BAE SYSTEMS Environmental

Factual Report

Stage 1 Site Investigation, Bishopton

Redrow Group & BAE Systems Property Investments Ltd

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1. INTRODUCTION

1.1. Instruction

BAE Systems Property Investments Ltd and Redrow Group entered into a legal agreement in relation to the redevelopment of the former Royal Ordnance site in Bishopton.

Under the agreement, on 15th June 2004 BAE Systems Property Investments Ltd appointed BAE Systems Environmental (a trade name of BAE Systems Properties Ltd) to act as Remediation Consultants for the project.

The scope of this commission was to undertake preliminary site investigations and develop an outline remediation strategy.

1.2. Background

The former Royal Ordnance factory in Bishopton ceased production in 2002 and proposals were prepared by BAE Systems (the owners) and Redrow (development partner in the project) to bring the Site back into beneficial use. It was proposed to regenerate and remediate the Site using redevelopment as the enabler.

The regeneration plan for the Site is outlined in a report prepared by Cass Associates (Masterplan Statement (in preparation), Cass Associates.) and includes mixed-use development including residential, commercial, employment, community and open space end uses. The Core Development Area 1005 ha, which occupies approximately 24% of the Site area, is situated in the north-eastern part of the Site, adjacent to the existing Bishopton village.

In view of the Site's 80 year industrial history, it was considered that remediation would be required in order to make the Site suitable for its proposed next use(s). In addition, there is a requirement for land contamination issues to be assessed and appropriately addressed as a material planning consideration.

It is therefore necessary to present a remediation strategy to support the application for outline planning for the redevelopment. In order to gain sufficient information to develop the remediation strategy, it is necessary to conduct preliminary intrusive investigations.

1.3. Scope & Objectives

A phased approach to the assessment was considered appropriate and agreed with Renfrewshire Council and SEPA, the Stage I site investigation being undertaken to support the outline planning application, with further investigations to be undertaken to support full planning thereafter.

Therefore, the principal objectives of the Stage 1 site investigation are:

- To provide sufficient information for the development of a robust preliminary remediation strategy; and,
- To support the Environmental Statement and Environmental Impact Assessment in the Outline Planning Application.

In order to achieve these objectives, the following scope of work has been undertaken:

- Provide information on the nature and extent of contamination, concentrating on identified potential sources of contamination from the desk study (BAE Systems Environmental, 2005).
- Develop an initial conceptual site model.
- Identify actual or potential pollutant linkages.
- Inform the remediation plan.
- Identify requirements for further investigations The main investigation will follow successful application for outline planning consent and will include:
- Intrusive works to determine if additional potential pollutant linkages exist (gap filling e.g. under buildings, structures)
- Intrusive works to confirm extent of previously identified contamination (delineation)
- Detailed Quantitative Risk Assessment to determine the significance of identified pollutant linkages
- Works necessary to discharge any conditions on the outline planning consent.

This document details the factual findings of the Stage I site investigation that was designed to meet the objectives outlined above. More detail on the investigation rationale and methodology for the Stage I investigation are described in the Stage 1 Site Investigation Outline Strategy report (BAE Systems Environmental, 2005) and in Section 3 of this report.

The general approach and scope of works outlined in the Investigation Strategy was agreed with Renfrewshire Council Environmental Services and the Scottish Environment Protection Agency prior to embarking upon the works.

This report should be read in conjunction with the following documents:

- Preliminary Risk Assessment for Land Contamination, Desk Study, Bishopton (BAE Systems Environmental 2005)
- Stage 1 Site Investigation Outline Strategy, (BAE Systems Environmental, 2005)
- Generic Quantitative Risk Assessment, (BAE Systems Environmental, 2006)
- Outline Remediation Strategy, (BAE Systems Environmental, 2006)

1.4. Definitions

The term 'Site' refers to land owned by BAE Systems to the south-west of Bishopton village encompassing the former Royal Ordnance factory, as shown in Figures 1 and 2.

1.5. Reporting Conditions

The report refers to the conditions present at the Site at the time of the study. No liability can be accepted by BAE Systems Environmental for any future changes of Site conditions. It should be noted that BAE Systems Environmental has relied on the accuracy of the information contained in the documents consulted and is in no circumstances responsible for the accuracy of such information or data supplied.

This report has been specifically prepared for the purposes stated in Section 1.3 and therefore should not be used for any other purpose without prior consultation with BAE Systems Environmental.

For explosives safety reasons it was not possible to sample soil beneath existing buildings. Underground process drains and beneath effluent lagoons were avoided for the same reasons. Sampling beneath such structures will be undertaken following decontamination.

In certain instances the reporting limits for particular elements may change from sample to sample; such as the analysis for Bismuth in soils, and leachate analysis for Lead and Tin. This change may be related to the soil type that is being analysed, or as a result of interference from other elements or materials within the soil.

2. SITE CHARACTERISTICS

2.1. General

This section provides a summary of the Site's history and physical setting. Reference should be made to the Preliminary Risk Assessment for Land Contamination (PRALC), (BAE Systems Environmental, 2005) for further details.

2.2. Location

The Site is located to the south-west of Bishopton village in Renfrewshire, Scotland, approximately 15 km west of Glasgow city centre. The Site is centred on National Grid Reference (NGR) NS 433 691.

2.3. Description

The Site is roughly rectangular in shape and occupies an area of approximately 1005 hectares (ha). The land surrounding the Site is predominantly agricultural, being a mix between arable, pasture and woodland.

Some 766 ha of the Site is fenced and contains the former Royal Ordnance factory, accessed via Station Road. The 230 ha of land between the factory fence and the Site boundary is predominantly arable and pasture land except for Barochan Moss, an area of afforested peat.

The centre and south of the Site is generally flat lying at between 5 and 15 metres Above Ordnance Datum (m.AOD). The land rises steeply in the north and north-west of the Site to elevations of around 60 m.AOD.

2.4. History

Prior to development the Site was predominantly agricultural land.

Industrial development of the Site can be divided into two eras, the first being the Scottish Filling Factory ('Georgetown') operational during the First World War.

Georgetown, an ordnance filling factory, occupies approximately 194 ha in the southern part of the Site, within the factory fence. Buildings associated with the Georgetown factory were demolished shortly after the Second World War (WWII) and the area is now predominantly wooded.

The Royal Ordnance factory was built from 1937 over much of the remainder of the Site and also occupies the northern part of Georgetown. The major function of the factory was the production of gun and rocket propellant for the armed services, and was in production until 2002.

The Royal Ordnance factory was conceived as three self-sufficient propellant factories (I, II and III), each having its own boiler house, nitroglycerine, nitrocellulose and acids production sections. Tetryl was manufactured in Factories II and III.

Although the layout of the factory has remained largely unchanged since it was built, the range in activities carried out has varied over the years. Of particular note were the manufacture of picrite and the breakdown of surplus ammunition. Other processes included the manufacture of RDX, Ball Powder, ammonium perchlorate

and Combustible Charge Containers (CCCs), and the filling of ordnance with phosphorus.

Previous uses of the factory are shown on the individual zone plans (figures 9A to 9R) and in Figure 7.

2.5. Published Geology

An extract of the British Geological Survey solid geology map is given in Figure 4 and a superficial geology map, which has been created using findings from exploratory points, is given in Figure 3.

2.5.1. Superficial Deposits

Glacial till of the Wilderness Till Formation (Fm.) overlies bedrock and is shown to outcrop on higher ground particularly in the north of the Site.

In the lower-lying central and southern areas the till is overlain by glaciomarine silts and clays of the Linwood Fm. and underlying Paisley Fm. (These deposits are practically indistinguishable from each other in the field so are referred to in this document as Linwood/Paisley Fm.)

The interface between till and the glaciomarine silt is often marked by beach/deltaic sands and gravels of the Killearn Fm.

A mound of granular material in the centre of the Site, south-east of Dargavel House, is attributed to the fluvio-glacial deposits of the Broomhouse Fm. directly overlying glacial till.

Peat of the Clippens Peat Fm. is shown on low lying land in the east and west of the Site. An outcrop of alluvium (Erskine Fm.) associated with the River Gryfe is indicated in the far south-western corner of the Site.

2.5.2. Bedrock

Higher ground in the northern part of the Site is formed by the Clyde Plateau Volcanic Fm. of Upper Carboniferous age.

The Bedrock of the lower lying areas comprises interbedded sandstone, mudstone, limestone and coal of Upper Carboniferous age (Lawmuir Fm., Limestone Coal Fm. and Lower Limestone Fm.).

The Upper Carboniferous strata are intruded by two quartz-dolerite dykes and displaced by a number of predominantly east-west trending faults.

2.6. Aquifer Classification

The Bedrock Aquifer Productivity Map (BGS, 2004) indicates that the Clyde Plateau Volcanic Fm has low productivity (0.1 – 1 l/s) arising from fracture flow. The Carboniferous sedimentary rocks are indicated to be moderately productive (1 – 10 l/s) comprising both fracture and intergranular flow. The Superficial Deposit Aquifer Productivity Map (BGS, 2004) indicates that the superficial deposits are moderately productive and flow is intergranular.

The Scottish Environment Protection Agency (SEPA) have advised that according to BGS records, Messrs J. Craig, Barr and Cook own a disused borehole located on Old Bishopton Estate. This tapped the Carboniferous, Calciferous Sandstone Measures. Although there is no information available concerning yield or water quality, SEPA advise that the presence of this borehole suggests that the aquifer has been important locally.

The Bedrock Aquifer Productivity Map and the Superficial Deposit Aquifer Productivity Map are presented as Figures 5a and 5b respectively.

The Groundwater Vulnerability Map of Scotland (SNIFFER, 2004) classifies the site as 'vulnerability category 2', which is defined as 'vulnerable to some pollutants, but only when continuously discharged/leached'. It should also be noted that in areas where fractured igneous bedrock is exposed at the surface the highest category of vulnerability should be applied. This is defined as 'vulnerable to most water pollutants with rapid impact in many scenarios' and is due to the absence, under these circumstances, of intergranular flow. The Groundwater Vulnerability Map of Scotland is presented as Figure 6.

2.7. Hydrology

Dargavel Burn runs through the centre of the Site flowing into the River Gryfe at the southernmost tip of the Site. Along its length the Burn is joined by numerous ditches, drainage pipes, former process water drains and small streams, some of which emanate from outside the factory boundary. The SEPA database suggests that the Dargavel Burn at Formakin has an overall classification of 'A2'(good).

Craigton Burn enters the Site at the eastern boundary just south of Bishopton village and flows in a northeast to southwesterly direction. It is joined by Cordite Burn, which flows from the northern boundary, before meeting Dargavel Burn near the centre of the Site.

The locations of principal watercourses are shown on figure 2.

3. INVESTIGATION METHOD

3.1. General

The investigation was undertaken between 6 June and 4 October 2005.

Work was carried out by BAE Systems Environmental's approved subcontractors under the supervision of BAE Systems Environmental personnel.

Site work was notified under the Construction Design and Management Regulations and was carried out in accordance with BAE Systems Environmental's Safety, Health and Environment (SHE) Plan (BAE Systems Environmental, 2005).

For the purposes of this investigation the Site was divided into 18 No. zones (A to R) based on the locations of former manufacturing sections and, to a lesser extent, the outline of the Core Development Area. Zone boundaries are shown on Figure 7 and the findings of each zone are presented in section 4.

A number of potential contamination sources were assessed separately, such as asbestos beneath steam mains, explosives contamination around buildings and the narrow-gauge railway, and PCB contamination around transformers. The results of these investigations are reported in separate sections of the report.

Exploratory point locations are shown on Figures 8 to 14. Detailed descriptions of the strata encountered at each exploratory point and a record of the type and frequency of samples recovered are given on the exploratory point records in Appendices 2, 3, 4 and 5. All depths are given in metres below ground level.

Minor adjustments were made to the position of exploratory points outlined in the investigation strategy to allow access and avoid underground services.

3.2. Scope of Investigation

The investigation included the following:

- Excavation of 770 No. exploratory points comprising:
  - 441 No. trial pits;
  - 74 No. hand-auger holes;
  - 37 No. boreholes advanced by cable percussive and rotary techniques, installed with combined groundwater and gas monitoring standpipes;
  - 13 No. window sample holes;
  - 122 No. hand-dug positions; and,
  - 83 No. exploratory positions beneath steam mains.
- Visual inspection of 16 km of narrow gauge railway.
- Collection of 22 No. surface water samples and 90 No. groundwater samples over 2 No. monitoring visits.

- Survey of exploratory points to determine their location relative to National Grid and Ordnance Datum.
- Geophysical survey of 1.6 ha and subsequent excavation of anomalies.
- Laboratory chemical analysis of 1529 No. soil samples and 118 No. water samples.
- *In-situ* and laboratory geotechnical tests.

The numbers of exploratory points are summarised below.

Element of Investigation	Trial Pits	Hand Augers	Bore-holes	Window sample boreholes	Hand Samples	Total
Zone A	24	-	1	-	-	25
Zone B	12	-	2	-	-	14
Zone C	10	2	2	-	-	14
Zone D	65	-	3	7	-	75
Zone E	15	1	1	-	-	17
Zone F	31	1	2	-	1	35
Zone G	74	1	5	-	-	80
Zone H	27	2	2	-	-	31
Zone I	21	1	1	-	-	23
Zone J	43	8	1	-	1	53
Zone K	25	4	2	-	-	31
Zone L	39	7	3	-	-	49
Zone M	26	-	4	6	2	38
Zone N	3	1	-	-	-	4
Zone O	3	9	-	-	-	12
Zone P	10	6	5	-	-	21
Zone Q	10	4	3	-	-	17
Zone R	3	24	-	-	-	27
Around buildings	-	-	-	-	108	108
Near steam mains	63	-	-	-	20	83
Near transformers	-	3	-	-	10	13
Total	504	74	37	13	142	770

Table 1 – Summary numbers of exploratory methods

A more detailed description of the scope and methodology of the investigation are provided in the following sub-sections.

3.3. Trial Pits

A total of 441 No. trial pits were excavated to an approximate depth of 3 m. (This includes 5 No. aborted borehole starter pits that were hand-dug to a depth of 1.2 m.)

Trial pits were excavated by JCB 3CXs owned and operated by AFP Construction (Bishopton) Ltd. Hand augers were used in place of trial pits where machine access was impractical (see Section 3.6).

Following excavation, each trial pit was backfilled and the materials replaced as far as practicable in reverse order to which they had been excavated, so as to minimise mixing of made ground and natural strata.

The excavator bucket was washed with water between exploratory positions.

A photographic record exists for each trial pit and they were logged in general accordance with BS5930:1999 – Code of Practice for Site Investigations. Trial pit logs are provided in Appendix 2; a selection of trial pit photographs is included in Appendix 6.

Soil samples were collected at the following approximate depths: 0.1, 0.3, 0.5 and 1.0 m, then each metre and/or change of strata to the base of the hole.

In-situ measurements of shear strength were obtained using a hand vane in a selection of trial pits.

3.4. Boreholes

A total of 37 No. boreholes were drilled to depths of between 1.8 and 16.2 m by Fugro Engineering Services Ltd. Drilling was preceded by hand-dug starter pits to a depth of 1.2 m.

Thirty-five boreholes were formed by cable percussive techniques. Rotary open-hole drilling was used to advance 2 No. of the cable percussive boreholes into bedrock, and to drill a further 2 No. boreholes from ground level.

The depths of groundwater strikes were noted and any changes in level observed for a minimum of 20 minutes.

Casing and tools were washed with water between boreholes.

Soil samples were collected from starter pits at approximate depths of 0.1, 0.3, 0.5 and 1.0 m, and in the cable percussive boreholes at every 1.5 m and change of strata. Obtaining soil samples from discreet depths during open-hole rotary drilling is not practical and was not attempted.

Inspection pits and cable percussive boreholes were logged in general accordance with BS5930:1999. Driller's descriptions are given for strata drilled using open-hole rotary methods.

Borehole logs are given in Appendix 3.

3.5. Monitoring Installations

Upon completion 36 No. boreholes were installed with 50 mm diameter HDPE standpipes for groundwater and gas monitoring. BH1529 was too shallow for a monitoring installation and was backfilled with arisings.

Dual installations were fitted in BH1074, BH1194 and BH1621.

Response zones (slotted pipe) were positioned to intercept any observed groundwater strikes or, where groundwater was absent, to coincide with the main strata in the borehole.

One-metre bentonite seals were placed above the slotted pipe. Bentonite seals were also installed below the slotted pipe for dual installations as well a number of the other boreholes to isolate the response zone from adjacent strata. A one-metre bentonite seal was placed at the top of each borehole to prevent entry of surface water. Surface reinstatement consisted of a cemented-in upstanding cover, except for BH1528, that was fitted with a flush cover.

Construction details are shown on the borehole logs in Appendix 3.

Following installation, monitoring wells were developed using a combination of surging and over-pumping. Ten well volumes were pumped from each borehole using a surge block, except boreholes that ran dry; these were allowed to recharge overnight and pumped dry again. Where boreholes pumped dry very quickly, at least one well volume of tap water was added to assist surging.

3.6. Window Sampling

Thirteen window sample holes were drilled around 2 No. above-ground fuel tanks in Zones D and M to a depth of approximately 4 m using a Competitor window sampling rig. Drilling was preceded by hand-dug starter pits to a depth of 1.2 m depth.

Window sample logs are given in Appendix 4.

3.7. Hand Augers

Hand augers were used in place of trial pits where machine access was impractical.

Hand augers were advanced to approximately 1.5 m depth dependent on the ground conditions encountered. The equipment was washed with water between exploratory points.

Samples were generally taken at depth ranges of 0.0 to 0.2 m, 0.3 to 0.5 m, 0.9 to 1.1 m and 1.4 to 1.6 m, dependent on the strata encountered.

Hand auger logs are given in Appendix 2.

3.8. Soil Sampling

Representative disturbed samples were obtained from all exploratory holes before being sent for chemical analysis and/or geotechnical testing.

Each sample was taken for a specific purpose, either to determine the nature of contamination or to confirm that underlying strata could be regarded as uncontaminated.

Soil samples were taken with stainless steel implements and/or disposable nitrile gloves. A new glove was used for each sample operation to minimise the potential for cross contamination. Samples from cable percussive boreholes were taken directly from the drilling tool.

Each sample consisted of a 500 ml amber glass jar with PTFE lined lid and a 1 litre plastic tub. The majority of analyses, including explosives, PAHs and TPH were carried out on the sample from the amber glass jar. A sub-sample for soil leachability analysis was taken from the tub.

Samples for VOC and SVOC analysis were collected in 60 ml amber glass jars with PTFE lined lids.

All amber glass jars were stored in an on-site refrigerator at approximately 6 °C before being couriered to the laboratory. Amber jars for VOC and SVOC analysis were transported in cool boxes.

Samples were transported with a completed chain of custody form.

3.9. Groundwater Sampling

Groundwater levels were determined using an electronic dip meter.

Where possible, each borehole was purged of 3 No. well volumes of groundwater prior to sampling using a dedicated inertial pump (Waterra™).

Measurements of pH, temperature, electrical conductivity, dissolved oxygen and redox potential were made following purging. The instruments used were calibrated prior to use in accordance with the manufacturer's instructions.

Samples were taken unfiltered from the Waterra™ pipe or from a dedicated HDPE bailer to minimise cross contamination. Appropriate sample containers were provided by the laboratory. The laboratory were under instruction to filter and fix immediately on receipt of samples.

3.10. Surface Water Sampling

Surface water samples were taken from predefined locations to coincide with the historical monitoring that has been undertaken at the site. Samples were taken using a grab method with efforts employed to minimise disturbance of bottom silts.

Measurements of pH, temperature, electrical conductivity, dissolved oxygen and redox potential were made following purging. The instruments used were calibrated prior to use in accordance with the manufacturer's instructions.

3.11. Gas Monitoring

Gas flow, pressure, atmospheric pressure and the concentrations of methane, carbon dioxide, carbon monoxide, hydrogen sulphide and oxygen were measured using a Geotechnical Instruments GA2000 infrared gas analyser and a Gas Data GF60 flow meter.

All instruments are maintained and calibrated by the manufacturers in accordance with BAE Systems Environmental's ISO Accredited Quality Management System.

Sampling was carried out by BAE Systems Environmental personnel who have been trained to undertake such sampling and monitoring.

3.12. Topographical Survey

The position of boreholes, trial pits and hand augers was determined relative to National Grid and Ordnance Datum (except for HA1526, due to difficult access) by Loy Survey Ltd.

Coordinates and ground levels are shown on the appropriate exploratory point records in Appendix 3 and Appendix 4.

3.13. Laboratory Analysis

Sample analysis was carried out by the following laboratories.

- BAE Systems Environmental, Chorley.
- STL Laboratories, Coventry.
- Mountainheath, Letchworth
- Marchwood, Southampton
- Bodycote, Glasgow
- Fugro, Consett
- DETS, Durham

Our in-house laboratory (with MCERTS accreditation) has undertaken the majority of soil analysis, generally using accredited methods. Bodycote Analytical, Clydebank and STL haven undertake all water analyses as well as specific soils analysis where required including asbestos. Both Bodycote and STL have been audited by BAE Systems Environmental chemists and have a fully operational quality system incorporating a wide scope of methods. Specialist testing has also been undertaken by other laboratories.

The main laboratories used regularly submit their analytical regimes to inter-laboratory comparison through the Water Research Centre AQUACHECK and Laboratory of the Government Chemist CONTEST schemes. Bodycote also participate in the RICE scheme for asbestos analysis.

In some cases, there are no commercial laboratories offering specialised testing using accredited methods e.g. soluble solvents where Mountainheath undertook these analyses. However, it is understood that the lab were working towards accreditation at the time of the analysis being undertaken and indeed they have now received such accreditation.

Summary analytical methods with limits of detection and laboratory accreditation are given in Appendix 13.

3.14. Explosives Safety

BAE Systems Environmental is considered a leading expert in the safe investigation and assessment of explosives sites, with over 15 years' experience of this type of work.

All intrusive works were closely supervised by appropriately trained and experienced BAE Systems Environmental engineers. These engineers were given a detailed site-specific induction covering the types of explosives and devices that could be encountered, their appearance and the associated hazards.

Explosives safety was included in the general site induction, which was given to all other personnel involved in the investigation.

Measures taken to mitigate the risks associated with encountering explosives included:

- Hand-dug starter pits through made ground prior to cable percussive drilling and window sampling.
- Enforcing ‘man limits’ of 2 persons for excavations and 3 persons for drilling.
- Damping down suspicious material with water (particularly important since the investigation was carried out during summer).
- Clear plans of action in the event of discovering suspicious materials.
- Utilisation of hand-held ordnance detectors and engineers experienced in ammunition recognition for certain areas of the Site.
- Trial pitting and subsequent sampling of groundwater in Nitroglycerine sections before drilling.

4. INVESTIGATION FINDINGS

4.1. General

The factual findings of the investigation are summarised in this Section, divided as follows:

- Zones A to R (Sections 4.2 to 4.19);
- Sampling beneath steam mains (4.20);
- Sampling around process buildings (Section 4.21);
- Sampling around electrical sub-stations (Section 4.22);
- Inspection of narrow gauge railway track (Section 4.23);
- Geophysical survey in Ammunition Breakdown Section (Section 4.24); and,
- Groundwater and surface water (Section 4.25).

Each zone section contains a scope of work, summary of ground conditions, summary tables of analytical results.

Figure 8 – Exploratory Point Location Plan – shows all trial pits, hand augers boreholes connected with the main part of the investigation. Exploratory point location plans for each zone are given as Figures 9A to 9Q. (Exploratory points in Zone R are shown on Figure 8 only.)

Figure 3 shows the refined superficial geology as interpreted from the findings of the investigation.

Locations of samples taken as part of additional investigations, such as around process buildings and beneath steam mains, are shown on Figures 10 to 14.

The geotechnical findings are out with the remit of this report and are not discussed further. Geotechnical data is presented in Appendix 12.

4.2. Zone A

4.2.1. Introduction

Zone A occupying approximately 17ha, includes the Factory I NG Section and Ball Powder Section.

Process buildings in nitroglycerine (NG) sections are generally well spaced, so a grid spacing of 150 m was selected. However, the spacing was reduced to 100 m for Zone A because Factory I NG Section is partly within the Core Development Area.

Potential contamination sources in this zone include process buildings, acid tanks, NG wash water settling ponds, solvent tanks and lead salts development.

4.2.2. Scope of Investigation

Investigation in Zone A comprised the following:

- 24 No. trial pits
- 1 No. borehole

The scope of investigation in this zone did not differ significantly from that outlined in the strategy document.

Of the 109 No. soil samples taken, 50 No. were analysed for a range of contaminants. Of these 32 No. were samples of made ground and 18 No. were natural.

4.2.3. Ground Conditions

Made Ground

Made ground was encountered in 18 No. exploratory locations with typical thicknesses of between 0.2 to 1.4 m.

Two types were observed. The first type of made ground comprised fragments of blaes, brick, glass, metal, sack cloth, ash, clinker, tarmac and concrete, and was found across most of the zone usually associated with buildings, narrow gauge railways and services.

Secondly, reworked natural material was evident across the zone, again, particularly where services/buildings were located. This reworked material comprised sand, silt, clay and fine to coarse angular to sub-rounded gravels of mixed lithology including basalt, quartzite, sandstone and schist with minor constituents of charcoal and blaes.

Superficial Deposits

Superficial deposits were encountered in all of the exploratory points, predominantly comprising brown sandy gravelly clay (Wilderness Till Fm.) on higher ground and dark brown/grey silt and clay (Linwood/Paisley Fm.) on lower ground. The maximum thickness of superficial deposits was 9.1 m, observed in BH1622.

Found on higher ground, the Wilderness Till Fm. was typically brown and described as firm to very stiff clay with fine to coarse angular to sub-rounded gravels of mixed lithology (including basalt, quartzite, sandstone and schist) and angular to sub-rounded cobbles and boulders.

The Linwood/Paisley Fm. found on lower ground was soft to firm and friable silt and clay with fine to coarse angular gravel, occasionally sandy, with occasional plant remains. The upper part of these deposits was brown, becoming grey typically at 1.5 m.

Light brown and grey silty gravelly sand with sub-rounded cobbles (Killearn Fm.) was observed at a number of locations typically below the made ground or near surface. These were observed across the zone generally on sloping ground at the boundary between the Wilderness Till Fm. and the Linwood/Paisley Fm. as well as

on higher ground. The ratio of sands to gravel varied, as did the proportion of rounded to sub-rounded cobbles.

Bedrock

Weathered bedrock was encountered in one trial pit (TP1006) at a depth of 1.8 m, recovered as angular light brown to grey coarse sub-angular gravel.

Groundwater

Groundwater was encountered in 4 No. exploratory points at depths of between 1.1 and 3.0 m. Groundwater inflow was generally observed as a seepage either in natural clay or above the boundary between made ground and clay.

Evidence of Contamination

Fragments of what appeared to be cement bonded asbestos sheet were found in TP1021 near surface.

Olfactory evidence of slight hydrocarbon contamination was noted in TP1014 at 1.3 m depth. Sheens of light non-aqueous phase liquid (LNAPL) were noted at 1.1 m in TP1022. A slight sulphurous odour was noted in TP1005 from 0.6m.

4.2.4. Laboratory Analysis

Summary analytical soil and leachability results are given below and complete results are given in Appendix 7 and Appendix 8.

Soil

Determinands	units	No.	Min.	Mean	Max.
2,4-DNT	mg/kg	52	<1	1	1
2,6-DNT	mg/kg	52	<1	-	<1
EGDN	mg/kg	52	<0.1	0.1	0.1
HMX	mg/kg	52	<2	-	<2
HNS	mg/kg	52	<0.5	-	<0.5
NC	mg/kg	52	<5,000	-	<5,000
NG	mg/kg	52	<0.1	0.2	1.7
PETN	mg/kg	52	<5	-	<5
Picric acid	mg/kg	52	<0.1	-	<0.1
Picrite	mg/kg	52	<0.25	-	<0.25
RDX	mg/kg	52	<2	-	<2
Tetryl	mg/kg	52	<1	-	<1
TNT	mg/kg	52	<0.5		<0.5

Table 2 – Zone A, Explosives

Determinand	units	No.	Min.	Mean	Max.
As	mg/kg	52	2	7.5	17
Cd	mg/kg	52	<0.3	0.9	9.5
Cr	mg/kg	52	10	31	64
Pb	mg/kg	52	<3	44	498

Determinand	units	No.	Min.	Mean	Max.
Hg	mg/kg	52	<0.1	0.1	0.7
Se	mg/kg	52	<0.3	0.4	2.6
Cu	mg/kg	52	<3	23	110
Ni	mg/kg	52	7	24	56
Zn	mg/kg	52	19	97	1,080
Ba	mg/kg	22	47	141	327
Be	mg/kg	22	1	5	15
Bi	mg/kg	22	<3	3	5
Mg	mg/kg	22	2,720	6,905	21,300
Mn	mg/kg	22	140	541	1,360
Mo	mg/kg	22	<5	-	<5
P	mg/kg	22	400	627	1,200
Sb	mg/kg	22	<5	-	<5
Sn	mg/kg	22	2	7	34
Sr	mg/kg	22	9	34	140
Ti	mg/kg	22	786	1,877	10,700
V	mg/kg	22	25	55	150

Table 3 – Zone A, Metals & semi-metals

Determinand	units	No.	Min.	Mean	Max.
pH		52	5.1	7.3	9.0
Sulphate	mg/kg	22	<250	431.4	1130
Sulphur	mg/kg	22	<10	22.1	113
Asbestos	Presence/Absence	52			2
Asbestos Quantification	%	2	<0.001	-	<0.001
Total PAHs (See Appendix 7 for Individual PAHs)	mg/kg	52	<0.1	23	526
TPH C5-C6	mg/kg	8	<1.5	-	<1.5
TPH >C6-C8	mg/kg	8	<2	-	<2
TPH >C8-C10	mg/kg	8	<1	-	<1
TPH >C10-C12	mg/kg	8	<2	-	<2
TPH >C12-C16	mg/kg	9	<20	30	109
TPH >C16-C21	mg/kg	9	<20	134	812
TPH >C21-C40	mg/kg	9	<20	707	4,450
Pesticides	mg/kg	1	<0.05		<0.10
Moisture content	%	11	6.4	18.8	40.0
Organic matter	%	4	1.5	2.5	3.3

Table 4 – Zone A, Others

Determinand	units	No.	Min.	Mean	Max.
As	µg/l	6	<1	2	4
B	µg/l	6	<300	-	<300
Be	µg/l	6	<5	-	<5
Cd	µg/l	6	<0.5	0.6	0.8
Cr	µg/l	6	<5	-	<5
Cu	µg/l	6	<5	7	8
Hg	µg/l	6	<0.1	-	<0.1
Mg	mg/l	6	0.2	0.4	0.8
Mn	µg/l	6	<5	-	<5
Mo	µg/l	6	<5	-	<5
Ni	µg/l	6	<5	-	<5
Pb	µg/l	6	<5	6.8	14
Sb	µg/l	6	<1	-	<1
Se	µg/l	6	<1	-	1.1
Sn	µg/l	6	<20	20.5	23
V	µg/l	6	<5	-	<5
Zn	µg/l	6	7	19	28
pH		6	6.3	7.1	8.3

Table 5 – Zone A, Leachability

NG was detected in 11 No. shallow samples at concentrations of between 0.1 and 1.7 mg/kg, the two highest levels being found next to an NG settling pond and a paste mixing house (TP1012 and 1013). EGDN and 2,4 DNT were found at the reporting limit in 3 and 1 sample, respectively.

Metal concentrations show little spatial variation or pattern.

Asbestos was found in two shallow samples from TP1021 in an area of disturbed ground in the Ball Powder Section, confirming the observation made in the field.

Field observations of hydrocarbon contamination in TP1014 were associated with detectable TPH particularly in the range C21-40 (4,450 mg/kg), and PAHs (total 526 mg/kg). Similar field observations in TP1022 were associated with much lower TPH and PAH concentrations (TPH C21-40 = 92 mg/kg, Total PAHs 1.6 mg/kg). Total PAHs above 50 mg/kg were found in three other samples but with no obvious point source. Laboratory analysis found no point source for either the sulphurous odour noted in TP1005 or the sheen of LNAPL noted in TP1022.

The leachable fraction was generally between 0.1 and 1.5 %. Magnesium leachability was particularly low in the order of 1.0E-4 %. Tin leachability was slightly higher at around 5 %.

4.3. Zone B

4.3.1. Introduction

Zone B, occupying approximately 15ha, comprises Factory II NG Section.

Process buildings in nitroglycerine sections are generally well spaced, and a site investigation grid spacing of 150 m was selected. The majority of this zone is

outside the Core Development Area with the exception of a small northern area of the zone.

Potential contamination sources in this zone include process buildings, acid tanks, fuel tanks, NG lagoons, lead salts development and general storage.

4.3.2. Scope of Investigation

Investigation in Zone B comprised the following:

- 12 No. trial pits
- 2 No. boreholes

The scope of investigation did not differ significantly from that proposed.

Of the 83 No. soil samples taken, 35 No. were analysed for a range of contaminants. Of these 20 No. were samples of made ground and 15 No. were natural.

4.3.3. Ground Conditions

Made Ground

Made ground was encountered in 11 No. exploratory points with typical thicknesses ranging from 0.2 m to 0.9 m. There were two main types of made ground. The first type, found in 7 No. exploratory points, comprised sandy clay with fragments of blaes, brick, glass, metal, clinker, slag, charcoal, glass, and concrete.

The second type, found in 4 No. exploratory points, consisted of reworked natural material with rare fragments of man-made materials, commonly observed near services and buildings. This material comprised sands, silts, clay and fine to coarse angular to sub-rounded gravels of mostly igneous rock, ranging in thickness between 0.2 and 0.6 m, typically.

Superficial Geology

Superficial deposits were encountered in all of the exploratory locations predominantly comprising brown sandy gravelly clay (Wilderness Till Fm.) on higher ground and dark brown/grey silt and clay (Linwood/Paisley Fm.) on lower ground.

The Wilderness Till Fm. varied in consistency from firm to stiff and was described as clay with fine to coarse rounded to sub-rounded gravels and rounded to sub-rounded cobbles and boulders.

The Linwood/Paisley Fm. consisted of sandy gravelly silts and clays with fine to coarse angular to sub-rounded gravel with occasional plant remains. Grey silty sand and gravel (Killearn Fm.) was observed at 2 No. locations, typically near surface.

Sand and gravels up to 9.7 m thick found in BH1027 are attributed to the Broomhouse Fm. on the published geological map. These were the maximum thickness of superficial deposits observed in Zone B.

Bedrock

Bedrock was not encountered in Zone B.

Groundwater

Groundwater was encountered in four locations; BH1027, BH1623, TP1026, and TP1028 at depths of 2.8, 2.7, 1.7 and 2.5 m respectively. In BH1027 and TP1028 the water was noted within sand and gravel, likely to be from the Killearn Fm., while in BH1623 and TP1026 the water was noted in clay/silt layers likely to be from the Linwood/Paisley Fm.

Evidence of Contamination

No visual or olfactory evidence of contamination was noted in Zone B.

4.3.4. Laboratory Analysis

Summary analytical soil and leachability results are given below and complete results are given in Appendix 7 and Appendix 8.

Soil

Determinand	units	No.	Min.	Mean	Max.
2,4-DNT	mg/kg	34	<1	-	<1
2,6-DNT	mg/kg	34	<1	1	2
EGDN	mg/kg	34	<0.1	0.1	1
HMX	mg/kg	34	<2	-	<2
HNS	mg/kg	34	<0.5	-	<0.5
NC	mg/kg	34	<5,000	-	<5,000
NG	mg/kg	34	<0.1	0.2	1.4
PETN	mg/kg	34	<5	-	<5
Picric acid	mg/kg	34	<0.1	-	<0.1
Picrite	mg/kg	34	<0.25	0.27	1.05
RDX	mg/kg	34	<2	-	<2
Tetryl	mg/kg	34	<1	-	<1
TNT	mg/kg	34	<0.5	-	<0.5

Table 6 – Zone B, Explosives

Determinand	units	No.	Min.	Mean	Max.
As	mg/kg	34	4	9	20
Cd	mg/kg	34	<0.3	0.4	2.8
Cr	mg/kg	34	27	42	120
Pb	mg/kg	34	4	2,055	65,700
Hg	mg/kg	34	<0.1	0.1	0.7
Se	mg/kg	34	<0.3	0.6	2.8
Cu	mg/kg	34	10	29	130
Ni	mg/kg	34	19	35	70
Zn	mg/kg	34	33	101	704
Ba	mg/kg	12	62	150	270
Be	mg/kg	12	1.0	2.5	5.6

Determinand	units	No.	Min.	Mean	Max.
Bi	mg/kg	12	<4	6	11
Mg	mg/kg	12	4,060	7,105	16,100
Mn	mg/kg	12	307	600	1,110
Mo	mg/kg	12	<5	-	<5
P	mg/kg	12	290	731	1,080
Sb	mg/kg	12	<5	25	250
Sn	mg/kg	12	2	11	59
Sr	mg/kg	12	13	40	90
Ti	mg/kg	12	631	1,466	3,520
V	mg/kg	12	32	68	110

Table 7 – Zone B, Metals & semi-metals

Determinand	units	No.	Min.	Mean	Max.
pH		34	5.2	6.7	9.5
Sulphate	mg/kg	12	<250	745.8	1730
Sulphur	mg/kg	12	<10	32.9	187
Asbestos	Presence/Absence	35	ND	ND	ND
Total PAHs (See Appendix 7 for Individual PAHs)	mg/kg	33	<0.1	12	123
TPH C5-C6	mg/kg	2	<1.5	-	<1.5
TPH >C6-C8	mg/kg	2	<2	-	<2
TPH >C8-C10	mg/kg	2	<1	-	<1
TPH >C10-C12	mg/kg	2	<2	-	<2
TPH >C12-C16	mg/kg	2	<20	29	38
TPH >C16-C21	mg/kg	2	<20	38	56
TPH >C21-C40	mg/kg	2	117	145	172
Moisture content	%	3	20.4	23.8	29.7
Organic matter	%	1	9.7	9.7	9.7

Table 8 – Zone B, Others

Determinand	units	No.	Min.	Mean	Max.
As	µg/l	7	<1	4	8
B	µg/l	7	<300	-	<300
Be	µg/l	7	<5	-	<5
Cd	µg/l	7	<0.5	-	<0.5
Cr	µg/l	7	<5	-	<5
Cu	µg/l	7	<5	6	11
Hg	µg/l	7	<0.1	0.1	0.4
Mg	mg/l	7	<0.1	0.3	0.5
Mn	µg/l	7	<5	5	7
Mo	µg/l	7	<5	-	<5
Ni	µg/l	7	<5	-	<5
Pb	µg/l	7	<5	29	144
Sb	µg/l	7	<1	4	25
Se	µg/l	7	<1	-	<1

Determinand	units	No.	Min.	Mean	Max.
Sn	µg/l	7	<20	-	<20
V	µg/l	7	<5	-	<5
Zn	µg/l	7	<5	11	22
pH		7	7.4	8.2	9.0

Table 9 – Zone B, Leachability

NG was detected in 4 No. shallow samples at concentrations of between 0.1 and 1.4 mg/kg, the two highest levels being found next to a shifting house and lead salts preparation building (TP1034 and TP1025). Also in TP1025, 2,6 DNT was found at a concentration of 1.5 mg/kg. Picrite was detected at a depth of 3.9 m adjacent to a wash water pond (TP1026) and EGDN was found at the reporting limit in 1 sample.

The highest levels of lead were detected adjacent to the lead salts preparation building in TP1025 (65,700 mg/kg) while other samples were generally less than 100 mg/kg and typically less than 50 mg/kg. Other metal concentrations show little spatial variation or pattern.

Asbestos was not detected in any of the samples.

Although there were no field observations of hydrocarbon contamination, detectable TPH in the range C21 to 40 (172 and 117 mg/kg) from TP1033 and TP1026 were found. TPH ranging from C12 - C16 and C16 - C21 was also detected at lower concentrations in TP1033. Made ground here contained clinker and total PAHs at a concentration of 54.4 mg/kg.

The highest total PAHs (123 mg/kg) was detected next to the lead salts preparation building (TP1025). Total PAHs above 50 mg/kg were found in one other sample but with no obvious point source.

The leachable fraction was generally between 0.1 and 1.5 %. Magnesium leachability was particularly low in the order of 1.0E-4 %. Tin leachability was slightly higher at around 3%.

4.4. Zone C

4.4.1. Introduction

Zone C, occupying approximately 23ha, is the Factory III NG Section and includes Boghall Dump and the Vegetation Tip (investigated in 2002).

Process buildings in nitroglycerine sections are generally well spaced, so a grid spacing of 150 m was selected. This zone also falls outside the Core Development Area.

Potential contamination sources in this zone include process buildings, NG wash water settling ponds, the aforementioned areas of waste disposal and a burning ground (building ref no. 16/007J).

4.4.2. Scope of Investigation

Investigation in Zone C comprised the following:

- 10 No. trial pits

- 2 No. boreholes
- 2 No. hand augers

The scope of investigation in this zone did not differ significantly from that proposed although it was necessary to replace two of the trial pits with hand augers due to access restrictions.

Of the 55 No. soil samples taken, 27 No. were analysed for a range of contaminants. Of these 13 No. were samples of made ground and 14 No. were natural.

4.4.3. Ground Conditions

Made Ground

Made ground was highly variable both in terms of depth and type across the zone. Made ground generally ranged from 0.25 m to 1.6 m in thickness, however, in TP1040 it was 2.4 m.

Made ground was encountered at all locations except HA1049, HA1051 and TP1045. It generally comprised a dark brown sandy, gravelly silt with varying amounts of man-made fragments including blaes, glass, porcelain, wood, bricks, tiles, metal pipe, asbestos sheet and concrete. In TP1040 and TP1052 a greater thickness of made ground was encountered (2.4 m and 1.6 m respectively). The material encountered in these pits (bricks, metal, glazed tile, asbestos and concrete) is consistent with general demolition materials from previously demolished buildings.

Superficial Geology

Superficial deposits were encountered in all of the exploratory points, usually Killearn Fm. and Wilderness Till Fm, although Linwood/Paisley Fm. was encountered in TP 1048 in the central part of the zone.

The Killearn Fm. comprised dark brown silty sands and gravels; the gravels tending to be fine to coarse rounded to sub-rounded of quartzite, sandstone, basalt and mixed metamorphic rocks.

The Linwood/Paisley Fm. was firm grey clay becoming light grey thinly bedded silt.

The Wilderness Till Fm. was generally brown sandy gravelly silts and clays. The gravel comprised fine to coarse sub-angular gravel of basalt and sandstone as well as grey cobbles to boulders of basalt.

Soft, wet, dark brown sandy peaty silt was encountered in HA1049.

The maximum thickness of superficial deposits was 2.4 m, observed in BH1050.

Bedrock

Bedrock was encountered in BH1046 at a depth of 1.6 m and although it was described by the drillers as grey sandstone, it was most likely basalt of the Clyde Plateau Volcanic Fm.

Groundwater

Groundwater was encountered in TP1045, TP1052, and BH1046 at depths of 1.4, 2.1 and 3.0 m, respectively. In BH1046 the water strike was within the bedrock while the other strikes were moderate flows within layers of sand and gravel.

Evidence of Contamination

Fragments of what appeared to be asbestos sheet were encountered near surface in TP1052.

4.4.4. Laboratory Analysis

Summary analytical soil and leachability results are given below and complete results are given in Appendix 7 and Appendix 8.

Soil

Determinand	units	No.	Min.	Mean	Max.
2,4-DNT	mg/kg	27	<1	-	<1
2,6-DNT	mg/kg	27	<1	-	<1
EGDN	mg/kg	27	<0.1	-	<0.1
HMX	mg/kg	27	<2	-	<2
HNS	mg/kg	27	<0.5	-	<0.5
NC	mg/kg	27	<5,000	-	<5,000
NG	mg/kg	27	<0.1	0.1	0.3
PETN	mg/kg	27	<5	-	<5
Picric acid	mg/kg	27	<0.1	-	<0.1
Picrite	mg/kg	27	<0.25	-	<0.25
RDX	mg/kg	27	<2	-	<2
Tetryl	mg/kg	27	<1	-	<1
TNT	mg/kg	27	<0.5	-	<0.5

Table 10 – Zone C, Explosives

Determinand	units	No.	Min.	Mean	Max.
As	mg/kg	27	4	12	40
Cd	mg/kg	27	<0.3	0.7	11.0
Cr	mg/kg	27	14	38	60
Pb	mg/kg	27	<3	826	16,700
Hg	mg/kg	27	<0.1	0.5	4.8
Se	mg/kg	27	<0.3	0.5	1.2
Cu	mg/kg	27	5	339	8,250
Ni	mg/kg	27	11	35	100
Zn	mg/kg	27	55	528	10,770
Ba	mg/kg	14	49	234	912
Be	mg/kg	14	1.6	5.8	16.8
Bi	mg/kg	14	<3	4	8
Mg	mg/kg	14	2,920	9,433	16,500
Mn	mg/kg	14	422	799	1,780

Determinand	units	No.	Min.	Mean	Max.
Mo	mg/kg	14	<5	-	<5
P	mg/kg	14	270	838	1,670
Sb	mg/kg	14	<5	5	9
Sn	mg/kg	14	<2	20	89
Sr	mg/kg	14	11	34	120
Ti	mg/kg	14	1,090	3,914	10,100
V	mg/kg	14	40	91	160

Table 11 – Zone C, Metals & semi-metals

Determinand	units	No.	Min.	Mean	Max.
pH		27	5.2	6.8	8.1
Sulphate	mg/kg	14	<250	759.3	1610
Sulphur	mg/kg	14	<10	50.2	573
Asbestos	Presence/Absence	27	ND	ND	ND
Total PAHs (See Appendix 7 for Individual PAHs)	mg/kg	27	<0.1	1	6
TPH C5-C6	mg/kg	6	<1.5	-	<1.5
TPH >C6-C8	mg/kg	6	<2	-	<2
TPH >C8-C10	mg/kg	6	<1	-	<1
TPH >C10-C12	mg/kg	6	<2	-	<2
TPH >C12-C16	mg/kg	6	<20	-	<20
TPH >C16-C21	mg/kg	6	<20	21	23
TPH >C21-C40	mg/kg	6	<20	39	120
Moisture content	%	8	5.1	17.6	28.4
Organic matter	%	3	4.0	5.2	7.2

Table 12 – Zone C, Others

Determinand	units	No.	Min.	Mean	Max.
As	µg/l	2	<1	-	<1
B	µg/l	2	<300	-	<300
Be	µg/l	2	<5	-	<5
Cd	µg/l	2	<0.5	-	<0.5
Cr	µg/l	2	<5	-	<5
Cu	µg/l	2	5	6	6
Hg	µg/l	2	<0.1	-	<0.1
Mg	mg/l	2	<0.1	-	<0.1
Mn	µg/l	2	<5	6	7
Mo	µg/l	2	<5	-	<5
Ni	µg/l	2	<5	-	<5
Pb	µg/l	2	<5	-	<5
Sb	µg/l	2	<1	-	<1
Se	µg/l	2	<1	-	<1
Sn	µg/l	2	<20	-	<20
V	µg/l	2	<5	-	<5
Zn	µg/l	2	7	9	10

Determinand	units	No.	Min.	Mean	Max.
pH		2	7.7	7.7	7.7

Table 13 – Zone C, Leachability

NG was detected in one near surface sample at a concentration of 0.3 mg/kg found next to a dry gun cotton expense store. No other explosives were detected.

The highest levels of lead were detected in made ground next to the road leaving the nitrating house from TP1040 (16,700 mg/kg) and TP1043 (3,190 mg/kg) while other samples were generally less than 50 mg/kg. Arsenic was found in TP1041 at a concentration of 40 mg/kg but other samples generally contained less than 20 mg/kg. Other metal concentrations show little spatial variation or pattern.

Field observations suspecting asbestos fragments were not confirmed. Asbestos was not detected in any samples.

Although no visual or olfactory field observations were noted, Total PAHs were found at the reporting limit or above in 14 No. samples with no obvious point source. Detectable TPH (C21 - C40 at 120 mg/kg, C16 - C21 at 23 mg/kg) and Total PAHs at 2.1 mg/kg were found in TP1053 located next to an air compression plant. TPH (C21 - C40) was also detected in BH1050 at a concentration of 33 mg/kg.

The leachable fraction was generally between 0.1 and 1.5 %

4.5. Zone D

4.5.1. Introduction

Zone D, occupying approximately 36ha, comprises Factory I NC and acids sections.

This Zone is characterised by large closely spaced process buildings and acid tank farms. A nominal grid spacing of 75 m was selected because of the density of potential contamination sources and the fact that Zone D is within the Core Development Area.

Zones D also includes the Ammonium Perchlorate, Demolition Guncotton and Lead Salts sections.

Specific potential contamination sources in this zone include process buildings, acid tanks, fuel tanks, settling lagoons, NC ETP and a burning ground.

4.5.2. Scope of Investigation

Investigation in Zone D comprised the following:

- 65 No. trial pits
- 3 No. boreholes
- 7 No. window sample boreholes

The scope of investigation in this zone did not differ significantly from that proposed. Following observations of hydrocarbons in TP1078 near two above-ground fuel oil

tanks (building ref no. 22/117), 7 No. window sample boreholes were positioned in the vicinity to delineate the contamination.

Of the 340 No. soil samples taken, 144 No. were analysed for a range of contaminants. Of these 106 No. were samples of made ground and 38 No. were natural.

4.5.3. Ground Conditions

Made Ground

Made ground was encountered in the majority of exploratory points varying in thickness between 0.2 and 1.3 m.

The made ground was predominantly dark brown sandy silt with fragments of blaes, clinker, brick, coal, glass, tarmac, concrete, slag, metal and whole bricks. Layers of made ground 0.2 to 0.5 m thick consisting almost entirely of blaes were encountered in 7 No. locations, mainly in the northern area of the zone. In TP1062 and TP1126 made ground was encountered at a thickness of 1.1 m and 1 m respectively. The material encountered in these pits (bricks, waste materials, asbestos and concrete) is consistent with general demolition materials from previously demolished buildings.

Reworked natural was encountered in much of the central area of the zone consisting of soft brown sandy gravelly silt with few fragments of man-made materials such as blaes, brick and charcoal.

Superficial Geology

Superficial deposits were encountered in all of the exploratory points.

In the northern area of the zone the deposits were generally dark brown silty sands and gravels (Killearn Fm.) overlying firm light brown becoming soft and grey sandy gravelly silts and clays (Linwood/Paisley Fm.). The gravel was generally fine to coarse angular to sub-rounded of basalt and sandstone, quartzite and schist.

In the central and southern areas of the zone the Linwood/Paisley Fm. was the predominant strata.

Firm to stiff brown sandy clay (Wilderness Till Fm.) was encountered around the north and western edges of the zone, as well as an area in the centre of the zone. In both cases it generally formed areas of slightly raised ground.

The maximum thickness of superficial deposits was 4.7 m, observed in BH1089.

Bedrock

Bedrock was encountered at between 4.0 and 4.7 m depth in the 3 No. boreholes in Zone D. Possible bedrock was also encountered in 7 No. trial pits at depths ranging between 1.5 and 2.8 m. Generally, the bedrock encountered was moderately strong weathered grey-brown sandstone, probably attributable to the Lawmuir Fm.

Groundwater

Within the made ground water was encountered in 7 No. exploratory points at depths of between 0.1 and 0.4 m.

In superficial deposits groundwater was encountered between 0.7 and 2.9 m depth.

Within the bedrock (sandstone) groundwater was encountered in 3 No. locations at depths of between 0.4 and 5.8 m and rose to depths of between 3 and 3.8 m after 20 minutes.

Evidence of Contamination

Olfactory evidence of hydrocarbons was reported in 3 No. trial pits: TP1078 at 0.9 m (strong); TP1102 at 1.0 m (strong, solvent-like); and, TP1111 between 0.4 and 0.6 m (slight).

Fragments of what appeared to be asbestos material were observed in the made ground between surface and 1.0 m depth in TP1126, 0.3m in TP1182, near surface in TP1123 and up to 0.4 m in TP1088.

A white paste-like substance was noted at 0.4 m in TP1125 and was subsequently confirmed in the laboratory as being NC.

4.5.4. Laboratory Analysis

Summary analytical soil and leachability results are given below and complete results are given in Appendix 7 and Appendix 8.

Soil

Determinand	units	No.	Min.	Mean	Max.
2,4-DNT	mg/kg	143	<1	-	<1
2,6-DNT	mg/kg	143	<1	-	<1
EGDN	mg/kg	143	<0.1	-	<1
HMX	mg/kg	143	<2	-	<2
HNS	mg/kg	143	<0.5	-	<0.5
NC	mg/kg	143	1,200	4,967	14,800
NG	mg/kg	143	<0.1	0.1	1.6
PETN	mg/kg	143	<5	-	<5
Picric acid	mg/kg	143	<0.1	-	<0.1
Picrite	mg/kg	143	<0.25	-	<0.25
RDX	mg/kg	143	<2	14	1,701
Tetryl	mg/kg	143	<1	-	<1
TNT	mg/kg	143	<0.5	-	<0.5

Table 14 – Zone D, Explosives

Determinand	units	No.	Min.	Mean	Max.
As	mg/kg	143	1	11	93
Cd	mg/kg	143	<0.3	0.3	1.7
Cr	mg/kg	143	9	35	160
Pb	mg/kg	143	<3	261	9,720
Hg	mg/kg	143	<0.1	0.5	24.2
Se	mg/kg	143	<0.3	0.6	3.0
Cu	mg/kg	143	<3	66	2,220
Ni	mg/kg	143	<5	33	150
Zn	mg/kg	143	13	179	3,380
Ba	mg/kg	86	14	357	3,940
Be	mg/kg	86	<0.1	1.4	11.5
Bi	mg/kg	86	<3	8	29
Mg	mg/kg	86	1,350	4,648	12,300
Mn	mg/kg	86	74	436	1,990
Mo	mg/kg	86	<5	5	10
P	mg/kg	86	200	723	1,530
Sb	mg/kg	86	<5	10	170
Sn	mg/kg	86	<2	8	100
Sr	mg/kg	86	5	40	260
Ti	mg/kg	86	390	1,332	3,620
V	mg/kg	86	19	59	180

Table 15 – Zone D, Metals & semi-metals

Determinand	units	No.	Min.	Mean	Max.
pH		143	5.1	7.4	9.5
Sulphate	mg/kg	86	<250	731.4	3650
Sulphur	mg/kg	86	<10	50.6	1050
Asbestos	Presence/Absence	143			2
Total PAHs (See Appendix 7 for Individual PAHs)	mg/kg	143	<0.1	34	1,860
TPH C5-C6	mg/kg	37	<1.5	-	<1.5
TPH >C6-C8	mg/kg	37	<2	2	5
TPH >C8-C10	mg/kg	37	<1	4	116
TPH >C10-C12	mg/kg	37	<2	16	505
TPH >C12-C16	mg/kg	37	<20	76	1,310
TPH >C16-C21	mg/kg	37	<20	122	2,090
TPH >C21-C40	mg/kg	37	<20	254	2,230
VOCs		14			
1,1,2,2-Tetrachloroethane	µg/kg				625
1,1,2-Trichloroethane	µg/kg				1400
1,2,3-Trichlorobenzene	µg/kg				305
1,2,3-Trichloropropane	µg/kg				1160
1,2,4-Trichlorobenzene	µg/kg				303
1,2,4-Trimethylbenzene	µg/kg				135

Determinand	units	No.	Min.	Mean	Max.
1,3,5-Trimethylbenzene	µg/kg				176
2-Chlorotoluene	µg/kg				275
4-Chlorotoluene	µg/kg				299
Isopropylbenzene	µg/kg				63
m,p-Xylene	µg/kg				31
n-Butylbenzene	µg/kg				392
n-Propylbenzene	µg/kg				184
o-Xylene	µg/kg				25
p-Isopropyltoluene	µg/kg				375
sec-Butylbenzene	µg/kg				1890
tert-Butylbenzene	µg/kg				118
SVOCs		14			
Di-n-butyl phthalate	mg/kg				1.01
Moisture content	%	51	12.5	23.0	41.6
Organic matter	%	16	1.0	5.1	21.0

Table 16 – Zone D, Others

Determinand	units	No.	Min.	Mean	Max.
As	µg/l	28	<1	7	10
B	µg/l	28	<300	-	<300
Be	µg/l	28	<5	-	<5
Cd	µg/l	28	<0.5	3.5	67.0
Cr	µg/l	28	<5	-	<5
Cu	µg/l	28	<5	6	9
Hg	µg/l	28	<0.1	-	<0.1
Mg	mg/l	28	<0.1	0.2	0.4
Mn	µg/l	28	<5	7	43
Mo	µg/l	28	<5	-	<5
Ni	µg/l	28	<5	7	22
Pb	µg/l	28	<5	5.5	6
Sb	µg/l	28	<1	-	<1
Se	µg/l	28	<1	1	2
Sn	µg/l	28	<20	-	<20
V	µg/l	28	<5	5	8
Zn	µg/l	28	<5	12	58
pH		28	6.9	7.9	9.1

Table 17 – Zone D, Leachability

NC was found in samples from 5 No. trial pits in the NC section. Both trial pits on burning ground building ref no. 16/007A contained NC as well as NG (up to 1.6 mg/kg) and RDX (at 1,710 mg/kg). The other 3 No. were adjacent trial pits in the centre of the Zone, where NC was found at between 1,810 and 14,800 mg/kg.

Away from the burning ground NG was found in 6 No. trial pits up to 0.5 m depth at concentrations below 0.4 mg/kg, but with no observable spatial pattern.

Asbestos was found in two samples: fragments in TP1085 at 0.5 m, located in the Acids Section, were reported as traces of insulation containing chrysotile and

crocidolite; and, TP1126 at 0.1 m, in the Demolition Guncotton Section, containing crocidolite and amosite.

Samples from burning ground building ref no. 16/007A had high concentrations of most metals relative to elsewhere in the zone, notably lead (up to 9,720 mg/kg) and barium (up to 4,340 mg/kg).

Total PAHs were detected at 1,860 mg/kg in TP1086 at 0.6 m, a sample of natural clay below a tarmac surface. In TP1068 a concentration of 1,510 mg/kg was detected in a sample of brick, ash and clinker in the bed of a broad-gauge railway. Total PAHs levels in excess of 100 mg/kg were found at shallow depth in TP1071 and 1082, both next to acid tanks and roads in the Acids Section.

Hydrocarbon contamination was observed in granular deposits in TP1078, near two above ground fuel oil tanks. This was shown in the lab to be predominantly TPH in the range C16 to C21 (up to 2,090 mg/kg), as well as other fractions. These samples also contained several VOCs including substituted benzenes and toluenes. However, because of overlapping peaks, the lab advise that many of the individual compounds were not conclusively identified.

Seven window sample boreholes (WS1651 to 1657) were subsequently drilled in the area around TP1078; photo-ionisation detector (PID) readings were taken of the headspace of samples. No visual or olfactory hydrocarbon contamination was observed and there were no positive PID readings. This suggests that the contamination seen in TP1078 is limited in extent, perhaps associated with a filling point where fuel oil was transferred from the broad-gauge railway to the two tanks.

'Strong solvent odours' observed in TP1102 showed in the lab as concentrations of hydrocarbons, C10 to C40 in the range 20 to 77 mg/kg. However, no SVOCs or VOCs were detected in samples from 1.0 and 1.5 m depth.

TPH's, SVOC's, VOC's or PAH's were not detected in TP1111 where a 'slight hydrocarbon odour' had been observed in the field.

The leachable fraction was generally between 0.1 and 1.5 %. Magnesium leachability was particularly low in the order of 1.0E-4 %.

4.6. Zone E

4.6.1. Introduction

Zone E, occupying approximately 7ha, encompassing Factory II NC Section, is characterised by large closely spaced process buildings. Correspondingly, a nominal grid spacing of 75 m was assigned because the zone is also within the Core Development Area.

Some of the Factory II NC production buildings were converted to white phosphorus filling and for the manufacture of Combustible Charge Containers.

Potential contamination sources in Zone E include process buildings, white phosphorus area, open storage, acid tanks, fuel tanks and NC settling lagoons.

4.6.2. Scope of Investigation

Investigation in Zone E comprised the following:

- 15 No. trial pits
- 1 No. borehole
- 1 No. hand auger

The scope of investigation in this zone did not differ significantly from that proposed although it was necessary to replace one trial pit with a hand auger.

Of the 84 No. soil samples taken, 35 No. were analysed for a range of contaminants. Of these 30 No. were samples of made ground and 5 No. were natural.

4.6.3. Ground Summary

Made Ground

Made ground varied in thickness between 0.3 and 1.9 m and was encountered in 15 No. of the exploratory points. The made ground was generally dark brown sandy gravelly silt with fragments of clinker, blaes, glass, concrete, coal, brick and tile. However, in parts of the west and north of the Zone, 0.3 to 0.7 m thick layers consisting almost entirely of blaes were encountered, predominantly near or under sections of railway. A greater thickness of made ground was encountered in TP1129 and TP1133 (1.7 m and 1 m respectively). The material encountered in these pits (bricks, metal, glazed tile, ceramic, wood, glass and concrete) is consistent with general demolition materials from previously demolished buildings.

Superficial Geology

Superficial deposits were encountered in all of the exploratory points, predominantly as the Linwood/Paisley Fm.

The Linwood/Paisley Fm. was generally firm brown/grey clay with some pockets of orange/brown silt overlying very soft to soft mottled brown silt with occasional pockets of brown fine sand.

Grey-brown fine-coarse sandy gravels (Killearn Fm) were encountered in the southern corner of the Zone on sloping raised ground.

Firm dark grey clay with occasional gravel, cobbles and boulders (Wilderness Till Fm.) was encountered in TP1130.

The maximum thickness of superficial deposits was 4.7 m, observed in BH1134.

Bedrock

Bedrock was not encountered.

Groundwater

Groundwater was observed at depths of between 1.7 and 2.3 m. Flow was generally described as slight to moderate from layers of silt, although in TP1129 water strikes were observed in made ground at 1.5 m depth as well at 1.9 m depth in the silt. The occurrence of groundwater in TP1132 was also in the made ground.

Evidence of Contamination

Fragments of what appeared to be asbestos were encountered near surface in TP1136 and TP1131.

4.6.4. Laboratory Analysis

Summary analytical soil and leachability results are given below and complete results are given in Appendix 7 and Appendix 8.

Soil

Determinand	units	No.	Min.	Mean	Max.
2,4-DNT	mg/kg	36	<1	-	<1
2,6-DNT	mg/kg	36	<1	-	<1
EGDN	mg/kg	36	<0.1	0.1	1
HMX	mg/kg	36	<2	2	5
HNS	mg/kg	36	<0.5	-	<0.5
NC	mg/kg	36	1,440	4,901	<5,000
NG	mg/kg	36	<0.1	0.3	3.9
PETN	mg/kg	36	<5	-	<5
Picric acid	mg/kg	36	<0.1	-	<0.1
Picrite	mg/kg	36	<0.25	0.3	2.33
RDX	mg/kg	36	<2	-	<2
Tetryl	mg/kg	36	<1	-	<1
TNT	mg/kg	36	<0.5	0.6	4

Table 18 – Zone E, Explosives

Determinand	units	No.	Min.	Mean	Max.
As	mg/kg	36	5	10	18
Cd	mg/kg	36	<0.3	0.3	1.0
Cr	mg/kg	36	27	46	81
Pb	mg/kg	36	4	150	1,820
Hg	mg/kg	36	<0.1	0.3	1.8
Se	mg/kg	36	<0.3	0.8	6.4
Cu	mg/kg	36	11	62	452
Ni	mg/kg	36	28	46	90
Zn	mg/kg	36	45	166	872
Ba	mg/kg	21	54	278	873
Be	mg/kg	21	1.2	2.2	4.7
Bi	mg/kg	21	<3	5	14
Mg	mg/kg	21	1,810	5,748	8,780
Mn	mg/kg	21	234	628	1,470
Mo	mg/kg	21	<5	5	5
P	mg/kg	21	300	1,218	4,430
Sb	mg/kg	21	<5	5	8
Sn	mg/kg	21	3	9	36
Sr	mg/kg	21	16	66	260
	mg/kg	21	782	1,218	2,440

V	mg/kg	21	38	65	110

Table 19 – Zone E, Metals & semi-metals

Determinand	units	No.	Min.	Mean	Max.
pH		36	5.3	7.0	8.2
Sulphate	mg/kg	21	<250	742.9	2580
Sulphur	mg/kg	21	<10	43.7	302
Asbestos	Presence/Absence	36	ND	ND	ND
Asbestos Quantification	%	2	<0.001	-	<0.001
Total PAHs (See Appendix 7 for Individual PAHs)	mg/kg	35	0.2	31	286
TPH C5-C6	mg/kg	5	<1.5	-	<1.5
TPH >C6-C8	mg/kg	5	<2	-	<2
TPH >C8-C10	mg/kg	5	<1	-	<1
TPH >C10-C12	mg/kg	5	<2	-	<2
TPH >C12-C16	mg/kg	5	<20	-	<20
TPH >C16-C21	mg/kg	5	<20	38	50
TPH >C21-C40	mg/kg	5	79	191	256
Moisture content	%	6	18.8	25.2	29.1
Organic matter	%	1	1.3	1.3	1.3

Table 20 – Zone E, Others

Determinand	units	No.	Min.	Mean	Max.
As	µg/l	6	<1	2	4
B	µg/l	6	<300	-	<300
Be	µg/l	6	<5	-	<5
Cd	µg/l	6	<0.5	-	<0.5
Cr	µg/l	6	<5	-	<5
Cu	µg/l	6	<5	8	20
Hg	µg/l	6	<0.1	0.2	0.5
Mg	mg/l	6	0.1	0.3	0.5
Mn	µg/l	6	<5	-	<5
Mo	µg/l	6	<5	-	<5
Ni	µg/l	6	<5	-	<5
Pb	µg/l	6	<5	-	<5
Sb	µg/l	6	<1	1	1
Se	µg/l	6	<1	-	<1
Sn	µg/l	6	<20	-	<20
V	µg/l	6	<5	-	<5
Zn	µg/l	6	<5	18	53
pH		6	7.5	8.2	8.8

Table 21 – Zone E, Leachability

NG was detected in 5 No. shallow samples at concentrations of between 0.1 and 3.9 mg/kg. The highest level was found next a propellant storage building (3.9 mg/kg, TP1135) as well as HMX and picrite in the same sample at concentrations of

4.5 and 2.33 mg/kg, respectively. NC was detected in 1 No. sample (HA1142) as well as NG adjacent to the effluent settling lagoons at concentrations of 1,440 and 1.8 mg/kg, respectively.

Detectable EGDN was found in 2 No. samples with the highest concentration of 0.2 mg/kg (TP1131) next to the main white phosphorous building. TNT was also found in 2 No. samples with the highest concentration of 4 mg/kg (TP1138) next to effluent settling lagoons and 1.3 mg/kg (TP1135).

The highest concentration of lead (1,820 mg/kg) was detected in made ground next the effluent setting lagoons (TP1136). Other metal concentrations show little spatial variation or pattern.

Field observations suspecting asbestos fragments were not confirmed. Samples from these locations were tested for asbestos and none was detected.

Total PAHs were detected in all 34 samples analysed, typically in samples of shallow made ground. The highest concentration was 286 mg/kg (TP1472) while four other samples were found with concentrations greater than 100 mg/kg. Generally, results were less than 30 mg/kg.

Detectable TPH (C21 - C40) between 79 and 256 mg/kg was found in all 5 No. samples analysed. Four had lower concentrations of TPH (C16 - C21) typically less than 50 mg/kg with no obvious point source.

The leachable fraction was generally between 0.1 and 1.5 %. Magnesium leachability was particularly low in the order of 1.0E-4 %.

4.7. Zone F

4.7.1. Introduction

Zone F, occupying approximately 25 ha, comprising Factory III NC and Acids sections is characterised by large closely spaced process buildings. Part of the Zone was later used for refurbishing and breaking down the Lance missile.

A nominal grid spacing of 100 m was chosen to reflect the density of potential contamination sources and because the zone is outside the Core Development Area.

Specific potential contamination sources in these sections include process buildings, acid tanks, ash dump, ammunition storage and incendiary bomb breakdown and settling lagoons.

4.7.2. Scope of Investigation

Investigation in Zone F comprised the following:

- 31 No. trial pits
- 2 No. boreholes
- 1 No. hand auger
- 1 No. hand sample

The scope of investigation in this zone did not differ significantly from that proposed although it was necessary to replace 2 No. trial pits with hand augers.

Of the 154 No. soil samples taken, 72 No. were analysed for a range of contaminants. Of these 54 No. were samples of made ground and 18 No. were natural.

4.7.3. Ground Conditions

Made Ground

Made ground was encountered in all of the exploratory locations with typical thicknesses ranging from 0.3 to 2.8 m. It predominantly comprised fragments of man-made material including blaes, brick, glass, plastic tile, porcelain, bituminous solid, wood, clinker and reinforced concrete with metal, particularly beneath former buildings in the central and northern part of the zone.

Reworked natural material was also evident and commonly observed near the boundary fence where embankments have been created. This material comprised sand, silt and clay and fine to coarse angular gravels and cobbles of mixed lithology including basalt, quartzite, sandstone and schist, and rare man-made constituents such as blaes.

Reinforced concrete was evident at depth in the north-east of the Zone within close proximity to the former burning grounds, in TP1144, TP1147, TP1150, TP1151 and TP1153. Here, thicknesses of made ground were typically found to be up to 2.0 m greater than across the remainder of the Zone. The increased thickness of made ground and buried obstructions are likely to be associated with below ground parts of NC process buildings that were of a particular construction type and previously existed in this part of the factory. Burning grounds were often constructed on top of old foundation slabs.

A greater thickness of made ground was encountered in TP1155 and TP1164 (2.8 m and 1.6 m respectively). The material encountered in these pits (bricks, metal, glazed tile, and concrete) is consistent with general demolition materials from previously demolished buildings.

Superficial Deposits

Superficial deposits were encountered in 27 No. of exploratory locations, the exceptions being where made ground could not be penetrated. It generally comprised mottled brown, grey and orange sandy gravelly silts and clays of the Linwood/Paisley Fm. The maximum thickness of superficial deposits was 4.7 m, observed in BH1297.

Varying consistencies were observed ranging from soft to stiff (typically becoming grey and soft with depth) with differing quantities of sand, friable silt and plant remains. Thin silt laminations were noticeable in clays. Fine to coarse rounded, sub-rounded, angular and sub-angular gravels of mixed lithology were noted.

Towards higher ground in the south of the Zone sand and gravels were noted below reworked natural material.

Bedrock

Bedrock was not encountered in any of the exploratory points.

Groundwater

Groundwater was encountered in 9 No. exploratory locations ranging from 0.6 to 2.5 m depth. Groundwater inflow was generally observed as a seepage from mixed strata of sand, gravel, silt, clay and made ground. Rapid ingress was observed above the boundary between made ground and concrete in TP1153.

Groundwater strikes were approximately 1.5 m deeper towards the east of the zone.

Evidence of Contamination

Fragments of what appeared to be cement bonded asbestos tile were found in TP1153 near surface.

4.7.4. Laboratory Analysis

Summary analytical soil and leachability results are given below and complete results are given in Appendix 7 and Appendix 8.

Soil

Determinand	units	No.	Min.	Mean	Max.
2,4-DNT	mg/kg	72	<1	-	<1
2,6-DNT	mg/kg	72	<1	-	<1
EGDN	mg/kg	72	<0.1	0.1	1.2
HMX	mg/kg	72	<2	-	<2
HNS	mg/kg	72	<0.5	-	<0.5
NC	mg/kg	72	<5,000	5,002	5,110
NG	mg/kg	72	<0.1	0.1	0.4
PETN	mg/kg	72	<5	-	<5
Picric acid	mg/kg	72	<0.1	0.1	0.1
Picrite	mg/kg	72	<0.25	-	<0.25
RDX	mg/kg	72	<2	-	<2
Tetryl	mg/kg	72	<1	-	<1
TNT	mg/kg	72	<0.5	-	<0.5

Table 22 – Zone F, Explosives

Determinand	units	No.	Min.	Mean	Max.
As	mg/kg	72	<1	10	26
Cd	mg/kg	72	<0.3	0.3	1.8
Cr	mg/kg	72	17	41	170
Pb	mg/kg	72	<3	109	1,200
Hg	mg/kg	72	<0.1	0.3	5.3
Se	mg/kg	72	<0.3	0.6	2.7
Cu	mg/kg	72	6	47	853
Ni	mg/kg	72	10	39	100

Determinand	units	No.	Min.	Mean	Max.
Zn	mg/kg	72	35	136	1,080
Ba	mg/kg	40	55	410	3,870
Be	mg/kg	40	0.7	3.0	15.7
Bi	mg/kg	40	<3	4	8
Mg	mg/kg	40	624	7,038	27,700
Mn	mg/kg	40	63	573	1180
Mo	mg/kg	40	<5	-	<5
P	mg/kg	40	140	606	1,090
Sb	mg/kg	40	<5	5	6
Sn	mg/kg	40	<2	10	84
Sr	mg/kg	40	14	52	190
Ti	mg/kg	40	740	1,903	11,600
V	mg/kg	40	36	72	180

Table 23 – Zone F, Metals & semi-metals

Determinand	units	No.	Min.	Mean	Max.
pH		72	5.4	7.4	11.3
Sulphate	mg/kg	40	<250	673.8	4350
Sulphur	mg/kg	40	<10	38.5	451
Asbestos	Presence/Absence	72			2
Total PAHs (See Appendix 7 for Individual PAHs)	mg/kg	71	<0.1	6	46
TPH C5-C6	mg/kg	14	<1.5	-	<1.5
TPH >C6-C8	mg/kg	14	<2	-	<2
TPH >C8-C10	mg/kg	14	<1	1	2
TPH >C10-C12	mg/kg	14	<2	3	10
TPH >C12-C16	mg/kg	14	<20	26	90
TPH >C16-C21	mg/kg	14	<20	33	149
TPH >C21-C40	mg/kg	14	<20	137	386
Calorific Value	kJ/kg	1	-	-	9,700
Moisture content	%	14	8.6	18.9	27.0

Table 24 – Zone F, Others

Determinand	units	No.	Min.	Mean	Max.
As	µg/l	14	<1	1	3
B	µg/l	14	<300	303	339
Be	µg/l	14	<5	-	<5
Cd	µg/l	14	<0.5	-	<0.5
Cr	µg/l	14	<5	-	<5
Cu	µg/l	14	<5	7	25
Hg	µg/l	14	<0.1	0.1	0.6
Mg	mg/l	14	<0.1	0.4	1.7
Mn	µg/l	14	<5	7	23
Mo	µg/l	14	<5	-	<5
Ni	µg/l	14	<5	5	6

Determinand	units	No.	Min.	Mean	Max.
Pb	µg/l	14	<5	6	22
Sb	µg/l	14	<1	1	3
Se	µg/l	14	<1	1	2
Sn	µg/l	14	<20	-	<20
V	µg/l	14	<5	6	15
Zn	µg/l	14	5	11	23
pH		14	6.4	7.3	8.7

Table 25 – Zone F, Leachability

NG and EGDN were found in 7 No. samples generally below 0.5 mg/kg. TP1165, next to the NC lagoons, contained 5,110 mg/kg NC as well as 0.2 mg/kg EGDN and 0.3 mg/kg NG.

PAHs were found mostly in shallow made ground samples, often where ash and/or was noted, with the highest level of Total PAHs detected at 46.5 mg/kg.

Samples from TP1153 were tested for asbestos and none was detected. Asbestos in the form of chrysotile was detected by the laboratory in samples from TP1144 at 0.2 m and TP1171 at 0.4 m.

A sample from TP1153, located on burning ground building ref no. 16/007M, yielded detectable TPH in the C8 – C10 and C10 – C12 ranges (1.7 and 10.3 mg/kg).

Two samples from the burning grounds contained lead greater than 1,000 mg/kg. Similar levels were reported in samples at 0.1 m from HA1159 and TP1162, which also contained mercury at 2.8 mg/kg and nickel at 100 mg/kg.

Barium was found at 3,230 and 3,870 mg/kg in TP1169, located next to buildings used for breakdown of incendiary bombs containing barium nitrate.

Magnesium and titanium was detected up to 27,700 and 11,600 mg/kg, respectively, with no obvious point source.

The leachable fraction was generally between 0.1 and 1.5 %. Magnesium leachability was particularly low in the order of 1.0E-4 %. Tin leachability was slightly higher at around 3 %.

4.8. Zone G

4.8.1. Introduction

Zone G, occupying approximately 100ha, encompasses the Factory I propellant manufacturing sections that fall within the Core Development Area. The Zone is characterised by a wide spacing of process buildings, so a nominal grid spacing of 125 m was selected to reflect this.

Potential contamination sources in this Zone are generally restricted to individual process buildings and materials storage as well as acids tanks, storage areas.

4.8.2. Scope of Investigation

Investigation in Zone G comprised the following:

- 74 No. trial pits
- 5 No. boreholes
- 1 No. hand auger

The scope of investigation in this Zone did not differ significantly from that proposed although it was necessary to replace one trial pit with a hand auger.

Of the 399 No. soil samples taken, 172 No. were analysed for a range of contaminants. Of these 132 No. were samples of made ground and 40 No. were natural.

4.8.3. Ground Conditions

Made Ground

Made ground was encountered in 69 No. exploratory locations with typical thicknesses ranging from 0.3 to 2.5 m.

Made ground comprising predominantly non-natural constituents including blaes, brick, glass, plastic, ceramic fragments, porcelain, pottery, wood, rubber, copper, metal, wire, asphalt, ash, clinker, tarmac, and concrete was encountered in 60 No. exploratory points. Made ground was encountered in TP1178, 1183, 1221, and 1246 to depths of 1 m, 1.6 m, 1.5 m, and 1.1 m respectively. The material encountered in these pits (bricks, metal, glazed tile, wood, cable, asbestos and concrete boulders) is consistent with general demolition materials from previously demolished buildings. .

This type of made ground was particularly apparent in the vicinity of the former shallow mineral workings (TP1209, 1214, 1218 and 1221).

Reworked natural material was evident across the Zone commonly observed where services/buildings were located and at the entrances to buildings. This material comprised sand, silt, clay and fine to coarse angular to sub-rounded gravels, with increasing proportion of cobbles and boulders with depth. Cobbles and boulders were of mixed lithology including basalt, quartzite, sandstone and schist. It contained occasional minor constituents of glass, blaes, charcoal and pottery.

TP1175 encountered a brick structure at 0.6m depth that is likely to be associated with an earlier building which existed on the site of the current drying stove. TP1195 and 1214 encountered a concrete obstruction at 1.2 m and 1.9 m respectively, the origin of which is not certain.

Superficial Deposits

Superficial deposits predominantly of the Linwood/Paisley Fm. were encountered in 73 No. of exploratory locations with a maximum thickness observed in BH1194 (15.7 m).

The Linwood/Paisley Fm. varied from soft to very stiff silt and clay, friable and slightly sandy particularly in trial pits located in the south-east of the zone (TP1247, 1249 and 1250). Occasionally, plant remains were observed within the silt, which was grey and softer with depth.

On higher ground in the extreme north-west, south-west and centrally within the zone, Wilderness Till Fm. was apparent. It generally comprised stiff to very stiff pinky brown sandy gravelly clay with pockets of coloured sand and angular to subangular cobbles and boulders increasing in proportion with depth. The stiffness together with the presence of boulders and cobbles often restricted excavation.

Sands and gravels of the Killearn Fm. were observed generally located on sloping ground on the boundary between the Wilderness Till Fm. and the Linwood/Paisley Fm. These areas are located centrally and in the extreme west of the Zone. The grading of the Killearn Fm. varied from sands to gravel as well as containing rounded to sub-rounded cobbles.

Bedrock

Bedrock was not encountered.

Groundwater

Groundwater was observed in 12 No. exploratory locations ranging from 0.5 to 5.0 m depth. Groundwater inflow was generally observed as a seepage from silt, clay and made ground.

Evidence of Contamination

A thin spread of white powder and one 7-hole grain of propellant was observed near the surface in TP1224.

Sheens of LNAPL were noted when water from a burst land drain entered TP1235 possibly originating from a cable that appeared to have a bituminous coating.

Olfactory evidence of hydrocarbon contamination was also noted in TP1218 at 2.0 m and TP1216 at 0.7 m, where wooden sleepers appeared to be coated with creosote-like substance.

Oily water from a cable was noted at 1.4m in TP1183.

4.8.4. Laboratory Analysis

Summary analytical soil and leachability results are given below and complete results are given in Appendix 7 and Appendix 8.

Soil

Determinand	units	No.	Min.	Mean	Max.
2,4-DNT	mg/kg	170	<1	-	<1
2,6-DNT	mg/kg	170	<1	-	<1
EGDN	mg/kg	170	<0.1	0.1	5
HMX	mg/kg	170	<2	-	<2
HNS	mg/kg	170	<0.5	-	<0.5
NC	mg/kg	170	<1,000	4,942	6,870
NG	mg/kg	170	<0.1	4.3	597
PETN	mg/kg	170	<5	-	<5
Picric acid	mg/kg	170	<0.1	-	<0.1
Picrite	mg/kg	170	<0.25	0.25	1

Determinand	units	No.	Min.	Mean	Max.
RDX	mg/kg	170	<2	2	12
Tetryl	mg/kg	170	<1	-	<1
TNT	mg/kg	170	<0.5	0.6	19

Table 26 – Zone G, Explosives

Determinand	units	No.	Min.	Mean	Max.
As	mg/kg	170	4	10	35
Cd	mg/kg	170	<0.3	0.3	0.7
Cr	mg/kg	170	15	39	110
Pb	mg/kg	170	<3	90	1,710
Hg	mg/kg	170	<0.1	0.2	1.2
Se	mg/kg	170	<0.3	0.6	2.2
Cu	mg/kg	170	4	79	3,320
Ni	mg/kg	170	11	38	92
Zn	mg/kg	170	26	108	650
Ba	mg/kg	64	67	211	1200
Be	mg/kg	64	0.6	2.0	5.3
Bi	mg/kg	64	<3	5	13
Mg	mg/kg	64	614	5,434	11,400
Mn	mg/kg	64	61	485	1,300
Mo	mg/kg	64	<5	-	<5
P	mg/kg	64	180	570	1,120
Sb	mg/kg	64	<5	5	6
Sn	mg/kg	64	<2	7	38
Sr	mg/kg	64	11	43	180
Ti	mg/kg	64	300	1,087	2,060
V	mg/kg	64	25	59	120

Table 27 – Zone G, Metals & semi-metals

Determinand	units	No.	Min.	Mean	Max.
pH		170	3.8	7.0	10.1
Sulphate	mg/kg	64	<250	497.7	2590
Sulphur	mg/kg	63	<10	54.5	1460
Asbestos	Presence/Absence	170			3
Total PAHs (See Appendix 7 for Individual PAHs)	mg/kg	170	<0.1	28	2,330
TPH C5-C6	mg/kg	46	<1.5	-	<1.5
TPH >C6-C8	mg/kg	46	<2	-	<2
TPH >C8-C10	mg/kg	46	<1	-	<1
TPH >C10-C12	mg/kg	46	<2	2	2.1
TPH >C12-C16	mg/kg	46	<20	21	38
TPH >C16-C21	mg/kg	46	<20	34	114
TPH >C21-C40	mg/kg	46	<20	185	753
VOCs	mg/kg	5	none detected		

Determinand	units	No.	Min.	Mean	Max.
SVOCs	mg/kg	5	none detected		
Moisture content	%	53	9.1	22.0	47.3
Organic matter	%	11	1.3	4.0	8.1

Table 28 – Zone G, Others

Determinand	units	No.	Min.	Mean	Max.
As	µg/l	34	<1	2.9	6.0
B	µg/l	34	<300	-	<300
Ba	µg/l	11	<5	7	16
Be	µg/l	34	<5	-	<5
Cd	µg/l	34	<0.5	0.6	1.9
Cr	µg/l	34	<5	-	<5
Cu	µg/l	34	<5	6	29
Hg	µg/l	34	<0.1	0	0
Mg	mg/l	34	<0.1	0	1
Mn	µg/l	34	<5	5.5	15.0
Mo	µg/l	34	<5	13	182
Ni	µg/l	34	<5	-	<5
Pb	µg/l	34	<5	5.5	22
Sb	µg/l	34	<1	1	10
Se	µg/l	34	<1	1	2
Sn	µg/l	34	<20	-	<20
V	µg/l	34	<5	5	8
Zn	µg/l	34	<5	8	30
pH		34	4.8	8.0	11.0

Table 29 – Zone G, Leachability

NG was detected in 34 out of 80 No. exploratory points at shallow depth usually adjacent to propellant processing buildings and/or narrow gauge railways. The highest concentrations were detected in TP1200 (597 mg/kg) at 0.1 m above a concrete slab outside a press house, and TP1233 and TP1239 (54.2 and 15.7 mg/kg) both in topsoil adjacent to 'temporary stores' and narrow gauge railway. Eighty-five percent of samples where NG was detected contained the explosive at less than 5 mg/kg.

NG was confirmed in TP1224 at 0.2 m (4.3 mg/kg) where white powder and propellant had been observed at the surface.

EGDN was detected at or just above the reporting limit in 9 No. trial pits, showing a comparable pattern to the occurrence of NG. There were also positive concentrations of NC, picrite, TNT, RDX in a total of 7 No. trial pits, again in those close to process buildings and narrow gauge railway.

The visual and olfactory evidence of hydrocarbon was generally not confirmed in the laboratory analysis, with no high concentrations of TPH, PAHs, SVOCs or VOCs when compared to other samples in the Zone. A sample from TP1218 yielded detectable TPH in the C16 – C21 range of 20 mg/kg and in the C21 – C40 range of 394 mg/kg, and a sample from 1 m in TP1235 yielded 3mg/kg Total PAH.

Most notable Total PAH results include 6 No. samples of made ground with concentrations over 100 mg/kg, the highest being found in TP1246 at 0.5 m, located at a narrow gauge railway junction. TPH >C16 concentrations were generally consistent over the Zone, with a handful of samples containing C10 to C16. These include TP1241 at 0.1 m located near underground diesel tanks (see Zone M). Samples from TP1216 at 0.3 m and 0.7 m contained total PAH's of 0.2 mg/kg and 0.5 mg/kg respectively.

Lead was found in made ground at concentrations of 1,090 and 1,710 mg/kg in TP1202 and 1214, respectively. Concentrations of other metals were generally consistent across the Zone, showing little overall spatial pattern or relationship with identified potential contamination sources.

Laboratory analysis did not identify any hydrocarbons associated with the "oily water" in TP1183. It is possible that it was been contained within the cable until it was disturbed and therefore has not affected the surrounding soil.

The leachable fraction was generally between 0.1 and 1.5 %. Magnesium leachability was particularly low in the order of 1.0E-4 %.

4.9. Zone H

4.9.1. Introduction

Zone H, occupying approximately 75ha, Factory II Rocket Propellant Section (including the ETF) is characterised by wide spacing of process buildings. Exploratory points in Zone H were assigned a nominal grid spacing of approximately 175 m to reflect the wide spacing of process buildings and its location out with the Core Development Area.

Potential contamination sources in this zone are generally restricted to individual process buildings and solvent storage as well as tipped ash and a former scrap metal compound.

4.9.2. Scope of Investigation

Investigation in Zone H comprised the following:

- 27 No. trial pits
- 2 No. boreholes
- 2 No. hand augers

The scope of investigation in this zone did not differ significantly from that proposed although it was necessary to replace 2 No. trial pits with hand augers.

Of the 156 No. soil samples taken, 67 No. were analysed for a range of contaminants. Of these 40 No. were samples of made ground and 27 No. were natural.

4.9.3. Ground Conditions

Made Ground

Made ground varied in thickness between 0.2 and 1.6 m across the Zone and was encountered in 23 No. exploratory points.

The material encountered was variable but was predominantly dark brown sandy gravelly silt with fragments of blaes, brick, coal, glass, tarmac, concrete, slag, metal and whole bricks. However, 2 No. locations in the north of the zone and 1 No. in the south contained layers of made ground 0.3 to 0.7 m thick consisting almost entirely of blaes. In TP1269 and 1286 a layer of made ground 1.3 m thick was encountered. The material encountered in these pits (tarmac, glazed tile, reinforced concrete and concrete boulders) is consistent with general demolition materials from previously demolished buildings. In TP1261 a layer of made ground 1.1 m thick was encountered. The material encountered (blaes, brick, ash, and concrete boulders) is consistent with general demolition materials from previously demolished buildings.

Reworked natural material consisting of soft brown sandy gravelly silt with few fragments of man-made material was also encountered.

Superficial Geology

Superficial deposits were encountered in all of the exploratory points with a maximum thickness of 9.8 m, observed in BH1271. Soft to firm light brown-grey sandy gravelly silts and clays (Linwood/Paisley Fm.) were the predominant strata in low lying parts of the Zone.

Firm to stiff brown sandy occasionally gravelly clay (Wilderness Till Fm.,) was encountered in 9 No. exploratory points on areas of raised ground around the edges of Zone H.

Dark brown-black fibrous peat (Clippens Peat Fm.) was encountered to depths of between 1.4 and 1.5 m near the wooded area in the north-east of the Zone.

Bedrock

Bedrock was not encountered.

Groundwater

Groundwater was encountered in five locations (TP1254, 1263, 1269, 1270, and 1286) at depths of between 1.6 and 2.4 m.

Evidence of contamination

Strong olfactory evidence of hydrocarbon contamination was noted at 1.5 m in TP1286.

4.9.4. Laboratory Analysis

Summary analytical soil and leachability results are given below and complete results are given in Appendix 7 and Appendix 8.

Soil

Determinand	units	No.	Min.	Mean	Max.
2,4-DNT	mg/kg	67	<1	-	<1
2,6-DNT	mg/kg	67	<1	-	<1
EGDN	mg/kg	67	<0.1	0.2	1
HMX	mg/kg	67	<2	-	<2
HNS	mg/kg	67	<0.5	-	<0.5
NC	mg/kg	67	<1,000	-	<5,000
NG	mg/kg	67	<0.1	0.8	13.1
PETN	mg/kg	67	<5	-	<5
Picric acid	mg/kg	67	<0.1	0.1	0.4
Picrite	mg/kg	67	<0.25	-	<0.25
RDX	mg/kg	67	<2	-	<2
Tetryl	mg/kg	67	<1	-	<1
TNT	mg/kg	67	<0.5	-	<0.5

Table 30 – Zone H, Explosives

Determinand	units	No.	Min.	Mean	Max.
As	mg/kg	67	<1	10	47
Cd	mg/kg	67	<0.3	0.3	1.7
Cr	mg/kg	67	<5	39	79
Pb	mg/kg	67	<3	50	290
Hg	mg/kg	67	<0.1	0.2	0.5
Se	mg/kg	67	<0.3	0.7	2.6
Cu	mg/kg	67	<3	38	200
Ni	mg/kg	67	<5	36	92
Zn	mg/kg	67	9	91	433
Ba	mg/kg	27	27	163	331
Be	mg/kg	27	<0.1	2.2	7.2
Bi	mg/kg	27	<3	4	12
Mg	mg/kg	27	1,110	4,747	11,000
Mn	mg/kg	27	33	398	1,020
Mo	mg/kg	27	<5	5	7
P	mg/kg	27	130	687	2,280
Sb	mg/kg	27	<5	-	<5
Sn	mg/kg	27	2	6	27
Sr	mg/kg	27	14	94	733
Ti	mg/kg	27	63	1101	3,010
V	mg/kg	27	<5	68	140

Table 31 – Zone H, Metals & semi-metals

Determinand	units	No.	Min.	Mean	Max.
pH		434	1.9	6.5	12.7
Sulphate	mg/kg	26	<250	882.3	11200
Sulphur	mg/kg	25	<10	53.5	427
Asbestos	Presence/Absence	67	ND	ND	ND

Determinand	units	No.	Min.	Mean	Max.
Total PAHs (See Appendix 7 for Individual PAHs)	mg/kg	67	<0.1	9	571
TPH C5-C6	mg/kg	16	<1.5	-	<6
TPH >C6-C8	mg/kg	16	<2	-	<8
TPH >C8-C10	mg/kg	16	<1	1	7
TPH >C10-C12	mg/kg	16	<2	4	24
TPH >C12-C16	mg/kg	16	<20	33	142
TPH >C16-C21	mg/kg	16	<20	59	183
TPH >C21-C40	mg/kg	16	31	728	6,620
TPHCWG		1			
>C6 to C8	mg/kg				< 5.0
>C8 to C10	mg/kg				10
>C10 to C12	mg/kg				70
>C12 to C16	mg/kg				300
>C16 to C21	mg/kg				280
>C21 TO C40	mg/kg				44
Total Aliphatic	mg/kg				700
>C6 to C8	mg/kg				< 25
>C8 to C10	mg/kg				< 5.0
>C10 to C12	mg/kg				6.7
>C12 to C16	mg/kg				83
>C16 to C21	mg/kg				170
>C21 TO C40	mg/kg				61
Total Aromatic	mg/kg				320
VOCs		1			
Ethyl Benzene	µg/kg				221
m,p-Xylene	µg/kg				120
n-Butylbenzene	µg/kg				27
o-Xylene	µg/kg				120
SVOCs		1	none detected		
Calorific Value	KJ/kg	1	-	-	3,300
Moisture content	%	19	11.7	33.2	85.2
Organic matter	%	3	8.3	19.4	25.0

Table 32 – Zone H, Others

Determinand	units	No.	Min.	Mean	Max.
As	µg/l	17	<1	3	11
B	µg/l	17	<300	365	1410
Be	µg/l	17	<5	-	<5
Cd	µg/l	17	<0.5	-	<0.5
Cr	µg/l	17	<5	5	12
Cu	µg/l	17	<5	6	10
Hg	µg/l	17	<0.1	-	<0.1
Mg	mg/l	17	<0.1	0.2	1.1
Mn	µg/l	17	<5	11	63
Mo	µg/l	17	<5	-	<5

Determinand	units	No.	Min.	Mean	Max.
Ni	µg/l	17	<5	6	13
Pb	µg/l	17	<5	-	<5
Sb	µg/l	17	<1	1	1
Se	µg/l	17	<1	2	12
Sn	µg/l	17	<20	-	<20
V	µg/l	17	<5	19	168
Zn	µg/l	17	<5	9	22
pH		17	7.1	7.9	8.4

Table 33 – Zone H, Leachability

The pattern of samples where explosives were detected was similar to other zones, i.e. a handful of shallow samples with NG and EGDN generally below 10 mg/kg. NG concentrations of 7.7 and 13.1 mg/kg were found in exploratory points next to a rocket propellant waste heating building and small Works Department workshop.

Asbestos was not detected in any sample.

The 'strong hydrocarbon odour and sheen' observed in TP1286 showed in the samples as TPH in the range C10 to C40 (up to 214 mg/kg), as well as the VOCs ethyl benzene (221 mg/kg), butyl benzene (27 mg/kg) and xylenes (120 mg/kg). The aliphatic:aromatic split in TPH compounds was approximately 70:30. The source of this hydrocarbon contamination is not known.

There were no discernible significant patterns in metal or PAH concentrations across the Zone.

The leachable fraction was generally between 0.1 and 1.5 %. Magnesium leachability was particularly low in the order of 1.0E-4 %.

4.10. Zone I

4.10.1. Introduction

Zone I, occupying approximately 55ha, encompassing Factory III Gun Propellant, is characterised by widely spaced process buildings and is outside the Core Development Area. Exploratory points in this zone were assigned a nominal grid spacing of 175 m accordingly.

A number of former process buildings (now just slabs) were used from the 1960s for ammunition storage prior to dismantling in the Ammunition Breakdown Section.

Potential contamination sources in this zone are generally restricted to individual process buildings and solvent storage.

4.10.2. Scope of Investigation

Investigation in Zone I comprised the following:

- 21 No. trial pits
- 1 No. borehole

- 1 No. hand auger

The scope of investigation in this zone did not differ significantly from that proposed although it was necessary to replace 1 No. trial pit with a hand auger.

Of the 117 No. soil samples taken, 48 No. were analysed for a range of contaminants. Of these 33 No. were samples of made ground and 15 No. were natural.

4.10.3. Ground Conditions

Made Ground

Made ground varied in thickness between 0.15 and 2.0 m across the zone and was encountered in 20 No. locations. It can be categorised as two distinct types, reworked natural material and fill material.

The first and most common type was fill material, found in 13 No. locations to depths of 0.3 m to 1.7 m. It was variable in composition but predominantly dark brown sandy gravelly silt with fragments of blaes, brick, coal, glass, tarmac, concrete, slag, metal and whole bricks. In 5 No. locations, layers of made ground 0.3 m to 0.95 m thick consisting almost entirely of blaes were encountered.

In TP1290 a layer of made ground 1.1 m thick was encountered. The material encountered (reinforced concrete) is consistent with general demolition materials from previously demolished buildings. In TP1295 a layer of made ground 1.7 m thick was encountered comprising clinker, blaes, slag, concrete, brick, glass, and pottery.

Made ground consisting of soft brown sandy gravelly silt with few fragments of non-natural material was also encountered in parts of Zone I and is considered to be reworked natural material.

Superficial Geology

Superficial deposits were encountered in most of the exploratory points. Soft to firm light brown-grey sandy gravelly silts and clays with occasional plant remains (Linwood/Paisley Fm.) were the predominant strata, being found across the entire Zone with the exception of those areas of slightly raised ground.

Firm to stiff brown sandy clay (Wilderness Till Fm.) was encountered in areas of raised ground around the north and north-west edges of Zone I.

Light brown sands and gravels of the Killearn Fm. were encountered in 4 No. locations in the north-west of the zone, particularly in areas between the Linwood/Paisley Fm. and the Wilderness Till Fm. The maximum thickness of superficial deposits was 4.1 m, observed in BH1306.

Bedrock

Bedrock, probably the Clyde Plateau Volcanic Fm. or dolerite, was encountered in TP1047 at 1.5 m, described as weathered rock.

Groundwater

Groundwater was encountered in seven exploratory points at depths of between 1.4 and 2.5 m, primarily in natural material although one occurrence was at the boundary between natural and made ground. When encountered the groundwater was as slight to moderate seepages.

Evidence of Contamination

Olfactory evidence of a hydrocarbon contamination was noted at 2.1 m in TP1248.

Pockets of asbestos-like material were observed in TP1293 between ground level and 0.15 m.

4.10.4. Laboratory Analysis

Summary analytical soil and leachability results are given below and complete results are given in Appendix 7 and Appendix 8.

Soil

Determinand	units	No.	Min.	Mean	Max.
2,4-DNT	mg/kg	49	<1	-	<1
2,6-DNT	mg/kg	49	<1	-	<1
EGDN	mg/kg	49	<0.1	0.1	0.2
HMX	mg/kg	49	<2	-	<2
HNS	mg/kg	49	<0.5	-	<0.5
NC	mg/kg	49	<5,000	-	<5,000
NG	mg/kg	49	<0.1	1.3	29.9
PETN	mg/kg	49	<5	-	<5
Picric acid	mg/kg	49	<0.1	-	<0.1
Picrite	mg/kg	49	<0.25	-	<0.25
RDX	mg/kg	49	<2	-	<2
Tetryl	mg/kg	49	<1	-	<1
TNT	mg/kg	49	<0.5	-	<0.5

Table 34 – Zone I, Explosives

Determinand	units	No.	Min.	Mean	Max.
As	mg/kg	49	5	11	23
Cd	mg/kg	49	<0.3	0.3	1.2
Cr	mg/kg	49	16	39	67
Pb	mg/kg	49	4	64	230
Hg	mg/kg	49	<0.1	0.2	0.9
Se	mg/kg	49	<0.3	0.6	1.8
Cu	mg/kg	49	5	73	1,260
Ni	mg/kg	49	10	35	100
Zn	mg/kg	49	24	128	290
Ba	mg/kg	17	57	244	807
Be	mg/kg	17	1.4	2.4	6.9
Bi	mg/kg	17	<4	5	12
Mg	mg/kg	17	2,100	5,300	10,500

Determinand	units	No.	Min.	Mean	Max.
Mn	mg/kg	17	100	421	751
Mo	mg/kg	17	<5	-	<5
P	mg/kg	17	150	614	1,010
Sb	mg/kg	17	<5	5	5
Sn	mg/kg	17	3	12	81
Sr	mg/kg	17	10	48	270
Ti	mg/kg	17	830	1,405	2,260
V	mg/kg	17	40	76	110

Table 35 – Zone I, Metals & semi-metals

Determinand	units	No.	Min.	Mean	Max.
pH		49	4.6	6.7	9.6
Sulphate	mg/kg	17	<250	690.6	2230
Sulphur	mg/kg	17	<10	41.6	318
Asbestos	Presence/Absence	49			2
Total PAHs (See Appendix 7 for Individual PAHs)	mg/kg	49	<0.1	15	195
TPH C5-C6	mg/kg	14	<1.5	-	<1.5
TPH >C6-C8	mg/kg	14	<2	-	<2
TPH >C8-C10	mg/kg	14	<1	-	<1
TPH >C10-C12	mg/kg	14	<2	-	<2
TPH >C12-C16	mg/kg	14	<20	20	20
TPH >C16-C21	mg/kg	14	<20	35	103
TPH >C21-C40	mg/kg	14	<20	351	854
VOCs		3			
Dichloromethane	µg/kg				54
SVOCs		3			
Di-n-butyl phthalate	mg/kg				1.8
Moisture content	%	16	7.1	22.5	48.3
Organic matter	%	1	1.0	1.0	1.0

Table 36 – Zone I, Others

Determinand	units	No.	Min.	Mean	Max.
As	µg/l	12	<1	1	5
B	µg/l	12	<300	-	<300
Ba	µg/l	10	<5	13	41
Be	µg/l	12	<5	-	<5
Cd	µg/l	12	<0.5	-	<0.5
Cr	µg/l	12	<5	-	<5
Cu	µg/l	12	<5	5	8
Hg	µg/l	12	<0.1	0.1	0.1
Mg	mg/l	12	<0.1	0.3	0.6
Mn	µg/l	12	<5	6	10
Mo	µg/l	12	<5	5	9
Ni	µg/l	12	<5	8	43

Determinand	units	No.	Min.	Mean	Max.
Pb	µg/l	12	<5	5.3	8
Sb	µg/l	12	<1	-	<1
Se	µg/l	12	<1	-	<1
Sn	µg/l	12	<20	-	<20
V	µg/l	12	<5	5	8
Zn	µg/l	12	<5	13	57
pH		12	7.1	7.4	9.5

Table 37 – Zone I, Leachability

NG was found in 12 No. exploratory points generally at less than 0.5 m depth. Levels in excess of 5 mg/kg were found in 3 No. exploratory points, including TP1288 located next to a former incorporator later used for ammunition storage where NG was detected at 7.3 mg/kg at 0.3 m and 29.9 mg/kg at 0.6 m.

Observations of asbestos in TP1293, which is adjacent to an overgrown railway track, were confirmed in the laboratory to be loose insulation comprising chrysotile and amosite. Chrysotile and amosite were found at 0.1 m depth and amosite was found at 0.3 m depth. No other samples contained asbestos at detectable levels.

Two samples had Total PAHs over 100 mg/kg, both from shallow made ground in BH1306. TPH concentrations showed little pattern across the Zone; C21 to 40 was typically at 100 to 800 mg/kg, with occasional detectable C16 to 21 and C12 to 16 in the 30 to 100 mg/kg range.

Dibutyl phthalate, used as a plasticiser in propellant manufacture, was found at 1.8 mg/kg in TP1304 at 0.2 m depth.

Dichloromethane was found at 54 µg/kg in TP1222 at 0.1 m depth in an area used to store waste oils, solvents and empty solvent containers.

Metal concentrations showed little spatial pattern.

The leachable fraction was generally between 0.1 and 1.5 %. Magnesium leachability was particularly low in the order of 1.0E-4 %.

4.11. Zone J

4.11.1. Introduction

Zone J, occupying approximately 31ha, includes the original Tetryl factory, later converted to RDX manufacture, (designated Tetryl/RDX B), and the Factory III Acids Section. The Picrite Section was later constructed in this area.

Zone J was assigned a nominal grid spacing of 85 m because of the generally closely spaced process buildings and frequency of specific potential contamination sources. More than half of the Zone is within the Core Development Area.

Potential contamination sources include process buildings, acid tanks, effluent lagoons, an ash dump and the main coal store.

4.11.2. Scope of Investigation

Investigation in Zone J comprised the following:

- 43 No. trial pits
- 1 No. borehole
- 8 No. hand augers
- 1 No. hand sample

The scope of investigation in this zone did not differ significantly from that proposed although it was necessary to replace 8 No. trial pits with hand augers.

Of the 225 No. soil samples taken, 104 No. were analysed for a range of contaminants. Of these 89 No. were samples of made ground and 15 No. were natural.

4.11.3. Ground Conditions

Made Ground

Made ground was encountered in 41 No. exploratory points with typical thicknesses ranging from 0.4 to 1.6 m. Made ground solely comprising fragments of non-natural material such as blaes, brick, glass, ceramic tile, porcelain, china, wood, metal piping, wire, ash, clinker, tarmac and reinforced concrete was encountered in 40 No. exploratory points. Made ground was also observed to be 2.2 m deep in TP1351 and 2.1 m in TP1334, although this was not characteristic for the zone. In TP1332 a layer of made ground 1.3 m deep was encountered and contained significant amounts of bricks and reinforced concrete. This is consistent with general demolition materials from previously demolished buildings.

Reworked natural material was also evident across the zone. This material was found deeper than previously noted (up to 2.7 m in TP1320). The material comprised gravelly silt and firm to stiff mottled brown and grey clay. Gravels, cobbles and boulders of mixed lithology including basalt, quartzite, sandstone and schist, were found increasing in proportion with depth. Infrequent fragments of charcoal and blaes were observed.

In TP1347 a concrete obstruction was encountered at 1.6 m that is likely to be associated with a former acid tank farm that existed on that part of the site prior to the construction of the newer boiler house. In TP1350 a concrete obstruction was encountered at 2.2 m and is likely to be the foundations of a former building that once stood in that part of the site.

Superficial Deposits

Superficial deposits were encountered in 36 No. exploratory locations with the exception where made ground could not be penetrated (typically due to reinforced concrete or underground services). The maximum thickness of superficial deposits was 4.35 m, observed in BH1349.

A large proportion of the zone is on higher ground compared with the remainder of Site and is predominantly underlain with Wilderness Till Fm. It was generally

comprised of stiff to very stiff pinky brown sandy gravely clay with pockets of coloured sand and angular to subangular cobbles and boulders. The density together with boulders and cobbles often hampered excavation.

Linwood/Paisley Fm. was observed in the north and south of the zone. Brown, grey and orange silt and soft to firm dark grey clay was identified. In the south gravels were fine to coarse angular to sub-angular of mixed lithology.

Sands and gravels of the Killearn Fm. were observed generally located on sloping ground in the north on the boundary between the Wilderness Till Fm. and the Linwood/Paisley Fm. The Killearn Fm. varied with pockets of red and greenish sand and rounded to sub-rounded gravels and cobbles of sandstone.

Clippens Peat Fm. was observed in the south of the zone, appearing dark brown to dark red and displaying spongy fibrous characteristics with a strong organic odour. Typical thicknesses ranged from 0.8 to 1.1 m.

Bedrock

Bedrock, assumed to be the Lawmuir Fm., was encountered in TP1323, TP1326 and TP1352 at depths of 2.7, 1.6 and 2.1 m, respectively as fine to coarse angular to sub-angular gravels.

Groundwater

Groundwater was encountered in 10 No. exploratory locations ranging from 0.4 to 3.6 m depth. Groundwater inflow was generally observed as seepage or rapid ingress (TP1334) from mixed strata of sand, silt, clay and made ground.

Evidence of Contamination

Hydrocarbons were observed seeping from the pit walls of TP1335 at 0.7 m.

Visible and olfactory evidence of hydrocarbon contamination was noted in TP1341 at 1.2 m and TP1353 between 0.5 and 1.7 m, where it was associated with bituminous coating on cast iron pipe. Olfactory evidence of hydrocarbon contamination was noted in TP1352 at 2.0 m, TP1330 near surface, TP1341 at 1.2 m, and TP1352 at 2 m.

Fragments of what appeared to be cement bonded asbestos sheet were noticed in TP1316 at 0.9 m.

A buried metal oil container was seen in TP1358 at 1.0 m.

4.11.4. Laboratory Analysis

Summary analytical soil and leachability results are given below and complete results are given in Appendix 7 and Appendix 8.

Soil

Determinand	units	No.	Min.	Mean	Max.
2,4-DNT	mg/kg	104	<1	-	<1
2,6-DNT	mg/kg	104	<1	-	<1
EGDN	mg/kg	104	<0.1	0.2	1
HMX	mg/kg	104	<2	-	<2
HNS	mg/kg	104	<0.5	-	<0.5
NC	mg/kg	104	<1,000	-	<5,000
NG	mg/kg	104	<0.1	0.2	1
PETN	mg/kg	104	<5	-	<5
Picric acid	mg/kg	104	<0.1	0.1	0.4
Picrite	mg/kg	104	<0.25	0.44	10.2
RDX	mg/kg	104	<2	2	16
Tetryl	mg/kg	104	<1	-	<1
TNT	mg/kg	104	<0.5	0.7	22.1

Table 38 – Zone J, Explosives

Determinand	units	No.	Min.	Mean	Max.
As	mg/kg	104	1	15	426
Cd	mg/kg	104	<0.3	0.5	12.0
Cr	mg/kg	104	<5	42	88
Pb	mg/kg	104	<3	125	2,860
Hg	mg/kg	104	<0.1	0.3	3.1
Se	mg/kg	104	<0.3	0.9	5.5
Cu	mg/kg	104	<3	75	911
Ni	mg/kg	104	<5	47	110
Zn	mg/kg	104	6	141	998
Ba	mg/kg	68	40	243	1,930
Be	mg/kg	68	<0.1	2.0	4.4
Bi	mg/kg	68	<3	6	23
Mg	mg/kg	68	787	5,922	30,800
Mn	mg/kg	68	50	609	1,650
Mo	mg/kg	68	<5	5	11
P	mg/kg	68	120	665	2,000
Sb	mg/kg	68	<5	5	13
Sn	mg/kg	68	<2	8	100
Sr	mg/kg	68	19	64	190
Ti	mg/kg	68	23	1,145	3,560
V	mg/kg	68	<5	68	120

Table 39 – Zone J, Metals & semi-metals

Determinand	units	No.	Min.	Mean	Max.
pH		104	3.8	7.0	9.8
Sulphate	mg/kg	68	<250	1019.0	9180
Sulphur	mg/kg	67	<10	72.8	916
Asbestos	Presence/Absence	104			2

Determinand	units	No.	Min.	Mean	Max.
Total PAHs (See Appendix 7 for Individual PAHs)	mg/kg	104	<0.1	90	5,850
TPH C5-C6	mg/kg	20	<1.5	1.6	4
TPH >C6-C8	mg/kg	20	<2	2	7
TPH >C8-C10	mg/kg	20	<1	1	5
TPH >C10-C12	mg/kg	20	<2	2	4
TPH >C12-C16	mg/kg	20	<20	42	259
TPH >C16-C21	mg/kg	20	<20	77	391
TPH >C21-C40	mg/kg	20	36	379	,1580
TPHCWG		2			
>C6 to C8	mg/kg				< 1.0
>C8 to C10	mg/kg				< 1.0
>C10 to C12	mg/kg				4.9
>C12 to C16	mg/kg				33
>C16 to C21	mg/kg				59
>C21 TO C40	mg/kg				84
Total Aliphatic	mg/kg				180
>C5 to C7	mg/kg				< 1.0
>C7 to C8	mg/kg				< 1.0
>C8 to C10	mg/kg				< 1.0
>C10 to C12	mg/kg				1.7
>C12 to C16	mg/kg				27
>C16 to C21	mg/kg				39
>C21 TO C40	mg/kg				60
Total Aromatic	mg/kg				130
VOCs		2			
Benzene	µg/kg				1.8
m,p-Xylene	µg/kg				0.6
Toluene	µg/kg				1.3
SVOCs		2	none detected		
Calorific Value	kJ/kg	9	970	7,552	15,000
Moisture content	%	25	10.8	23.0	86.9
Organic matter	%	5	0.1	7.6	25.0

Table 40 – Zone J, Others

Determinand	units	No.	Min.	Mean	Max.
As	µg/l	25	<1	5	72
B	µg/l	25	<300	-	<300
Be	µg/l	25	<5	-	<5
Cd	µg/l	25	<0.5	0.6	1.8
Cr	µg/l	25	<5	-	<5
Cu	µg/l	25	<5	5	10
Hg	µg/l	25	<0.1	0.1	0.1
Mg	mg/l	25	<0.1	1	6
Mn	µg/l	25	<5	14	140

Determinand	units	No.	Min.	Mean	Max.
Mo	µg/l	25	<5	-	<5
Ni	µg/l	25	<5	-	<5
Pb	µg/l	25	<5	5.6	21
Sb	µg/l	25	<1	1	3
Se	µg/l	25	<1	1	5
Sn	µg/l	25	<20	<20	<20
V	µg/l	25	<5	5	12
Zn	µg/l	25	<5	14	31
pH		25	5.9	8.0	9.4

Table 41 – Zone J, Leachability

Picrite was detected in 10 No. exploratory points in the Picrite Section at concentrations up to 10.2 mg/kg. TNT and RDX were found in 2 No. trial pits in the north of the zone. Buildings in this area are believed to have been used for mixing RDX (manufactured at the Site) with TNT (imported from other factories) prior to dispatch.

Traces of NG, EGDN and picric acid were detected in 9 No. samples.

A sample from TP1355 containing tarmac fragments yielded Total PAHs of 5,850 mg/kg. Other notable concentrations of Total PAHs were: 1,960 mg/kg in a sample of ash above tarmac from TP1337 and, 193 mg/kg in made ground below tarmac in TP1351.

TPH and BTEX were detected in TP1358 where a buried metal oil container was noted. Lighter fractions in the range C5 to C12 were found at 4 to 7 mg/kg, and benzene was detected at 1.8 mg/kg.

The aliphatic:aromatic split was determined for TPHs in TP1347 (next to fuel oil tanks) at 1.5 m. TPHs were found to be predominantly C21 to C40, reducing in concentration with decreasing carbon number, and an approximate 50/50 split between aliphatic and aromatic compounds.

Analysis on samples from TP1330 and TP1341 confirmed the olfactory evidence noted in the field with generally low concentrations of TPH's and PAH's.

Other visual and/or olfactory evidence of hydrocarbon contamination was generally not confirmed in the laboratory.

Analysis for asbestos on samples fro TP1316 did find any asbestos with in the soil.

Lead at 2,860 mg/kg was reported in TP1346 at 0.1 m, located outside an instrument repair shop in the former Acids Section. Arsenic at 1,333 mg/kg was detected in TP1333, beneath the slab of the original Factory II boilerhouse.

Elsewhere metals were generally at consistent concentration, including surface samples from the former coal store where ash and coal was reported to be abundant.

Elevated moisture contents and soil organic matter are generally attributable to peat.

The leachable fraction was generally between 0.1 and 1.5 %. Magnesium leachability was particularly low in the order of 1.0E-4 %. Tin leachability was slightly higher at around 4 %.

4.12. Zone K

4.12.1. Introduction

Zone K, occupying approximately 20ha, was the area formally used for manufacture of Tetryl/RDX and then Ammunition Breakdown. This area was assigned a nominal grid spacing of 85 m to reflect the general close spacing of process buildings and number of specific potential contamination sources. This zone is outside the Core Development Area.

Potential contamination sources include process buildings, acid tanks, fuel tanks Tetryl effluent lagoons, and materials storage.

4.12.2. Scope of Investigation

Investigation in Zone K comprised the following:

- 25 No. trial pits
- 2 No. boreholes
- 4 No. hand augers

The scope of investigation in this zone did not differ significantly from that proposed although it was necessary to replace 8 No. trial pits with hand-augured samples.

Of the 164 No. soil samples taken, 67 No. were analysed for a range of contaminants. Of these 41 No. were samples of made ground and 26 No. were natural.

4.12.3. Ground Conditions

Made Ground

Made ground was encountered in all of the exploratory locations with depths ranging from 0.3 to 2.0 m. Two types were observed; firstly, made ground comprising predominantly fragments of non-natural material including blaes, brick, glass, ceramic tile, wood, metal piping, rubber, ash, asphalt, clinker, tarmac and reinforced concrete was found in 27 No. of exploratory points. In TP1376, 1379 and 1390 a layer of made ground 1.3 m, 1 m, and 2 m thick respectively was encountered. The material encountered in these pits (bricks, glass, metal, wood, reinforced concrete and concrete) is consistent with general demolition materials from previously demolished buildings. .

Secondly, reworked natural material was also evident and observed where services/buildings were located. This disturbed material was found to reach depths of up to 1.8 m where drainage had been installed (TP1381).

Superficial Deposits

Superficial deposits were encountered in all of the exploratory locations with a maximum thickness of 11m, observed in BH1375. Towards the western fringe on higher ground HA1371 and TP1362 encountered Wilderness Till Fm. It generally comprised dark brown silty and clayey sandy gravel. The gravel was fine to coarse angular to sub-angular of basalt and dolerite.

The Linwood/Paisley Fm. was found to underlie the majority of the zone with varying consistencies. The material was encountered as a soft to firm grey sandy gravelly silt and clay becoming softer with depth, particularly in the extreme east of the zone. Typically, silt contained organic material in the east of the zone and fine to coarse rounded to sub-rounded igneous gravel. Towards the north-east boundary of the zone mottled brown and orange clay together with laminated silt was present.

Sands and gravels of Killearn Fm. were observed generally located on slightly sloping ground on the boundary between Wilderness Till Fm. and Linwood/Paisley Fm. This area was located centrally, including TP1374, TP1376, and TP1379, where it was generally described as fine to coarse rounded to sub-rounded sandy gravel with pockets of organic silt.

Clippens Peat Fm. was observed along both southern boundaries (TP1381, HA1389, HA1388 and TP1387) of the zone and varied in appearance from dark brown black spongy fibrous to amorphous, and occasionally produced a strong natural organic odour.

Bedrock

Rockhead was encountered in one trial pit, TP1362 at 1.8 m, and was recovered as weathered angular coarse-grained porphyritic basalt, attributable to the Clyde Plateau Volcanic Fm.

Groundwater

Groundwater was encountered in 16 No. exploratory locations ranging from 0.3 to 2.8 m depth. Groundwater inflow varied from a seepage to rapid flow from a variety of strata. Groundwater strikes were generally 1.0 m deeper towards the northern and eastern zone boundaries.

Evidence of Contamination

Visible and olfactory evidence of hydrocarbon contamination was noted in TP1377 at 0.95 m.

Fragments of what appeared to be asbestos tiles were found in TP1369 near surface and a yellow fibrous matter was noted in TP1391.

4.12.4. Laboratory Analysis

Summary analytical soil and leachability results are given below and complete results are given in Appendix 7 and Appendix 8.

Soil

Determinand	units	No.	Min.	Mean	Max.
2,4-DNT	mg/kg	67	<1	-	<1
2,6-DNT	mg/kg	67	<1	-	<1
EGDN	mg/kg	67	<0.1	0.2	5
HMX	mg/kg	67	<2	3	83
HNS	mg/kg	67	<0.5	-	<0.5
NC	mg/kg	67	<1,000	-	<5,000
NG	mg/kg	67	<0.1	0.2	5
PETN	mg/kg	67	<5	-	<5
Picric acid	mg/kg	67	<0.1	0.6	17.5
Picrite	mg/kg	67	<0.25	0.25	0.28
RDX	mg/kg	67	<2	749	50,000
Tetryl	mg/kg	67	<1	4	197
TNT	mg/kg	67	<0.5	1,152	77,100

Table 42 – Zone K, Explosives

Determinand	units	No.	Min.	Mean	Max.
As	mg/kg	66	3	10	29
Cd	mg/kg	66	<0.3	0.3	0.6
Cr	mg/kg	66	<5	38	73
Pb	mg/kg	66	<3	52	250
Hg	mg/kg	66	<0.1	0.2	0.7
Se	mg/kg	66	<0.3	0.6	3.9
Cu	mg/kg	66	7	38	190
Ni	mg/kg	66	6	38	140
Zn	mg/kg	66	17	149	2,210
Ba	mg/kg	30	73	217	632
Be	mg/kg	30	0.4	4.0	9.8
Bi	mg/kg	30	<3	4	8
Mg	mg/kg	30	464	8,370	32,600
Mn	mg/kg	30	170	543	1,970
Mo	mg/kg	30	<5	5	7
P	mg/kg	30	120	835	2,540
Sb	mg/kg	30	<5	5	5
Sn	mg/kg	30	<2	9	19
Sr	mg/kg	30	14	116	748
Ti	mg/kg	30	38	2,267	5,060
V	mg/kg	30	20	82	180

Table 43 – Zone K, Metals & semi-metals

Determinand	units	No.	Min.	Mean	Max.
pH		66	3.6	6.6	9.2
Sulphate	mg/kg	30	<250	600.3	2430
Sulphur	mg/kg	30	<10	22.9	197
Asbestos	Presence/Absence	67			2

Determinand	units	No.	Min.	Mean	Max.
Total PAHs (See Appendix 7 for Individual PAHs)	mg/kg	63	<0.1	4	19
TPH C5-C6	mg/kg	15	<1.5	-	<4.5
TPH >C6-C8	mg/kg	15	<2	-	<6
TPH >C8-C10	mg/kg	15	<1	-	<3
TPH >C10-C12	mg/kg	15	<2	-	<6
TPH >C12-C16	mg/kg	15	<20	34	156
TPH >C16-C21	mg/kg	15	<20	815	11,700
TPH >C21-C40	mg/kg	15	<20	673	5,580
TPHCWG		1			
>C6 to C8	mg/kg				< 1.0
>C8 to C10	mg/kg				3.3
>C10 to C12	mg/kg				40
>C12 to C16	mg/kg				230
>C16 to C21	mg/kg				200
>C21 TO C40	mg/kg				63
Total Aliphatic	mg/kg				540
>C5 to C7	mg/kg				< 1.0
>C7 to C8	mg/kg				< 1.0
>C8 to C10	mg/kg				2
>C10 to C12	mg/kg				4
>C12 to C16	mg/kg				75
>C16 to C21	mg/kg				110
>C21 TO C40	mg/kg				60
Total Aromatic	mg/kg				250
VOCs		1			
Ethyl benzene	µg/kg				31
SVOCs		1	none detected		
Moisture content	%	16	8.0	23.8	68.0
Organic matter	%	2	3.9	14.5	25.0

Table 44 – Zone K, Others

Determinand	units	No.	Min.	Mean	Max.
As	µg/l	15	<1	1.5	6.5
B	µg/l	15	<300	462	1,760
Be	µg/l	15	<5	-	<5
Cd	µg/l	15	<0.5	-	<0.5
Cr	µg/l	15	<5	-	<5
Cu	µg/l	15	<5	6	12
Hg	µg/l	15	<0.1	0.1	0.1
Mg	mg/l	15	<0.1	0	2
Mn	µg/l	15	<5	17	86
Mo	µg/l	15	<5	-	<5
Ni	µg/l	15	<5	-	<5
Pb	µg/l	15	<5	5.8	14
Sb	µg/l	15	<1	1	2

Determinand	units	No.	Min.	Mean	Max.
Se	µg/l	15	<1	1	4
Sn	µg/l	15	<20	26	114
V	µg/l	15	<5	8	30
Zn	µg/l	15	6	19	38
pH		15	5	7.7	8.6

Table 45 –Zone K, Leachability

Compared to other zones, a greater range of explosives was found in Zone K, consistent with the history of this area of the factory.

The highest concentrations were of TNT and RDX outside a building used to steam out high explosive fillings from shells (TP1364). The detection of picric acid and HMX in these samples at lower concentrations indicates that some devices also contained these explosives.

Picric acid is also a breakdown product of tetryl and was detected up to 8.5 mg/kg along with tetryl (up to 197 mg/kg) in TP1374 and 1379, near the settling lagoon in the Tetryl Section.

TNT, RDX, picrite, NG and EGDN were detected at lower concentrations around former process buildings, but also in 2 No. trial pits on the perimeter road (TP1381 - NG and RDX, 2 and 0.8 mg/kg, TP1387 – EGDN 0.1 mg/kg).

The maximum total PAH concentration (18.8 mg/kg) was detected in HA1385 at 0.1 m, a sample of natural surface material located outside the main section area.

Evidence of hydrocarbon seen in TP1377 was proved in the laboratory to be predominantly aliphatic hydrocarbons in the range C12 to C21 (Total aliphatic TPH 540 mg/kg). TPH C16 to C21 was reported at 11,700 mg/kg in TP1364 probably due to the high concentrations of explosives, some of which can interfere with the analysis (e.g. TNT, DNT).

Metal concentrations were reasonably consistent across the zone and laboratory results did not confirm the observations of asbestos tiles in the field from TP1369. Asbestos was confirmed from two samples from TP1391 (confirming the observation in the field) and HA1389, both near surface.

The leachable fraction was generally between 0.1 and 1.5 %. Magnesium leachability was particularly low in the order of 1.0E-4 %. Tin leachability was slightly higher at around 7 %.

4.13. Zone L

4.13.1. Introduction

Zone L, occupying approximately 45ha, comprises the main burning grounds, the sewage works and parts of Factory III Gun Propellant Section, which is outside the Core Development Area.

A nominal 100 m grid spacing was selected, although exploratory points were concentrated in the southern part near identified potential contamination sources.

The woodland to the north of the zone is not recorded to have been used by the factory; therefore fewer exploratory points were constructed in that area.

Potential contamination sources include the burning grounds (which were previously investigated in 1995), coal storage area, scrap metal compound, ash dumps and disturbed areas of made ground.

4.13.2. Scope of Investigation

Investigation in Zone L comprised the following:

- 39 No. trial pits
- 3 No. boreholes
- 7 No. hand augers

The scope of investigation in this zone did not differ significantly from that proposed although it was necessary to replace 7 trial pits with hand-augured samples.

Of the 220 No. soil samples taken, 106 No. were analysed for a range of contaminants. Of these, 62 No. were samples of made ground and 44 No. were natural.

4.13.3. Ground Conditions

Made Ground

Made ground was encountered in the majority of exploratory locations with typical thicknesses ranging from 0.3 to 1.2 m.

Two types were observed; firstly, made ground comprising predominantly of non-natural materials including blaes, brick, glass, ceramic tile, ash, clinker, tarmac and reinforced concrete was noted in 40 No. exploratory positions. This type of made ground was generally thickest around the former burning grounds, observed at 2.8 m in TP1410, and within close proximity to the former broad gauge railway track located centrally within the zone.

TP1437, 1438 and 1439 located in one of the ash dumps, confirmed the presence of brown and grey sand sized ash. North of this area, TP1426 and TP1428 also encountered similar material. In the east of the zone next to the sewage farm an area of made ground containing coal gravel, ash and clinker was found, encompassing TP1417, 1422, 1423, 1429, 1432 and 1625.

Secondly, reworked natural material was also evident in this zone in 8 No. exploratory points and contained disturbed natural sand, silt, clay and fine to coarse angular to sub-rounded gravel and cobbles of mixed lithology including basalt, quartzite, dolerite, sandstone and schist as well as minor constituents of blaes, glass and charcoal.

Superficial Deposits

Superficial deposits were encountered in all of the exploratory locations predominantly comprising very soft to firm dark brown clay and grey silt of the

Linwood/Paisley Fm. The maximum thickness of superficial deposits was 4.6 m, observed in BH1429.

The Linwood/Paisley Fm. varied in texture between silt and clay, typically grey becoming softer with depth, with occasional fine to coarse angular to rounded gravel with sand and occasional plant remains. In the west and north-west of the zone the Linwood/Paisley Fm. was observed to be banded with layers of sand and silt.

Wilderness Till Fm. was observed centrally towards the south-west of the zone in TP1411, TP1416 and TP1406 and comprised brown medium to coarse sandy clayey gravel with cobbles and stiff friable brown clay. The gravel, cobbles and boulders were observed to be rounded to sub-rounded of quartz and increased in proportion with depth. Pockets of soft to firm friable sandy clay were observed.

Sands and gravels of the Killearn Fm. were observed in one trial pit, TP1394, in the extreme north-west of the zone at a depth of 2.0 m. The gravel was found to be rounded to sub-rounded of quartzite and schist. This was near the boundary between the Linwood/Paisley Fm. and where bedrock outcrops at surface in the west of the zone.

Clippens Peat Fm., typically dark brown spongy and fibrous, was encountered in TP1437, TP1438 and TP1439 in the southern part of the zone and along the south-western boundary in TP1432, BH1429 and TP1436.

Bedrock

Bedrock was encountered in 3 No. trial pits, TP1400, TP1402 and TP1404 at depths of 0.9, 1.8 and 0.4 m, respectively, and was generally recovered as fine to coarse angular gravel, cobbles and boulders of basalt, attributable to the Clyde Plateau Volcanic Fm.

Groundwater

Groundwater was encountered in 15 No. exploratory locations ranging from 1.0 to 2.8 m depth. Groundwater inflow was generally observed ranging from seepage to rapid ingress in silt, clay or gravel and was also encountered in made ground.

Evidence of Contamination

Olfactory evidence of hydrocarbon contamination was noted in TP1422 at 1.5 m and TP1413 at 1.2 m. Both olfactory and visible indication of hydrocarbon contamination was recorded in TP1423 at 1.9 and 3.0 m. Burnt cardboard was noted in TP1410 near surface.

4.13.4. Laboratory Analysis

Summary analytical soil and leachability results are given below and complete results are given in Appendix 7 and Appendix 8.

Soil

Determinand	units	No.	Min.	Mean	Max.
2,4-DNT	mg/kg	103	<1	1	1
2,6-DNT	mg/kg	103	<1	-	<1
EGDN	mg/kg	103	<0.1	0.1	0.2
HMX	mg/kg	103	<2	2	3
HNS	mg/kg	103	<0.5	0.5	2.8
NC	mg/kg	103	<1,000	4,907	5,000
NG	mg/kg	103	<0.1	5	279
PETN	mg/kg	103	<5	-	<5
Picric acid	mg/kg	103	<0.1	0.1	1.8
Picrite	mg/kg	103	<0.25	0.34	3.2
RDX	mg/kg	103	<2	5	211
Tetryl	mg/kg	103	<1	1	12
TNT	mg/kg	103	<0.5	1.7	58

Table 46 – Zone L, Explosives

Determinand	units	No.	Min.	Mean	Max.
As	mg/kg	103	2	15	250
Cd	mg/kg	103	<0.3	0.4	4.4
Cr	mg/kg	103	9	44	260
Pb	mg/kg	103	<3	139	2,200
Hg	mg/kg	103	<0.1	0.3	2.9
Se	mg/kg	103	<0.3	1.2	21.0
Cu	mg/kg	103	5	94	1,270
Ni	mg/kg	103	16	47	140
Zn	mg/kg	103	22	273	7,820
Ba	mg/kg	66	41	310	1,510
Be	mg/kg	66	<0.1	3.0	12.0
Bi	mg/kg	66	<3	6	18
Mg	mg/kg	66	93	6,237	40,600
Mn	mg/kg	66	36	518	5,920
Mo	mg/kg	66	<5	6	29
P	mg/kg	66	9	816	2,850
Sb	mg/kg	66	<5	5	13
Sn	mg/kg	66	<2	13	99
Sr	mg/kg	66	9	117	1,010
Ti	mg/kg	66	73	1,568	6,920
V	mg/kg	66	15	92	630
Al	mg/kg	8	10000	17,375	32,000

Table 47 – Zone L, Metals & semi-metal

Determinand	units	No.	Min.	Mean	Max.
pH		103	4.7	6.6	10.2
Sulphate	mg/kg	66	<250	827.7	5960
Sulphur	mg/kg	66	<10	132.8	2670

Determinand	units	No.	Min.	Mean	Max.
Asbestos	Presence/Absence	103			2
Total PAHs (See Appendix 7 for Individual PAHs)	mg/kg	103	<0.1	37	1,080
TPH C5-C6	mg/kg	30	<1.5	1.5	1.6
TPH >C6-C8	mg/kg	30	<2	2	3
TPH >C8-C10	mg/kg	30	<1	3	58
TPH >C10-C12	mg/kg	30	<2	20	437
TPH >C12-C16	mg/kg	30	<20	74	726
TPH >C16-C21	mg/kg	30	<20	169	1,460
TPH >C21-C40	mg/kg	30	<20	653	7,190
TPHCWG		1			
>C6 to C8	mg/kg				< 5.0
>C8 to C10	mg/kg				< 5.0
>C10 to C12	mg/kg				20
>C12 to C16	mg/kg				110
>C16 to C21	mg/kg				110
>C21 TO C40	mg/kg				45
Total Aliphatic	mg/kg				280
>C6 to C8	mg/kg				< 25
>C8 to C10	mg/kg				< 5.0
>C10 to C12	mg/kg				< 5.0
>C12 to C16	mg/kg				30
>C16 to C21	mg/kg				67
>C21 TO C40	mg/kg				61
Total Aromatic	mg/kg				160
VOCs		3			
1,1,2,2-Tetrachloroethane	µg/kg				566
1,1,2-Trichloroethane	µg/kg				773
1,2,3-Trichlorobenzene	µg/kg				133
1,2,3-Trichloropropane	µg/kg				395
1,2,4-Trichlorobenzene	µg/kg				214
1,2,4-Trimethylbenzene	µg/kg				7710
1,3,5-Trimethylbenzene	µg/kg				5420
Ethyl Benzene	µg/kg				90
Isopropylbenzene	µg/kg				363
m,p-Xylene	µg/kg				391
n-Butylbenzene	µg/kg				2370
n-Propylbenzene	µg/kg				492
o-Xylene	µg/kg				55
p-Isopropyltoluene	µg/kg				127
sec-Butylbenzene	µg/kg				1460
tert-Butylbenzene	µg/kg				87
SVOCs		3	none detected		
Dioxins	ng/g	3	0.0796	0.1057	0.1240
Pesticides	mg/kg	1	<0.05		<0.10
Calorific Value	kJ/kg	2	<500	9,750	19,000
Moisture content	%	32	8.0	26.1	54.3

Determinand	units	No.	Min.	Mean	Max.
Organic matter	%	2	1.3	6.7	12.0

Table 48 – Zone L, Others

Determinand	units	No.	Min.	Mean	Max.
As	µg/l	31	<1	2	9
B	µg/l	31	<300	333	1,310
Ba	µg/l	9	<5	28	114
Be	µg/l	31	<5	-	<5
Cd	µg/l	31	<0.5	0.5	0.9
Cr	µg/l	31	<5	-	<5
Cu	µg/l	31	<5	7	46
Hg	µg/l	31	<0.1	0.1	0.3
Mg	mg/l	31	<0.1	0.7	5.8
Mn	µg/l	31	<5	61	600
Mo	µg/l	31	<5	-	<5
Ni	µg/l	31	<5	6	20
Pb	µg/l	31	<5	7.3	66
Sb	µg/l	31	<1	1	1
Se	µg/l	31	<1	1	9
Sn	µg/l	31	<20	-	<20
V	µg/l	31	<5	12	85
Zn	µg/l	31	<5	30	294
pH		31	6.6	7.4	7.9

Table 49 – Zone L, Leachability

Explosives were found in most of the samples taken from the main burning grounds, dominated by RDX (up to 211 mg/kg), NG (up to 44.1 mg/kg) and TNT (up to 58 mg/kg).

Elsewhere in the Zone, explosives were found in BH1429, BH1430 and TP1434 in areas of general open storage, and TP1398 located next to a former propellant drying stove (1,940 mg/kg NC and 279 mg/kg NG).

Field evidence of hydrocarbon contamination in TP1413 was shown in the laboratory to be TPH mainly in the C10 to C12 range, characteristic of kerosene, which was used on the burning grounds and stored nearby. A number of VOCs were also detected in this exploratory point, particular ethyl and methyl benzenes, although the laboratory reported that identification of individual compounds was difficult due to overlapping peaks.

TPH was also detected in TP1422 and 1423 where hydrocarbon contamination had been noted in the field. Here, aliphatic C16 to C40 was dominant, with a maximum concentration of 1,410 mg/kg (C16 to C21). Nearby BH1429 contained lower concentrations of a lighter fraction of TPH in a surface sample.

Total PAH concentrations in excess of 100 mg/kg were generally associated with made ground containing clinker (TP1411, 1409), often beneath former rail lines (TP1400, 1438).

The highest concentrations of metals were generally detected in samples of shallow made ground from the burning grounds. However, comparable concentrations were found in shallow made ground in areas of open storage, e.g. TP1434 at 0.1 m that yielded 150 mg/kg arsenic, 4.4 mg/kg cadmium, 260 mg/kg chromium, 2,200 mg/kg lead and 7,820 mg/kg zinc.

Laboratory analysis detected Dioxins in TP1410 where burnt cardboard was noted in the field.

Samples from the ash tip contained metals and PAH concentrations similar to other areas of the Zone.

The leachable fraction was generally between 0.1 and 1.5 %. Magnesium leachability was particularly low in the order of 1.0E-4 %. Tin leachability was slightly higher at around 2%.

4.14. Zone M

4.14.1. Introduction

Zone M, occupies approximately 24ha outside the explosives manufacturing/processing sections that includes the main administration building, laboratories, works department, Dargavel ponds and the Stores Yard. Zone M is within the Core Development Area.

A nominal grid spacing of 125 m was deemed sufficient to characterise this Zone for the purposes of the Stage I site investigation.

Particular potential contamination sources in this zone include, laboratory stores, hydraulic oil tanks, fuel USTs, a burning ground, laundry, and possible former mineral workings. Where necessary, additional boreholes and trial pits were positioned to characterise these.

4.14.2. Scope of Investigation

Investigation in Zone M comprised the following:

- 26 No. trial pits
- 4 No. boreholes
- 6 No. window sample boreholes
- 2 No. hand samples

The scope of investigation in this zone did not differ significantly from that proposed. Window sample boreholes were positioned around UST tank building ref no. 37/018 within the development area to delineate any hydrocarbon contamination.

Of the 152 No. soil samples taken, 76 No. were analysed for a range of contaminants. Of these 56 No. were samples of made ground and 20 No. were natural.

4.14.3. Ground Conditions

Made Ground

Made ground was encountered in 35 No. exploratory locations to typical depths of 0.2 to 2.3 m. Two types were observed; firstly, made ground dominated by non-natural constituents including blaes, brick, glass, ceramic tile, wood, metal, ash, clinker, tarmac and reinforced concrete. This type of made ground was generally found to be thickest around Dargavel ponds (TP1454, TP1459 and TP1460).

Secondly, reworked natural material was evident in particular areas within the zone, commonly observed where services/buildings were located, at depths of up to 2.0 m (TP1442). The material comprised banded layers of angular to sub-angular gravelly silt, gravelly clay and gravelly sand, with infrequent fragments of non-natural material such as blaes.

In TP1442 concrete was encountered at 2 m, the origin of which is not certain. An obstruction was encountered at 2.3 m in TP1454, this is likely to be associated with a historic drain which previously existed on the site.

Superficial Deposits

Superficial deposits were encountered in all exploratory locations with the exception of 4 No. where made ground could not be penetrated (typically due to reinforced concrete or underground services). The maximum thickness of superficial deposits was 5.0 m, observed in BH1621.

In general, Wilderness Till Fm. was encountered on higher ground to the north of the zone and Linwood/Paisley Fm. was encountered on lower lying ground to the south.

The Wilderness Till Fm. generally comprised firm to very stiff sandy clay with fine to coarse angular to sub-rounded gravels and angular to sub-rounded cobbles and boulders of sandstone. The stiffness of the clay and frequency of boulders and cobbles often limited excavation depth.

Linwood/Paisley Fm. generally comprised brown and orange silt as well as soft to firm dark brown and grey clay. Silt and clay was often observed with orange mottling and rare fine to medium angular to sub-angular gravel of mixed lithology.

Fairly small areas of sands and gravels of the Killearn Fm. were observed, generally located on sloping ground near the boundary between Wilderness Till Fm. and Linwood/Paisley Fm. This area was located in the north of the zone. The Killearn Fm. varied in sand and gravel composition with gravel observed to be sub-rounded to sub-angular.

Bedrock

The Lawmuir Fm. was encountered in BH1621, BH1445, TP1464, TP1188, TP1191, and TP1448 at depths of between 0.4 and 6.1 m. It comprised moderately strong grey to green slightly weathered fine-grained sandstone recovered as angular cobbles and boulders.

Groundwater

Groundwater was encountered in 9 No. exploratory locations ranging in depth from 1.3 to 6.1 m. Groundwater inflow was generally observed as seepage or rapid ingress from sand, silt, clay and made ground.

Evidence of Contamination

Field observations indicating potential contamination were as follows:

Exploratory point	Depth	Evidence
BH1455	1.5	visual & olfactory hydrocarbon (HC)
TP1093	1.5	olfactory HC
TP1443	0.1-0.5	olfactory HC
TP1447	0.4-1.9	olfactory HC
TP1464	1.3	LNAPL sheen on groundwater
TP1465	1.0	visible free product HC
WS1647	1.4	olfactory HC (PID reading 2.1 & 3.4 ppm near surface)
WS1648	1.0	olfactory HC (PID reading 3.1 ppm)
WS1649	0.0-2.1	visual and olfactory HC (PID readings from 0.6 to 21.1 ppm). LNAPL sheen on groundwater.
WS1650	0.4	visual and olfactory HC (PID reading 0.1 ppm). LNAPL sheen on groundwater.

Table 50 – Field evidence of contamination – Zone M

4.14.4. Laboratory Analysis

Summary analytical soil and leachability results are given below and complete results are given in Appendix 7 and Appendix 8.

Soil

Determinand	units	No.	Min.	Mean	Max.
2,4-DNT	mg/kg	75	<1	1	12
2,6-DNT	mg/kg	75	<1	-	<1
EGDN	mg/kg	75	<0.1	0.2	5.3
HMX	mg/kg	75	<2	-	<2
HNS	mg/kg	75	<0.5	-	<0.5
NC	mg/kg	75	<1,000	-	<5,000
NG	mg/kg	75	<0.1	0.4	8.9
PETN	mg/kg	75	<5	-	<5
Picric acid	mg/kg	75	<0.1	-	<0.1
Picrite	mg/kg	75	<0.25	0.25	0.5
RDX	mg/kg	75	<2	-	<2
Tetryl	mg/kg	75	<1	-	<1
TNT	mg/kg	75	<0.5	0.5	0.8

Table 51 – Zone M, Explosives

Determinand	units	No.	Min.	Mean	Max.
As	mg/kg	75	1	10	46
Cd	mg/kg	75	<0.3	0.6	12.0
Cr	mg/kg	75	16	36	86
Pb	mg/kg	75	3	98	734
Hg	mg/kg	75	<0.1	0.3	1.8
Se	mg/kg	75	<0.3	0.8	6.4
Cu	mg/kg	75	<3	66	511
Ni	mg/kg	75	15	49	200
Zn	mg/kg	75	9	132	914
Ba	mg/kg	37	71	294	1,870
Be	mg/kg	36	0.8	2.8	8.9
Bi	mg/kg	37	<3	6	13
Mg	mg/kg	37	1,110	4,662	13,100
Mn	mg/kg	37	140	450	1,230
Mo	mg/kg	37	<5	5	11
P	mg/kg	37	200	690	1,610
Sb	mg/kg	37	<5	5	8
Sn	mg/kg	37	<2	11	62
Sr	mg/kg	37	8	81	240
Ti	mg/kg	37	390	1,087	1,810
V	mg/kg	37	41	76.8	150

Table 52 – Zone M, Metals & semi-metals

Determinand	units	No.	Min.	Mean	Max.
pH		75	5.0	8.2	12.0
Sulphate	mg/kg	37	<250	1193.2	19000
Sulphur	mg/kg	35	<10	186.9	2220
Asbestos	Presence/Absence	72	ND	ND	ND
Total PAHs (See Appendix 7 for Individual PAHs)	mg/kg	75	<0.1	46	787
TPH C5-C6	mg/kg	41	<1.5	-	<1.5
TPH >C6-C8	mg/kg	41	<2	2	6
TPH >C8-C10	mg/kg	41	<1	3	62
TPH >C10-C12	mg/kg	41	<2	7	120
TPH >C12-C16	mg/kg	41	<20	93	2,190
TPH >C16-C21	mg/kg	41	<20	168	2,690
TPH >C21-C40	mg/kg	41	<20	528	8,150
TPHCWG		1			
>C6 to C8	mg/kg				< 1.0
>C8 to C10	mg/kg				< 7.3
>C10 to C12	mg/kg				< 16
>C12 to C16	mg/kg				< 31
>C16 to C21	mg/kg				< 46
>C21 TO C40	mg/kg				< 130
Total Aliphatic	mg/kg				< 230
>C5 to C7	mg/kg				< 1.0

Determinand	units	No.	Min.	Mean	Max.
>C7 to C8	mg/kg				< 1.0
>C8 to C10	mg/kg				< 7.3
>C10 to C12	mg/kg				< 16
>C12 to C16	mg/kg				< 31
>C16 to C21	mg/kg				< 46
>C21 TO C40	mg/kg				< 130
Total Aromatic	mg/kg				< 230
VOCs		6			
1,1,2,2-Tetrachloroethane	µg/kg				32
1,2,3-Trichlorobenzene	µg/kg				118
1,2,3-Trichloropropane	µg/kg				35
1,2,4-Trichlorobenzene	µg/kg				86
1,2,4-Trimethylbenzene	µg/kg				36
1,2-Dibromo-3-chloropropane	µg/kg				167
n-Butylbenzene	µg/kg				98
sec-Butylbenzene	µg/kg				68
SVOCs		6			
Bis(2-ethylhexyl) phthalate	mg/kg				2.53
Di-n-butyl phthalate	mg/kg				1.09
Pesticides	mg/kg	6	<0.05		<0.10
Moisture content	%	42	9.6	21.4	42.5
Organic matter	%	3	2.3	3.5	4.3

Table 53 – Zone M, Others

Determinand	units	No.	Min.	Mean	Max.
As	µg/l	14	<1	2	6
B	µg/l	14	<300	-	<300
Be	µg/l	14	<5	-	<5
Cd	µg/l	14	<0.5	0.7	1.6
Cr	µg/l	14	<5	-	<5
Cu	µg/l	14	<5	6	9
Hg	µg/l	14	<0.1	-	<0.1
Mg	mg/l	14	<0.1	0.3	0.9
Mn	µg/l	14	<5	-	<5
Mo	µg/l	14	<5	-	<5
Ni	µg/l	14	<5	5	8
Pb	µg/l	14	<5	-	<5
Sb	µg/l	14	<1	1	3
Se	µg/l	14	<1	1	2
Sn	µg/l	14	<20	-	<20
V	µg/l	14	<5	7	15
Zn	µg/l	14	6	24	145
pH		14	7.3	8.1	9.9

Table 54 – Zone M, Leachability

Explosives were detected in 17 No. samples from 13 No. exploratory points, mostly NG and EGDN in shallow soil at less than 10 mg/kg. Locations of samples with

detectable explosives include the main stores yard, works department, scrap compound and around the Main Administration building. 2,4 DNT was detected at 12 mg/kg as well as NG 8.9 mg/kg at TP1456 0.7 m with no obvious point source.

Asbestos was not detected in any sample.

Detectable levels of sulphur and sulphate from samples taken located near to the ponds have no obvious point source.

TPH was found in TP1443, TP1446 and BH1455 located in the main stores yard. The C21 to C40 fraction dominated, with a measured maximum of 8,150 mg/kg (TP1453, 0.1 m). The 'slight hydrocarbon odour – possible petrol' in BH1455 next to the underground petrol tank, was not confirmed in the lab by TPH in the C4 to C12 range, or detectable BTEX compounds. TPHCWG analysis for the aromatic and aliphatic fractions at 1.5 m from the same BH were less than the reporting limit for all bands. A number of shallow made ground samples in this area also contained higher than average Total PAH concentrations, up to 758 mg/kg.

Boreholes and trial pits positioned next to other potential sources of TPH contamination (such as the hydraulic oil tanks building ref no. 37/005 and underground diesel tank building ref no. 37/006A&B opposite the stores yard) yielded comparable concentrations to exploratory points away from fuel and oil storage. Total PAHs up to 787 mg/kg were detected in TP1443 next to the hydraulic oil tanks.

Visual and olfactory hydrocarbon contamination found around the underground diesel tank (situated on the main road near the laundry building ref no. 37/018) was shown in the laboratory as TPH in the range C12 to 21, which is typical of diesel.

Surrounding exploratory points and the subsequent window sampling and photo-ionisation detector survey showed that contamination is limited to soil immediately adjacent to the tank.

A range of VOCs were found in TP1465 in the sample with the highest TPH levels. Individual substances detected included chlorinated benzenes and alkanes, but the laboratory could not make conclusive identification of some compounds because of overlapping peaks.

Elevated PAHs were detected in a number of shallow made ground samples in the Works Department area, particularly those under tarmac.

A sample of ash in BH1455 at 0.3 m contained 512 mg/kg lead and 120 mg/kg nickel. Other notable metal concentrations include a sample of natural silt from TP1456 at 2.7 m that contained 705 mg/kg lead and 200 mg/kg nickel, and shallow ash gravel at the surface of burning ground building ref no. 16/007D which yielded arsenic, lead and nickel at 46, 734 and 69 mg/kg, respectively.

The leachable fraction was generally between 0.1 and 1.5 %. Magnesium leachability was particularly low in the order of 1.0E-4 %.

4.15. Zone N

4.15.1. Introduction

Zone N, occupying approximately 7ha, includes Dargavel House, its grounds, and a small number of factory buildings. As a result the zone was assigned a nominal grid spacing of 150 m. A very small portion of the northern area of the zone falls within the Core Development Area.

4.15.2. Scope of Investigation

Investigation in Zone N comprised the following:

- 3 No. trial pits
- 1 No. hand auger

The scope of investigation in this zone did not differ significantly from that proposed although it was necessary to replace 1 No. trial pit with a hand-augured sample.

Of the 18 No. soil samples taken, 8 No. were analysed for a range of contaminants. Of these 5 No. were samples of made ground and 3 No. were natural.

4.15.3. Ground Conditions

Made Ground

Made ground was encountered in all exploratory locations with thicknesses of between 0.6 and 0.7 m. Two types were observed: made ground predominantly comprising fragments of blaes, brick, ash, tile, glass and concrete; and reworked natural material comprising soft to firm dark brown to light brown clay with small quantities of non-natural material such as blaes.

Superficial Deposits

The Linwood/Paisley Fm. was encountered in all of the exploratory locations. It generally comprised banded layers of soft to firm mottled light/dark brown, orange and grey, silt and clay. Dark grey silt was observed to depths of up to 3.7 m.

Bedrock

Bedrock was not encountered.

Groundwater

Groundwater was not encountered.

Evidence of Contamination

No visual or olfactory evidence of contamination was noted.

4.15.4. Laboratory Analysis

Summary analytical soil and leachability results are given below and complete results are given in Appendix 7 and Appendix 8.

Soil

Determinand	units	No.	Min.	Mean	Max.
2,4-DNT	mg/kg	8	<1	-	<1
2,6-DNT	mg/kg	8	<1	-	<1
EGDN	mg/kg	8	<0.1	-	<0.1
HMX	mg/kg	8	<2	-	<2
HNS	mg/kg	8	<0.5	-	<0.5
NC	mg/kg	8	<5,000	-	<5,000
NG	mg/kg	8	<0.1	0.1	0.4
PETN	mg/kg	8	<5	-	<5
Picric acid	mg/kg	8	<0.1	-	<0.1
Picrite	mg/kg	8	<0.25	-	<0.25
RDX	mg/kg	8	<2	-	<2
Tetryl	mg/kg	8	<1	-	<1
TNT	mg/kg	8	<0.5	-	<0.5

Table 55 – Zone N, Explosives

Determinands	units	No.	Min.	Mean	Max.
As	mg/kg	8	8	11	14
Cd	mg/kg	8	<0.3	-	<0.3
Cr	mg/kg	8	33	48	67
Pb	mg/kg	8	6	1,635	12,600
Hg	mg/kg	8	<0.1	0.5	1.8
Se	mg/kg	8	<0.3	0.9	1.9
Cu	mg/kg	8	13	143	942
Ni	mg/kg	8	27	48	89
Zn	mg/kg	8	63	174	681
Ba	mg/kg	6	94	150	260
Be	mg/kg	6	1.5	2.0	3.3
Bi	mg/kg	6	<3	4	4
Mg	mg/kg	6	1,030	4,797	6,670
Mn	mg/kg	6	262	493	682
Mo	mg/kg	6	<5	-	<5
P	mg/kg	6	400	649	1,030
Sb	mg/kg	6	<5	24	120
Sn	mg/kg	6	<2	4	5
Sr	mg/kg	6	17	44	150
Ti	mg/kg	6	569	1,048	1,330
V	mg/kg	6	43	54	64

Table 56 – Zone N, Metals & semi-metals

Determinands	units	No.	Min.	Mean	Max.
pH		8	5.7	6.8	7.8
Sulphate	mg/kg	6	<250	373.3	780
Sulphur	mg/kg	6	<10	11.2	17
Asbestos	Presence/Absence	8	ND	ND	ND

Determinands	units	No.	Min.	Mean	Max.
Total PAHs (See Appendix 7 for Individual PAHs)	mg/kg	8	<0.1	9	27
TPH C5-C6	mg/kg	1	-	-	<1.5
TPH >C6-C8	mg/kg	1	-	-	<2
TPH >C8-C10	mg/kg	1	-	-	<1
TPH >C10-C12	mg/kg	1	-	-	<2
TPH >C12-C16	mg/kg	1	-	-	<20
TPH >C16-C21	mg/kg	1	-	-	<20
TPH >C21-C40	mg/kg	1	-	-	48
Moisture content	%	1	17.1	17.1	17.1

Table 57 – Zone N, Others

Determinands	units	No.	Min.	Mean	Max.
As	µg/l	1		-	<1
B	µg/l	1		-	<300
Be	µg/l	1		-	<5
Cd	µg/l	1		-	<0.5
Cr	µg/l	1		-	<5
Cu	µg/l	1		-	5
Hg	µg/l	1		-	<0.1
Mg	mg/l	1		-	<0.1
Mn	µg/l	1		-	<5
Mo	µg/l	1		-	<5
Ni	µg/l	1		-	<5
Pb	µg/l	1		-	<5
Sb	µg/l	1		-	<1
Se	µg/l	1		-	<1
Sn	µg/l	1		-	<20
V	µg/l	1		-	<5
Zn	µg/l	1		-	14
pH		1		7.7	7.7

Table 58 – Zone N, Leachability

NG was found at 0.4 mg/kg near the end of the proof range in the house grounds. This is likely to be fragments of projectile and shot associated with the range. TP1469 also contained lead at 12,600 mg/kg.

The leachable fraction was generally between 0.1 and 1.5 %.

4.16. Zone O

4.16.1. Introduction

Zone O, occupying approximately 50ha, is predominantly woodland but also includes the picrite lagoons and a burning ground used by Factory II Rocket Propellant Section. The picrite lagoons were previously investigated in late 2002.

A site investigation nominal grid spacing of 200 m was assigned as this zone is out with the Core Development Area.

Particular potential contamination sources in this zone include the picrite lagoons, miscellaneous made ground, acid tanks and a burning ground.

4.16.2. Scope of Investigations

Investigation in Zone O comprised the following:

- 3 No. trial pits
- 9 No. hand augers

The scope of investigation in this zone did not differ significantly from that proposed.

Of the 49 No. soil samples taken, 25 No. were analysed for a range of contaminants. Of these 6 No. were samples of made ground and 19 No. were natural.

4.16.3. Ground Conditions

Made Ground

Made ground was encountered in 4 No. exploratory locations (TP1478, TP1479, TP1481 and TP1474) to depths of 0.3 to 1.3 m. It comprised ash, clinker, brick, glass, tile, wood, metal and reinforced concrete. Shallow made ground (0.3 m) was observed on the Site boundary (TP1474).

Superficial Deposits

Clippens Peat Fm. was observed in all exploratory locations except TP1478, generally from near surface and reaching depths of between 0.9 and 3.6 m. In TP1481, in the south of the zone, peat was encountered at 2.8 m depth. It was observed as moist dark red to dark brown/black and displayed spongy fibrous characteristics with a strong organic odour and recognisable plant remains.

Bedrock

Bedrock, probably Lawmuir Fm., was encountered in TP1470 at a depth of 3.2 m. The horizon above was observed to comprise fine to medium angular gravely clay with pockets of red and blue/green gravels and cobbles of sandstone.

Groundwater

Groundwater was encountered in peat in two of the exploratory locations; HA1476 and HA1479 at 0.8 and 1.0 m, respectively.

Evidence of Contamination

No visual or olfactory evidence of contamination was noted.

4.16.4. Laboratory Analysis

Summary analytical soil and leachability results are given below and complete results are given in Appendix 7 and Appendix 8.

Soil

Determinands	units	No.	Min.	Mean	Max.
2,4-DNT	mg/kg	25	<1	7	138
2,6-DNT	mg/kg	25	<1	3	39
EGDN	mg/kg	25	<0.1	-	<1
HMX	mg/kg	25	<2	-	<2
HNS	mg/kg	25	<0.5	-	<0.5
NC	mg/kg	25	1,660	5,566	22,500
NG	mg/kg	25	<0.1	13.1	258
PETN	mg/kg	25	<5	-	<5
Picric acid	mg/kg	25	<0.1	-	<0.1
Picrite	mg/kg	25	<0.25	1.88	27.5
RDX	mg/kg	25	<2	-	<2
Tetryl	mg/kg	25	<1	-	<1
TNT	mg/kg	25	<0.5	-	<0.5

Table 59 – Zone O, Explosives

Determinands	units	No.	Min.	Mean	Max.
As	mg/kg	23	<1	6	17
Cd	mg/kg	23	<0.3	0.4	2.7
Cr	mg/kg	23	<5	22	64
Pb	mg/kg	23	4	201	1,430
Hg	mg/kg	25	<0.1	0.2	0.9
Se	mg/kg	25	<0.3	1.0	2.9
Cu	mg/kg	23	<3	136	1,650
Ni	mg/kg	23	<5	26	110
Zn	mg/kg	23	23	253	2,,730
Ba	mg/kg	10	22	429	2410
Be	mg/kg	10	<0.1	1.0	2.6
Bi	mg/kg	10	<3	-	<4
Mg	mg/kg	10	350	2,123	5,350
Mn	mg/kg	10	57	172	431
Mo	mg/kg	10	<5	-	<5
P	mg/kg	10	270	480	716
Sb	mg/kg	10	<5	7	16
Sn	mg/kg	10	<2	10	33
Sr	mg/kg	10	14	48	130
Ti	mg/kg	10	91	464	1,520
V	mg/kg	10	8	29	71

Table 60 – Zone O, Metals & semi-metals

Determinands	units	No.	Min.	Mean	Max.
pH		24	3.5	5.7	7.6
Sulphate	mg/kg	12	<250	11991.7	68000
Sulphur	mg/kg	13	<10	17.6	67
Asbestos	Presence/Absence	25	ND	ND	ND
Total PAHs (See Appendix 7 for Individual PAHs)	mg/kg	24	<0.1	7	54
TPH C5-C6	mg/kg	3	<1.5	-	<12
TPH >C6-C8	mg/kg	3	<2	-	<16
TPH >C8-C10	mg/kg	3	<1	3	8
TPH >C10-C12	mg/kg	3	<2	-	<16
TPH >C12-C16	mg/kg	3	<20	64	152
TPH >C16-C21	mg/kg	3	<20	83	203
TPH >C21-C40	mg/kg	3	89	1,647	4740
Moisture content	%	7	15.2	66.5	85.2
Organic matter	%	4	1.4	19.1	25.0

Table 61 – Zone O, Others

Determinands	units	No.	Min.	Mean	Max.
As	µg/l	7	<1	1	3
B	µg/l	7	<300	-	<300
Ba	µg/l	1	12	12	12
Be	µg/l	7	<5	-	<5
Cd	µg/l	7	<0.5	-	<0.5
Cr	µg/l	7	<5	-	<5
Cu	µg/l	7	<5	6	11
Hg	µg/l	7	<0.1	0.1	0.3
Mg	mg/l	7	0.3	1	5
Mn	µg/l	7	<5	24	57
Mo	µg/l	7	<5	-	<5
Ni	µg/l	7	<5	-	<5
Pb	µg/l	7	<5	-	<5
Sb	µg/l	7	<1	-	<1
Se	µg/l	7	<1	-	<1
Sn	µg/l	7	<20	-	<20
V	µg/l	7	<5	-	<5
Zn	µg/l	7	7	18	36
pH		7	5.7	6.8	7.4

Table 62 – Zone O, Leachability

Picrite was detected in a number of trial pits and hand augers around the Picrite Lagoons (up to 27.5 mg/kg) as well as HA1476 near the Environmental Test Facility. NC, NG, 2,4 DNT and 2,6 DNT were found in surface material at burning ground building ref no. 16/007B at concentrations up to 22,500, 258, 38.8 and 138 mg/kg respectively. Higher concentrations were found in the shallow samples from each of the two hand augers in this area.

Samples from the burning ground also account for the majority of detectable TPH in this zone, as well as lead up to 1,430 mg/kg and barium up to 2,410 mg/kg.

The leachable fraction was generally between 0.1 and 1.5 %. Magnesium leachability was particularly low in the order of 1.0E-4 %.

4.17. Zone P

4.17.1. Introduction

Zone P occupies approximately 70ha and is agricultural land inside the factory fence out with the Core Development Area. The zone was assigned a nominal site investigation grid spacing of 250 m because of the lack of identified potential contamination sources. The samples in this zone were generally taken to confirm the absence of contamination.

4.17.2. Scope of Investigation

Investigation in Zone P comprised the following:

- 10 No. trial pits
- 6 No. hand augers
- 5 No. boreholes

The scope of investigation in this zone did not differ significantly from that proposed although it was necessary to replace 6 No. trial pits with hand-augured samples.

Of the 104 No. soil samples taken, 48 No. were analysed for a range of contaminants. Of these, 16 No. were samples of made ground and 32 No. were natural.

4.17.3. Ground Conditions

Made Ground

Made ground was encountered in 13 No. locations and was restricted to those areas that are or have been close to buildings or roads. On the perimeter road, compacted ash and blaes was encountered to depths of 0.2 and 0.3 m in BH1528 and 1529 respectively.

The made ground adjacent to the roads through the zone was generally between 0.35 and 0.7 m thick and contained fragments of blaes, metal, brick, and pottery. At locations TP1494 and TP1496, where the road is adjacent to a hill, the thickness of made ground was 1.6 and 1.4 m respectively.

In TP1491, 1.6 m of made ground consisting of many whole bricks with fragments of pipe, tile, concrete, blaes and glass was encountered and is likely to be the remnants of a demolished building. In TP1484 and TP1486, dark brown sandy silt with fragments of tile and blaes was encountered and is likely to be reworked natural material.

Superficial Geology

Superficial deposits were encountered in all of the exploratory locations predominantly comprising brown sandy gravelly clay (Wilderness Till Fm.) with brown-grey sandy silt (Linwood/Paisley Fm) in lower areas and frequent layers of grey-brown silty sand and gravel (Killearn Fm.). The maximum thickness of superficial deposits was 15.0 m, observed in BH1531.

The Wilderness Till Fm. varied from a firm to stiff clay with fine to coarse rounded to sub-rounded gravel and rounded to sub-rounded cobbles and boulders. This material was found at 15 No. locations across the zone, particularly in the north and central area.

The Linwood/Paisley Fm. varied from soft to firm, sandy gravelly silts and clays with fine to coarse angular to sub-rounded gravel with occasional organic remains.

In the west and southern area of the zone, light brown-orange clayey sands and gravels were encountered probably attributable to the Killearn Fm.

Bedrock

Basalt of the Clyde Plateau Fm. was encountered in 2 No. exploratory holes; BH1528 at 3.5 m and BH1529 at 1.6 m.

Groundwater

Groundwater was only encountered in one exploratory hole; BH1528 at a depth of 4.7 m.

Evidence of Contamination

No visual or olfactory evidence of contamination was noted.

4.17.4. Laboratory Analysis

Summary analytical soil and leachability results are given below and complete results are given in Appendix 7 and 8.

Soil

Determinands	units	No.	Min.	Mean	Max.
2,4-DNT	mg/kg	48	<1	-	<1
2,6-DNT	mg/kg	48	<1	-	<1
EGDN	mg/kg	48	<0.1	-	<0.1
HMX	mg/kg	48	<2	-	<2
HNS	mg/kg	48	<0.5	-	<0.5
NC	mg/kg	48	<5,000	-	<5,000
NG	mg/kg	48	<0.1	0.1	0.6
PETN	mg/kg	48	<5	-	<5
Picric acid	mg/kg	48	<0.1	-	<0.1
Picrite	mg/kg	48	<0.25	-	<0.25
RDX	mg/kg	48	<2	-	<2
Tetryl	mg/kg	48	<1	-	<1

Determinands	units	No.	Min.	Mean	Max.
TNT	mg/kg	48	<0.5	0.6	4.4

Table 63 – Zone P, Explosives

Determinands	units	No.	Min.	Mean	Max.
As	mg/kg	48	3	8	15
Cd	mg/kg	48	<0.3	0.3	0.3
Cr	mg/kg	48	20	32	95
Pb	mg/kg	48	<3	28	86
Hg	mg/kg	48	<0.1	0.2	1.6
Se	mg/kg	48	<0.3	0.5	2.3
Cu	mg/kg	48	5	20	83
Ni	mg/kg	48	12	29	90
Zn	mg/kg	48	41	87	230
Ba	mg/kg	19	44	114	280
Be	mg/kg	19	1.6	3.4	7.6
Bi	mg/kg	19	<3	4	11
Mg	mg/kg	19	3,840	6,905	12,500
Mn	mg/kg	19	150	577	1,020
Mo	mg/kg	19	<5	-	<5
P	mg/kg	19	330	712	1,420
Sb	mg/kg	19	<5	5	6
Sn	mg/kg	19	4	8	20
Sr	mg/kg	19	8	29	160
Ti	mg/kg	19	1,080	2,277	5,830
V	mg/kg	19	27	64	130

Table 64 – Zone P, Metals & semi-metals

Determinands	units	No.	Min.	Mean	Max.
pH		48	4.1	6.8	9.0
Sulphate	mg/kg	19	<250	579.5	1050
Sulphur	mg/kg	19	<10	12.5	47
Asbestos	Presence/Absence	48	ND	ND	ND
Total PAHs (See Appendix 7 for Individual PAHs)	mg/kg	48	<0.1	4	42
TPH C5-C6	mg/kg	8	<1.5	-	<1.5
TPH >C6-C8	mg/kg	8	<2	-	<2
TPH >C8-C10	mg/kg	8	<1	-	<1
TPH >C10-C12	mg/kg	8	<2	-	<2
TPH >C12-C16	mg/kg	8	<20	-	<20
TPH >C16-C21	mg/kg	8	<20	35	140
TPH >C21-C40	mg/kg	8	<20	252	1,550
Pesticides	mg/kg	2	<0.05		<0.10

Determinands	units	No.	Min.	Mean	Max.
Moisture content	%	9	10.2	26.3	55.2
Organic matter	%	1	16.0	16.0	16.0

Table 65 – Zone P, Others

Determinands	units	No.	Min.	Mean	Max.
As	µg/l	5	<1	1	1
B	µg/l	5	<300	-	<300
Be	µg/l	5	<5	-	<5
Cd	µg/l	5	<0.5	-	<0.5
Cr	µg/l	5	<5	-	<5
Cu	µg/l	5	<5	6	7
Hg	µg/l	5	<0.1	-	<0.1
Mg	mg/l	5	<0.1	0.3	0.6
Mn	µg/l	5	<5	6	10
Mo	µg/l	5	<5	-	<5
Ni	µg/l	5	<5	-	<5
Pb	µg/l	5	<5	-	<5
Sb	µg/l	5	<1	-	<1
Se	µg/l	5	<1	-	<1
Sn	µg/l	5	<20	-	<20
V	µg/l	5	<5	6	7
Zn	µg/l	5	<5	9	17
pH		5	7.0	7.5	7.7

Table 66 – Zone P, Leachability

NG and TNT were found in 5 No. exploratory points to a maximum concentration of 4.4 mg/kg (TNT in HA1493), all within a few metres of the perimeter road.

Concentrations of metals, PAHs, and TPH show little or no spatial pattern or relationship with potential contamination sources.

The leachable fraction was generally between 0.1 and 1.5 %. Magnesium leachability was particularly low in the order of 1.0E-4 %.

4.18. Zone Q

4.18.1. Introduction

Zone Q, occupying approximately 200ha, is Georgetown, the First World War filling factory out with the Core Development Area. It includes the later AFV Depot, Rail and Road Magazines, and was the subject of an extensive ground investigation in 1995.

Further investigation of this area was deemed unnecessary at this stage, except for a small number of potential contamination sources that were not addressed during the 1995 investigation. These are areas of tipping around Nethermill Station and next to the refuse incinerator, and a suspected fuel tank in the AFV Depot.

4.18.2. Scope of Investigation

Investigation in Zone Q comprised the following:

- 10 No. trial pits
- 4 No. hand augers
- 3 No. boreholes

The scope of investigation in this zone did not differ significantly from that proposed although it was necessary to replace 2 trial pits with hand-augured samples.

Of the 83 No. soil samples taken, 37 No. were analysed for a range of contaminants. Of these, 19 No. were samples of made ground and 18 No. were natural.

4.18.3. Ground Conditions

Made Ground

Made ground was encountered in 14 No. exploratory locations with typical depths ranging from 0.25 to 2.9 m.

Made ground comprising predominantly man-made materials included fragments of blaes, brick, glass, ceramic tile, porcelain, lino, rubber, paint tins, wood, corrugated iron, ash, clinker, tarmac and concrete. The material is consistent with either general demolition materials from previously demolished buildings or the areas may have been used for tipping waste materials in the past.

Reworked natural material was evident in TP1500 at a depth of 1.8 m where a drain was located within peat.

Made ground was observed to be deeper near the perimeter road (TP1499, TP1501 and TP1506).

Superficial Deposits

Superficial deposits were encountered in all of the exploratory locations with the exception of TP1501, where made ground could not be penetrated due to concrete.

Linwood/Paisley Fm. was the predominant strata and generally comprised grey sandy silt and soft mottled brown/grey clay.

Clippens Peat Fm. was observed along the northern boundary of the zone and appeared orange to dark brown and dark red and displayed spongy fibrous characteristics with a strong organic odour.

Bedrock

Bedrock was not encountered.

Groundwater

Groundwater was encountered in 5 No. exploratory locations ranging from depth of 1.5 to 3.6 m. Groundwater was observed to be deeper along the northern boundary of the zone (TP1499 and BH1624), encountered in a gravel, clay and peat.

Evidence of Contamination

Fragments of possible cement bonded asbestos were found in:

- TP1501 between 0.4 and 2.1 m;
- TP1626 near surface; and,
- TP1629 at 1.1 m.

4.18.4. Laboratory Analysis

Summary analytical soil and leachability results are given below and complete results are given in Appendix 7 and Appendix 8.

Soil

Determinands	units	No.	Min.	Mean	Max.
2,4-DNT	mg/kg	37	<1	-	<1
2,6-DNT	mg/kg	37	<1	-	<1
EGDN	mg/kg	37	<0.1	-	<1
HMX	mg/kg	37	<2	-	<2
HNS	mg/kg	37	<0.5	-	<0.5
NC	mg/kg	37	<5,000	-	<5,000
NG	mg/kg	37	<0.1	0.3	1
PETN	mg/kg	37	<5	-	<5
Picric acid	mg/kg	37	<0.1	0.1	0.2
Picrite	mg/kg	37	<0.25	4.16	144
RDX	mg/kg	37	<2	-	<2
Tetryl	mg/kg	37	<1	-	<1
TNT	mg/kg	37	<0.5	-	<0.5

Table 67 – Zone Q, Explosives

Determinands	units	No.	Min.	Mean	Max.
As	mg/kg	37	1	19	165
Cd	mg/kg	37	<0.3	0.7	7.3
Cr	mg/kg	37	<5	52	190
Pb	mg/kg	37	<3	378	6,700
Hg	mg/kg	37	<0.1	0.5	2.9
Se	mg/kg	37	<0.3	3.1	66.4
Cu	mg/kg	37	<3	165	1,380
Ni	mg/kg	37	<5	58	230
Zn	mg/kg	37	5	281	1,590
Ba	mg/kg	25	28	458	2,890

Determinands	units	No.	Min.	Mean	Max.
Be	mg/kg	25	<0.1	3.6	21.5
Bi	mg/kg	25	<3	4	14
Mg	mg/kg	25	982	3,418	6,720
Mn	mg/kg	25	74	375	980
Mo	mg/kg	25	<5	5	9
P	mg/kg	25	180	969	4,620
Sb	mg/kg	25	<5	6	15
Sn	mg/kg	25	<2	86	1,600
Sr	mg/kg	25	15	154	520
Ti	mg/kg	25	37	989	1,560
V	mg/kg	25	<5	81	320
Al	mg/kg	1	-	-	9,000

Table 68 – Zone Q, Metals & semi-metals

Determinands	units	No.	Min.	Mean	Max.
pH		37	4.5	6.5	7.9
Sulphate	mg/kg	25	<250	1834.0	17200
Sulphur	mg/kg	25	<10	71.0	602
Asbestos	Presence/Absence	37			2
Total PAHs (See Appendix 7 for Individual PAHs)	mg/kg	37	<0.1	22	172
TPH C5-C6	mg/kg	7	<1.5	-	<1.5
TPH >C6-C8	mg/kg	7	<2	-	<2
TPH >C8-C10	mg/kg	7	<1	3	8
TPH >C10-C12	mg/kg	7	<2	12	47
TPH >C12-C16	mg/kg	7	<20	46	101
TPH >C16-C21	mg/kg	7	<20	72	207
TPH >C21-C40	mg/kg	7	25	393	806
VOCs	mg/kg	1	none detected		
SVOCs	mg/kg	1	none detected		
Moisture content	%	7	11.1	25.9	41.1

Table 69 – Zone Q, Others

Determinands	units	No.	Min.	Mean	Max.
As	µg/l	11	<1	3	12
B	µg/l	11	<300	306	368
Be	µg/l	11	<5	-	<5
Cd	µg/l	11	<0.5	0.8	2.1
Cr	µg/l	11	<5	-	<5
Cu	µg/l	11	<5	6	9
Hg	µg/l	11	<0.1	0.1	0.1
Mg	mg/l	11	<0.1	0.4	1.9
Mn	µg/l	11	<5	18	138
Mo	µg/l	11	<5	-	<5
Ni	µg/l	11	<5	6	9

Determinands	units	No.	Min.	Mean	Max.
Pb	µg/l	11	<5	5.7	13
Sb	µg/l	11	<1	2	7
Se	µg/l	11	<1	1	5
Sn	µg/l	11	<20	-	<20
V	µg/l	11	<5	8	22
Zn	µg/l	11	<5	50	295
pH		11	6.5	7.3	8.3

Table 70 – Zone Q, Leachability

Picrite was detected in TP1499 and 1500 adjacent to the southernmost picrite lagoon. Other occurrences of explosives were in 2 No. trial pits in tipped material, TP1501 (0.2 mg/kg picric acid) and TP1629 (0.3 mg/kg NG). Two samples from the latter area, 'Netherfield Tip 2', contained insulation comprising amosite, crocidolite and chrysotile.

Samples from TP1499 and TP1501 around the area around the former 'refuse coup' yielded lead concentrations up to 6,700 mg/kg as well as higher than average arsenic, chromium, cadmium and barium concentrations.

Detectable TPH was accounted for in this zone by samples from BH1505 on burning ground building ref no. 16/007E (also known as the Georgetown Hearth). The most abundant fraction was C12 to C16.

The leachable fraction was generally between 0.1 and 1.5 %. Magnesium leachability was particularly low in the order of 1.0E-4 %.

4.19. Zone R

4.19.1. Introduction

Zone R, occupying approximately 198ha, is land outside the factory fence. It includes agricultural land to the north of the factory, Barochan Moss and Barochan Hill to the west, Gladstone Hill to the east, and the large car park outside the main gate. A nominal site investigation grid spacing of 350 m was assigned. While the majority of this zone falls outside the Core Development Area, a portion is within.

4.19.2. Scope of Investigation

Investigation in Zone R comprised the following:

- 3 No. trial pits
- 24 No. hand augers

The scope of investigation in this zone did not differ significantly from that proposed although it was necessary to replace 20 trial pits with hand-augured samples. The main reason for replacing trial pits with hand augers was to minimise disruption to tenanted farmland. Other locations included the community playing fields where settlement of trial pits may have posed a physical hazard to the users of the playing fields even after reinstatement and therefore a less intrusive method of investigation was adopted. In addition, access to a number of locations was not possible due to dense woodland.

Of the 75 No. soil samples taken, 44 No. were analysed for a range of contaminants. Of these, 8 No. were made ground and 36 No. were natural.

4.19.3. Ground Conditions

Made Ground

Made ground was encountered in 8 No. exploratory points and was restricted to those areas that are or have been close to buildings or roads. In TP1509, TP1515, TP1517, HA1510 and HA1618 made ground was found to depths of 0.9, 0.35, 1.8, and 0.5 m, respectively.

Superficial Geology

Superficial deposits were encountered in all of the exploratory locations. In the south of the zone, particularly in wooded areas, Clippens Peat Fm. was encountered and was generally dark brown-black fibrous peat. In open areas in the south of the zone, soft light brown silts and grey clays of the Linwood/Paisley Fm were encountered.

The Wilderness Till Fm. found on higher ground varied from light to dark brown, sandy, gravelly to very gravelly clay with fine to coarse rounded to sub-rounded gravels of mixed lithologies.

In the north and east of the zone sands (Killearn Fm.) were encountered in HA1507, HA1618 and TP1509. The sands varied from light brown to orange, silty to very silty and were occasionally gravelly.

Bedrock

Bedrock was not encountered.

Groundwater

Groundwater was encountered in 1 No. exploratory hole, TP1517 at 3.5 m depth in Wilderness Till Fm.

Evidence of contamination

A hydrocarbon odour was noted in TP1515 between surface and 0.5 m depth.

4.19.4. Laboratory Analysis

Summary analytical soil and leachability results are given below and complete results are given in Appendix 7 and Appendix 8.

Soil

Determinands	units	No.	Min.	Mean	Max.
2,4-DNT	mg/kg	44	<1	-	<1
2,6-DNT	mg/kg	44	<1	-	<1
EGDN	mg/kg	44	<0.1	-	<0.1
HMX	mg/kg	44	<2	-	<2
HNS	mg/kg	44	<0.5	-	<0.5

Determinands	units	No.	Min.	Mean	Max.
NC	mg/kg	44	<5,000	-	<5,000
NG	mg/kg	44	<0.1	0.3	1
PETN	mg/kg	44	<5	-	<5
Picric acid	mg/kg	44	<0.1	-	<0.1
Picrite	mg/kg	44	<0.25	-	<0.25
RDX	mg/kg	44	<2	-	<2
Tetryl	mg/kg	44	<1	-	<1
TNT	mg/kg	44	<0.5	-	<0.5

Table 71 – Zone R, Explosives

Determinands	units	No.	Min.	Mean	Max.
As	mg/kg	44	1	11	44
Cd	mg/kg	44	<0.3	0.4	1.4
Cr	mg/kg	44	<5	33	73
Pb	mg/kg	44	9	69	327
Hg	mg/kg	44	<0.1	0.2	1.1
Se	mg/kg	44	<0.3	0.7	3.1
Cu	mg/kg	44	4	30	110
Ni	mg/kg	44	<5	27	96
Zn	mg/kg	44	20	111	378
Ba	mg/kg	33	8	365	6,920
Be	mg/kg	33	<0.1	2.4	5.8
Bi	mg/kg	33	<3	4	9
Mg	mg/kg	33	360	5,132	10,700
Mn	mg/kg	33	10	491	1,350
Mo	mg/kg	33	<5	-	<5
P	mg/kg	33	90	885	1,620
Sb	mg/kg	33	<5	5	8
Sn	mg/kg	33	<2	7	15
Sr	mg/kg	33	9	48	290
Ti	mg/kg	33	96	1,712	3,940
V	mg/kg	33	<5	70	150

Table 72 – Zone R, Metals & semi-metals

Determinands	units	No.	Min.	Mean	Max.
pH		43	3.7	5.8	8.4
Sulphate	mg/kg	31	<250	670.6	1730
Sulphur	mg/kg	33	<10	14.0	79
Asbestos	Presence/Absence	44	ND	ND	ND
Asbestos Quantification	%	29	<0.001	-	<0.001
Total PAHs (See Appendix 7 for Individual PAHs)	mg/kg	44	<0.1	10	148
TPH C5-C6	mg/kg	9	<1.5	-	<18
TPH >C6-C8	mg/kg	9	<2	-	<24

Determinands	units	No.	Min.	Mean	Max.
TPH >C8-C10	mg/kg	9	<1	-	<12
TPH >C10-C12	mg/kg	9	<2	-	<24
TPH >C12-C16	mg/kg	11	<20	54	160
TPH >C16-C21	mg/kg	11	<20	88	266
TPH >C21-C40	mg/kg	11	<20	1785	6,900
Dioxins	ng/g	1	-	-	0.0669
Calorific Value	kJ/kg	1	-	-	1,100
Moisture content	%	13	11.9	35.0	87.1
Organic matter	%	4	5.0	16.5	25.0

Table 73 – Zone R, Others

Determinands	units	No.	Min.	Mean	Max.
As	µg/l	12	<1	2	12
B	µg/l	12	<300	-	<300
Be	µg/l	12	<5	-	<5
Cd	µg/l	12	<0.5	0.5	0.5
Cr	µg/l	12	<5	-	<5
Cu	µg/l	12	<5	5	5
Hg	µg/l	12	<0.1	-	<0.1
Mg	mg/l	12	0.1	0.3	0.5
Mn	µg/l	12	<5	6	17
Mo	µg/l	12	<5	-	<5
Ni	µg/l	12	<5	-	<5
Pb	µg/l	12	<5	5.5	11
Sb	µg/l	12	<1	2	7
Se	µg/l	12	<1	2	12
Sn	µg/l	12	<20	-	<20
V	µg/l	12	<5	20	179
Zn	µg/l	12	<5	15	44
pH		12	5.7	6.7	7.7

Table 74 – Zone R, Leachability

NG was found at 0.2 mg/kg (0.1 m) and 0.1 mg/kg (0.4 m) in HA1618 located on the recreation ground. Four hand augers (HA1682 to 85) were subsequently positioned around HA1618 to confirm the initial results. NG was not detected in any of the subsequent hand augers.

It is strongly suspected that the NG initially found in HA1618 was 'carry-over' from the previous hand augers, HA1478 and 1479, located on the burning ground in Zone O, which contained up to 258 mg/kg.

NG was also found in HA1512 on Gladstone Hill at 0.4 mg/kg, although carry-over from previous sampling is considered unlikely in this case because the preceding exploratory points did not contain NG.

Total TPH concentrations of 43mg/kg C12-C16, 86mg/kg C16-C21, 453mg/kg C21-C40 and 26.8mg/kg were identified by laboratory analysis to confirm the HC odour noted in TP1515 in the car park and is therefore a potential source.

The leachable fraction was generally between 0.1 and 1.5 %. Magnesium leachability was particularly low in the order of 1.0E-4 %.

4.20. Beneath Steam Mains

4.20.1. Scope of Works

Sampling beneath steam mains was carried out in two phases:

Firstly, 20 No. 20 m lengths of representative steam main runs were selected, being a variety of heights, diameters, locations and whether the lagging or pipe remained. At each 20 m length a composite of 5 No. shallow soil sub-samples was taken and analysed in the laboratory. The sub-samples were spaced along the length of the pipe at intervals of 2, 6, 10, 14 and 16 m.

The characteristics of each steam main run are given in the table below; locations are shown on Figure 10:

Pipe Run Reference	Factory No.	Height (m)	Diameter (mm)	Comments
AS01	III	1.1	45	lagging removed
AS02	II	1.0	50	lagging removed
AS03	II	~4.0	215	lagging removed
AS04	II	0.5	215	pipe removed
AS05	II	1.5	90	lagging removed
AS06	II	0.5	90	pipe removed
AS07	II	-	-	pipe removed
AS08	II	1.2	90	lagging removed
AS09	II	1.0	65	lagging removed
AS10	II	0.5	140	lagging replaced
AS11	II	0.5	140	lagging replaced
AS12	I	0.3	480	pipe removed
AS13	I	1.0	90	lagging removed
AS14	I	0.5	65	lagging replaced
AS15	I	0.5	100	pipe removed
AS16	I	1.0	100	lagging removed
AS17	I	1.0	140	lagging replaced
AS18	I	1.0	75	lagging removed
AS19	I	1.5	90	lagging replaced
AS20	I	~4.0	90	lagging replaced

Table 75 – Steam Mains Sampled

Secondly, to gain information on the likely vertical and lateral occurrence of asbestos, AS04, 07 and 14 were revisited for intensive sampling. These three locations were chosen to represent a range of pipe construction and condition, and included one length where asbestos had been detected (AS04) in the initial sampling exercise (see Section 4.20.2).

At each of the 3 No. pipe runs, samples were taken directly beneath the steam main and at 1, 3 and 5 m away from the steam main on both sides. At each of the 7 No.

positions, samples were taken at depths of 0.05, 0.15 and 0.3 m. This was repeated at 3 No. cross sections at each pipe run, a total of 189 No. samples.

Figure 11 shows sampling locations and corresponding sample references.

4.20.2. Findings

In the first phase asbestos was found at 2 No. of the 20No, locations, namely AS07 and AS16, both identified as amosite.

In the second phase asbestos was detected in 10 No. out of 189 No. samples as follows:

Ref.	Distance from pipe	Depth	Type	Quantification (%)	Product
AS04	0 m	0.05 m	chrysotile	2.541	insulation
	0 m	0.15 m	chrysotile	0.133	insulation
	1 m	0.05 m	amosite & chrysotile	<0.001	insulation
	3 m	0.05 m	amosite	0.077	insulation
AS07	5 m	0.05 m	chrysotile	0.018	insulation
	5 m	0.30 m	all three types	0.656	insulation
	1 m	0.05 m	amosite & chrysotile	0.002	insulation
	1 m	0.05 m	all three types	1.656	insulation
	3 m	0.05 m	chrysotile	0.048	felt
AS14	0 m	0.05 m	chrysotile	0.012	insulation

Table 76 – Steam Mains Findings

Quantification of asbestos content was undertaken on all 189 No. samples with the results for those detected provided in the table above. All other samples recorded concentrations below the reporting limit of 0.001%.

No visual identification of asbestos was made in the field with one exception at AS14 near surface and was confirmed by laboratory analysis to be chrysotile.

Full analytical results are given in Appendix 7.

4.21. Around Process Buildings

4.21.1. Scope of Works

A total of 84 No. buildings were selected, mostly from NG, NC and propellant production sections but also former tetryl, RDX, picrite, white phosphorus and ammunition breakdown buildings. The buildings selected were considered to be representative of the different building uses as well as representative of building type.

At each building the most likely location for the accumulation of contamination was selected based upon the building layout, access and egress points etc and a soil sample taken at between 0.05 and 0.15 m depth (HS1533 to 1616). Each sample was a composite of 4 samples at the corners of 2.0 by 0.75 m rectangle, comparable to a trial pit. This method of sampling was considered appropriate in view of the objectives of this part of the investigation i.e. to gain information on the presence of explosives in such areas.

The locations of HS1533 to 1616 are shown on Figure 12. Sample descriptions are given in Appendix 5.

Two buildings in Zone G where explosives had been detected (building ref no. 28/112F, a blending house, and building ref no. 28/101C, a paste store) were chosen for more intensive sampling in order to establish the approximate lateral extent of contamination. Twelve soil samples were taken around each of these buildings at the locations shown on Figure 13.

4.21.2. Findings

One or more explosives were detected in 62 No. of the 85 No. initial samples. In almost all cases the particular explosives found were consistent with the former use of the adjacent building.

Buildings in NG Sections

In NG sections NG was found in half the samples, up to 237 mg/kg, and NC was found up to 8,750 mg/kg nearer the base of the NG hills. DNT and carbamite were detected outside a carbamite preparation house and RDX was reported at 20.6 mg/kg next to a paste breaking building. The occurrence of explosives was less frequent in Factory II and III NG sections.

Buildings in NC Sections

NC was detected in a third of samples from buildings in the NC sections. NG was detected in 4 No. samples but at low concentrations when compared to NG and propellant buildings, as expected.

Buildings in Propellant Sections

NG was detected in 83% of samples, averaging 10 mg/kg with a maximum of 136 mg/kg. NC was found in 6 samples up to 6,190 mg/kg. Again, the occurrence of explosives was more frequent in Factories I and II compared to III.

Four samples contained other explosives including RDX, EGDN and DNT.

Buildings in Other Sections

Tetryl and picric acid (a breakdown product of tetryl) were detected next to a building in the former Tetryl A Section, at 289 and 110 mg/kg, respectively. Traces of picric acid were detected in three other samples in this area, but RDX was not reported next to former RDX manufacturing buildings. Picrite was found outside 2 buildings in the Picrite Section, up to 0.89 mg/kg.

Tetryl and picric acid were also detected in Tetryl B at concentrations of up to 0.3 and 1.4 mg/kg, respectively. RDX was also detected in this area (in 3 samples up to 13 mg/kg), but next to ammunition breakdown buildings rather than former RDX manufacturing buildings. TNT up to 12.4 mg/kg was found in two samples that contained RDX.

NG and PETN were found in one sample each.

Two samples from Ammonium Perchlorate Section could not be analysed for perchlorate due to high explosive content.

Laboratory Analysis

Summary analytical results are given below and complete results are given in Appendix 15.

Determinands	units	No.	Min.	Mean	Max.
2,4-DNT	mg/kg	107	<1	1.2	12.5
2,6-DNT	mg/kg	107	<1	1.0	2.4
EGDN	mg/kg	107	<0.1	-	<0.1
HMX	mg/kg	107	<2	-	<2
HNS	mg/kg	107	<0.5	-	<0.5
NC	mg/kg	107	1,000	4,543	10,800
NG	mg/kg	107	<0.1	7.5	237
PETN	mg/kg	107	<5	<5	5
Picric acid	mg/kg	107	<0.1	1.1	110
Picrite	mg/kg	107	<0.25	0.3	0.89
RDX	mg/kg	107	<2	2.4	20.6
Tetryl	mg/kg	107	<1	3.7	289
TNT	mg/kg	107	<0.5	0.6	12.4

Table 77 – Around Process Buildings, Explosives

Determinand	units	No.	Min.	Mean	Max.
TPH C5-C6	mg/kg	5	<1.5	-	<1.5
TPH >C6-C8	mg/kg	5	<2	-	<2
TPH >C8-C10	mg/kg	5	<1	-	<1
TPH >C10-C12	mg/kg	5	<2	-	<2
TPH >C12-C16	mg/kg	5	<20	-	<20
TPH >C16-C21	mg/kg	5	<20	21.6	28
TPH >C21-C40	mg/kg	5	76	328.8	704
MTBE	mg/kg	5	<0.5	-	<0.5
Benzene	mg/kg	5	<0.5	-	<0.5
Toluene	mg/kg	5	<0.5	-	<0.5
Ethyl Benzene	mg/kg	5	<0.5	-	<0.5
m,p-Xylene	mg/kg	5	<0.5	-	<0.5
o-Xylene	mg/kg	5	<0.5	-	<0.5
Carbamite	mg/kg	6	<5	93	491
Cu	mg/kg	1	-	-	65
Dimethylaniline	mg/kg	7	<0.5	-	<0.5
Dipheylamine	mg/kg	7	<0.5	-	<0.5
Hexamine	mg/kg	7	<0.5	-	<0.5
P	mg/kg	2	666	751.5	837
Pb	mg/kg	2	82	87.5	93
Solvents		6	-	-	-
Methanol	mg/kg	1	-	-	14
Ethanol	mg/kg	1	-	-	62
Iso-propanol	mg/kg	1	-	-	21
SVOC's		3			
Phenanthrene	mg/kg	2	<1.0		1.5

Determinand	units	No.	Min.	Mean	Max.
Fluoranthene	mg/kg	2	<1.0		4.0
Pyrene	mg/kg	2	<1.0		3.2
Benzo(a)anthracene	mg/kg	2	<1.0	2.1	2.9
Benzo(b)fluoranthene	mg/kg	2	<1.0	1.9	2.7
Benzo(k)fluoranthene	mg/kg	2	<1.0	2.0	2.8
Benzo(a)pyrene	mg/kg	2	<1.0	2.1	3.0
Indeno(1,2,3-cd)pyrene	mg/kg	2	<2.0	2.9	3.9
Benzo(ghi)perylene	mg/kg	2	<2.0	2.4	2.9
Chrysene	mg/kg	2	<1.0	1.9	2.6
VOC		1	none detected		

Table 78 – Around Process Buildings, Others

Additional Sampling

In the original sample from outside building ref no. 28/122F, located in Zone G, NG was found at 31.3 mg/kg and NC at 1,070 mg/kg. Five out of the 12 No. subsequent samples contained NG, at concentrations between 0.6 and 25.9 mg/kg. Samples of the traverse and those located to the rear of the building did not contain explosives above the reporting limit.

NG and NC were found at comparable concentrations (16.3 & 1,900 mg/kg) in the original sample from building ref no. 28/101C, located in Zone G. Only one of the subsequent 12 No. samples did not contain NG, and 3 No. contained NC. The highest concentrations were detected in HS1673 (57.2 mg/kg NG, 3,510 mg/kg NC) and HS1679 (22.4 & 5,860 mg/kg), both near one of the two entrances to this building.

Complete analytical results are given in Appendix 15 - Hand Samples.

4.22. Around Sub-stations

4.22.1. Scope of Works

Samples were taken outside 13 No. of 28 No. electrical sub-stations located in Factories I, II and III to determine whether oils containing PCBs had caused soil contamination. Each sub-station has usually 2 No. underground oil sumps outside the building; samples were taken on soft ground near to the sump, being considered the most likely place to find contamination.

Hand samples of surface soil were taken outside 10 No. sub-stations. At each location a composite of up to 4 No. sub-samples was taken, the sub-samples being up to a few metres apart depending on the location of the oil sumps relative to un-made ground.

At 3 No. sub-stations hand augers were excavated to obtain deeper samples.

Sample locations are shown in Figure 14, sample descriptions are given in Appendix 5.

4.22.2. Findings

No visual or olfactory evidence of hydrocarbon contamination was observed.

PCBs were found in 4 No. samples, as follows:

Exp. Pt.	Substation	Location	Total PCBs	Comments
HS1630	09/102K (3C)	Factory I NG (Zone A)	330 µg/kg	6 No. congeners at between 10 and 96 µg/kg
HS1631	09/102J (2C)	Factory I Acids (Zone D)	28 µg/kg	PCB138 at 23 µg/kg, PCB180 at 5 µg/kg
HA1642 0.1 m	09/302E (8C)	Factory III Prop (Zone I)	26.7 µg/kg	PCB138 at 3.7 µg/kg, PCB180 at 23 µg/kg
HS1638	09/102J (7A)	Picrite (Zone J)	39.4 µg/kg	PCB138 at 8.4 µg/kg, PCB180 at 31 µg/kg

Table 79 – Occurrence of PCBs

Complete results are given in Appendix 15.

4.23. Narrow gauge railway Track Inspection

4.23.1. Scope of works

A visual inspection of narrow gauge railway tracks was undertaken to record evidence of propellant fragments/paste at the surface. The track was walked slowly by a BAE Systems Environmental Geo-environmental Engineer instructed in the identification of propellant in its various forms, and its precursors in the manufacturing process.

The inspection was carried out along 16 km of the approximate 50 km of track, half of which was within the Core Development Area (8 km) and half outside. The inspected track lengths are shown on Figure 15, along with details of observations, summarised below.

4.23.2. Findings

Narrow gauge railway track conditions were observed to vary in terms of thickness and nature of vegetation cover. Often, much of the track was found to be completely overgrown with moss, long grass and topsoil particularly in Zone J (Factory II picrite magazines) making it difficult to see propellant fragments. Narrow gauge railway tracks in Zone I have been removed and only the concrete bases remain.

Propellant was observed at 33 No. locations ranging from single to numerous grains, commonly of the seven-hole variety (29 grains in gun propellant and 4 in rocket propellant). As expected, the majority of sightings were in the Factory I propellant section, typically at track junctions, bends and close to building entrances.

Results are summarised as follows:

Factory	Length inspected	No. of observations
I	7 km	28
II	13 km	4
III	0.2 km	1

Table 80 – Propellant observations

4.24. Geophysical Survey

4.24.1. Scope of works

Zone K includes the Ammunition Breakdown Section where various types of ordnance were dismantled and the explosive components removed.

An electromagnetic survey (EM61 at 1 m line spacing) was conducted in 9 No. rectangles, each of between 1,000 and 3,000 m^2. Area 5 was used as a control, located in the Factory I propellant section where buried ordnance was not expected to be found. A total of 1.4 ha was surveyed in the Ammunition Breakdown Section shown in Figure 16.

The ratio of primary ('coil 1') and secondary coil measurements was taken (the 'differential' reading) to give an indication of anomaly depth.

Prior to the geophysical survey inert items of ordnance were buried in Area 5, the control area, to aid interpretation of the data obtained from the Ammunition Breakdown Section.

After the survey, 32 No. anomalies in the Ammunition Breakdown Section were excavated to determine their source.

4.24.2. Survey Findings

The results of the geophysical survey are shown in Figure 16.

In the control area the buried 105 mm shell produced a strong signal, and the 30 mm cartridge case and shell nose fuze may have been detected but with weaker signals. The smaller objects such as the corroded smoke grenade and grenade stem assembly were not detected. Unfortunately, the 20 mm projectile was buried near a cable which masked any response.

The geophysical survey of the investigated areas yielded numerous discreet anomalies and larger areas of interference. Those subsequently excavated included man-hole covers, fragments of metal pipe, sheet pile, reinforced concrete and large metal pins.

None of the 32 No. metallic objects were ordnance-related.

4.25. Groundwater and Surface Water Sampling

4.25.1. Introduction

Thirty-seven boreholes were drilled during the Stage I Site Investigation. BH1529 was too shallow for a monitoring installation, and 3 No. boreholes were fitted with dual installations (BH1074, 1194 and 1621) making a total of 39 No. monitoring wells. BH1050 was subsequently found to be dry.

Two rounds of water sampling were carried out; between 10 August and 7 September, and between 19 September and 4 October 2005.

In the first round samples were taken from 38 No. Stage I monitoring wells, 25 No. boreholes from previous investigations (where it was possible to take samples) and 11 No. surface water monitoring points.

In the second round samples were taken from the 38 No. Stage I monitoring wells and 11 No. surface water monitoring points.

In order to compliment the existing data set for surface monitoring, existing monitoring points were chosen as well as additional points in the fire ponds. However, locations SW7, SW8 and SW9 were either dry or inaccessible at the time of sampling.

The samples were analysed for a range of determinands.

4.25.2. Groundwater Levels

Rest groundwater levels varied between 0.26 and 6.82 m.bgl. Table 81 below lists the various groundwater strikes recoded during drilling and average rest water levels measured over the two rounds of monitoring. Levels were on average 0.27 m higher on the first visit.

Borehole	Response Zone Depth Range (mbgl)	Groundwater strike (mbgl)	Average rest Groundwater level (mbgl)	Comment (e.g. strata being encountered)
BH1027	7 – 10	2.80	1.87	Grey/brown mottled green slightly clayey sandy angular to subrounded, fine to coarse GRAVEL (Killearn Fm.)
BH1046	5 – 10	3.00	0.65	Dark grey basalt (Clyde Plateau Volcanic Fm.)
BH1050	1 – 2	-	Dry	Firm red/brown slightly sandy slightly gravelly CLAY. (Wilderness Till Fm.)
BH1074S	3 – 5	4.70 & 7.90	0.83	Soft grey sandy slightly gravelly SILT/CLAY (Linwood/Paisley Fm.)
BH1074D	7 – 12	4.70 & 7.90	0.90	Light grey sandstone and mudstone (Lawmuir Fm.)
BH1089	1 – 6	5.80	2.41	Firm brown slightly sandy CLAY (Linwood/Paisley Fm.)
BH1108	1 – 3.5	4.00	0.72	Firm grey mottled brown slightly sandy slightly gravelly CLAY (Wilderness Till Fm.)
BH1134	2 – 5	-	0.88	Grey sandy silt (Linwood/Paisley Fm.)
BH1167	2 – 5	2.9	1.15	Firm dark grey slightly sandy CLAY (Linwood/Paisley Fm.)
BH1194S	7 – 9	7.80 & 16.00	0.49	Soft brown/reddish brown very sandy CLAY (Wilderness Till Fm.)
BH1194D	13 – 16	7.80 & 16.00	0.83	Stiff brown/reddish brown slightly sandy

Borehole	Response Zone Depth Range (mbgl)	Groundwater strike (mbgl)	Average rest Groundwater level (mbgl)	Comment (e.g. strata being encountered)
				slightly gravelly CLAY (Wilderness Till Fm.)
BH1219	2 – 5	-	1.46	Firm brown sandy slightly gravelly CLAY (Wilderness Till Fm.)
BH1231	8.5 – 10.5	10.00	1.72	Reddish brown very clayey slightly gravelly fine to medium SAND (Wilderness Till Fm.)
BH1242	2 – 5	-	1.04	Firm dark brown slightly gravelly sandy CLAY (Wilderness Till Fm.)
BH1258	3.9 – 6.9	-	0.98	Firm brown mottled orange brown slightly sandy CLAY (Linwood/Paisley Fm.)
BH1271	4.2 – 7.2	-	0.37	Soft grey/brown slightly sandy CLAY (Linwood/Paisley Fm.)
BH1297	2 – 4	2.80	0.86	Soft brown/grey slightly sandy SILT/CLAY (Linwood/Paisley Fm.)
BH1306	2 – 5	-	1.12	Soft grey mottled dark grey slightly sandy SILT/CLAY (Linwood/Paisley Fm.)
BH1349	1.5 – 4.5	4.80	1.0	Stiff brown slightly sandy slightly gravelly CLAY (Wilderness Till Fm.)
BH1366	2 – 5	1.50	1.11	Firm brown slightly sandy gravelly CLAY (Wilderness Till Fm.)
BH1375	7.5 – 9	-	0.51	Grey/brown sandy angular to subrounded fine to coarse GRAVEL of basalt, mudstone and quartz (Wilderness Till Fm.)
BH1412	2 – 5	2.90	1.59	Soft grey/brown slightly sandy CLAY (Linwood/Paisley Fm.)
BH1429	2 – 5	-	1.3	Firm grey slightly sandy SILT with traces of organic material (Linwood/Paisley Fm.)
BH1430	3.4 – 4.5	3.50	0.44	Firm brown slightly gravelly slightly sandy CLAY (Wilderness Till Fm.)
BH1445	2 – 5	4.60	1.71	Firm dark grey slightly sandy slightly gravelly CLAY (Wilderness Till Fm.)
BH1451	5 – 8	2.60 & 9.40	1.36	Soft dark grey slightly sandy SILT/CLAY (Linwood/Paisley Fm.)
BH1455	2 – 5	-	1.16	Soft grey slightly sandy SILT/CLAY (Linwood/Paisley Fm.)
BH1495	2 – 5	-	1.44	Soft to firm brown slightly gravelly slightly sandy CLAY (Wilderness Till Fm.)
BH1504	2 – 5	-	1.57	Grey fine silty SAND.
BH1505	2 – 5	2.50	0.60	Soft grey slightly sandy SILT/CLAY (Linwood/Paisley Fm.)
BH1528	1 – 4	4.70	1.88	Orange brown fine to medium clayey gravelly SAND.
BH1530	7 – 10	-	1.09	Stiff dark brown slightly sandy slightly gravelly CLAY (Wilderness Till Fm.)
BH1531	9 – 15	-	4.31	Firm reddish brown slightly sandy slightly gravelly CLAY (Wilderness Till Fm.)
BH1532	2 – 5	-	0.59	Stiff dark brown slightly sandy slightly gravelly CLAY (Wilderness Till Fm.)
BH1621S	3 – 6	6.10	3.40	Stiff brown sandy slightly gravelly CLAY (Wilderness Till Fm.)
BH1621D	8 – 14	6.10	1.37	Brown/grey sandstone (Lawmuir Fm.)
BH1622	8.5 – 9.5	9.00	0.88	Firm brown CLAY (Wilderness Till Fm.)
BH1623	2 – 5	2.70	0.64	Soft grey slightly sandy SILT/CLAY (Linwood/Paisley Fm.)
BH1624	2 – 5	3.80	1.33	Firm grey/brown mottled orange slightly sandy CLAY (Linwood/Paisley Fm.)

Table 81 : Groundwater strikes and average rest water levels

4.25.3. Groundwater Flow

In order to determine shallow groundwater flow direction, groundwater levels were compared both between boreholes and relative to nearby surface watercourses and drainage channels.

Approximately 30 No. triangulations were made in locations to gain a representative picture of the Site as a whole. For each triangulation, boreholes were chosen that were far enough apart while still being on the same side of the nearest surface watercourse.

These calculations confirm that groundwater flow is predominantly towards the nearest local watercourse and that there is no discernible regional flow pattern across the Site in shallow groundwater, defined as groundwater within superficial deposits or made ground.

Groundwater is shown to be flowing into the Site on the northern, western and north-eastern boundaries. Groundwater flows out of the Site across the southern boundary towards the River Gryfe, and also to some extent across the southern part of the eastern boundary.

The deep groundwater (defined as groundwater within bedrock) regional flow pattern has not been confirmed during this investigation due to the limited information available. Interpretation of information from the 5 no. rotary boreholes drilled into rockhead (3 no. confirmed rockhead), is further complicated by the two igneous intrusions (dykes) running across the site. However, it should be noted that where deep groundwater was encountered, rest water levels were at much shallower depths indicating that the deep groundwater is confined.

4.25.4. Groundwater Quality

Laboratory analytical results are summarised in the following tables and discussed below.

Determinands	Units	No.	Min.	Mean	Max.
Al	mg/l	103	<0.02	58.16	5,960
As	mg/l	103	<0.001	0.005	0.078
B	mg/l	103	<0.3	0.4	2.5
Ba	mg/l	103	<0.005	0.226	1.350
Ca	mg/l	103	<0.1	62.5	307
Cd	mg/l	103	<0.0005	0.0006	0.0025
Cr	mg/l	103	<0.005	0.005	0.026
Cu	mg/l	96	<0.005	0.009	0.121
Hg	mg/l	104	<0.0001	0.0001	0.0008
K	mg/l	103	<0.1	9.6	79.0
Mg	mg/l	103	<0.1	18.9	69.0
Mn	mg/l	103	<0.005	0.797	10.4
Na	mg/l	103	0.5	125.7	1,320
Ni	mg/l	103	<0.005	0.010	0.222
P	mg/l	103	<0.1	0.2	2.3
Pb	mg/l	103	<0.005	0.006	0.063
Sb	mg/l	103	<0.001	0.001	0.002

Determinands	Units	No.	Min.	Mean	Max.
Se	mg/l	103	<0.001	0.064	4.9
Zn	mg/l	103	<0.005	1.492	32

Table 82 - Groundwater, Metals

NB. results are 'in filtrate'

Determinands	Units	No.	Min.	Mean	Max.
Alkalinity	mg/l	101	6.7	314.7	2,390
Ammoniacal N	mg/l	102	<0.3	2.3	18.7
Chloride	mg/l	102	6	202	7,780
COD	mg/l	4	131	7,781	29,600
EC	µS/cm	101	187	949	6,760
Nitrate	mg/l	101	<0.3	0.7	5.7
Nitrate as NO_3	mg/l	16	<2.5	3.2	3
Nitrite	mg/l	101	<0.1	0.1	0.3
pH	-	101	4.7	7.6	9.6
Sulphate	mg/l	104	<5	90	1350
Sulphide	mg/l	104	<0.01	3.25	318
Suspended Solids	mg/l	102	6	6,363	437,000
Total PAH	µg/l	103	<0.01	0.35	20.80
TPH >C6-C8	mg/l	18	<0.01	-	<0.01
TPH >C8-C10	mg/l	18	<0.01	-	<0.01
TPH >C10-C12	mg/l	18	<0.01	-	<0.01
TPH >C12-C16	mg/l	18	<0.01	-	<0.01
TPH >C16-C21	mg/l	18	<0.01	0.02	0.02
TPH >C21-C40	mg/l	18	<0.01	-	<0.01
SVOC		18			
Bis(2-ethylhexyl)phthalate	µg/l		<0.1	112	112
VOC		18			
Ethylbenzene	mg/l		<0.001	-	0.003
m,p-xylene	mg/l		<0.001	-	0.003
o-xylene	mg/l		<0.001	-	0.001

Table 83 - Groundwater, Others

Explosives

Each groundwater sample was analysed for explosives. The only explosive to be detected was picrite from one borehole – ASPA – at a concentration of 6770 µg/l.

Metals

Introduction

Metals in groundwater were analysed 'in filtrate'. Previous comparisons of analytical results between 'in filtrate and 'total' revealed that metal concentrations are strongly influenced by relative turbidity, with concentrations consistently higher and more erratic in samples that were analysed for total metal.

In clays and silts 'in filtrate' concentrations are more representative of mobile potential contaminants in groundwater because the often high solid fraction is not mobile in these strata. Therefore, the monitoring of any potential contamination entering the groundwater from the surface (either directly from spills, or leaching from made ground) is more accurately carried out by analysis of metals in filtrate.

Findings

Detectable concentrations of **aluminum** were found in 23 No. samples. Notable concentrations were found ranging between 0.025 and 5960 mg/l (BH1349, Factory II Acids). Other notable concentrations were found in the sulphur dump (BH1504, 5.66 mg/l) and on the perimeter road (BH1528, 20.6 mg/l). Results from BH1624 next to Netherfield Tip were less than the reporting limit.

Antimony was detected in 4 No. samples at concentrations up to 0.0023 mg/l (BH1167) located next to a solvent drum store. The other detected concentrations were either at the reporting limit or were marginally above it and show no spatial pattern.

The highest detectable concentration of **arsenic** was 0.0557 mg/l (PER02) and the highest levels ranged between 0.0101 and 0.557 mg/l from 10 No. samples. Two were located on the perimeter road (PER02 and GT13) and 2 No. were next to storage areas (BH1430 - scrap dump/general store) and (BH1167 – storage compound). Other detectable concentrations were at trace levels.

Barium concentrations were found in all but one (BH1445) of the samples analysed. The highest levels found were those located next to the Romney huts 0.931 mg/l (GT16), 0.921 mg/l (BH1528) on the perimeter road and 1.35 mg/l in Factory II Rocket Propellant Section, next to a press house. The majority of samples contained levels less than 0.4 mg/l and showed no spatial pattern.

Boron concentrations were found up to 2.49 mg/l (PER02, located on the perimeter road). Concentrations greater than 1.0 mg/l were also found in the ash dump PER04 (2.03 mg/l), next to the picrite lagoons ASPC (1.43 mg/l) and at the Romney huts GT16 (1.29 mg/l).

Cadmium was found in 22 No. samples with notable concentrations 0.001 and 0.002 mg/l located next to solvent drum stores BH1167 and BH1219, respectively. A concentration of 0.0025 mg/l was found in a sample from the sulphur dump (BH1504). Other detectable concentrations were only marginally above the reporting limit and show no spatial pattern.

Detectable **copper** concentrations were found in 21 No. samples up 0.121 mg/l (BH1504) in the sulphur dump. Other concentrations were either at the reporting limit or marginally above the reporting limit and show no spatial pattern.

Lead concentrations were detected in 4 No. samples at between 0.006 and 0.063 mg/l. The three highest levels, 0.015, 0.053 and 0.063 mg/l, were found next to an UST fuel tank (BH1451), on the perimeter road (BH1528) and in Factory II Acids Section next to an AST acid tank.

Manganese was detected in all but 2 No. of the samples analysed with notable concentrations ranging between 1.0 and 10.4 mg/l. Samples taken from the sulphur dump contained the highest levels up to 10.4 mg/l and other notable concentrations were found in the Netherfield tips, Romney huts, perimeter road, coal store/lead

compound, Factory II Acids Section, solvent drum stores, ammonium perchlorate section and next to lead salts building in Factory I.

Mercury was detected in 17 No. boreholes up to 0.0008 mg/l (GT16) next to a Romney building in Georgetown. Seven of these samples were at reporting limit. Mercury concentrations show little spatial variation or pattern across the Site.

Nickel was detected in 12 No. samples. The highest concentrations ranged from 0.032 to 0.222 mg/l, the highest being found in BH1504 in the sulphur dump. All other samples were less than the reporting limit.

Detectable concentrations of **phosphorus** were found in 12 No. samples. The highest concentrations were found associated with samples from the perimeter road/ash PER02 (2.348 mg/l), PER04 (0.935 mg/l), BH1528 (0.97 mg/l) and in Factory II Acids Section in BH1349 (1.448 mg/l). Other detectable concentrations show little spatial pattern.

Selenium was detected in 24 No. samples of which 16 No. samples were either found at reporting limit or marginally above. The 2 No. highest concentrations were in samples GT13 (1.6 mg/l) and GT16 (4.9 mg/l) from Georgetown, and the positive results show no spatial distribution trend.

Notable **zinc** concentrations ranged between 0.051 and 32.0 mg/l. The highest level was found next to a scrap compound (BH1623, 32 mg/l). Zinc was also found next to solvent stores at concentrations of 25, 17, 15 and 13 mg/l (BH1194, BH1532, BH1306 and BH1219), workshop store 12 mg/l (BH1242) and at lower levels in the sulphur dump 0.924 mg/l (BH1504).

In summary, areas where trace metals are higher than average are listed as the perimeter road, solvent storage areas, ASTs and USTs, acids sections in Factory 1 and 2, Romney huts, scrap compounds, sulphur dump and Nether field Tips.

pH and Major Ions

Each sample was analysed for the major ions calcium, magnesium, potassium, sulphate, chloride, sodium and bicarbonate alkalinity.

The results show that major ion groundwater chemistry is markedly variable between boreholes and the majority are calcium/sodium and bicarbonate rich.

pH ranges from 4.7 to 9.6 with the majority of the readings between 7.0 and 8.2.

Ammoniacal Nitrogen and Nitrate

Notable concentrations of ammoniacal nitrogen ranged from 0.6 to 23.5 mg/l. The highest levels found were in perimeter boreholes ASPA, ESGC and PER04 (23.5, 9.6 and 18.4 mg/l) where ASPA has previously confirmed the highest levels. Generally higher than average concentrations were found in Georgetown, around the picrite lagoons and south/south-east of the main burning ground (BH1430, 18.7mg/l and BH1429, 11.5 mg/l) while samples within the development area were less than the reporting limit.

Nitrate concentrations follow a similar pattern to that of ammoniacal nitrogen albeit less pronounced, with levels marginally above the reporting limit.

Sulphate and Sulphide

The highest sulphate concentrations were found associated with the sulphur dump, up to 927 mg/l (BH1504), the ash dump 652 mg/l (PER04) and in Factory III NC Section (Lance), 1,350 mg/l (PER22). Other notable concentrations were found around the picrite lagoons. The majority of concentrations from other samples were below 150 mg/l.

Sulphide concentrations follow a similar pattern to that of sulphate albeit less pronounced with levels marginally above the reporting limit.

Organics

All TPH fractions analysed for were found to be less than the reporting limit with the exception of one sample out of 18 where the fraction C16-C21 was detected up to 0.02 mg/l. This sample was recorded from BH1621D located next to an underground fuel tank.

Bis(2-ethylhexyl)phthalate was detected up to 112 µg/l in BH1089 with no obvious point source. All other SVOCs analysed were found less than the reporting limit.

VOCs were detected in one sample (BH1167) including ethylbenzene, m,p-xylene and o-xylene up to 0.003, 0.003 and 0.001 mg/l, respectively. This borehole is located through a former solvent drum storage area. All other VOC analysis were less than the reporting limit.

PAHs

Total PAHs were detected in 25 No. samples. Where detected, notable concentrations in 8 No. samples ranged between 0.14 and 20.8 mg/l. The highest concentrations were found in perimeter borehole PER22 (20.8mg/l) and from around the picrite lagoons ESGC (6.68 mg/l). PAHs were also identified in boreholes near potential contamination sources such as: BH1445 (0.24 mg/l) next to hydraulic oil ASTs; BH1455 (3.43 mg/l), near the former petrol underground tank; and, BH1366 (2.34 mg/l) next to a fuel AST.

A concentration of 0.63 mg/l was found in BH1089 located approximately 170 m south-east of a drum store and fuel oil AST. No evidence of any hydrocarbon contamination in soils was found after intensive window sampling around the AST.

Levels were less than the reporting limit from samples taken next to other fuel USTs (BH1451 and BH1495) although a concentration marginally above the reporting limit was found next to an underground diesel tank (BH1621, 0.04 mg/l).

The elevated levels of COD and suspended solids recorded in the groundwater samples Table 83) are attributed to boreholes P04 and P22 both of which have comments of “V.silty” associated with them from the monitoring records (Appendix 10) which could explain the results.

4.25.5. Surface Water Quality

Laboratory analytical results are summarised in the following tables and discussed below.

Determinand	Units	No.	Min.	Mean	Max.
Al (total)	mg/l	22	0.04	0.17	1.68
As (total)	mg/l	22	<0.001	0.002	0.006
B (total)	mg/l	22	<0.3	0.2	0.6
Ba (total)	mg/l	22	0.028	0.093	0.630
Ca (total)	mg/l	22	<0.1	25.4	126.0
Cd (total)	mg/l	22	<0.0005	0.0006	0.0011
Cr (total)	mg/l	22	<0.005	0.005	0.012
Cu (total)	mg/l	22	<0.005	0.006	0.024
Hg (total)	mg/l	22	<0.0001	0.0001	0.0009
K (total)	mg/l	22	1.1	2.9	12.0
Mg (as Mg)	mg/l	22	4.8	8.3	28
Mn (total)	mg/l	22	0.007	0.105	1.370
Na (total)	mg/l	22	9.2	24.4	118.0
Ni (total)	mg/l	22	<0.005	0.005	0.008
P (total)	mg/l	22	<0.1	0.2	1.1
Pb (total)	mg/l	22	<0.005	0.008	0.052
Sb (total)	mg/l	22	<0.001	-	<0.001
Se (total)	mg/l	22	<0.001	0.001	0.002
Zn (total)	mg/l	22	0.009	0.041	0.200

Table 84 - Surface Water, Metals

Determinand	Units	No.	Min.	Mean	Max.
Alkalinity	mg/l	21	51.4	86.9	221
Ammoniacal N	mg/l	22	<0.3	0.4	0.8
BOD	mg/l	22	<1	1	3
Chloride	mg/l	22	12	38	211
COD	mg/l	21	<20	44	341
EC	µS/cm	21	166	321	1450
Nitrate as N	mg/l	22	<0.3	1.7	4.5
Nitrite as N	mg/l	22	<0.1	0.1	0.4
pH	-	21	6.5	7.8	8.5
Sulphate	mg/l	22	<5	34	276
Sulphide	mg/l	22	<0.01	0.04	0.37
Suspended Solids	mg/l	22	<2	18	232
Total PAH	µg/l	22	<0.01	0.04	0.41
Total Hardness as $CaCO_3$	mg/l	22	70	141	582

Table 85 - Surface Water, Others

The water entering the Site in the Dargaval Burn (represented by SW01) shows little evidence of significant upstream sources with detectable levels of aluminium, lead, zinc, copper and iron being the only noteworthy contaminants. The water entering the site in the Craigton Burn (represented by SW12) shows little evidence of significant upstream sources with detectable levels of Ammoniacal Nitrogen and total PAH being the only noteworthy items.

Aluminium, zinc, copper, iron, arsenic and ammoniacal nitrogen were found at slightly higher concentrations in the Dargavel Burn downstream of the Site (represented by SW02).

Each surface water sample was analysed for explosives. No explosives were detected in any of the surface water samples.

4.26. Gas Monitoring

Each borehole was monitored for gas flow, pressure, atmospheric pressure and the concentrations of methane, carbon dioxide, carbon monoxide, hydrogen sulphide and oxygen. Results are given in the following table:

Parameter	Units	No.	Min.	Mean	Max.
CH_4 peak	% v/v	101	0.0	0.2	6.4
CH_4 steady	% v/v	101	0.0	0.2	6.4
CO_2	% v/v	101	0.0	0.7	10.2
O_2	% v/v	101	1.8	20.5	19.4
CO peak	ppm	101	0.0	0.2	13.0
CO steady	ppm	101	0.0	0.0	1.0
H_2S peak	ppm	100	0.0	0.0	1.0
H_2S steady	ppm	100	0.0	0.0	0.0
BH pressure	mbar	101	-0.9	1.0	29.8
peak BH flow	l/hr	101	-1.8	0.3	5.3
steady BH flow	l/hr	101	-1.0	0.0	1.3

Table 86 – Gas monitoring results

5. REFINED CONCEPTUAL SITE MODEL

The following section outlines the key changes or confirmation of the Initial Conceptual Site Model as detailed in the Preliminary Risk Assessment for Land Contamination (BAE Systems Environmental, 2005)

The sources identified in the preliminary risk assessment for land contamination (A138-00-R1-1) have been confirmed as existing with the exception of pesticides, which were thought to have been used for weed control within the factory's grounds. Contaminants found are consistent with those expected in view of the historical uses of the Site.

Other sources of contamination have been identified although mainly in relation to disposal of demolition materials.

The ground conditions encountered were as anticipated and generally are consistent with published geology, although geological boundaries have been refined as indicated in Figure 3.

The shallow groundwater regime has been more fully characterised both in terms of quality and flow with predominant shallow flow towards surface watercourses.

Deep groundwater is indicated to be confined.

Further information has also been gained in relation to surface water quality, which is generally fair to good.

The revised Conceptual Site Model is given in the Generic Quantitative Risk Assessment report (BAE Systems Environmental, 2006).