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

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Defence Estates

Site D and Site E, DSDC Bicester

Land Quality Assessment

Phase One: Desk Study
DE Project No.: 13104

Final LQA Report

14 May 2010

Prepared by Entec UK Limited for the Ministry of Defence under commission FTS3/PTSELM/03

DEFENCE ESTATES
Delivering Estate Solutions to Defence Needs

Report for

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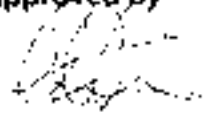

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Document Revisions

No.	Details	Date
1	Draft Report	22 March 2010
2	Final Report	14 May 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 One Land Quality Assessment of the Ministry of Defence (MOD) sites known as Site D and Site E, DSDC Bicester ('the site'). This commission was carried out under the interim contracting arrangement and FATS/3 framework between Entec and Defence Estates.

Site Location, Description and History

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 freight terminal (BIFT) located to the immediate east of E Site. The site covers a total area of approximately 130 ha.

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 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 Sensitivity

Geology/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 of E Site.

Almost the entire site is underlain by a Non-Aquifer (Negligibly Permeable), 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 Minor 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 Minor Aquifer (both High and Low

Leaching Potential). Beneath the Oxford Clay and Kellaways formations, the Cornbrash Formation is also classified as a Minor 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.

Groundwater Sensitivity: Low

Hydrology

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, the Aquatrine Contractor for the site, it was indicated that no discharge consents related to the site are still extant.

Surface Water Sensitivity: Moderate/High

Ecology

There are three Environmentally Sensitive Areas (ESA) within 0.5 km of the site, which 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).

Ecological Sensitivity: Moderate

Sources of Information

General mapping sources and public body records were consulted for this study, including topographical, geological and groundwater vulnerability maps of the area, the British Geological Survey (BGS), the local authority, emapsite™ GroundSure reports, reference books and aerial photographs from the National Monuments Record. Specialist radiological and explosive ordnance desk studies were commissioned. MOD sources of information include plans, previous reports as well as anecdotal information from site personnel. Additionally, a brief review of archaeological and cultural heritage information has been undertaken.

Potential Site Contamination

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

On site sources relate to former and current areas of fuel storage and handling, including POL stores and points (fuel tanks and refuelling areas), along with the former railway workshops and fire training building, areas of tipping and Made Ground and the site-wide railway network. Off site sources include the former firing range along with the sewage treatment works and other areas of the DSDC Bicester site and St David's Barracks.

Most of the above identified on-site sources are generally likely to be limited in their extent, with the exception of the site-wide railway network, which has recently been upgraded.

Environmental Risks

The risks to most human receptors, including current site users/visitors, construction and maintenance workers, future residential/commercial/industrial users and neighbouring site users have been assessed in the range of **moderate** to **low**, with the **moderate** risks generally associated with future residential users and construction/maintenance works from 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.

There is a generally **negligible** risk for contaminant migration to groundwater due to the generally negligible permeability strata beneath the site, with a **moderate/low** risk associated with the suspected ash ballast stockpile to the south of D7 on a Minor (Secondary) Aquifer. 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**, with the highest risk associated with the waste tip near E15.

Although a number of ecologically sensitive receptors have been identified in the vicinity of the site, 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**. Similarly, the risks to agricultural receptors have been assessed as **negligible** to **low**.

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

Overall Land Quality and Suitability for Redevelopment

In general, it is considered that the land quality at the majority of the site is likely to be generally good, with isolated areas of potentially poor land quality associated with the principal areas used for the current and historic storage of hydrocarbon fuels, areas of waste tipping/Made Ground, railway line infrastructure and asbestos either from the degradation of building fabric or the disposal of demolished buildings containing ACMs. Therefore, the site is considered to be suitable for its present commercial/industrial use given the current site configuration.

Due to the uncertainty regarding the nature of the some of the areas of waste tipping/Made Ground (including stockpile(s) of ash ballast material) together with the number of as-yet uninvestigated areas of former and current fuel/oil handling, storage and use, these potential land quality issues have carried forward into the risk assessment. In areas associated with these current and former potentially contaminative uses it is likely that land quality will have been impacted and redevelopment proposals, especially those related to a residential with gardens end use, will need to be tailored to the potential contamination present in these areas.

It is considered likely that construction/redevelopment workers will come into direct contact with areas of potential contamination (identified by the Enviros Aspinwall Phase Two LQA, and suspected in other areas) and all workers should be made aware of potential risks that exist at the site and take suitable measure to avoid or mitigate potential risk. Appropriate personal protective equipment (PPE) should be used and good working practices adhered to during any future investigation or redevelopment work at the site.

Development may involve the removal of the subsurface infrastructure and obstructions. Remediation may be required if following the removal of infrastructure the soils and waters are found to have been impacted by any contamination. Development may also require the removal or alteration of building foundations, building fabric, underground pipework/services and underground voids.

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.

Finally, it should be noted that the high sulphate concentrations present within the Oxford Clay present beneath the site are likely to be detrimental to concrete foundations. Therefore, any new foundations will likely require construction with a Sulphate Resistant Portland Cement.

Contents

Glossary of Terms

Site Specific

BFI	Bulk Fuel Installation
Bolero	Colloquial Term for an all-steel construction half-round 'Romney Shed'. The Bolero term relates to Operation Bolero from WWII.
DE	Defence Estates
DSTL	Defence Science and Technology Laboratory
DSTL RPS	DSTL Radiation Protection Service
MOD	Ministry of Defence
MT	Motor Transport
OSU	Operational Service Unit
OWI	Oil Water Interceptor
POL	Petrol, Oil and Lubricants
RPC	Regional Prime Contractor
UXO	Unexploded Ordnance
WWII	World War 2
QM	Quarter Master

Environmental

ACM	Asbestos Containing Material
AOD	Above Ordnance Datum
AONB	Area of Outstanding Natural Beauty
bgl	below ground level
BGS	British Geological Survey
CLEA	Contaminated Land Exposure Assessment
DEFRA	Department for Food and Rural Affairs
EA	Environment Agency
EPA	Environmental Protection Act 1990
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
NGR	National Grid Reference
NNR	National Nature Reserves
NRPB	National Radiological Protection Board
NGR	National Grid Reference
OS	Ordnance Survey
PAH	Polycyclic Aromatic Hydrocarbons
Part 2A	Part 2A of the Environmental Protection Act (1990)
PCB	Polychlorinated Biphenyls
PPE	Personal Protective Equipment
QRA	Quantitative Risk Assessment
SAC	Special Area of Conservation
SPA	Special Protection Areas
SPZ	Source Protection Zone (groundwater)
SSSI	Site of Special Scientific Interest
TPH	Total Petroleum Hydrocarbons

1. Introduction

1.1 Terms of Reference

Entec UK Ltd (Entec) was commissioned by Defence Estates (DE) to undertake a Phase One Land Quality Assessment of the Ministry of Defence (MOD) sites known as Site D and Site E, DSDC Bicester ('the site'). This commission was carried out under the interim contracting arrangement and the 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

The aim and purpose of the Phase One Land Quality Assessment (LQA) report is to collate and review desk study information on the likely ground and contamination conditions at the site to enable a health and environmental risk assessment to be undertaken. The assessment also addresses the potential for ground contamination to arise from the demolition of buildings and structures presently on the site. The objective of the risk assessment is to identify any potential health or environmental risks and liabilities posed by the site which may affect its valuation or future use and to describe the scale of any identified risks.

The following methodology was adopted:

- A site reconnaissance visit was carried out to record potentially contaminative features and operations on site and to gather any evidence of past contaminative uses;
- During the site reconnaissance, potential pathways and environmental receptors were identified, both on the site and within the immediate surrounding area;
- Interviews were carried out with site personnel and staff connected with the site (where present), who possess a knowledge of the present and past operations;
- Historical maps, aerial photographs and site layout plans indicating areas where potentially contaminative activities may have been undertaken were inspected;
- Environmentally pertinent information was gathered regarding the site and the surrounding locality from a variety of sources including the Environment Agency (EA), the Local Authority (LA), British Geological Survey (BGS) and Dstl Radiological Protection Service (DRPS);
- Present day maps, geological records, and groundwater information were inspected.

The findings of the study are based on the information made available to Entec by the MOD and personnel at the time of the visits, together with information obtained from public domain and other sources.

1.1.2 Site Management and Future Use

It is understood from Defence Estates that Site D and Site E at DSDC Bicester (hereafter referred to as 'the site') are scheduled for disposal to a currently unconfirmed end use. Consequently, this report considers the risks applicable to all potential end uses including commercial/industrial and residential.

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 Description

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 Visit

Entec staff conducted a site walkover on 20 and 21 January 2010, including a meeting with the Site Manager, LQA Sponsor and DE Task Officer. Hardcopy and electronic data was obtained from the Site Manager and LQA Sponsor. Entec staff were able to access the majority of the site areas, with the exception of the inside of some of the buildings which were locked or otherwise inaccessible at the time for health and safety reasons. Selected photographs taken during the site walkover are presented as Annex A to this report.

General 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 1.4.3 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 the site which are used for agricultural grazing.

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
D Site	
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.
E Site	
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.
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.

Table 1.1 (continued) Site Buildings and Activities

Building No.	Description and Activities
E Site (continued)	
E10	Part of the recently installed site-wide sprinkler system plant.
E14	Former (disused) boiler plant with large (30 m long) 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.
OSU, including buildings S2, S3, S11 and S905	A number of (now disused) Nissen hut-type buildings, smaller brick buildings and a large above ground probable water tank within a fenced compound.
BIFT, including buildings 1, 2A, 2, 3 and 4	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.

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

The predominant surface cover at the site is a mixture of hardstanding, soft landscaping and woodland. Evidence of several former structures, fill material and/or disturbed ground was noted during the site walkover, and, with reference to historic maps and plans is summarised in the following table:

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

Building No.	Description
D Site	
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 engineers 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.
E Site	
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.
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 these designation may both refer to the building now known as E15.
BIFT	An area of infilled/raised ground, approximately 5 m x 50 m x 3 m high noted on the south-western boundary.

Waste

Waste materials collected from the site are placed in designated skips and other purpose-built waste containers for collection and disposal to appropriately licensed disposal facilities by Grundons.

Drainage

Surface water drainage plans were not known to exist at the site and hence were not available from site staff according to enquiries made by Entec both during and after the site walkover. However, from the site walkover it would appear that 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, with discharge understood to be to the adjacent Langford Brook. Foul drainage is understood to be sent to the adjacent sewage treatment works. Located around the site, notably around vehicle/container parks and POL facilities are a number of interceptors. Maintenance of these facilities is understood to be undertaken by site contractors.

Topography

The site is located on the lower slopes and generally flat surroundings of Graven Hill. The summit of Graven Hill is at 115 m AOD with most of the site between approximately 60 and 75 m AOD.

1.3.3 Site Boundaries

Land uses surrounding the site are summarised in Tables 1.3 and 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

1.3.4 Tenants, 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 KBR) along with three areas of allotments, agricultural land and grazing leased by individuals.

1.4 Site-Sourced Information

Additional environmentally pertinent information relating to the site was requested from the site contact. This information is summarised in the following sections.

1.4.1 COSHH Register and Material Safety Data Sheets

According to site staff, each building has an individual hardcopy COSHH Register. Due to availability and time constraints, it was not possible to review individual COSHH Registers for each building, and an electronic summary of the COSHH registers was not available. However, it is understood from a conversation with the Site Manager that the COSHH records are generally for minor quantities of substances kept in each building. Dedicated COSHH lockers were also noted adjacent to several of the buildings during the site walkover.

1.4.2 Asbestos Register

Most of the buildings on site date from the 1940s and have asbestos in their fabric. Although many of the buildings were modernised with fire protection systems 15 years ago, some still contain substantial amount of asbestos, which is labelled and managed using individual building asbestos registers, which were not available for Entec to review at the time of writing of this report. However, an updated asbestos survey is understood to be currently in progress and will be reported on in June 2010.

1.4.3 Ordnance

As part of this Phase One LQA, an Explosive Ordnance Threat Assessment (EOTA) was commissioned. The EOTA was undertaken by BACTEC International Ltd (BACTEC), a specialist consultancy. The EOTA 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 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;

- 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.

The full EOTA is included as Annex B to this report.

1.4.4 Ionising Radiation Sources

As part of this Phase One LQA, a desk study was commissioned through the Dstl Environmental Services Department (Dstl ESD). As part of this study, 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 full Dstl ESD desk study is included as Annex C to this report.

1.5 Site History

1.5.1 Historical Landuse Summary

Historic mapping and aerial photographs indicate that 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. A 500 yard rifle range is marked on historic maps from 1898 and 1920 to the west of E2, with the rifle targets and butts marked within an area of the present day St Georges Barracks. A plan of the depot dated June 1943, included in the 1998 Aspinwall Phase One LQA factual report, shows that the vast majority of the existing site infrastructure was in place by that time. The June 1943 plan states that, at the time, D Site was the site armaments depot, whereas E Site was the small arms sub-depot. In addition, a series of three workers camps (Camps 5, 6 and 7) are marked on the 1943 plan within the present day St David's Barracks adjacent to the site. The Aspinwall Phase One LQA factual report indicates that these camps consisted of Nissen huts and were used to accommodate troops and depot workers.

Historic aerial photographs and mapping indicate that the number of buildings present in 1943 was more extensive than that of the present day. There were many boleros (long half-round corrugated sheds) on site, especially in the north-east of E Site and the south-east of D Site, as detailed in Table 1.2. In addition, a building is marked in the vicinity of the location of the D site Fire Station, along with a long narrow building on the south-western boundary of the BIFT. 'Static Tanks' are shown on the 10 June 1948 historic plan in eight locations on D Site; to north of D8, to the north-east of D4, between the boleros to the south-east of D4, between these boleros and D10, to the north of D35, to the north-east of D2, to the north-east of D5 and to the north of D9. Static Tanks are also shown on the 10 June 1948 historic plan in three locations in E Site; south-east of E11, west of E1 and north-east of E14. A Static Tank is also marked in the south-east corner of the BIFT on the 1940 plan. It is possible that the static tanks are water tanks used for re-filling steam locomotives, although this has not been confirmed.

The 1950 historic mapping shows the site in a very similar layout to that of the present day. The historic aerial photographs from this era also show that the wooded areas of the site were generally planted in the period 1950-1975 and that the building in the vicinity of the D Site Fire Station was demolished by 1950.

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 1950's, 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.

In 1965 there was a major fire at D34 (boleros) and the historic mapping from 1966 shows a pond and water lagoon on the northern boundary of the site which are no longer present, along with 'Tanks' at the OSU and a series of smaller buildings on the south-eastern boundary of the BIFT. The E1 Paint Store is marked 'TCB' and there are a series of small buildings marked adjacent to E1 similar to those currently adjacent to D2. The 1966 aerial photographs also show small buildings surrounded by hardstanding 'islands' to the south of D13 and near E5; it is likely that these were the former filling stations D18 and E11 mentioned in Table 1.2. In addition, the cluster of buildings to the north of the present day D9 is marked 'Contractor's Yard'.

The 1977 historic mapping shows that the D and E site boleros had been mainly demolished by then. By 1983 the processing of ammunition containers was transferred to the site from the depot in Ruddington Ordnance & Supply Depot in Nottinghamshire. The 1986 historic mapping shows that the D18 and E11 filling stations had been demolished by then and were car parks. In addition, the 1986 historic mapping shows that the long building on the south-western boundary of the BIFT had been demolished. By 1992, the whole site became known as the Defence Storage and Distribution Centre, Bicester.

Although the site has been used for storage of military hardware and processing of ammunition containers, according to the BACTEC EOTA and a local historian, author of '*50 years of COD Bicester'*, there is 'no record of explosive ordnance ever being stored, processed or disposed of within the confines of the depot [site] perimeter'.

Selected historic aerial photographs are included as Annex D.

1.6 Environmental Setting and Sensitivity

1.6.1 Geology

Geological information on the site is provided within the emapsite™ GroundSure GeoInsight Report obtained as part of the site data acquisition exercise, a copy of which is included in Annex E. The geological information provided in the GeoInsight report is derived from the British Geological Survey (BGS) Digital Geological map of Great Britain and 1:50 000 scale, Sheet 219.

According to the GeoInsight report, the anticipated geological sequence consists of undivided Made Ground (in the far north-west 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 of E Site.

Beneath the Oxford Clay and Kellaways Formation is the Cornbrash Formation (predominantly calcareous shelly mudstones and fossiliferous limestones) which outcrops to the north-west and south-east of the site. Drift deposits are generally absent, although deposits of alluvium (clay, silt, sand and gravel) are shown in the north and west of E Site and the extreme south of D Site.

A total of twenty-one inferred normal faults are shown within 500 m of the site. Although none of the faults are marked within the site boundary, a total of five faults are marked as crossing the strip of land connecting D Site and DSDC Bicester C Site approximately 1.5 km to the south. The closest fault to the site is marked within 18 m of the south-eastern boundary of D Site, with a strike trending north-west to south-east.

The natural ground subsidence section of the GeoInsight Report presents the following assessment of risks by the BGS for potential geological hazards that may be present in the general area of the site:

- Potential for shrink-swell clay ground stability hazards: Negligible to Moderate (source: BGS);
- Potential for landslide ground stability hazards: Very Low to Moderate (source: BGS);

- Potential for ground dissolution of soluble rocks stability hazards: Very Low (source: BGS);
- Potential for compressible deposits stability hazards: Negligible to Moderate (source: BGS);
- Potential for collapsible deposits stability hazards: No Hazard to Negligible (source: BGS);
- Potential for running sand stability hazards: Negligible to Low (source: BGS);
- Radon: The site is not within a radon Affected Area, as less than 1% of properties are above the Action Level. No radon protection measures are necessary (sources: Health Protection Agency and Building Research Establishment);
- Mining: There are no historical mining and/or coal mining areas within 1 km of the site boundary. The maximum hazard rating of subsidence relating to shallow mining within the site is Negligible. There are no non-coal mining cavities, natural cavities, brine extraction areas, gypsum extraction areas, tin mining areas or clay mining areas within 1 km of the site boundary (sources: GroundSure, Coal Authority, BGS, Peter Brett Associates mining cavities and natural cavities databases, British Gypsum and relevant tin and clay mining records).

Ground Workings

According to the GroundSure GeoInsight Report, included within Annex E of this report, historic surface ground workings have been carried out in the following locations:

- **North western boundary of Site E:** various cuttings, ponds, water bodies, 'unspecified heaps' and workings related to the sewage works are marked on or within 250 m of this boundary. These various workings date from the 1880s through to the 1990s;
- **To the east of Site E:** there are eight entries for ponds approximately 220 m from the eastern boundary of Site E dating from the 1880s to the 1990s. According to the mapping provided in the GeoInsight Report, these entries may all relate to a single pond;
- **Strip of land connecting Site D with DSDC Bicester Site C:** cuttings dating from the 1950s are shown on this strip of land, and there are further entries for four ponds (1880s-1990s) within 100 m of the southern boundary of this area and an 'unspecified heap' (1950s) within 100 m of the northern boundary of this area.

In addition to the above, the site Estate Development Plan (v1.1, dated 15 August 2008) states in Section 16.38 that: *'High sulphate concentrations in clay which are detrimental to concrete foundations, require construction with a Sulphate Resistant Portland Cement'.*

1.6.2 BGS Borehole Records

The GroundSure GeoInsight report provides details of 64 exploratory holes on site or within 250 m of the site boundary. Of these exploratory holes, approximately 26 appear to be trial pits. Of the remaining boreholes, there are only records of seven boreholes on site; a cluster of two boreholes within the eastern part of E Site and five boreholes within D site, four of which are

clustered together in the railway sidings near the south-western site boundary with the other borehole located near the south-eastern site boundary.

As the site has already been subject to intrusive site investigation on behalf of DE, borehole logs were not ordered from the BGS. The ground conditions encountered during the June 2001 Phase Two LQA generally concur with the BGS geological mapping, indicating Made Ground overlying the Oxford Clay, which typically comprised of pale grey mudstone, typically weathered to clays at depths of 2 to 5 m bgl across most of the site. The thickness of the clay has not been fully established, although the Aspinwalls 2001 Phase Two LQA report states that: *'The Oxford Clay is an estimated 15m minimum thickness below DSDC Bicester and there is no hydraulic continuity with the underlying Great Oolite Aquifer'*. Perched groundwater was encountered in only two exploratory locations within the Made Ground.

1.6.3 Groundwater

Hydrogeological information on the site is provided within the emapsite™ GroundSure EnviroInsight Report obtained as part of the site data acquisition exercise, a copy of which is included in Annex E.

It is understood by Entec that the Environment Agency intends to change aquifer designations in line with the updated Groundwater Protection Policy (GP3) and the Water Framework Directive. As part of this change, Minor Aquifers will now be generally referred to as 'Secondary (A) Aquifers', with Non-Aquifers referred to as 'Unproductive Strata'.

According to the Aquifer and Abstraction License Map provided in the EnviroInsight Report, almost the entire site is underlain by a Non-Aquifer (Negligibly Permeable), 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 Minor 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 Minor Aquifer (both High and Low Leaching Potential).

Beneath the Oxford Clay and Kellaways formations, the Cornbrash Formation (part of the Great Oolite Group) that outcrops to the north-east and south-west of the site is also classified as a Minor Aquifer of Low Leaching Potential.

According to the site Estate Development Plan (EDP) (v1.1, 15 August 2008) groundwater levels, although recorded at 70m Above Ordnance Datum (AOD) are within the aquifer of the Great Oolite Group (approximately 30 m below ground level), comprising limestone and sands. The EDP states that this confined aquifer is under high pressure conditions, which if penetrated by a borehole will produce artesian conditions with a head of approximately 20 m.

The site does not fall within a groundwater Source Protection Zones (SPZ) and there are no SPZ marked within 1 km of the site.

Groundwater Abstraction Licenses

The EnviroInsight Report provides details of seven groundwater abstraction licenses within 1 km of the site. The closest is 407 m to the north-west of the site and relates to a general farming and domestic supply from a borehole at Wendlebury Lane, Bicester.

Potable Water Abstraction Licenses

The EnviroInsight Report provides details of three potable water abstraction licenses within 2 km of the study site, of which only one is within 1 km of the study site. This relates to a groundwater abstraction for domestic purposes at Bicester Trailer Park, Oxford Road, Wendlebury, some 667 m north-west of the site.

Groundwater Sensitivity: Low

1.6.4 Surface Water

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.

The EA record the quality of the Langford Brook in two reaches within 500 m of the site. The first (Stratton Audley - Bicester STW) is rated by the EA as chemical grade 'D' (fair) and biological grade B (good). The second reach (Bicester STW - Ray) is rated as chemical grade 'C' (fairly good) and biological grade B (good).

Surface Water Abstractions

There are records of one surface water abstraction license within 1 km of the site. This relates to abstraction of 'make-up or top up water' from the Langford Brook at Merton Grounds Farm, Merton, 317 m south-west (downgradient) of the site.

Discharges

There are records of thirty-three Licensed Discharge Consents within 500 m of the site, nineteen of which relate to permits that are now revoked. Details of the extant permits are as follows:

- Four relate to the discharge of sewage effluent by the site to the Langford Brook;
- Three relate to the discharge of sewage effluent by the site to the River Ray;
- Three relate to storm water or final/treated sewage discharge by Bicester STW to the Langford Brook;
- One relates to discharge of final/treated sewage by Wretchwick Farm to a tributary of the Langford Brook;
- One relates to miscellaneous discharges by Bicester Retail Park to a tributary of the Langford Brook;
- Two relate to discharge of final/treated sewage by Alchester House to a tributary of the Gagle Brook.

During a conversation with a representative of Kelda Water Services, the Aquatrine Contractor for the site, it was indicated that no discharge consents related to the site are still extant.

Flooding

The Surface Water Flood Map provided with the EnviroInsight Report shows that the extreme northern and western corners of the site are within Zone 2 and Zone 3 floodplains. Zone 2 floodplains are those with a greater than one in a thousand (0.1%) annual probability of

flooding, but less than one in a hundred (1%). Zone 3 refers to an annual probability of flooding of 1% or greater. There are no flood defences or areas benefiting from flood defences within 250 m of the site.

In addition, there are BGS groundwater flooding susceptibility flood areas within 50 m of the site boundary, and a high groundwater flooding susceptibility is indicated. This means that due to the underlying geology, the area groundwater flooding hazard should be considered in all land use planning decisions. The BGS confidence rating for the groundwater flooding susceptibility areas is moderately high; meaning the groundwater flooding susceptibility areas can be used with confidence.

Surface Water Sensitivity: Moderate/High

1.6.5 Ecology

The EnviroInsight Report provides details of three Environmentally Sensitive Areas (ESA) 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 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).

Ecological Sensitivity: Moderate

1.7 Additional Information

1.7.1 IPPC Authorisations

According to the EnviroInsight report, there are records of three Integrated Pollution Prevention and Control (IPPC) Authorisations within 500 m of the site. These authorisations appear to be related to two poultry farms located 233 m east and 416 m north-west of the site.

1.7.2 List 2 Dangerous Substance Inventory Sites

According to the EnviroInsight report, there are records of a List 2 Dangerous Substance Inventory Site within 500 m of the site. This relates to the Bicester STW 258 m north-west of the site and the 'authorised substance' is iron.

1.7.3 Environment Agency Recorded Pollution Incidents

According to the EnviroInsight report, there are records of two recorded pollution incidents within 250 m of the site. The first relates to a diesel spill on site on 21 April 2003 and was a Category 2 (Significant) incident with regard to the impacts to land and water. The second incident relates to spillage/discharge of 'other sewage material' on 17 April 2002 at a location 37 m north-east of the site. This incident was a Category 3 (Minor) and Category 4 (No Impact) incident with respect to the impacts to water and land respectively.

1.7.4 Waste Sites

According to the EnviroInsight report, there are records of a historic landfill 474 m north of the site boundary at NGR 458800 221900. The operator was Ploughley Rural District Council and the waste types included inert, industrial, commercial and household.

In addition, there are records of four 'other waste sites' within 1.5 km of the site, all of which are metal recycling sites. The closest site is 598 m north-east of the site boundary and is operated by McGregor Railway Services Ltd for a metal recycling site with an annual throughput of between 25 000 and 75 000 tonnes. The Waste Management License number for this site is 86100.

1.7.5 Petrol and Fuel Sites

According to the EnviroInsight report, there are records of an 'obsolete' petrol station 474 m north-east of the site boundary, which is known as Three Corners Garage. There are no further details of this site provided.

1.7.6 Archaeological Issues

According to the Multi-Agency Geographic Information for the Countryside (MAGIC) website (www.magic.gov.uk , accessed 15 January 2010) there are records of three Scheduled Ancient Monuments (SAMs) within 1 km of the site, details of which are as follows:

- Alchester Roman Site (75 m south-west of the site);
- Ambrosden Churchyard Cross (100 m to the north-east of the strip of land connecting the site and DSDC Bicester C site); and
- Wretchwick Deserted Medieval Settlement (two areas 300 m and 600 m north-east of the site).

In addition, historic mapping shows St David's Barracks to be the site of a battle between Danes and Saxons, and a roman road crossing the site in an approximate south-west to north-east orientation in the vicinity of building E15.

1.7.7 Local Authority Environmental Services Department

A response for an information request was received by Entec from Cherwell District Council Environmental Service Department (ESD) on 19 January 2010. The response is extensive, amounting to a 52 page report using information gathered from the Landmark Group and the BGS, as well as records held within Cherwell ESD.

The response includes detailed information on the site geology (including information on borehole records), hydrogeology and hydrology, naturally occurring arsenic (no naturally occurring arsenic at the site), historical mapping, infilled sites, landfill sites, licensed waste management facilities, environmentally sensitive data, sites of environmental importance and heritage sites.

The data from Landmark and BGS is noted by Cherwell ESD to be current up to 01/04/07. Therefore, it has been assumed that the majority of information provided is superseded by the emapsite™ reports, which was commissioned by Entec in January 2010. However, information

on infilled ground and pollution incidents from the Cherwell ESD has been included in this section for the sake of completeness.

'Unknown Infilled Ground' (pond, marsh, river, stream, etc.) is marked on an infilled sites plan (c.1840-1997) included with the Cherwell ESD report in four locations within the site boundary: in the west of the BIFT, to the north-west of D5, to the south-east of D8 and to the south-west of the OSU.

In addition, five historical (1987-2001) pollutions incidents are recorded on site, of which two were 'major incidents' involving spillage of oil/diesel/gas oil in the vicinity of Rodney House. Two minor current pollution incidents (2001-) are also recorded to the immediate north of D4; no further details are provided. There are also records of nineteen historical and one current pollution incidents within 500 m of the site, which generally relate to spillages of sewage, oils, fuels and poultry manure, the closest of which is almost immediately off site to the north-east of D9.

The full Cherwell ESD response is included as Annex F to this report.

1.7.8 DSTL Radiological Assessment

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

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.

The full Dstl ESD desk study is included as Annex C to this report.

1.8 Previous Assessments

1.8.1 BOD Bicester Land Quality Assessment Phase One: Desk Study, Aspinwall & Company Ltd, August 1998

This desk study, presented in three volumes (Factual Report, Interpretive Report and Land Quality Statement) covers the entire DSDC Bicester site, which is referred to in the reports as the Base Ordnance Depot (BOD) Bicester.

A number of current and historical activities/issues are identified that may give rise to contamination. Those specific to the site include the following:

- Leakages from underground fuel tanks or lines north of the BIFT freight terminal (between D & E sites), or spillage during refuelling. The reports note there were former refuelling facilities at both D and E sites;
- Leakages from current or former heating oil tanks or supply lines, including the known spills in the vicinity at the OSU (E Site) and Rodney House (E Site);
- Leakages or spills from the locomotive fuelling area at E Site;

- Suspected landfill area near building E15 (E Site). The reports also mention earth mounds between buildings on D Site which are suspected inert fill from site regrading;
- Railway siding areas where stored materials may have leaked. The reports state that a spill of 300 gallons on hydrochloric acid occurred from a rail wagon at an unknown location following a fire in 1970.

The reports also state that asbestos is present in the fabric of a number of the buildings, mainly as cement cladding or roofing. The asbestos register recommended that asbestos in 50% of the locations was replaced, which was taking place as part of an ongoing programme at the time.

It is understood from the reports that large quantities of explosive ordnance have never been stored or used at the site, although small calibre explosive ordnance could be present in near surface soils at the former range at Graven Hill.

In addition, the reports state that the only radioactive sources kept on site are night sights and related equipment at the barracks sites at DSDC Bicester, none of which are on site.

Although a number of generators and transformers were identified on site, the reports state that they have been checked and PCBs are not present.

The environmental risk assessment carried out as part of the reports concludes that the risk to current site users/workers is low, unless ground conditions are disturbed. The greatest risks identified were to surface waters, which provide a preferential route for the migration of any pollutants present in surface run-off. Groundwater pollution risks were not considered significant at the site.

In summary, Aspinwall state that the 'vast majority' of the site is unlikely to have been contaminated by historical activities, but that current activities, generally associated with fuel storage, may give rise to localised contamination of soils and surface water. It is unlikely that there would be any major constraints to further developments at the site proposed as part of ongoing operations, although there may be a requirement to remove localised sources of ground contamination prior to building construction. If the site was to be sold for redevelopment for commercial/industrial use, some limited remedial works would likely be necessary. In addition, although 'large tracts' of the site would potentially be suitable for housing with gardens, some areas of the site (particularly the depot areas) would not be suitable for housing without some form of remedial work.

1.8.2 DSDC Bicester Land Quality Assessment Phase Two: Intrusive Survey, Enviros Aspinwall Ltd, June 2001

This report, presented in two volumes (LQA Report and Technical Note) covers the potentially contaminated areas of the site identified from the previous Phase One LQA reports. These included the following, specific to the site:

- E Site landfill site;
- Freight Terminal POL point;
- OSU oil storage area.

These areas were investigated by a combination of radiological walkover survey and machine excavated trial pits (suspected landfills) and shallow window sample holes (underground storage tanks near OSU oil storage area and POL point).

Samples of soil and groundwater obtained during the investigation were compared to the relevant ICRCL and Dutch Intervention values used at the time. The results identified the following contamination:

- E Site landfill: elevated arsenic, copper, nickel and zinc as well as slightly elevated soluble sulphates and hydrocarbons;
- Freight Terminal POL point: slightly elevated phytotoxic metals, soluble sulphates and hydrocarbons;
- OSU oil storage area: slightly elevated phytotoxic metals and hydrocarbons.

In summary, the sources of contamination found included metals and soluble sulphate in Made Ground across the whole Bicester site, hydrocarbon (including PAH) contamination in ground and perched groundwater as well as localised radioactive contamination in the burning grounds. The Oxford Clay beneath the Made Ground was found to be free of contamination in the majority of areas investigated, and the perched groundwater was not thought to be in continuity with the regional aquifer beneath the Oxford Clay. Explosive ordnance was not considered a source of contamination based on information obtained during the Phase One LQA and observations made during the Phase Two investigation.

The environmental risk assessment undertaken as part of the reports concluded that the risks to all environmental receptors based on continuing current use is low or negligible. Under a more sensitive end use, such as housing with gardens, the environmental risks are assessed as low to moderate.

In summary, Aspinwall consider that the areas investigated are generally unsuitable for redevelopment to a domestic end use without remediation, although the majority of the site is potentially suitable for redevelopment to sensitive end uses.

1.8.3 DSDA Bicester - Graven Hill Depot - D Site and E Site Draft Phase I Land Quality Assessment. DE&S Environmental Science Group, February 2010

A copy of this draft Phase 1 LQA report, produced internally to MOD by DE&S ESG, was received by Entec close to the time of finalisation of this Entec draft Phase 1 LQA report. Therefore, the above draft report has only been subject to a brief review by Entec.

In summary, a total of seven ‘areas of potential contamination’ (three within D Site, three within E site and one off site source) were identified, as follows:

- Above ground storage tanks and apparatus adjacent to Buildings D2 and D6;
- Former POL point located to the north-west of Building D9;
- Building D11 vehicle wash down area;
- Locomotive POL point adjacent to Building E16;

- Redundant above ground storage tanks and ancillary apparatus adjacent to building E3;
- Fire training area (building E20);
- St David's Barracks (offsite), with particular reference to vehicle storage and workshops within the barracks.

The above areas of potential concern were considered to represent a moderate risk to surface water receptors only.

It is important to note that the DE&S ESG draft report assumes there are no current plans for divestment of the site, and the OSU, BIFT and Rodney House are not included within the area studied in the draft DE&S ESG report.

In addition, it should be noted that all of the areas of potential contamination highlighted in the DE&S ESG draft report are considered within this Entec Phase One LQA, with the exception of the building D11 washdown area. This washdown area was not noted during the Entec site walkover and does not appear to exist according to recent Google Earth imagery. Given that a washdown area was noted during the Entec walkover adjacent to building D12, approximately 200 m south-west of D11, it is possible that DE&S ESG may be confusing the location of the washdown area. Page 21 of the DE&S ESG draft report notes: *'Building D11 houses the site's former fire station and the adjacent Building D12 the workshop and stabling for Barlow World, MHE contractor. The building was equipped with vehicle lifts and a wash down area'*. Therefore, it has been assumed that DE&S are referring to the building D12 washdown area, which is considered within this Entec Phase One LQA.

The draft DE&S ESG report concludes that the majority of the site is unlikely to be contaminated by historical or current practices/processes. DE&S ESG consider it unlikely that there will be any limitations put on further redevelopment of the site, although a number of areas (as outlined above) were identified where potential contaminants may pose unacceptable risks to sensitive receptors.

Recommendations were put forward by DE&S ESG. These include the following:

- Cleaning/decommissioning of above ground storage tanks at buildings D2/D6;
- Cleaning/decommissioning of former POL point at D9 and a soil vapour probe hole survey;
- Determination of the drainage system for the building D11 (D12) wash down area and establishment of whether or not an interceptor is fitted to the system;
- Paving and limited intrusive investigation of the building E16 locomotive POL point;
- Decommissioning of the above ground storage tanks at building E3 and a soil vapour probe hole survey;
- Limited intrusive investigation of the building E20 fire training area;
- Routine inspection of the boundary between St David's Barracks and the site to identify if any migration of any contaminative material occurs across the site boundary.

In addition, DE&S recommend that pipes running between the recent oil storage tanks and containerised boiler plants should be provided with some form of containment bunding to ensure compliance with the Control of Pollution (Oil Storage) (England) Regulations 2001.

1.9 Historical MOD Practices

1.9.1 On Site

During the development and function of the site, historical MOD practices and activities may have led to contamination issues. The site has had a generally consistent land use since development in the 1940s. Potential activities that may have led to contamination include the following:

- Unrecorded disposal of waste materials in the ground. The MOD historically tended to opt for local waste disposal practices;
- Burning grounds and disposal of ash/clinker waste, often to ground, as an aggregate material;
- Demolition of former buildings which may have contained Asbestos Containing Materials (ACMs) and subsequent retention of some demolition rubble as fill or founding aggregate;
- Use and storage of fuels, oils and other chemicals, potentially including the historical unspecified tanks on site;
- Workshops and maintenance facilities, which may have handled fuels, oils and/or other chemicals along with hazardous materials such as asbestos brake pads;
- Use and storage of limited quantities of explosive ordnance probably relating to small arms (for guard/defence personnel);
- Former district heating system including stand-alone boiler houses, solid fuel store and associated infrastructure;
- Railway lines, which can be constructed using ash/clinker as a ballast material which could potentially be contaminated from spills of fuels/oils or other chemicals from locomotives and other rolling stock;
- Electrical distribution substation transformers that are likely to have contained polychlorinated biphenyls (PCBs).

1.9.2 Off Site

Historically, land at and surrounding the site has been used for residential, agricultural, transport (road and rail) and various MOD activities (St David's Barracks, the former firing range and the other component sites of the whole DSDC Bicester site).

The above various MOD activities are assessed in the 1998 Aspinwall Phase One LQA, which mentions that limited quantities of small arms ammunition and radioactive sources (night sights and related equipment) are stored at the St David's Barracks site and that small arms ammunition is likely to have been used at the former firing range. The rest of the DSDC

Bicester site is discussed in detail in the Aspinwall Phase One LQA, which describes a number of potential issues related to use and storage of fuels and oils, infilled areas and burning grounds, potential radiological contamination and possible small arms ordnance. However, the Aspinwall Phase One LQA concludes that the vast majority of the DSDC Bicester site is unlikely to have been contaminated by historical activities.

Historical construction and demolition activities of MOD buildings in the vicinity may have resulted in the presence of some demolition rubble. This could potentially include asbestos containing materials.

2. Sources of Information

2.1 Sources of Information

The following sources of information have been used to inform the Land Quality Assessment and have been selected based on the requirements contained in the following MOD documents and from Entec experience of undertaking LQAs:

- Land Quality Assessment (LQA) Management Guide, Defence Estates, April 2007;
- Detailed Statement of Requirement (LQA Directive), Ref: 27/104/3/TBC dated 30/10/2009.

Public Domain and Non-MOD Sourced Information:

- General mapping/plans: recent and historical;
- BGS Digital Geological mapping;
- Hydrogeology mapping and Groundwater Vulnerability mapping;
- emapsite™ GroundSure data search (GeoInsight and EnviroInsight reports);
- 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;
- Multi-Agency Geographic Information for the Countryside (MAGIC) website www.magic.gov.uk.

Specialist Data Searches:

- A search of records relating to any radiological contamination issues was requested from Dstl ESD. The letter response was received on 5 February 2010, reference ESD/AS/490158 /ENTEC/SH and is included as Annex C;
- An Explosive Ordnance Threat Assessment (EOTA) was commissioned through BACTEC. The report was received on 2 February 2010, reference 3063TA and is included as Annex B.

Site and MOD Sourced Information:

- 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;
- OS Tiles provided by DE Geographical Information Unit.

Site Visit Information:

- Observations, notes and review of site and on-site documents observations, notes and review of site documents including the site building list;
- Photographs and visual assessment of the site and surrounding area.

Information on site conditions was provided by staff that appear to have a good knowledge of the site and its operation.

2.2 Presentation of Data within Report

Information is contained in the following annexes:

- Annex A Site Photographs;
- Annex B Explosive Ordnance Threat Assessment;
- Annex C Dstl Radiological Information Letter Response;
- Annex D Selected Historic Aerial Photographs;
- Annex E emapsite™ GroundSure reports;
- Annex F Local Authority Correspondence;
- Annex G Environmental Risk Assessment Table.

2.3 Gaps in Information

The following gaps in information were encountered during the preparation of this report. The availability of any of this data may alter the information available to this report, the interpretation of information already held, and may change the overall findings and conclusions of this report.

Table 2.1 Summary Table of Gaps in Information

Information	Not Known	Not Found	Not Examined (reason)	Not Relevant
Site Asbestos Registers			Asbestos Register - Information requested but not made available. New asbestos survey currently in progress, to be reported on in June 2010	

Note on terminology:
Not known: no data available.
Not found: looked for or requested in this assessment but not located.
Not examined: information known to be available but excluded for specific reason (lost, withheld, awaited).
Not relevant: where an item of information is not relevant to the property as a matter of fact.

3. Sources of Contamination

3.1 Historical On-Site Issues

The following areas of concern, relating to historical uses of the site from a contaminated land perspective, are described below and shown on Figure 3.

3.1.1 Former Boiler House and Associated Infrastructure

Building E14 is the former boiler plant for the (now disused) district heating system. According to the *Bicester Military Railway* book, the boiler houses were originally coal-fired, were subsequently converted to oil and finally new coal-fired equipment was fitted in 1985/1986. The coal was supplied directly to the boiler house from rail wagons, and the oil was understood to be supplied form the two large above ground tanks that are still in-situ to the north of E14 (see Annex A Plate 6). The boiler house and district heating system was replaced with new modular oil-fired boilers at each of the larger warehouse buildings some time after 1998.

Directly to the south of E14 is a large (approximately 60 x 30 m) empty concrete coal storage bunker. The bunker appears to be constructed of steel-reinforced concrete which appears to be in a relatively good condition. Surrounding the boiler house is sealed concrete hardstanding which appears to be in generally good order, although some plants are growing through some of the seals between the concrete slabs.

The site Estate Development Plan states in Section 16.26 that: *'It is understood that the decommissioning certificates for the boilerhouses are held by Defence Estates/PRIDE.'*. These certificates were not available for inspection at the time of writing.

There is an extensive network of (now disused) above ground pipelines over the site which distributed steam from the boiler houses to the site buildings. These pipes are lagged with a material that appears to be glass fibre (see Plate 4 of Annex A). During an interview during the site visit, the Site Manager indicated that this lagging material had been tested and was not asbestos, although test certificates were not available.

Due to the generally good condition of the surfacing in the vicinity of the now understood to be decommissioned former boiler house and nature of the materials likely to have been used to lag the above ground heating pipes, this potential source has not been carried forward into the risk assessment.

3.1.2 Former Vehicle Fuelling Areas

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 building D18 to the north-west of D9, both of which are marked as a filling stations. Both of the facilities have been subsequently demolished and are now car parks. According to the Aspinwalls Phase One LQA factual report, the nature of decommissioning of these facilities is not recorded. Therefore, these areas have been carried forward into the risk assessment.

3.1.3 Former Railway Workshops

The *Bicester Military Railway* book makes reference to a Royal Electrical and Mechanical Engineers workshop used for metal turning of steam locomotive parts at D11. On the undated site plan included in this book, D11 is marked as the current D9. On the same plan D6 is marked as the 'REME former heavy lift shed'. No further information was available on either of these former workshops at the time of writing, and neither former workshop is mentioned in the Aspinwalls Phase One LQA. Both of these buildings are now warehouses, storing clothing and textiles. During the site walkover, there was no evidence of either buildings former use as workshops. However, given that these buildings were formerly used as REME workshops, they have been carried forward into the risk assessment.

3.1.4 Demolished Buildings

Evidence of several former structures was evident during the site walkover, including the areas of demolished bolero buildings to the south-east of D4 and D7 and to the north-west of E2, along with the small demolished buildings to the north of D3 and opposite D11.

The bolero buildings are understood to have been used for general storage, and the other smaller demolished buildings are likely to have been small stores, garages or offices. Due to the limited extent of these structures, the lack of evidence of vegetation dieback in the vicinity, the typical all-metal construction of these buildings and the nature of the items that are likely to have been stored within them (non-hazardous dry goods), these former structures have not been carried forward into the risk assessment.

3.1.5 Former Above Ground Tanks

Along the south-eastern wall of E1 are two disused square concrete bunds, one of which has a broken base. There is no evidence of staining within these bunds and the tanks have been removed. Consequently, these former tanks are not considered further and have not been carried forward into the risk assessment.

3.1.6 Fire Training Building

Building E20 is a single storey partly collapsed derelict brick building, signposted as 'fire training area'. There is a former coal storage yard at rear of building, which is now empty and has a concrete floor in generally good condition. On the brick wall surrounding the coal storage yard is a sign that reads: *'fuel 3500 sec cap 54552 ltrs'* with a small concrete bund below (see Annex A Plate 5). This is likely to relate to the filling point for a heavy fuel oil tank. There is no evidence of an above ground fuel tank in the vicinity, therefore the sign is likely to relate to an underground storage tanks or a (now removed) above ground storage tank. In addition, rusty drums of lubricants, paints and oil are loosely stored in part of the now derelict building.

Due to the likelihood of historic fuel storage and usage in the vicinity of this building, and the ad-hoc nature of the storage of potential contaminants, Building E20 has been carried forward into the risk assessment.

3.1.7 Waste Disposal

To the north-west of E15 is a heavily vegetated and wooded area with very uneven ground in places (see Annex A Plate 8). This area is understood to be a former tipping area, with evidence of broken 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. In comparison to the surrounding ground, it would appear that the ground level is approximately 2-3 m higher in the tipping area, indicating a possible land raise of 2-3 m of tipped materials. The area bisected by a south-west to north-east trending drainage ditch, which appeared to be relatively clean during the site walkover.

The 1998 Aspinwalls Phase One LQA interpretative report indicates that this area was tipped over prior to the 1980s. The area was investigated during the subsequent Aspinwalls 2001 Phase Two LQA, the scope of which included a limited radiological walkover survey (due to the dense nature of vegetation) with a Mini Instruments 900 series rate meter connected to a 44B probe and excavation of 5 No. trial pits to a depth of 4 m bgl. The results of the investigation revealed elevated metals and slightly elevated sulphates and hydrocarbons within soil samples, but no radiological readings above twice that of background levels (8-11 counts per second).

Due to the above, the E15 tipping area has been carried forward into the risk assessment.

3.2 Historical Off-Site Issues

A 500 yard rifle range is marked on historic maps from 1898 and 1920 to the west of E2, with the rifle targets and butts marked within an area of the present day St David's Barracks. Small arms ammunition is likely to have been used at the former firing range. Given the possibility of a potential pollutant linkage via surface water drainage between the rifle targets and butts and the site, and the proximity of this potential source to the site the rifle range has been carried forward into the risk assessment.

Historical construction and demolition activities of MOD buildings in the vicinity may have resulted in the presence of some demolition rubble. This could potentially include ACMs. Given the proximity of this potential source, it has been carried forward into the risk assessment.

According to the EnviroInsight report, there are records of a historic landfill 474 m north of the site boundary. The operator was Ploughley Rural District Council and the waste types included inert, industrial, commercial and household. In addition the report provides records of an 'obsolete' petrol station 474 m north-east of the site boundary, which is known as Three Corners Garage. No further details of this site are provided. Given the distance of the historic landfill and obsolete petrol station to the site, and the low permeability of the geological strata beneath the site limiting the potential for dissolved or gaseous contaminant migration, these potential sources have not been carried through into the risk assessment.

3.3 Current and Recent On-site Operations

3.3.1 Railway Lines and Associated Infrastructure

There is an extensive network of railway lines and associated infrastructure (including platforms, sheds and sidings) across the site that was built in the early 1940s and remains to the present day. Waste materials, including clinker, slag and ash may have been used in the construction of railway tracks and sidings. The *Bicester Military Railway* book states in Chapter 7 (Maintenance of the Permanent Way) that: *'Ash, a readily available waste product of the steam age, was used as ballast. During the hasty construction period this was more easily*

unloaded and packed by hand shovels than stone ballast which, at the time, was difficult to obtain in large quantities'. The chapter goes on to state that the ash was laid directly on the underlying clay.

According to the *Bicester Military Railway*, steam locomotives were used on the site from original construction in the 1940s through to the 1960s when the steam locomotives were replaced by 6 No. diesel hydraulic locomotives in 1965.

It is understood from site railway staff that much of the track at the site was replaced in 2007 in a programme to upgrade the Bicester site-wide rail network. This work was undertaken by Volker Rail. According to their website (www.volkerrail.co.uk , accessed 18/02/2010), *'the project commenced in late 2007…works were initiated to bring the east sidings up to modern standards, replacing 1940´s 75lb flatbottom rail on lightweight concrete and 1st generation steel sleepers, bedded in ash ballast...The redundant tracks were removed in panels using large telehandlers to load the panels to MOD flat wagons before being moved to the internal stockyard location for transhipping to empty lorries (used for delivering concrete sleepers to site) for return for re-use and recycling. The formation was graded using a laser controlled dozer with the redundant ash/ballast mix being transported to an internal stockyard for subsequent re-use on site in 30 tonne dumpers.'*

Currently it has not been possible to establish the precise location of the 'internal stockyard', although a large (approximately 3 m high) soil/stone bund was noted during the site walkover, along with piles of concrete and wooden sleepers in the vicinity of one of the two demolished bolero areas to the south-west of D7.

In addition, a copy of the Project Completion Report for the rail upgrade works (Defence Estates Contract SERP/1001/15, Rider Levett Bucknall, 25/06/09) was requested from DE. On page 9 of this report is a section on Sustainability/KPI which states that: '*The table above also includes the tonnage of materials either recycled* [400 tonnes] *or disposed to land fill* [600 tonnes]*. It should be noted that the latter actually was tipped on site within DCSA Garrison for future use as granular fill.'* It is assumed that at least a proportion of the 'waste' referred to in the above statement includes spent or fouled ballast, as on page 7 of the report it states that: '*Spent or fouled ballast or other material was excavated and removed'*.

The main contaminants arising from railway running lines include polycyclic aromatic hydrocarbons (PAHs), metals, herbicides and potentially asbestos. Fuel oils, lubricating oils, PCBs, greases, and solvents may also be present in areas where locomotives have stood for longer periods of time, such as sidings to the south-west of the locomotive shed E16.

Due to the low solubility (and therefore mobility) of PAHs, it is likely that PAHs and metals from running lines would only affect the immediate vicinity around the railway infrastructure present on site. In the past, herbicides such as atrazine and simazine have been used to control weeds on tracks and embankments, but even with worst case soil conditions it is likely that residual contamination will have disappeared within 5-10 years. However, given the extensive nature of the railway network across the site, and the likely storage of spent ash ballast on site, this potential source has been carried forward into the risk assessment.

3.3.2 Maintenance Workshops

A number of maintenance workshops were noted during the site walkover, as follows:

- Building D12 is maintenance workshop for forklift trucks and other mechanical handling equipment. The building stores minor quantities of greases, oils and other chemicals generally on drip trays. In addition, many car-type batteries for electric forklifts were noted throughout the building within metal trays. In a shed opposite D12 is a four-post hydraulic ramp with a good condition, but stained, concrete floor. Within this shed are modern plastic containers used to store used oil filters and oily plastics. Waste oils are kept in steel drums on drip trays. The adjacent stained concrete wash down area is protected by an interceptor. To the north-east of D12 is a small concrete building that used to be used to store waste oil from D12. Although it was not possible to access this building during the walkover, there was no sign of any obvious staining in the vicinity;

- Building E16 (loco shed) - within the loco shed are drums of OMD-90 (engine oil), AL-39 (antifreeze) and other lubricants, greases, etc. Drums are generally stored on drip trays. In addition, there are two concrete lined inspection pits which drain to an interceptor.

Due to the interceptor protection of both workshops and the limited quantities of fuel, oils and other chemicals present which appear to be stored in an appropriate manner, these workshops have not been carried forward into the risk assessment.

3.3.3 Petrol, Oil and Lubricants

There are several fuel storage tanks distributed across the site, as follows:

- Building D2 - brick bunded 10 000 litre capacity above ground DIESO tank and wall-mounted small DIESO tank with broken brick bund beneath. The brick bunding around the larger tank appears to be in good condition but is half full of clean looking water The wall beneath the wall mounted DIESO tank is heavily stained, although the ground surrounding the broken brick bund does not appear to be stained (see Plates 9 and 10 in Annex A);

- Building D6 - brick bunded 10 000 litre capacity above ground DIESO tank and wall-mounted small DIESO tank with brick bund beneath. The brick bunding around the larger tank appears to be in good condition but is part full of clean looking water and has a heavily stained filling point. The brick bund beneath the wall-mounted tank looks in good condition and is dry;

- Grounds maintenance contractors compound in north-east of E Site with large modern above ground fuel tanks that appear to be self-bunded;

- Most of the larger warehouse buildings have a modern self-bunded 20 000 litre capacity 3/50 FFO heating oil tanks connected to a modern ISO-contained boiler with either an above-ground or buried pipes (see Plate 2 of Annex A). This system provides heat to the buildings replacing the older site wide District Heating System;

- Building E3 - brick-bunded empty 1300 litre DIESO above ground tank. The brick bund is in a poor condition (see Plate 1 in Annex A);
- Building E14 - brick bunded 12 000 litre DIESO tank which appears empty. The bund appears to be in reasonable condition but is overgrown. There are also two very large concrete bunded 413 680 litre capacity FFO tanks which appear to be well maintained. The concrete bund is part full of clean-looking water. It is anticipated that that tanks were used to provide fuel to the oil-fired boilers in the adjacent boiler house;
- Building E16 - there is a small brick POL store to the immediate south of the E16 loco shed along with a concrete bunded 9000 litre capacity above ground gas oil tank (see Plate 7 in Annex A) and fuel dispenser for refuelling the site diesel locomotives;
- BIFT - there are 2 x 33 000 litre capacity underground fuel storage tanks at the BIFT POL point. This POL point was investigated by Aspinwalls as part of the site Phase Two LQA in 2001, which included the drilling and sampling of 6No. window sample boreholes to 2 m bgl. The results of the laboratory analysis revealed slightly elevated phytotoxic metals, soluble sulphates and hydrocarbons in the soil samples obtained;
- Rodney House (far north of the site) - there is a bunded above ground Gas Oil tank within this area of the site. Staining was noted during the site walkover at the tank fill point, which is located outside of bund. The inside of the bund holds some water with no visible sheen. The tank has some corrosion but generally looks to be in a reasonably good condition. It should be noted that two 'major incidents' involving spillage of oil/diesel/gas oil in the vicinity of Rodney House have been previously recorded;
- OSU - the 1998 Aspinwalls Phase One LQA factual report notes 3 No. heating oil tanks at the OSU. Due to an oil spill at this location in July/September 1994, this area was investigated during the Aspinwalls Phase Two LQA in 2001 with 4 No. window sample boreholes. The results of the analysis revealed slightly elevated phytotoxic metals and hydrocarbons in the soil samples obtained.

All of the above fuel storage tanks have been carried forward into the risk assessment.

In addition, many empty DIESO, kerosene and UKGAS metal jerry cans were noted stored within racking on hardstanding to the north-east of E1 which is understood to be interceptor protected. Some of the empty jerry cans are stored within a modern bunded fuel locker. Due to the interceptor protection and good condition of the containers, the E1 fuel storage area has not been carried forward to the risk assessment.

POL Stores

There is a small brick POL store to the immediate south of the E16 which appears to be disused and appears to have been replaced with a small modern steel hazardous store directly opposite. In addition, modern 'COSHH lockers' were noted adjacent to some of the buildings, including the D11 former fire station. Owing to the modern construction and robust nature of these containers, they are not considered further into the risk assessment.

Fuel/Oil/Chemicals Containers

A 200 litre drum of Gas Oil was noted during the site walkover on bare ground on the western side of E2. In addition, a yellow 25 litre container marked 'TM' was noted during the walkover in the former coal bunker to the south of E14. Four blue drums with unknown contents were also noted on hard standing on the western side of the building during the site walkover, along with a drum of antifreeze on unpaved ground near D16 and three drums of wood preservative on unpaved ground in Engineers Store 3 adjacent to building D1. Given that none of the above containers have appeared to have leaked and the limited quantities contained, they are not considered further into the risk assessment.

3.3.4 Oil Water Interceptors

Several oil water interceptors are located across the site and are situated at zones prone to hydrocarbon spillage, such as the fuel locker near E1 and the loco shed E15. Where a risk of hydrocarbon spillage is expected, the local site drainage is directed to the nearest interceptor. All infrastructure associated with the interceptors is maintained and managed through the Project Aquatrine Contractors, Brey Utilities (a joint venture between Kelda Water Services and Earth Tech Engineering). The interceptors were all observed as below ground structures, and no anecdotal evidence was provided by the site describing the condition of the interceptors. Due to the limited information available on the condition of the interceptors, they have been carried forward into the risk assessment.

3.3.5 Disturbed Ground

The areas of Made Ground that were observed during the site visit include the following:

- Large grassy mounded area between D6 and D9. 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;
- Large (approximately 3 m high) soil/stone bund noted during the site walkover in the vicinity of one of the two demolished bolero areas to the south-west of D7. This material is understood from conversations with site staff to be the surplus ash ballast material from the recent railway line upgrade;
- Large area of raised/infilled land (3 m high by 5 m wide by 50 m long) on the south-western boundary of the BIFT.

These areas of Made Ground have been carried forward into the risk assessment.

3.3.6 Distribution Substations and Transformers

There are many distribution substations (DSS) across the site; each of the large warehouse buildings appears to have at least one DSS. They all appear to be in good order with no obvious signs of leaks (see Plate 3 in Annex A). However, the ground within the DSS compounds has recently been covered with gravel, making it difficult to check for signs of previous leaks. During the site walkover, contractors were noted on site replacing some of the transformers and laying down gravel. They do not recollect there being any obvious signs of major leakage at any of the DSS. According to the contractors, transformers within the DSS compounds are

replaced as soon as there is the slightest indication of any leakage onto their respective concrete plinths.

PCBs are known to have been used historically within electrical equipment and smaller units would have held minor quantities. PCBs have generally been withdrawn from use in external transformers. The 1998 Aspinwalls Phase One LQA factual report states that *'information supplied by the Works Services Manager (WSM) indicates that the substations and transformers have all undergone coolant change in the past five years, and that there are therefore no polychlorinated biphenyl (PCB) containing coolants on site. The WSM is not aware of any historic spills or leaks of coolants at substation or transformer sites.'*

Owing to the above, the limited quantities of oils contained within the transformers, the low mobility of PCBs and the negligible permeability of the underlying strata, the DSS are not considered further into the risk assessment.

3.3.7 Asbestos within Structures

Buildings constructed pre 1990 are generally expected to have been built with some asbestos containing material prior to the UK Asbestos Regulations (1985) which prohibited the use of all forms of asbestos. Although many of the buildings at the site were modernised with fire protection systems around 15 years ago, some still contain substantial amount of asbestos, which is labelled and managed using individual building asbestos registers, which were not available for review by Entec at the time of writing of this report. However, an updated asbestos survey is understood to be currently in progress and will be reported on in June 2010.

3.3.8 Emergency Water Supplies

The site has several large volume water underground storage tanks (USTs) used as an emergency source of water in the event of a fire. These are not considered to present significant potential sources of contamination and are therefore not considered further.

3.3.9 Radiation Sources

The 1998 Aspinwalls Phase One LQA factual report states that *'no radioactive substances are held on site. The only items utilising small radioactive sources are night sights and related items, small quantities of which at kept at the Barracks sites. These are routinely inspected by an officer from BOD Donnington'*.

The Dstl ESD desk study report includes a search of records relating to any radiological contamination issues at the whole DSDC Bicester site. The desk study concluded that the likelihood of contamination being present on parts of 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.

The E15 waste tip and areas of Made Ground identified on site have been carried forward into the risk assessment with regard to potential radiological contaminants.

3.4 Current and Recent Off-site Operations

According to the EnviroInsight report, there are records of three IPPC Authorisations within 500 m of the site, related to two poultry farms located 233 m east and 416 m north-west of the

site. Given the distance of the poultry farms to the site and the low permeability of the geological strata beneath the site limiting the potential for dissolved or gaseous contaminant migration, these potential sources have not been carried through into the risk assessment.

In addition, the EnviroInsight report notes the Bicester STW approximately 258 m north-west of the site as a 'List 2 Dangerous Substance Inventory Site' related the iron as an 'authorised substance'.

The EnviroInsight Report also notes four 'other waste sites' within 1.5 km of the site, all of which are metal recycling sites. The closest site is 598 m north-east of the site boundary and is operated by McGregor Railway Services Ltd for a metal recycling site with an annual throughput of between 25 000 and 75 000 tonnes. Given the distance of these waste sites to the site, and the low permeability of the geological strata beneath the site limiting the potential for dissolved or gaseous contaminant migration, these potential sources have not been carried through into the risk assessment.

There are records of two recorded pollution incidents within 250 m of the site boundary according to the EnviroInsight Report. The first relates to a diesel spill on site to the immediate north of building D4 on 21 April 2003 and was a Category 2 (Significant) incident with regard to the impacts to land and water. The second incident relates to spillage/discharge of 'other sewage material' on 17 April 2002 at a location 37 m north-east of the site in the vicinity of Langford Park Farm. This incident was a Category 3 (Minor) and Category 4 (No Impact) incident with respect to the impacts to water and land respectively. In addition, nineteen historical (1987-2001) and one current (2000-) pollution incidents are recorded on site in the response from Cherwell DC within 500 m of the site, which generally relate to spillages of sewage, oils, fuels and poultry manure, the closest of which is almost immediately off site to the north-east of D9.

Land at, and surrounding, the site continues to be used for various MOD activities including barracks (St David's Barracks) and the other component sites of the DSDC Bicester site. These MOD activities are assessed in the 1998 Aspinwall Phase One LQA, which mentions that limited quantities of small arms ammunition and radioactive sources (night sights and related equipment) are stored at the St David's Barracks site. The rest of the DSDC Bicester site is also discussed in detail in the Aspinwall Phase One LQA, which describes a number of potential issues related to use and storage of fuels and oils, infilled areas and burning grounds, potential radiological contamination and possible small arms ordnance. However, the Aspinwall Phase One LQA concludes that the vast majority of the DSDC Bicester site is unlikely to have been contaminated by historical activities. Given the proximity of particularly the St David's Barracks to the site, military land use near, or adjacent, to the site has been carried forward into the risk assessment.

4. Preliminary Qualitative Risk Assessment

4.1 Approach

4.1.1 Legislative Framework

The potential risks and liabilities associated with contaminants identified 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 regulatory regime for defining, identifying and remediating contaminated land is Part 2A of the Environmental Protection Act (EPA) 1990. It was introduced in England in April 2000 by the Contaminated Land (England) Regulations 2000, which were later 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.

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 and groundwater. According to the Act, 'contaminated land' is defined as:

> *"any land which appears to the local authority in whose area it is situated to be in such a condition, by reason of substance in, on, or under the land that:*
>
> - *Significant harm is being caused, or there is significant possibility of such harm being caused; or*
> - *Pollution of controlled waters is being, or is likely to be caused."*

Where harm is attributable to radioactivity, the definition of contaminated land has been modified as:

> *"any 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 the land, that:*
>
> - *Harm is being caused, or*
> - *There is a significant possibility of such harm being caused."*

The following situations are defined where harm is to be regarded as significant:

i) Death, disease, serious injury, genetic mutation, birth defects or the impairment of reproductive functions of humans;

ii) Irreversible or other substantial adverse change to an ecological system, or harm which affects any special interest and which endangers the long term maintenance of the population of that species;

iii) Structural failure, substantial damage, or interference with the right of occupation of buildings;

iv) Death, serious disease or other physical damage to livestock or crops;

v) The pollution of controlled waters.

Central to the Part 2A regulatory approach is a rigorous procedure of risk assessment which is used to determine whether land meets the definition of 'contaminated land' in accordance with the Statutory Guidance. Under the risk assessment procedure for such harm to humans, the environment or pollution of controlled waters to be possible, there must be a 'pollutant linkage', as follows:

- A **Source** of pollution (Hazard);
- A **Pathway** for the pollutant to move from source to receptor;
- A **Receptor** (Target) which is affected by the pollutant. This includes human beings, other living organisms, controlled waters, physical systems and built structures which could be affected by the hazard.

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.

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 fulfill 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.

4.1.2 Assessment Framework

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 below:

Table 4.1 Tiered Framework

Tier 1: Preliminary Risk Assessment	• Development of a conceptual model; • Preliminary Risk Assessment examining potential contaminants, pathways and receptors to identify the potential 'pollutant linkages'; • Identification of further risk assessment requirements.
Tier 2: Generic Quantitative Risk Assessment (GQRA)	• 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; • Identification of further risk assessment or risk management requirements.
Tier 3: Detailed Quantitative Risk Assessment (DQRA)	• Refinement of site conceptual model which may require the collection of additional data; • Application of detailed quantitative risk assessment procedures in accordance with CLR Guidance to further assess potential pollutant linkages: - 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); - 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. • To undertake the assessment proprietary software such as RISC4, RBCA or RAM may be used; • Identification of further risk assessment or risk management requirements.

In general the application of increased tiers of analysis will result in less conservative remediation targets resulting in less costly remedial action. Therefore the cost for increased tiers of assessment is justified where remediation liabilities are potentially high and less costly solutions can be established as acceptable by detailed risk assessment.

This report is based upon a Tier 1 assessment. No quantitative data is available for this site and therefore only the qualitative contaminant→pathway→receptor assessment has been undertaken.

The contaminant→pathway→receptor relationship allows an assessment of potential environmental risk to be determined based on the nature of the source, the degree of exposure of a receptor to a source and the sensitivity of the receptor. On this basis an assessment is made of the environmental liabilities associated with the risk. These can be expressed, for example, in terms of: additional costs associated with site redevelopment or remedial measures; the potential for costs, fines or penalties imposed for breaches of environmental legislation or third party claims; and loss of land value.

The identified potential environmental liabilities have been evaluated with respect to the potential for:

- Impacts on current and future site users;
- Impacts on construction and maintenance workforce;
- Impacts on neighbouring site users;
- Impacts on site buildings and buried services;

- Impacts on groundwater;
- Impacts on surface water bodies;
- Impacts on ecological receptors.

4.2 Summary of Potential Contamination

4.2.1 On Site Sources

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;
- Made Ground: stockpile(s) of ash ballast materials.

4.2.2 Off Site Sources

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;
- Military use (particularly the adjacent St David's Barracks)

4.3 Receptors and Pathways

Potential receptors and pathways from identified sources to receptors are as follows:

Table 4.2 Potential 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

4.4 Environmental Risk Assessment

The preliminary risk assessment and conceptual model have identified a number of potential pollutant linkages (contaminant-pathway-receptor linkages) on the site. These are tabulated in Annex G. Each pollutant linkage has been qualitatively assessed using the following criteria:

i) Potential consequence of pollutant linkage;

ii) Likelihood of pollutant linkage; and

iii) Risk classification.

The '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 source 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 criteria are set-out in Table 4.3.

Table 4.3 Risk Assessment Criteria

Potential Consequence of Contaminant (Source)-Receptor Linkage	
Severe	Acute risks to human health. Short-term risk of pollution of sensitive water resource (e.g. major spillage into controlled waters). Impact on controlled waters e.g. large scale pollution or very high levels of contamination. Catastrophic damage to buildings or property (e.g. explosion causing building collapse). Ecological system effects – irreversible adverse changes to a protected location. Immediate risks.
Medium	Chronic risks to human health. Pollution of sensitive water resources (e.g. leaching of contaminants into controlled waters). Ecological system effects - substantial adverse changes to a protected location. Significant damage to buildings, structures and services (e.g. damage rendering a building unsafe to occupy, such as foundation damage).
Mild	Non-permanent health effects to human health. Pollution of non-sensitive water resources (e.g. pollution of non-classified groundwater). Damage to buildings, structures and services (e.g. damage rendering a building unsafe to occupy, such as foundation damage). Substantial damage to non-sensitive environments (unprotected ecosystems e.g. crops).
Negligible	Non-permanent health effects to human health (easily prevented by appropriate use of PPE). Minor pollution to non-sensitive water resources. Minor damage to non-sensitive environments (unprotected ecosystems e.g. crops). Easily repairable effects of damage to buildings, structures, services or the environment (e.g. discoloration of concrete, loss of plants in a landscaping scheme).
Likelihood of Contaminant (Source)-Receptor Linkage	
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.
Potential Significance	
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 worse normally be mild.
Negligible	Low likelihood that harm could arise to a receptor. Such harm unlikely to be any worse than mild.

The potential significance for each Contaminant-Receptor Linkage is calculated from the following matrix (Table 4.4):

Table 4.4 Potential Significance of Contaminant-Receptor Linkage Matrix

Matrix		Likelihood			
		High Likelihood	**Likely**	**Low Likelihood**	**Unlikely**
Potential consequence	**Severe**	Very High	High	Moderate	Moderate/Low
	Medium	High	Moderate	Moderate/Low	Low
	Mild	Moderate	Moderate/Low	Low	Negligible
	Negligible	Moderate/Low	Low	Negligible	Negligible

Figure 3 shows the areas of potential contamination and Figure 4 shows the accompanying Conceptual Model for the site.

An environmental risk assessment for the site is included in Annex G, which comprises an analysis of potential pollutant linkages (source-pathway-receptor) on the site.

4.4.1 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.**

4.4.2 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.

4.4.3 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**.

4.4.4 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.

4.4.5 Groundwater

According to the Aquifer and Abstraction License Map provided in the EnviroInsight Report, almost the entire site is underlain by a Non-Aquifer (Negligibly Permeable), 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 Minor (Secondary) Aquifer (High Leaching Potential), which is likely to be related to the alluvial deposits in these areas. 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 Minor (Secondary) Aquifer.

4.4.6 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.

4.4.7 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**.

4.4.8 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**.

4.4.9 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.

5. Conclusions

5.1 Potential Site Contamination

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

On site sources relate to former and current areas of fuel storage and handling, including POL stores and points (fuel tanks and refuelling areas), along with the former railway workshops and fire training building, areas of tipping and Made Ground and the site-wide railway network. Off site sources include the former firing range along with the sewage treatment works and other areas of the DSDC Bicester site and St David's Barracks.

Most of the above identified sources are generally likely to be limited in their extent, with the exception of the site-wide railway network, which has recently been upgraded.

5.2 Environmental Risks

The risks to most human receptors, including current site users/visitors, construction and maintenance workers, future residential/commercial/industrial users and neighbouring site users have been assessed in the range of **moderate** to **low**, with the **moderate** risks generally associated with future residential users and construction/maintenance works from 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.

There is a generally **negligible** risk for contaminant migration to groundwater due to the generally negligible permeability strata beneath the site, with a **moderate/low** risk associated with the suspected ash ballast stockpile to the south of D7 on a Minor (Secondary) Aquifer. 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.

Although a number of ecologically sensitive receptors have been identified in the vicinity of the site, 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**. Similarly, the risks to agricultural receptors have been assessed as **negligible** to **low**.

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

5.3 Overall Land Quality and Suitability for Redevelopment

In general, it is considered that the land quality at the majority of the site is likely to be generally good, with isolated areas of potentially poor land quality associated with the principal areas used for the current and historic storage of hydrocarbon fuels, areas of waste tipping/Made Ground, railway line infrastructure and asbestos either from the degradation of building fabric or the disposal of demolished buildings containing ACM. Therefore, the site is considered to be suitable for its present commercial/industrial use given the current site configuration.

Due to the uncertainty regarding the nature of the some of the areas of waste tipping/Made Ground (including stockpile(s) of ash ballast material) together with the number of as-yet uninvestigated areas of former and current fuel/oil handling, storage and use, these potential land quality issues have carried forward into the risk assessment. In areas associated with these current and former potentially contaminative uses it is likely that land quality will have been impacted and redevelopment proposals, especially those related to a residential with gardens end use, will need to be tailored to the potential contamination present in these areas.

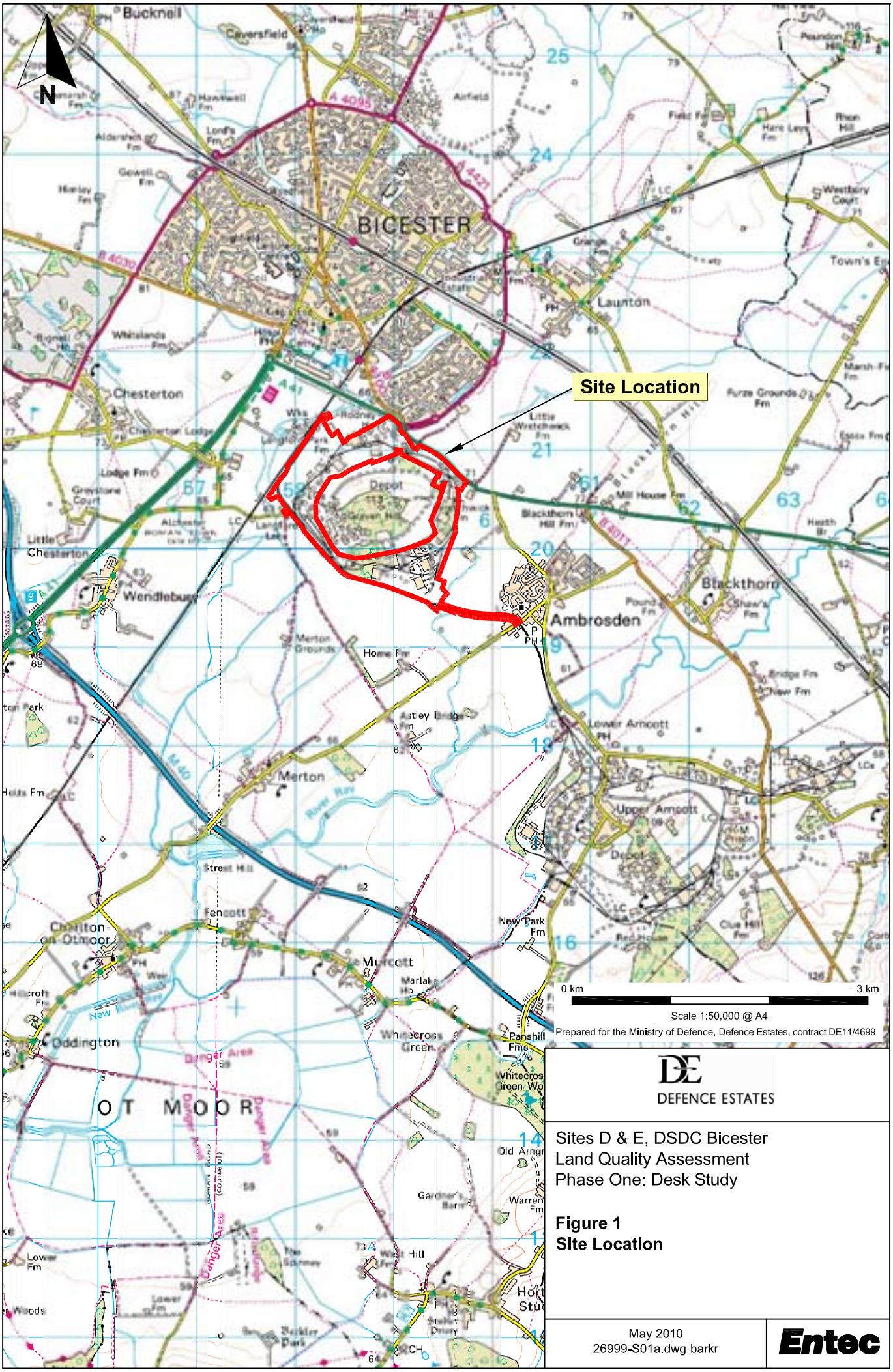
It is considered likely that construction/redevelopment workers will come into direct contact with areas of potential contamination (identified by the Enviros Aspinwall Phase Two LQA, and suspected in other areas) and all workers should be made aware of potential risks that exist at the site and take suitable measure to avoid or mitigate potential risk. Appropriate personal protective equipment (PPE) should be used and good working practices adhered to during any future investigation or redevelopment work at the site.

Development may involve the removal of the subsurface infrastructure and obstructions. Remediation may be required if following the removal of infrastructure the soils and waters are found to have been impacted by any contamination. Development may also require the removal or alteration of building foundations, building fabric, underground pipework/services and underground voids.

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.

Finally, it should be noted that the high sulphate concentrations present within the Oxford Clay present beneath the site are likely to be detrimental to concrete foundations. Therefore, any new foundations will likely require construction with a Sulphate Resistant Portland Cement.

Figures



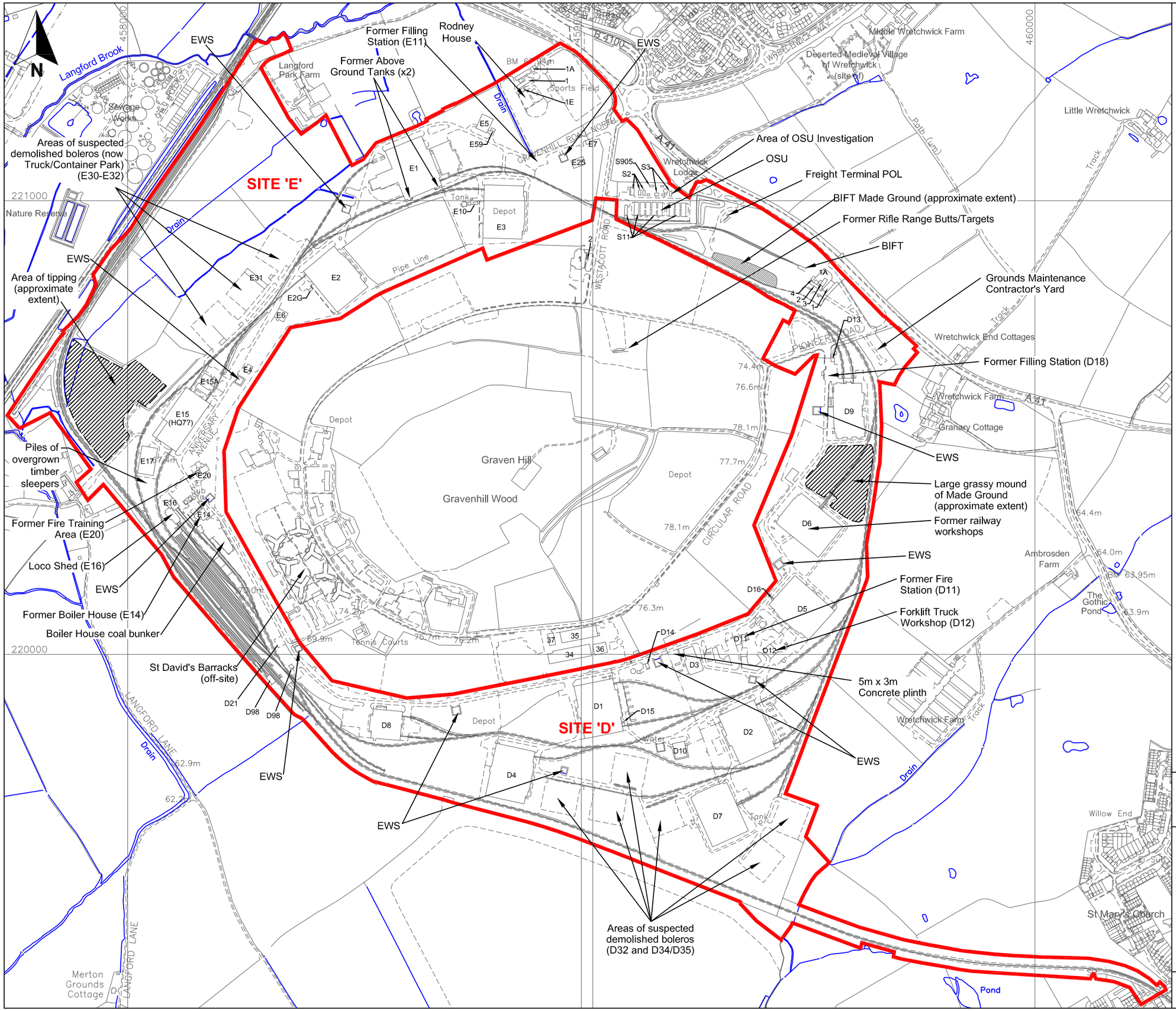
DEFENCE ESTATES

Sites D & E, DSDC Bicester
Land Quality Assessment
Phase One: Desk Study

Figure 1
Site Location

May 2010
26999-S01a.dwg barkr

Entec



Key

- Site boundary
- D14 — Building numbers
- EWS — Emergency water supply

0 m — 400 m

Scale 1:8000 @ A3

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

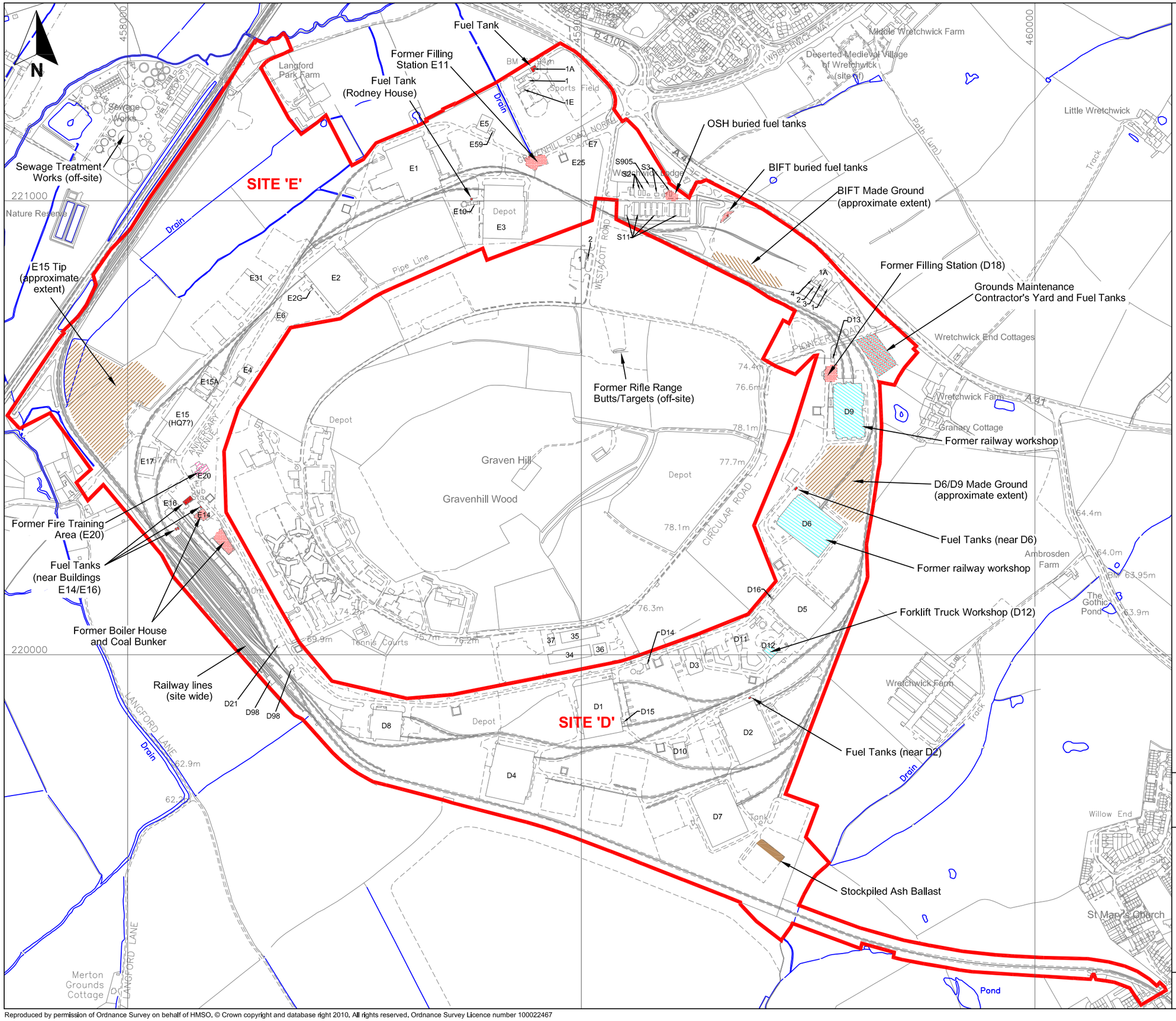
DEFENCE ESTATES

Sites D & E, DSDC Bicester
Land Quality Assessment
Phase One: Desk Study

Figure 2
Site Layout

May 2010
26999-S02a.dwg barkr

Entec



Key

- Site boundary
- Fuel and oil (POL)
- Waste disposal/disturbed ground
- Workshops (including vehicle/plant storage, solvents, fuels, metals etc)
- Fire training area

Note:
Solid colour denotes potential source.
Coloured hatching or shading is used for areas of uncertainty over contaminant dispersal.

Site wide oil water interceptors not shown.

0 m 400 m

Scale 1:8000 @ A3

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

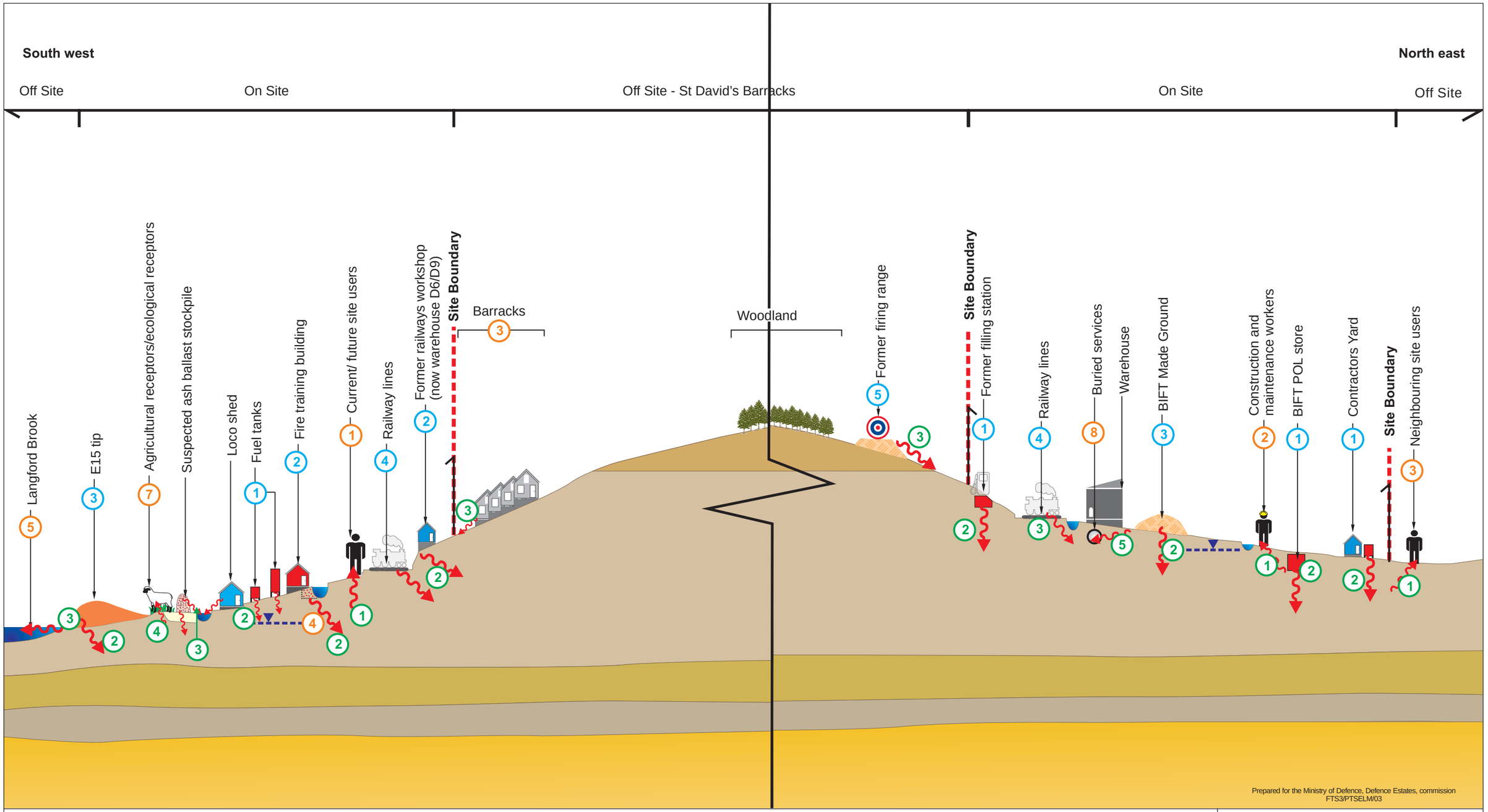
DEFENCE ESTATES

Sites D & E, DSDC Bicester
Land Quality Assessment
Phase One: Desk Study

Figure 3
Areas of Potential Contamination

May 2010
26999-S03a.dwg barkr

Entec



Key

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

Mudstone

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

Potential Sources

1. Former/current fuel storage areas
2. Former railway workshops and fire training building
3. Former waste tip/Made ground
4. Railway lines
5. Off site sources

Receptors

1. Current/ future site users/visitors
2. Construction and maintenance workers
3. Neighbouring site users
4. Groundwater (perched)
5. Surface water
6. Ecological receptors
7. Agricultural receptors
8. Buildings and buried services

Pathways

1. Dermal contact, direct contact, ingestion, inhalation
2. Leaching, transport, groundwater contamination
3. Leaching, transport, groundwater contamination, runoff
4. Uptake, direct contact
5. Degradation, direct, vapour migration, explosion

DEFENCE ESTATES

Sites D & E, DSDC Bicester
Land Quality Assessment
Phase One: Desk Study

Figure 4
Conceptual Model

May 2010
26999-S04a.cdr barkr

Entec

Annex A
Site Photographs

2 Pages

Plate 1: Above Ground Fuel Tank at Building E3

Plate 2: Modern Above Ground Fuel Tank and Containerised Boilers - Typical Arrangement

Plate 3: DSS Typical Arrangement

Plate 4: Exposed Cladding of Site-Wide Steam Pipes

Plate 5: Building E20 Suspected Fuel Tank Filling Point

Plate 6: Large Above Ground Fuel Tanks Adjacent to E14 Former Boiler House

Plate 7: Loco Shed Above Ground Fuel Tank

Plate 8: E15 Tip

Plate 9: Building D2 Above Ground Fuel Tank

Plate 10: Stained Bunding on Wall Mounted Fuel Tank at Building D2

Annex B
Explosive Ordnance Threat Assessment

45 Pages

BACTEC | Globally Trusted
Locally Dependable

Explosive Ordnance Threat Assessment

in respect of

DSDC Bicester, Oxfordshire

for

Entec UK Ltd

3063TA 29th January 2010

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Date of Issue: 29th January 2010 Copy no. 1

Originator: PBB

This Report has been produced in compliance with the Construction Industry Research and Information Association guidelines for the preparation of Detailed Risk Assessments in the management of UXO risks in the construction industry.

Glossary of Terms

AAA	Anti-Aircraft Artillery
ARP	Air-raid Precautions
BDO	Bomb Disposal Officer
EOD	Explosive Ordnance Disposal (current term for “bomb” disposal)
HE	High Explosive
HG	Home Guard
IB	Incendiary Bomb
kg	Kilogram
LCC	London County Council
LM	Land Mine
LSA	Land Service Ammunition (includes grenades, mortars, etc.)
Luftwaffe	German Air Force
m bgl	Metres Below Ground Level
MoD	Ministry of Defence
OB	Oil Bomb
PM	Parachute Mine
RAF	Royal Air Force
SI	Site Investigation
SAA	Small Arms Ammunition (small calibre cartridges used in rifles & machine guns)
UXB	Unexploded Bomb
UXO	Unexploded Ordnance
V-1	“Doodlebug” the first cruise type missile, used against London from June 1944. Also known as ‘Flying Bomb’.
V-2	The first ballistic missile, used against London from September 1944
WWI	First World War (1914 -1918)
WWII	Second World War (1939 – 1945)

Executive Summary

The Site: DSDC Bicester is split over two areas to the immediate south-west of the town of Bicester in Oxfordshire. The northern site, known as Graven Hill is situated approximately 3km north-west of the southern site, Arncott Hill. The two sites are linked by a military railway. Site location maps are presented in Annex A. This report will focus on four specific sites within the boundary of the facility which are referred to as Site A and Site C at the Arncott site and Site D and Site E at the Graven Hill site.

Proposed Works: Site investigation works are planned across the site areas. Final details were not available at the time of the production of this report.

Risk Assessment Methodology: In accordance with CIRIA guidelines this assessment has carried out research, analysed the evidence and considered the risks that the site has been contaminated with unexploded ordnance; that such items remained on site; that they could be encountered during the proposed works and the consequences that could result. Appropriate risk mitigation measures have been proposed.

Explosive Ordnance Risk Assessment: BACTEC concludes that there is a **Low-Medium** risk from unexploded ordnance at the site of the proposed works. This is based on the following factors:

- 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 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.
- 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.

Risk Mitigation Measures: The following risk mitigation measures are recommended to support the proposed works:

All Areas

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

In making this assessment and recommending these risk mitigation measures, the proposed works outlined in the 'Scope of the Proposed Works' section were considered. Should the planned works be modified or additional intrusive engineering works be considered, BACTEC should be consulted to see if a re-assessment of the risk or mitigation recommendations is necessary.

Contents

Annexes

Explosive Ordnance Threat Assessment

In Respect of

DSDC Bicester, Oxfordshire

1. Introduction

1.1. Background

Entec UK Ltd has commissioned BACTEC International Limited to conduct an Explosive Ordnance Threat Assessment for the proposed works at DSDC Bicester, Oxfordshire.

Unexploded Ordnance presents a significant threat to construction projects in parts of the UK as a result of enemy actions during the two 20th Century World Wars and historic British and Allied military activity.

DSDC Bicester is a large military facility constructed in 1941 to supply the British Army with equipment and stores, its purpose and layout not changing significantly since this time. As with any historic military base, there is the potential for explosive ordnance contamination to be present, despite the facility not having been designed as an armaments storage depot. This report will assess the historic use of the site, compile and present the available information regarding the potential for an ordnance threat and present recommendations if deemed necessary to reduce or eliminate this threat. The potential for encountering unexploded air-delivered weapons will also be considered.

As a result of a generally increased risk awareness amongst professionals involved in ground engineering works and proactive health and safety measures, the threat to life and limb from unexploded ordnance has been minimised. However even the simple discovery of a suspected device during ongoing works can cause considerable disruption to production and cause unwanted delays and expense.

Such risks can be more fully controlled by a better understanding of the site-specific threat and the implementation of appropriate risk mitigation measures.

2. Construction Industry Duties and Responsibilities

2.1. The UK Regulatory Environment

There is no specific legislation covering the management and control of the UXO risk in the UK construction industry but issues regarding health and safety are addressed under a number of regulatory instruments, as outlined below.

In practice the regulations impose a responsibility on the construction industry to ensure that they discharge their obligations to protect those engaged in ground-intrusive operations (such

as archaeology, site investigation, drilling, piling or excavations) from any reasonably foreseeable UXO risk.

2.2. The Health and Safety at Work Act, 1974

The Act places a duty of care on an employer to put in place safe systems of work to address, as far as is reasonably practicable, all risks (to employees and the general public) that are reasonably foreseeable.

2.3. Construction (Design and Management) Regulations 2007

This legislation defines the responsibilities of all parties (primarily the Client, the CDM Co-ordinator, the Designer and the Principal Contractor) involved with works.

Although UXO issues are not specifically addressed the regulations effectively place obligations on all these parties to:

- Ensure that any potential UXO risk is properly assessed
- Put in place appropriate risk mitigation measures if necessary
- Keep all parties affected by the risk fully informed
- Prepare a suitably robust emergency response plan

2.4. Other Legislation

Other relevant legislation includes the “Management of Health and Safety at Work Regulations 1999” and “The Corporate Manslaughter and Corporate Homicide Act 2007”.

3. The Role of the Authorities and Commercial Contractors

3.1. The Authorities

The Police have the responsibilities for co-ordinating the emergency services in the case of an ordnance-related incident on a construction site. They will make an initial assessment (i.e. is there a risk that the find is ordnance or not?) and if they judge necessary impose a safety cordon and/or evacuation and call the military authorities (JSEOD - Joint Services Explosive Ordnance Disposal Operations centre) to arrange for investigation and/or disposal. In the absence of an EOD specialist on site many Police Officers will use the precautionary principle, impose cordon(s)/evacuation and await advice from the JSEOD.

The priority given to the request by JSEOD will depend on their judgement of the nature of the threat (ordnance, location, people and assets at risk) and the availability of resources. They may respond immediately or as resources are freed up. Depending on the on-site risk assessment the item of ordnance may be removed or demolished (by controlled explosion) in-situ. In the latter case additional cordons and/or evacuations may be necessary.

Note that the military authorities will only carry out further investigations or clearances in very high profile or high risk situations. If there are regular ordnance finds on a site the JSEOD may not treat each occurrence as an emergency and will encourage the construction company to put in place alternative procedures (i.e the appointment of a commercial contractor) to manage the situation and relieve pressure from the JSEOD disposal teams.

3.2. Commercial Contractors

In addition to pre-construction site surveys and clearances a commercial contractor is able to provide a reactive service on construction sites. The presence of a qualified EOD Engineer with ordnance recognition skills will avoid unnecessary call-outs to the authorities and the Contractor will be able to arrange for the removal and disposal of low risk ordnance. If high risk ordnance is discovered actions will be co-ordinated with the authorities with the objective of causing the minimum possible disruption to site operations whilst putting immediate, safe and appropriate measures in place.

4. This Report

4.1. Aims and Objectives

The aim of this report is to examine the possibility of encountering any explosive ordnance during the proposed works at the Bicester site. Risk mitigation measures will be recommended, if deemed necessary, to reduce the threat from explosive ordnance during the envisaged works. The report follows the CIRIA Guidelines.

4.2. Risk Assessment Methodology

The following issues will be addressed in the report:

- The risk that the site was contaminated with unexploded ordnance.
- The risk that unexploded ordnance remains on site.
- The risk that ordnance may be encountered during the proposed works.
- The risk that ordnance may be initiated.
- The consequences of initiating or encountering ordnance.

Risk mitigation measures, appropriate to the assessed level of risk and site conditions, will be recommended if required.

4.3. Approach

In preparing this Explosive Ordnance Threat Assessment Report, BACTEC has considered general and, as far as possible, site specific factors including:

- Evidence of German bombing and delivery of UXBs.
- Site history, occupancy and conditions during WWII.
- The legacy of Allied military activity.
- Details of any known EOD clearance activity.
- The extent of any post war redevelopment.
- Scope of the current proposed works.

4.4. Sources of Information

BACTEC has carried out detailed historical research for this Explosive Ordnance Threat Assessment including accessing military records and archived material held in the public domain and in the MoD.

Material from the following sources has been consulted:

- The National Archives, Kew.
- Landmark Maps.
- English Heritage National Monuments Record.
- Relevant information supplied by Entec UK Ltd.
- Available material from 33 Engineer Regiment (EOD) Archive.
- BACTEC's extensive archives built up over many years of research and hands-on Explosive Ordnance Disposal activities in the UK.
- Open sources such as published books, local historical records and the internet.

4.5. Reliability of Historical Records

4.5.1. General Considerations

This report is based upon research of historical evidence. Whilst every effort has been made to locate all relevant material BACTEC cannot be held responsible for any changes to the assessed level of risk or risk mitigation measures based on documentation or other information that may come to light at a later date.

The accuracy and comprehensiveness of wartime records is frequently difficult or impossible to verify. As a result conclusions as to the exact location, quantity and nature of the ordnance threat can never be definitive but must be based on the accumulation and careful analysis of all accessible evidence. BACTEC cannot be held responsible for inaccuracies or gaps in the available historical information.

4.5.2. Bombing Records

During WWII considerable efforts were expended in recording enemy air raids. Air Raid Precautions (ARP) wardens were responsible for making records of bomb strikes either through direct observation or by post-raid surveys. However their immediate priority was to deal with casualties and limit damage, so it is to be expected that records are often incomplete and sometimes contradictory. Record keeping in the early days of bombing was not comprehensive and details of bombing in the early part of the war were sometimes destroyed in subsequent attacks. Some reports may cover a single attack, others a period of months or the entire war.

Records of raids that took place on sparsely or uninhabited areas were often based upon third party or hearsay information and are not always reliable; records of attacks on military or strategic targets were often maintained separately from the general records and have not always survived.

5. The Site

5.1. Site Location and Description

DSDC Bicester is split over two areas to the immediate south-west of the town of Bicester in Oxfordshire. The northern site, known as Graven Hill is situated approximately 3km north-west of the southern site, Arncott Hill. The two sites are linked by a military railway. Site location maps are presented in Annex A.

This report will focus on four specific sites within the boundary of the facility which are referred to as Site A and Site C at the Arncott site and Site D and Site E at the Graven Hill site.

Site E (grid reference SP 58682 20892) is the northernmost site and comprises the strip of land around the north side of Graven Hill, bounded by a railway line to the north-west and the A41 Aylesbury Road to the north-east. Site D (SP 59191 19919) occupies the area of land around the southern side of Graven Hill, bound to the south by the military rail line. Both sites comprise a dispersed collection of large, square warehouses linked with road and rail sidings. All of the sidings link to a rail depot on the south-western boundary of Site D. The land between the warehouses primarily comprises open grassed areas with the north-western section of Site E occupied by undeveloped agricultural land.

Site C (SP 60731 17579) is situated at the western side of the Arncott site. Railway lines form the north-western and north-eastern boundaries, with Ploughley Road and Murcott Road bordering the area to the east. Site A (SP 63553 17507) is located on the eastern edge of the Arncott site and comprises and irregularly shaped parcel of land bordered by Widnell Lane to the south and the B4011 to the east. As with sites D and E, these areas are occupied by large dispersed warehouses, roads and rail sidings.

Recent aerial photographs and site plan showing the boundary of the site areas is presented in Annex B and C respectively.

6. Scope of the Proposed Works

6.1. General

Site investigation works are planned across the site areas. Final details were not available at the time of the production of this report.

7. History of DSDA Bicester

7.1. General

At the start of WWII the Royal Army Ordnance Corps required a purpose built Central Ordnance Depot (COD) to be able to respond to the requirements of the British Army. Bicester was selected due to its central location and easy access to major sea and air ports.

Construction on the site began in June 1941, took two years to complete and covered 1800 acres. In an effort to protect stock from wartime bombing raids, the depot was split over two sites – Graven Hill to the north and Arncott Hill 3.5km to the south, linked by a military railway. By September 1942, the Headquarters and first storehouse had opened and in 1943, the depot assumed its first role as a main Support Base for future operations in Europe and became an Army Mobilisation Centre (see 1943 plan of the southern section of the depot, Annex D). The Depot achieved its peak activity in the latter part of the war, when some 20,000 troops and members of the ATS were employed here. Since then the Depot has had a number of roles. In 1961 COD Bicester was selected to perform a key role in a major reorganisation of the UK Base Ordnance Installations. The Ordnance Depots at Didcot and Branston, together with their associated 'out-stations' were closed and their functions concentrated at Bicester. Further reorganisation in 1980-82 led to the closure of COD Bicester. In 1992, the facility became known as the Defence Storage and Distribution Centre, Bicester.

The depot is not understood to have ever been used for the storage and distribution of ammunition and explosive ordnance. A local historian, author of *50 Years of COD Bicester*, states that there is 'no record of explosive ordnance ever being stored, processed or disposed of within the confines of the depot perimeter'.

7.2. WWII-era Aerial Photography

Historic aerial photography of the site area was requested from the National Monuments Record Office, Swindon. Images covering sites A, C and D dated August 1945, April 1947 and October 1974 are presented in Annex E. Examination of the wartime images confirms that there are no structures present considered to be associated with the large-scale storage of explosive ordnance. The site was newly opened at this time and appears well-maintained and fully operational. Evidence of camouflaging can be seen on the roofs of some of the warehouse structures, but no signs of damage, clearance or bomb craters are noted. A large military camp is noted in the central area of the Arncott site, to the east of Site C. A legacy of explosive ordnance contamination is considered more likely in such an encampment, but the area does not fall within any of the designated work zones.

8. The Threat from Aerial Bombing

8.1. Bicester During WWII

At the start of WWII, Bicester started receiving evacuees from London due to its relatively safe position in the centre of the UK away from major industrial centres, ports and other important strategic infrastructure.

Home Guard units were organised from May 1940 to protect the area from parachutists, patrol the locality and man defensive positions. The Home Guard numbered 1600 men by 1944 in detachments scattered throughout the Bicester area. A range of defences were constructed to repulse the threat of invasion.

Military activity in the area was pronounced with a large number of airfields, the opening of COD Bicester and many military exercises and troop movements being undertaken in the

surrounding countryside. The local airfields provided vital training bases for RAF aircrews and many important secret missions were flown from RAF Bicester, situated to the north-east of the town.

8.2. Bombing History of Bicester

At the start of WWII, the Luftwaffe planned to destroy key military installations, including RAF airfields and Royal Navy bases, during a series of daylight bombing raids. After the Battle of Britain these tactics were modified to include both economic and industrial sites. Targets included dock facilities, railway infrastructure, power stations, weapon manufacturing plants and gas works. As a result of aircraft losses, daylight raids were reduced in favour of attacking targets under the cover of darkness.

References could be found to only three bombing raids in the Bicester area, all apparently targeted against the RAF station to the north-east of the town. Very few details of the raids are available, but they appeared to only involve single aircraft and amounted to around 20 incendiary bombs and four high explosive bombs being dropped. No references could be found to the Ordnance Depot being targeted, possibly due to the fact work did not start on the facility until after the main period of bombing in the UK. It should be noted however that no original ARP records for the depot could be located to confirm the lack of air raids.

8.2.1. Abandoned Bombs

A post-air raid survey of buildings, facilities and installations would have included a search for evidence of bomb entry holes. If evidence were encountered, Bomb Disposal Officer teams would normally have been requested to attempt to locate, render safe and dispose of the bomb. Occasionally evidence of UXBs was discovered but due to a relatively benign position, access problems or a shortage of resources the UXB could not be exposed and rendered safe. Such an incident may have been recorded and noted as an Abandoned Bomb.

Given the inaccuracy of WWII records and the fact that these bombs were ‘abandoned’, their locations cannot be considered definitive, nor the lists exhaustive. The MoD states that ‘action to make the devices safe would be taken only if it was thought they were unstable’. It should be noted that other than the ‘officially’ abandoned bombs, there will inevitably be UXBs that were never recorded.

BACTEC holds no records of officially registered abandoned bombs at or near the sites of the proposed works.

8.3. Likelihood of Post-raid UXO Detection

Utilising the available historical bombing it is possible to make an assessment of the likelihood that evidence of unexploded ordnance would have been noted on a site during the war and the incident dealt with or recorded at the time. Factors such as bombing density, frequency of access, ground cover, damage and failure rate have been taken into consideration.

8.3.1. Density of Bombing

Bombing density is an important consideration for assessing the possibility that UXBs remain in an area. A very high density of bombs can for example result in increased levels of damage sustained to structures, greater likelihood of errors in record keeping and a higher risk that UXBs fell over the area.

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. Attempts were made to bomb RAF Bicester, to the north-east of the town, but it appears that none succeeded with only a handful of HE bombs and 20 incendiaries dropped, all falling outside the station perimeter. ARP records for 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. In 1940/41 prior to its construction the site of the facility would not have constituted a viable bombing target.

8.3.2. Frequency of Access and Ground Cover

Unexploded ordnance at sites where human access was infrequent would have a higher chance of being overlooked than at those sites which were subject to greater occupancy. The importance of a site or facility to the war effort is also an important consideration as such sites are likely to have been both frequently accessed and are also likely to have been subject to post-raid checks for evidence of UXO.

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.

8.3.3. Damage

If structures on a site have been subject to significant bomb or fire damage, rubble and debris are likely to have been present; similarly an HE bomb strike on open ground is likely to have resulted in a degree of soil disturbance. Under such conditions there is a greater risk of the entry holes of unexploded bombs dropped during subsequent raids being obscured and going unnoticed.

If any damage had indeed been sustained to structures within the boundary of the depot, efforts would have been made to repair and rebuild in order to keep the depot running at full capacity. It is also likely that dedicated post-raid searches to check for damage and evidence of unexploded bombs would have been undertaken, given the importance of the facility.

8.3.4. Bomb Failure Rate

There is no evidence to suggest that the bomb failure rate in the region of the site would have been different from the “approximately 10%” figure normally used.

9. The Threat from Allied Military Ordnance

9.1. General

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. The design and layout of the depot substantiate this. The conventional design of an armaments storage facility comprises a number of small bunded structures designed to minimise the effects of an accidental explosion. No such structures are present within the DSDC depot.

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 (see section 9.2.1). 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.

9.2. Land Service and Small Arms Ammunition (LSA and SAA)

Typical examples of LSA are discussed below and presented in Annex F. Such weapons may have been stored and made available for use historically at the DSDC Bicester and could conceivably be encountered during intrusive works within the depot boundary, especially in previously undeveloped areas.

a. Unexploded Munitions – Mortars, Grenades and Explosives. A mortar relies on a striker hitting a detonator for explosion to occur. It is possible that the striker may already be in contact with the detonator and that only a slight increase in pressure would be required for initiation. Similarly, a grenade striker may either be in contact with the detonator or still be retained by a spring under tension, and therefore shock may cause it to function. Mortars and grenades can both be lethal. A grenade can have an explosive range of 15-20m.

b. Fuzes – The fuzes used with munitions fired on ranges are mainly of the direct impact action variety. This means that if they failed to function on impact a needle/pin may have been driven into the detonator or a very sensitive explosive compound leaving the fuze in a dangerous state. An inadvertent impact on the fuze or munition could cause the munition to detonate. The 81mm mortar falls into this category and is known throughout the EOD community as a very dangerous munition to dispose of.

c. Miscellaneous Items – Pyrotechnics come in a variety of types of flares and smoke generating compounds and can include the following:

a. Magnesium
b. Thermite
c. Phosphorus (red – white)
d. Calcium Phosphate
e. Sodium Nitrate
f. Aluminium Powder
g. Sodium Phosphide – phosphorus mixture
h. Magnesium – aluminium phosphide
i. Potassium bisulphate
j. Smoke compounds i.e. HC, FM and FS.

d. Small Arms Ammunition – Ammunition boxes are known to have been processed in certain areas of DSDC Bicester and SAA may be encountered during the proposed intrusive works. However, it should be noted that even if an item functioned the explosion would not be contained within a barrel and detonation would only result in local overpressure and very minor fragmentation from the cartridge case. Images of SAA are presented in Annex F-3.

Items of ordnance do not become inert or lose their effectiveness with age. Time can indeed cause items to become more sensitive and less stable. This applies equally to items submerged in water or embedded in silts, clays or similar materials. The greatest risk occurs when an item of ordnance is struck or interfered with. This is likely to occur when mechanical equipment is used or when unqualified personnel pick up munitions.

9.2.1. EOD Bomb Disposal and Clearance Tasks

Several Explosive Ordnance Clearance Tasks have been undertaken in certain areas of the DSDC site by 33 Engineer Regiment (EOD). The first was a 12.5% search undertaken between 19th and 29th March 1975. The areas covered by this search have been overlaid onto the site map and presented in Annex G. They comprise only small sections of land, jointly comprising approximately 127 acres, and mostly fall outside this report's areas of interest. The operation did not produce any explosive ordnance finds.

The second search was undertaken between the 23rd and 25th November 1981. It covered an area of 1.4 acres centred at OS grid reference SP 595 207 (map not available, but located in the eastern section of Site E). No finds were recorded.

The site was further investigated in 2002. There was a requirement to certify sites A, B and G of the depot free from explosive ordnance contamination for the purposes of alienation (these areas have also been overlaid, Annex G). A desk-top study was undertaken by the Environmental Science Group of the Defence Logistics Organisation for these three areas. No requirement was found to conduct additional proactive EOC operations in sites A and G, but a limited intrusive and visual investigation was undertaken in the south-western corner of Site

B. No explosive ordnance was found during this operation and a clearance certificate was issued by the Ministry of Defence stating that sites A, B and G are 'clear, as far as is reasonably practical, of explosive ordnance contamination'.

BACTEC does not hold records of any additional clearance tasks having been undertaken in the remaining areas of the site historically.

9.3. Defending Bicester from Aerial Attack

Both passive and active defences were deployed against enemy bombers attacking targets in the Bicester region.

Passive defences included measures to hinder the identification of targets (such as a lighting blackout at night and the camouflaging of strategic installations); to mislead bomber pilots into attacking decoy sites located away from the city and to force attacking aircraft to higher altitudes with the use of barrage balloons.

Active air defence relied on a coordinated combination of fighter aircraft to act as interceptors, anti-aircraft gun batteries and later the use of rockets and missiles, in order to actively engage and oppose attacking aircraft.

9.3.1. Anti-Aircraft Artillery and Projectiles

At the start of the war two types of AAA guns were deployed: Heavy Anti-Aircraft Artillery (HAA), using large calibre weapons such as the 3.7" QF (Quick Firing) gun and Light Anti-Aircraft Artillery (LAA) using smaller calibre weapons such as 40mm Bofors gun.

During the early war period there was a severe shortage of AAA available and older WWI 3" and modified naval 4.5" guns were deployed alongside those available 3.7" weapons. The maximum ceiling height of fire at that time was around 11,000m (for the 3.7" gun and less for other weapons). As the war progressed improved variants of the 3.7" gun were introduced and, from 1942, large 5.25 inch weapons began to be brought into service. These had significantly improved ceiling heights of fire reaching over 18,000m.

The LAA batteries were intended to engage fast low flying aircraft and were typically deployed around airfields or strategic installations. These batteries were mobile and could be moved to new positions with relative ease when required. The most numerous of these was the 40mm Bofors gun which could fire up to 120 x 40mm HE shells per minute to over 1800m.

The HAA projectiles were high explosive shells, usually fitted with a time delay or barometric pressure fuze to make them explode at a pre-determined height. If they failed to explode or strike an aircraft, they would eventually fall back to earth. Details of the most commonly deployed WWII AAA projectiles are shown below:

Gun type	Calibre	Shell Weight	Shell Dimensions
3.0 Inch	76mm	7.3kg	76mm x 356mm
3.7 Inch	94mm	12.7kg	94mm x 438mm
4.5 Inch	114mm	24.7kg	114mm x 578mm
40mm	40mm	0.9kg	40mm x 311mm

Although the larger unexploded projectiles could enter the ground they did not have great penetration ability and are therefore likely to be found close to WWII ground level. These shells are frequently mistakenly identified as small German air-delivered bombs, but are differentiated by the copper driving band found in front of the base. With a high explosive fill and fragmentation hazard these items of UXO present a significant risk if encountered. The smaller 40mm projectiles are similar in appearance and effect to small arms ammunition and, although still dangerous, present a lower risk.

Numerous unexploded AAA shells were recovered during and following WWII and are still occasionally encountered on sites today.

There are no recorded HAA batteries in the Bicester area. However, the ordnance depot to the south-east of the town and the airfield to the north-east would both have been equipped with light anti-aircraft guns to defend against attack.

Illustrations of Anti-Aircraft artillery, projectiles and rockets are presented at Annex H.

10. Ordnance Clearance and Post-WWII Ground Works

10.1. General

The extent to which any ordnance clearance activities have taken place on site or extensive ground works have occurred is relevant since on the one hand they may indicate previous ordnance contamination but also may have reduced the risk that ordnance remains undiscovered.

10.2. EOD Clearance

Explosive ordnance clearance operations have been undertaken at certain small areas within the boundary of DSDC Bicester. However, the majority of the facility has not been subject to clearance. Those sections which have been searched were only subject to 12.5% clearance. The risk of encountering explosive ordnance has therefore not been eliminated or significantly reduced as a result of these operations.

10.3. Post war Redevelopment

Examination of the available historical mapping and aerial photography indicates that relatively little development has occurred at DSDC Bicester in the post-war years. The main warehouse structures which were installed in the 1940s are still present, and the primary changes are to ancillary buildings. The majority of open, grassed areas appear never to have been subject to development or significant intrusive works.

11. The Overall Explosive Ordnance Threat Assessment

11.1. General Considerations

Taking into account the quality of the historical evidence, the assessment of the overall threat to the proposed works from unexploded ordnance must evaluate the following risks:

- That the site was contaminated with unexploded ordnance
- That unexploded ordnance remains on site
- That such items will be encountered during the proposed works
- That ordnance may be activated by the works operations
- The consequences of encountering or initiating ordnance

11.2. The Risk that the Site was Contaminated with Unexploded Ordnance

For the reasons discussed in section 8.3, BACTEC believes that there is a minimal risk of Allied explosive ordnance contamination at the DSDC Bicester site, or that unexploded high explosive bombs and/or anti-aircraft projectiles or incendiary bombs fell unnoticed and unrecorded within the site boundary.

- 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 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.
- 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.

11.3. The Risk that Unexploded Ordnance Remains on Site

The sites have not been subject to significant post-war redevelopment or intrusive works. Most of the sections of open ground which were present during WWII are extant today. Where intrusive works have occurred post-war, this will largely have mitigated any risk of encountering ordnance as any contamination is likely to be present at only shallow depths. In areas which have not been subject to intrusive works, there is still a risk that ordnance could remain in situ.

11.4. The Risk that Ordnance may be Encountered during the Works

The most likely scenarios under which a UXO could be encountered during construction works is during piling, drilling operations or bulk excavations for basement levels. The overall risk will depend on the extent of the works, such as the numbers of boreholes/piles (if required) and the volume of the excavations.

The primary threat on the DSDC Bicester sites comes from items such as small arms and land service ammunition, lost, burnt, buried or otherwise discarded. Such items are only likely to be present, and therefore encountered, at shallow depths.

11.5. The Risk that Ordnance may be Initiated

The risk that UXO could be initiated if encountered will depend on its condition, how it is found and the energy with which it is struck. The most violent activity on most construction sites is percussive piling.

As a result items that are shallow buried present a lower risk than those that are deep buried, since the force of impact is usually lower and they are more likely to be observed – when immediate mitigating actions can be taken.

11.6. The Consequences of Encountering or Initiating Ordnance

Clearly the consequences of an inadvertent detonation of UXO during construction operations would be catastrophic with a serious risk to life, damage to plant and a total site shutdown during follow-up investigations.

Since the risk of initiating ordnance is comparatively low if appropriate mitigation measures are undertaken, the most important consequence of the discovery of ordnance will be economic. This would be particularly so in the case of high profile locations and could involve the evacuation of the public. The unexpected discovery of ordnance may require the closing of the site for any time between a few hours and a week with a potentially significant cost in lost time. Note also that the suspected find of ordnance, if handled solely through the authorities, may also involve loss of production since the first action of the Police in most cases will be to isolate the locale whilst awaiting military assistance, even if this turns out to have been unnecessary.

11.7. BACTEC's Assessment

Taking into consideration the findings of this study, BACTEC considers there to be a **Low-Medium** risk from unexploded ordnance during the proposed works at DSDC Bicester:

	Level of Risk			
Type of Ordnance	**Negligible**	**Low**	**Medium**	**High**
German HE UXBs		*		
British AAA		*		
German incendiaries and anti-personnel bombs		*		
LSA/SAA		*		

12. Proposed Risk Mitigation Methodology

12.1. General

BACTEC believes the following risk mitigation measures should be deployed to support the proposed works at the DSDC Bicester site.

12.2. Recommended Risk Mitigation Measures

All Works

- ***Explosive Ordnance Safety and Awareness Briefings to all personnel conducting intrusive works:*** A specialised briefing is always advisable when there is a possibility of explosive ordnance contamination. It is an essential component of the Health & Safety Plan for the site and conforms to requirements of CDM Regulations 2007. All personnel working on the site should be instructed on the identification of UXB, actions to be taken to alert site management and to keep people and equipment away from the hazard. Posters and information of a general nature on the UXB threat should be held in the site office for reference and as a reminder.
- ***The Provision of Unexploded Ordnance Site Safety Instructions:*** These written instructions contain information detailing actions to be taken in the event that unexploded ordnance is discovered. They are to be retained on site and will both assist in making a preliminary assessment of a suspect object and provide guidance on the immediate steps to be taken in the event that ordnance is believed to have been found.

In making this assessment and recommending these risk mitigation measures, the proposed works outlined in the 'Scope of the Proposed Works' section were considered. Should the

planned works be modified or additional intrusive engineering works be considered, BACTEC should be consulted to see if a re-assessment of the risk or mitigation recommendations is necessary.

BACTEC International Limited 29th January 2010

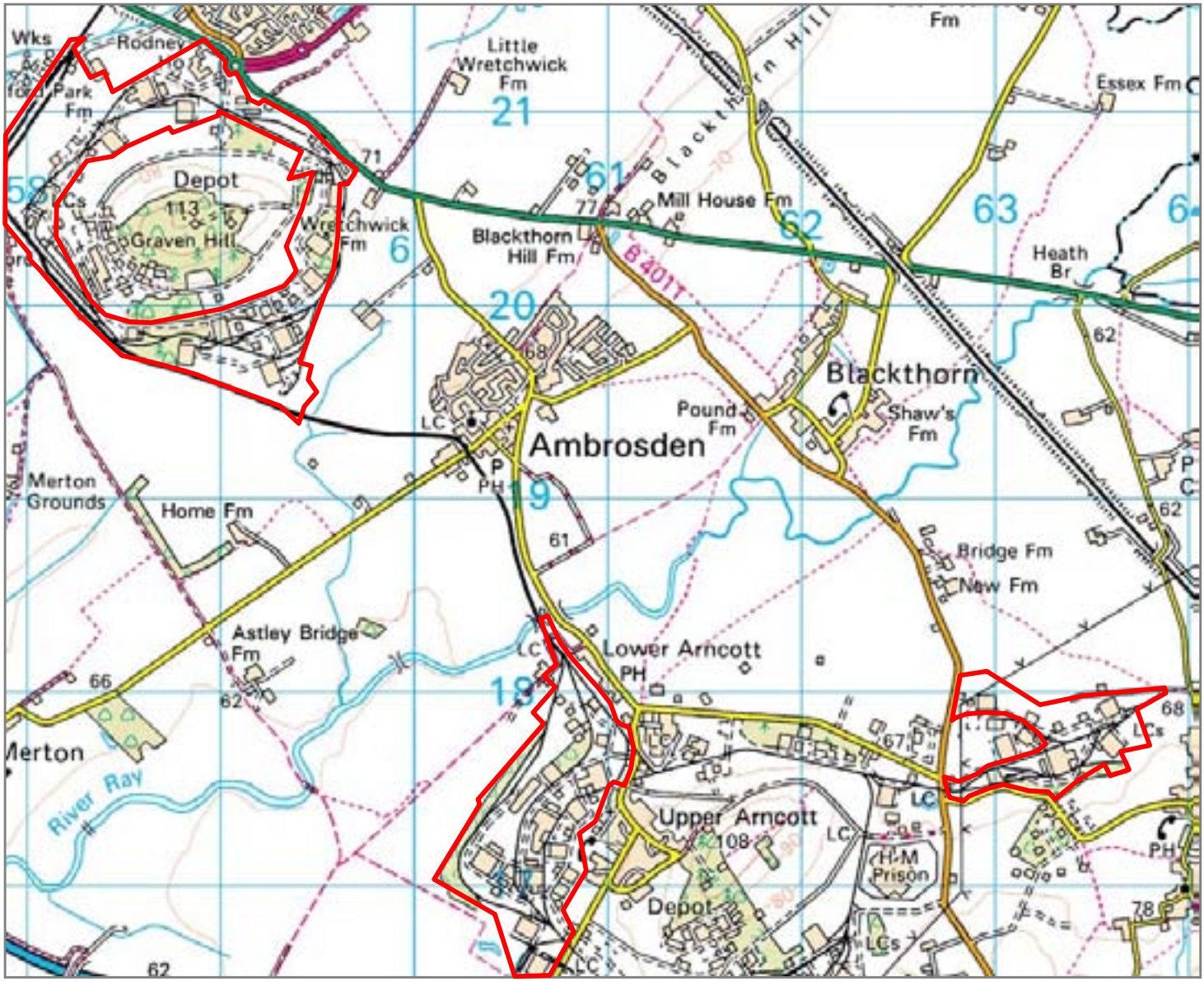
Bibliography

The key published documents consulted during this assessment are listed below:

- Bates, H, E., *Flying Bombs over England*, Frogletts Publications Ltd. 1994.
- Dobinson, C., AA Command: Britain's Anti-Aircraft Defences of the Second World War, Methuen. 2001.
- Fegan, T., The Baby Killers': German Air raids on Britain in the First World War, Leo Cooper Ltd. 2002.
- Fleischer, W., *German Air-Dropped Weapons to 1945,* Midland Publishing. 2004.
- Jappy, M. J., Danger UXB: The Remarkable Story of the Disposal of Unexploded Bombs during the Second World War. Channel 4 Books, 2001.
- Price, A., Blitz on Britain, The Bomber Attacks on the United Kingdom 1939 – 1945, Purnell Book Services Ltd. 1977.
- Ramsey, W., *The Blitz Then and Now, Volume 1*, Battle of Britain Prints International Limited. 1987.
- Ramsey, W., *The Blitz Then and Now, Volume 2*, Battle of Britain Prints International Limited. 1988.
- Ramsey, W., *The Blitz Then and Now, Volume 3*, Battle of Britain Prints International Limited. 1990.
- Whiting, C., Britain Under Fire: The Bombing of Britain's Cities 1940-1945, Pen & Sword Books Ltd. 1999.

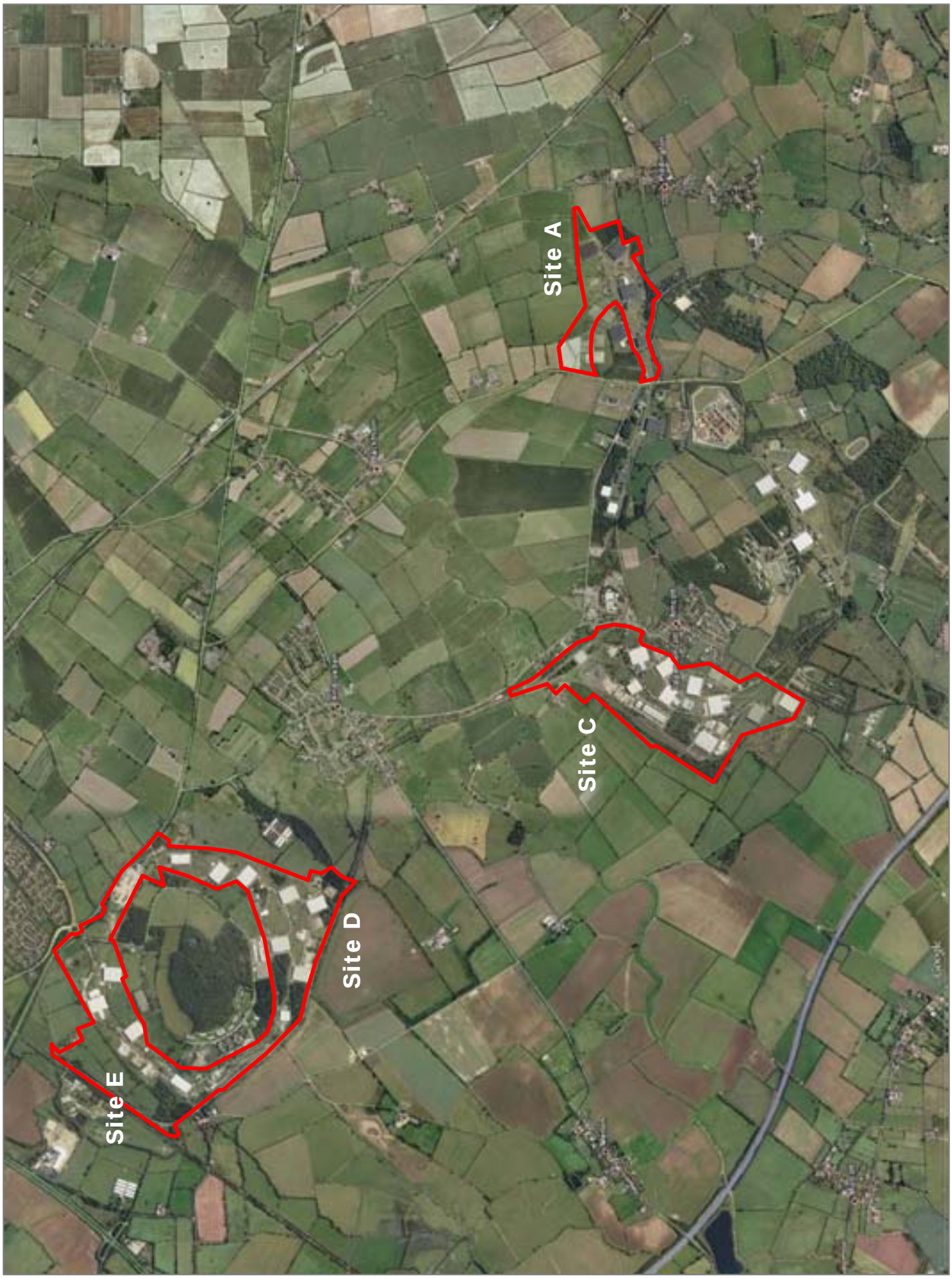
Annex A: Site Location Maps

North



Report Reference:	Client:	
3063TA	Entec UK Ltd	BACTEC
	Project: DSDC Bicester, Oxfordshire	

Annex B: Recent Aerial Photographs of the Site



Report Reference:	Client:	
3063TA	Entec UK Ltd	
	Project: DSDC Bicester, Oxfordshire	

Source: Google Earth ™ Mapping Services

North

Approximate site boundary

Report Reference:	Client:	
3063TA	Entec UK Ltd	
	Project: DSDC Bicester, Oxfordshire	

Source: Google Earth ™ Mapping Services

North

Approximate site boundary

Report Reference:	Client:	
3063TA	Entec UK Ltd	
	Project: DSDC Bicester, Oxfordshire	

Source: Google Earth ™ Mapping Services

North

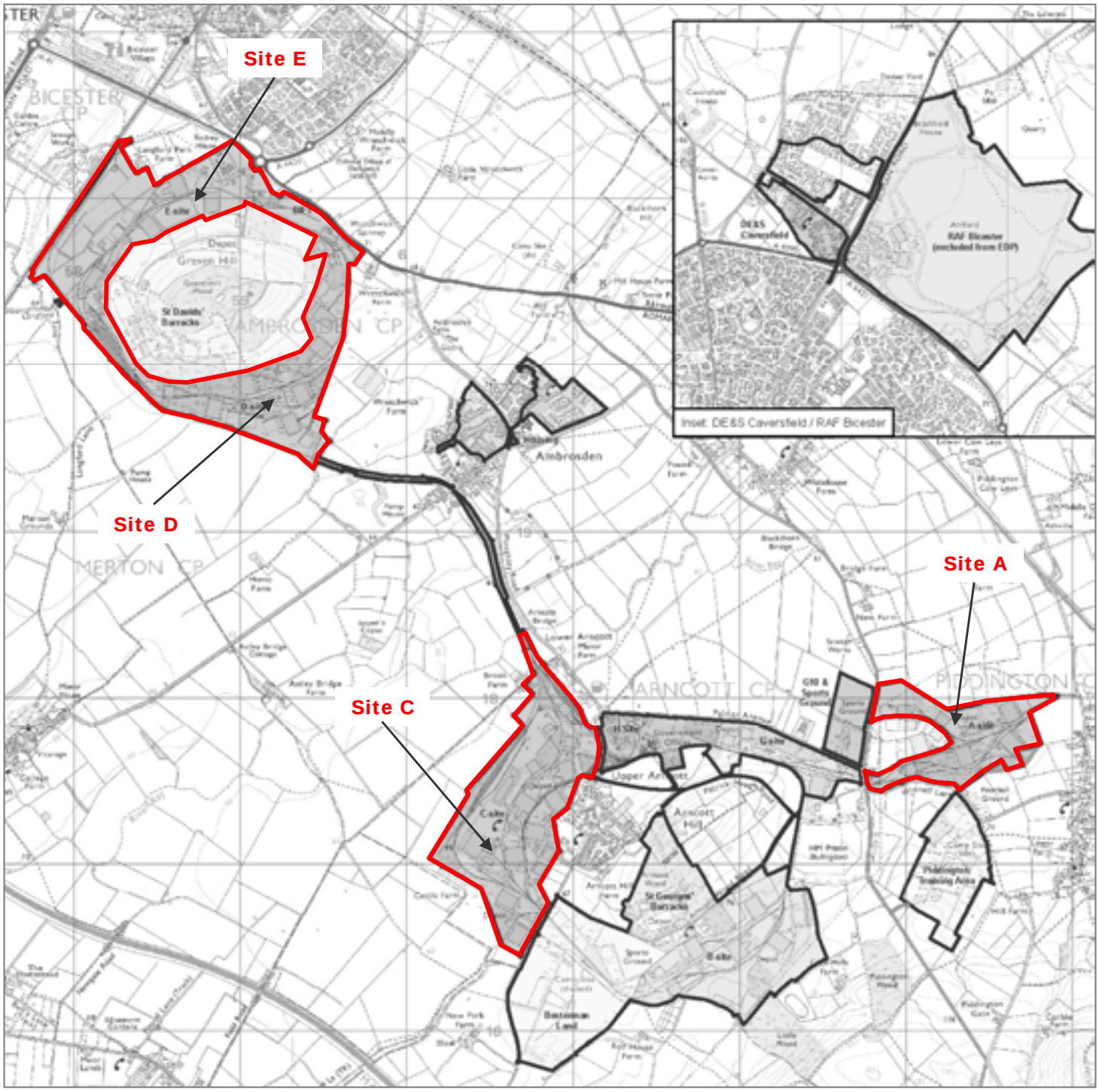
Approximate site boundary

Report Reference:	Client:	
3063TA	Entec UK Ltd	
	Project: DSDC Bicester, Oxfordshire	

Source: Google Earth ™ Mapping Services

Annex C: Site Plan

North

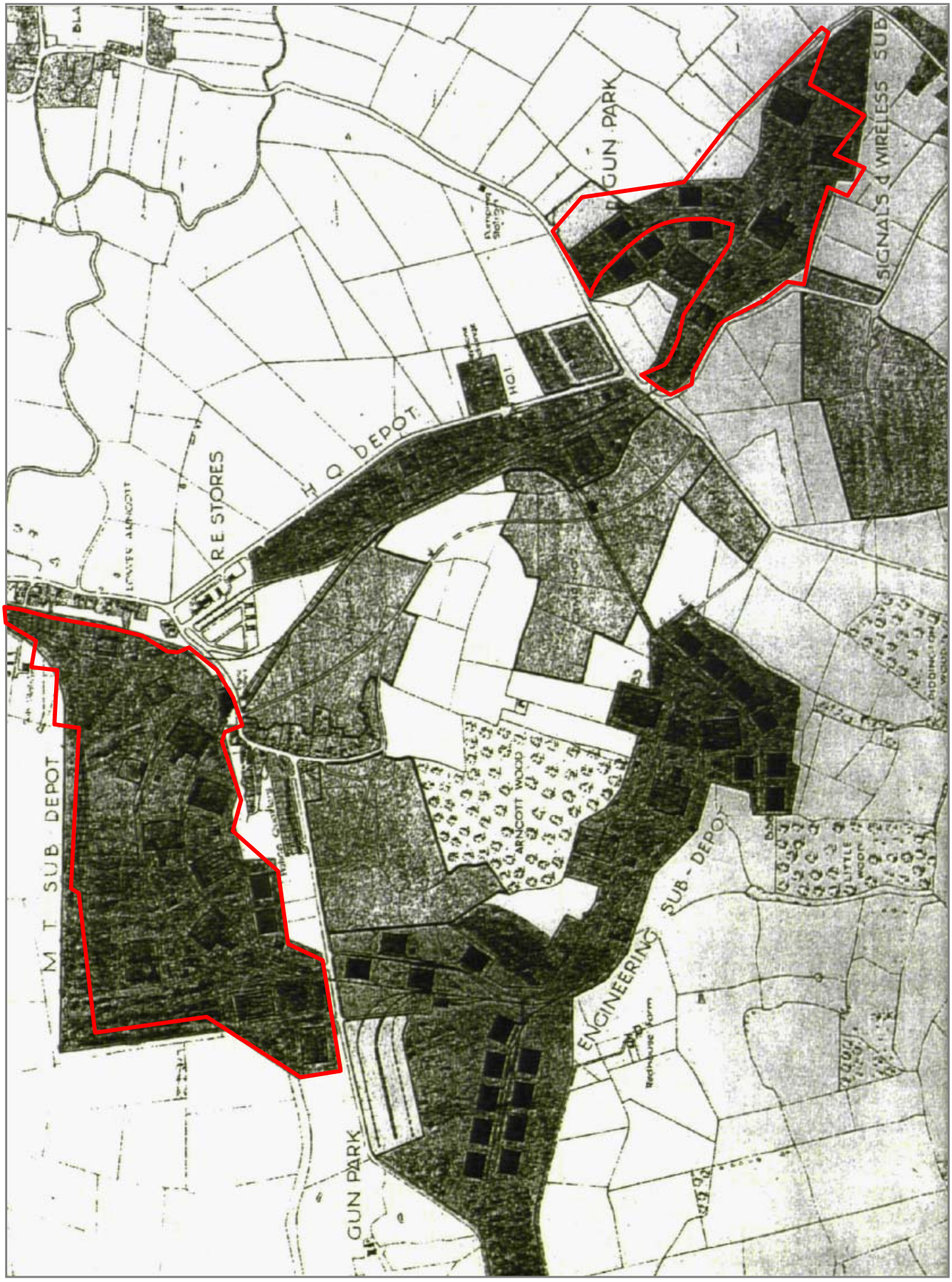


Approximate site boundary

Report Reference:	Client:	
3063TA	Entec UK Ltd	
	Project: DSDC Bicester, Oxfordshire	

Source: Entec UK Ltd

Annex D: 1943 Map of Arncott Site



Approximate site boundary

Report Reference:	Client:	
3063TA	Entec UK Ltd	
	Project: DSDC Bicester, Oxfordshire	

Source: Environmental Science Group

Annex E: Historic RAF Aerial Photography

Approximate site boundary

Report Reference:	Client:	
3063TA	Entec UK Ltd	
	Project: DSDC Bicester, Oxfordshire	

Source: English Heritage National Monuments Record

North

Approximate site boundary

Report Reference:	Client:	
3063TA	Entec UK Ltd	BAC TEC
	Project: DSDC Bicester, Oxfordshire	

Source: English Heritage National Monuments Record

Approximate site boundary

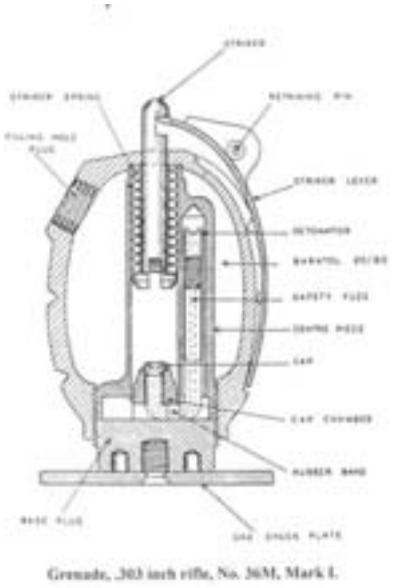
Report Reference:	Client:	
3063TA	Entec UK Ltd	
	Project: DSDC Bicester, Oxfordshire	

Source: English Heritage National Monuments Record

Annex F: LSA/SAA

No. 36 'Mills' Grenade

Weight:	0.7kg filled (1lb 6oz)
Type:	Hand or discharger, fragmentation
Dimensions:	95 x 61mm (3.7 x 2.4in)
Filling:	Alumatol, Amatol 2 or TNT
Remarks:	4 second hand-throwing fuse with approximate 30m range. First introduced May 1918.



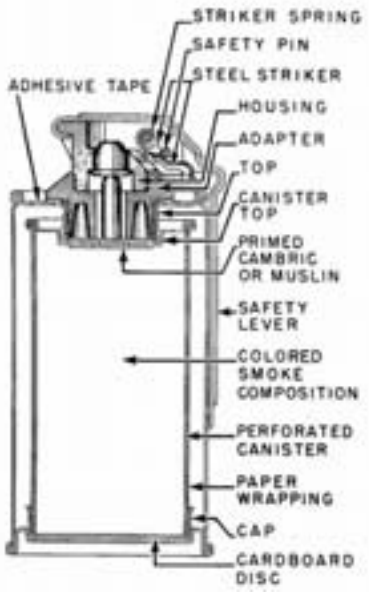
Grenade, .303 inch rifle, No. 36M, Mark I.

No. 69 Grenade

Weight:	0.38kg filled (0.8lb)
Type:	Percussion/Blast
Date Introduced:	December 1940
Remarks:	Black Bakelite body. Blast rather than fragmentation type. After unscrewing the safety cap, a tape is held when throwing the grenade releasing the safety bolt in the throwing motion. Detection is problematic due to its very low metal content.

Typical Smoke Grenade

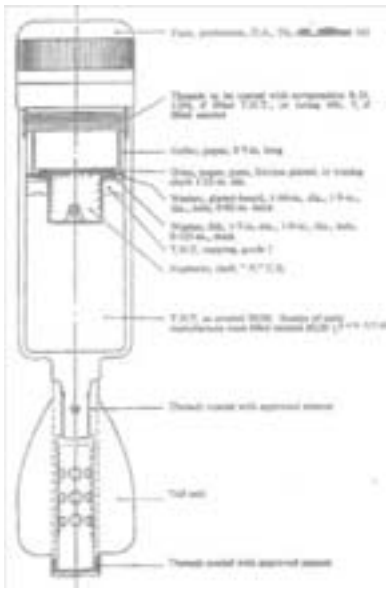
Dimensions:	Approx. 65 x 115mm (2.5 x 4.5in)
Type:	Smoke
Date Introduced:	Current MoD issue
Remarks:	Smoke grenades are used as ground-to-ground or ground-to-air signalling devices, target or landing zone marking devices, and screening devices for unit movement.



Source: BACTEC International Limited and various historical sources

Typical 2 inch High Explosive Mortar

Bomb Weight:	1.02kg (2.25lb)
Type:	High Explosive
Dimensions:	51 x 290mm (2in x 11.4in)
Filling:	200g RDX/TNT
Maximum Range:	457m (500yds)
Remarks:	Fitted with an impact fuze which detonates the fuze booster charge (exploder) and, in turn, the high explosive charge. The main charge shatters the mortar bomb body, producing near optimum fragmentation and blast effect at the target.

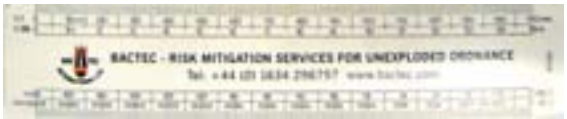


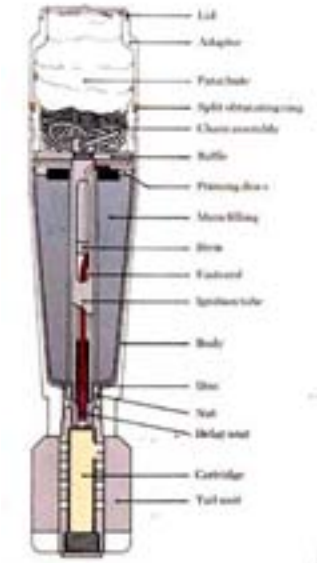
Typical 3 inch Smoke Mortar

Type:	Smoke
Dimensions:	c490 x 76mm (19.3in x 3in)
Filling:	Typically white phosphorous
Maximum Range:	2515m (2,750yds)
Remarks:	On impact, the fuze functions and initiates the bursting charge. The bursting charge ruptures the mortar bomb body and disperses the white phosphorous filler. The white phosphorous produces smoke upon exposure to the air.

Typical 2 inch Illuminating Mortar

Type:	Illum.
Dimensions:	51 x 290mm
Filling:	Various
Remarks:	The expulsion charge ignites and ejects the candle assembly. A spring ejects the parachute from the tail cone. The parachute opens, slowing the descent of the burning candle which illuminates the target.





Report Reference:	Client:	
3063TA	Entec UK Ltd	
	Project: DSDC Bicester, Oxfordshire	

Source: BACTEC International Limited and various historical sources

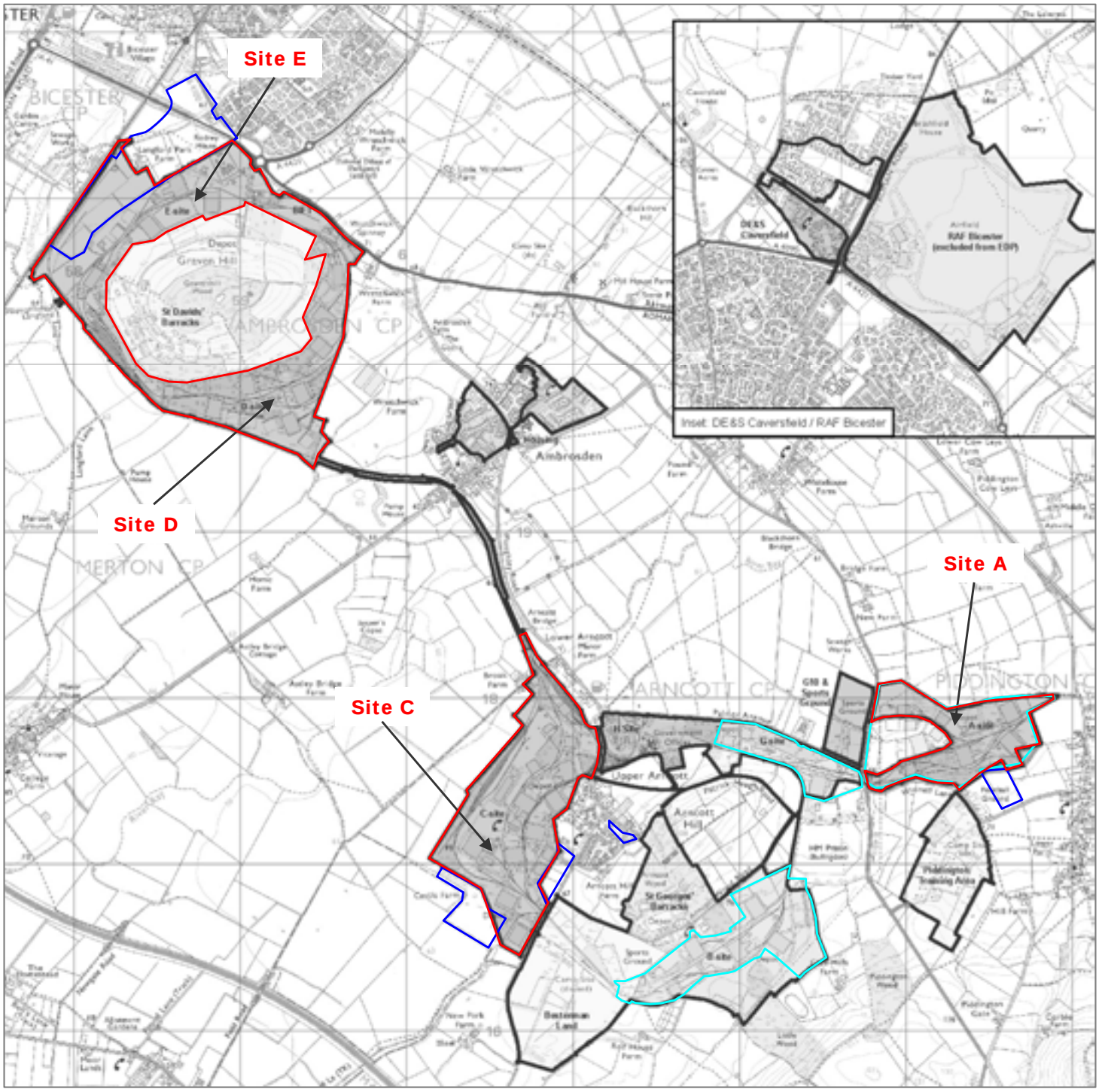
Small arms ammunition and cannon rounds up to 30mm

Recovered British WWII era SAA

Annex G: Map Showing Locations of EOD Clearance Tasks

North

Areas 12.5% Searched 19th Mar 1975 to 29th March 1975



Areas certified by MoD as being clear 'as far as reasonably practical' of explosive ordnance contamination

Areas subject to 12.5% search and clear operations by 33 Engineer Regiment (EOD)

Approximate site boundary

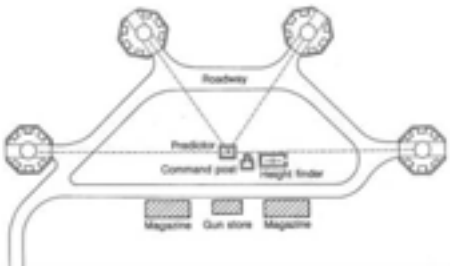
Report Reference:	Client:	
3063TA	Entec UK Ltd	BACTEC
	Project: DSDC Bicester, Oxfordshire	

Source: BACTEC International Limited

Annex H: Anti-Aircraft Artillery

3.7 inch Anti-Aircraft Projectile

Weight:	12.7kg (28lb)
Dimensions:	94 x 360mm (3.7 x 14.7in)
Carriage:	Mobile and Static Versions
Rate of Fire:	10-20 rounds per minute
Ceiling:	9-18,000m (29-59,000ft)
Muzzle Velocity:	792m/s (2,598ft/s)
Remarks:	4.5 inch projectiles were also commonly utilised



Layout plan for a typical HAA battery site.

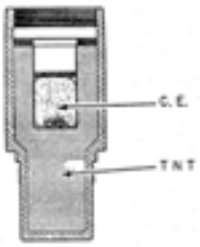
Slade Green's HAA battery, Dartford showing typical size and layout of the installation.

Hyde Park 1939 3.7 Inch QF gun on mobile mounting

3.7 inch AA Projectile Minus Fuze

Rockets / Unrotated Projectiles

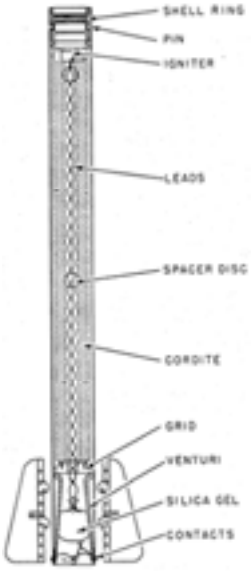
Weight:	Overall: 24.5kg (54lb) Warhead: 1.94kg (4.28lb)
Dimensions:	1930mm x 82.6mm (76 x 3.25in)
Carriage:	Mobile – transported on trailers
Ceiling:	6770m (22,200ft)
Maximum Velocity:	457mps (1,500 fps)



MK II HE Shell (3.5kg)

Rocket Battery in action

Home Guard soldiers load an anti-aircraft rocket at a 'Z' Battery



2" U.P AA Rocket

40mm Bofors Gun Projectile

Weight:	0.86kg (1.96lb)
Dimensions:	40mm x 310mm (1.6in x 12.2in)
Rate of Fire:	120 rounds per minute
Ceiling:	23,000ft (7000m)
Muzzle Velocity:	2,890 ft/s (881m/s)
Remarks:	Mobile batteries – normally few records of where these guns were located

Unexploded 40mm Bofors projectile recovered from a marine environment

40mm Bofors gun and crew at Stanmore in Middlesex, 28 June 1940.

Report Reference: 3063TA	Client: Entec UK Ltd	
	Project: DSDC Bicester, Oxfordshire	

Source: BACTEC International Limited and various historical sources

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United Kingdom

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Fax: +44 (0)1634 296779
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BACTEC SE Asia Pty. Limited
Unit1/43
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Offices in:

- o Lao PDR
- o Cambodia
- o Mozambique
- o Libya

Website: www.bactec.com

BACTEC

Annex C
Dstl Radiological Desk Study

5 Pages

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F +44(0)23 92 768150
acscarlett@dstl.gov.uk

Entec UK Ltd
Cannon Court North
Abbey Lawn
Abbey Foregate
Shrewsbury
Shropshire
SY2 5DE

(For attention of Simon Howard)

Our Ref: ESD/AS/490158/ENTEC/SH
Your Ref: Email from Simon Howard (Entec UK Ltd) dated 7th January 2010

Date: 1 February 2010

PHASE ONE LAND QUALITY ASSESSMENT (DESK STUDY) – DSDC BICESTER

1. In response to your request, Dstl has conducted a search of records relating to any radiological contamination issues at Defence Storage and Distribution Centre (DSDC) Bicester, formerly Base Ordnance Depot (BOD) Bicester. This desk study will provide an input into the Phase One Land Quality Assessment of the afore-mentioned site.

2. It should be noted that the specific area of the site being investigated is A, C, D and E parts of DSDC Bicester. Dstl do not hold any information specifically relating to these areas, but have undertaken an information search for DSDC Bicester as a whole.

Desk Study Methodology

3. Dstl have searched a number of information sources including the MOD radioactive holdings database, archive and published information etc. In addition, a number of people within the Dstl Radiation Protection Advisory Body and site representatives have been consulted in order to obtain any information available relating to radiological issues.

Results of Information Search

4. Findings of the desk study are summarised in Table 1 (Annex A) which includes full references for any information identified. This table also includes information searches which did not yield any relevant information.

5. Dstl 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 DSDA 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 cockpit containing radium-226 (Ra-226) has been stored on site since at least 1999.

6. A previous Phase One Radiological Land Quality Assessment was undertaken for the Army Base Repair Organisation (ABRO) Facility at DSDC Bicester. This report noted that a Royal Electrical and Mechanical Engineers (REME) workshop operated at the site until approximately 1986; such facilities being known for work with radioactive material. In addition, there was also a burning ground for disposal of combustible materials on one of the depot sites (specific location not known).

7. The former REME workshop (Building C32) including instrument workshop was subject to a radiological survey in 1998 to determine the extent of any contamination which may be present. No radioactive contamination was identified in the buildings themselves although Ra-226 contamination was detected at a depth of 1.5 metres to the rear of the building (activity concentration: 275 Bq/g). The report concluded by recommending that any future intrusive work in the area should be supported by health physics cover for safety purposes. Dstl do not hold any information to indicate that the area has been subject to remediation.

8. A further radiological survey was undertaken in 1998 of an area in 'A' site planned for re-development. Whilst this survey did identify a number of areas of elevated radiation measurements, subsequent analysis of recovered soil samples indicated that these measurements were due to naturally occurring radioactive material rather than man-made contamination.

9. In addition, low level tritium contamination was identified in the site Armoury (Armourer's workshop) in September 2001, where maintenance work had been carried out on equipment containing gaseous tritium light sources (GTLSs). The area was decontaminated by the Dstl survey team in 2004.

Summary

10. The information gathered in this information search has highlighted that there is Ra-226 contamination present in the ground surrounding building C32 which was formerly operated as a REME workshop. It would be appropriate to carry out further characterisation of this contamination and the surrounding areas. Based on this information and the large number of radioactive items which have been stored on site, 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.

11. Should you obtain additional historical information which you would like Dstl to comment upon, please do not hesitate to contact me.

Regards

Signed on original

AARON SCARLETT
Health Physicist
Dstl RPA Body

Report prepared by:

KEVIN WHITE
Environmental Technician

Table 1. Information Sources for Phase One LQA (Desk Study) of DSDC Bicester.

INFORMATION SOURCE	COMMENTS	REFERENCE
MOD Radioactive Holdings Database	*Current units holding radioactive material:* • In addition to DSDC Bicester, a number of units are based at the site including 16 Cadet Training Team, 23 Pioneer Regt RLC and the Garrison SP Unit. The site holds a large number of standard items of military equipment containing minor radioactive sources including tritium (H-3), thorium (Th-232), strontium (Sr-90), cobalt (Co-57) and chlorine (Cl-36). A master indicator from a Canberra cockpit containing radium (Ra-226) is also stored on site. *Former units known to hold radioactive material:* • The units previously based at the site include 25 Freight Dist Sqn RLC, 16 Sup Regt RLC, 25 Sqn RCT, 25 Sqn RLC, 602 Signal Troop, BOD (Bicester), BOD (Bicester) - Thatcham Sub Depot and HQ 23 GP RLC. They held standard pieces of military equipment and instruments containing tritium (H-3) and nickel-63 (Ni-63). **NOTE:** The regulatory controls associated with the handling and storage of radioactive material at MOD establishments limits the likelihood of radiological contamination arising.	MOD Radioactive Holdings Database (maintained by Dstl) [date of search: 28/01/2010]
Environment Agency Notifications/Approvals	DSDC Bicester hold a Notification from the Environment Agency for the keeping and use of closed sources (MOD parallel arrangements under the Radioactive Substances Act 1993).	EA Notification No. BS2453
Internet / MOD Intranet Search	An internet search did not reveal any specific information relating to possible radiological contamination issues. A search of the MOD intranet did not return any relevant information regarding the site.	Internet search: [date of search: 29/01/2010] MOD Intranet [date of search: 29/01/2010]

INFORMATION SOURCE	COMMENTS	REFERENCE
Archive Information	A previous phase one land quality assessment was undertaken on the ABRO Facility at DSDC Bicester. This report noted that a Royal Electrical and Mechanical Engineers (REME) workshop operated at the site until approximately 1986; such facilities being known for work with radioactive material. In addition, there was also a burning ground for disposal of combustible materials on one of the depot sites (specific location not known).	Dstl internal records: 490/0103/14780/DRPS dated September 2000
Published Information	There is some published historical information relating to RAF Bicester, but this site is separate from what is now DSDA Bicester.	Bower, M.J.F (1983) 'Action Stations No. 6 Military Airfields of the Cotswolds and the Central Midlands.
Dstl Radiological Surveys	A smear survey was undertaken in the Armourer's workshop in September 2001. This identified a number of areas of tritium contamination in locations where equipment containing GTLSs had been maintained. This area was de-contaminated by the Dstl survey team in 2004. The former instrument shop and areas external to Building C32 were surveyed in April 1998: some Ra-226 contamination was found in one of the trial pit locations at the rear of the building (activity concentration 275 Bq/g). No contamination was found within the building. A further radiological survey was undertaken in 1998 of an area in 'A' site planned for re-development. Whilst this survey did identify a number of areas of elevated radiation measurements, subsequent analysis of recovered soil samples indicated that these measurements were due to naturally occurring radioactive material rather than man-made contamination. The Garrison Support Centre was monitored for concentrations of naturally occurring radon gas in 2008-2009: no significant levels were detected. The rest of DSDC Bicester including A, C, D and E sites are due to be monitored in February 2010.	DRPS/GMH/20068/DSDCB/GP dated 21 September 2001 283/2004 - 2 December 2004 DERA/CHS/DRPS/22/98 dated 28 May 1998 DERA/CHS/DRPS/31/98 dated 1998 ESD/LJK/630007/RADON/0X60DL dated 10 June 2009 Dstl internal records [date of search: 29/01/10]

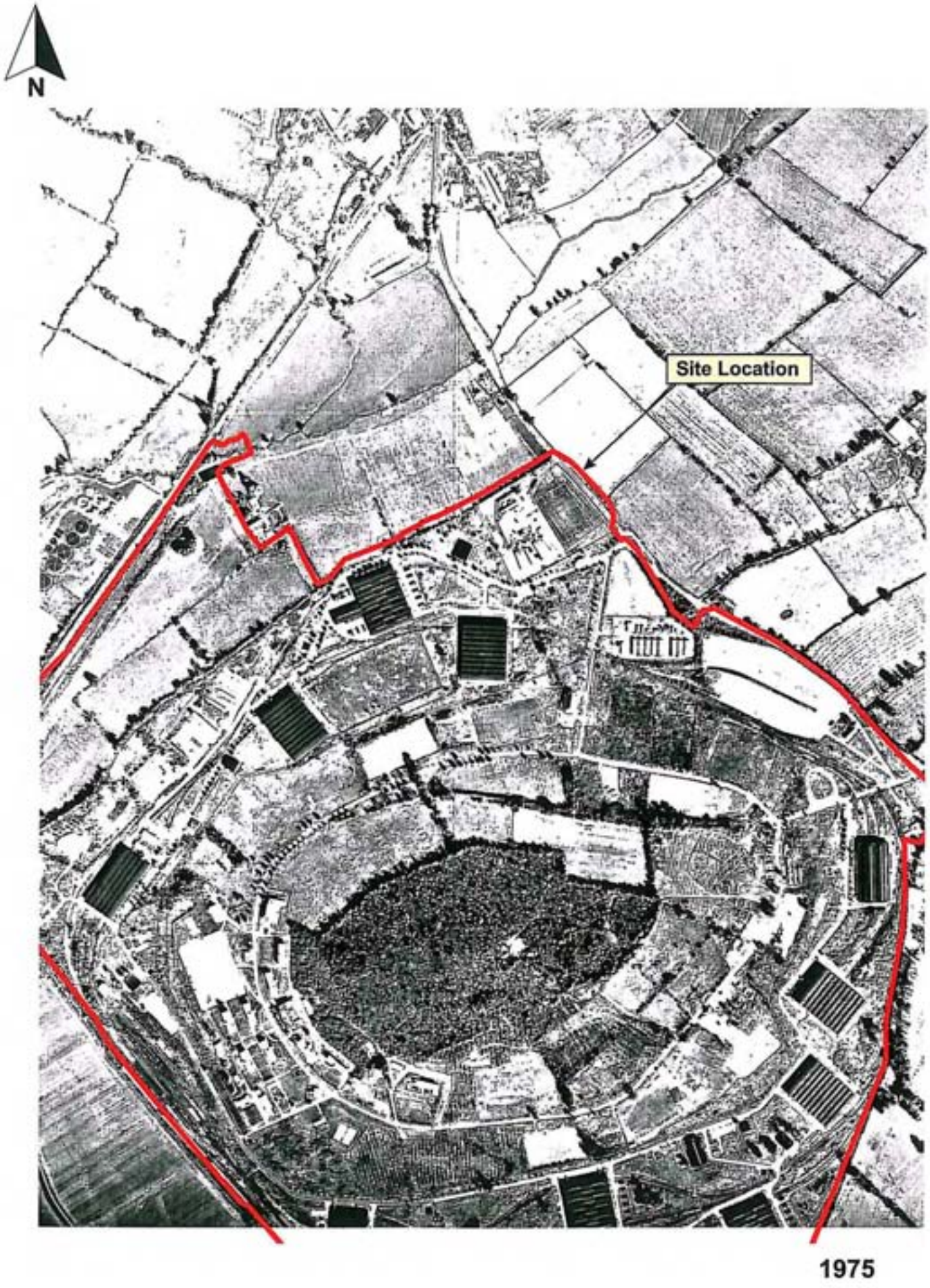
INFORMATION SOURCE	COMMENTS	REFERENCE
Site Contacts (eg. Radiation Safety Officer)	The Radiation Safety Officer (RSO) for DSDA Bicester was contacted by telephone. No information relating to potential radiological contamination was known, other than what has already been identified.	Telephone Conversation: White (Dstl) / RSO (SHEQ for DSDA Bicester) of 29/01/10.
Information from Radiation Protection Advisory Body.	A number of personnel within the Dstl RPA Body were contacted requesting information on any potential contamination issues. The only additional information available related to the use of the site as a distribution centre for the main storage facility at DSDA Donnington; hence the large number of radioactive items which have been stored on site. Previous advisory visit reports for DSDA Bicester were scrutinised, but no issues relating to radiological contamination were identified.	Email References: Brown (Dstl- Senior Health Physicist) / White (Dstl) of 28/01/10 Clark (Dstl – Senior Health Physicist) / White (Dstl) of 28/01/10 Gibbs (Dstl – Group Leader Radiation Protection) / White (Dstl) of 28/01/10 Hughes (Dstl – DSDA RPA) / White (Dstl) of 28/01/10 Lee (Dstl RAF RPA) / White (Dstl) of 28/01/10 Morgan (Dstl- Senior Health Physicist) / White (Dstl) of 28/01/10 ESD Report No. 257/2007 dated 13 September 2007

Annex D
Selected Historic Aerial Photographs

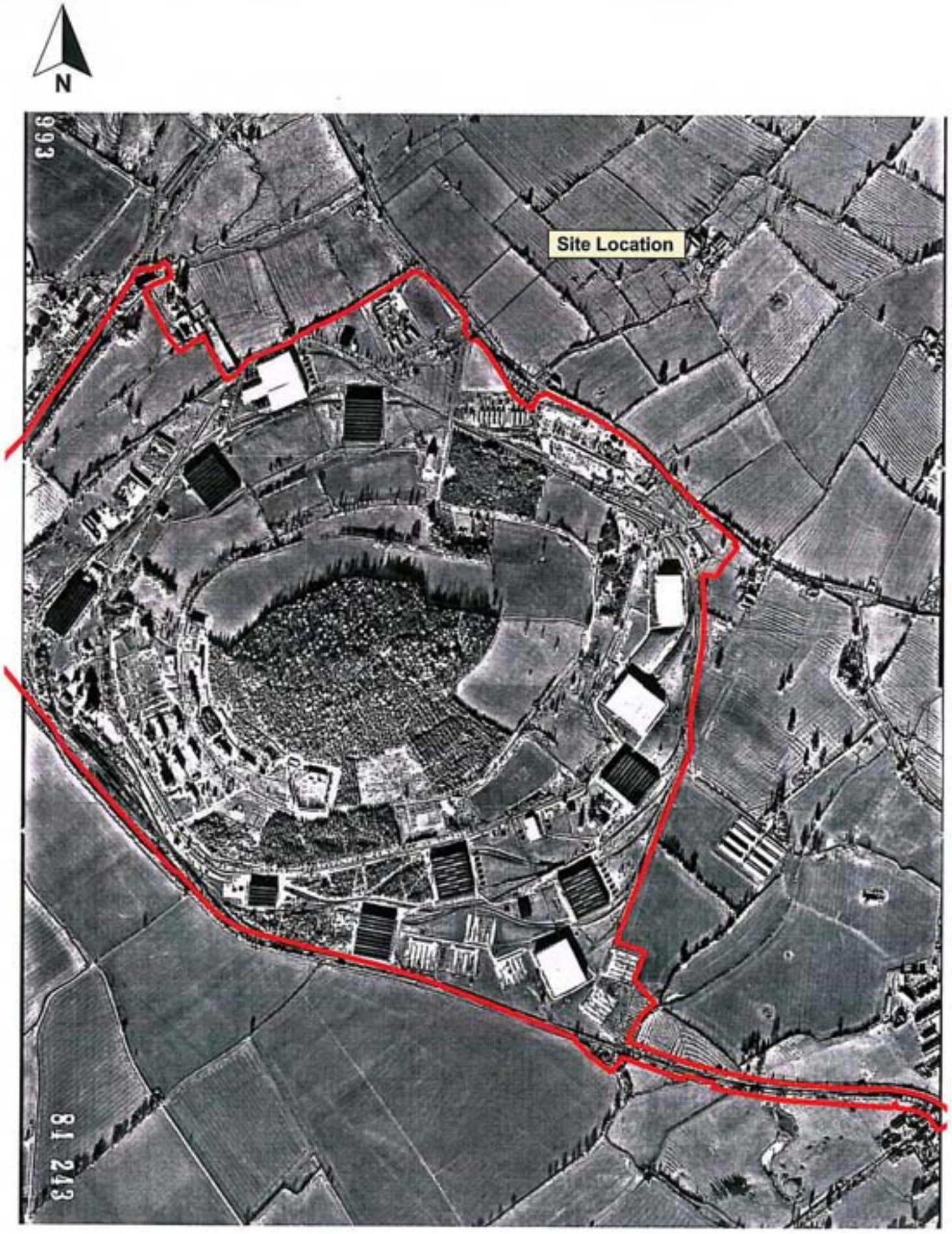
5 Pages

1947

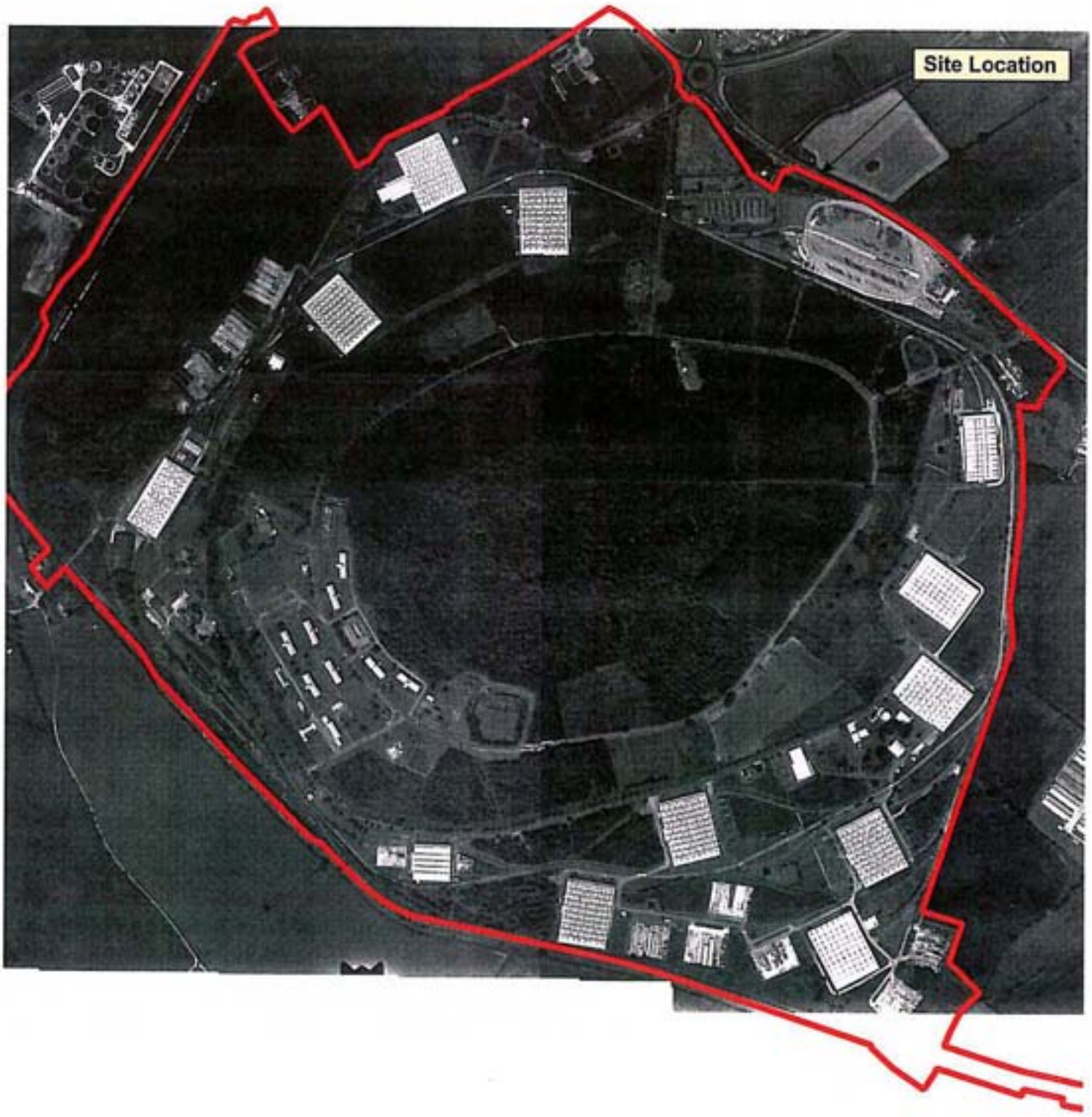
1950



1975



1984



1984

Annex E
emapsite™ Reports

240 Pages

Entec

EmapSite
Masdar House, 1 Reading Road,
Hants, RG27 0RP

Report Reference:	EMS-97881_123436
Your Reference:	EMS_97881_123436
Report Date	Jan 7, 2010
Report Delivery Method:	Email - pdf

GroundSure GeoInsight

Address:

Dear Sir/Madam,

Thank you for placing your order with GroundSure. Please find enclosed the **GroundSure GeoInsight** as requested.

If you would like further assistance regarding this report then please contact the emapsite customer services team on 0118 9736883 quoting the above report reference number.

Yours faithfully,

emapsite customer services team

Enc.
GroundSure GeoInsight

GroundSure GeoInsight

Address:

Date: Jan 7, 2010

Report Reference: EMS-97881_123436

Your Reference: EMS_97881_123436

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If you would like any further assistance regarding this report then please contact
emapsite on (T) 0118 9736883, (F) 0118 9730002 or email: sales@emapsite.com

Aerial Photograph of Study Site

NW ▲ N NE

◄W E►

SW ▼ S SE

Site Name:
Grid Reference: 458830,220408

Overview of Findings

The GroundSure GeoInsight provides high quality geo-environmental information that allows geo-environmental professionals and their clients to make informed decisions and be forewarned of potential ground instability problems that may affect the ground investigation, foundation design and possibly remediation options that could lead to possible additional costs.

The report is based on the BGS 1:50,000 Digital Geological Map of Great Britain, BGS Geosure data; BRITPITS database; Shallow Mining data and Borehole Records, Coal Authority data including brine extraction areas, PBA non-coal mining and natural cavities database and GroundSure's unique database including historical surface ground and underground workings.

For further details on each dataset, please refer to each individual section in the report as listed. Where the database has been searched a numerical result will be recorded. Where the database has not been searched '-' will be recorded.

Report Section	Number of records found within (X) m of the study site boundary
1. Geology	Description
1.1 Artificial Ground,	
1.1.1 Is there any Artificial Ground /Made Ground present beneath the study site? *	Yes
1.1.2 Are there any records relating to permeability of artificial ground within the study site* boundary?	Yes
1.2 Superficial Geology & Landslips	
1.2.1 Is there any Superficial Ground /Drift Geology present beneath the study site? *	Yes
1.2.2 Are there any records relating to permeability of superficial geology within the study site* boundary?	Yes
1.2.3 Are there any records of landslip within 500m of the study site boundary?	No
1.2.4 Are there any records relating to permeability of landslips within the study site* boundary?	No
1.3 Bedrock, Solid Geology & Faults	
1.3.1 For records of Bedrock and Solid Geology beneath the study site* see the detailed findings section.	
1.3.2 Are there any records relating to permeability of bedrock within the study site* boundary?	Yes
1.3.3 Are there any records of faults within 500m of the study site boundary?	Yes
1.3.4 Is the property in a Radon Affected Area as defined by the Health Protection Agency (HPA) and if so what percentage of homes are above the Action Level?	The property is not in a radon Affected Area, as less than 1% of properties are above the Action Level
1.3.5 Is the property in an area where Radon Protection Measures are required for new properties or extensions to existing ones as described in publication BR211 by the Building Resea rch Establishment?	No radon protective measures are necessary

*** This includes an automatically generated 50m buffer zone around the site**

Source:Scale 1:50,000 BGS Sheet No:219

2. Ground Workings	on-site	0-50	51-250	251-500	501-1000
2.1 Historical Surface Ground Working Features from Small Scale Mapping	9	6	26	-	-
2.2 Historical Underground Workings Features from Small Scale Mapping	0	0	0	0	0
2.3 Current Ground Workings	1	0	0	0	0

3. Mining, Extraction & Natural Cavities	on-site	0-50	51-250	251-500	501-1000
3.1 Historical Mining	0	0	0	0	0
3.2 Coal Mining	0	0	0	0	0
3.3 Shallow Mining*	2	-	-	-	-
3.4 Non – Coal Mining Cavities	0	0	0	0	0
3.5 Natural Cavities	0	0	0	0	0
3.6 Brine Extraction	0	0	0	0	0
3.7 Gypsum Extraction	0	0	0	0	0
3.8 Tin Mining	0	0	0	0	0
3.9 Clay Mining	0	0	0	0	0

*This includes an automatically generated 150m buffer zone around the site

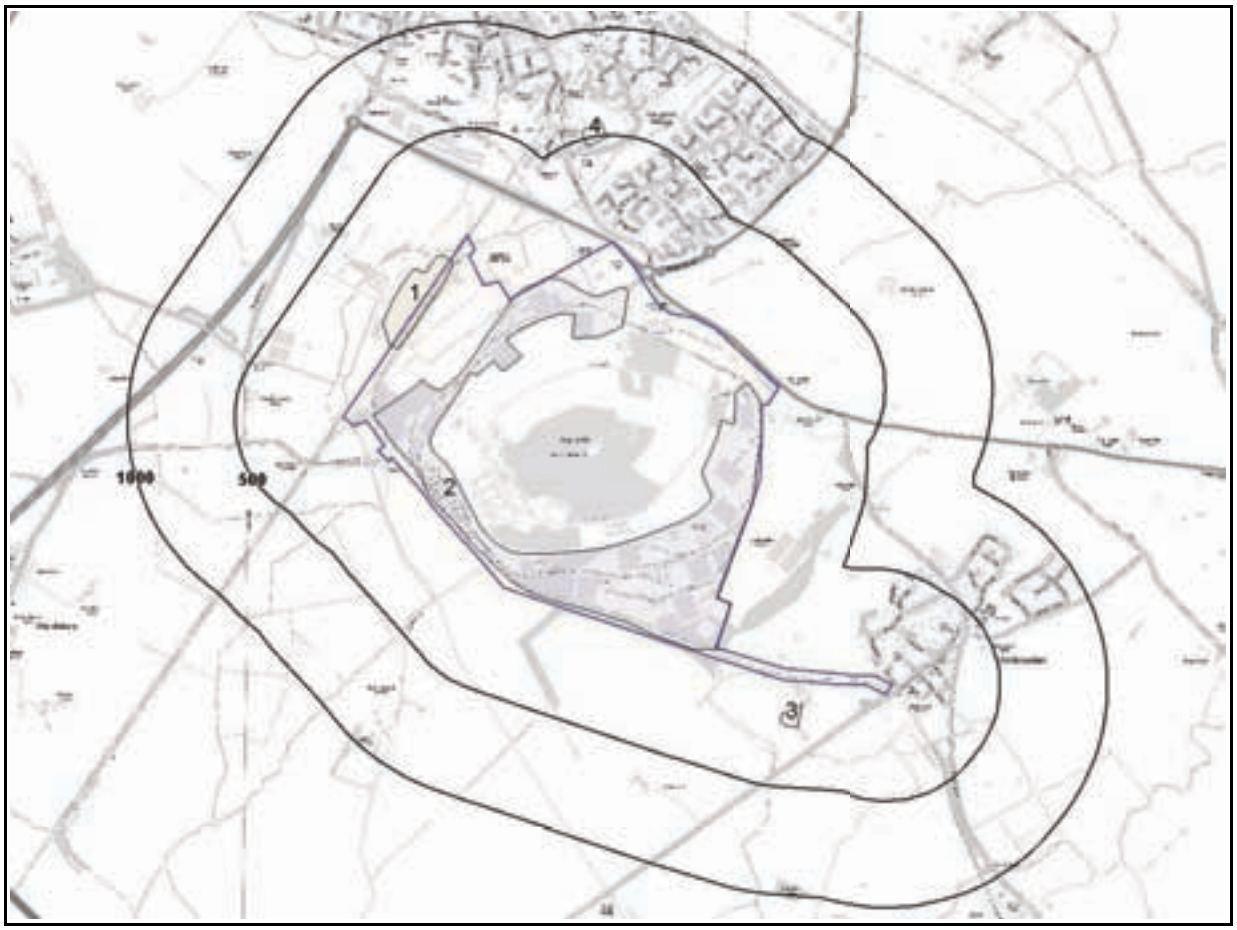
4. Natural Ground Subsidence	on-site*	0-50	51-250	251-500	501-1000
4.1 Shrink-Swell Clay	Moderate	-	-	-	-
4.2 Landslides	Moderate	-	-	-	-
4.3 Ground Dissolution of Soluble Rocks	Very Low	-	-	-	-
4.4 Compressible Deposits	Moderate	-	-	-	-
4.5 Collapsible Deposits	Negligible	-	-	-	-
4.6 Running Sand	Low	-	-	-	-

* This includes an automatically generated 50m buffer zone around the site

5. Borehole Records	on-site	0-50	51-250	251-500	501-1000
5.1 BGS Recorded Boreholes	27	22	15	-	-

1.1 Artificial Ground Map

NW N NE



◄W E►

SW S SE

Artificial Ground Legend

Site Outline

500
1000
Search Buffers (m)

Made Ground (undivided)

Disturbed Ground (undivided)

Worked Ground (undivided)

Landscaped Ground (undivided)

Infilled Ground

Reclaimed Ground

Geological information represented on the mapping is derived from the BGS Digital Geological map of Great Britain at 1:50,000 scale.

1.1 Artificial Ground

The following geological information represented on the mapping is derived from 1:50,000 scale BGS Geological mapping, Sheet No:219

1.1.1 Artificial/Made Ground

Are there any records of Artificial/Made Ground within 500m of the study site boundary: **Yes**

ID	Distance (m)	Direction	LEX Code	Description	Rock Description
1	0.0	On Site	MGR-MGRD	MADE GROUND (UNDIVIDED)	ARTIFICIAL DEPOSIT
2	0.0	On Site	LSGR-UNKN	LANDSCAPED GROUND (UNDIVIDED)	UNKNOWN/UNCLASSIFIED ENTRY
3	102.0	S	MGR-MGRD	MADE GROUND (UNDIVIDED)	ARTIFICIAL DEPOSIT
4	464.0	N	WGR-VOID	WORKED GROUND (UNDIVIDED)	VOID

1.1.2 Permeability of Artificial Ground

Are there any records relating to permeability of artificial ground within the study site* boundary: **Yes**

Distance (m)	Direction	Flow type	Maximum Permeability	Minimum Permeability
0.0	On Site	Intergranular	Very High	Very Low
0.0	On Site	Intergranular	Very High	Very Low
0.0	On Site	Intergranular	Very High	Very Low
0.0	On Site	Intergranular	Very High	Very Low

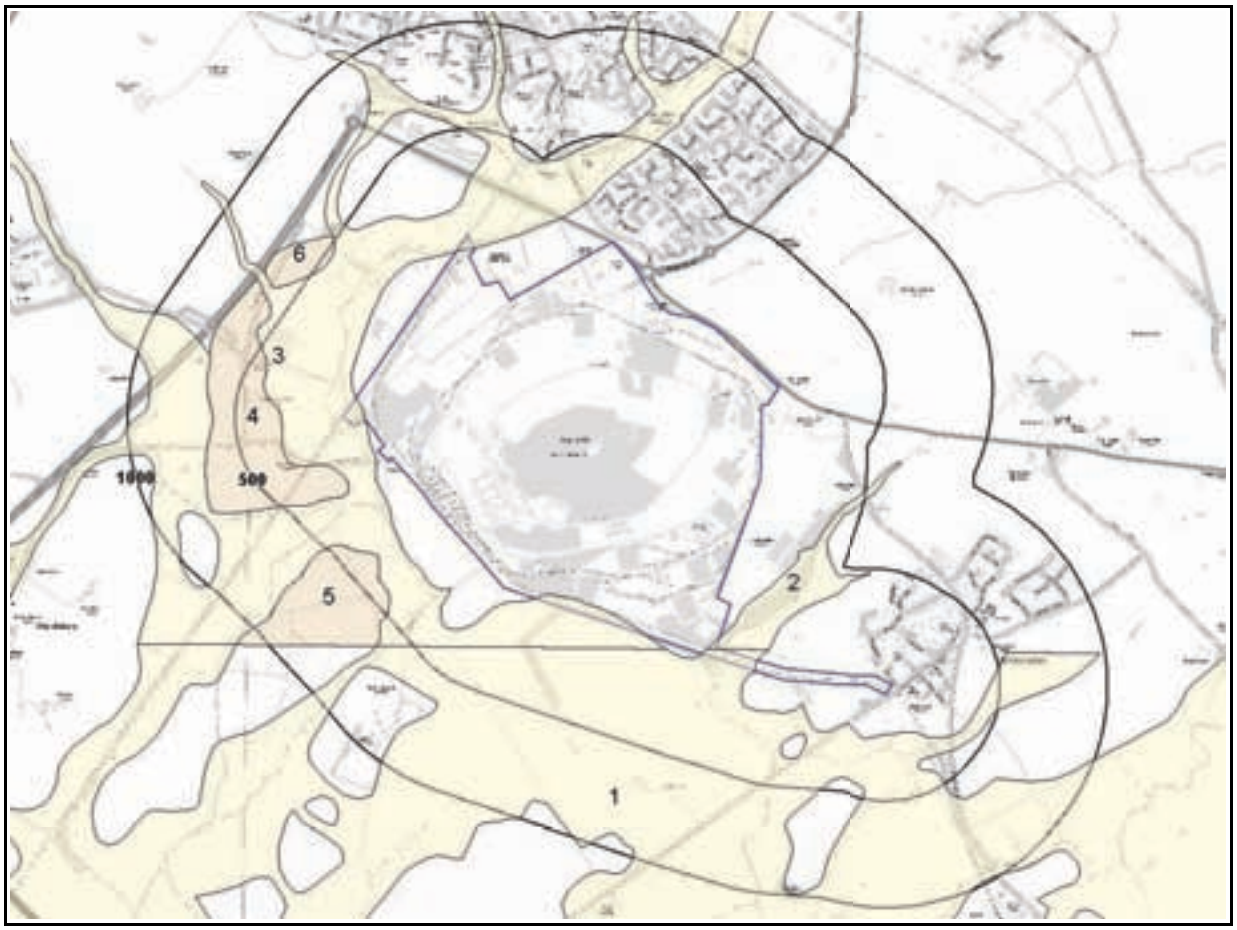
* This includes an automatically generated 50m buffer zone around the site.

1.2 Superficial Deposits and Landslips Map

NW N NE

◄W E►

SW S SE



Superficial and Landslips Legend

Site Outline

500
1000
Search Buffers (m)

Geological information represented on the mapping is derived from the BGS Digital Geological map of Great Britain at 1:50,000 scale.

1.2 Superficial Deposits and Landslips

1.2.1 Superficial Deposits/Drift Geology

Are there any records of Superficial Deposits/Drift Geology within 500m of the study site boundary: Yes

ID	Distance (m)	Direction	Lex Code	Description	Rock Description
1	0.0	On Site	ALV-CSSG	ALLUVIUM	CLAY, SILT, SAND AND GRAVEL
2	0.0	On Site	ALV-CSSG	ALLUVIUM	CLAY, SILT, SAND AND GRAVEL
3	0.0	On Site	ALV-CSSG	ALLUVIUM	CLAY, SILT, SAND AND GRAVEL
4	200.0	SW	RTD1-SAGR	RIVER TERRACE DEPOSITS, 1	SAND AND GRAVEL
5	345.0	SW	RTD1-SAGR	RIVER TERRACE DEPOSITS, 1	SAND AND GRAVEL
6	465.0	NW	RTD1-SAGR	RIVER TERRACE DEPOSITS, 1	SAND AND GRAVEL

1.2.2 Permeability of Superficial Ground

Are there any records relating to permeability of superficial ground within the study site* boundary: Yes

Distance (m)	Direction	Flow type	Maximum Permeability	Minimum Permeability
0.0	On Site	Intergranular	High	Very Low
0.0	On Site	Intergranular	High	Very Low

1.2.3 Landslip

Database searched and no data found.

Are there any records of Landslip within 500m of the study site boundary? No

The geology map for the site and surrounding area are extracted from the BGS Digital Geological Map of Great Britain at 1:50,000 scale.
This Geology shows the main components as discreet layers, these are: Artificial / Made Ground, Superficial / Drift Geology and Landslips. These are all displayed with the BGS Lexicon code for the rock unit and BGS sheet number. Not all of the main geological components have nationwide coverage.

1.2.4 Landslip Permeability

Are there any records relating to permeability of landslips within the study site* boundary: No

Database searched and no data found.

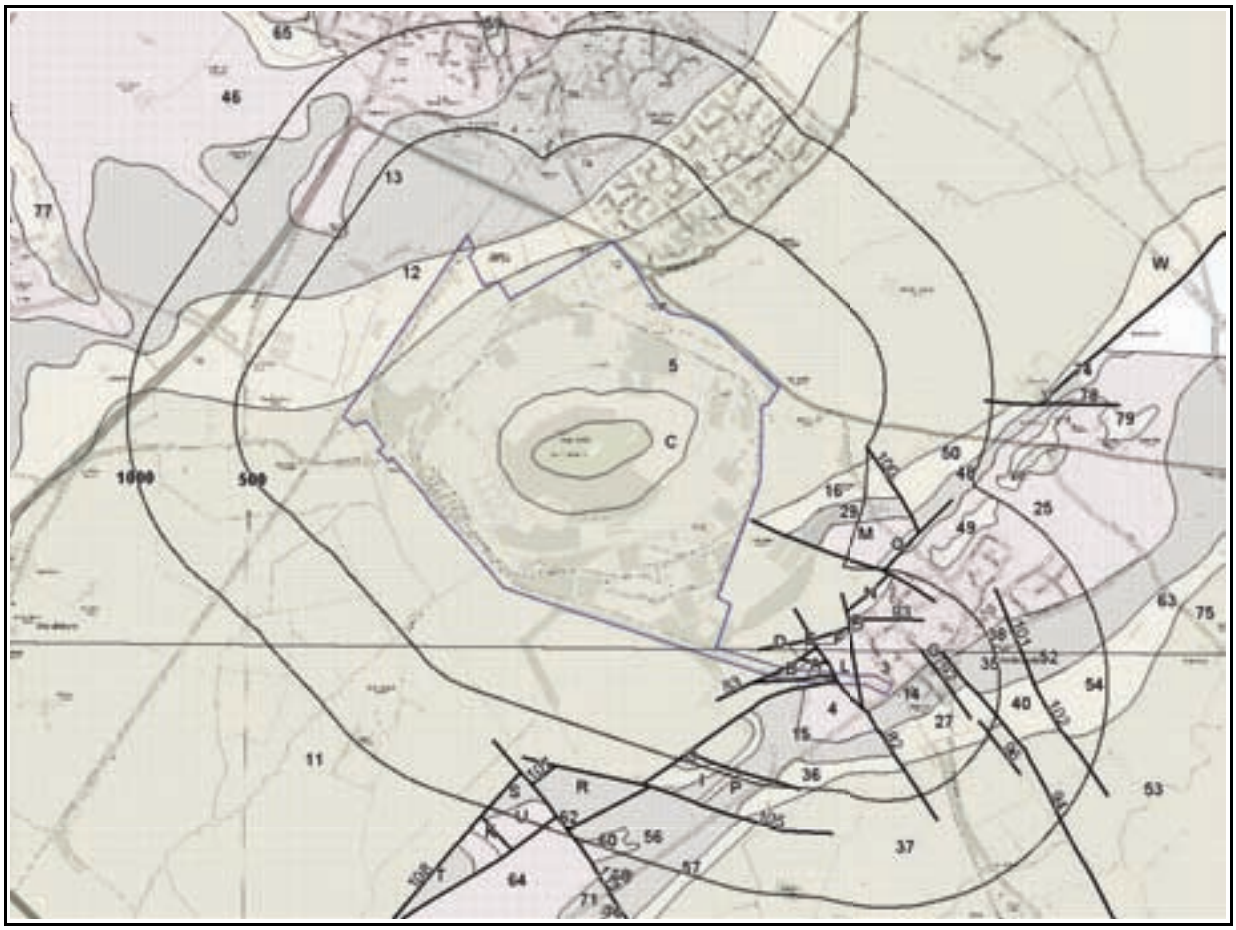
* This includes an automatically generated 50m buffer zone around the site.

1.3 Bedrock and Faults Map

NW ▲ N NE

◄W E►

SW ▼ S SE



Bedrock & Faults Deposits Legend

Site Outline

500
1000
Search Buffers (m)

Geological information represented on the mapping is derived from the BGS Digital Geological map of Great Britain at 1:50,000 scale.

1.3 Bedrock, Solid Geology & Faults

The following geological information represented on the mapping is derived from 1:50,000 scale BGS Geological mapping, Sheet No:219

1.3.1 Bedrock/Solid Geology

Records of Bedrock/Solid Geology within 500m of the study site boundary:

ID	Distance (m)	Direction	LEX Code	Rock Description	Rock Age
1B	0.0	On Site	KLC-MDST	Kellaways Clay Member - Mudstone	Callovian
2L	0.0	On Site	CB-LMST	Cornbrash Formation - Limestone	Callovian / Bathonian
3	0.0	On Site	CB-LMST	Cornbrash Formation - Limestone	Callovian / Bathonian
4	0.0	On Site	CB-LMST	Cornbrash Formation - Limestone	Callovian / Bathonian
5	0.0	On Site	PET-MDST	Peterborough Member - Mudstone	Callovian
6A	0.0	On Site	KLS-SDSL	Kellaways Sand Member - Sandstone And Siltstone, Interbedded	Callovian
7A	0.0	On Site	PET-MDST	Peterborough Member - Mudstone	Callovian
8B	0.0	On Site	CB-LMST	Cornbrash Formation - Limestone	Callovian / Bathonian
9C	0.0	On Site	SBY-MDST	Stewartby Member - Mudstone	Callovian
10C	0.0	On Site	WEY-MDST	Weymouth Member - Mudstone	Oxfordian
11	0.0	On Site	PET-MDST	Peterborough Member - Mudstone	Callovian
12	0.0	On Site	KLS-SDSL	Kellaways Sand Member - Sandstone And Siltstone, Interbedded	Callovian
13	0.0	On Site	KLC-MDST	Kellaways Clay Member - Mudstone	Callovian
14	18.0	SE	KLC-MDST	Kellaways Clay Member - Mudstone	Callovian
15	26.0	S	KLC-MDST	Kellaways Clay Member - Mudstone	Callovian
16	37.0	E	KLS-SDSL	Kellaways Sand Member - Sandstone And Siltstone, Interbedded	Callovian
17A	46.0	N	CB-LMST	Cornbrash Formation - Limestone	Callovian / Bathonian
18D	51.0	N	PET-MDST	Peterborough Member - Mudstone	Callovian
19D	53.0	N	KLS-SDSL	Kellaways Sand Member - Sandstone And Siltstone, Interbedded	Callovian
20A	71.0	N	KLC-MDST	Kellaways Clay Member - Mudstone	Callovian
21D	93.0	N	KLS-SDSL	Kellaways Sand Member - Sandstone And Siltstone, Interbedded	Callovian
22E	97.0	N	KLC-MDST	Kellaways Clay Member - Mudstone	Callovian
23E	101.0	N	CB-LMST	Cornbrash Formation - Limestone	Callovian / Bathonian
24F	102.0	N	CB-LMST	Cornbrash Formation - Limestone	Callovian / Bathonian
25	116.0	N	CB-LMST	Cornbrash Formation - Limestone	Callovian / Bathonian
26F	130.0	N	KLC-MDST	Kellaways Clay Member - Mudstone	Callovian
27	152.0	SE	KLS-SDSL	Kellaways Sand Member - Sandstone And Siltstone, Interbedded	Callovian
28H	182.0	S	KLS-SDSL	Kellaways Sand Member - Sandstone And Siltstone, Interbedded	Callovian
29	194.0	E	KLC-MDST	Kellaways Clay Member - Mudstone	Callovian
30G	204.0	NE	CB-LMST	Cornbrash Formation - Limestone	Callovian / Bathonian
31G	209.0	NE	KLC-MDST	Kellaways Clay Member - Mudstone	Callovian
32H	219.0	S	PET-MDST	Peterborough Member - Mudstone	Callovian
33N	262.0	N	FMB-LSMD	Forest Marble Formation - Limestone And Mudstone, Interbedded	Bathonian
34G	278.0	NE	CB-LMST	Cornbrash Formation - Limestone	Callovian / Bathonian
35	284.0	NE	KLC-MDST	Kellaways Clay Member - Mudstone	Callovian
36	287.0	S	KLS-SDSL	Kellaways Sand Member - Sandstone And Siltstone, Interbedded	Callovian
37	336.0	S	PET-MDST	Peterborough Member - Mudstone	Callovian
38	350.0	NE	KLC-MDST	Kellaways Clay Member - Mudstone	Callovian
39 M	355.0	E	CB-LMST	Cornbrash Formation - Limestone	Callovian / Bathonian
40	398.0	E	KLS-SDSL	Kellaways Sand Member - Sandstone And Siltstone, Interbedded	Callovian
41O	456.0	S	PET-MDST	Peterborough Member - Mudstone	Callovian
42P	467.0	S	KLC-MDST	Kellaways Clay Member - Mudstone	Callovian
43I	468.0	S	KLC-MDST	Kellaways Clay Member - Mudstone	Callovian

44I	468.0	S	KLS-SDSL	Kellaways Sand Member - Sandstone And Siltstone, Interbedded	Callovian
45I	469.0	S	CB-LMST	Cornbrash Formation - Limestone	Callovian / Bathonian
46	472.0	NW	CB-LMST	Cornbrash Formation - Limestone	Callovian / Bathonian
47Q	493.0	N	FMB-LSMD	Forest Marble Formation - Limestone And Mudstone, Interbedded	Bathonian

1.3.2 Permeability of Bedrock Ground

Are there any records relating to permeability of bedrock ground within the study site* boundary: **Yes**

Distance (m)	Direction	Flow type	Maximum Permeability	Minimum Permeability
0.0	On Site	Fracture	Low	Very Low
0.0	On Site	Fracture	Low	Very Low
0.0	On Site	Mixed	Moderate	Moderate
0.0	On Site	Mixed	Moderate	Moderate
0.0	On Site	Fracture	Low	Very Low
0.0	On Site	Fracture	Very High	High
0.0	On Site	Fracture	Very High	High
0.0	On Site	Fracture	Very High	High
0.0	On Site	Fracture	Low	Very Low
0.0	On Site	Fracture	Low	Very Low
0.0	On Site	Fracture	Low	Very Low
0.0	On Site	Fracture	Low	Very Low
18.0	SE	Fracture	Low	Very Low
26.0	S	Fracture	Low	Very Low
37.0	E	Mixed	Moderate	Moderate

1.3.3 Faults

Are there any records of Faults within 500m of the study site boundary? **Yes**

ID	Distance (m)	Direction	Category Description	Feature Description
80H	0.0	On Site	FAULT	Normal fault, inferred
81B	0.0	On Site	FAULT	Normal fault, inferred
82	0.0	On Site	FAULT	Normal fault, inferred
83	0.0	On Site	FAULT	Normal fault, inferred
84L	0.0	On Site	FAULT	Normal fault, inferred
85M	18.0	E	FAULT	Normal fault, inferred
86E	46.0	N	FAULT	Normal fault, inferred
87D	51.0	N	FAULT	Normal fault, inferred
88E	101.0	N	FAULT	Normal fault, inferred
89E	103.0	N	FAULT	Normal fault, inferred
90	116.0	N	FAULT	Normal fault, inferred
91F	148.0	N	FAULT	Normal fault, inferred
92	204.0	NE	FAULT	Normal fault, inferred
93	262.0	N	FAULT	Normal fault, inferred
94	278.0	NE	FAULT	Normal fault, inferred
95N	291.0	N	FAULT	Normal fault, inferred
96	435.0	SE	FAULT	Normal fault, inferred
97O	456.0	S	FAULT	Normal fault, inferred
98P	467.0	S	FAULT	Normal fault, inferred
99Q	493.0	N	FAULT	Normal fault, inferred
100	495.0	SE	FAULT	Normal fault, inferred

The geology map for the site and surrounding area are extracted from the BGS Digital Geological Map of Great Britain at 1:50,000 scale.

This Geology shows the main components as discreet layers, these are: Bedrock/ Solid Geology and linear features such as Faults. These are all displayed with the BGS Lexicon code for the rock unit and BGS sheet number. Not all of the main geological components have nationwide coverage.

* This includes an automatically generated 50m buffer zone around the site.

1.3.4 Radon Affected Areas

Is the property in a Radon Affected Area as defined by the Health Protection Agency (HPA) and if so what percentage of homes are above the Action Level?

The property is not in a radon Affected Area, as less than 1% of properties are above the Action Level

1.3.5 Radon Protection

Is the property in an area where Radon Protection are required for new properties or extensions to existing ones as described in publication BR211 by the Building Research Establishment?

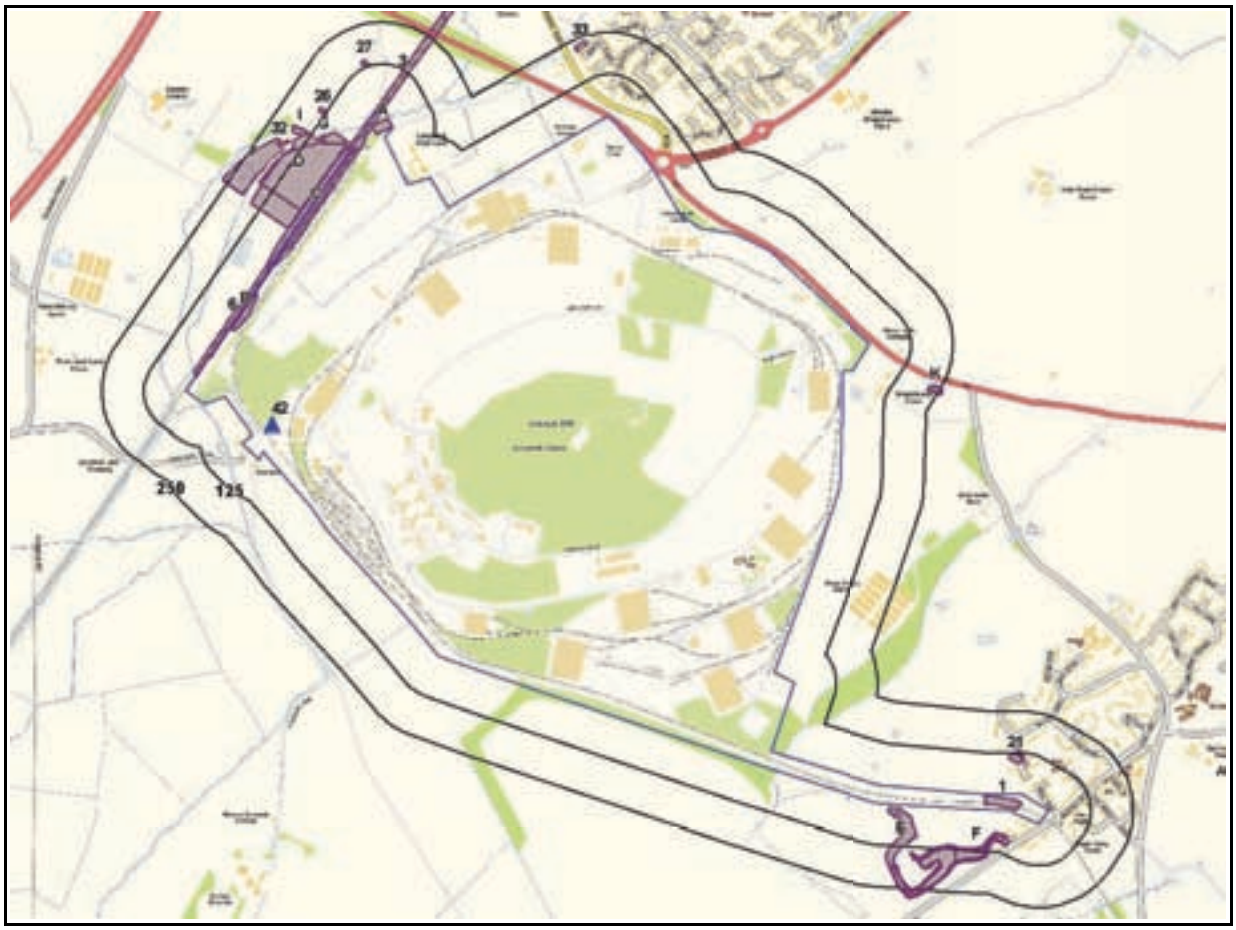
No radon protective measures are necessary

2. Ground Workings Map

NW ▲ N NE

◄W E►

SW ▼ S SE



Ground Workings Legend

Site Outline

125
250
Search Buffers (m)

Historic Surface Ground Workings

Historic Underground Workings

Current Ground Workings

2. Ground Workings

2.1 Historical Surface Ground Working Features derived from the Historical Mapping

This dataset is based on GroundSure's unique Historical Land Use Database derived from 1:10,560 and 1:10,000 scale historical mapping.

Are there any Historical Surface Ground Working Features within 250m of the study site boundary? **Yes**

The following Historical Surface Ground Working Features are provided by GroundSure:

ID	Distance (m)	Direction	NGR	Use	Date
1	0.0	On Site	460140,219307	Cuttings	1950
2A	0.0	On Site	458293,221325	Pond	1970
3	0.0	On Site	458371,221492	Cuttings	1880
4C	0.0	On Site	458093,221079	Pond	1880
5A	0.0	On Site	458293,221325	Pond	1995
6	0.0	On Site	457849,220743	Cuttings	1880
7B	0.0	On Site	457884,220770	Pond	1995
8A	0.0	On Site	458293,221325	Pond	1985
9B	0.0	On Site	457884,220770	Pond	1985
10C	3.0	NW	458075,221086	Water Body	1880
11D	11.0	NW	458051,221163	Sewage Works	1985
12D	11.0	NW	458051,221163	Sewage Works	1995
13E	12.0	S	459814,219165	Ponds	1980
14E	12.0	S	459814,219165	Ponds	1992
15D	22.0	NW	458056,221176	Sewage Farm	1970
16F	68.0	S	460072,219174	Pond	1950
17F	73.0	S	459912,219129	Pond	1880
18G	77.0	NW	458117,221286	Sewage Tank	1879
19G	77.0	NW	458117,221286	Sewage Tank	1919
20G	77.0	NW	458117,221286	Sewage Tank	1898
21	94.0	N	460178,219439	Unspecified Heap	1950
22H	108.0	S	459951,219100	Water Body	1879
23H	108.0	S	459951,219100	Water Body	1919
24H	108.0	S	459951,219100	Water Body	1898
25H	113.0	S	459820,219104	Ponds	1950
26	120.0	NW	458117,221369	Unspecified Heap	1950
27	127.0	N	458241,221515	Unspecified Heap	1950
28I	138.0	NW	458049,221314	Pond	1880
29I	166.0	NW	458009,221279	Sewage Tank	1880
30J	169.0	NW	457909,221207	Ponds	1995
31J	169.0	NW	457909,221207	Ponds	1985
32	180.0	NW	457988,221272	Unspecified Heap	1950
33	214.0	NW	458885,221563	Pond	1880
34K	217.0	SE	459936,220538	Pond	1970
35K	217.0	SE	459936,220538	Pond	1995
36K	217.0	SE	459936,220538	Pond	1950
37K	217.0	SE	459936,220538	Pond	1985
38K	218.0	SE	459937,220537	Pond	1880
39K	218.0	SE	459937,220537	Pond	1879
40K	218.0	SE	459937,220537	Pond	1919
41K	218.0	SE	459937,220537	Pond	1898

2.2 Historical Underground Workings Features derived from the Historical Mapping

This data is derived from the GroundSure unique Historical Land Use Database. It contains data derived from 1:10,000 and 1:10,560 historical Ordnance Survey Mapping and includes some natural topographical features (Shake Holes for example) as well as manmade features that may have implications for ground stability. Underground and mining features have been identified from surface features such as shafts. The distance that these extend underground is not shown.

Are there any Historical Underground Working Features within 1000m of the study site boundary? **No**

Database searched and no data found.

2.3 Current Ground Workings

This dataset is derived from the BGS BRITPITS database covering active; inactive mines; quarries; oil wells; gas wells and mineral wharves; and rail deposits throughout the British Isles.

Are there any BGS Current Ground Workings within 1000m of the study site boundary? **Yes**

The following Current Ground Workings information is provided by British Geological Society:

ID	Distance (m)	Direction	NGR	Use	Date Updated
42	0.0	On Site	457965.0,220435.0	Limestone	16-Jul-2007

3. Mining, Extraction & Natural Cavities Map

NW ▲ N NE

◄W E►

SW ▼ S SE

Mining, Extraction & Natural Cavities Legend

Site Outline

250
500
Search Buffers (m)

Historical Mining

Non-Coal Mining Cavities

Natural Cavities

3. Mining, Extraction & Natural Cavities

3.1 Historical Mining

This dataset is derived from GroundSure unique Historical Land-use Database that are indicative of mining or extraction activities.

Are there any Historical Mining areas within 1000m of the study site boundary? **No**

Database searched and no data found.

3.2 Coal Mining

This dataset provides information as to whether the study site lies within a known coal mining affected area as defined by the coal authority.

Are there any Coal Mining areas within 1000m of the study site boundary? **No**

Database searched and no data found.

3.3 Shallow Mining

This dataset refers to the (largely very old) extraction of mineral deposits by means of near surface underground workings.

What is the maximum hazard rating of subsidence relating to shallow mining within the study site* boundary? **Negligible**

*This includes an automatically generated 150m buffer zone around the study site boundary

The following Shallow Mining information provided by the British Geological Survey is not represented on Mapping:

Distance (m)	Direction	Hazard Rating	Details
0.0	On Site	Negligible	Where negligible potential is indicated, this means that the rocks underlying the area are not likely to have been mined at shallow depth. However, you should still find out whether or not a Coal Authority mining search is required in the area, for example, to check for deeper mining.
0.0	On Site	Negligible	Where negligible potential is indicated, this means that the rocks underlying the area are not likely to have been mined at shallow depth. However, you should still find out whether or not a Coal Authority mining search is required in the area, for example, to check for deeper mining.

3.4 Non – Coal Mining Cavities

This dataset provides information from the Peter Brett Associates (PBA) mining cavities database (compiled for the national study entitled "Review of mining instability in Great Britain, 1990" PBA has also continued adding to this database) on mineral extraction by mining.

Are there any Non-Coal Mining cavities within 1000m of the study site boundary? **No**

Database searched and no data found.

3.5 Natural Cavities

This dataset provides information based on Peter Brett Associates natural cavities database.

Are there any Natural Cavities within 1000m of the study site boundary? **No**

Database searched and no data found.

3.6 Brine Extraction

This dataset provides information from the Brine compensation board which has been discontinued and is now covered by the Coal Authority.

Are there any Brine Extraction areas within 1000m of the study site boundary? **No**

Database searched and no data found.

3.7 Gypsum Extraction

This dataset provides information on Gypsum extraction from British Gypsum records.

Are there any Gypsum Extraction areas within 1000m of the study site boundary? **No**

Database searched and no data found.

3.8 Tin Mining

This dataset provides information on tin mining areas and is derived from tin mining records.

Are there any Tin Mining areas within 1000m of the study site boundary? **No**

Database searched and no data found.

3.9 Clay Mining

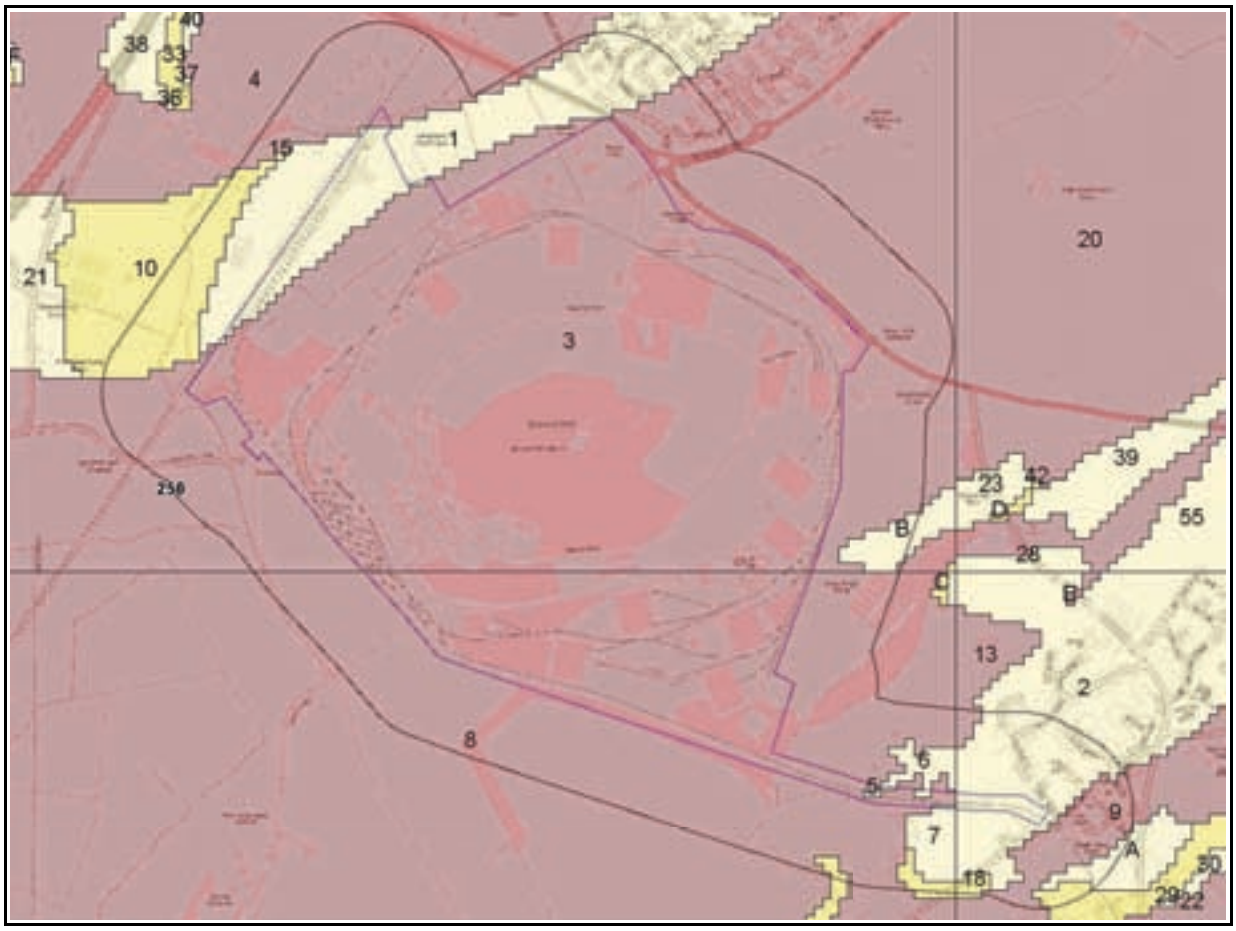
This dataset provides information on Kalin and Ball Clay mining from relevant mining records.

Are there any Clay Mining areas within 1000m of the study site boundary? **No**

Database searched and no data found.

4. Natural Ground Subsidence
4.1 Shrink-Swell Clay Map

NW ▲ N NE



◄W E►

SW ▼ S SE

Shrink-Swell Clay Legend

Site Outline

125
250
Search Buffers (m)

No Data / Null
Negligible
Very Low

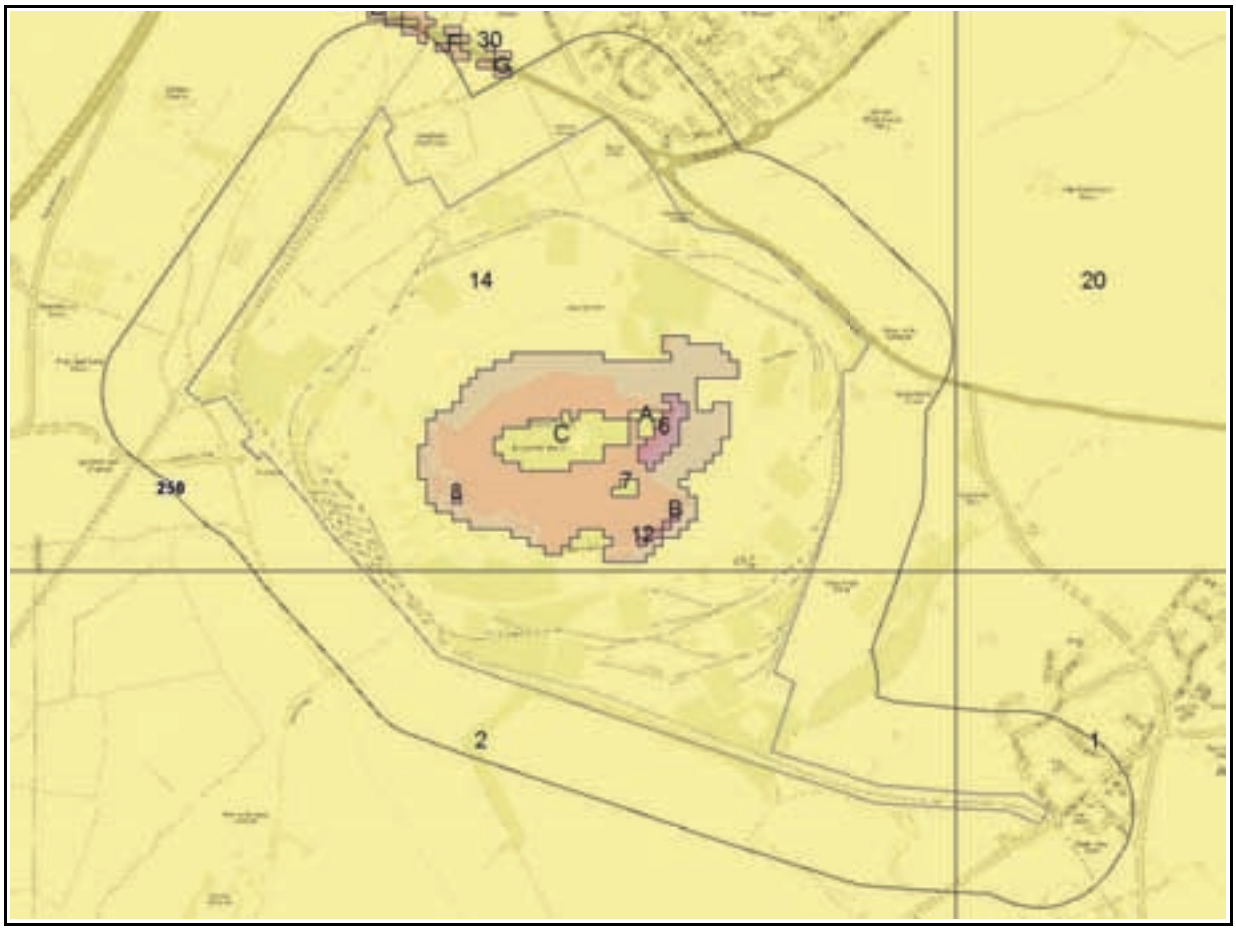
Low
Moderate
High

4.2 Landslides Map

NW ▲ N NE

◄W E►

SW ▼ S SE



Landslides Legend

Site Outline

125
250
Search Buffers (m)

No Data / Null

Negligible

Very Low

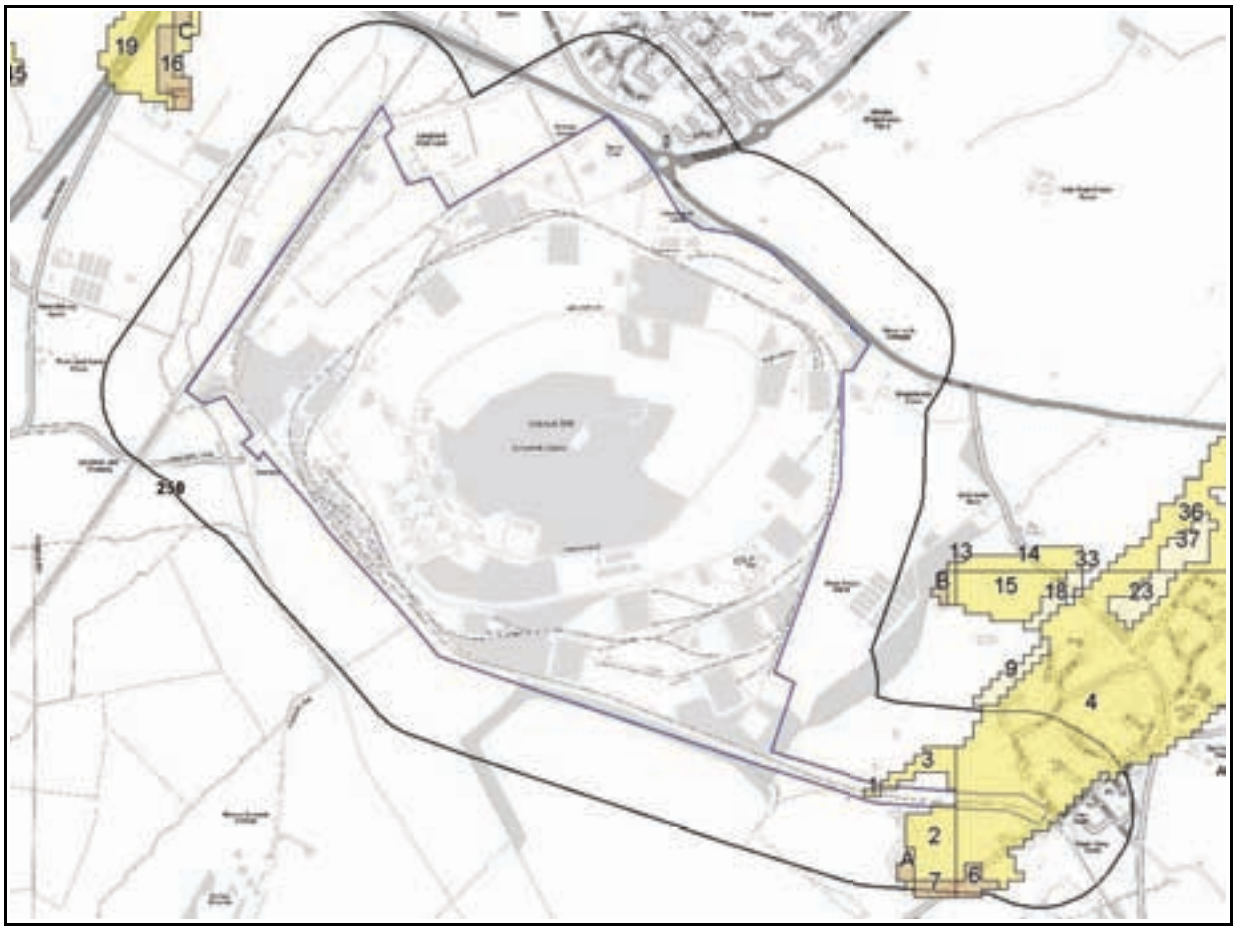
Low

Moderate

High

4.3 Ground Dissolution Soluble Rocks Map

NW ▲ N NE



◄W E►

SW ▼ S SE

Ground Dissolution Soluble Rocks Legend

Site Outline

125
250
Search Buffers (m)

No Data / Null
Negligible
Very Low

Low
Moderate
High