for SWD06 and 18 August 2010 for SWD09, as this location was dry on 4 August 2010).

The pH value recorded in this zone was between 7.09 and 8.44, with a mean of 7.84 indicating slightly alkaline groundwater conditions.

#### ***Metal and Inorganic Contaminants***

- There were no exceedences of the WQT screening criteria used for metals in the samples obtained from this zone, with the exception of zinc, which was detected at concentrations that slightly exceed the conservative EQS WQT in two samples from SWD09;
- Ammonical nitrogen was detected at concentrations of up to 12.7 mg/l (SWD06) in the surface water samples obtained, which exceeded the conservative DWS WQT of 0.5 mg/l in four of the six samples obtained;
- Sulphate was detected at a concentration of up to 416 mg/l (SWD09, 21 July 2010) in the surface water samples obtained. The above sample very slightly exceeds the EQS WQT of 400 mg/l.

#### ***Organic Contaminants***

- BTEX and MTBE, along with speciated PAHs were generally not detected above the individual MDL in the samples obtained from this zone. However, all Extractable Petroleum Hydrocarbon (EPH) bands >C10 were detected at concentrations in excess of the conservative EQS for naphthalene used in all except one of the samples from this zone. The highest exceedance was in the >C21-C28 band from the 29 July 2010 sample from SWD06 (0.267 mg/l) compared to the EQS for naphthalene of 0.01 mg/l.

### **7.3.3 D Site Zone 3: Area of Made Ground between buildings D6 and D9**

A total of nine soil samples (two of natural ground and seven of Made Ground) and one surface water sample were scheduled for laboratory analysis from this zone. The samples targeted the locations of the area of Made Ground between buildings D6 and D9.

#### **Soils Analysis**

The pH values in D Site Zone 3 varied between 5.47 and 8.54 in the Made Ground (average of 7.60) and between 6.01 and 7.62 within the natural ground (average of 6.82).

Asbestos was not identified in the Made Ground sample screened for asbestos within this zone.

#### ***Metal and Inorganic Contaminants***

- No metal/metalloid concentrations exceeding the relevant screening criteria were recorded in this zone;
- Ammoniacal nitrogen analysis was undertaken on seven Made Ground and two natural samples from this zone, of which no Made Ground and one natural sample were above the MDL of 15 mg/kg. The highest result (138 mg/kg) was recorded in a natural sample from TPD05 (3.8 m bgl);
- Water soluble sulphate analysis was undertaken on seven Made Ground and two natural samples from this zone, all of which were above the MDL of 0.003 g/l. The highest result was 1.42 g/l in a Made Ground sample from TPD3 (0.60 m bgl).



### ***Organic Contaminants***

- None of the concentrations of the individual TPH fractions exceeded the relevant Entec/LQM GAC for residential with plant uptake land use for the two natural ground samples analysed;
- The highest TPH fraction (aromatic hydrocarbons C21-C40) concentration was recorded in a sample of natural ground from TPD01 at 1.3 m bgl (403 mg/kg). One or more of the heavier range TPH bands (>C10) were detected at concentrations above the MDL in all of the natural samples analysed;
- No samples were scheduled for speciated PAH, SVOC or VOC analysis from this area.

### **Ground Gas and Vapours**

As there are no monitoring well installations within Zone 3, no further gas monitoring was undertaken.

### **Groundwater Analysis**

As no groundwater monitoring wells were installed within D Site Zone 3, no groundwater monitoring was undertaken.

### **Surface Water Analysis**

Surface water was sampled in one location within this zone (SWD08) on one occasion (18 August 2010). This location had been dry during all previous monitoring rounds.

The pH value recorded in this zone was 8.43 indicating alkaline groundwater conditions.

### ***Metal and Inorganic Contaminants***

- There were no exceedences of the WQT screening criteria used for metals in the samples obtained from this zone;
- Ammonical nitrogen was not detected in the sample obtained;
- Sulphate was detected at a concentration of 112 mg/l. This sample therefore does not exceed the EQS WQT of 400 mg/l.

### ***Organic Contaminants***

- BTEX and MTBE, along with speciated PAHs were not were not scheduled for analysis on the sample obtained from this zone, based on a lack of visual/olfactory contamination during the investigation;
- However, all of the EPH bands >C16 were detected at concentrations in excess of the conservative EQS for naphthalene used in the sample from this zone. The highest exceedance was in the >C21-C28 band (0.0301 mg/l) compared to the EQS for naphthalene of 0.01 mg/l.

### 7.3.4 E Site Zone 1: Rodney House and OSU

A total of eleven soil samples (six of natural ground and five of Made Ground), four groundwater samples and three surface water samples were scheduled for laboratory analysis from this zone. The samples targeted the locations of:

- The Rodney House above ground fuel storage tank, where there are records of previous fuel spillage;
- The OSU below ground fuel storage tanks, where there are records of previous fuel spillage.

#### Soils Analysis

The pH values in E Site Zone 1 varied between 7.45 and 8.36 in the Made Ground (average of 8.06) and between 4.51 and 7.91 within the natural ground (average of 6.52).

Asbestos was not identified in the single Made Ground sample screened for asbestos within this zone.

#### *Metal and Inorganic Contaminants*

- No metal/metallloid concentrations exceeding the relevant screening criteria were recorded in this zone;
- Ammoniacal nitrogen analysis was undertaken on five Made Ground and six natural samples from this zone, of which none of the Made Ground and two natural samples were above the MDL of 15 mg/kg. The highest result (55.4 mg/kg) was recorded in a natural sample from WSE17 (0.60-0.80 m bgl);
- Water soluble sulphate analysis was undertaken on five Made Ground and six natural samples from this zone, all of which were above the MDL of 0.003 g/l except one Made Ground sample. The highest result was 1.6 g/l in a natural sample from WSE17 (2.40-2.60 m bgl).

#### *Organic Contaminants*

- None of the concentrations of the individual TPH fractions exceeded the relevant Entec/LQM GAC for residential with plant uptake land use for the five samples analysed;
- The highest TPH fraction (aromatic hydrocarbons C21-C40) concentration was recorded in a sample of Made Ground from WSE27 at 0.50-0.60 m bgl (224 mg/kg). One or more of the heavier range TPH bands (>C16) were detected at concentrations above the MDL in both of the Made Ground and two of the natural samples analysed;
- One sample of natural ground was submitted for speciated PAH analysis. None of the individual PAH species exceeded the Entec GAC used;
- One sample of natural ground was submitted for SVOC (including PAH) and VOC analysis. There were no exceedences of the GAC used, with the exception of some aliphatic and aromatic TPH bands above the MDL;

- BTEX along with MTBE was not detected in the natural ground sample above the respective MDL.

### **Ground Gas and Vapours**

Screening of soil samples using a PID prior to dispatch to laboratories did not indicate the presence of VOCs.

Gas and vapour monitoring of the four installations present in this zone was carried out on five (WSE27, BHE01 and BHE02) and on six occasions (WSE17). VOCs were recorded at concentrations ranging between 0.1 and 17.8 ppm, although WSE27 did not record VOCs above 0.1 ppm. The highest concentration of 17.8 ppm was recorded in BHE01 on 23 July 2010 with an atmospheric pressure of 1009 mb.

Methane was not detected in any of the installations within this zone. Carbon dioxide was detected at concentrations ranging between 0.1% and 1.5% v/v, although only WSE17 and BHE01 recorded carbon dioxide concentrations over 1.0% v.v. The highest concentration of 1.5% v/v was recorded in BHE01 on 23 July 2010 with an atmospheric pressure of 1009 mb. This concentration of carbon dioxide is not considered to be significant. Oxygen levels were generally indicative of normal atmospheric conditions.

The GSVs generally indicate a 'green' NHBC traffic light classification, meaning ground gas protection measures are not likely to be required.

### **Groundwater Analysis**

Groundwater was sampled from two of the boreholes in this zone (BHE02 and WSE17) on two occasions (4 and 18 August 2010).

The pH values recorded in this zone ranged from 7.22 to 7.88, with an average of 7.61, indicating slightly alkaline conditions.

### ***Metal and Inorganic Contaminants***

- There were no exceedences of the WQTs used for metals in the samples obtained from this zone;
- Ammonical nitrogen was detected at concentrations of up to 2.21 mg/l (WSE17, 18 August 2010) which exceeds the conservative DWS WQT of 0.5 mg/l;
- Sulphate was detected at a concentration of up to 1,170 mg/l (4 August 2010) which exceeds the EQS WQT of 400 mg/l.

### ***Organic Contaminants***

- BTEX and MTBE were not detected above the individual MDL for the samples obtained from this zone;
- Benzo(a)pyrene was also detected at concentrations up to 14.1 µg/l in three samples (WSE17, 4 August 2010 and BHE02, 13 and 18 August 2010) which exceeds the conservative DWS WQT of 0.01 µg/l. All other PAH species were only detected at concentrations above the WQTs used within both samples from BHE02, although not at concentrations above that of benzo(a)pyrene above;

- Some of the EPH bands >C16 were detected at concentrations in excess of the conservative EQS for naphthalene used in three of the samples from this zone. The highest exceedance was in the >C16-C21 band (0.569 mg/l) compared to the EQS for naphthalene of 0.01 mg/l;
- No VOC/SVOCs were detected above MDL in any of the samples obtained.

### **Surface Water Analysis**

Surface water was sampled from one location within this zone, SWE01, on three occasions (21 and 29 July 2010, as well as 4 August 2010).

The pH values recorded in this zone ranged between 7.71 and 8.24, with a mean of 7.95 indicating slightly alkaline groundwater conditions.

### ***Metal and Inorganic Contaminants***

- There were no exceedences of the WQTs used for metals in the samples obtained from this zone;
- Sulphate was not detected above the EQS WQT of 400 mg/l in any of the samples from this zone.

### ***Organic Contaminants***

- BTEX and MTBE were not detected above the individual MDL for the samples obtained from this zone;
- Fluoranthene was detected at 0.106 µg/l in the sample from 4 August 2010, very slightly exceeding the conservative DWS WQT of 0.1 µg/l;
- Benzo(a)pyrene was also detected at a concentration of 0.06 µg/l in one sample (4 August 2010) which exceeds the conservative DWS WQT of 0.01 µg/l. All other PAH species were below the WQTs used;
- All EPH bands >C12 were detected at concentrations in excess of the conservative EQS for naphthalene used in one sample from this zone (29 July August 2007). The highest exceedance was in the >C16-C21 band at 0.0558 mg/l, compared to the EQS for naphthalene of 0.01 mg/l;
- No VOC/SVOCs were detected above MDL in any of the samples obtained.

### **7.3.5 E Site Zone 2: Car Park by E25 and Building E10**

A total of six soil samples (five of natural ground and one of Made Ground) and three surface water samples were scheduled for laboratory analysis from this zone. The samples targeted the locations of:

- A former refuelling facility in the vicinity of the building E25 car park;
- The above ground fuel tank near building E10 (decommissioned in 2010).

### **Soils Analysis**

The pH values in E Site Zone 2 were 7.92 in the Made Ground sample and between 4.92 and 8.0 within the natural ground (average 6.56).

Asbestos was not screened within any samples within this zone, although there was no obvious sign of asbestos in the logs.

### ***Metal and Inorganic Contaminants***

- No metal/metalloid concentrations exceeding the relevant screening criteria were recorded in this zone;
- Ammoniacal nitrogen analysis was undertaken on one Made Ground and five natural samples from this zone, of which none of the Made Ground or natural samples were above the MDL of 15 mg/kg;
- Water soluble sulphate analysis was undertaken on one Made Ground and five natural samples from this zone, all of which with the exception of the Made Ground sample were above the MDL of 0.003 g/l. The highest result was 1.86 g/l in a natural sample from WSE03 (2.30-2.50 m bgl).

### ***Organic Contaminants***

- None of the concentrations of the individual TPH fractions exceeded the relevant Entec/LQM GAC for residential with plant uptake land use for the three natural samples analysed;
- The highest TPH fraction (aromatic hydrocarbons C21-C40) concentration was recorded in a sample of natural ground from WSE4 at 1.60-1.80 m bgl (160 mg/kg). One or more of the heaviest range TPH bands (>C21) were detected at concentrations above the MDL in two of the natural samples analysed;
- No samples were scheduled for speciated PAH, SVOC or VOC analysis from this areas as the arisings appeared to have little visual or olfactory evidence of contamination.

### **Ground Gas and Vapours**

Screening of soil samples prior to dispatch to laboratories did not indicate the presence of VOCs.

Gas and vapour monitoring of the one installation present in this zone (WSE03) was carried out on four occasions. VOCs were not recorded at concentrations above 0.1 ppm in this borehole. This concentration of VOCs is not considered to be significant.

Methane was not detected in the installation within this zone. Carbon dioxide was detected at concentrations ranging between 0.5% and 1.1% v/v. The highest concentration of 1.1% v/v was recorded on 4 and 13 August 2010 with an atmospheric pressure of 996 mb and 1006 mb respectively. This concentration of carbon dioxide is not considered to be significant. Oxygen levels were generally indicative of normal atmospheric conditions.

The GSVs generally indicate a 'green' NHBC traffic light classification, meaning ground gas protection measures are not likely to be required.

### **Groundwater Analysis**

No groundwater monitoring was undertaken in this zone, due to the availability of a suitable surface water monitoring point.

### **Surface Water Analysis**

Surface water was sampled from one location within this zone, SWE15, on three occasions (21 and 29 July 2010, as well as 4 August 2010).

The pH values recorded in this zone ranged between 7.35 and 7.97, with a mean of 7.69 indicating slightly alkaline groundwater conditions.

### ***Metal and Inorganic Contaminants***

- There were no exceedences of the WQTs used for metals in the samples obtained from this zone;
- Ammonical nitrogen was detected at concentrations of up to 0.868 mg/l (29 July 2010). One sample [SWE05] (21 and 29 July 2010) slightly exceeded the conservative DWS WQT of 0.5 mg/l; and
- Sulphate was not detected above the EQS WQT of 400 mg/l in any of the samples from this zone.

### ***Organic Contaminants***

- BTEX, MTBE and speciated PAH were not analysed in any of the samples obtained from this zone, although it should be noted that the soil arisings from boreholes in this zone appeared to have little visual or olfactory evidence of contamination;
- All EPH bands >C12 were detected at concentrations in excess of the conservative EQS for naphthalene used in one sample from this zone (21 July August 2010). The highest exceedance was in the >C12-C16 band at 0.0348 mg/l, compared to the EQS for naphthalene of 0.01 mg/l;
- No VOC/SVOCs were scheduled for analysis in any of the samples obtained.

### **7.3.6 E Site Zone 3: Building E14/E16 Fuel Tanks and Building E20**

A total of thirteen soil samples (six of natural ground and seven of Made Ground) and two groundwater samples were scheduled for laboratory analysis from this zone. The samples targeted the locations of:

- Building E14 (former boiler house) and Building E16 (loco shed) above ground fuel tanks;
- Building E20 (former Fire Training Area).

### **Soils Analysis**

A summary of the soil exceedance data compared with residential with plant uptake screening criteria is provided in Table 7.6.

**Table 7.6 Summary of E Site Zone 3 Soil Exceedances Compared to GAC**

Analyte	No of Samples Tested	Conc. Range (mg/kg)	Screening Criteria	Screening Value (mg/kg)	Samples Exceeding	Location and Depth (where GAC available)
Arsenic	13	4.29-357 mg/kg	2009 SGV	32 mg/kg	1	357 mg/kg WSE13 0.2-0.4 m bgl
Benzo(a)pyrene	3	0.024-5.88 mg/kg	LQM CIEH GAC (Res. with plant uptake)	1 mg/kg	2	5.88 mg/kg WSE09 0.4-0.5 m bgl

The pH values in E Site Zone 3 varied between 4.89 and 9.01 in the Made Ground (average of 7.81) and between 4.23 and 8.31 within the natural ground (average of 6.87).

Asbestos was identified at chrysotile sheeting in one of the five Made Ground samples screened for asbestos within this zone (WSE11, 0.10-0.30 m bgl).

#### ***Metal and Inorganic Contaminants***

- No metal/ metalloid concentrations exceeding the relevant screening criteria were recorded in this zone, with the exception of arsenic, which was detected at a concentration of 357 mg/kg in a Made Ground sample from WSE13. The mean of the arsenic concentrations from the Made Ground samples was 62 mg/kg;
- Ammoniacal nitrogen analysis was undertaken on seven Made Ground and six natural samples from this zone, of which none of the Made Ground and three natural samples were above the MDL of 15 mg/kg. The highest result (66.6 mg/kg) was recorded in a natural sample from WSE5 (0.50 to 0.70 m bgl);
- Water soluble sulphate analysis was undertaken on seven Made Ground and six natural samples from this zone, all of which were above the MDL of 0.003 g/l. The highest result was 1.97 g/l in a natural sample from WSE06 (2.80 to 3.00 m bgl).

#### ***Organic Contaminants***

- None of the concentrations of the individual TPH fractions exceeded the relevant Entec/LQM GAC for residential with plant uptake land use for the nine samples analysed;
- The highest TPH fraction (aromatic hydrocarbons C21-C40) concentration was recorded in a sample of Made Ground from WSE10 at 0.10-0.30 m bgl (359 mg/kg). One or more of the heavier range TPH bands (>C16) were detected at concentrations above the MDL in all of the Made Ground and natural samples analysed;
- Three Made Ground samples were submitted for speciated PAH analysis. None of the individual PAH species exceeded the LQM GAC used, with the exception of a

single exceedance of benzo(a)pyrene in a Made Ground sample from WSE09 (0.40-0.50 m bgl) at 3.21 mg/kg. The mean benzo(a)pyrene concentration from the Made Ground samples was 1.2 mg/kg;

- Three Made Ground samples were submitted for SVOC (including PAH) and VOC analysis. One sample (WSE09, 0.40-0.50 m bgl) recorded an exceedance of the LQM GAC for benzo(a)pyrene (1 mg/kg) of 5.88 mg/kg. It should be noted that this is the same sample as the above benzo(a)pyrene exceedance. The discrepancy is likely to be attributable to slight differences in the heterogeneity of the soils between individual samples in different containers making up this sample together with differences in analytical methods;
- Benzene, toluene, ethylbenzene and xylenes (BTEX), along with Methyl Tertiary Butyl Ether (MTBE) was not detected in the any of the three Made Ground samples above the respective MDL.

### **Ground Gas and Vapours**

Screening of soil samples prior to dispatch to laboratories did not indicate the presence of volatile organic compounds.

Gas and vapour monitoring of the three installations present in this zone was carried out on six occasions. VOCs were only recorded in WSE10 at concentrations above 0.1 ppm. The highest concentration of 20.2 ppm was recorded on 29 July 2010 with an atmospheric pressure of 1007 mb.

Methane was not detected in any of the installations within this zone. Carbon dioxide was detected at concentrations ranging between 0.2% and 6.3% v/v, although only WSE09 and WSE10 recorded carbon dioxide concentrations greater than 1.0% v/v. The highest concentration of 6.3% v/v was recorded in WSE10 on 18 August 2010 with an atmospheric pressure of 997 mb. Oxygen levels were generally indicative of normal atmospheric conditions.

The GSVs generally indicate a 'green' NHBC traffic light classification, meaning ground gas protection measures are not likely to be required. However, the carbon dioxide concentration of up to 6.3% in WSE10 give rise to an 'Amber 1' classification, meaning low to moderate gas protection measures are likely to be required.

### **Groundwater Analysis**

Groundwater was sampled from one location within this zone, WSE10, on two occasions (4 and 18 August 2010).

The pH values recorded in this zone ranged between 7.66 and 7.74, with a mean of 7.7, indicating slightly alkaline groundwater conditions.

### **Metal and Inorganic Contaminants**

- There were no exceedences of the WQTs used for metals in the samples obtained from this zone;
- Ammonical nitrogen was not detected above the DWS WQT of 0.5 mg/l in any of the samples from this zone;



- Sulphate was not detected above the EQS WQT of 400 mg/l in any of the samples from this zone.

#### **Organic Contaminants**

- BTEX and MTBE were not detected above the individual MDL for the samples obtained from this zone;
- Most EPH bands >C12 were detected at concentrations in excess of the conservative the naphthalene EQS used for both of the samples taken from this zone. The highest exceedance was in the >C16-C21 band at 0.84 mg/l, compared to the EQS for naphthalene of 0.01 mg/l;
- No VOC/SVOCs were scheduled for analysis in any of the samples obtained.

#### **Surface Water Analysis**

Surface water was not sampled within this zone, as all identified potential monitoring locations were dry during the monitored period.

#### **7.3.7 E Site Zone 4: E15 Tip Area**

A total of twelve soil samples (three of natural ground and nine of Made Ground) and one surface water sample were scheduled for laboratory analysis from this zone. The samples targeted the former tip to the north-west of Building E15.

#### **Soils Analysis**

A summary of the soil exceedance data compared with residential with plant uptake screening criteria for Made Ground samples is provided in Table 7.7. There were no exceedences of the screening criteria for natural ground.

**Table 7.7 Summary of E Site Zone 4 Soil Exceedances from Made Ground Compared to GAC**

Analyte	No of Samples Tested	Conc. Range (mg/kg)	Screening Criteria	Screening Value (mg/kg)	Samples Exceeding	Location and Depth (where GAC available)
Arsenic	9	9.13-50.3 mg/kg	2009 SGV (Res. with plant uptake)	32 mg/kg	1	50.3 mg/kg WSE19 0.6-0.7 m bgl
Chromium (hexavalent)	9	0.6-9.06 mg/kg	LQM CIEH GAC (Res. with plant uptake)	4.3 mg/kg	1	9.06 mg/kg WSE19 0.3-0.5 m bgl
Copper	9	12.2-36 200 mg/kg	LQM CIEH GAC (Res. with plant uptake)	2300 mg/kg	1	36 200 mg/kg WSE19 0.6-0.7 m bgl

**Table 7.7 (continued) Summary of E Site Zone 4 Soil Exceedances from Made Ground Compared to GAC**

Analyte	No of Samples Tested	Conc. Range (mg/kg)	Screening Criteria	Screening Value (mg/kg)	Samples Exceeding	Location and Depth (where GAC available)
Lead	9	9.78-589 mg/kg	2002 SGV (Res. with plant uptake)	450 mg/kg	1	589 mg/kg WSE19 0.6-0.7 m bgl
Nickel	9	12.9-913 mg/kg	2009 SGV (Res. with plant uptake)	130 mg/kg	1	913 mg/kg WSE19 0.6-0.7 m bgl
Zinc	9	34-24 200 mg/kg	LQM CIEH GAC (Res. with plant uptake)	3,800 mg/kg	1	24 200 mg/kg WSE19 0.6-0.7 m bgl
Benzo(a)pyrene	3	0.406-4.4 mg/kg	LQM CIEH GAC (Res. with plant uptake)	0.83 mg/kg	2	4.4 mg/kg WSE23 0.7-1.0 m bgl
Indeno(1,2,3-cd)pyrene	3	0.52-3.27 mg/kg	LQM CIEH GAC (Res. with plant uptake)	3.2 mg/kg	1	3.27 mg/kg WSE23 0.7-1.0 m bgl
Trichloroethene	3	0.0719-0.248 mg/kg	LQM CIEH GAC (Res. with plant uptake)	0.011 mg/kg	1	0.248 mg/kg WSE21 0.85-0.95 m bgl

The pH values in E Site Zone 4 varied between 7.51 and 8.88 in the Made Ground (average of 8.22) and between 7.33 and 8.66 within the natural ground (average of 7.81).

Asbestos was not identified in any of the six Made Ground samples screened for asbestos within this zone.

#### ***Metal and Inorganic Contaminants***

- Arsenic, hexavalent chromium, copper, lead, nickel and zinc were all detected above the screening criteria used in samples from WSE19 as detailed in Table 7.7. Other than within samples from WSE19, no metal/metalloid concentrations exceeding the relevant screening criteria were recorded in this zone. The mean copper concentration from the Made Ground samples was 4,093 mg/kg;
- Ammoniacal nitrogen analysis was undertaken on nine Made Ground and three natural samples from this zone, of which one of the Made Ground and none of the natural samples were above the MDL of 15 mg/kg. The highest result (18.6 mg/kg) was recorded in a Made Ground sample from WSE23 (0.70-1.00 m bgl);

- Water soluble sulphate analysis was undertaken on nine Made Ground and three natural samples from this zone, all of which were above the MDL of 0.003 g/l. The highest result was 1.35 g/l in a Made Ground sample from TPE01 (0.50 m bgl).

### ***Organic Contaminants***

- None of the concentrations of the individual TPH fractions exceeded the relevant Entec/LQM GAC for residential with plant uptake land use for the five samples analysed;
- The highest TPH fraction (aromatic hydrocarbons C21-C40) concentration was recorded in a sample of Made Ground from TPE2 at 0.50 m bgl (700 mg/kg). One or more of the heavier range TPH bands (>C16) were detected at concentrations above the MDL in all of the Made Ground and natural samples analysed;
- Three Made Ground samples were submitted for speciated PAH analysis. None of the individual PAH species exceeded the LQM GAC used, with the exception of a two exceedances of benzo(a)pyrene in Made Ground samples from WSE19 (0.60-0.70 m bgl, 1.03 mg/kg) and WSE23 (0.70-1.00 m bgl, 2.96 mg/kg) respectively;
- Three Made Ground samples were submitted for SVOC (including PAH) and VOC analysis. Two samples (WSE19, 0.60-0.70 m bgl and WSE23, 0.70-1.00 m bgl) recorded slight exceedances of the LQM GAC for benzo(a)pyrene (0.83 mg/kg) of 1.11 and 4.4 mg/kg respectively. It should be noted that these are the same samples as the above benzo(a)pyrene exceedances. The mean benzo(a)pyrene concentration from the samples was 2.02 mg/kg against an assessment criteria concentration 0.83 mg/kg. The discrepancy is likely to be attributable to slight differences in the samples between individual sampling containers making up these samples and differences in analytical techniques;
- One sample (WSE23, 0.70-1.00 m bgl) also very slightly exceeded the LQA GAC for indeno(1,2,3-cd)pyrene (3.2 mg/kg) at 3.27 mg/kg. Another sample (WSE21, 0.85-0.95 m bgl) also slightly exceeded the LQM GAC for trichloroethene (0.11 mg/kg) at 0.248 mg/kg. The mean trichloroethene concentration from the samples was 0.166 mg/kg against an assessment criteria concentration 0.11 mg/kg.;
- Benzene, toluene, ethylbenzene and xylenes (BTEX), along with Methyl Tertiary Butyl Ether (MTBE) was not detected in the any of the three Made Ground samples above the respective MDL.

### **Ground Gas and Vapours**

Screening of soil samples prior to dispatch to laboratories did not indicate the presence of volatile organic compounds within the soil matrix.

Gas and vapour monitoring of the three installations present in this zone was carried out on four (WSE22 and WSE23) and five (WSE21) occasions respectively. VOC concentrations were not recorded in all any of these boreholes at concentrations above 0.1 ppm. This concentration of VOCs is not considered to be significant.

Methane was not detected in any of the installations within this zone. Carbon dioxide was detected at concentrations ranging between 0.4% and 3.3% v/v. The highest concentration of

3.3% v/v was recorded in WSE23 on 4 August 2010 with an atmospheric pressure of 997 mb. Oxygen levels were generally indicative of normal atmospheric conditions.

The GSVs generally indicate a 'green' NHBC traffic light classification, meaning ground gas protection measures are not likely to be required.

### **Groundwater Analysis**

As all groundwater monitoring wells installed within this have remained dry during post investigation monitoring, no groundwater samples have been taken. However, it was possible to obtain a surface water sample from a ditch that drains this area of the site on one occasion, as discussed below.

### **Surface Water Analysis**

Surface water was sampled from one location within this zone, SWE10, on one occasion (18 August 2010). This location had been dry during previous monitoring rounds.

The pH values recorded in this zone was 8.31 indicating alkaline groundwater conditions.

### ***Metal and Inorganic Contaminants***

- There were no exceedences of the WQTs used for metals in the sample obtained from this zone; and
- Sulphate was not detected above the EQS WQT of 400 mg/l in the sample obtained from this zone.

### ***Organic Contaminants***

- BTEX and MTBE were not detected above the individual MDL for the sample obtained from this zone;
- Benzo(a)pyrene was also detected at a concentration of 0.011 µg/l in the sample obtained from this zone, which very slightly exceeds the conservative DWS WQT of 0.01 µg/l. All other PAH species were below the WQTs used;
- No VOC/SVOCs were detected above MDL in the sample obtained from this zone.

## **7.3.8 E Site Zone 5: Agricultural Land on North-Western Boundary**

A total of five soil samples (all of natural ground) and four groundwater samples were scheduled for laboratory analysis from this zone. The samples targeted the outcrop of Kellaways Sand (Secondary Aquifer) in this area.

### **Soils Analysis**

The pH values in E Site Zone 5 varied between 5.28 and 8.03 within the natural ground (average of 7.09).

Asbestos was not screened within any samples within this zone, although there was no obvious sign of asbestos in the logs.

### ***Metal and Inorganic Contaminants***

- No metal/ metalloid concentrations exceeding the relevant screening criteria were recorded in this zone;
- Ammoniacal nitrogen analysis was undertaken on all five of the natural samples from this zone, of which two were above the MDL of 15 mg/kg. The highest result (22.2 mg/kg) was recorded in a natural ground sample from WSE26 (2.00-2.30 m bgl); and
- Water soluble sulphate analysis was undertaken all five of the natural samples from this zone, all of which were above the MDL of 0.003 g/l. The highest result was 1.52 g/l in a natural ground sample from WSE26 (2.00-2.30 m bgl).

### ***Organic Contaminants***

- None of the concentrations of the individual TPH fractions exceeded the relevant Entec/LQM GAC for residential with plant uptake land use for the four samples analysed;
- The highest TPH fraction (aromatic hydrocarbons C21-C40) concentration was recorded in a sample of natural ground from WSE24 at 0.30-0.50 m bgl (187 mg/kg). The heaviest range TPH band (>C21-C40) was detected at concentrations above the MDL in all of the four natural samples analysed;
- No samples were scheduled for speciated PAH, SVOC or VOC analysis from this areas as the arisings appeared to have no visual or olfactory evidence of contamination.

### **Ground Gas and Vapours**

Screening of soil samples prior to dispatch to laboratories did not indicate the presence of volatile organic compounds within the soil matrix.

Gas and vapour monitoring of the three installations present in this zone was carried out on four occasions. VOCs were only recorded at concentrations above 0.1 ppm in WSE25. The highest concentration of 20.1 ppm was recorded in WSE25 on 29 July 2010 with an atmospheric pressure of 1007 mb.

Methane was not detected in any of the installations within this zone. Carbon dioxide was detected at concentrations ranging between 0.1% and 1.8% v/v, although only WSE24 recorded carbon dioxide concentrations greater than 1.0% v/v. The highest concentration of 1.8% v/v was recorded in WSE24 on 4 August 2010 with an atmospheric pressure of 996 mb. This concentration of carbon dioxide is not considered to be significant. Oxygen levels were generally indicative of normal atmospheric conditions.

The GSVs generally indicate a 'green' NHBC traffic light classification, meaning ground gas protection measures are not likely to be required.

### **Groundwater Analysis**

Groundwater was sampled from three of the boreholes in this zone. Boreholes WSE24 and WSE25 were sampled on one occasion (13 and 4 August 2010 respectively). Borehole WSE26 was sampled on two occasions (4 and 18 August 2010).

The pH values recorded in this zone ranged between 7.37 and 8.31, with a mean of 7.8, indicating slightly alkaline groundwater conditions.

#### ***Metal and Inorganic Contaminants***

- There were no exceedences of the WQT screening criteria used for metals in the samples obtained from this zone, with the exception of boron, which slightly exceeded the EQS of 2 mg/l in all of the samples from WSE25 and WSE26 at concentrations up to 3.91 mg/l (WSE26, 18 August 2010);
- Ammonical nitrogen was detected at concentrations of up to 2.15 mg/l (WSE25, 4 August 2010) which exceeded the conservative DWS WQT of 0.5 mg/l in all of the samples;
- Sulphate exceeded the EQS WQT of 400 mg/l in all of the samples from this zone. The highest result (2,400 mg/l) was from WSE25 on 4 August 2010.

#### ***Organic Contaminants***

- BTEX and MTBE were not detected above the individual MDL for the two samples obtained from this zone;
- Benzo(a)pyrene was detected at a concentration of up to 0.08 µg/l in both of the samples from WSE26, which exceeds the conservative DWS WQT of 0.01 µg/l. All other PAH species were below the WQTs used;
- Aliphatic TPH bands >C12-C21 and >C21-C35 were detected at concentrations in excess of the conservative naphthalene EQS used in three samples from this zone (both WSE26 samples and WSE24, 13 August 2010). The highest exceedance was in the >C16-C21 band at 0.059 mg/l, compared to a conservative naphthalene EQS of 0.01 mg/l;
- No VOC/SVOCs were detected above MDL in a single sample analysed from WSE26.

#### **Surface Water Analysis**

Surface water was not sampled within this zone, as all identified potential monitoring locations were dry during the monitored period.

### **7.3.9 Radiological Survey Results**

#### **Site D**

The radiological walkover survey of the site was undertaken by Entec between 8 and 15 July 2010. The survey was successfully completed, using RadSurvey equipment with GPS coverage being available throughout.

The recorded data were downloaded on a daily basis and plotted to show the daily coverage, allowing any omissions to be rectified during the survey period and preliminary findings to be reported. Where elevated readings were identified, areas were locally re-surveyed to confirm the findings.

The total area of survey coverage (based on actual recorded data) is shown on Figure 3a with the total surveyed area estimated at 2.65 ha.

At Site D there was one elevated point source, located within the BIFT, with a maximum count reading was 769 cps.

### **Site E**

The radiological walkover survey of the site was undertaken by Entec between 12 and 18 July 2010. Due to the dense woodland present on the E15 Tip Area it was not possible to use RadSurvey equipment, as such the area was surveyed using the Ludlum 2" probe.

The total area of the tip targeted for surveying is estimated at 3.5 ha. The area targeted for survey is shown on figure 5b. Due to the dense and overgrown nature of the E15 Tip Area 100% survey coverage was not possible. Coverage achieved with the E15 Tip Area is estimated to be 50%.

The vast majority of the area, which was successfully surveyed, displayed surface radioactivity readings at natural background activity levels of around 200 cps. Two small areas of elevated radioactivity were identified towards the southern part of the E15 Tip Area. One area had a maximum count rate of 800 cps and was a diffuse source covering approximately 4 m<sup>2</sup>. The measurement is indicative of exempt waste. The other point had a maximum count rate of 340 cps and was a localised point source. The surface readings are indicative of free release material but the locally elevated readings may be indicative of material with higher activity at depth.

### **Data Presentation Site D**

The data recorded at Site D has been graphically represented using GIS software. The grid coordinates are overlaid onto the site base plan and each data point is colour coded according to the recorded probe measurement.

Probe readings ranging from background radioactivity levels to maximum probe reading encountered are colour coded in suitable increments to enable identification of variations in radioactivity. The output is used to assist in identification of any areas surveyed which merit further investigation.

Figure 3a shows the coverage of the non-intrusive radiological walkover survey and Figure 8a shows the results of the radiological walkover survey. Figure 9 shows the distribution of indicative exempt waste and LLW identified during the surveys. Areas of indicative exempt waste were defined by RadSurvey probe readings in the range 771-5,300 cps. Areas of indicative LLW are defined by RadSurvey probe readings above 5,300 cps. Table 7.8 summarises Probe readings in each of the point source locations.

**Table 7.8 Radiological Survey: Probe Readings in Point Source Locations Site D**

Point Source	Maximum Probe Reading (cps)*	Location (Easting, Northing Grid Reference)	Comment	Indicative Ra-226 Activity Concentration (Bq/g)**	Indicative Waste Classification
D1	769	459298, 220954	Small area in grass adjacent to speed limit sign in BIFT compound	0.37	Free Release

Notes:

\* Maximum Recorded Value; cps = counts per second

\*\* Calculated as [observed reading (cps) - background activity (cps)]/1000. Threshold = 0.37 Bq/g for Ra-226 to be classified as radioactive material (under Radioactive Substances Regulations of EPR10 and the remaining provisions of RSA93).

Background = 400 cps

### Data Presentation Site E

Site E was surveyed using the non GPS Ludlum 2" probe as such there is no data to graphically plot on GIS software, only points of elevated readings were recorded. Figure 3b shows the area targeted by the non-intrusive radiological walkover survey and Figure 8b shows approximate locations of the area of elevated counts. Table 7.9 summarises Probe readings in each of the point source locations.

**Table 7.9 Radiological Survey: Probe Readings in Point Source Locations Site E**

Point Source	Maximum Probe Reading (cps)*	Location (Easting, Northing Grid Reference)	Comment	Indicative Ra-226 Activity Concentration (Bq/g)**	Indicative Waste Classification
E1	700	457923, 220488	Diffuse area approximately 4m <sup>2</sup>	0.60	Exempt Waste
E2	340	457921, 220512	Point source, locally elevated readings above surrounding area	0.28	Free Release

Notes:

\* Maximum Recorded Value; cps = counts per second

\*\* Calculated as [observed reading (cps) - background activity (cps)]/500. Threshold = 0.37 Bq/g for Ra-226 to be classified as radioactive material (under Radioactive Substances Regulations of EPR10 and the remaining provisions of RSA93).

Background = 200 cps

### 7.3.10 Radiological Intrusive Investigation

Based on the results of the radiological survey, all three areas identified as exhibiting elevated probe measurements were targeted for hand excavated exploratory holes.

The purpose of the exploratory holes was to assess the source of the elevated readings, the nature of the radioactive contamination present and identify whether it could be attributable to a specific type of source. The findings of the radiological intrusive investigation are summarised in Table 7.10, and radiological exploratory hole logs are presented as Annex F.



**Table 7.10 Intrusive Radiological Summary**

Point Source	Exploratory Hole reference	Maximum Probe Reading (cps) <sup>#</sup>	Source of Elevated Count	Indicative Ra-226 Activity Concentration (Bq/g) <sup>**</sup>	Indicative Waste Classification
D1	HDPDR01	700 (RadSurvey)	Large granite cobbles	Not applicable – source of elevated counts is of natural origin	Free Release
E1	HDPER01	800	Layer of ashy material between 0.2 and 0.45m bgl. Ashy material appears widespread across E15 Tip Area	1.2	Exempt Waste
E2	HDPER02	38,000	Small artefact (damaged luminised dial) at 0.6m bgl. Surrounding material does not exhibit elevated readings	75.6	Low Level Waste

Notes:

# Intrusive investigation count readings are taken using Ludlum 2" detector

\*\* Calculated as [observed reading (cps) – background activity (cps)]/500. Threshold = 0.37 Bq/g for Ra-226 to be classified as radioactive material (under Radioactive Substances Act 1993).

Background = 200 cps

## 7.4 Conceptual Model

The conceptual model developed during the Entec Phase One LQA has been refined to account for the results of this Phase Two Site Investigation. Figure 10 illustrates the revised conceptual model.

### 7.4.1 Summary of Ground Conditions

In summary, general ground conditions comprised of the following:

- Made Ground (where present) and/or topsoil overlying;
- Clay strata, likely to be representative of the Oxford Clay Formation.

On the north western boundary of Site E, natural sand and clay layer was encountered, believed to be representative of the Kellaways Sands and Kellaways Clays.

#### Made Ground

Variable Made Ground is present within almost all of the areas investigated across the site, with the exception of the area investigated along the north-western boundary of Site E.

In the majority of areas, Made Ground consisted of clay with 'inert' materials (such as brick and concrete) and little evidence of significant contamination was noted. No gross contamination was noted in any areas of the site, although evidence of burnt materials and ash layers were noted in the Made Ground within the BIFT area, E15 Tip Area and the building E14/E16 area. Potential ACMs were also noted in a number of locations across the site.

## Groundwater

Shallow groundwater was sampled from ten of the installed wells (boreholes BHD01, WSD03, WSD07, WSD08, WSD09, BHE01, WSE10, WSE17, WSE25 and WSE26) at depths varying between 0.28 and 5.36 m bgl. The boreholes were generally installed into Made Ground or the natural sand or clay strata. None of the trial pits (TPD01-TPD10, TPE01 and TPE02, excavated to depth between 2.00 and 4.30 m bgl) encountered groundwater.

### 7.4.2 Summary of Contaminants

The potential contamination sources investigated as part of this Phase Two LQA were zoned according to current/previous land uses and ground conditions. The following sections focus on contaminants within these zones that exceed relevant Generic Assessment Criteria (GAC) for soils or Water Quality Targets (WQT) only.

#### Site D Zone 1: BIFT

- One sample of natural ground recorded a very slight exceedance (1.2x Entec GAC) for carbon disulphide;
- Exceedances of WQTs within groundwater samples from this zone related to ammoniacal nitrogen (6x Drinking Water Standard [DWS]), sulphate (5.3x Environmental Quality Standard [EQS]), selenium (1.07x DWS), boron (1.04x EQS) and PAHs. PAH species including fluoranthene, phenanthrene, pyrene, benzo(b)fluoranthene and benzo(k)fluoranthene were all detected at concentrations very slightly in excess of the DWS of 0.1 µg/l. Benzo(a)pyrene was also detected at a concentrations of up to 12.5x DWS. No surface water samples were taken from this zone;
- The Gas Screening Values (GSVs) generally indicate a 'green' NHBC 'traffic light' classification, meaning ground gas protection measures as not likely to be required. However, the carbon dioxide concentration of 5.2% in BHD01 give rise to an 'Amber 1' classification, meaning low to moderate gas protection measures may be required.

#### Site D Zone 2: Buildings D2, D6, D9 and Maintenance Yard

- A very slight exceedance of the arsenic (1.02x SGV GAC) was detected in soils together with asbestos (chrysotile) from a Made Ground sample from borehole WSD3;
- Selenium was found to very slightly exceed the WQT (1.13x DWS) in a single groundwater sample. Zinc also exceeded the WQT in one surface water sample (2.5x WQT) Ammonical nitrogen was detected at concentrations exceeding the WQT, at up to 8.1x DWS in groundwater and 32x DWS in surface water in three of the groundwater and two of the surface water samples obtained. Sulphate, at concentrations up to 5.3x EQS, was identified in all of the groundwater samples with some surface water samples also slightly exceeding the EQS. Petroleum hydrocarbons were detected at concentrations in excess of the conservative EQS for naphthalene in one groundwater sample (>C16-C21 band at 11.4x EQS) and for at least one band in all surface water samples from this zone (the highest was for >C21-C28 band at 26.7x EQS);

- The GSVs indicate a 'green' NHBC traffic light classification, meaning ground gas protection measures as not likely to be required.

#### **D Site Zone 3: Area of Made Ground between buildings D6 and D9**

- No soil contamination exceeding appropriate GAC was identified within this zone. No water contamination exceeding WQTs was identified within this zone. No groundwater or gas monitoring was performed in this zone.

#### **E Site Zone 1: Rodney House and OSU**

- No soil contamination exceeding appropriate GAC was identified within this zone.
- Ammonical nitrogen was detected at concentrations exceeding the WQT, at up to 7.4x DWS in groundwater and 1.03x DWS in surface water. Sulphate, at concentrations up to 2.9x EQS, was identified in two of the boreholes monitored for groundwater. In addition, speciated PAHs, including benzo(a)pyrene, were detected at concentrations of up to 1400x the conservative DWS in two of the locations monitored for groundwater and 6x the DWS in the surface water monitoring location within this zone;
- Petroleum hydrocarbons were detected at concentrations in excess of the conservative EQS for naphthalene in all groundwater and surface water samples from this zone. The highest concentration detected in groundwater was in the >C16-C21 band at 57x EQS. Within surface water, the highest concentration detected was in the >C21--C28 band at 5.6x EQS;
- The GSVs generally indicate a 'green' NHBC traffic light classification, meaning ground gas protection measures are not likely to be required.

#### **E Site Zone 2: Car Park by E25 and Building E10**

- No soil contamination exceeding appropriate GAC was identified within this zone;
- Ammonical nitrogen was detected at concentrations exceeding the WQT, at up to 1.7x DWS in surface water;
- Petroleum hydrocarbons were detected at concentrations in excess of the conservative EQS for naphthalene in one surface water sample from this zone. The highest concentration detected was in the >C12-C16 band at 3.5x EQS.

#### **E Site Zone 3: Building E14/E16 fuel tanks and Building E20**

- Asbestos was identified at chrysotile sheeting in one of the five Made Ground samples screened for asbestos within this zone (WSE11, 0.10-0.30 m bgl);
- Arsenic was detected at a concentration of 11x SGV GAC within a single soil sample from this zone. In addition, benzo(a)pyrene was detected at a concentration of 6x GAC in another single soil sample from this zone;
- Petroleum hydrocarbons were detected at concentrations in excess of the conservative EQS for naphthalene in one groundwater sample from this zone. The highest concentration detected was in the >C16-C21 band at 84x EQS;

- The GSVs generally indicate a 'green' NHBC traffic light classification, meaning ground gas protection measures are not likely to be required. However, the carbon dioxide concentration of up to 6.3% in WSE10 give rise to an 'Amber 1' classification, meaning low to moderate gas protection measures are likely to be required.

#### **E Site Zone 4: E15 Tip Area**

- Arsenic, hexavalent chromium, copper, lead, nickel and zinc were all detected as concentrations above the GAC used from a single location within this zone, at concentrations of up to 7x the relevant GAC. In addition, benzo(a)pyrene was detected at concentrations up to 5.3x GAC in two locations within this zone, and ideno(1,2,3-cd)pyrene was detected at 1.02x GAC in a single soil sample from this zone. Trichloroethene was also detected at a concentration of 2.3x GAC in a single soil sample;
- The GSVs generally indicate a 'green' NHBC traffic light classification, meaning ground gas protection measures are not likely to be required.

#### **E Site Zone 5: Agricultural Land on North-Western Boundary**

- No soil contamination exceeding appropriate GAC was identified within this zone;
- Ammonical nitrogen was detected at concentrations exceeding the WQT, at up to 5.5x DWS in groundwater. Sulphate, at concentrations up to 5.6x EQS was identified in all of the boreholes monitored for groundwater. In addition, benzo(a)pyrene, were detected at concentrations of up to 8x the conservative DWS in one of the locations monitored for groundwater, Boron was also detected at concentrations up to 2x EQS in two of the locations monitored for groundwater within this zone;
- The GSVs generally indicate a 'green' NHBC traffic light classification, meaning ground gas protection measures are not likely to be required.

#### **Summary of Radiological Survey**

- A hand-held scintillation detector (Ludlum model 2241-3) was used to survey arisings excavated from the trial pits, window samples and hand dug pit during the intrusive ground works in the E15 Tip Area. Arisings rates in counts per second (cps) in the trial pits and window samples in the E15 Tip Area ranged between 90 cps and 200 cps across the site. These levels are not considered to represent a significant radiological risk or a matter for regulatory concern within the areas surveyed;
- At Site D there was one elevated point source, located within the BIFT, with a maximum count reading was 769 cps;
- At Site E, two small areas of elevated radioactivity were identified towards the southern part of the E15 Tip Area. One area had a maximum count rate of 800 cps and was a diffuse source covering approximately 4 m<sup>2</sup>. The measurement is indicative of exempt waste. The other point had a maximum count rate of 340 cps and was a localised point source. The surface readings are indicative of free

release material but the locally elevated readings may be indicative of material with higher activity at depth;

- Based on the results of the radiological survey, all three areas identified as exhibiting elevated probe measurements were targeted for hand excavated exploratory holes. The purpose of the exploratory holes was to assess the source of the elevated readings, the nature of the radioactive contamination present and identify whether it could be attributable to a specific type of source;
- The results of the hand excavation revealed that the source of the elevated readings in the location within the BIFT was naturally occurring, as large granite cobbles, which are classified as 'free release'. Within the E15 Tip Area, hand pit E1 HDPER01 encountered a layer of ashy material between 0.20 and 0.45 m bgl, which appears widespread across E15 Tip Area, but would likely be classified as 'exempt waste'. Hand pit E2 HDPER02 revealed a small artefact (a damaged luminised dial) at 0.60 m bgl, which is likely to be classified as LLW. It should be noted that the surrounding material does not exhibit elevated readings.

### 7.4.3 Receptors and Pathways

The updated receptors and pathways identified are included in Table 7.11.

**Table 7.11 Updated Receptors and Pathways**

Receptor	Pathway
Current Site Visitors/Users (Commercial/Industrial)	Dermal contact, direct contact, ingestion, inhalation
Construction and Maintenance Workers	Dermal contact, direct contact, ingestion, inhalation
Future Site Users (Commercial/Industrial)	Dermal contact, direct contact, ingestion, inhalation
Future Site Users (Residential)	Dermal contact, direct contact, ingestion, inhalation
Neighbouring Site Users	Dermal contact, direct contact, ingestion, inhalation
Groundwater (Secondary Aquifer and unproductive strata)	Leaching from soils, transport in groundwater, groundwater contamination
Surface Water (site drainage ditches, Langford Brook)	Leaching from soils, transport in groundwater, groundwater contamination, run-off
Ecological Receptors	Uptake, direct contact
Agricultural Receptors	Uptake, direct contact
Buildings and Buried Services (current and future)	Degradation (chemical attack), direct contact, vapour migration

## 7.5 Risk Assessment

The generic quantitative risk assessment and refined conceptual model have identified a number of potential pollutant linkages (contaminant-pathway-receptor) on the site which are tabulated in Annex F. Each linkage is qualitatively assessed by the following criteria:

- i) Potential consequence of pollutant linkage;
- ii) Likelihood of pollutant linkage; and
- iii) Risk classification.

‘Potential Consequence of Pollutant Linkage’ gives an indication of the sensitivity of a given receptor to a particular source or contaminant of concern under consideration. It is a worst case classification and is based on full exposure via the particular linkage being examined.

‘Likelihood of Pollutant Linkage’ is an assessment of the probability of the selected contaminant and receptor being linked by the identified pathway. This assessment is ranked based on site-specific conditions.

The ‘Risk Classification’ column is an overall assessment of the actual risk, which considers the likely effect on a given receptor, taking account of both of the previous rankings. The risk assessment criteria are included as Table 7.12 with the Consequence Matrix presented as Table 7.13.

**Table 7.12 Risk Assessment Criteria**

<b>Classification of Consequence</b>	
Severe	<ul style="list-style-type: none"> <li>- Acute risks to human health</li> <li>- Short term risk of pollution of sensitive water resource (e.g. major spillage into controlled waters)</li> <li>- Impact on controlled waters e.g. large scale pollution or very high levels of contamination</li> <li>- Catastrophic damage to buildings or property (e.g. explosion causing building collapse)</li> <li>- Ecological system effects – irreversible adverse changes to a protected location. Immediate risks</li> </ul>
Medium	<ul style="list-style-type: none"> <li>- Chronic risks to human health.</li> <li>- Pollution of sensitive water resources (e.g. leaching of contaminants into controlled waters).</li> <li>- Ecological system effects – substantial adverse changes to a protected location.</li> <li>- Significant damage to buildings, structures and services (e.g. damage rendering a building unsafe to occupy, such as foundation damage).</li> </ul>
Mild	<ul style="list-style-type: none"> <li>- Non-permanent health effects to human health.</li> <li>- Pollution of non-sensitive water resources (e.g. pollution of non-classified groundwater).</li> <li>- Damage to buildings, structures and services (e.g. damage rendering a building unsafe to occupy, such as foundation damage).</li> <li>- Substantial damage to non-sensitive environments (unprotected ecosystems e.g. crops).</li> </ul>

**Table 7.12 (continued) Risk Assessment Criteria**

<b>Classification of Probability</b>	
Minor/Negligible	<ul style="list-style-type: none"> <li>- Non-permanent health effects to human health (easily prevented by appropriate use of PPE).</li> <li>- Minor pollution to non-sensitive water resources.</li> <li>- Minor damage to non-sensitive environments (unprotected ecosystems e.g. crops).</li> <li>- Easily repairable effects of damage to buildings, structures, services or the environment (e.g. discoloration of concrete, loss of plants in a landscaping scheme).</li> </ul>
High Likelihood	An event is very likely to occur in the short term, and is almost inevitable over the long term OR there is evidence at the receptor of harm or pollution.
Likely	It is probable than an event will occur. It is not inevitable, but possible in the short term and likely over the long term.
Low Likelihood	Circumstances are possible under which an event could occur. It is by no means certain that even over a longer period such an event would take place, and less likely in the short term.
Unlikely	It is improbable that an event would occur even in the very long term.

**Table 7.13 Consequence Matrix**

<b>Consequence</b>	<b>Probability</b>			
	<b>High Likelihood</b>	<b>Likely</b>	<b>Low Likelihood</b>	<b>Unlikely</b>
<b>Severe</b>	Very High Risk	High Risk	Moderate Risk	Moderate/Low Risk
<b>Medium</b>	High Risk	Moderate Risk	Moderate/Low Risk	Low Risk
<b>Mild</b>	Moderate Risk	Moderate/Low Risk	Low Risk	Negligible
<b>Minor/Negligible</b>	Moderate/Low Risk	Low Risk	Negligible	Negligible

The basis of the assessment is detailed in Annex G and the outcome with respect to each receptor is discussed below.

### 7.5.1 Current Site Users (Commercial/ Industrial)

The site is an operational facility which is secure. Access to the site area is restricted to MOD staff and visitors.

Visual and olfactory evidence of hydrocarbon contamination was encountered at a small number of locations across the site, and elevated concentrations of soil and water contaminants were detected across the site when compared to the screening criteria used. In particular, slightly elevated concentrations of PAHs (benzo(a)pyrene) were detected in soil samples from E Site Zones 3 and 4, as well as in water samples from D Site Zone 1 and E Site Zones 1 and 5. Asbestos was identified in samples from D Site Zone 2 and E Site Zone 3. One point source of

elevated radiological activity was detected in the BIFT with a further two point sources in the E15 Tip Area.

The risks to current site users from contamination with all of the zones investigated are generally assessed as **low** to **moderate/low**. **Moderate/low** risks were associated with landfill gas in the E15 Tip Area.

### 7.5.2 Future Site Users (Residential and Commercial/ Industrial)

It is understood that the site may be redeveloped to a combination of residential with gardens, public open space and commercial/ industrial use.

The risks to future residential site users from contamination with all of the zones investigated are generally assessed as **moderate/low**. However, **moderate** risks were identified from hydrocarbons, metals and asbestos within the E15 Tip Area.

The risks to future commercial/industrial site users from contamination with all of the zones investigated are generally assessed as **low** to **moderate/low**. The **moderate/low** risks were assessed related to hydrocarbons, metals, asbestos and landfill gas in the E15 Tip Area.

### 7.5.3 Construction and Maintenance Workers

Increased potential for exposure is created during maintenance or redevelopment activities, as extensive ground disturbance or entry into confined spaces may take place. Risks to site workers may arise as a result of exposure to contaminants through direct contact, ingestion or inhalation exposure pathways.

Overall risks to construction workers from the contamination identified in all of the zones investigated have been assessed as **low** to **moderate/low** based on the potential for exposure, particularly due to a range of contaminants in the E15 Tip Area. It should be noted that in close proximity to underground tanks and flow lines higher concentrations of hydrocarbons may be present than identified in this investigation. However, exposure times are likely to be short and exposure can be controlled by design considerations, environmental management during construction and suitable personal protective equipment. The risk to this receptor will be mitigated through use of appropriate PPE and control measures.

### 7.5.4 Neighbouring Site Users

The site is bounded in the main by agricultural areas and St David's Barracks. Whilst there is some potential for contaminants to be present on site, the localised nature of much of the identified potential contamination and negligible permeability of the underlying strata means that it is less likely to migrate from the site, especially given the distances in most cases.

The risks to neighbouring site users from contamination with all of the zones investigated are generally assessed as **low** to **moderate/low**. **Moderate/low** risks were assessed related to landfill gas in the E15 Tip Area.

### 7.5.5 Groundwater

The anticipated geological sequence consists of undivided Made Ground (in the north-west boundary of E Site) and Landscaped Ground (over the rest of the site) directly overlying solid geology consisting of the Peterborough Member (mudstone) of the Oxford Clay Formation.



Beneath the Oxford Clay Formation, the Kellaways Sand and Kellaways Clay members of the Kellaways Formation both outcrop in the north-west of E Site. Almost the entire site is underlain by negligibly permeable strata, which appears to relate to the Oxford Clay Formation.

Exceedances of the WQT used can be summarised as follows:

- Elevated concentrations of ammoniacal nitrogen and sulphate across the site;
- Slightly elevated concentrations of PAH species, including benzo(a)pyrene, in samples from D Site Zone 1 (BIFT), E Site Zone 1 (OSU and Rodney House) and E Site Zone 5 (agricultural land on north-western boundary of E Site);
- Slightly elevated banded EPH in samples from D Site Zone 2 as well as E Site Zones 1, 3 and 5;
- Slightly elevated boron in a single sample from E Site Zone 5.

It is considered likely that the sulphate is naturally derived (e.g. gypsum crystals were noted within the clays on the borehole logs). Therefore, risks to groundwater from contamination present within the zones investigated have been assessed as **negligible**.

#### 7.5.6 Surface Water

Precipitation from roofs and hardstanding areas drains to a network of surface water drainage ditches that drain the low-lying, poorly draining parts of the site. The closest major surface water feature to the site is the Langford Brook, which enters the site at the extreme northern tip of Site E.

Exceedances of the WQT used can be summarised as follows:

- Elevated concentrations of ammoniacal nitrogen and sulphate across the site;
- Slightly elevated concentrations of PAH species, including benzo(a)pyrene, in samples from E Site Zone 1 (OSU and Rodney House);
- Slightly elevated banded EPH in samples from D Site Zone 2 and E Site Zones 1 and 2.

Risks to surface water from contamination present within the zones investigated have been assessed as **low** to **moderate**. **Moderate/low** risks were assessed related to former vehicle fuelling areas (D18 and E11), the E20 former fire training building, site-wide POL stores and Made Ground in the BIFT and between buildings D6 and D9. Risks associated with the E15 Tip Area were assessed as **moderate**.

#### 7.5.7 Ecological Receptors

There are records of three ESAs within 0.5 km of the site. These three areas are all part of the same ESA, the Upper Thames Tributaries. The closest of these areas is 16 m south-east of the site boundary. A SSSI (Arncott Bridge Meadows) is located 50 m to the north-east of the strip of land connecting D Site and DSDC Bicester C site. The condition of this site is recorded as 'favourable'. In addition, the site falls within a Nitrate Vulnerable Zone (NVZ). However, given the limited potential contamination identified on site and the dilution and attenuation of contaminants given the distance of most of the identified sources to potential receptors, the risk

to ecological receptors and vegetation from the areas investigated is assessed as **negligible** to **low**.

#### **7.5.8 Agricultural Receptors (Arable and Livestock)**

Parts of the site are leased by DE for use as agricultural land, with further agricultural land to the east, south and west. These areas are mainly used for the grazing of livestock at the time of the site visit. However, given the nature and distance of these receptor areas from the potential sources of contamination and the negligible permeability of the underlying strata, risks to agricultural receptors from the areas investigated have been assessed as **negligible**.

#### **7.5.9 Buildings and Buried Services**

Risks to buildings and buried services may occur via direct contact or vapour migration from contaminants in soils. The potential presence of fuel contamination (especially heating oil) at the site from the areas investigated generally gives rise to **low** to **negligible** risks.



## 8. Overall Land Quality and Suitability for Continued Use

### 8.1 Site Sensitivity

The anticipated geological sequence consists of undivided Made Ground (in the north-west boundary of E Site) and Landscaped Ground (over the rest of the site) directly overlying solid geology consisting of the Peterborough Member (mudstone) of the Oxford Clay Formation. Beneath the Oxford Clay Formation, the Kellaways Sand and Kellaways Clay members of the Kellaways Formation both outcrop in the north-west of E Site. Almost the entire site is underlain by a Non-Aquifer (Negligibly Permeable), which appears to relate to the Oxford Clay Formation. Groundwater sensitivity has been assessed as **low**.

Precipitation from roofs and hardstanding areas drains to a network of surface water drainage ditches that drain the low-lying, poorly draining parts of the site. The closest surface water feature to the site is the Langford Brook, which enters the site at the extreme northern tip of Site E. The Langford Brook discharges into the River Ray approximately 3 km south-west of the site. There are records of one surface water abstraction license within 1 km of the site and thirty-three Licensed Discharge Consents within 500 m of the site, nineteen of which relate to permits that are now revoked. During a conversation with a representative of Kelda Water Services during preparation of the Phase One LQA, it was indicated that no discharge consents related to the site are still extant. Surface water sensitivity has been assessed as **moderate/high**.

There are records of three ESAs within 0.5 km of the site, which collectively form part of the Upper Thames Tributaries ESA. The closest of these areas is 16 m south-east of the site boundary. A SSSI, Arncott Bridge Meadows, is located 50 m to the north-east of the strip of land connecting D Site and DSDC Bicester C site. The condition of this site is recorded as 'favourable'. In addition, the site falls within a Nitrate Vulnerable Zone (NVZ). Ecological sensitivity has been assessed as **moderate**.

### 8.2 Overall Land Quality

DSDC Bicester Site D and Site E is a storage and distribution hub for a variety of military equipment, including clothes, rations, tents, packaging materials as well as general stores. The findings of the Entec Phase One LQA were used to inform the scope of this Phase Two LQA. Based on this information, a number of areas of potentially significant contamination risk were prioritised for further investigation. Assessment of the site was based on the potential residential with gardens future use of the site, which is likely to be the most sensitive receptor.

- Laboratory analysis of soil samples indicated the presence of organic and inorganic contaminants, particularly hydrocarbons including PAHs as well as metals/metalloids including boron, selenium, arsenic, and within the E15 Tip Area, hexavalent chromium, copper, lead, nickel and zinc. This is indicative of there having been some impact by site activities. This largely corresponded with visual

and olfactory evidence of contamination noted at a number of locations across the site;

- Asbestos was also identified, generally as chrysotile (white asbestos) in the form of cement board in samples from D Site Zone 2 and E Site Zone 3;
- Laboratory analysis of groundwater and surface water samples from across the site generally indicated widespread, but typically moderate, exceedances for ammoniacal nitrogen and sulphate, as well as generally limited exceedances for hydrocarbons including speciated PAHs, as well as metals and metalloids, including boron and selenium;
- The vast majority of the areas investigated displayed surface radioactivity readings at natural background activity levels of 90-200 cps. Three small areas of elevated radiological readings were identified, one within the BIFT and two within the E15 Tip Area. Based on the results of the radiological survey, all three areas identified as exhibiting elevated probe measurements were targeted for hand excavated exploratory holes. The results of the hand excavation revealed that the source of the elevated readings in the location within the BIFT was naturally occurring, as large granite cobbles. Within the E15 Tip Area, one hand pit encountered a layer of ashy material whilst the other revealed a small artefact (a damaged luminised dial). Only the luminised dial is likely to be classified as LLW;
- Soil gas, comprising volatile organic compounds, methane and carbon dioxide were generally recorded at low concentrations. The GSVs generally indicate a 'green' NHBC traffic light classification, meaning ground gas protection measures are not likely to be required. However, the carbon dioxide concentration of within D Site Zone 1 and E Site Zone 3 give rise to an 'Amber 1' classification, meaning low to moderate gas protection measures are likely to be required.

### 8.3 Environmental Risks

The risks to current site users from contamination with all of the zones investigated are generally assessed as **low** to **moderate/low**. **Moderate/low** risks were associated with landfill gas in the E15 Tip Area.

The risks to future residential site users from contamination with all of the zones investigated are generally assessed as **moderate/low**. However, **moderate** risks were identified from hydrocarbons, metals and asbestos within the E15 Tip Area.

The risks to future commercial/industrial site users from contamination with all of the zones investigated are generally assessed as **low** to **moderate/low**. The **moderate/low** risks were assessed related to hydrocarbons, metals, asbestos and landfill gas in the E15 Tip Area.

Overall risks to construction workers from the contamination identified in all of the zones investigated have been assessed as **low** to **moderate/low** based on the potential for exposure, particularly due to a range of contaminants in the E15 Tip Area. It should be noted that in close proximity to underground tanks and flow lines higher concentrations of hydrocarbons may be present than identified in this investigation. However, exposure times are likely to be short and exposure can be controlled by design considerations, environmental management during

construction and suitable personal protective equipment. The risk to this receptor will be mitigated through use of appropriate PPE and control measures.

The risks to neighbouring site users from contamination with all of the zones investigated are generally assessed as **low** to **moderate/low**. **Moderate/low** risks were assessed related to landfill gas in the E15 Tip Area.

It is considered likely that the sulphate is naturally derived (e.g. gypsum crystals were noted within the clays on the borehole logs). Therefore, risks to groundwater from contamination present within the zones investigated have been assessed as **negligible**.

With the possible exception of ammoniacal nitrogen and sulphate, there appears to be no consistent linkage between soil contamination and the minor groundwater exceedances. Therefore, risks to surface water from contamination present within the zones investigated have been assessed as **low** to **moderate**. **Moderate/low** risks were assessed related to former vehicle fuelling areas (D18 and E11), the E20 former fire training building, site-wide POL stores and Made Ground in the BIFT and between buildings D6 and D9. Risks associated with the E15 Tip Area were assessed as **moderate**.

The risk to ecological receptors and vegetation is assessed as **negligible** to **low**. The risks to agricultural receptors have also been assessed as **negligible**.

The potential presence of fuel contamination (especially heating oil) at the site from the areas investigated generally gives rise to **low** to **negligible** risks to buildings and buried services.

## 8.4 Suitability of the Site for Continued Use

Based on findings of this risk-based Phase Two LQA, which targeted areas of potential contamination identified from the Entec Phase One LQA, the majority of the site (Site D and Site E) is considered suitable for current use with only a few localised occurrences of contamination identified.

However, localised elevated concentrations of metals and hydrocarbons were detected, particularly in the E Site Zones 3 (Building E14/E16 fuel tanks and building E20 Fire Training Area) and 4 (E15 Tip Area). Asbestos, as chrysotile, has been detected in D Site Zone 2 and E Site Zone 3, and elevated radiological readings were recorded in the D Site Zone 1 (BIFT) and the E15 Tip Area. The laboratory results generally correlate with visual and olfactory evidence of contamination encountered during the investigation. For much of the site, the contamination identified is unlikely to affect continued use of the site.

Although little ACM was identified within the Phase Two investigation, some of the existing buildings contain suspected ACMs as part of external building fabric which could degrade and fall onto the adjacent ground. Continued suitability for use is dependent on the management of ACM and the effectiveness of the actions will impact this status.

## 8.5 Suitability of the Site for Future Development

The future use of Site E is likely to be a combination of residential (which will include garden areas), public open space and commercial/industrial use. The future use of D Site is likely to be similar to that of E Site.

Based on the results of the investigation, the site (Site D and Site E) is considered to be suitable for redevelopment for a residential (with gardens) end use and further commercial/ industrial use which may include further development.

However, due to the limited nature and extent of the intrusive investigation and the potential for residual contamination to be present in and around existing (and in most cases still operational) infrastructure, it is possible that additional investigation will be required as part of the development process. Such investigation will be dependant upon the development design. Ground gas/ vapours may also need to be considered if new residential or commercial/ industrial developments are built on areas of localised hydrocarbon contamination but will again be dependant upon the development design.

Development may involve the removal of the subsurface fuel storage tanks and pipework and remediation will be required following the removal of these tanks if the soils and waters are found to have been impacted by any contamination. Development may also require the removal or alteration of building/ tank foundations, building fabric, underground pipework and underground voids, which will have a cost implication. It is considered likely that construction / redevelopment workers will come into direct contact with areas of potential contamination and all workers should be made aware of potential risks that exist at the site and take suitable measures to avoid or mitigate potential risk. Appropriate personal protective equipment (PPE) should be used and good working practices adhered to during any future redevelopment work at the site.

Development of the land is also likely to involve the removal of buildings present on site, some of which potentially contain asbestos within the building fabric. Disposal of all asbestos containing material would need to be carried out by a specialist contractor.

---

# List of Annexes

---

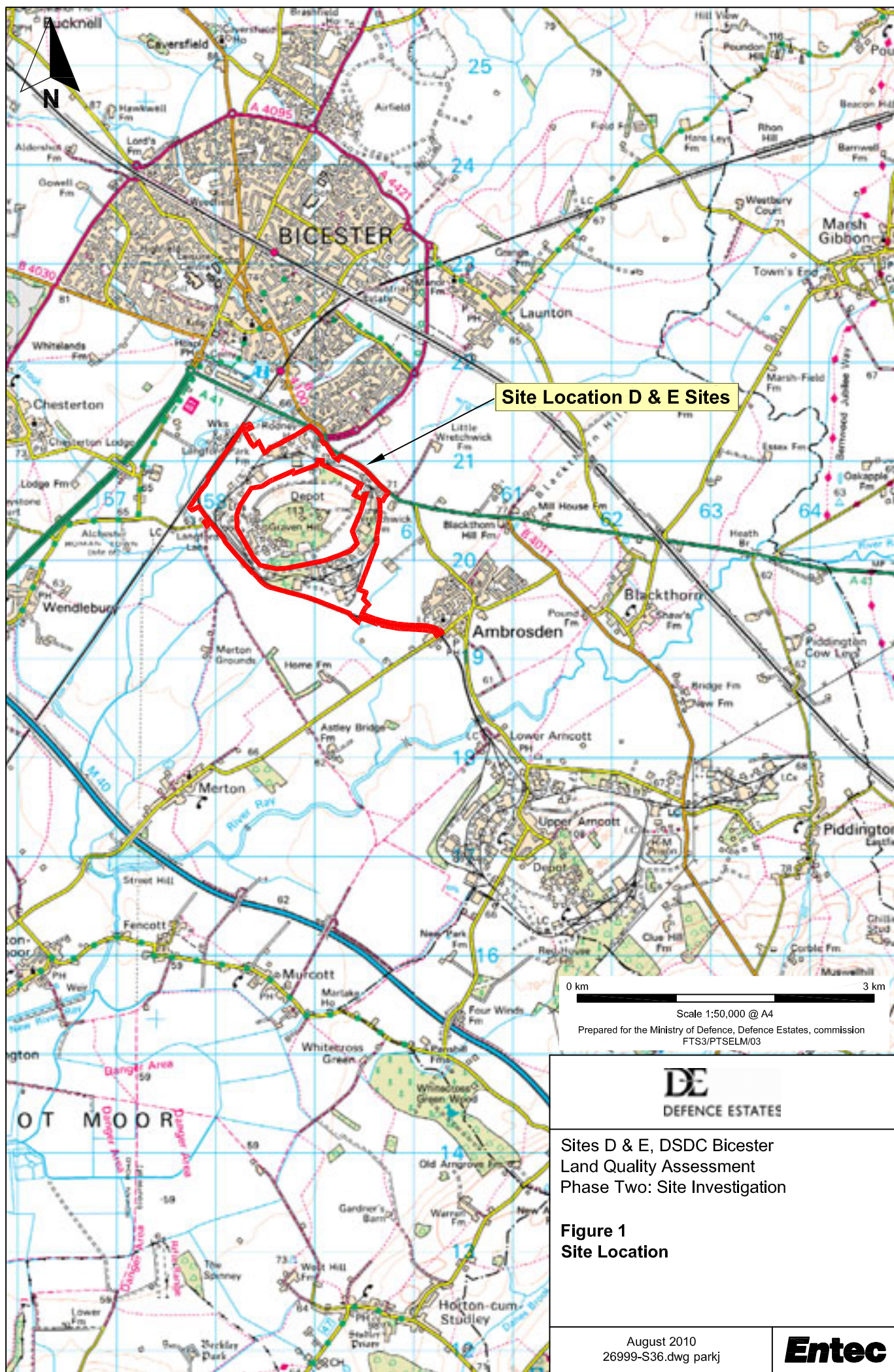
Annex A	Intrusive Hole Logs
Annex B	Gas Monitoring Tables
Annex C	Water Monitoring Data
Annex D	Screened Laboratory Data
Annex E	Laboratory Analysis Certificates
Annex F	Radiological Trial Pit Logs
Annex G	Environmental Risk Assessment Tables



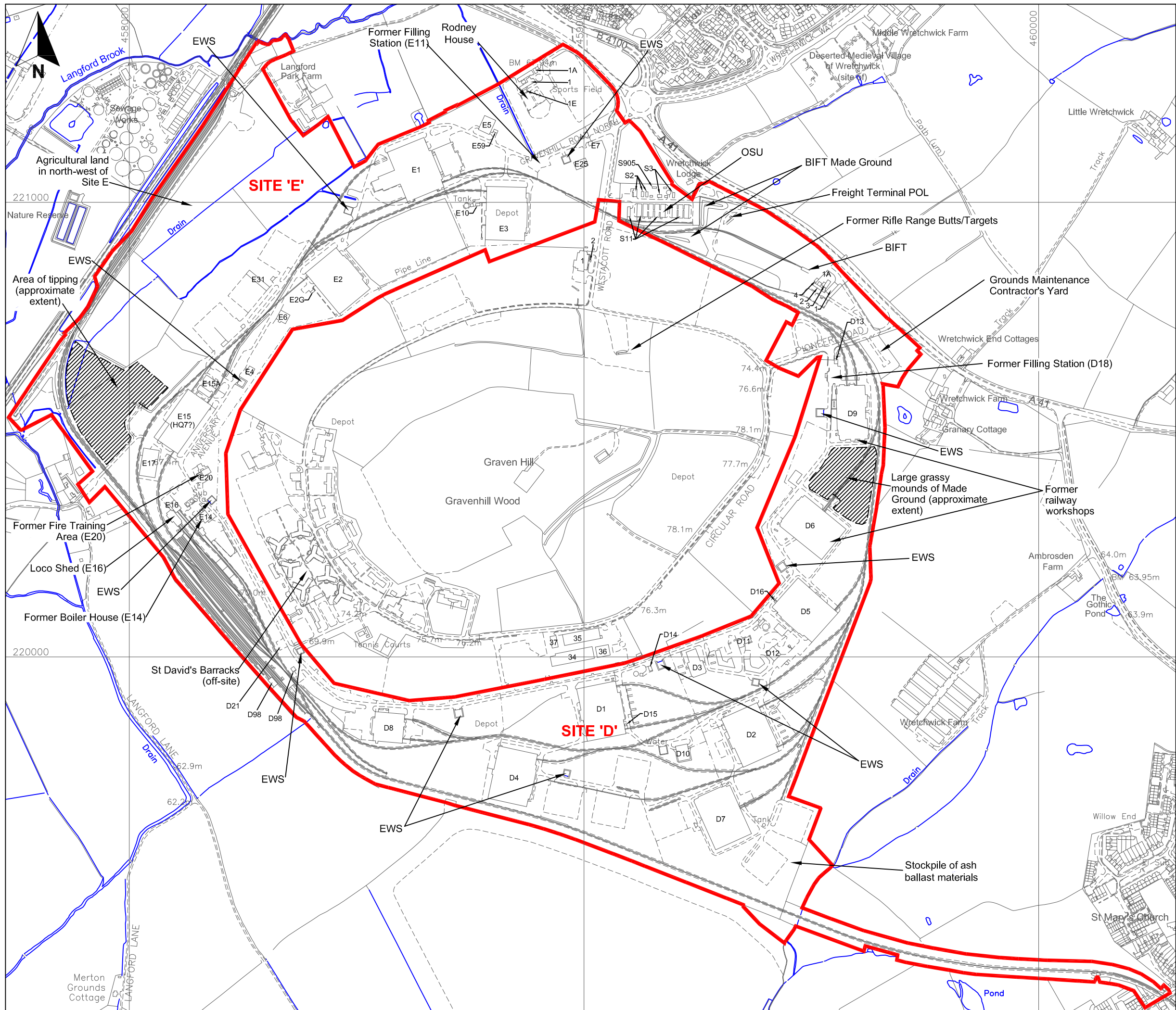
---

## Figures

---







**Key**

- Site boundary
- D14 Building numbers
- EWS Emergency water supply
- OSU Operational Service Unit
- BIFT Bicester International Freight Terminal

0 m 400 m

Scale 1:8000 @ A3

Prepared for the Ministry of Defence, Defence Estates, commission FTS3/PTSELM/03

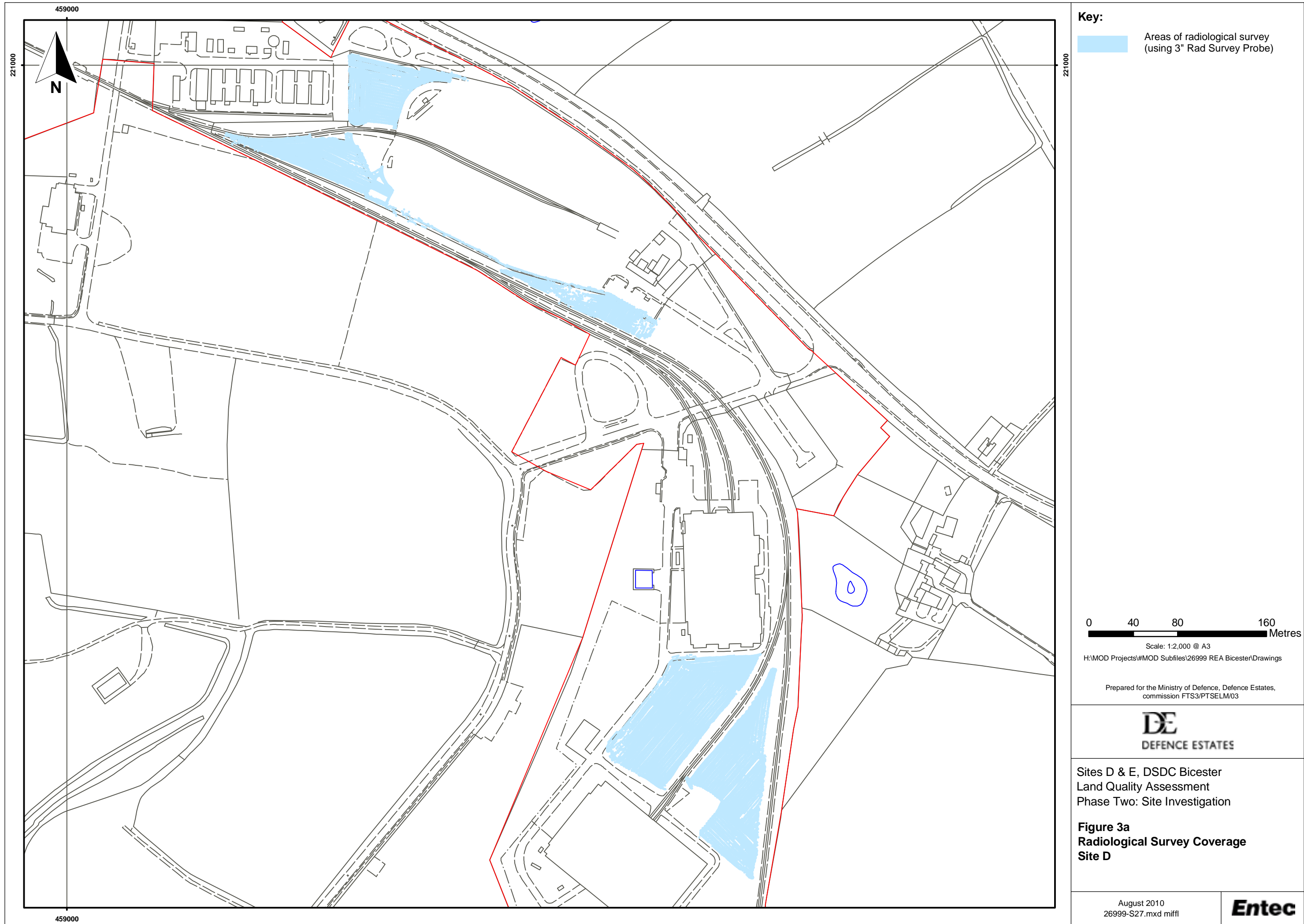
**DE**  
DEFENCE ESTATES

Sites D & E, DSDC Bicester  
Land Quality Assessment  
Phase Two: Site Investigation

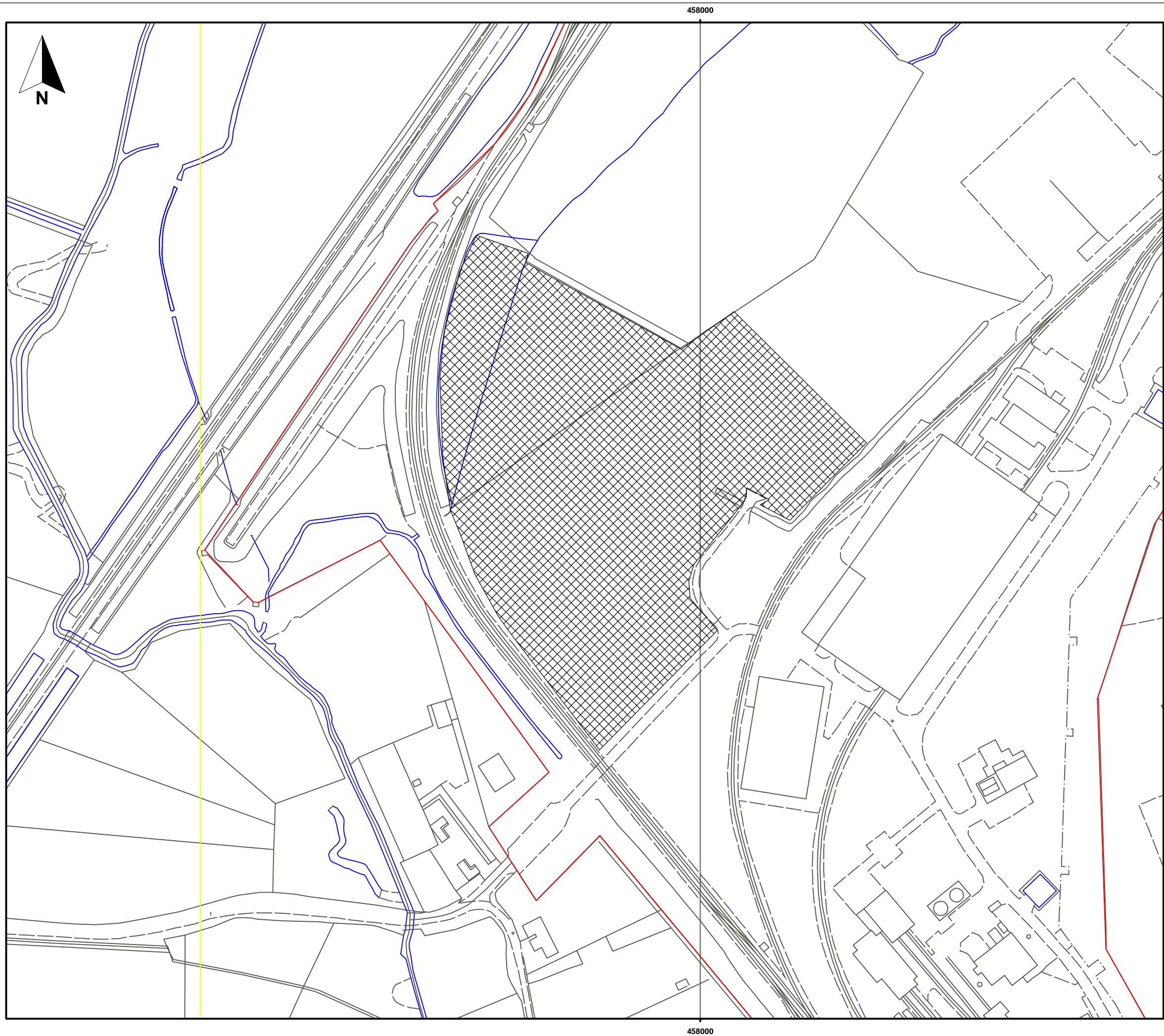
**Figure 2**  
**Site Layout**

September 2010  
26999-S37a.dwg parkj

**Entec**







**Key:**



Area of handheld radiological  
survey (using 2" Ludlum Probe)

0 25 50 100  
Metres

Scale: 1:2,000 @ A3

H:\MOD Projects\#MOD Subfiles\26999 REA Bicester\RadSurvey

Prepared for the Ministry of Defence, Defence Estates,  
commission FTS3/PTSELM/03



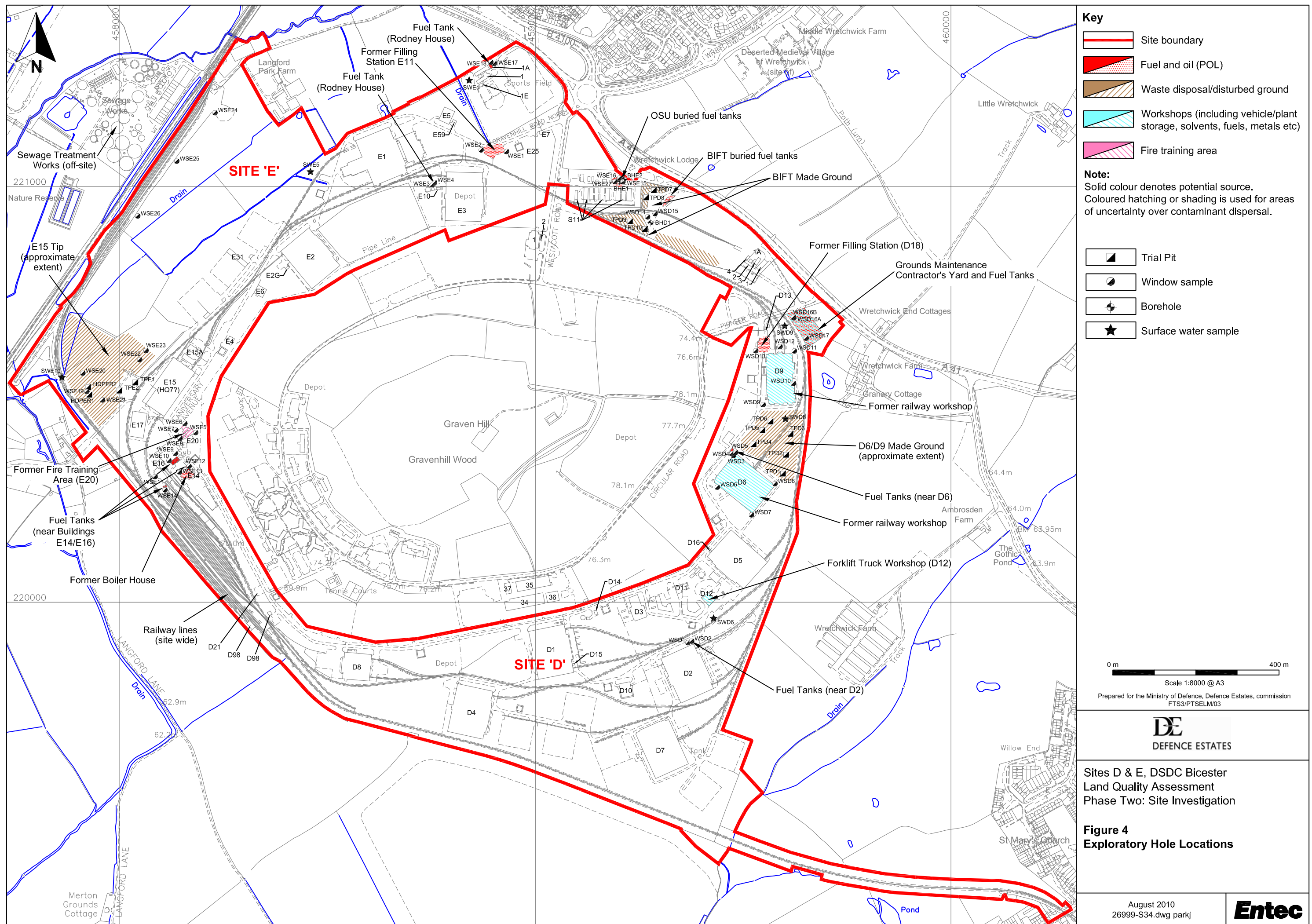
Sites D & E, DSDC Bicester  
Land Quality Assessment  
Phase Two: Site Investigation

**Figure 3b**  
**Radiological Survey Coverage**  
**Site E**

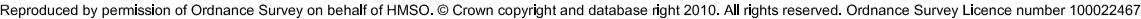
August 2010  
26999-S30.mxd miffi

**Entec**

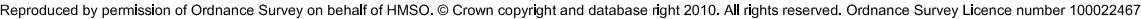




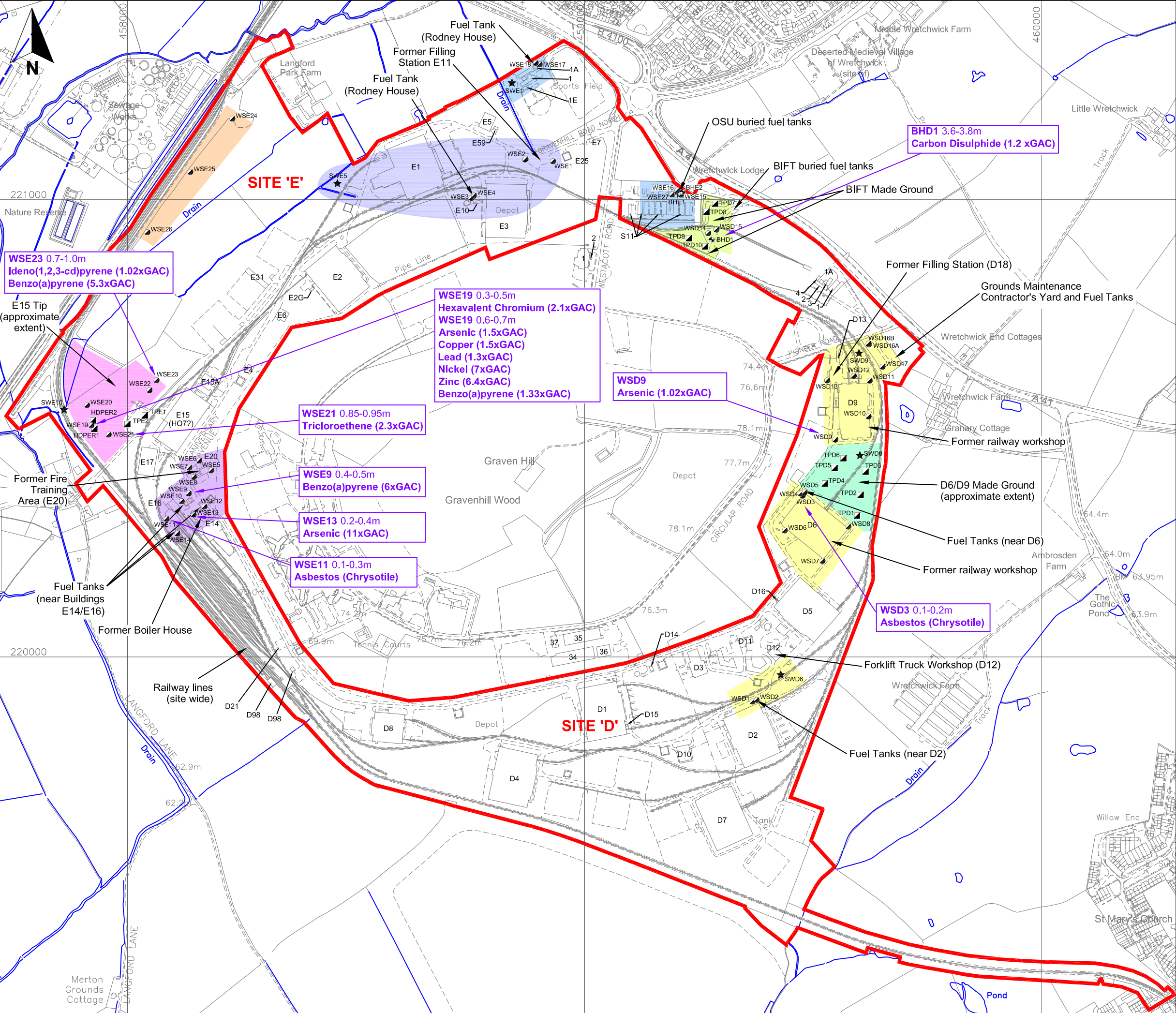












**Key**

- Trial Pit
- Window sample
- Borehole
- Surface water sample

**Site D**

- Zone 1
- Zone 2
- Zone 3

**Site E**

- Zone 1
- Zone 2
- Zone 3
- Zone 4
- Zone 5

Exceedance of human health GAC for residential with gardens use

0 m 400 m

Scale 1:8000 @ A3

Prepared for the Ministry of Defence, Defence Estates, commission FTS3/PTSELM/03

**DEFENCE ESTATES**

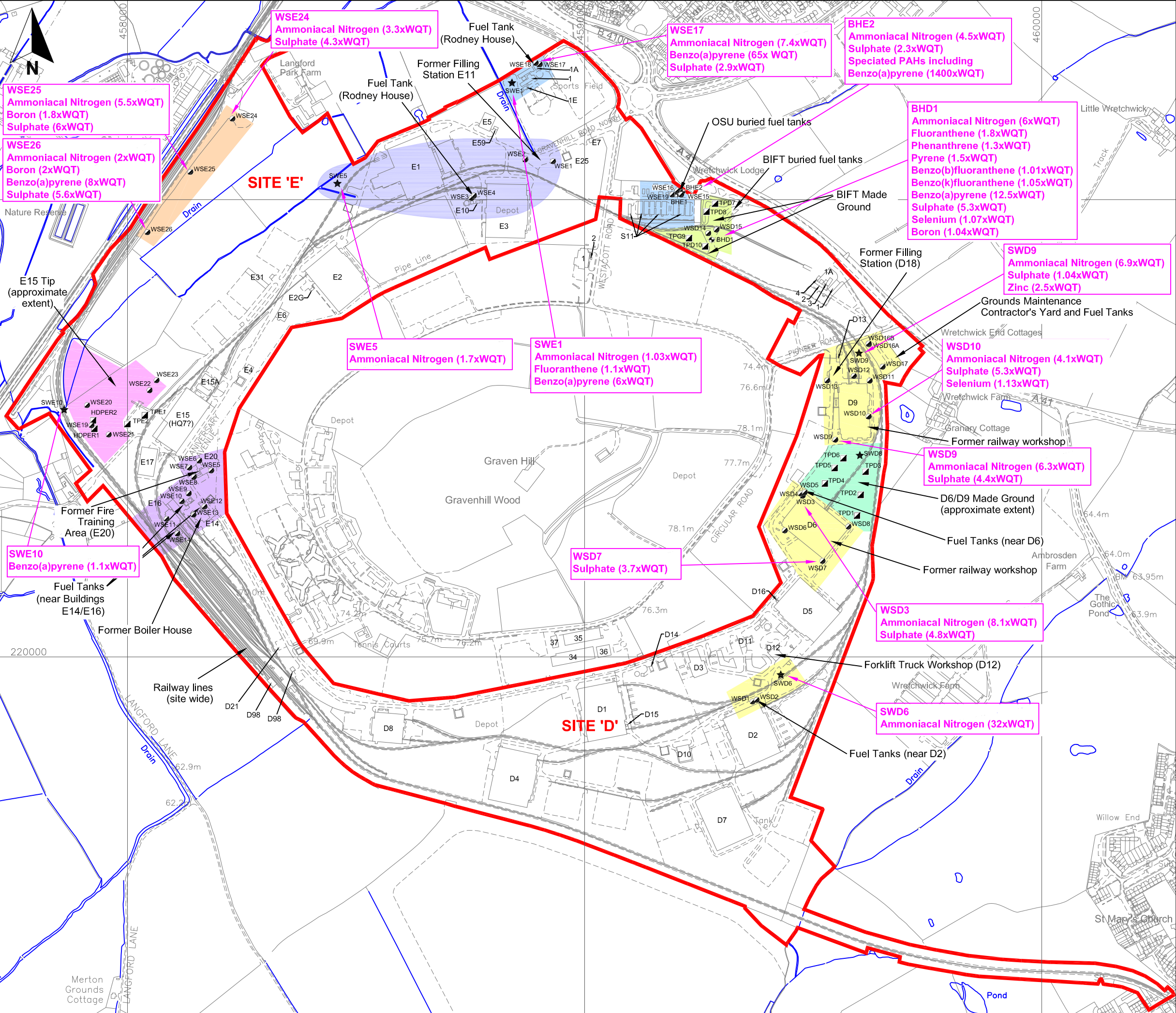
Sites D & E, DSDC Bicester  
Land Quality Assessment  
Phase Two: Site Investigation

**Figure 7a**  
**Soil Exceedances of Generic Assessment Criteria (GAC)**

September 2010  
26999-S38a.dwg parkj

**Entec**





**Key**

Trial Pit

Window sample

Borehole

Surface water sample

**Site D**

Zone 1

Zone 2

Zone 3

**Site E**

Zone 1

Zone 2

Zone 3

Zone 4

Zone 5

Exceedance of WQT

**Note:**  
Elevated sulphate concentration may be attributable to natural sources such as gypsum.

0 m

400 m

Scale 1:8000 @ A3

Prepared for the Ministry of Defence, Defence Estates, commission  
FTS3/PTSELM/03

DEFENCE ESTATES

Sites D & E, DSDC Bicester

Land Quality Assessment

Phase Two: Site Investigation

Figure 7b

Ground and Surface Water

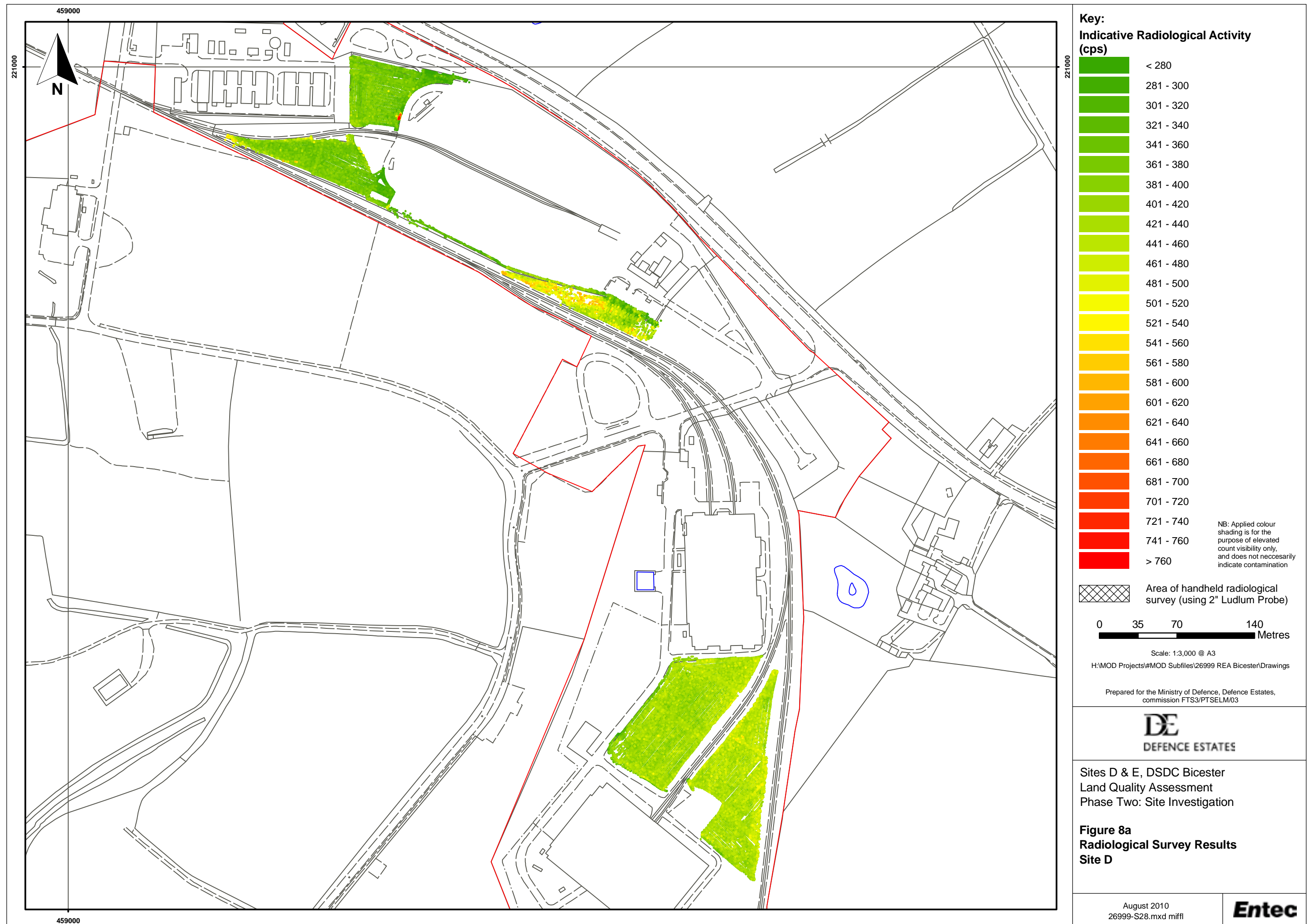
Exceedances of Water Quality

Targets (WQT)

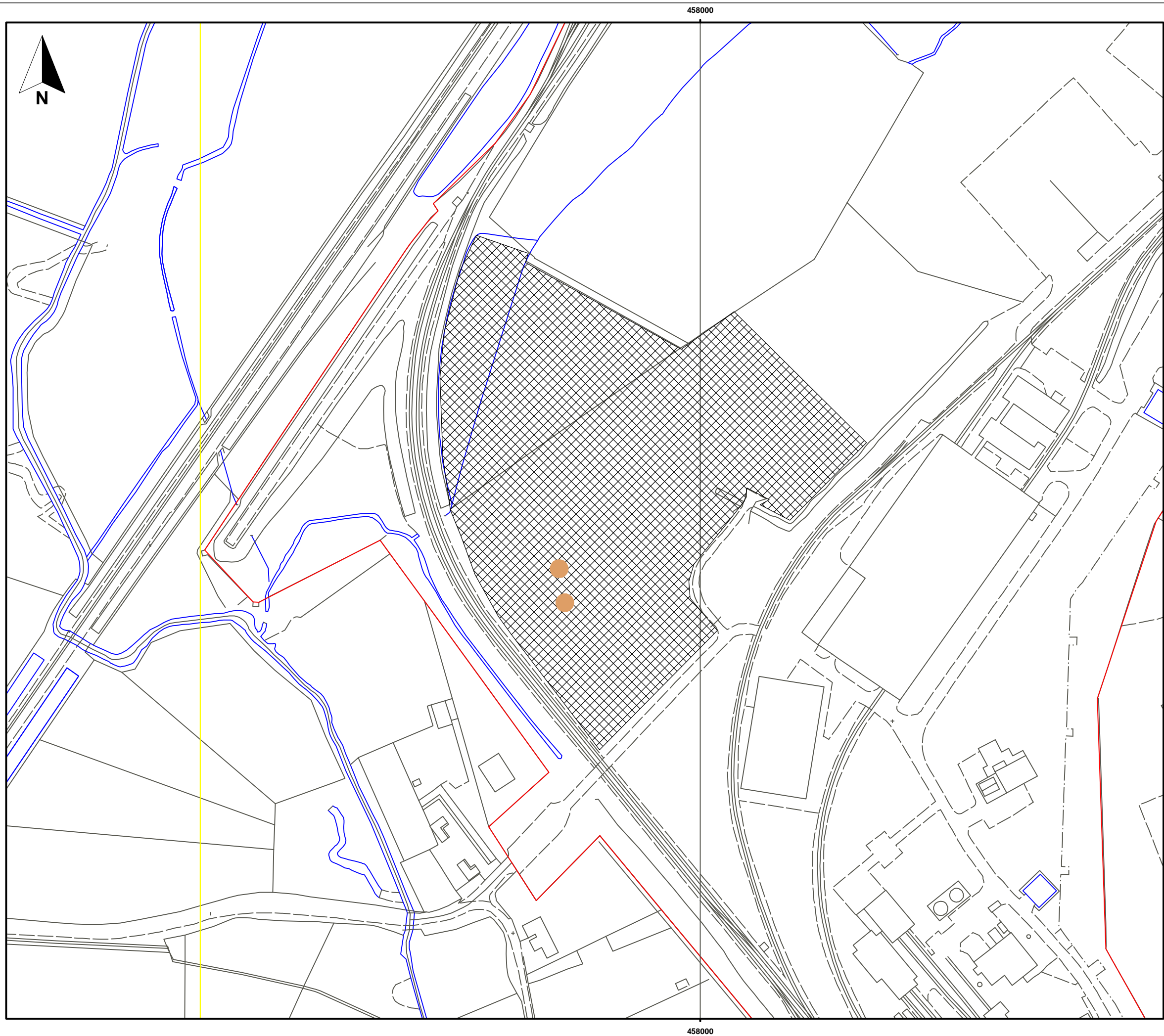
September 2010

26999-S39a.dwg parkj


Entec








**Key:**

 Area of handheld radiological survey (using 2" Ludlum Probe)

 Areas of elevated activity



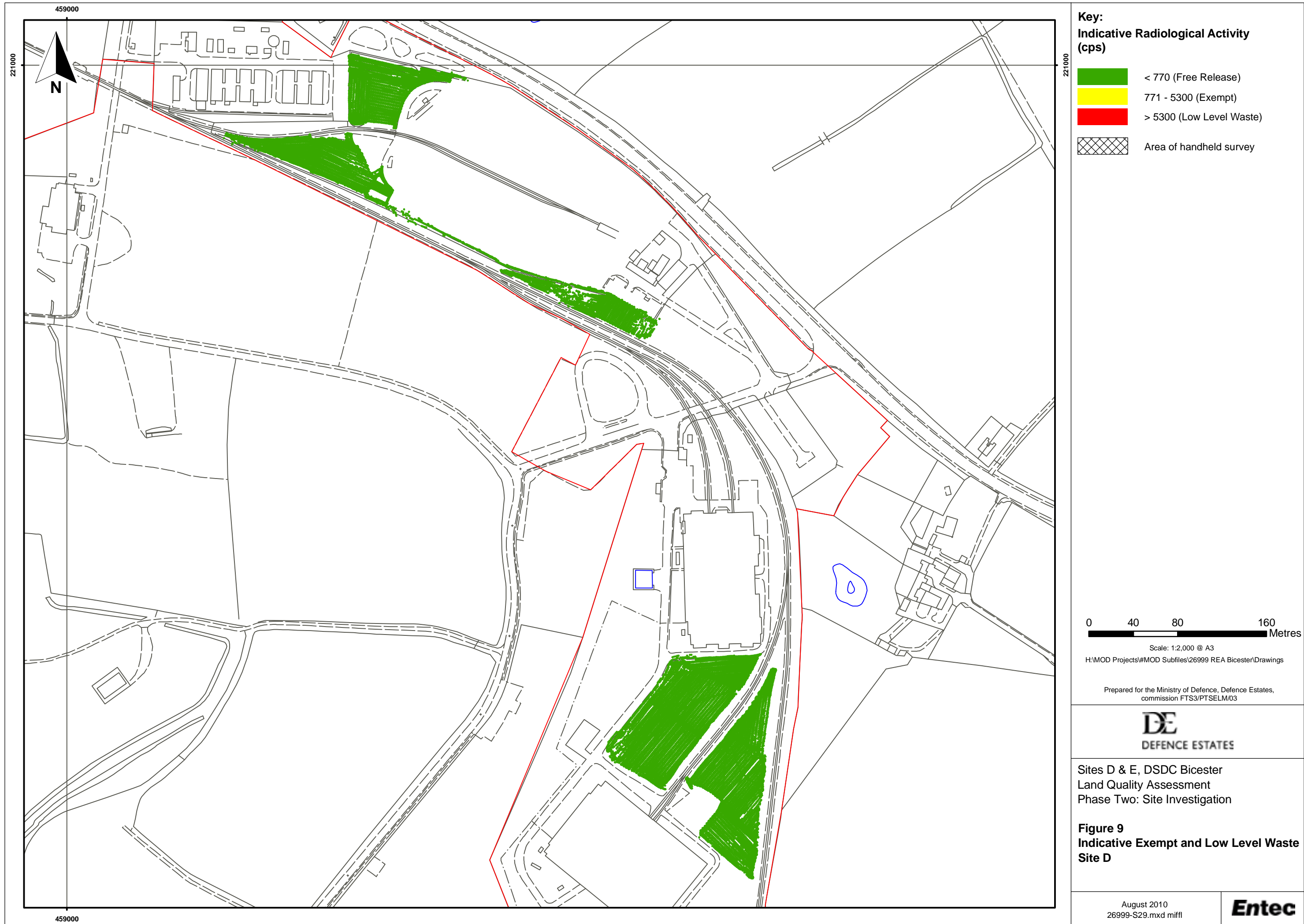
Scale: 1:2,000 @ A3  
H:\MOD Projects\#MOD Subfiles\26999 REA Bicester\RadSurvey

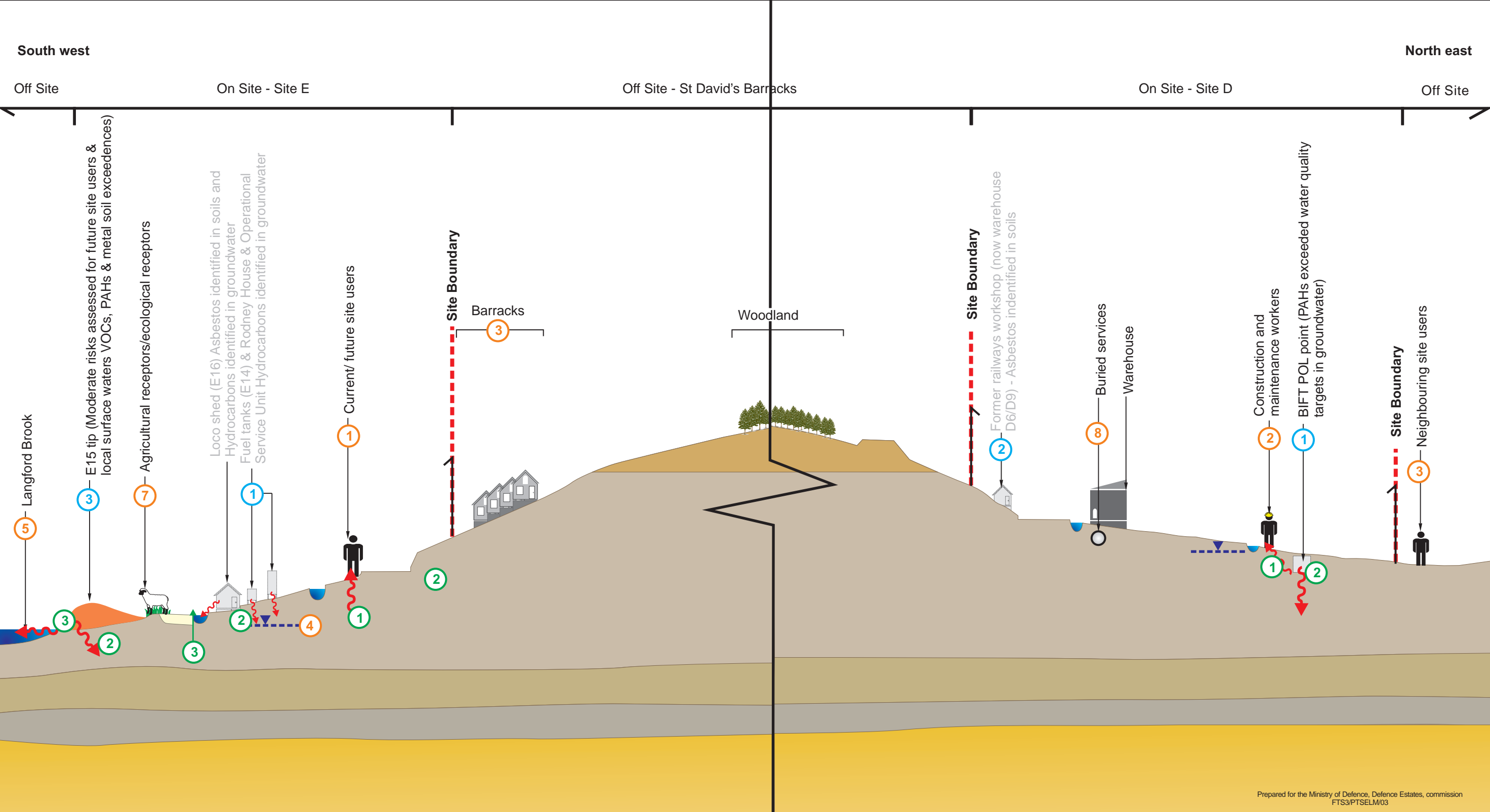
Prepared for the Ministry of Defence, Defence Estates,  
commission FTS3/PTSELM/03



Sites D & E, DSDC Bicester  
Land Quality Assessment  
Phase Two: Site Investigation

**Figure 8b**  
**Location of Areas of Elevated Activity**  
**Site E**





Prepared for the Ministry of Defence, Defence Estates, commission  
FTS3/PTSELM/03

Key	
	Alluvial Deposits (Secondary Aquifer)
	Made Ground
	Stewartby Member
	Peterborough Member (Oxford Clay Formation)
	Kellaways Sand (Interbedded Sandstone and Siltstone)
	Kellaways Clay (Mudstone)

	Cornbrash (Limestone)
	Potential pathway
	Perched groundwater
	Drain
	Tipping
	Fuel/oil storage
	Workshops

Potential Sources	
	Former/current fuel storage areas
	Former railway workshops and fire training building
	Former waste tip/Made ground

Receptors	
	Current/ future site users/visitors
	Construction and maintenance workers
	Neighbouring site users
	Groundwater (perched)
	Surface water
	Ecological receptors
	Agricultural receptors
	Buildings and buried services

Pathways	
	Dermal contact, direct contact, ingestion, inhalation
	Leaching, transport, groundwater contamination
	Leaching, transport, groundwater contamination, runoff
	Uptake, direct contact
	Degradation, direct, vapour migration, explosion



Sites D & E, DSDC Bicester  
Land Quality Assessment  
Phase Two: Site Investigation

Figure 10  
Conceptual Model

September 2010  
26999-S40a.cdr bernb



---






# **Annex A**

## **Intrusive Hole Logs**






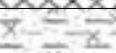
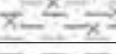
















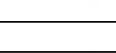
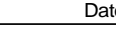
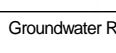

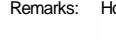

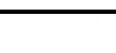
61 Pages

---


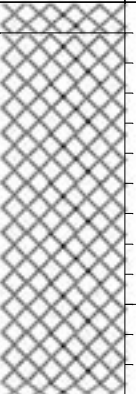

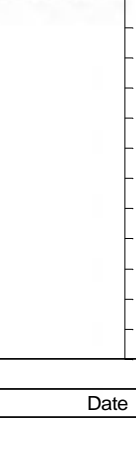



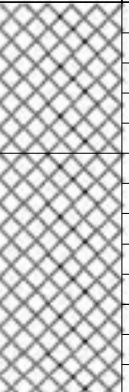
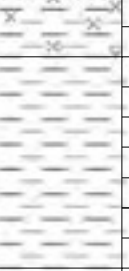
 <div> May Gurney Limited  Geotechnical - Site Investigation  Ayton Road, Wymondham, NR18 0RH  Tel: 01953 609856  Fax: 01953 609819  Web: www.maygurney.co.uk </div>		Borehole Record				BHD01		Sheet 1 of 1			
Project ID: SI1622		Client : Entec UK Limited				Ground Level: 71.531mAOD					
		Engineer : James Ridehalgh				Coordinates: 459277.64E 220912.29N					
Description	Legend	Depth (m)	O.D. Level (m)	Sample Test		SPT/CPT		Remarks and Test Results SPT/HV/PP (Recovery) PID (ppm)	Installations		
				Type	Depth (m)	Casing Depth (m)	Water Depth (m)				
MADE GROUND: CONCRETE.		0.15	71.38	CS01	0.70-0.90			0.00			
MADE GROUND (TYPE 1): Dolomite fill.		0.30	71.23								
MADE GROUND: TARMAC.		0.45	71.08								
MADE GROUND: CONCRETE.		0.60	70.93								
MADE GROUND (Reworked Natural): Blue grey slightly gravelly clay. Gravel is subangular to subrounded medium consisting of sandstone and burnt limestone. Slight organic odour.		1.60	69.93	CS02	1.60-2.00			0.00			
Firm brown laminated CLAY with highly weathered chalk.		2.00	69.53								
Firm brown laminated CLAY.		3.60	67.93	CS03	3.60-3.80			0.00			
Soft brown CLAY with sand bands. Slight organic odour.		4.60	66.93								
Firm to stiff blue-grey CLAY with shell fragments.		5.00	66.53								
Borehole Complete at 5.00 m											
		Water Level Observations									
Hole Diameter Detail			Chiseling Details			Date	Water Strike (m)	Standing Time (mins)	Standing Level (m)	Casing Depth (m)	Depth Sealed (m)
Diameter (mm)	Depth (m)	Casing Depth (m)	From (m)	To (m)	Time (hours)						
150	5.00	4.70				13/07/10	3.80	20	3.00	-	
Client: Entec UK Limited Engineer: James Ridehalgh Contractor: May Gurney Geotechnical Dates: 13/07/2010 Plant: Dando Drilled By: T. York Logged By: JSR Checked By: P. Lewin						Remarks: 1. Starter pit dug from GL to 1.20mbgl. 2. Installation details: 50mm HDPE Standpipe installed from GL to 4.60mbgl. Plain pipe installed from GL to 2.00mbgl and a slotted pipe from 2.00m to 4.60mbgl. Hole backfilled with concrete from GL to 0.40mbgl, bentonite from 0.40m to 2.00mbgl, gravel from 2.00m to 4.60mbgl and bentonite from 4.60m to 5.00mbgl. Hole finished with a flush cover and gas tap.					


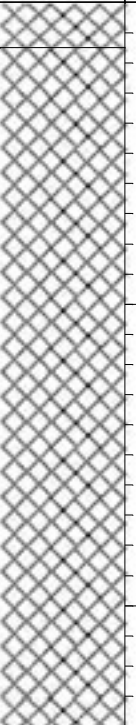



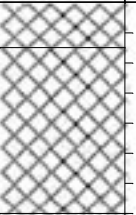
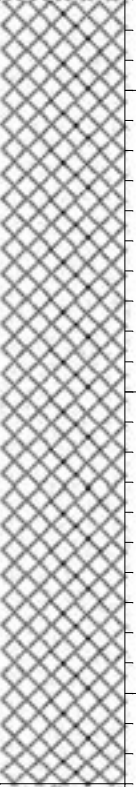

 <div> May Gurney Limited  Geotechnical - Site Investigation  Ayton Road, Wymondham  NR18 0RH  Tel: 01953 609856 Fax: 01953 609819  Web: www.maygurney.co.uk </div>	<h2 style="text-align: center;">Trial Pit Record</h2>				<h2 style="text-align: center;">TPD01</h2> <p style="text-align: center;">Sheet 1 of 1</p>						
Project ID: SI1622		Client: Entec UK Limited  Engineer: John Tomalin				Ground Level: 72.345mAOD Coordinates: 459595.95E 220309.09N					
Orientation of Trial Pit:		Length: -		Width: -		Depth: 2.80		Sample / Test		Remarks and Test Results	
<b>Description</b>		<b>Legend</b>	<b>Depth (m)</b>	<b>O.D. Level</b>	<b>Water</b>	<b>Type</b>	<b>Depth (m)</b>	<b>Test Results</b> <small>PID (ppm)</small>			
MADE GROUND: Brown-grey slightly sandy silt.			0.15	72.20							
MADE GROUND: Very stiff yellow-brown dessicated slightly gravelly clay. Gravel is angular fine to coarse limestone. Occasional fine roots upto 0.60mbgl.			0.70	71.65		ES1	0.50	0.00			
MADE GROUND: Stiff brown-grey slightly gravelly clay.			1.00	71.35							
MADE GROUND: Stiff mottled grey and yellow-grey slightly gravelly clay. Gravel is angular fine to coarse limestone.			1.10	71.25							
Grey-brown slightly sandy silty CLAY, with occasional fine roots. Slight organic odour. (possibly old topsoil).			1.40	70.95		ES2	1.30	0.00			
Stiff grey with occasional grey-brown mottling CLAY.											
...From 2.10mbgl stiff mottled grey and brown clay.											
...From 2.40mbgl grey-brown closely fissured and thinly bedded occasional brown iron staining.											
End of Trial Pit at 2.80 m			2.80	69.55							
											
											
											
											
											
											
											
											
											
											
											
											
											
											
											
											
											
											
											
											

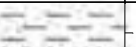
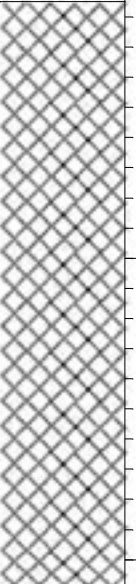
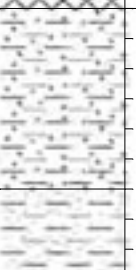
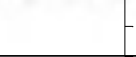
<div> Client: Entec UK Limited  Engineer: John Tomalin  Contractor: May Gurney Geotechnical  Date: 14/07/2010  Plant: JCB   Logged By: J. Tomalin  Checked By: P. Lewin </div>		Water Level Observations			
		Date	Water Strike (m)	Standing Time (Mins)	Standing Level (m)
			No Groundwater Encountered		
		Groundwater Remarks: No groundwater encountered.			
		Remarks: Hole backfilled with arisings.			
Hole Stability: Trial pit stable during excavation and on completion.					
<div style="text-align: right;">Print Date: 21/09/2010</div>					



 <div> May Gurney Limited  Geotechnical - Site Investigation  Ayton Road, Wymondham  NR18 0RH  Tel: 01953 609856 Fax: 01953 609819  Web: www.maygurney.co.uk </div>		<h2 style="text-align: center;">Trial Pit Record</h2>			<h2 style="text-align: center;">TPD02</h2> <p style="text-align: center;">Sheet 1 of 1</p>				
Project ID: SI1622		Project: Bicester							
		Client: Entec UK Limited			Ground Level: 73.513mAOD				
		Engineer: John Tomalin			Coordinates: 459603.79E 220354.46N				
Orientation of Trial Pit:		Length: -	Width: -	Depth: 3.30	Sample / Test		Remarks and Test Results <small>PID (ppm)</small>		
Description		Legend	Depth (m)	O.D. Level	Water	Type			
MADE GROUND: Grey-brown slightly sandy clay.			0.10	73.41					
MADE GROUND: Very stiff dessicated mottled grey and brown-grey clay. Occasional angular fine to coarse limestone gravel.						ES1	0.50	0.00	
...From 1.10mbgl stiff mottled grey and yellow-brown slightly gravelly (5%) CLAY. Gravel is angular fine to coarse limestone.			1.30	72.21					
Stiff slightly green-grey CLAY with occasional fine roots.						ES2	1.90	0.00	
...From 1.80mbgl stiff mottled grey and yellow-brown.									
...From 2.80mbgl brown-grey and yellow-brown.									
...From 3.10mbgl closely fissured, blocky texture, occasional brown iron staining.			3.30	70.21					
End of Trial Pit at 3.30 m									
Client: Entec UK Limited Engineer: John Tomalin Contractor: May Gurney Geotechnical Date: 14/07/2010 Plant: JCB  Logged By: J. Tomalin Checked By: P. Lewin		Water Level Observations							
		Date		Water Strike (m)		Standing Time (Mins)		Standing Level (m)	
				No Groundwater Encountered					
		Groundwater Remarks: No groundwater encountered throughout.							
		Remarks: Hole backfilled with arisings.							
		Hole Stability: Trial pit stable during excavation and on completion.							
		Print Date: 21/09/2010							

 <div> May Gurney Limited  Geotechnical - Site Investigation  Ayton Road, Wymondham  NR18 0RH  Tel: 01953 609856 Fax: 01953 609819  Web: www.maygurney.co.uk </div>		<h2 style="text-align: center;">Trial Pit Record</h2>				<h2 style="text-align: center;">TPD03</h2> <p style="text-align: center;">Sheet 1 of 1</p>		
Project ID: SI1622		Project: Bicester						
		Client: Entec UK Limited Engineer: John Tomalin				Ground Level: 74.039mAOD Coordinates: 459614.75E 220405.08N		
Orientation of Trial Pit:		Length: -		Width: -		Depth: 2.20		
<b>Description</b>		<b>Legend</b>	<b>Depth (m)</b>	<b>O.D. Level</b>	<b>Water</b>	<b>Sample / Test Type</b>	<b>Depth (m)</b>	
MADE GROUND: Brown-grey sandy clay.			0.50	73.54		ES1	0.60	
MADE GROUND: Very stiff mottled brown-grey and brown slightly gravelly (5%) clay. Gravel is angular fine to coarse limestone.							0.00	
Stiff green-grey granular silty CLAY. Organic odour. Occasional fine roots.			1.30	72.74		ES2	1.40	
Stiff mottled green-grey and yellow-grey CLAY.			1.50	72.54			0.00	
End of Trial Pit at 2.20 m			2.20	71.84				
Client: Entec UK Limited Engineer: John Tomalin Contractor: May Gurney Geotechnical Date: 14/07/2010 Plant: JCB  Logged By: J. Tomalin Checked By: P. Lewin		Water Level Observations						
		Date		Water Strike (m)		Standing Time (Mins)		Standing Level (m)
				No Groundwater Encountered				
		Groundwater Remarks: No groundwater encountered throughout.						
		Remarks: Hole backfilled with arisings.						
		Hole Stability: Trial pit stable during excavation and on completion.						


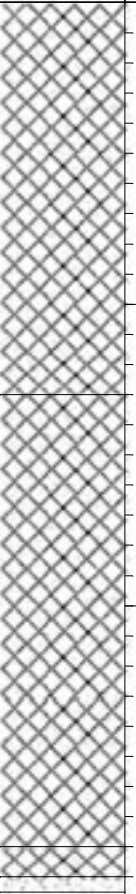
 <div> May Gurney Limited  Geotechnical - Site Investigation  Ayton Road, Wymondham  NR18 0RH  Tel: 01953 609856 Fax: 01953 609819  Web: www.maygurney.co.uk </div>		<h2 style="text-align: center;">Trial Pit Record</h2>			<h2 style="text-align: center;">TPD04</h2> <p style="text-align: center;">Sheet 1 of 1</p>			
Project ID: SI1622		Project: Bicester						
		Client: Entec UK Limited			Ground Level: 75.366mAOD			
		Engineer: John Tomalin			Coordinates: 459525.53E 220379.25N			
Orientation of Trial Pit:		Length: -	Width: -	Depth: 3.20	Sample / Test		Remarks and Test Results <small>PID (ppm)</small>	
Description		Legend	Depth (m)	O.D. Level	Water	Type		
MADE GROUND: Brown-grey slightly sandy clay. Occasional angular fine and medium limestone and flint gravel.			0.15	75.22		ES1	0.00-0.10	0.00
MADE GROUND: Very stiff grey and yellow-grey clay with occasional angular fine to coarse limestone gravel.						ES2	0.50	0.00
...From 1.40mbgl stiff.								
...From 2.20mbgl pockets of brown clay.								
POSSIBLE MADE GROUND: Firm to stiff slightly green-grey slightly sandy CLAY.			2.40	72.97				
Stiff brown-grey slightly sandy CLAY with occasional fine decayed roots. Slight organic odour. (possible buried topsoil).			2.80	72.57		ES3	2.80-2.90	0.00
End of Trial Pit at 3.20 m			3.20	72.17				
Client: Entec UK Limited Engineer: John Tomalin Contractor: May Gurney Geotechnical Date: 13/07/2010 Plant: JCB  Logged By: J. Tomalin Checked By: P. Lewin		Water Level Observations						
		Date		Water Strike (m)		Standing Time (Mins)		Standing Level (m)
				No Groundwater Encountered				
		Groundwater Remarks: No groundwater encountered throughout.						
		Remarks: Hole backfilled with arisings.						
		Hole Stability: Trial pit stable during excavation and on completion.						
		Print Date: 21/09/2010						

 <div> May Gurney Limited  Geotechnical - Site Investigation  Ayton Road, Wymondham  NR18 0RH  Tel: 01953 609856 Fax: 01953 609819  Web: www.maygurney.co.uk </div>		<h2 style="text-align: center;">Trial Pit Record</h2>			<h2 style="text-align: center;">TPD05</h2> <p style="text-align: center;">Sheet 1 of 1</p>				
		Project: Bicester							
Project ID: SI1622		Client: Entec UK Limited Engineer: John Tomalin			Ground Level: 76.346mAOD Coordinates: 459546.88E 220413.20N				
Orientation of Trial Pit:		Length: 2.50 Width: 0.60 Depth: 3.95			Sample / Test		Remarks and Test Results <small>PID (ppm)</small>		
Description		Legend	Depth (m)	O.D. Level	Water	Type		Depth (m)	
MADE GROUND: Stiff brown-grey slightly sandy clay.			0.15	76.20				0.00	
MADE GROUND: Very dessicated yellow-grey slightly sandy slightly gravelly (5%) clay. Gravel is angular fine to coarse limestone and rare brick fragments.						ES1	0.50-0.60		
MADE GROUND: Stiff to very stiff mottled grey and yellow-grey slightly gravelly (5%) clay. Gravel is angular fine to coarse limestone. ...From 0.90mbgl becoming mottled grey and brown.				0.70	75.65				
...At 1.80mbgl slight water seepage.								0.00	
...From 2.20mbgl stiff grey and yellow-grey clay with pockets of dark brown silty clay with rootlet. Slight organic odour.									
Grey-brown sandy silty CLAY with fine rootlets. (Possible buried topsoil). ...From 3.50mbgl brown-grey.			3.30	73.05				0.00	
Stiff slightly green-grey CLAY with occasional dark grey specks. Slight organic odour.				3.60	72.75		ES2		3.80
End of Trial Pit at 3.95 m				3.95	72.40				
Client: Entec UK Limited Engineer: John Tomalin Contractor: May Gurney Geotechnical Date: 14/07/2010 Plant: JCB  Logged By: J. Tomalin Checked By: P. Lewin		Water Level Observations							
		Date		Water Strike (m)		Standing Time (Mins)		Standing Level (m)	
				No Groundwater Encountered					
		Groundwater Remarks: No groundwater encountered throughout.							
		Remarks: Hole backfilled with arisings.							
Hole Stability: Trial pit stable during excavation and on completion.						Print Date: 21/09/2010			

 <div> May Gurney Limited  Geotechnical - Site Investigation  Ayton Road, Wymondham  NR18 0RH  Tel: 01953 609856 Fax: 01953 609819  Web: www.maygurney.co.uk </div>		<h2 style="text-align: center;">Trial Pit Record</h2>			<h2 style="text-align: center;">TPD06</h2> <p style="text-align: center;">Sheet 1 of 1</p>			
Project ID: SI1622		Project: Bicester						
		Client: Entec UK Limited			Ground Level: 76.445mAOD			
		Engineer: John Tomalin			Coordinates: 459566.13E 220434.60N			
Orientation of Trial Pit:		Length: -	Width: -	Depth: 4.30	Sample / Test		Remarks and Test Results <small>PID (ppm)</small>	
Description		Legend	Depth (m)	O.D. Level	Water	Type		
MADE GROUND: Brown-grey sandy clay with rootlets.			0.15	76.30			ES1	
MADE GROUND: Very stiff dessicated yellow-grey slightly gravelly (5%) clay. Gravel is angular fine to coarse limestone.  ...From 0.40mbgl mottled grey and yellow-grey.								
MADE GROUND: Firm to stiff mottled dark grey, grey and yellow-grey slightly gravelly (5%) clay. Locally slightly sandy. Slight organic odour. Occasional plant debris (roots). ...Slight water seepage from 2.10mbgl.			2.10	74.35			ES2	
POSSIBLE MADE GROUND: Stiff mottled grey and yellow-grey slightly gravelly (5%) CLAY. Gravel is angular fine to coarse limestone.			3.00	73.45				
Grey-brown slightly sandy CLAY with occasional fine roots. (Possible old topsoil). Slight organic odour.			3.60	72.85				
Stiff slightly green-grey CLAY with occasional fine roots.			3.90	72.55				
End of Trial Pit at 4.30 m			4.30	72.15				
Client: Entec UK Limited Engineer: John Tomalin Contractor: May Gurney Geotechnical Date: 14/07/2010 Plant: JCB  Logged By: J. Tomalin Checked By: P. Lewin		Water Level Observations						
		Date		Water Strike (m)		Standing Time (Mins)		Standing Level (m)
				No Groundwater Encountered				
		Groundwater Remarks: Slight water seepage from 2.10mbgl.						
		Remarks: Hole backfilled with arisings.						
		Hole Stability: Trial pit stable during excavation and on completion.						
		Print Date: 21/09/2010						

 <div> May Gurney Limited  Geotechnical - Site Investigation  Ayton Road, Wyndham  NR18 0RH  Tel: 01953 609856 Fax: 01953 609819  Web: www.maygurney.co.uk </div>		<h2 style="text-align: center;">Trial Pit Record</h2>			<h2 style="text-align: center;">TPD07</h2> <p style="text-align: center;">Sheet 1 of 1</p>			
Project ID: SI1622		Project: Bicester						
		Client: Entec UK Limited			Ground Level: 73.060m AOD			
		Engineer: John Tomalin			Coordinates: 459285.38E 220991.16N			
Orientation of Trial Pit:		Length: -	Width: -	Depth: 2.60	Sample / Test		Remarks and Test Results <small>PID (ppm)</small>	
Description		Legend	Depth (m)	O.D. Level	Water	Type		
MADE GROUND: Brown-grey sandy clay.			0.15	72.91		ES1	0.30-0.40	0.00
MADE GROUND: Mixed brown and grey silty gravelly fine to coarse sand and very stiff clay, gravel and cobbles. Gravel is angular fine to coarse brick, limestone and concrete.			0.90	72.16		ES2	1.10-1.20	0.00
MADE GROUND: Stiff brown, brown-grey and dark brown slightly sandy slightly gravelly (10%) clay. Gravel is angular fine to coarse tarmac, concrete and limestone. Occasional silty gravelly sand pockets. Locally slight ammonia odour.			2.10	70.96		ES3	2.10-2.20	0.00
...From 1.90mbgl abundant brown and dark brown silty very gravelly fine to coarse sand. Gravel is limestone and occasional ash.			2.60	70.46				
MADE GROUND: Firm to stiff grey and green-grey slightly sandy slightly gravelly (10%) clay. Gravel is angular fine to coarse limestone, flint and concrete. Organic odour. Occasional fragments of glass.								
End of Trial Pit at 2.60 m								
Client: Entec UK Limited Engineer: John Tomalin Contractor: May Gurney Geotechnical Date: 13/07/2010 Plant: JCB  Logged By: J. Tomalin Checked By: P. Lewin		Water Level Observations						
		Date		Water Strike (m)		Standing Time (Mins)		Standing Level (m)
				No Groundwater Encountered				
		Groundwater Remarks: No groundwater encountered throughout.						
		Remarks: 1. Hole abandoned at 2.60mbgl upon concrete obstruction. 2. Hole backfilled with arisings.						
		Hole Stability: Trial pit stable during excavation and on completion.						
		Print Date: 21/09/2010						



 <div> May Gurney Limited  Geotechnical - Site Investigation  Ayton Road, Wymondham  NR18 0RH  Tel: 01953 609856 Fax: 01953 609819  Web: www.maygurney.co.uk </div>		<h2 style="text-align: center;">Trial Pit Record</h2>			<h2 style="text-align: center;">TPD08</h2> <p style="text-align: center;">Sheet 1 of 1</p>				
Project ID: SI1622		Project: Bicester							
		Client: Entec UK Limited Engineer: John Tomalin			Ground Level: 73.386mAOD Coordinates: 459266.79E 220973.60N				
Orientation of Trial Pit:		Length: -	Width: -	Depth: 2.95	Sample / Test		Remarks and Test Results <small>PID (ppm)</small>		
Description		Legend	Depth (m)	O.D. Level	Water	Type			
MADE GROUND: Brown-grey silty gravelly, cobbly fine to coarse sand. Gravel is angular to subangular fine to coarse concrete, tarmac and limestone. Occasional very stiff clay fragments, wire and rubber.  ...From 0.50m to 0.80mbgl black gravelly sand pocket, abundant ash.  ...From 0.90m to 1.00mbgl light yellow-brown gravelly sand pocket.  ...From 1.10m to 1.20mbgl black silty sand with abundant ash.			1.30	72.09		ES1	0.40-0.50	0.00	
						ES2	1.10-1.20	0.00	
MADE GROUND: Firm to stiff grey and brown clay. Slight organic odour. Occasional dark grey sandy gravelly pockets. Gravel is angular fine to coarse limestone, concrete and occasional ash. Occasional limestone and concrete cobbles. ...From 1.60mbgl grey with occasional dark grey.						ES3	2.50-2.60	0.00	
MADE GROUND: Black silty fine to coarse sand and angular fine to coarse limestone gravel. Slight hydrocarbon odour.						ES4	2.80-2.90	0.00	
CONCRETE End of Trial Pit at 2.95 m			2.80 2.90 2.95	70.59 70.49 70.44					
Client: Entec UK Limited Engineer: John Tomalin Contractor: May Gurney Geotechnical Date: 13/07/2010 Plant: JCB  Logged By: J. Tomalin Checked By: P. Lewin		Water Level Observations							
		Date		Water Strike (m)		Standing Time (Mins)		Standing Level (m)	
				No Groundwater Encountered					
		Groundwater Remarks: No groundwater encountered throughout.							
		Remarks: 1. Hole abandoned at 2.95mbgl upon concrete obstruction. 2. Hole backfilled with arisings.							
		Hole Stability: Trial pit stable during excavation and on completion.						Print Date: 21/09/2010	





**TPD09**

Project: Bicester

Coordinates: 459228.37E  
220915.76N

Test Results PID (ppm)


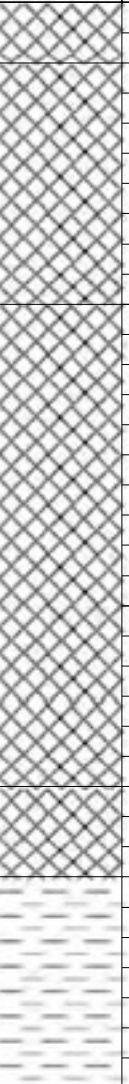
0.00








0.00

0.00

Age Group	Percentage of Respondents
18-29	65
30-49	75
50-69	80
70+	85

Print Date: 21/09/2010

 <div> May Gurney Limited  Geotechnical - Site Investigation  Ayton Road, Wymondham  NR18 0RH  Tel: 01953 609856 Fax: 01953 609819  Web: www.maygurney.co.uk </div>		<h2 style="text-align: center;">Trial Pit Record</h2>		<h2 style="text-align: center;">TPD10</h2> <p style="text-align: center;">Sheet 1 of 1</p>			
		Project: Bicester					
Project ID: SI1622		Client: Entec UK Limited		Ground Level: 72.543mAOD			
		Engineer: John Tomalin		Coordinates: 459263.75E 220897.72N			
Orientation of Trial Pit:		Length: -	Width: -	Depth: 3.60	Sample / Test	Remarks and Test Results	
Description	Legend	Depth (m)	O.D. Level	Water	Type	Depth (m)	PID (ppm)
MADE GROUND: Brown-grey sandy slightly gravelly (10%) clay. Gravel is angular fine to coarse limestone and tarmac. Occasional fragments of sheet asbestos.		0.20	72.34		ES1	0.20-0.30	0.00
MADE GROUND: Very stiff dessicated brown and grey slightly gravelly (10%) clay. Gravel is angular fine to coarse limestone, concrete, tarmac and fragments of fabric and plastic.					ES2	0.50-0.60	0.00
MADE GROUND: Firm to stiff grey and dark grey slightly sandy slightly gravelly (8%) clay. Gravel is angular fine to coarse limestone, brick, concrete and fragments of geotextile. Organic odour.		1.00	71.54		ES3	1.00-1.10	0.00
...At 2.50mbgl large reinforced concrete block (0.50m x 0.50m x 0.40m).		2.60	69.94		ES4	2.60-2.70	0.00
MADE GROUND: Black slightly silty very gravelly fine to coarse sand. Gravel is angular fine to medium limestone and abundant ash.		2.90	69.64		ES5	3.00	0.00
Stiff to very stiff thinly bedded closely fissured brown CLAY. Occasional light brown silty lenses.							
End of Trial Pit at 3.60 m		3.60	68.94				
Client: Entec UK Limited Engineer: John Tomalin Contractor: May Gurney Geotechnical Date: 14/07/2010 Plant: JCB  Logged By: J. Tomalin Checked By: P. Lewin		Water Level Observations					
		Date	Water Strike (m)	Standing Time (Mins)	Standing Level (m)		
		No Groundwater Encountered					
		Groundwater Remarks: Water seepage at 2.50mbgl.					
		Remarks: Hole backfilled with arisings.					
		Hole Stability: Trial pit stable during excavation and on completion.					
		Print Date: 21/09/2010					

 <div> May Gurney Limited  Geotechnical - Site Investigation  Ayton Road, Wyndham, NR18 0RH  Tel: 01953 609856 Fax: 01953 609819  Web: www.maygurney.co.uk </div>			<h2>Window Sample Record</h2>			<h2>WSD01</h2> <p>Sheet 1 of 1</p>		
Project ID: SI1622 Contractors ID:			Project: Bicester					
Client: Entec UK Limited Engineer: James Ridehalgh			Ground Level: 66.600m AOD Coordinates: 459367.86E 219902.91N					
Description	Legend	Depth (m)	O.D. Level (m)	Sample Test		Remarks and Test Results	PID (ppm)	Installations
				Type	Depth (m)			
MADE GROUND (Topsoil): Stiff brown sandy gravelly clay. Gravel is angular to subangular fine to coarse consisting of sandstone, gritstone and limestone. Firm brown-orange-grey mottled sandy CLAY.		0.20	66.40	CS01	0.00-0.20		0.00	
		1.30	65.30	C1	1.20-2.00			
Firm brown sandy CLAY with yellow and brown organic laminations and angular fine to medium gypsum crystals.				CS02	1.60-1.80		0.00	
		2.20	64.40	C2	2.00-3.00			
Firm to stiff grey sandy laminated CLAY with gypsum crystals.				C3	3.00-4.00			
		4.00	62.60					
Window Sample Complete at 4.00 m								
<h3>Water Level Observations</h3>								
<h4>Drive Records</h4>			Date	Water Strike (m)	Standing Time (Mins)	Standing Level (m)	Casing Depth (m)	Depth Sealed (m)
Diameter (mm)	To (m)	Recovery (%)						
102 86 76	2.00 3.00 4.00			No Groundwater Encountered				
Client: Entec UK Limited Engineer: James Ridehalgh Date: 20/07/2010 Plant: Terrier Drilled By: M. Earl Logged By: JSR Checked By: P. Lewin			Remarks: 1. Starter pit dug from GL to 1.20mbgl. 2. Hole backfilled with arisings.					
<p>Print Date: 22/09/2010</p>								



May Gurney Limited  
Geotechnical - Site Investigation  
Ayton Road, Wyndham, NR18 0RH  
Tel: 01953 609856 Fax: 01953 609819  
Web: www.maygurney.co.uk

## Window Sample Record

### WSD02

Sheet 1 of 1

Project: Bicester

Project ID: SI1622

Contractors ID:

Client: Entec UK Limited

Engineer: James Ridehalgh

Ground Level: 66.321m AOD

Coordinates: 459376.76E

219906.77N

Description	Legend	Depth (m)	O.D. Level (m)	Sample Test		Remarks and Test Results	PID (ppm)	Installations
				Type	Depth (m)			
MADE GROUND (TOPSOIL): Stiff brown sandy slightly gravelly clay. Gravel is angular medium consisting of brick.		0.20	66.12	CS01	0.20-0.40		0.00	
Firm brown-grey-orange mottled sandy slightly gravelly CLAY with rootlets. Gravel is angular fine chalk. Rootlets disappearing with depth.		1.20	65.12	CS02 C1	1.20-1.40 1.20-2.00		0.00	
...From 1.00m to 1.20mbgl becoming soft.		2.00	64.32	C2	2.00-3.00			
Firm grey-brown sandy CLAY with yellow and brown organic laminations and fine to medium gypsum crystals.		2.60	63.72	C3	3.00-4.00			
Firm brown sandy CLAY with orange and yellow laminations and fine gypsum crystals.		2.60	63.72	C3	3.00-4.00			
Firm to stiff grey laminated sandy CLAY with gypsum crystals. Occasional cobbles of mudstone.		2.60	63.72	C3	3.00-4.00			
...From 4.00mbgl shell fossils.		4.00	61.52	CS03 C4	4.00-4.20 4.00-4.80		0.00	
Window Sample Complete at 4.80 m		4.80	61.52					

#### Water Level Observations

#### Drive Records

Diameter (mm)	To (m)	Recovery (%)	Date	Water Strike (m)	Standing Time (Mins)	Standing Level (m)	Casing Depth (m)	Depth Sealed (m)
102	2.00			No Groundwater Encountered				
96	3.00							
76	4.00							
66	4.80							

Client: Entec UK Limited

Engineer: James Ridehalgh

Date: 20/07/2010

Plant: Terrier

Drilled By: M. Earl

Logged By: JSR

Checked By: P. Lewin

Remarks:

1. Starter pit dug from GL to 1.20mbgl.
2. Hole abandoned at 4.80mbgl as window sampling techniques unable to progress.
3. Installation details: 32mm HDPE Standpipe installed from GL to 4.50mbgl. Plain piep from GL to 0.50mbgl and a slotted pipe from 0.50m to 4.50mbgl. Hole backfilled with bentonite from GL to 0.50mbgl, gravel from 0.50m to 4.50mbgl and bentonite from 4.50m to 4.80mbgl. Hole finished with a flush cover and gas tap.

Print Date: 22/09/2010