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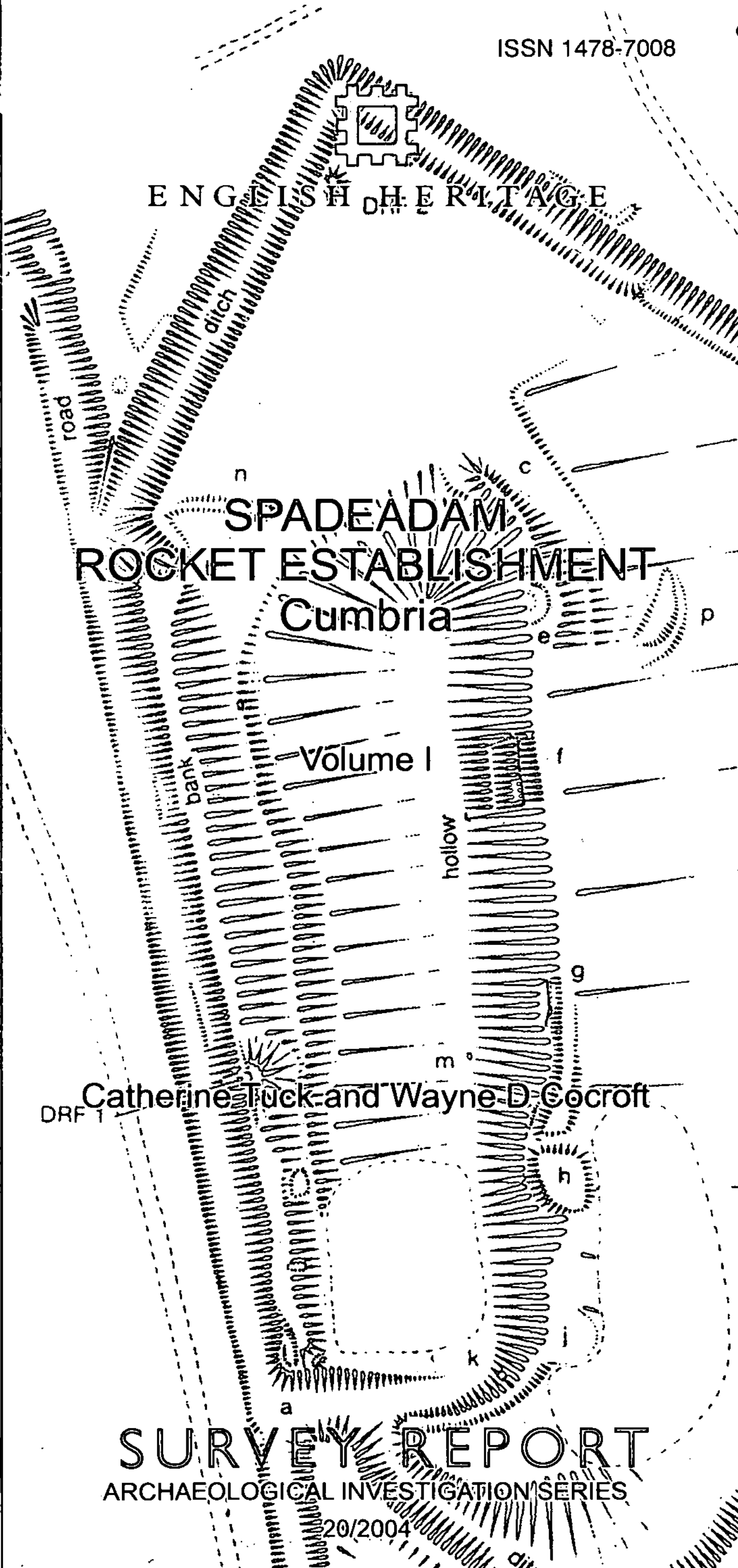

SPADEADAM ROCKET ESTABLISHMENT
Cumbria

Volume I

Catherine Tuck and Wayne D Cocroft

SURVEY REPORT

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SPADEADAM

ROCKET ESTABLISHMENT, CUMBRIA

Volume I

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Europa I launch at Woomera, Australia

There will be something of almost Greek irony in the situation, if this latest refinement in civilised mass-destruction emerges upon the world from roots so fundamental and primordial as a combination of Spade and Adam.
I hope that Blue Streak will be rechristened Eve; the effect of the latter day Eve upon mankind may well be hardly less drastic than that of the first Eve.

R T Armstrong, Treasury Official in correspondence to the Ministry of Supply, 22 December 1955 (TNA: PRO T225/1339)

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Volume I

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Introduction

Between February 2003 and February 2004 English Heritage carried out a field survey and investigation of the former Rocket Establishment at RAF Spadeadam, Cumbria. The area of the former test facility correlates closely with that of the modern RAF Spadeadam range and the survey was undertaken at the request of Defence Estates who, in partnership with RAF Spadeadam, are developing an Integrated Management Plan for the range. The remains of the Blue Streak test facilities had also been identified by the English Heritage thematic study of Cold War monuments, *Cold War Monuments: an assessment by the Monuments Protection Programme* (Cocroft 2001), as being of national importance. The Monuments Protection Programme (MPP) report recommended that the test facilities should be protected as Scheduled Monuments. In parallel to this English Heritage's Research and Standards Department submitted a project proposal entitled *Cold War, People and Place* to record four Cold War Research and Development sites (English Heritage 2002). This project was designed to be exemplary in nature and to establish a recording methodology for others to follow. Sites were selected for multiple reasons including the needs of the Monuments Protection Programme for better documentation to inform their designation procedures.

Access to Spadeadam has been restricted for the past fifty years so previous archaeological investigation within the area has been limited. This report provides a record and interpretation of the visible archaeological features, both earthwork and architectural, of the former test facilities and later military features. Documentary material, some of which has, until very recently, remained classified, was also examined as part of the project.

The report comprises two volumes, the first constituting the main report and Volume II professional papers. Volume I contains historical background which sets out a brief history of the Blue Streak project and the subsequent use of the Spadeadam range based on available secondary sources and selected records deposited with the National Archives, Kew. It aims to provide a concise historical context for the archaeological remains of rocket testing and later activities at Spadeadam. It is, however, not the appropriate place for a wider analysis of British nuclear deterrent strategy (see Wynn 1994; Norris *et al* 1994, 82-179) nor for detailed discussions of the engineering of the rocket and its warhead (see Hancock 1997, 5-14; Martin 2004; Technical Editor 1961, 221-6) beyond what is needed to understand the functioning of the facilities at Spadeadam. It is also premature to attempt to construct a history of the Blue Streak project as it is the subject of active historical research by many investigators who are analysing the official records that have been opened to the public during the last decade, while others still remain closed. Recent published summaries of Blue Streak and its test facilities include Hancock 1997; Cocroft 2000, 255-59; Hill 2001; and Cocroft and Thomas 2003, 255-59. The principal forum for the discussion of research into the Blue Streak project is the British Rocketry Oral History Project and their newly established journal *Prospero*, which brings together researchers with the scientists and engineers who worked on Britain's pioneering rocket projects. An important source on the social history of the rocket and Spadeadam is the archive of the oral history project run by the Tullie House Museum, Carlisle, which recorded the experiences of many of the people who worked on and around the range. Photographs included in this report that are not held in the National Monuments Record Centre, Swindon are available for consultation at the Tullie House Museum, Carlisle. The historical background is followed by a description of the visible remains, a conclusion and back matter (including a bibliography and sources section). As part of the current survey, architectural plans were produced of a sample of four major structures on site: at the Component Test Area, the Control Room B1; at Priorlancy Rigg, the Control Centre A11 and Engine Test Stand A2; and at Greymare Hill, the Missile Test Stand C2. These are included at the end of the report as Appendix 1. Appendix 2 provides an outline chronology for the Blue Streak project and RAF Spadeadam. Appendices 3 and 4 comprise brief inventories of range features dating from 1960-62 and from 1974 respectively.

Volume II contains a detailed Component Sheet for every numbered building or significant feature on site. Original Rocket Establishment numbers have been used but where these are not available features have been given the prefix EH and a unique identifying number for the purposes of this survey.

Measurements recorded during the current survey are given as metric values; measurements from contemporary documentary sources are quoted in their original imperial form but have also been translated into metric and these values are given in parentheses after the imperial figure.

Location and Topography

RAF Spadeadam occupies an expanse of moorland in the north-east of Cumbria between Hadrian's Wall and the Scottish border. The area lies some 26km north-east of Carlisle and falls within the district of Carlisle. It is the largest RAF Station in the United Kingdom stretching 9km from east to west and 6km north to south and covering some 3,642 hectares. The range extends to the north of the modern A69 Carlisle to Newcastle upon Tyne road and is approached from the village of Gilsland, 5km to the south (Fig 1).

Figure 1
Location of RAF Spadeadam, Cumbria

The remains of the Rocket Establishment occupy an area of moorland that rises gently from an elevation of 190m above Ordnance Datum in the south to 331m above Ordnance Datum at Greymare Hill to the north. The local geology comprises sandy glacial till deposits over Carboniferous limestone, which produces a gently undulating landscape with occasional ridges or crests. This is dissected by numerous small streams principally draining southwards to the River Irthing which flows in a south-westerly direction. Prior to the planting of coniferous plantations by the Forestry Commission since the early 1950s, most of the area was rough grazing land without any natural afforestation and with localised pockets of peat up to 1m in depth. Most of the land on the range is sub-let to the Forestry Commission, Advantica, and three tenant farmers, the remaining areas being under direct RAF control.

Summary

The place name *Spathe Adam* was first recorded in the late 13th century (Armstrong *et al* 1950, 96-7). The medieval and post-medieval settlement pattern of the area was one of isolated smallholdings and seasonal shielings, occupied by shepherds, this picture remained until 1955 when its remoteness and sparse population met the requirements for testing Britain's intermediate range missile, Blue Streak. The main functions of the new establishment were to be two-fold. Firstly, it was required for the development and thorough testing of the missile's engines, internal systems and its associated ground control equipment. After the development phase the range would be required for the systematic testing of each missile before they entered service. The project required close collaboration between many government departments although most of the work on the design of the missile and its engines was carried out by two private sector companies – the de Havilland Propellor Company and Rolls-Royce Inc.

The Spadeadam Rocket Establishment was of international importance and during the late 1950s was the most advanced in Europe, reflecting Britain's aspirations to superpower status. Features in their design reflect the close collaboration with the United States in the development of large launch vehicles and propulsion systems, and display many similarities with Rocketdyne's facilities in America. Spadeadam is also important in international space history for non-military reasons. After the cancellation of the Intermediate Range Ballistic Missile (IRBM) project in 1960, *Blue Streak* was used as the first stage of the European Launcher Development Organisation (ELDO) rocket *Europa 1* and the facilities continued in use as part of this project until 1971. The test facilities at Spadeadam consisted of areas for the testing of components, engines and assembled missiles as well as a production area for the manufacturing of cryogenics. The site was administered from a central area and supported by an infrastructure for the supply of essential resources, such as fuel and water, and for the removal and treatment of waste products.

As the result of the restricted nature of the Spadeadam range, this report represents the first full investigation of one of the most important sites in Britain's space history.

Previous Research

Archaeological research within the area covered by RAF Spadeadam has, due to the nature of the site, been constrained for almost fifty years. Access was originally restricted as a result of secret rocket testing and latterly by the use of the area for electronic warfare training. A programme of low-level flying undertaken by the RAF as part of this training has inhibited aerial archaeological reconnaissance.

During the 1950s large tracts of Cumbria and Northumberland were acquired for forestry plantation which was recognised as a potential threat to the archaeological remains of the area. In addition, a threat was posed by the siting of rocket testing beds in the Spadeadam area (Ramm *et al* 1970, xii) prompting the Royal Commission on Historical Monuments of England (RCHME) to record some of the most distinctive settlement evidence of the area, namely its sheilings and bastles (Ramm *et al* 1970). Further work by the RCHME in the late 1980s identified a Roman signal station at NY 5959 7516 just to the north-west of the range boundary (Topping 1987, 298-300).

Recent archaeological interest in the remains of the Blue Streak project began in the early 1990s during research into the history of the explosives industry, and subsequently during the study of the built legacy of the Cold War (Cocroft 2000; Cocroft and Thomas 2003). For the purposes of these projects investigation work at Spadeadam was limited to ground photography, the bulk of which was completed in April 1994. Some published accounts of the research work at Spadeadam were consulted and a short report was written for the National Monuments Record (NMR number NY 67 SW 9). At this time some of the archive sources used in this report remained closed under the thirty-year rule at the National Archives, formerly the Public Records Office, in Kew. In 2001 English Heritage published an assessment of the most significant Cold War sites in England (Cocroft 2001). This report recognised the national importance of the Blue Streak related remains at Spadeadam and recommended that they should be designated as Scheduled Monuments.

Historical Background

Introduction

The place name *Spathe Adam* was first recorded in the late 13th century. It is suggested that Spadeadam is derived from *ysbyddaden*, the Welsh for hawthorn although its current form did not occur until the late 16th century. Christopher Saxton's first survey sheets of England and Wales were engraved and printed in 1574-79 and the Westmorland and Cumberland sheets show a large, roughly circular area some 32km north-east of Carlisle marked *Spadeadam*. Its long standing reputation as an inhospitable landscape is confirmed by an 18th century copy of a cartulary from Lanercost priory which refers to the area '*ye Waste*' and a number of variations in spelling were recorded into the 18th century (Armstrong *et al* 1950, 96-7).

It was widespread practice during the Middle Ages in northern England for cottages, or shielings, to be temporarily inhabited during the seasonal migration of pastoral people with their herds from winter settlement to summer pasture (Fig 2). This practice continued in a few areas as late as the 16th and 17th centuries.

Figure 2
Hut with turf roof at Tinkler Crags © Crown copyright NMR; Ramm et al 1970

Several groups of shielings that survive as rectangular building footings are recorded in the eastern part of RAF Spadeadam. These occur in sheltered positions close to water supplies at Rowantree Crag, Crying Crag, Tinkler Crags and at Butter Burn. At Rowantree Crag a pair of shielings lies on the valley floor within a meander of the steep-sided King Water burn. The first shieling (RCHME Gazetteer No.17; SM25140) stands at NY 6280 7065 and the second (RCHME Gazetteer No.16; SM25139) immediately to its north-east at NY 6285 7066. At the foot of Crying Crag, 1km to the north-east, are the poorly preserved remains of a further pair of shielings. These stand, end to end, 3m apart near the edge of the King Water burn at NY 6388 7105 (RCHME Gazetteer Nos.14 and 15; SM25141) and parallel to the river. Some 45m north-west of these at NY 6348 7123 are the remains of a shieling (SM28570). Situated just above the King Water burn, the shieling is attached to a 19th century stone sheep fold and until relatively recently retained a roof of wood and turves.

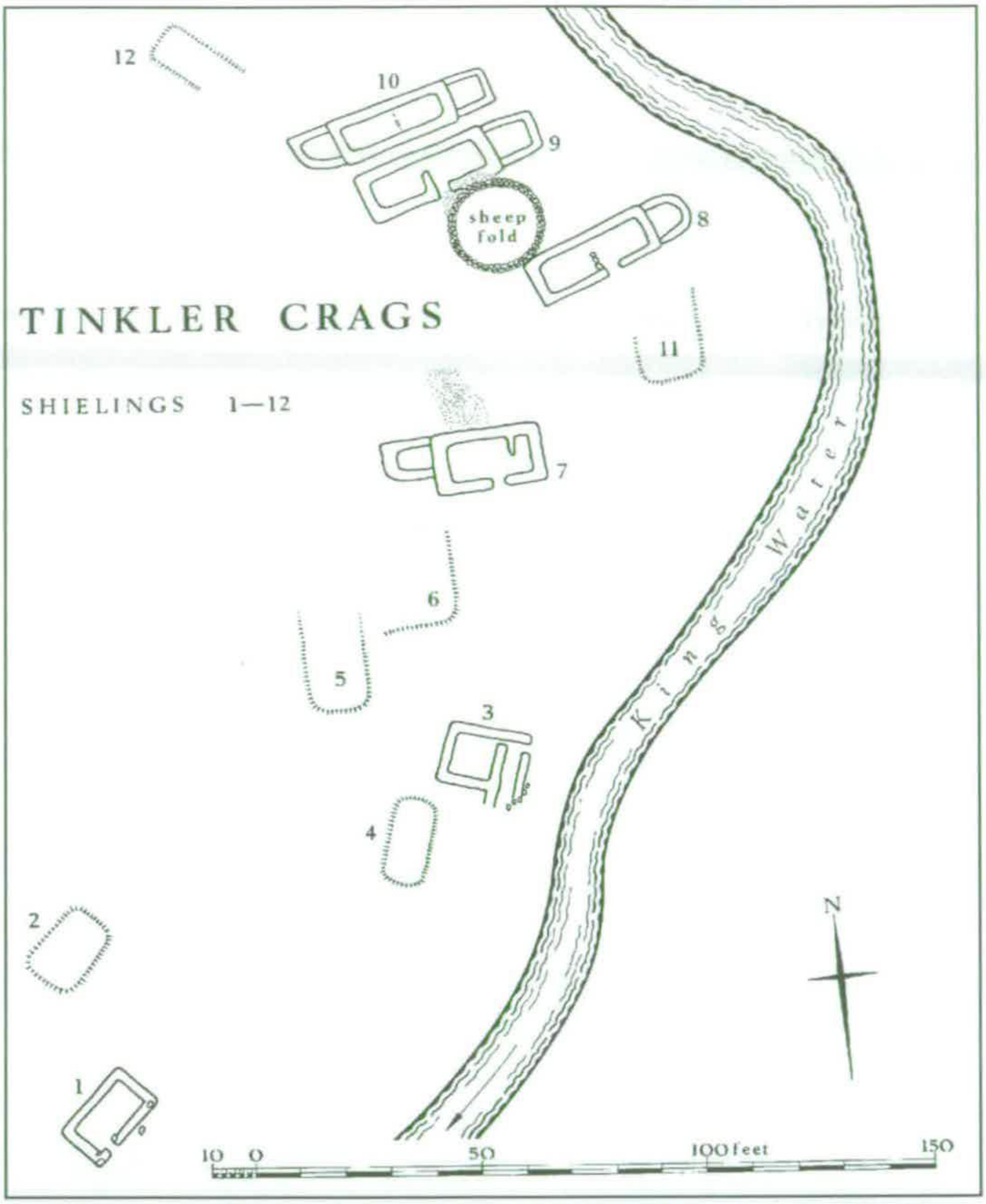

Figure 3
Plan of shielings 1-12 at Tinkler Crags © Crown copyright NMR; Ramm et al 1970

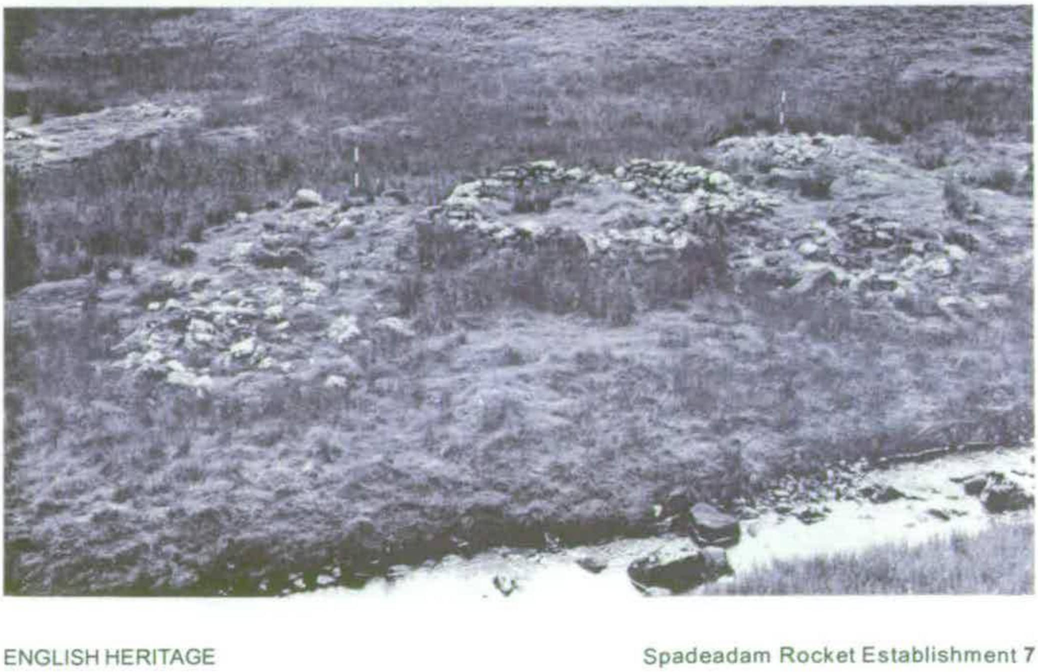

Figure 4
Remains of sheepfold flanked by huts 8 and 9 at Tinkler Crags © Crown copyright NMR; Ramm et al 1970

There is an entrance in the south wall above which is a small opening interpreted as a smoke vent (RCHME 1970, 10). On flat ground within a meander of the King Water at Tinkler Crags are the remains of at least twelve shielings (RCHME Gazetteer Nos.1-12; SM28571) centred at NY 6345 7170 (Fig 3). Half survive as earthworks but the others are derelict rectangular stone structures (Fig 4). The name Tinkler (or gypsy) may reflect the use of the site for temporary accommodation. To the north-west at NY 6330 7163 is a single shieling (RCHME Gazetteer No.13; SM25142). This is divided internally into two rooms and an entrance to one of these is marked by the survival of an upright stone door jam. On the Butter Burn some 1.6km to the north, a pair of shielings (RCHME Gazetteer Nos.18 and 19; SM25143) lies close to the stream at NY 6332 7330. They stand immediately south of an area where the name Green Hill indicates the former existence of good pasture (RCHME 1970, 14).

Further ruined structures were noted during the survey close to the water courses of Whipperslack Sike (at NY 6355 7392 and NY 6356 7400) and by Blackshaws Sike (at NY 6370 7445). In the 19th century a farmstead was established part way up the southern slope of Little Blackshaws Hill at NY 6403 7468; the house lying within an enclosure defined by a ditch and a stone-revetted bank. Historically, the estate now occupied by RAF Spadeadam was owned by Lord Carlisle and was known as Spadeadam Waste. By the late 1930s there were four farms, or small-holdings, within the estate at Dumblar Rigg, Wylie Sike, Blackshaws and Spadeadam, however, reports produced by the Ministry of Agriculture and Fisheries noted that the landowner had not carried out improvements to the farms for many years. The wider area of Spadeadam remained remote and sparsely populated until 1955 when these qualities met the requirements of testing Britain's intermediate range missile Blue Streak.

Government acquisition of Spadeadam Waste

Negotiations began in 1936 regarding the acquisition of the estate by the Ministry, but these were soon terminated and were not revived until after the war. Subsequent to further discussions the Minister acquired the estate in May 1950 on a 999 year lease from Lord Carlisle, the land being managed by the Agricultural Land Commission. The intention was that about two-thirds of the estate would be transferred to the Forestry Commission for afforestation while the remainder would be devoted to rough hill grazing. It was also planned that the small-holding at Blackshaws would be demolished. In 1958 the lease on the estate was assigned to the Ministry of Supply and subsequently to the Ministry of Aviation, later to become part of the Ministry of Technology (TNA:PRO MAF 107/97 and CM6/290).

The Blue Streak Project

The idea for a long range bombardment missile was proposed by the Air Staff in 1953 and subsequent to a feasibility study, the Blue Streak project was formally initiated by Operational Requirement 1139 (TNA:PRO AIR2/14805). In this document, issued by the Air Ministry on 8 August 1955, the specification was laid out for a Medium Range Ballistic Missile, and for it to be fitted with a megaton warhead through Operational Requirement 1142 (Wynn 1994, 373-4). The original specification was for a missile with a range of 2,000 nautical miles

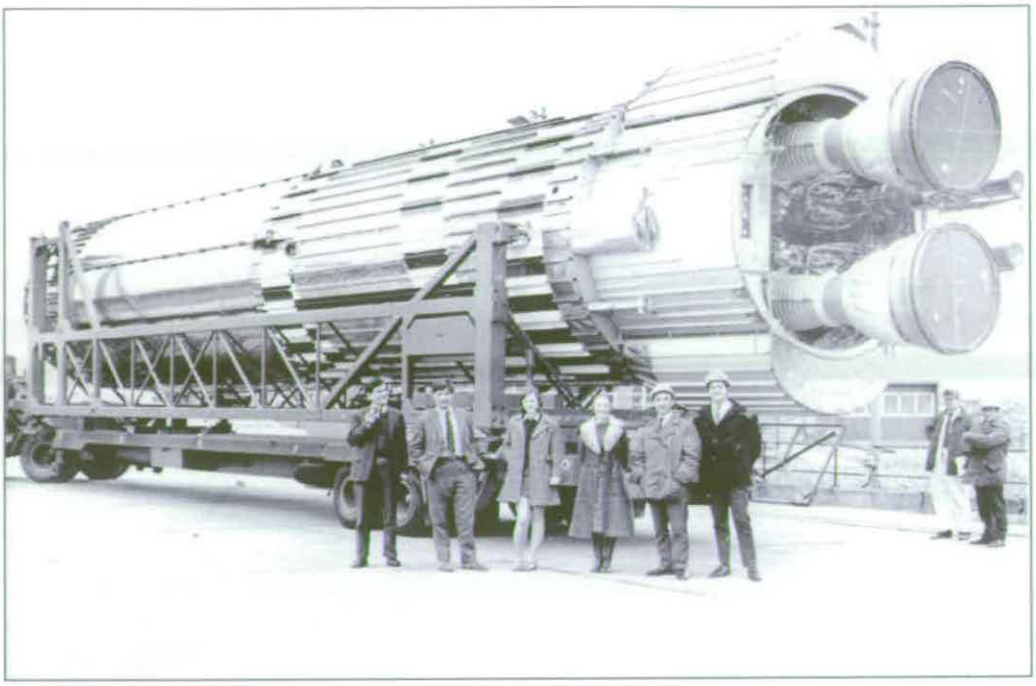

Figure 5
A Blue Streak missile in its transport and handling frame at Greymare Hill, Spadeadam
© Rolls-Royce plc

(3,218 km), with a 50% probability that it would strike within 8,000ft (2,438m) of the aiming point. This was further refined by calculations within the Air Ministry which showed that 57% of the Russian urban population lay less than 1,500 nautical miles (2,413km) from the United Kingdom with Moscow lying 1,350 nautical miles (2,172km) away. These studies considered that by raising the range to 2,000 nautical miles (3,218km) a far greater percentage of the Russian people would be within range but this needed to be weighed against increased technical difficulties which would delay the missile's entry into service (TNA: PRO AIR2/ 14805). By bringing the operational range down to 1,500 nautical miles (2,413km) the technical difficulties would be significantly reduced whilst enough of the Russian population could still be threatened for the missile to act as a credible deterrent (Fig 5).

One of the most important factors in designing the missile was the size of the warhead it was to carry, in terms of both dimensions and weight. However, in the 1950s nuclear weapons technology was rapidly advancing and it was not known what size or power of warhead would be available when the missile entered service. After the specification for the missile had been issued it was clear that a large area would be required for engine and missile testing. Another of the requirements was remoteness due to the amount of noise that would be generated and the need for explosive safety distances. Natural factors were also important; a location was needed that was out of sight and where hills might offer some natural protection against accidental explosions and which might be supplemented by local tree cover. A good supply of water was also required for cooling the test stands during firings, and suitable local geology for construction purposes and for ensuring good drainage. But these needs also had to be balanced against adequate access for moving the missiles, proximity to the national electricity grid, and accommodation for the workforce. Discussions began in earnest in January 1955 to find the most suitable location for a test site. Places considered included 30 disused airfields and 28 other areas including artillery and proof ranges (TNA: PRO AVIA 54/2137; AVIA 65/1906). After a number of sites were rejected the search began to focus on the north of England. Spadeadam Waste fulfilled many of the selection criteria; also it was under Forestry Commission control which would both reduce the cost and speed up negotiations about the acquisition of the land (TNA: PRO AIR2/ 14805).

The main functions of the new establishment were to be two-fold. Firstly, it was required for the development and thorough testing of the missile's engines, internal systems and its associated ground control equipment. After the development phase the range would be required for the systematic testing of each missile before they entered service. In the final scheme it was envisaged that around sixty missiles would be deployed.

To bring the project to fruition would require close collaboration between many government departments although most of the work on the design of the missile and its engines was carried out by private sector companies. The staff of the Royal Aircraft Establishment, Farnborough, Hampshire, was responsible for producing the initial technical requirements for the booster and throughout 1954 papers were written discussing various design issues (Dommett 2003). Advice on the design of rocket engines and engine test facilities was provided by the Rocket Propulsion Establishment, Westcott, Buckinghamshire. The lead contractor for the project was the de Havilland Propeller Company which was responsible for the co-ordination and design of the whole system, while its sister firm the de Havilland Aircraft Company was in charge of designing and manufacturing the missile's body or airframe. Rolls-Royce was tasked with building its engines (Fig 6) and the Sperry Gyroscope Company was given charge of developing its inertial guidance system. The design of the warhead was the responsibility of the Atomic Weapons Research Establishment, Aldermaston, Berkshire, but as far as is known they were not directly involved in any research activities at Spadeadam.

Figure 6
Rolls-Royce RZ-2 rocket engine
© Rolls-Royce plc

Another vital element in the project was the development of the re-entry head in which the warhead would be encased (Dommett 2003). Trials were, for example, required to test resistance of its materials to heat, its optimal shape and to determine how visible it might be to detection systems such as radar. To carry out these experiments a smaller test rocket called Black Knight was designed by Saunders Roe. For this work a small test bed was erected on the Isle of Wight at The Needles (Fig 7). No facilities in the United Kingdom provided either the range or safety margins required for test launches and these were to be carried out in the Australian desert at the Weapons Research Establishment, Woomera (Hume 1964b; Williams and Hume 1964) (Fig 8). The original intention was that after proof

Figure 7
High Down rocket test site at the Needles, Isle of Wight © Crown copyright NMR (BB94/16348)

Figure 8
The impact zone for the Weapons Research Establishment at Woomera was 2040km into the Great Sandy Desert © M Short

firing at Spadeadam, the missiles would be flown by Lockeed Hercules aircraft to Woomera, however, when Blue Streak became a civilian project the rockets were transported to Australia by ship. Within the Woomera range, at Lake Hart, two launch stands were built almost identical in design to those at Spadeadam along with ground support equipment, which had been also been trialled at Spadeadam. Topographically, the contrast between Spadeadam and Woomera could not have been greater (Fig 9); one of the most noticeable effects this had on the design of the launcher stand at Woomera was the use a dry efflux deflector.

Figure 9
Construction of the test stand at Woomera, Australia © Weapons Research Establishment, Salisbury, Australia

The impact zone for the missile was about 1,100 miles (2,040 km) in the Great Sandy Desert of Western Australia, which is now being explored as a source for astronautical artefacts including sections of Blue Streak and Europa rockets which have been recovered and are now on display at Woomera (Henwood and Dougherty 1999). In common with Spadeadam, subsequent to the announcement of the cancellation of the missile project, only one launch stand was fully equipped (Fig 10). It was also intended to build experimental underground launching facilities at Woomera where it is believed that work began on two facilities including the laying of concrete in one hole (pers. comm. Kerry Dougherty).

Figure 10
A single launch stand was fully equiped at Woomera, Australia © Weapons Research Establishment, Salisbury, Australia

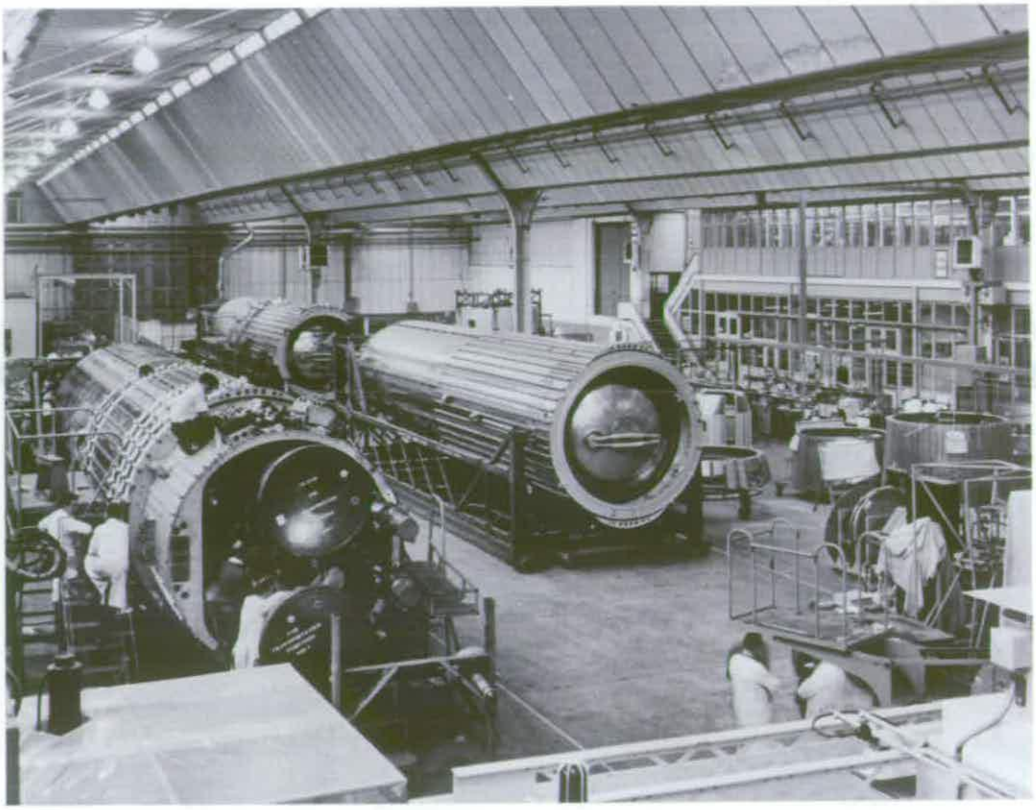

Figure 11
Missiles were manufactured at the de Havilland factory in Stevenage
© BAe Systems

Detailed discussions of the facilities built elsewhere in England for the development of Blue Streak lie outside the scope of this report. Most of the design work for the missile was carried out in de Havilland's London offices in Conquest House, Theobalds Road and in Welkins House, Charterhouse. At de Havilland's Hatfield factory large test stands were built to develop vehicle and ground mechanical systems including the release gear. At their Stevenage factory the erecting shops were extended to accommodate the manufacture of the missile (Fig 11), while the rocket engines were manufactured at Rolls-Royce's Derby works. At the Rocket Propulsion Establishment, Westcott (Fig 12), an existing stand was converted for the test firing of RZ-1 engines. This engine was a very close copy of the Rocketdyne S3 engine, which was used in United States' Atlas, Jupiter and Thor missiles. A mutual technical assistance agreement was signed between Rolls-Royce and Rocketdyne in August 1955 (Technical Editor 1960, 475) and the S3 was developed into the RZ-2 used by Blue Streak.

Figure 12
Blue Streak vertical firing point at the Rocket Propulsion Establishment, Wescott, Buckinghamshire. Octagonal section in foreground is part of a one-sixth scale silo model
© Crown copyright NMR (BB94/4874)

By the mid-1950s it had been almost a decade since British scientists had worked with large liquid fuelled rockets when they had fired a number of captured German V2 rockets at Cuxhaven, Germany, in 1946. Fortunately the United Kingdom was able to make up some lost ground through an understanding with the United States; the 'Wilson-Sandy Collaboration Agreement' signed in June 1954 (Technical Editor 1960, 475) provided for the sharing of information on the development of long-range guided missiles. Through this arrangement a team from the Ministry of Works was able to inspect North American Aviation's engine test site at Santa Susana, California, which was to supply the model for the facilities at Spadeadam. Three of the engine test stands at Priorlancy Rigg may be seen to be copies of United States designs, however, the fourth stand A42 was an innovative British design using pre-stressed concrete (Walley 2001, 19). This stand was originally designed for double engine firings and in September 1958 the Ministry of Supply wrote to the Treasury for the approval to spend £600,000 on this facility. This was later reduced to around £400,000 when it was decided to build the stand for single engine firings (TNA: PRO T225/1424).

Assistance with the design of the rocket was also received from United States companies. The Convair Division of General Dynamics Corporation, who were concerned with the development of the Atlas missile, liaised with de Havilland over the design of the missile. Help was also given to Sperry Gyroscope with the design of the guidance gyros and, as described above, Rolls-Royce worked closely with Rocketdyne on the engine design. Blue Streak was, however, not a simple copy of United States' designs. Beyond the initial design concept virtually all aspects of the missile needed to be redesigned to meet British engineering practices, material standards, electrical systems and safety standards. The mechanisms for the exchange of information were also relatively slow either through team visits or 'missions', reports that needed to be cleared before release, or through the embassy's defence attaché (Dommett 2003).

Responsibility for the construction of the Rocket Establishment lay with the Ministry of Supply, later Ministry of Aviation, while the functional specifications were drawn up by the Ministry of Works in consultation with the Royal Aircraft Establishment, Rolls-Royce and de Havilland Propellers. Given the size and complexity of the project a new consortium, British Oxygen-Wimpey, was formed to carry out the construction work. On completion the establishment was managed on behalf of the Ministry by Rolls-Royce although sections of the site were under the day to day control of de Havilland Propellers Ltd. The provision and movement of liquid and high pressure gases was a specialised activity and it was managed on an agency basis by British Oxygen Gases (BOG) (TNA: PRO AVIA 92/3). Despite the central position that the Rocket Establishment had in developing the next generation of the British nuclear deterrent missiles the Treasury kept a careful watch on all expenditure, and although all the buildings were well designed for their purpose they betray no trace of architectural extravagance. A Treasury official, J M Marshall, sent to inspect the works in July 1959 commented on the Component Test Area 'The administration block is a modest and simple construction as far as I saw it, and there certainly appears to be nothing lavish here' (TNA: PRO T225/1424). Most of the structures were, however, well finished. Concrete work was completed with smooth surfaces and chamfered corners and today shows few outward signs of degradation. The fitting-out of the test facilities was completed to the highest standards often involving technical work never before attempted in the United Kingdom.

The construction of the Rocket Establishment was a major civil engineering undertaking in a remote and inhospitable environment. To the north of Gilsland and beyond Moscow Farm the only access was along a dirt track; much of the area was also covered by virgin peat that made movement by vehicle difficult. One of the first tasks was to construct an access road to the establishment and to lay the roads that would connect the various test areas. To overcome the waterlogged ground many of the roads were laid on rafts of birch wood, represented today by rows of bushes that have sprung up along the road sides (Fig 13). Hardcore embankments were then laid on top of the wooden rafts to carry the roads. Some

Figure 13
Access roads across waterlogged ground at Spadeadam were constructed on rafts of birch wood and today birch bushes have sprung up along the roadsides
© English Heritage (AF00134/road)

of this hardcore was provided from old colliery workings at Prudhoe, Northumberland (Hancock 1997, 24). Additional hardcore was also won from a quarry opened up close to the site entrance. The scale of many Cold War building projects was comparable to the building of the canals and railways in the 19th century and similarly required a large itinerant labour force that was in part provided by Irish workers. To accommodate this workforce a temporary labour camp was built close to the entrance to the site. Other temporary contractor's huts were also built in the administration area, to the north of the BOC compound and at Greymare Hill. At the peak of construction the workforce numbered around 1,500 (TNA: PRO AVIA 92/28). Further accommodation was provided in 'Killoran', a large house in Wetheral, Cumbria, which was used for important visitors and as a drawing office until facilities were available on site. Two housing estates were also constructed at Brampton with a total of 262 houses (Fig 14). One estate, called Greenfield, was reserved for senior staff while Millfields was for the remainder of personnel (TNA: PRO AVIA 65/1906; Hancock 1997, 23). There were also plans to build a further estate in Carlisle but these were abandoned when the missile project was cancelled.

Figure 14
Workers' houses in Sawmill Lane, Brampton, Cumbria © English Heritage (AF00134/sawmill)

The economic benefits of this large construction project stretched to beyond the local area. Wider off-site improvements were needed to the county's roads and bridges to accommodate the large rocket transporters and the fitting-out of the Rocket Establishment required the services of many sub-contractors from across the country who provided both standard industrial equipment and specialised components. Archaeologically these contractors are represented by nameplates which remain attached to derelict plant and fittings. Companies who supplied the establishment with fittings, include Pye Ltd, Cambridge, who were responsible for most of the electrical consoles and monitoring equipment. Smaller electrical suppliers, such as the Record, Broadheath, Cheshire, provided one-off measuring instruments. The Lea Recorder Company, Manchester, manufactured a water gauge for use in the sewage works. Other major sub-contractors for instrumentation included New Electronic Products, SE Laboratories, Metrovick and Honeywell-Brown (Technical Editor 1960, 475). The skills of the local heavy engineering industry were also required. The Redheugh Iron and Steel Company (1936) of Teams, Gateshead was responsible for the erection of the steelwork for the test stands. Steel concertina doors were produced by Potter Rax Limited, London, and fans for the air conditioning systems were made by The Airscrew Company, Weybridge, Surrey.

Cancellation of the Blue Streak Missile

Even while the intense building activity was underway at Spadeadam, cabinet and departmental committees were questioning both the cost of the project and Blue Streak's viability as part of Britain's nuclear deterrent forces. By late 1959 there were mounting concerns about rising costs. Opinions at the Ministry of Defence and amongst the Chiefs of Staff were moving in favour of flexible nuclear deterrent forces. Blue Streak, being deployed in an underground silo, was potentially vulnerable to a pre-emptive attack and once it had been launched it could not be recalled – it was therefore viewed as inflexible. In contrast, the manned bombers of the V-force carrying long range missiles offered mobility and with the prospect of new stand-off missiles - Britain's Blue Steel and the United States' Skybolt - the V-force might form a credible deterrent until at least the end of the 1960s. There was also the expectation that sea launched systems, such as Polaris, would become available during the next decade. On strategic grounds, set against a background of the need to reduce the defence budget, at a Cabinet Defence Committee meeting on 24 February 1960 it was decided to cancel Blue Streak as a military project (Wynn 1994, 328). The Macmillan government's formal decision to cancel Blue Streak as a weapons system was announced in Parliament on 13 April 1960 (Martin 2002, 19).

To the point of cancellation about £84 million had been spent on the project (Wynn, 1994, 399) of which £17¼ million had been spent at Spadeadam (TNA: PRO T225/2020). The Cabinet was eager to recover some benefit from the heavy investment made in Blue Streak and to retain the scientific and technological expertise that had been accumulated (Wynn 1994, 397). Consideration was therefore to be given to whether or not Blue Streak could be adapted for space research. In the meantime, one of the most pressing problems resulting from the cancellation decision was the future of the workforce employed on the project. The number of employees at Spadeadam was close to 900, around 500 of whom had been recruited locally (TNA: PRO AVIA 92/28). Even while the future of the establishment was being discussed it was clear that the range would be less intensively used than had originally been envisaged. It was calculated that the workforce at Spadeadam could be reduced through people leaving of their own volition and through transfers within the parent companies, but that this would leave around seventy people who would be forced to leave.

The projected reduced level of testing also had implications for the site's infrastructure. A report produced by Rolls-Royce in May 1960 envisaged that the Component Test Area should be closed except for the Hydraulic Flow Building B2. At Priorlancy Rigg work would cease on the fourth Test Stand A42, and Test Stand A1 would, in future, be used for turbo-pump tests. At Greymare Hill work ceased on fitting out Test Stand C2 and any future tests would be carried out at Test Stand C3 (TNA: PRO AVIA 65/597).

European Launcher Development Organisation

Before the cancellation of the Blue Streak missile project the potential of the rocket for space research, primarily geophysics and astronomy, was realised by British scientists. In the summer of 1958 consideration was given to using a combination of Blue Streak and Black Knight as a satellite launcher, known as Black Prince (Millard 2001, 4-8). Within the Ministry of Supply evaluations were carried out by the Chief Scientist, Sir Owen Wansbrough-Jones, while at the Royal Aircraft Establishment, Farnborough, Dr Desmond King-Hele and Doreen Gilmour carried out technical assessments (Hill 2001, 117). Outside of government the views of the independent scientific community was exerted through the Royal Society (Massey and Robins 1986, 65-6; 226). It was foreseen during these early discussions that any space research would probably need to be conducted in co-operation with other partners. Possible collaborators identified included the United States, the Commonwealth, Europe, or NATO. Discussions between the British National Committee for Space Research and potential European colleagues began in 1959 and prior to the cancellation announcement a meeting was set for 29 April 1960. A further series of meetings culminated in March 1962 in the signing of the European Launcher Development Organisation (ELDO) convention between Australia, Belgium, France, Germany, Holland, Italy, and the United Kingdom (Massey and Robins 1986, 111-5; 125).

While discussions were taking place on the possible use of Blue Streak as a launch vehicle the Ministry of Aviation continued to fund work at Spadeadam but on a reduced scale. At Greymare Hill, the C3 Test Stand was made serviceable for launcher testing and elsewhere work focussed on frost proofing the test facilities. In contrast, other areas of the establishment saw a distinct upturn in activity. Rolls-Royce relocated the rocket engine work from the Sinfin 'B' engine shop, Derby, to Spadeadam (Hancock 1997, 38), with most of its activities

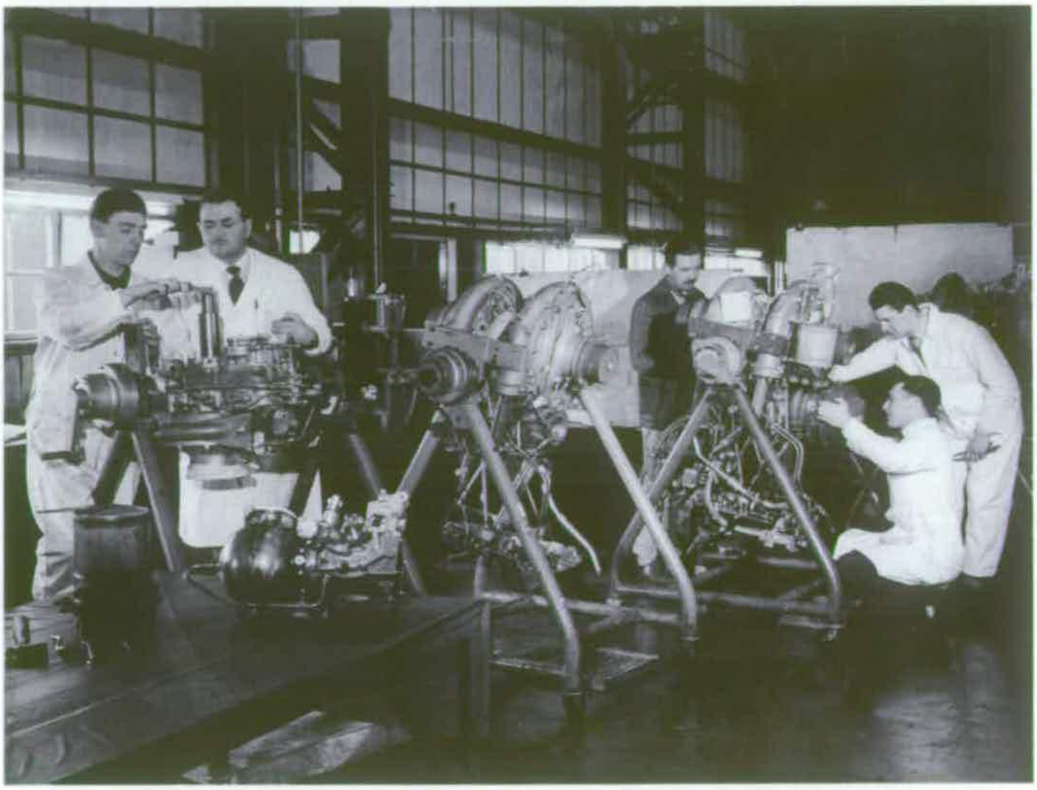

Figure 15
Work on Blue Streak rocket engines was relocated from Derby to building F1 at Spadeadam
© Rolls-Royce plc

being moved to the Main Building F1, resulting in some internal reorganisation of this building (Fig 15). In early 1964 approval was given for the completion of the fourth test stand at Priorlancy Rigg A42 with modifications to allow it to be used for the testing of up-rated Mark III engines with a thrust of up to 150,000lbs (68,040kg) (TNA: PRO T225/2020). Minor building work carried out during this period included the construction of temporary wooden huts in the Administration Area, Priorlancy Rigg and at Greymare Hill, traces of which survive as concrete floor slabs. Innovative technical equipment, including colour television monitors, was installed in the Control Centres (Hancock 1997, 60). The design of the test stands was closely based on those at Rocketdyne's establishment at Santa Susana,

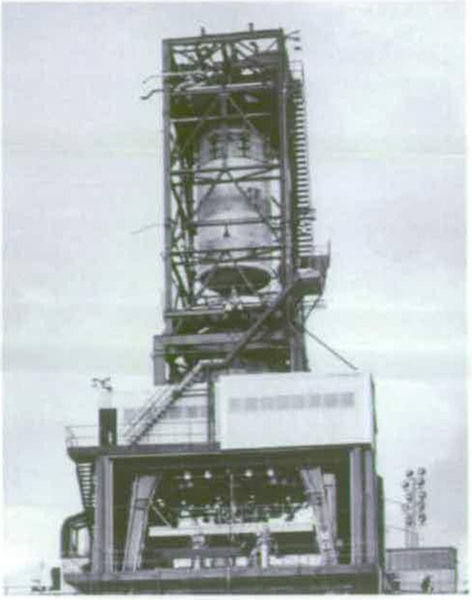

Figure 16
Metal shuttering added as frostproofing at Test Stand A2, Priolancy Rigg, Spadeadam
© Rolls-Royce plc

California. The open framework structures were, however, not designed for Cumbrian winters and further money was authorised for frost protection measures (TNA: PRO T225/2020). At Priorlancy Rigg sections of the test stands were enclosed by corrugated sheeting and on Test Stand A2 a metal concertina door was installed. At Test Stand C3 the walkway beneath the thrust pad main was partly enclosed by corrugated sheeting and a metal concertina door was fitted to the eastern side to protect the efflux bucket.

In parallel with the establishment of ELDO, the European Space Research Organisation (ESRO) was formed in 1962 to develop both a programme of space research and the satellites needed to undertake it. Although the full development of the establishment was curtailed by the cancellation of the missile project, it still represented the largest facility devoted to the development of large rockets outside of the United States and the USSR. The world class research facilities at Spadeadam attracted many distinguished visitors and in 1963 a royal visit was made by the Queen and the Duke of Edinburgh (TNA: PRO INF6/140). The establishment was also visited by one of the pioneers of large liquid-fuelled missiles, Werner von Braun. In April 1965 the two organisations combined to form the European Space Agency (ESA). ELDO's original proposal was to undertake a project known as ELDO A for the development of a three-stage rocket Europa I. France later suggested that the upper stages should use a liquid oxygen/liquid hydrogen combination; this project was to be known as ELDO B and the rocket as Europa III.

Confirmation that a modified Blue Streak was to be the launch vehicle for ELDO gave a new impetus for the workforce at Spadeadam, and by 1965 the workforce had again risen to around 900 (TNA: PRO AVIA 65/1906). The most significant building project of this period was the construction of a new canteen and hostel known as 'Kingwater House', which provided accommodation for fifty single members of personnel and the kitchen staff. It was completed in 1965, at which time the temporary Labour Camp was demolished.

But following a financial crisis in 1966, the United Kingdom reduced its contribution from 38% to 27%, and the project proceeded with a modified design known as Europa II (Massey and Robins 1986, 227). The ELDO project was to be further beset by development delays and escalating costs. In March 1966 an article that appeared in the local newspaper, *The Journal*, reported that 'To the employees at Spadeadam, the future of the station looks as bleak as the wasteland it was built upon' (TNA: PRO AVIA 65/1906). Many staff from the troubled Establishment were poached by the Atomic Energy Authority and I.C.I. and concerns were expressed in the Ministry at the number of skilled scientists and engineers leaving Spadeadam in search of more secure employment. Staff at Spadeadam even set up their own employment bureau in anticipation of a mass exodus of workers from the site (TNA:

PRO 65/1906). In December 1971 Britain withdrew from the ELDO organisation and the final cancellation of the project came in April 1972 (Massey and Robins 1986, 232).

Jet Noise Fatigue Testing

One of the reasons for locating the Rocket Establishment at Spadeadam was the relatively small number of people in the vicinity who would be affected by the noise produced by tests. This remoteness combined with its existing infrastructure also made the range attractive to others involved in acoustic testing. In June 1959 the Royal Aircraft Establishment made representations to be permitted to conduct noise fatigue trials at Spadeadam on sections of the *Scimitar* aircraft which was about to enter service. This work involved subjecting sections of the aircraft to prolonged periods of exposure to engine noise. Testing had begun at Farnborough, Hampshire, but was halted due to complaints about the noise (TNA: PRO DEFE 51/119). Whether or not these discussions resulted in any trials work is unknown but interest was revived in November 1962 when experiments were conducted in the flameway of the unfinished C2 Test Stand at Greymare Hill. Noise tests were carried out using an engine from a *Javelin* aircraft to assess the nuisance it might cause to the Rocket Establishment and its neighbours (TNA: PRO DEFE 51/120). It was proposed to monitor the trials work from mobile cabins. Evidently some work was permitted and during the mid-to-late 1960s experiments were undertaken to investigate the effects of jet noise on the structural integrity of the supersonic airliner *Concorde* (TNA: PRO BT242/207). No fixed infrastructure relating to this activity has been found. The flameway of C2, where tethering hooks for securing aircraft being used as noise sources and other fixtures might be expected, is now covered by spoil.

Liquid Hydrogen - Liquid Oxygen Rocket Testing

While Blue Streak was being developed as a satellite launcher, the European Launcher Development Organisation (ELDO) was considering future propulsion systems for its upper stages. One possible system was the use of liquid hydrogen-liquid oxygen engines. In the mid-1960s ELDO began preliminary studies into the use of this more efficient fuel combination and in 1965 awarded Rolls-Royce a contract to develop an experimental thrust chamber (Hill 2001, 37-8). Basic research into the use of liquid hydrogen as a rocket fuel was also being undertaken at the government's Explosive Research and Development Establishment, Waltham Abbey, Essex, and the Rocket Propulsion Establishment, Westcott, Buckinghamshire, where there were limited research facilities. These establishments were more usually concerned with the development of military propellants and missile systems whereas it was envisaged that the principal use for liquid hydrogen engines would be in large civilian launch vehicles.

To support their design work Rolls-Royce required a test site for the experimental versions of the liquid hydrogen rocket motor, designated the RZ-20. A number of sites were considered where this work might be carried out, and in some respects Spadeadam was too remote both from Rolls-Royce's main Derby factory and from BOC's plant at Morden in Surrey, which was to produce the liquid hydrogen. Despite these geographical drawbacks it was decided to locate the test stand at Spadeadam to provide the establishment with experience of working with liquid hydrogen with a view to future development work. Rolls-Royce also preferred Spadeadam because the facility was to be erected as a private venture and they favoured a site which they directly managed. It was also felt that after the uncertainties of the Blue Streak and Europa project that this innovative work would raise staff morale and inspire confidence in the future of the establishment. In addition the Treasury was keen to

Figure 17
A single firing of the Liquid Hydrogen-Liquid Oxygen Thrust Chamber Facility at Spadeadam was made in 1969
© Rolls-Royce plc

see more use being made of what it regarded as an underused range (TNA: PRO AVIA 92/232). The Liquid Hydrogen-Liquid Oxygen Thrust Chamber Facility, which was estimated to cost £81,000, was built to the north of the Component Test Area, an area that had been largely redundant since 1961. The test stand was used on one occasion, on Monday 8th September 1969, when two 10 second firings of an RZ-20 engine were made (Fig 17). Subsequently funding for the project was withdrawn and all the salvageable parts of the stand were removed.

This work on the development of liquid hydrogen rocket engines represented some of the most innovative investigations into rocket engine technology undertaken in Britain during the 1960s. Work on other engines, including those for Europa I, was essentially refining 1950s technology, and in subsequent decades no major new rocket projects were initiated. This small test stand may therefore be seen as symbolising the swan song of Britain's short-lived post-war rocket age.

Closure of the Rocket Establishment

Subsequent to the announcement that rocket testing was to cease at Spadeadam, Rolls-Royce (1971) Ltd gradually reduced their responsibilities on the range and, after testing had ceased, they were engaged by the Ministry of Defence to remove some of the site's infrastructure. Some items were reserved for the Indian government for use in their rocket development programmes. Equipment removed from Priorlancy Rigg included all the fixtures and fittings from Test Stand A3 and spare parts from Test Stand A2 at Greymare Hill. All the steelwork from Test Stand C2, including the Servicing Tower C3.2, was earmarked for India as were the Gaseous Nitrogen Tanks C16. All other fittings that were not required were stripped out and scrapped. Some of the demolition debris was dumped or buried. Along the southern edge of Priorlancy Rigg ETA is a dump of concrete rubble which also contains some stainless-steel pipes. The quarry to the south of the main gate was also used for tipping debris and this, too, contains scrap metalwork including stainless-steel pipes. Anecdotal evidence suggests there may be other burial pits some containing rocket components elsewhere on site.

Proof and Experimental Establishment

The next phase in the development of the Spadeadam range was determined by events at the other end of the country when, in 1971, Edward Heath's Conservative government decided that London's third airport should be placed on Maplin Sands in the Thames estuary off the Essex coast (TNA: PRO PREM15/1251; PREM 15/1252). This site lay adjacent to the Shoeburyness Proof and Experimental Establishment (P&EE) and before development could begin its facilities needed to be relocated. Planning for this move determined that its current activities would be split between a number of existing ranges. Prior to the announcement of the cancellation of the Europa project the Treasury had been concerned that the Spadeadam range was relatively underused and even if the project did continue, engine testing and development work would probably cease by about 1980 (TNA: PRO CM6/290). Spadeadam fulfilled many of the criteria being sought. It was remote and provided sufficient space for three basic types of research: fragmentation patterns of munitions, destructive testing of airframes and aero-engines, and mine testing. Another attraction was that the new facility would be able to share much of the infrastructure constructed for rocket testing including the 11kV power supply, roads, water for fire-fighting and domestic use, the water treatment plants for disposing of effluent, as well as on- and off-site accommodation. Nevertheless, extensive and expensive civil engineering work was required to provide the specialised facilities needed by the new establishment and, in anticipation of the change of function, the management of the range was formally handed over to the government's Property Services Agency (PSA) on 1st December 1973 (TNA: PRO CM6/289). The Department of the Environment (Chessington) had responsibility for the design of the new range which it undertook in consultation with P&EE Shoeburyness.

Testing was to be concentrated at four main sites. Rowantree Crag (NY 628 710) was to be for mines trials and proofing at R8/K Site; at Caud Beck (NY 624 724) the destructive testing of airframes and aero-engines was to be done at R5/J Site, including R5a engine attack site, R5b attack of part aircraft and R5c static site whole aircraft. Green Hill (NY 639 737) was to be the demolition of structures static R7/H site (including R52 Dropping tower) and finally Berry Hill (NY 641 731) or R51 was to be for testing the fragmentation patterns of munitions. Construction of the new roads began in August 1972 and the sites for the new range facilities were handed over to the main contractors, Brimms of Newcastle, in April 1973. Specifications for this work included roads capable of bearing the weight of a tank transporter and with enough clearance for moving aircraft to link the new test facilities to the existing spine road running from the south of the range to Greymare Hill in the north. The longest road was built from close to the entrance to Greymare Hill to Berry Hill, which was to be the control centre for Range 51, and this included difficult ground works to carry the route over Berry Bog. New roads were also laid along Caud Beck to serve Range 5 and to the Rowntree Crag area, R8, which was to be used for mine evaluation. Other work included the laying of a new fire main and drains to carry away contaminated water as well as cable ducts to link the test areas to the control centres. Elsewhere the overhead electrical power supply was placed in underground channels to protect them from accidental damage.

In addition to the new test areas a meteorological station was built to the north-east of the Component Test Area to support the work of the range. When it was announced that rocket testing was to cease, as part of the decommissioning process, evaluations were carried out to ascertain if any structures might be of use to the new establishment. A number of structures including the Control Centre A11, Workshop A12 and the Reservoir Q23.1 were earmarked for retention (TNA: PRO T225/3825). At Greymare Hill it was suggested that the Servicing Tower C2 and some of its infrastructure might be retained for tests requiring elevated platforms or dropping facilities. Interest was also shown in retaining and modifying the Control Centre C4 for use as part of R54 Project. At Priorlancy Rigg Naval Magazine Trials were to be put in place at a site known as R50 (TNA: PRO CM6/291).

Most of the civil engineering work for the new establishment was completed by the end of 1974. By this time, however, opposition had grown to the plans for London's third airport. Many of these objections were on environmental grounds and were compounded by the world economic recession brought about by the 1973 oil crisis. In 1974 Harold Wilson's Labour government announced the abandonment of the project. In the following year, on 14th February 1975, the government announced that P&EE Spadeadam was to be run down and closed over a two year period and that the new facilities would not be occupied for their intended purpose. The total calculated cost for the construction work was £3,314,053 (TNA: PRO CM6/291).

RAF Spadeadam

RAF Spadeadam was established in 1976 and began operating as an Electronic Warfare Tactics Range in 1977; today it is one of only two such facilities in Europe. It is contained within Low Flying Area 13, covering about 2,035km², extending south from Hawick in Scotland to Alston in Cumbria, and from Langholm, Scotland, in the west to Hexham, Northumberland in the east. The role of the range is to train aircrew to fight and survive in a hostile electronic warfare environment. This training involves simulating the threats faced by military aircraft during conflict including the electronic

Figure 18
Obsolete English Electric Thunderbird surface to air missile used to simulate a hostile missile at Spadeadam
© Crown copyright NMR (AA94/2973)

Figure 19
SA-6 (Gainful) surface to air missile. Former eastern bloc hardware forms mobile simulators for training © English Heritage NMR (DP003991)

emissions sent out by radar guided surface-to-air missiles and anti-aircraft artillery systems (Fig 18). For training purposes a wide variety of specially built simulators and emulators, as well as original Soviet-built radar systems (the majority acquired from former East German stockpiles), are employed (Fig 19). Most of these systems are mobile and are moved around the range to vary the training routines.

Comparatively few structures have been built during the last 25 years or so. Most activities are accommodated within the structures built for the Blue Streak project or the planned proof establishment; they are well maintained and generally retain their late-1950s or 1970s character. On the range some of the concrete hardstandings have been extended and in recent years garages have been erected to house the mobile radar systems. The range also provides a number of camera targets for training purposes. A mock airfield was created,

Figure 20
A mock airfield, known as Kolinski, with derelict aircraft parked alongside © English Heritage NMR (17801/30)

originally located to the south of Priorlancy Rigg, by cutting swathes through the vegetation to represent runways and this may still be distinguished by differential vegetation growth (Fig 20). In recent years another dummy airfield, Kolinski, has been created to the north-east of Berry Hill and derelict aircraft have been parked alongside to complete the effect.

Figure 21
Test Stand A1 at Priorlancy Rigg was used in the late 1970s for destructive pipeline testing by the British Gas Council © Crown copyright NMR (AA94/2954)

The remoteness of the Spadeadam range had attractions for other industries who wished to test hazardous products. In the mid-1960s when British Gas was investigating the laying of long underground gas mains, it used the then moth-balled A1 Test Stand at Priorlancy Rigg for the destructive testing of pipes (Hancock 1997, 78; *pers. comm.* Godfrey Moy). The section of the proposed proof range along Caud Beck, R5, was occupied in the late 1970s by the British Gas Council for the destructive testing of gas pipelines (TNA: PRO AB7/ 24421) (Fig 21). This work continues today under the management of Advantica, formerly British Gas Technology Ltd, and its activities have expanded into other areas of potentially hazardous research and technical research work for the oil and gas, process and energy industries. This area of the site was not investigated during the survey.

Site Description

Spadeadam Waste

Some 2.5km north of the village of Gilsland, at the aptly named Moscow Farm, the public road bends sharply eastward and continues as a track leading in the direction of a small settlement at Wiley Sike. The road that continues north leads to the camp entrance and the vast restricted area beyond known as Spadeadam Waste (Fig 22).

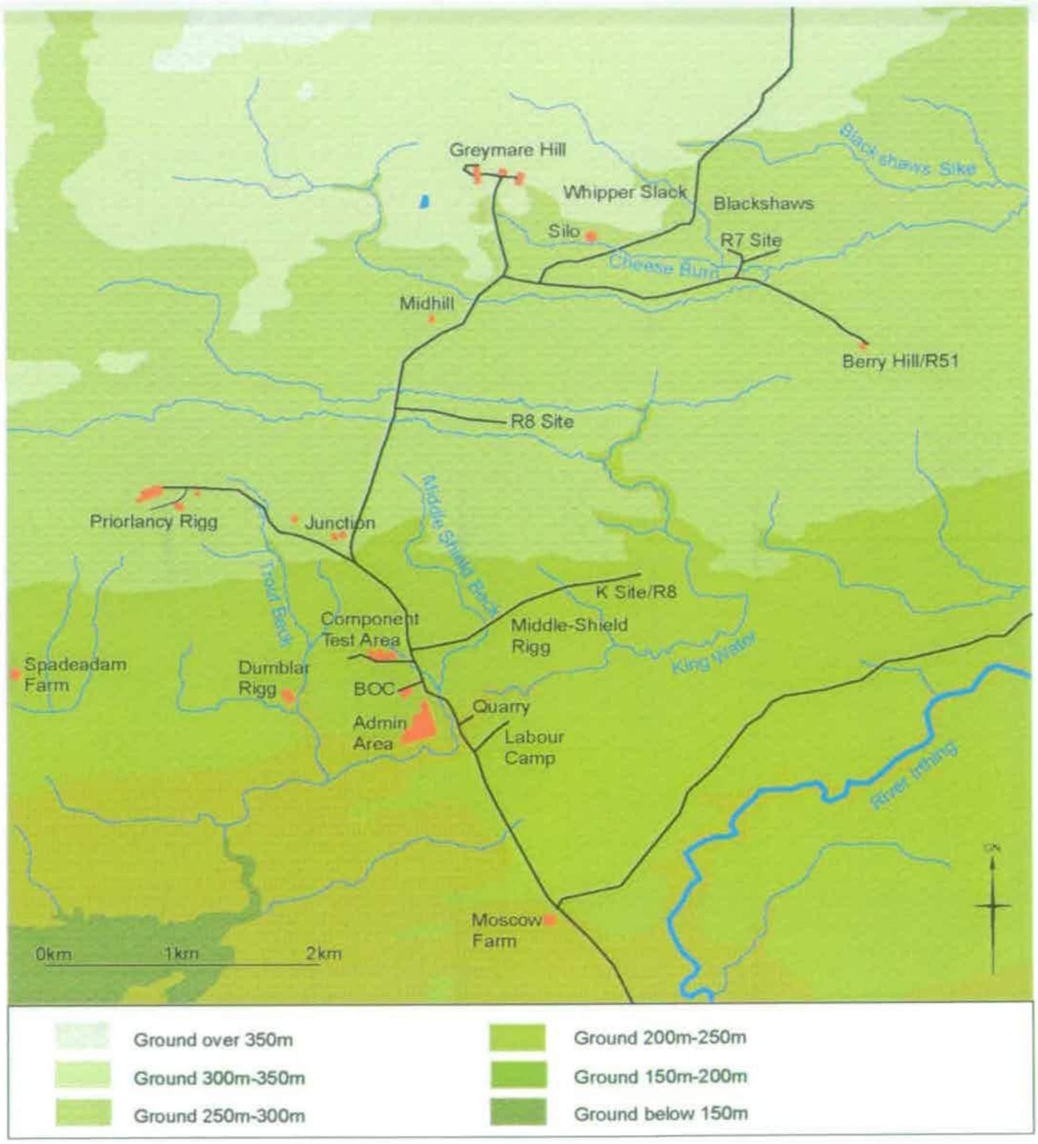

Figure 22
The Spadeadam Rocket Test Establishment

Over three and a half thousand hectares of open moorland and Forestry Commission plantation is today used by the RAF as an Electronic Warfare training range, but the area also contains the structural remains of the former Rocket Establishment, built to test the Blue Streak missile. The remains, now redundant and largely derelict, are concentrated in five main sites. These sites are serviced by well made roads and include the remnants of an extensive scheme for the supply of water and propellants necessary for the testing process, and also for the removal and treatment of waste products.

Outside the main test establishment area, 0.5km to the south of the entrance (centred at NY 621 701) was the former labour camp for the workforce originally drafted in to construct the Spadeadam facility. Built in 1957 when work first began on the Rocket Establishment, the labour camp consisted of around ten bunkhouses providing basic accommodation for the construction workers. Sewage from the site was piped down to a treatment plant situated on the west bank of the King Water water course at NY 617 700 where waste was processed before being discharged into the stream.

Immediately inside the entrance to the range is the main Administration Area (centred at NY 615 702). There are a number of administrative buildings, accommodation blocks, a surgery, fire and ambulance stations, and assembly and engineering workshops including a large assembly hangar originally used to prepare the Blue Streak launch vehicle.

To the north of the Administration Area are the remains of the British Oxygen Company (BOC) compound (centred at NY 614 704). A distinct area within the establishment demarcated by its own fence, this formerly housed an air separation plant for the on-site production of liquid oxygen and liquid nitrogen. All the buildings associated with cryogenic production have now been demolished with the exception of a single storey brick substation but substantial concrete bases remain, marking the position of many of the former structures.

Some 200m further north, at the foot of Rushy Knowe, is a compound referred to as the Component Test Area or Site B (centred at NY 613 707). This area comprised a large single storey concrete Control Centre from where trials carried out in a series of nine test cells could be remotely controlled. To the east of this group is a large building formerly the Water Flow Laboratory used for component pressurisation testing. The Component Test Area is now largely derelict although a few buildings remain in use.

To the north of the Component Test Area the ground rises gently along the line of an east-west ridge. Towards the western end of this ridge and below the crest line on its southern side (centred NY 596 719) is the Priorlancy Rigg Engine Test Area. The test area comprises a line of four large concrete test stands set into the hillside. Three of these remain intact although lacking most of their associated metal work and smaller service buildings. The western stand has been partially demolished. Engine firings were controlled and observed from a Control Centre to the east of the test stands. This was connected to the stands via a 1100ft (330m) underground tunnel that served as a massive duct for instrument cabling. Five reinforced concrete structures covered by earthen mounds also survive at Priorlancy: four observation posts and a terminal house for the distribution of monitoring circuits to the test stands. Excavated spoil from the construction of the stands was tipped at the western end of the site and remains as a large flat-topped mound.

The principal static firing stands on the range were located around 3km north-east of Priorlancy Rigg within the Greymare Hill Missile Test Area (centred at NY 621 743). Like the Engine Test Area, this complex was also sited to exploit the contours of the hill, being set into a natural bowl-shaped arena along the 310m contour line. The test firing facilities at Greymare Hill were the largest on the range and were designed for the full test firing of a complete Blue Streak launch vehicle. The site comprises two separate concrete test stands known as Greymare Hill East C3 and Greymare Hill West C2. These shared a common Control Centre to the south and a number of service buildings along the northerly road connecting them.

A number of other areas within the range post date its role as a Blue Streak rocket establishment. Nearly 3km south-east of Greymare Hill at NY 647 731 is Berry Hill. A group of buildings here, collectively labelled R51, were constructed for experiments into the fragmentation of munitions; it now serves as RAF Spadeadam Range Control. At Green Hill, around 1km to the west, a series of four platforms lie terraced into the hillside (centred NY 640 738). Known as R7 (or H site), these are documented as being for testing the static attack of structures. In the easternmost bay was R52, a dropping tower, now demolished. At Caud Beck 2.2km to the south-west (centred NY 621 725) is R5 (or J site). Built for the destructive testing of airframes and aero-engines this area was never used for that purpose and was later occupied by British Gas (afterwards by Advantica Ltd.) for hydrocarbon research. At Rowantree Crag, centred (NY 628 712), is an area that was used for investigating land mines. Originally known as R8 (or K site), this is now largely abandoned.

Labour Camp

0.5km south of the main entrance to the range a rough track leads eastward from the road to an area that was formerly Spadeadam's Labour Camp. A wide plateau of flat ground is oriented north-east to south-west mirroring with the course of the King Water some 200m to the north. This area is clear of trees and the ground appears to have been bulldozed relatively recently such that little evidence of the former labour camp remains (Fig 23).

Figure 23
An area of temporary labourers' huts known as Paddy's Camp was built outside the main entrance to the Spadeadam Rocket Establishment
© English Heritage NMR (17818/03)

Figure 24
The remains of temporary huts are aligned along the access track at Paddy's Camp
© English Heritage (AF00134/paddy1)

Figure 25
A series of brick drains survive on the site of the former labourers' huts
© English Heritage (AF00134/paddy2)

The access track leads due north-east at a width of 3.2m for nearly 280m into the area (Fig 24); slight traces of the former camp are aligned along this or at right angles to it. A rectangular area approximately 85m x 70m in area lies on the north side of the track and is defined by a scarp approximately 0.3m in height. In the northern quadrant of this feature is a low sub-circular mound of building rubble approximately 0.5m high with a maximum diameter of 25.2m. There is a series of brick drains, 1.4m square, arranged in lines throughout (Fig 25). A tarmac hardstanding flanking the south-eastern edge of the rectangular feature is now overgrown and degraded. Immediately north of the rectangular feature is a further sub-square concrete hardstanding

Figure 26
A building footing with complex internal ramps and levels at Paddy's Camp may have been a sub-station
© English Heritage (AF00134/paddy3)

with maximum dimensions of 28.3m x 25.3m; this may have been an electrical sub-station (Fig 26). This building footing has a complex series of internal levels and ramps and maximum dimensions of 7.9m x 5.4m. Some 25m due west-south-west of this is a separate hardstanding, 5.5m x 4.1m in area, within which a transformer, now derelict, once stood (Fig 27).

Figure 27
Derelict transformer, Paddy's Camp
© English Heritage (AF00134/paddy4)

To the south of the main rectangle is a rectangular tank sunk into the ground. Measuring 4.9m x 2.1m the tank is currently water-filled and partially covered by rotten wooden beams so its depth could not be safely be ascertained. A number of linear scarps around 0.3m in height also flank the opposite, southern, edge of the track. These define levelled areas within the natural slope and are indicative of the sites of former structures.

Figure 28
An aerial photograph taken in 1957 shows the arrangement of temporary labourers' huts at Paddy's Camp © Rolls-Royce plc

Although the labour camp is no longer extant the visible traces that do survive correspond closely with views of the site shown on early aerial photographs (Fig 28). Images dating to 1957-9 show a complex of at least fifteen single storey gable-roofed timber huts arranged parallel to the track or at right angles to it. A central core of huts with adjoining porches mid-length and a car park to the south-east seem to be reflected in the surveyed rectangular feature. The surviving brick man-holes within this area probably represent the remains of a drainage system serving ablution blocks and leading to the Sewage Plant Q44 (described below) on the farthest bank of the King Water. A set of double timber huts with an adjoining porch lies at right angles to the east of this central area and to the north of these a two storey structure can be seen in the position now marked by the ramped, split-level footing. Further timber huts and ancillary sheds flank the three remaining sides of the central core. A detailed document outlining plans for the construction of the establishment lists the buildings that will be provided in the labour camp (TNA: PRO AVIA 65/1906). Appropriate segregation was evidently an issue as these include dormitory blocks, a bachelors' block, two female staff blocks and married quarters blocks.

A square pit (possibly a fire pool) shown on the aerial photographs survives as a similarly-shaped earthwork that is visible on the ground and on modern aerial photographs as a dark area (Fig 29). No trace of a water tower depicted on early aerial photographs was noted during the current survey and this may lie in an area now covered by coniferous plantation.

Figure 29
An earthwork survives around a possible fire pool
© English Heritage (AF00134/paddy5)

Whilst these photographs show the labour camp in an apparently completed state, test facilities in the background are either still under construction or not yet begun, suggesting that the camp was one of the first areas to be built at Spadeadam. The north-west edge of the area is defined by a vertical drop down to a quarry beyond. Aerial photographs indicate that this was excavated in 1957 to provide hardcore for the construction of the test establishment (Fig 30). The quarry has since been partly back-filled with building waste as a result of the site's demolition in the 1970s (Fig 31).

Figure 30
Aerial photograph taken in 1957 shows that quarrying for construction hardcore had already begun by that date
© Rolls Royce plc

Figure 31
The quarry was partly back filled with demolition rubble in the 1970s
© English Heritage (AF00134/quarry)

Sewage Plant

Near the entrance to the main establishment an access road leads south to the main site **Sewage Plant Q44**. Situated on the west bank of the King Water watercourse, the plant

Figure 32
Sewage Plant
© English Heritage NMR (DP003933)

comprises two circular filtration beds, 15.7m in diameter, two settlement tanks and a pair of small brick huts (Fig 32). It processed all foul waste from Spadeadam site including the nearby labour camp. The sewage pipe which carried this waste has since been removed but brick piers which supported it across the stream valley are still standing (Fig 33). To the west of the filter beds is a small brick building containing a water gauge meter. Following treatment, waste was discharged into the King Water stream. An aerial photograph taken during the early construction phase at Spadeadam (Rolls Royce Collection, Tullie House Museum) (Fig 34) shows that the sewage plant was one of the first features to be built on site. This reflects the need to service the accommodation blocks of the early labour camp to the east of the plant and the pipework that spans the King Water connecting the two areas is in place in 1957. The sewage plant was recently closed and was disused at the time of survey.

Figure 33
Brick piers which supported the pipe that carried waste from Paddy's Camp to the sewage plant are still in place
© English Heritage NMR (DP003934)

Figure 34
The sewage plant was one of the first features to be completed (middle left of picture)
© Rolls-Royce plc

Access to the modern RAF range is via the **Guard Room F110**. Structures associated with access to the original test facility lie opposite the guardroom on the south of the approach road. A former **Police Control Post F25** stood here but since been demolished and the site is turfed over. A **Weighbridge F22** was also located in this area. It comprised a single storey hut, 12ft x 10ft (3.66m x 3.05m) and 8ft (2.44m) in height that was built of brick with a reinforced concrete and granolithic floor and board roof. The weighbridge pit measured 35ft x 9ft (10.67m x 2.74m) internally and was 5ft 6in (1.68m) deep. Both the pit and associated hut have since been demolished and now lie beneath the site entrance lay-by. From the guardroom the road leads into the Spadeadam Range where the first area to be encountered is the Administration Area.

Administration Area

This represents the most southerly part of the main establishment and it occupies a level area to the west of the narrow, steep-sided ravine of the King Water (Fig 35).

Figure 35
Modern aerial view of the Administration Area at Spadeadam from the south © English Heritage NMR (17818/08)

The Administration Area is surrounded by chain-link fencing with another fence sub-dividing the whole area into two parts. The larger area to the west lay within a 2,500 ft (762m) chain link security fence and buildings within this enclosure were associated with core functions – assembly workshops, laboratories and offices (Fig 36). The smaller area that lay immediately outside the fence to the east contained many of the service-oriented features: garages, a medical centre, a hostel and canteen (Fig 37).

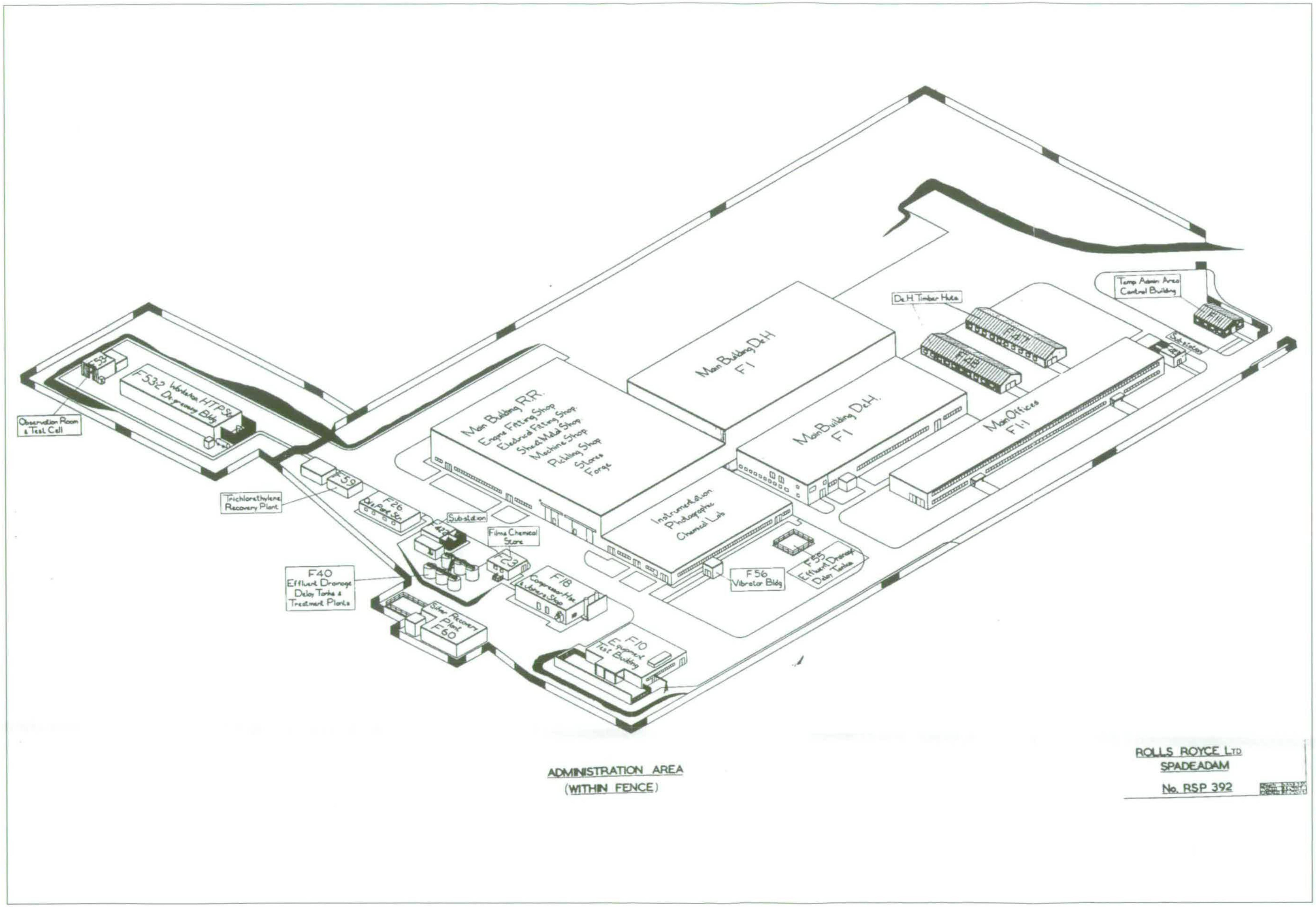

Figure 36
Diagram of the Administration Area within the chain link fence
© Rolls-Royce plc

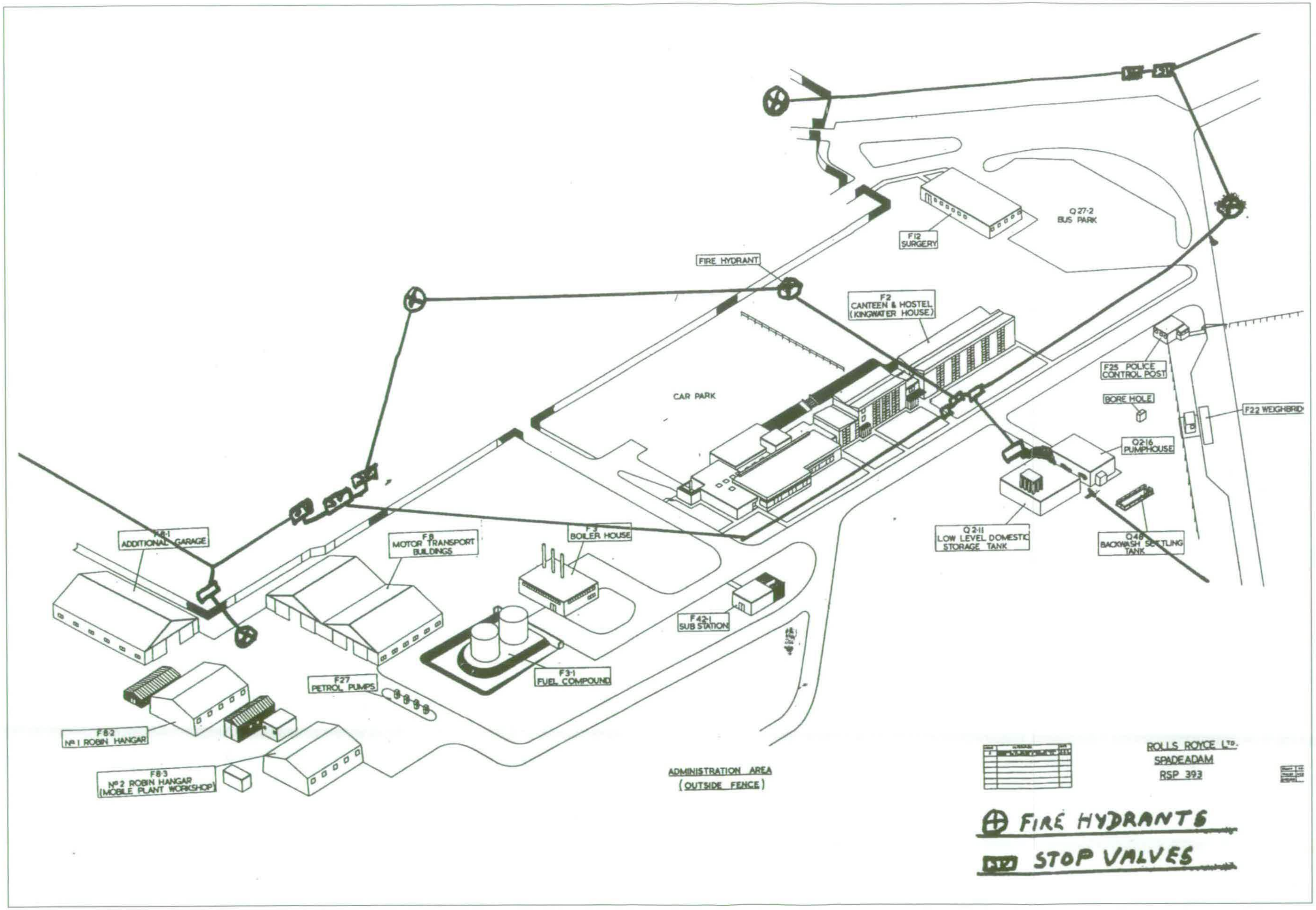

Figure 37
Diagram of the Administration Area outside the chain link fence
© Rolls-Royce plc

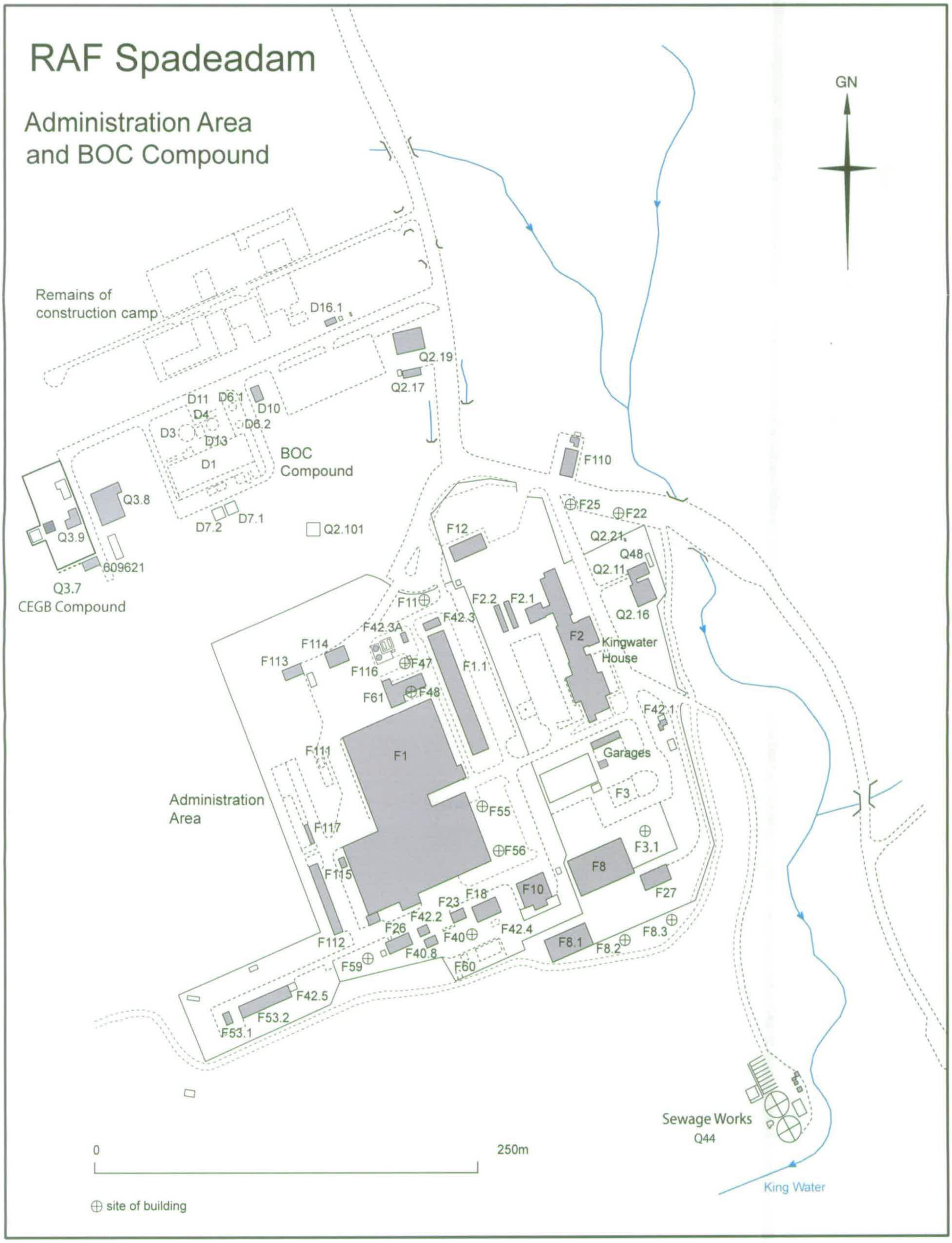

Figure 38 Plan of the Administration Area and BOC Compound after Atkins site plan

The Administration Area was not surveyed as part of the current survey. A diagram of the area (Fig 38) is based upon an existing service diagram of the area.

The **Main Offices** building **F1.1** lies inside the line of the original inner enclosure fence. A two storey steel-framed structure, this has a reinforced concrete floor, corrugated aluminium sheet walls and a roof of steel deck. It measures 264ft x 38ft (80.47m x 11.58m) and stands 20ft (6.1m) in height. Dual occupancy of the building is reflected by the porches at either

Figure 39
Main Office Building F1.1 was occupied by staff of Rolls-Royce and de Havilland © English Heritage NMR (DP003979)

end of the eastern elevation (Fig 39). Staff of de Havillands were accommodated on the ground floor and Rolls-Royce staff had offices on the first floor. Internally the building was sub-divided into offices by plasterboard partitions.

Figure 40
To the north of the Main Office Building F1.1 is a Sub-station F42.3 © Crown copyright NMR (AA94/1924)

Immediately to the north of the Main Offices is a **Sub-Station F42.3** (Fig 40). This single storey structure measures 25ft x 19ft 6in (7.62m x 5.94m) and stands 11ft (3.35m) high. It originally housed bases for two 750kVA transformers divided by a brick wall and surrounded by chain link fence. The temporary **Administration Area Control Building F11**, also known as Police Control, was a single storey timber hut on a reinforced concrete base situated to the north of Sub-Station F42.3. It has since been demolished and the site has been turfed over.

Figure 41
Modern aerial photograph of the Main Building F1
© English Heritage NMR (17818/06)

To the west of F1.1 is the **Main Building F1**. This is a single storey steel-framed structure clad externally in corrugated aluminium sheeting (Fig 41). It has a reinforced concrete floor, a steel deck roof and internal partitions of brick and concrete blocks. The building is divided into two rectangular blocks separated by an internal covered roadway (Fig 42). The northern section of the Main Building consisted of a rocket assembly bay and laboratory that was occupied by de Havilland Propellers. This area was used to receive rockets after their long journey from the main assembly factory at Stevenage, Hertfordshire. The assembly bay measures 120ft x 175ft (36.58m x 53.34m) and stands 47ft (14.3m) in height; it had three internal bays equipped with 10 ton (10.16 tonnes) capacity travelling cranes. The laboratory

Figure 42
The Main Building F1comprises two rectangular blocks separated by an internal covered roadway
© English Heritage NMR (DP003980)

section, also with mobile cranes and fitted with machine tools, measures 80ft x 175ft (24.38 x 53.34m) and stands 20ft (6.1m) in height. The southern section of the Main Building consisted of a workshop and laboratory controlled by Rolls-Royce. The main function of this section was the assembly of engines from components supplied by Rolls-Royce factories at Shrewsbury, Derby, Barnoldswick and Hucknall, which were brought together for assembly (Technical Editor 1960, 477). The main engine workshop has dimensions of 200ft x 150ft (60.96m x 45.72m) at a height of 37ft (11.28m). To fulfil a number of engineering tasks it housed an engine fitting shop, an electrical fitting shop, a sheet metal shop, a machine shop, an acid pickling shop and wash tanks, a welding area, heat treatment furnaces, and a forge. It was also equipped with electric hoist travelling cranes, a trichloroethylene degreasing and fume extraction system, and storage facilities. Adjoining the main workshop, to the east, was the Rolls-Royce laboratory. Measuring 80ft x 150ft (24.38m x 45.72m) and standing 15ft (4.57m) in height, this building housed instrumentation repairing and testing equipment and photographic processing equipment. It also contained a chemical laboratory, a Permutit water softening plant and a softened water chilling plant.

To the north of the Main Office Building were two single storey timber huts occupied by de Havilland. One of these, **Workshop F47** measured 80ft x 24ft (24.38m x 7.32m) and stood 9ft (2.74m) high to the eaves. It had a reinforced concrete floor and a board roof. Within the workshop were machine tools, a blacksmiths hearth, an asbestos-lined welding shop and a crane. Flanking its south side was a **Power Supply and Equipment Store F48**. Of similar construction to F47 this temporary timber hut was demolished along with F47 and the de Havilland **Power and Supplies Building F61** was built on the site (Fig 43). This single storey structure is L-shaped in plan with brick walls and a floor of reinforced concrete with acid resistant floor tiles. Windows were double glazed and doors were sound proof with special sound proof ducts to the intake and extract vents. The principal function of this building was battery charging.

Figure 43
The de Havilland Power and Supplies Building F61
© English Heritage (AF00134/F61)

To the east of the Main Building F1 were **Drainage Delay Tanks for the Photographic Laboratory Effluent F55**. Originally consisting of four 6,000 gallon receiving tanks, the site is marked by a grassy mound. Developer fluid was stored in unlocated **Holding Tanks F4.1** before being removed from site by tanker for disposal. The final effluent from this plant was pumped up to a water storage reservoir near the Engine Test Area for dilution to form part of a closed circuit system that prevented harmful chemicals ending up in the main catchment area of site.

South of the tanks was the **Vibrator Building F56**. This housed vibration testing equipment and the structure of the building was dictated by its function. This single storey building had brick walls, a reinforced concrete floor and measured 14ft x 14ft (4.27m x 4.27m) and stood 11ft (3.35m) high. It had triple glazing, sound proof doors and was lined with mineral wool, polythene and wire netting; inside was a 2 ton (2.03 tonne) runway beam. The vibrator building has been demolished and its site turfed over.

A line of ancillary buildings flanked the south-east side of the Main Building. These contained machine shops and laboratories the easternmost of which was the **Rolls-Royce Equipment Test Laboratory F10**. This single storey structure measures 63ft x 60ft (19.2m x 18.29m) and stands to a height of 12ft (3.66m). It is a steel-framed building with walls of sheet corrugated aluminium, a steel deck roof and a floor of reinforced concrete (Fig 44).

Figure 44
The Rolls-Royce Equipment Test Laboratory F10
© English Heritage NMR (DP003977)

Within the structure were test cells housing pneumatic, hydrostatic and cold testing equipment and facilities for the stripping, testing and reassembling of components; there were also machine tools and an I.C.I. degreasing plant. There is a reinforced concrete hardstanding to the south of F10. Along one long side of this was a 10ft (3.05m) high, 18in (0.46m) thick wall; the remaining sides are bound by a 6ft (1.83m) high chain link fence with gates at both ends. Liquid Nitrogen waste from F10 was taken via copper drains for discharge over-ground. The former Test Laboratory is currently in use as supply store.

Figure 45
Compressor House and Joiner's Shop F18
© English Heritage (AF00134/F18)

To the west of F10 was the **Compressor House and Joiner's Shop F18**. Measuring 55ft x 35ft (16.76m x 10.67m) and standing to a height of 15ft (4.57m), this single storey building has a reinforced concrete floor and roof and brick walls (Fig 45). It housed machine tools and four compressors.

To the south of F18 was **Sub-Station F42.4**. This comprised a reinforced concrete plinth measuring 11ft x 9ft (3.35m x 2.74m) on which stood an 11kV transformer, distribution board and switching gear. The transformer bay is now derelict (Fig 46).

Figure 46
The area to the south of the Main Building contains numerous upstanding structures as well as building remains
© English Heritage NMR (17818/08)

Immediately south of here was the **Silver Recovery Plant F60**. This building housed pumps, a 3ft (0.91m) diameter carbon filter, an ion exchange unit, and storage tanks for the concentration of toxic liquor. It was a brick structure measuring 55ft x 27ft (16.76m x 8.23m) with a split-level roof 24ft (7.32m) and 11ft (3.35m) in height. The reinforced concrete floor had a central drainage channel and this foundation is all that survives of the plant (Fig 46).

To their north was the **Film and Chemical Store F23**. A single storey building with brick walls it has a reinforced concrete roof, a floor of concrete covered in quarry tiles and dimensions of 27ft x 22ft (8.23m x 6.71m). It is currently in use as a store (Fig 46).

To the north were the **Effluent Drainage Delay Tanks and Acid Treatment Plant F40**. This plant processed effluent from the wash and pickling rooms, chemical laboratory and photographic laboratory. It contained numerous pumps and storage tanks used in the process of neutralizing acid and waste and treated waste was discharged into the King Water watercourse. Lime filter cake was produced here as a waste product and this was transferred to the Waste Kerosene Central Storage facility Q31 (described below) for incineration. Structure F40 is no longer extant but its position is marked by concrete footings for the treatment tanks (Fig 46). Used in association with the effluent and acid treatment area was a **Lime Store and Plant Room F40.8**. Measuring 31ft x 17ft (9.45m x 5.18m) and standing to a height of 11ft (3.35m), this is a single storey brick built structure with a concrete and granolithic floor and a flat concrete roof. Internally, a brick structure provided raised storage for lime. A documentary source (TNA: PRO 92/2) also refers to a **Treated Water Plant F30.1** and a **Softened Water Plant F30.2** within the Administration Area but the location of these features is unknown. The treated water plant comprised an acid mixing tank, a mixed bed unit, a soda mixing tank, an air compressor and a 500 gallon (2,273 litre) water storage tank. The softened water plant was equipped with a water softener, a saturator, a water storage tank and a sump tank. It is possible that these features are not shown on plans of the site because they were located inside a numbered building.

Figure 47
Sub-station F42.2
© English Heritage
(AF00134/F42.2)

To its east is the **Sub-Station F42.2**, a single storey brick building with a flat concrete roof (Fig 47). 25ft x 19ft 6in (7.62m x 5.94m) and 11ft (3.35m) in height, this Sub-Station had concrete bases for two 750kV transformers that were separated by a brick dividing wall and surrounded by chain link fencing.

Figure 48
Oil and Paint Store F26
© English Heritage
(AF00134/F26)

To the west of the Sub-Station was an **Oil and Paint Store F26** (Fig 48). A flameproof installation, this had a floor of reinforced concrete with granolithic finish, brick walls and a flat concrete roof. The store has dimensions of 60ft x 27ftxm (18.29m x 8.23m) and stands to a height of 9ft (2.74m). Adjacent to this store was the **Trichloroethylene Recovery Plant F59**. Originally this comprised two buildings but it was demolished and the site has been turfed over.

Protruding from the western side of the Administration Area, and within a separate fenced compound, were the Auxilliary Test Facilities. These included a **High Test Peroxide Store and Workshop F53.2** which measures 116ft x 28ft (35.36m x 8.53m) and stands to

Figure 49
High Test Peroxide Store and Workshop F52.3
© English Heritage
NMR (DP003986)

a height of 15ft (4.57m). This is a single storey brick structure with a floor and flat roof of reinforced concrete. It contained a degreasing pit, measuring 26ft 6in x 7ft 6in (8.08m x 2.29m) and 4ft 6in (1.37m) deep, and a sunken cable duct within the building runs to a switch room. This building is currently in use as offices.

Adjacent to F53.2 are reinforced concrete tanks for the collection of trade waste. At the eastern end of the building was a **Sub-Station F42.5**. The transformer and distribution board have now been removed and the concrete base with surrounding wire mesh fence are used for the storage of gas cylinders.

Figure 50
Observation Room and Test Cell F53.1
© English Heritage NMR (DP003985)

Adjacent to the High Test Peroxide Store and Workshop, at the western perimeter of the compound, was the **Observation Room and Test Cell F53.1** (Fig 50). This is a single storey, two bay structure with reinforced concrete floor, walls and roof. The building has dimensions of 28ft x 17ft (8.53m x 5.18m) but the Test Cell (southern bay) stands considerably higher at 16ft (4.88m) than the Observation Room (northern bay) with a height of 10ft (3.05m). Beyond these buildings was the **Oil Interceptor and Balancing Tank** for the processing of over ground drainage water before it was discharged in the King Water watercourse.

Figure 51
Modern aerial photograph of Canteen F2
© English Heritage (NMR 17802/02)

To the east of the central dividing fence was the domestic and technical area. The largest of these buildings was the **Canteen F2**. Originally a temporary structure almost square in ground plan, the canteen lay to the east of F12. This was replaced in the early 1960s as part of the ELDO project by a much larger, rectangular suite of buildings known as Kingwater House (Fig 51). The new structure was located just to the south of the original and it provided a three storey hostel and single storey canteen facilities (Fig 52). To the north and south of it were blocks of garages and to the west, a large car parking area. F2 still fulfills its original function although a section of two storey accommodation has been added to the west and to the east a single storey bar has been built. To the north-west of F2 are two **Portakabins F2.1** and **F2.2**

Figure 52
Canteen F2
© English Heritage NMR (DP003983)

Figure 53
Surgery F12
© English Heritage
(AF00134/F12)

Immediately north-west of F2 was the **Surgery F12** (Fig 53). A large single storey building, the surgery is built in brick with a reinforced concrete floor with granolithic finish, a flat concrete roof and measures 71ft x 35ft (21.64m x 10.67m). It remains in use as a medical centre.

The water processing and effluent treatment facilities are concentrated at the lowest part of the site on the crest of the King Water stream valley. A **Borehole Q2.21** comprising a pump housed in a small brick hut with a flat timber roof is situated due south of the former weighbridge (Fig 54). To the south of the borehole was the **Domestic Water Pump House Q2.16** (Fig 55). A single storey brick building with reinforced concrete roof and floor, the pump house had dimensions of 42ft x 27ft (12.8m x 8.23m) and stood 14ft (4.27m) in height. It was joined by a short wooden corridor to the **Low Level Domestic Water Storage Tank Q2.11** (Fig 55). Measuring 42ft (12.8m) square and standing to a height of 15ft (4.57m), this reinforced concrete tank had a louvred aerator on its roof. Next to these structures stood the **Backwash Settling Tank Q48** (Fig 55). With walls and a floor of reinforced concrete, the tank measured 31ft x 11ft (9.45m x 3.35m) and 11ft (3.35m) deep and was uncovered but had guard rails along each side.

Figure 54
Borehole Q2.21
© English Heritage
(AF00134/Q2.21)

Figure 55
Domestic Water Pump Q2.16, Low Level Domestic Water Storage Tank Q2.11 and Backwash Settling Tank Q48
© English Heritage NMR (17818/06)

Immediately to the south of the entrance to the sewage plant access road is the **Midshield Sub-Station F42.1** (Fig 56). This single storey brick building on a reinforced concrete floor has a flat concrete roof and measures 25ft x 19ft 6in (7.62m x 5.94m) and 11ft (3.35m) in height. The hut is adjoined by two transformer bases divided by a brick wall and each measuring 12ft x 10ft (3.66m x 3.05m); the entire Sub-Station is still in use.

Figure 56
Midshield Sub-station F42.1
© English Heritage (AF00134/F42.1)

Directly south of the Sub-Station was the **Boiler House F3**. This was a single storey steel-framed structure clad in aluminium sheeting with a steel deck roof. It had a floor of reinforced concrete and dimensions of 50ft x 40ft (15.24m x 12.19m) and stood to a height of 18ft (5.49m). The building has been demolished and its location is marked by concrete footings. South of here was a **Fuel Compound F3.1**. Comprising two cylindrical storage tanks, 25ft (7.62m) in diameter and 17ft (5.18m) high, on a hardcore foundation, this probably supplied the fuel used in the adjacent boiler house. The structure has been subsequently demolished and the site turfed over.

In the south-east corner of the Administration Area is the motor transport section. The **Rolls-Royce Workshop and Garage F8** (Fig 57) is a large steel-framed building formed from two Robin hangars and is clad in corrugated iron sheeting with a concrete floor. It was equipped as a garage and workshop with vehicle lifts, battery charging facilities and lubrication equipment. An additional **Rolls-Royce Workshop and Transport Garage F8.1** stands immediately due south of F8 and is of similar construction with a tarmac floor, corrugated

Figure 57
Motor Transport related structures in the south-east corner of the Administration Area
© English Heritage NMR (17818/08)

aluminium walls and sliding doors at either end. Both F8 and F8.1 are currently in use. Two **Robin Hangars F8.2** and **F8.3** to the east were evidently amongst the first structures to be erected on site from their appearance on early aerial photographs (Charles H Martin archive). Of standard steel-framed construction these have both now been demolished but their locations are indicated by their respective concrete floors. The **Petrol Filling Station F27** (Fig 57) is located just to the north between the fuel compound F3.1 and F8.3. Two petrol pumps and two diesel pumps were housed in a flameproof installation and supplied from four 2,000 gallon (9,092 litre) tanks located underground in a pit measuring 35ft x 13ft (10.67m x 3.96m) and 13ft (3.96m) deep. The function of this feature has remained unchanged although the 1950s pumps have now been replaced with modern fixtures.

Post Blue Streak Features

Figure 58
A number of structures to the west of the Main Building F1 were built in association with the ELDO project and are visible as concrete floor slabs painted pale blue
© English Heritage NMR (17818/06)

Numerous buildings were added to the Administration Area following the abandonment of the Blue Streak project in 1960. A number of these that are not shown on original Blue Streak plans of the area and do not appear on contemporary photographs have been attributed to the phase of activity on site associated with the 1960s ELDO project. Immediately to the west of the Main Building F1 (and running parallel to its west wall) are two long, narrow areas of floor slabs (Fig 58). Their surfaces retain traces of pale blue paint and they clearly represent the positions of former structures. A third and smaller pale-blue hardstanding survives just north of here. All three floor surfaces now support secondary features, as described below.

Several of the buildings in this area are modern additions made during the use of the site by the RAF and largely provide garage facilities and storage. On the hardstanding immediately adjacent to F1 is a modern brick **Sub-Station F115 (Fig 59)**.

Figure 59
Modern brick Sub-station F115 built on top of a pale blue concrete floor slab that dates to the ELDO phase of construction
© English Heritage (AF00134/F115)

Figure 60
Modern steel framed garage F112
© English Heritage (AF00134/F112)

Figure 61
Gas Cylinder Store F111
© English Heritage (AF00134/F111)

On the adjacent ELDO-phase footing is a modern steel-framed **Garage F112** (Fig 60). A wire mesh enclosure that functions as a **Gas Cylinder Store F111** stands on the third, smaller hardstanding (Fig 61). Between the last two, a modern **Chemical Store F117** has been added. Two modern steel-framed **Garages F113** (Fig 62) and **F114** (Fig 63) stand in the north of the Administration Area. These double bay structures are three-sided and open to the south.

Figure 62
Modern steel framed garage F113
© English Heritage (AF00134/F113)

Figure 63
Modern steel framed garage F114
© English Heritage (AF00134/F114)

Figure 64
Modern Fuel Store F116 and brick structure F42.3a
© Crown copyright NMR (AA94/1924)

To the east is a **Modern Fuel Store F116** comprising a brick bund and cylindrical fuel tanks. A single storey brick built structure **F42.3a** has been constructed to the east of the fuel store (Fig 64).

In the north of the Administration Area, preserved in its handling frame, is a single Blue Streak launch vehicle (Figs 65 and 66). The vehicle, which was in three main sections: the separation bay, tank section and propulsion bay, had a combined handling cradle. This was used for transporting the complete vehicle by road and for erecting it at the test site. Facilities for mechanically tensioning the tank section to induce additional structural strength during handling were provided by hydraulic jacks on the tank section handling frame itself. The LOX tank could also be pressurised from gaseous nitrogen bottles mounted on the frame. This example was used as a model to measure electrical components before fitting to an actual rocket assembly. It was formerly held by the RAF Museum Hendon before it was moved to Spadeadam in 1988.

Figure 65
A Blue Streak launch vehicle in its handling frame stands in the Administration Area car park
© Crown copyright NMR (AA94/1927)

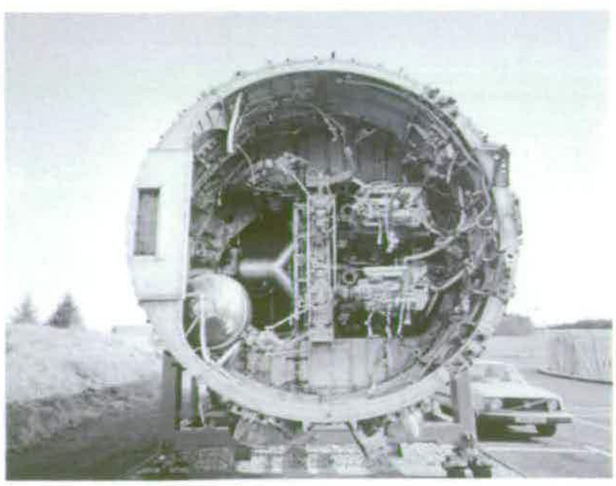

Figure 66
The complex interior of a BlueStreak launch vehicle is exposed in the Administration Area car park
© Crown copyright NMR (AA94/ 1925)

A triangular piece of turfed ground immediately to the north-west of the Guard Room F110 is covered in slight earthwork scarps. Aerial photographs taken during the construction phase at Spadeadam (Charles H Martin Archives) show three single storey timber huts and two smaller auxiliary buildings in this area (Fig 67). These huts, oriented north-east to south-west, provided accommodation for a temporary workforce during the construction work.

Figure 67
Aerial photographing taken in 1957 showing temporary huts near the Admninistration Area
© Rolls-Royce plc

Figure 68
Aerial photograph of the Administration Area taken in 1957
© Rolls-Royce plc

Figure 68 dates to 1957 and was taken in the early stages of building work (Fig 68). An aerial image taken two years later indicates that by 1959 construction work was much more advanced (Fig 69). The temporary huts, though still in existence at this time, were evidently subsequently demolished.

Figure 69
Aerial photograph of the Administration Area taken in 1959
© Rolls-Royce plc

Figure 70
Fire Station Q2.19
© English Heritage
(AF00134/Q2.19)

To the north of the Administration Area is the fire services area. The **Fire Station Q2.19** is a double-bay steel-framed Robin hangar clad in corrugated iron (Fig 70). The **Central Fire Pump House Q2.17** is a single storey brick structure with a flat concrete roof (Fig 71). In front of it was a **Hose Drying Tower Q2.20** and the foundations of this can still be seen. There was also a **High Level Water Storage Tank Q2.101** in this area, where foundations and ground level pipe-work remain (Fig 72).

Figure 71
Central Fire Pump House Q2.17
© English Heritage
(AF00134/Q2.17)

Figure 72
Site of the High Level Water Storage Tank Q2.101
© English Heritage
(AF00134/Q2.101)

British Oxygen Company (BOC) Compound

Background History

Fundamental to Blue Streak test firings - either of the RZ-1 engines or entire missiles - were supplies of kerosene, liquid oxygen (LOX), liquid and gaseous nitrogen. The weapons programme required such large quantities of cryogenics (a maximum combined total of 250 tons per day of liquid oxygen and liquid nitrogen) not only because of the amount actually used during firings but also because of the high levels of evaporation when pre-cooling the tanks and piping networks. It was obvious at the outset that to obtain supplies from commercial sources, the nearest of which was some fifty miles from Spadeadam, would be uneconomic. Apart from the high commercial cost, the difficulties incurred in the transportation of volatile gases and the necessity of obtaining reliable supplies in bad winter weather had to be considered. For these reasons it was decided to build a designated plant for the manufacture of cryogenics within the test establishment. This would have a maximum potential daily output of 100 tons (101.6 tonnes) of LOX, 60 tons (60.96 tonnes) of gaseous nitrogen and 8 tons (8.126 tonnes) of liquid nitrogen. British Oxygen Gases Limited, the company tasked with the supply of liquid oxygen (LOX), liquid and gaseous nitrogen, was one of the key members of the consortium of companies originally involved in the experimental work at Spadeadam. Various agreements were drafted throughout the late 1950s between the Ministry of Supply and British Oxygen Gases Limited or the British Oxygen Company Limited (BOC) for the construction of the factory by British Oxygen Engineering that would then be operated by BOC on behalf of the Ministry (TNA: PRO AVIA 92/3; TNA: PRO AVIA 92/4). By January 1957, work had begun on the first stage of the LOX plant. A second plant stage was approved by the Ministry of Supply in February 1958 and the entire plant was scheduled for completion in August 1959 at a total cost of £1,543,280. The plant was to be kept in a state of readiness for full production at all times costing an estimated £150-£1,010 per week depending on whether it was in full operation. The actual amounts required seem to have fallen significantly short of the plant's maximum production capacity due to the cancellation of the full missile testing programme. The average amount of LOX produced annually between 1962 and 1966 was 11,360 tons (11,541 tonnes) at 26,920 cu.ft/ton and the amount of liquid nitrogen produced rose from 452 tons (459 tonnes) at 30,780 cu.ft/ton in 1962 to 1,010 tons (1,026 tonnes) in 1966 reflecting the increased pace of rocket testing by ELDO (TNA: PRO AVIA 65/1906; TNA: PRO AVIA 92/4). Essential services including water, security and fire-fighting facilities were supplied by the establishment (under the general management of Rolls-Royce). The LOX plant used large amounts of electricity (also supplied by the establishment) so it was situated adjacent to the site's main intake from the national grid. The plant was run by employees of BOC who were subject to the Official Secrets Act but were entitled to the use of canteen, medical and safety facilities provided for all establishment staff. The disposal of caustic effluent produced during the manufacture of liquid oxygen and liquid/gaseous nitrogen was a significant consideration. Re-causticising by conventional plant or electro-dialysis means was not available on site so waste had to be transported off site. ICI Limited offered to absorb some of the effluent for use as a neutraliser for their own acidic waste.

Figure 73
At the British Oxygen Company (BOC) Compound cryogenics were manufactured for use at Spadeadam
© English Heritage NMR (17818/05)

The LOX manufacturing compound lies some 100m to the north of the Administration Area on a plateau of ground to the west of a tributary of the King Water (Fig 73). The production area is today defined on three sides by a substantial sub-square earthwork around 2.0m high. The south and east sides comprise a well-formed bank whereas the west side is defined by a scarp cut into the existing ground level. The earthwork is discontinuous in the south-west corner providing an access point 7.0m wide to the adjacent **Central Electricity Generating Board Compound** (CEGB) **Q3.7** some 20m further west. The central core of the cryogenic production factory was enclosed by a tubular steel **Perimeter Fence D19**. The only surviving section of this fence is at the former entrance where a pair of concrete gateposts, 3.0m high, still stand. To either side of the gateposts are sections of fencing in the middle of which are square steel plates bearing the BOC logo (Fig 74). The southern gate of what was originally a double leaf gate also survives.

Figure 74
A perimeter fence with a gate bearing the company logo surrounded the BOC Compound
© Crown copyright NMR (AA94/2901)

Cryogenic Production of Liquid Nitrogen and Liquid Oxygen

In order to interpret the derelict remains at the BOC Compound it is helpful to look briefly at the cryogenic production process (Fig 75).

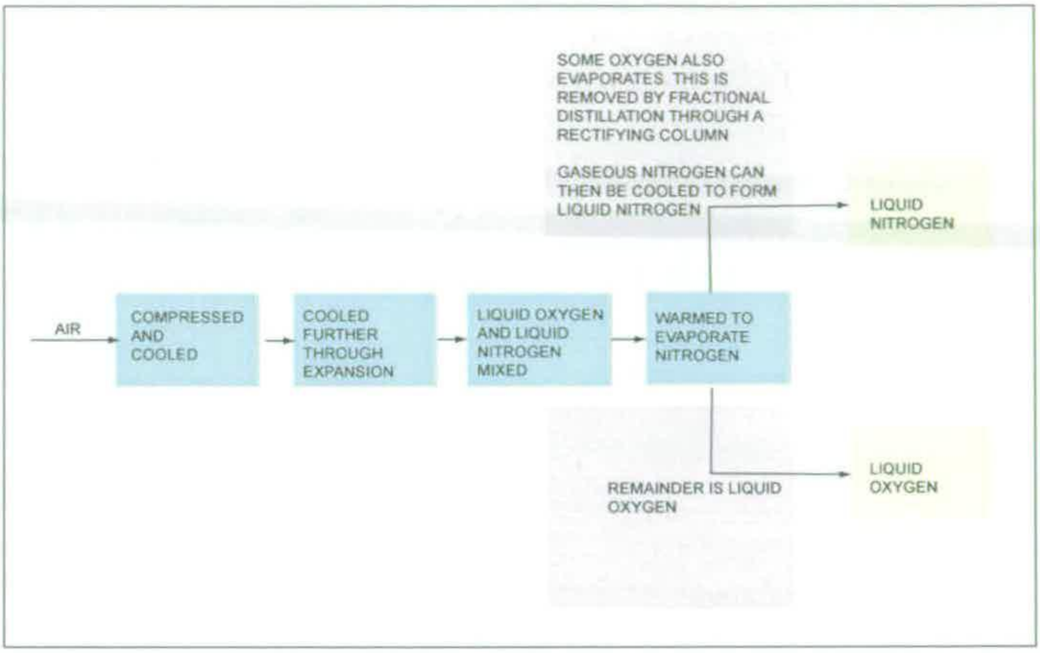

Figure 75
The cryogenic production of liquid nitrogen and liquid oxygen was carried out at the BOC Compound

The atmosphere is largely composed of gaseous nitrogen and oxygen. If these components can be cooled and separated then liquid oxygen and liquid nitrogen can be obtained. The cryogenic production process therefore essentially involved four phases: compression (which inevitably creates heat), cooling (to remove that heat), expansion (to cool further) and separation. If air is compressed and cooled and then allowed to expand again there is a resultant net drop in temperature. If this process is repeated enough times the air is eventually cooled to the point where it liquifies as a mixture of oxygen and nitrogen. To liquify nitrogen gas it must be cooled to –196°C; oxygen turns into a liquid at the slightly higher temperature of –183°C. To separate the two, the mixture is warmed enough for the more volatile nitrogen to turn back into a gas leaving liquid oxygen. Some oxygen inevitably evaporates with the nitrogen so fractional distillation (i.e. bubbling the evolved gas mixture through liquid in a rectifying column) is necessary for the separation of the two gases. Separation results in the production of liquid oxygen and, after re-cooling, liquid nitrogen. The total cost in terms of energy of producing 1 ton (1.02 tonnes) of liquid oxygen from a raw material of air was 920kWhr (Gardner, 1963-4).

Figure 76
Aerial photograph of the BOC Compound taken in 1957
© Rolls-Royce plc

An aerial photograph taken in 1957 shows that construction had begun at this time on the steel frame of the main BOC Compound building (Fig 76). A similar view taken in 1959

Figure 77
Aerial photograph of the BOC Compound taken in 1959
© Rolls-Royce plc

indicates that by this date the manufacturing plant was complete or nearing completion (Fig 77). This main building D1 is shown in a contemporary ground view (Fig 78).

Figure 78
Contemporary view of the BOC Compound taken from the north-east
© Rolls-Royce plc

To its north is the yellow LOX storage tank D3 and two grey cylindrical Nitrogen Gas Holders D6.1 and D6.2. The LOX Sub-Station D10 is clearly visible in front of these but a wooden structure in the foreground is not depicted on plans of plant. This may have been a temporary structure and its site is currently covered in tussocky grass.

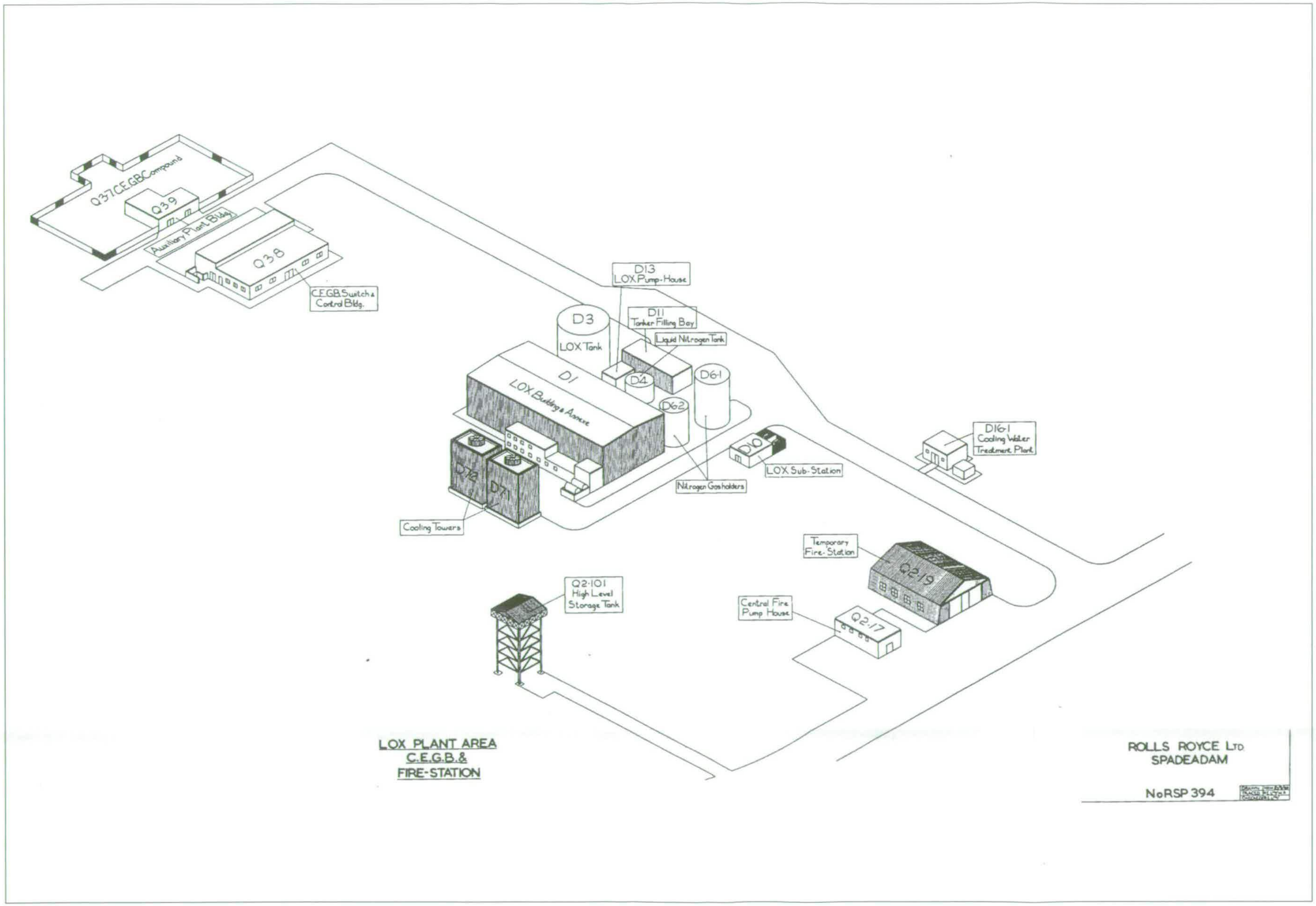

Figure 79
Diagram of the BOC Compound
© Rolls-Royce plc

The main structure within the BOC compound (Fig 79) was the **LOX Building and Annexe D1 and D2** (Fig 80). This two storey steel-framed building measured 182ft x 65ft (55.5m x 19.8m) and stood to a height of 38ft 6in (11.73m) high. Its external walls were of windowless corrugated aluminium sheeting and it had a steel deck roof. Nothing now remains of the walls or roof of D1. The ground floor was of 8in reinforced concrete with a granolithic finish.

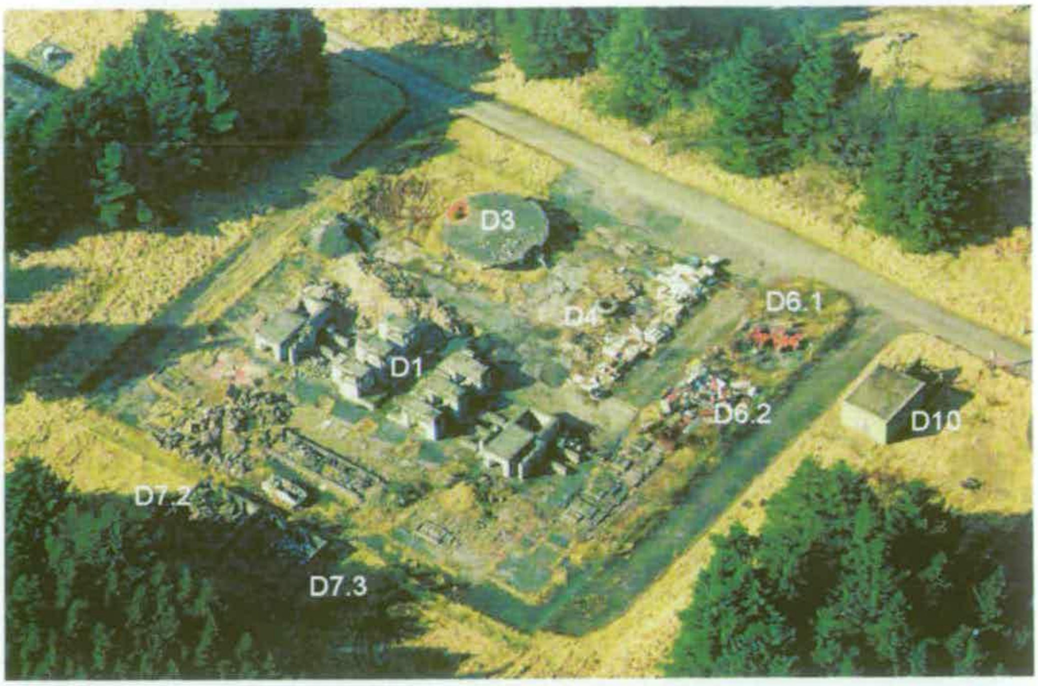

Figure 80
Modern aerial photograph of the BOC Compound © English Heritage NMR (17802/10)

Equipment used in the production of liquid nitrogen and oxygen was supported at first floor level by a series of massive concrete bases that still survive as the derelict and rubble-strewn remains of the plant (Fig 81). The most substantial of these remains comprise six

Figure 81
Concrete bases supported equipment used in the production of cryogenics in building D1 © Crown copyright NMR (AA94/2904)

rectangular concrete blocks with maximum dimensions of 6.5m x 2.6m standing 3.5m in height. These have integral concrete corbels on their inner faces indicative of either the former presence of a travelling crane or supports for the superstructure. To the east and west of these are single hollow machine footings. These have maximum dimensions of 8.6m x 6.1m, stand approximately 3m in height and have a pentagonal cross section 1.8m high and 1.85m wide. All the concrete work is finished to a high standard with smooth surfaces and chamfered corners although the tops of the bases are capped with coarse concrete. This may indicate that the machine bases were cast and some of the steel work was put in place before being sealed by a final layer of concrete. The bases are arranged in a symmetrical layout that reflects the division between the two plants, each being similar in form and function. The first floor level, or operational floor, was of reinforced concrete and steel chequer plate, and was reached by steel stairs.

Figure 82
Compressor housed in building D1
© Rolls-Royce plc

Each plant had a **Compressor Section D1.2** and **D2.2** with a main 6-stage compressor capable of compressing air to 3510 psig (Figs 82 and 83). Plant 1 was capable of supplying 50 tons (50.8 tonnes) of liquid oxygen and 60 tons (60.96 tonnes) of liquid nitrogen every 24 hours. Plant 2 was capable of supplying 46 tons (46.74 tonnes) of liquid oxygen, 8 tons (8.13 tonnes) of liquid nitrogen and 60 tons (60.96 tonnes) of gaseous nitrogen in a similar time. The action of compressing air generated heat so this was reduced with the use of a water coolant.

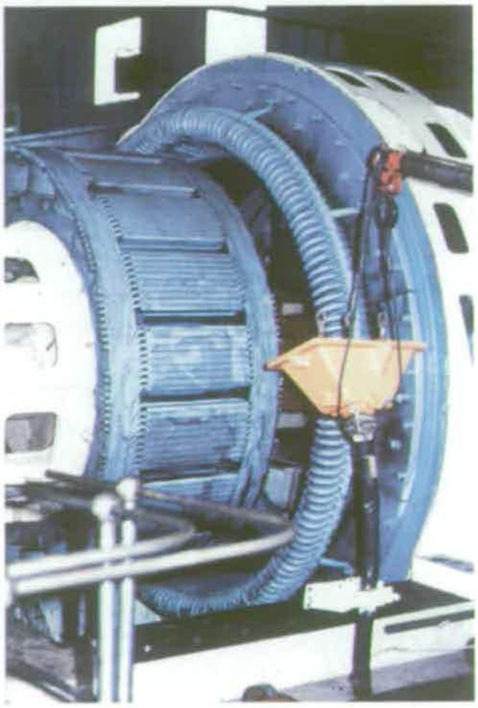

Figure 83
Compressor housed in building D1
© Rolls-Royce plc

Heated water from the main and nitrogen compressors ran into a hotwell from where it was pumped to the top of **Cooling Tanks D7.1** and **D7.2** to the south of the main building. Similar in form and function, these concrete tanks, measuring 7.9m square, formed an enclosed well above which was supported a timber superstructure. The water percolated down the cooling tanks, dissipating heat, to a coldwell from where it was pumped back into the plant. Water for use in the cooling system was provided by the remote **Cooling Water**

Figure 84
Cooling Tanks D7.1 and D7.2 now derelict, stand to the south of the main BOC Compound building © Crown copyright NMR (AA94/2910)

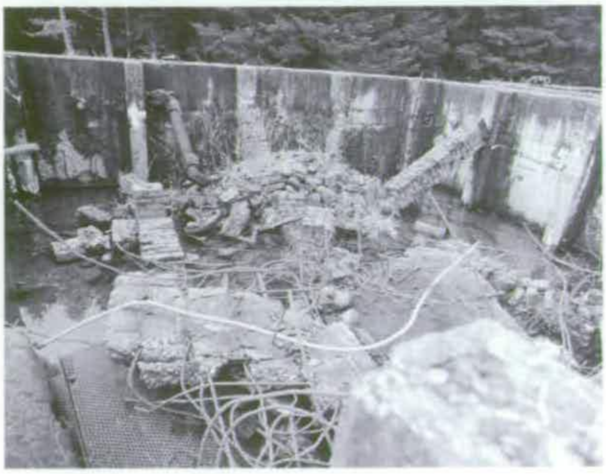

Figure 85
Interior of derelict Cooling Tanks D7.1 and D7.2 © Crown copyright NMR (AA94/2911)

Treatment Plant D16.1. This rectangular single storey structure is located some 70m to the east of the BOC Compound. The building, which measures 18ft x 12ft (5.49m x 3.66m) and stands to a height of 13ft (3.96m), was built to treat water that was circulated as coolant in the cryogenic production process and contained a salt saturator and softener. To the west of the plant is a raised and covered drain. To the east is a covered tank measuring 3.36m x 3.07m; immediately to the east of this is an open water-filled tank 1.85m square.

Figure 86
Cooling Water Treatment Plant D16.1 © English Heritage NMR (AF00134/ D16.1)

Each plant also had an **Air Expansion System D1.4** and **D2.4**. Air cooled significantly upon re-expansion in the network of pipes, heat exchangers and columns run at low temperature. Air entering the system at high pressure was also cooled by waste nitrogen and pure nitrogen products of the LOX plant. Between the second and third stages of compression, air was diverted into respective **Caustic Sections D1.3** and **D2.3** where it passed into a carbon dioxide removal system. This involved air being fed through a series of two caustic scrubbers before re-entering the compressors in a carbon dioxide-free state. Two **Air Separation Units D5.1** and **D5.2** were located within a single storey building measuring 23ft x 17ft (7.01m x 5.18m) and 25ft (7.62m) high situated adjacent to the north side of the main building. The structure was of corrugated aluminium sheeting with a reinforced concrete floor with granolithic finish and no windows. Today these are marked by partly exposed sections of concrete flooring. An Argon Gas Column was included to increase the yield of LOX from the main column. From here, liquid oxygen was pumped to the **LOX Storage Tank D3** and liquid nitrogen flowed to the **Liquid Nitrogen Storage Tank D4**.

Figure 87
Steel edged conduits and concrete machinery plinths mark the position of the former plant room and electrical switch room
© Crown copyright NMR (AA94/2909)

Along the eastern side of the main building were the plant room and electrical switch room marked by steel edged conduits and concrete machinery plinths between 0.2m and 0.4m in height.

There was a separate **Caustic Area D1.3** within the main building measuring 17ft 6in x 24ft (5.33m x 7.32m), probably for the storage of caustic materials. This area seems to have existed as a sealed unit as its height is recorded as being 21ft (6.4m). Flooring within the caustic area comprised distinctive acid resistant tiles, remnants of which are still visible as a frost-shattered surface in the south-west corner of D1.

A narrow two storey **Annexe D1**, with dimensions of 144ft x 12ft (43.89m x 3.66m) and 21ft (6.4m) high, ran along the south wall of the main building. This was a brick structure with steel windows and a ground floor of 8in (0.2m) reinforced concrete with granolithic finish and part acid resistant tiles. The upper storey, reached by steel stairs, had a floor of 6in (0.15m) and 9in (0.23m) concrete with granolithic finish and a roof of reinforced concrete. Entry to the annexe was gained via the main building. Although the site of the annexe is now obscured by tipping, it may have encompassed a substantial concrete bund that survives as a damaged feature.

Within the south-east corner of the main building and annexe was a **Boiler House D1.5**. This single storey brick building measured 21ft x 18ft (6.4m x 5.49m) and stood to a height of 21ft (6.4m). It had an 8in (0.2m) reinforced concrete floor with granolithic finish and a roof also of reinforced concrete as well as metal louvres and timber entrance doors. Adjacent to the boiler house, a brick **Fuel Compound** with dimensions of 22ft x 17ft (6.71m x 5.18m) stood to a height of 3ft 6in (1.07m) and comprised a bunded area containing two tanks on concrete plinths.

Storage and Distribution of Cryogenics

Storage facilities for cryogenic fluids must be effectively insulated. For normal industrial uses for LOX super-insulation is not necessary. More conventional 'powder-vacuum insulation' at atmospheric pressure is satisfactory. Stratification is important in handling liquefied gases i.e. a thin layer of relatively warm liquid on top of the main bulk in a storage tank. Where transfer by pressurisation is required, the presence of stratification is an advantage as it enables the pressure of a stored liquefied gas to be raised without appreciably affecting the temperature and hence heat content of the bulk of the stored liquid. Transfer of liquid oxygen on a large scale is almost always effected by means of appropriate transfer pumps, usually of centrifugal type. For intermittent operation and where rapid priming is necessary, a submersible pump is used. Liquid nitrogen can be dealt with similarly. LOX cannot be handled in carbon or low alloy steel. Stainless steel or various alloys of copper, nickel etc can be used. Equipment to contain oxygen must be cleaned for oxygen service.

Storage of finished products manufactured at the compound was to the north of the main building. A **Liquid Nitrogen Tank D4** here originally comprised a storage tank of 3,000,000ft^3 (84,900m^3) capacity but this no longer survives. It was supported on an octagonal base, 2.6m in diameter and 1.3m high, that stands on reinforced concrete raft foundations. The tank base may originally have included a surrounding circular brick wall, as with LOX bases elsewhere on site (see C2.5 and C3.5). To the west of here was the **LOX Storage Tank D3 Fig 88)**. The feature comprises an octagonal base of reinforced

Figure 88 *Contemporary photograph of the Liquid Oxygen Storage Tank D3* *© Rolls-Royce plc*

Figure 89
D3, raised concrete support for the Liquid Oxygen Storage Tank © Crown copyright NMR (AA94/2907)

concrete, 11.0m in diameter, with 21 concrete columns, each 0.4m in diameter (Fig 89). These support a raised circular platform that once held the LOX tank with a capacity of 15,000,000ft³ (424.5m³) off the ground for reasons of insulation. Two lines exited the LOX storage facility: the first was a gravity feed to the adjacent Tanker Filling Bay and the second went via two Lawrence vertical pumps. The **LOX Pump House D13** was situated between the two storage tanks. This single storey brick building measured 22ft x 17ft (6.71m x 5.18m) and stood to a height of 17ft (5.18m). It had a floor of reinforced concrete with a granolithic finish, a roof also of reinforced concrete and gantry beams at ceiling level. It has been demolished and the site obscured by tipping. Directly to the north was the **Tanker Filling Bay D11**. This single storey steel framed structure was 50ft (15.24m) long and of uncertain width. It had one side of aluminium sheeting on steel rails and the other three were open. The floor was of reinforced concrete with an aluminium sheeting roof. LOX was transported by road tankers from the plant to storage tanks in the test areas. Nitrogen gas was pumped by pipeline to high pressure reservoirs in each of these areas.

To the east of here were two **Nitrogen Gas Holders D6.1** and **D6.2** (Fig 90). Although now obscured by tipping, these seem to have been similar structures comprising circular reinforced concrete bases, 9.0m in diameter with an external concrete kerb.

Figure 90
Concrete bases for Nitrogen Gas Holders D6.1 and D6.2. The photograph was taken in 1994 but these features had been obscured by tipping at the time of survey © Crown copyright NMR (AA94/2908)

Visible concrete footings, 0.6m square, are indicative that cylindrical steel framed tanks were once supported here.

Within the area between the main earthwork and the core of the LOX compound are various other features. A row of concrete stanchions 0.5m high follows the line of the east arm of the earthwork bank, between the Sub-Station D10 and the south-east corner of the area. These are topped with galvanised metal brackets and would originally have supported cabling or pipes. Two brick valve housings, each around 1.5m square, are respectively located immediately to the west and east of the former cooling towers D7.1 and D7.2. Other features that served the LOX compound included the **Effluent Drainage D9**, delay tanks and treatment plant; **External Services D12** including roads, drains, ducts and pipe bridges; **Fire-fighting D14** water mains, ducts and trenches within the area; the **Domestic Water Mains D15**; and the **Process Proving Equipment D100**.

Figure 91
Sub-station D10
© Crown copyright
NMR (AA94/2902)

Electricity for the BOC compound was regulated by the **LOX Compound Sub-Station D10** (Fig 91). Located on the line of the eastern section of the perimeter fence this single storey brick structure measures 25ft x 20ft (7.62m x 6.1m) and stands 11ft (3.35m) in height. It has a 6in reinforced concrete floor with granolithic finish, a similarly constructed roof and a brick wall dividing the two transformer bays. The north side was enclosed by a chain link security fence and, excepting the removal of the actual transformers, survives today in its original form.

Central Electricity Generating Board Compound

The main electrical distribution system for the range is located some 20m to the west of the BOC Compound in the **Central Electricity Generating Board Compound Q3.7 (Fig 92)**.

Figure 92
Modern aerial photograph of the Central Electricity Generating Board Compound Q3
© English Heritage NMR (17818/05)

This comprises a single storey brick **Switch and Control building Q3.8** originally equipped with an 11kV switchboard with batteries and associated metering equipment. To the west of this is the **Auxiliary Plant Building Q3.9**. An L-shaped brick building, this originally housed oil filtering equipment. Immediately north-west of the Auxiliary Plant Building was a **Transformer Compound** containing two 13kVA transformers. From here power was carried to the rest of the site; originally this was by overhead cable but power lines were transferred below ground in association with the development of the Proof and Testing Establishment in the 1970s. A brick built structure (numbered 609621) adjoins the south of the power plant. This is a modern addition and post-dates the Blue-Streak phase of the site. A second modern brick building lies to the west of the Auxilliary Plant building Q3.9. Although this plant supplied electricity to the entire establishment, the system was not designed to cope with supplying the vast amounts of power needed for simultaneous firings at the Engine and Missile Test Areas (TNA: PRO 65/350).

Equipment Yard

North of the BOC Compound is a steep scarp around 2.5m in height that defines an area of higher ground to the north. This area is terraced into the general gradient and within it survive the traces of concrete hardstandings. A T-shaped building footing has maximum dimensions of 22m x 27m; it contains a row of rectangular brick plinths, 0.2m x 0.7m in area. An adjacent hardstanding is roughly square in shape and measures a maximum of 23m x 26m; the two are separated by a line of four low concrete plinths each around 1.0m square. This area, shown on aerial photographs dating to October 1957 and to 1959 (see BOC Compound above) as containing a number of single storey timber huts, associated

Figure 93
Contemporary photograph of the Equipment Yard taken from the BOC Compound looking north. The partially constructed Component Test and Engine Test Areas are visible in the background
© Rolls-Royce plc

smaller sheds and storage tanks, appears to have functioned as an equipment yard during the initial construction phase. A contemporary photograph, possibly taken from the roof of the main BOC Compound building D1 (Fig 93), shows a single storey timber hut and stock piles of building materials in this area.

Component Test Area

The Component Test Area (Fig 94) occupies a level site some 300m to the north-west of the LOX compound and is reached by a minor road that branches west from the main spine road. The facility was used for the testing and calibration of sub-assemblies of the component

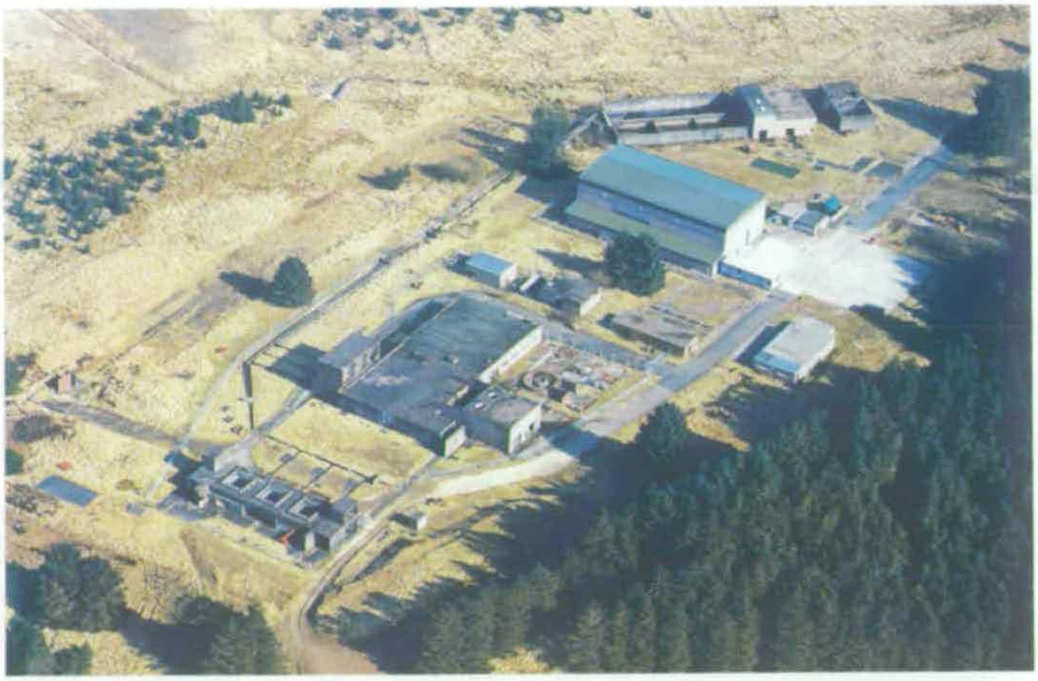

Figure 94
Modern aerial photograph of the Component Test Area looking north-east © English Heritage NMR (17818/11)

parts. Individual parts were placed under extreme conditions to assure their reliable performance once assembled prior to the testing, elsewhere on site, of the complete rocket engine units. Most features in this area were constructed between 1957-9 in association with the Blue Streak missile phase of the site. An aerial photograph dating to 1957 (see

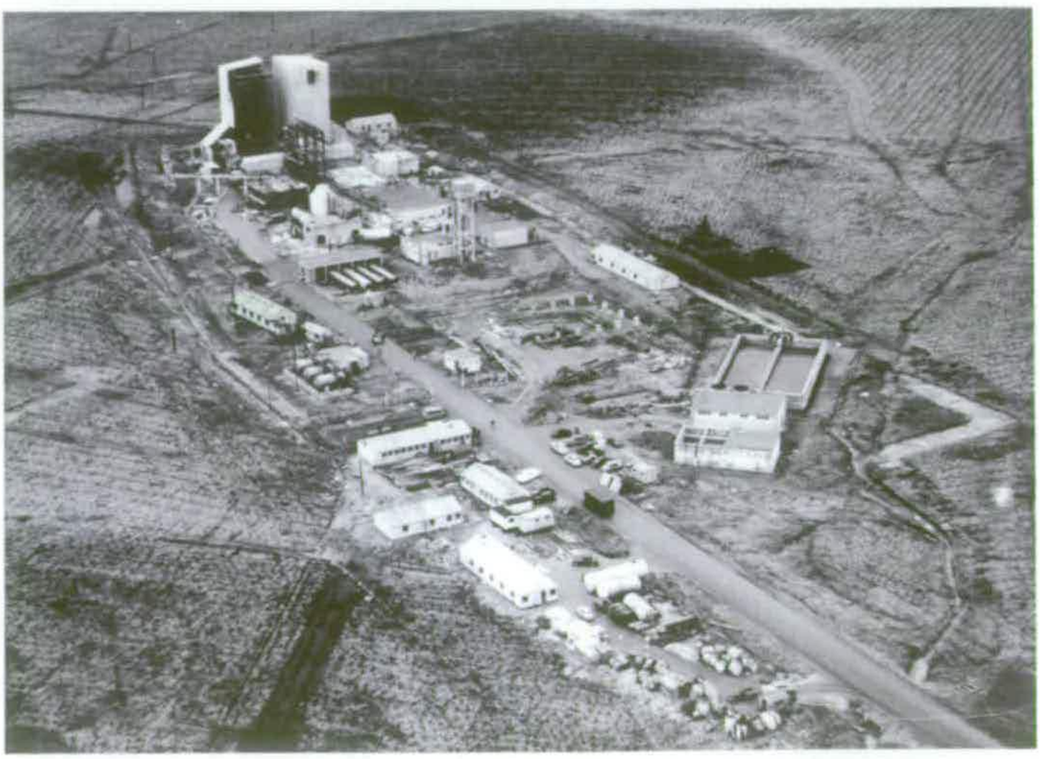

Figure 95
Aerial photograph of the Component Test Area taken in 1959 looking north-west showing advanced construction work © Rolls-Royce plc

BOC Compound above) shows that some ground works had been begun at this time though few upstanding buildings are visible. Construction work was significantly further advanced in 1959 as indicated by an aerial photograph taken at this time (Fig 95). Five or six timber huts were erected at the Component Test Area during this construction period alongside an area of general storage to the south of the main access road. The huts were removed following the completion of building work but a hardstanding measuring 20.9m x 6.3m, one of the original hut bases, survives. The track to this area and further hardstandings may also survive but this area is covered by coniferous plantation. The test area is also shown in an early colour photograph, possibly taken from the roof of the main BOC Compound building D1 (Fig 96). This facility was also diagramtically depicted by Rolls-Royce (Fig 97).

Figure 96
Contemporary photograph of the Component Test Area taken from the BOC Compound looking north
© Rolls-Royce plc

The access road runs westwards past a Police Control Post B5 into what was originally a fenced enclosure. The southern side of the area is defined by a steep scarp, around 2.5m in height that creates a level platform for buildings to the north. Within the main test area was a Central Control Room B1, test cells and associated supply systems. In the east of the compound was the Water Flow bench Laboratory B3. A secondary compound to the east of here housed structures associated with the treatment of effluent. The modern fence encloses derelict buildings but does not, for the most part, follow the original fence lines.

A later test facility was added by Rolls-Royce in 1967 in the area immediately to the north of the original test area. This was the Liquid Hydrogen-Liquid Oxygen Thrust Chamber Facility and its substantial remains, principally comprising an earthwork flameway, were also recorded during the survey. Some minor features were subsequently added to the site in association with its use by the RAF and a small number of buildings within the Component Test Area are currently still in use.

Entry into the area was past a **Police Control Post B5** (Fig 98). This is a single storey rectangular brick building measuring 4.35m x 5.95m which was substantially altered to convert into a Plant Room and numbered B3.1.

Figure 98
Police Control Post B5
© Crown copyright NMR (AA94/2936)

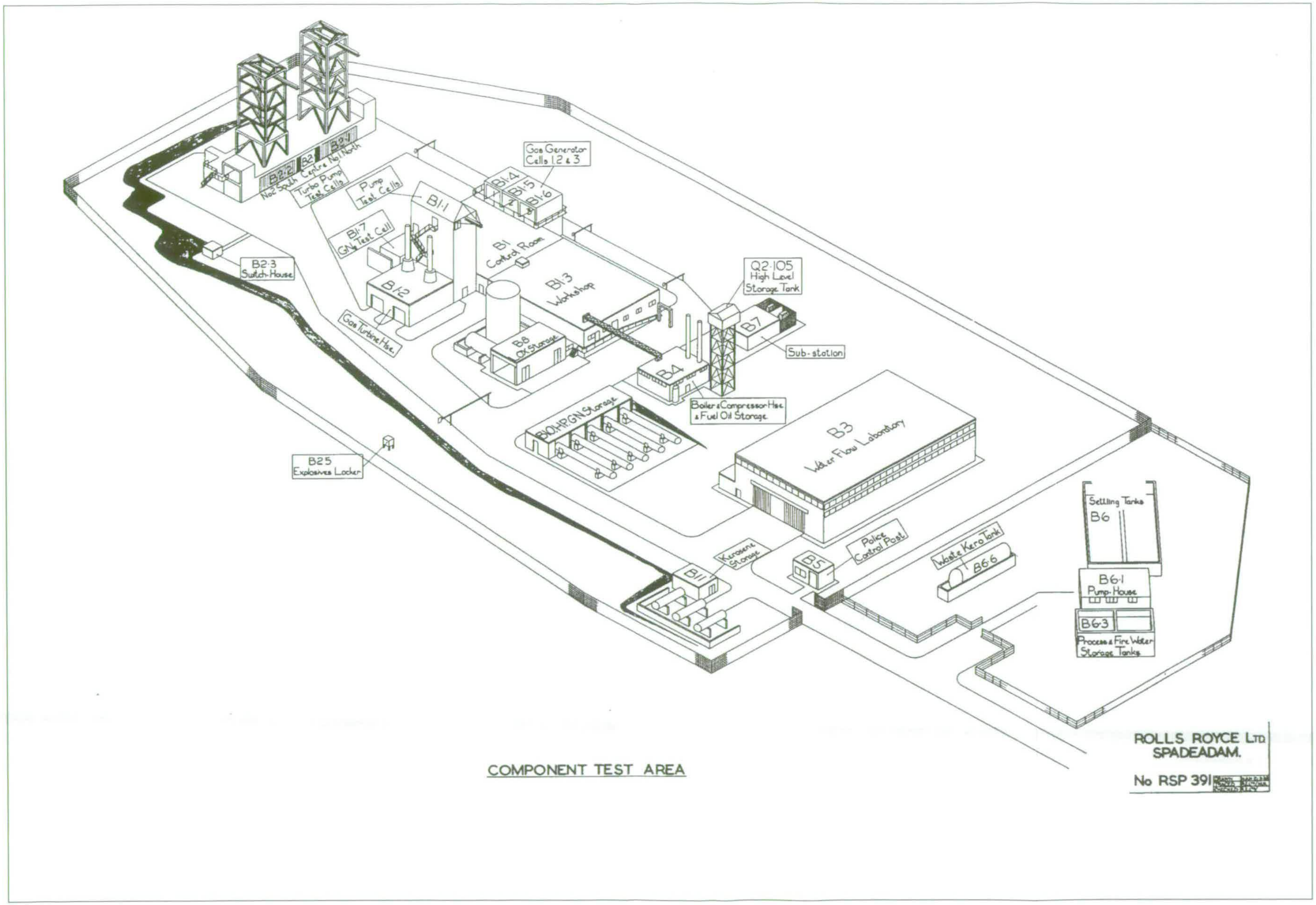

Figure 97
Diagram of the
Component Test Area
© Rolls-Royce plc

Figure 99
Component Test Area Control Room B1
© Crown copyright NMR (AA94/2952)

Central to the Component Test Area was the main **Control Room B1** (Fig 99). A large single storey building, the Control Room is of concrete construction measuring 20.2m x 19.2m with a flat concrete roof supported on six concrete pillars (Fig 100). Originally it housed the central instrumentation and control, public address and warning systems and from here all operations in the Component Test Area were overseen. Six test cells from a total of nine adjoined the Control Room. A number of toughened windows consisting of two

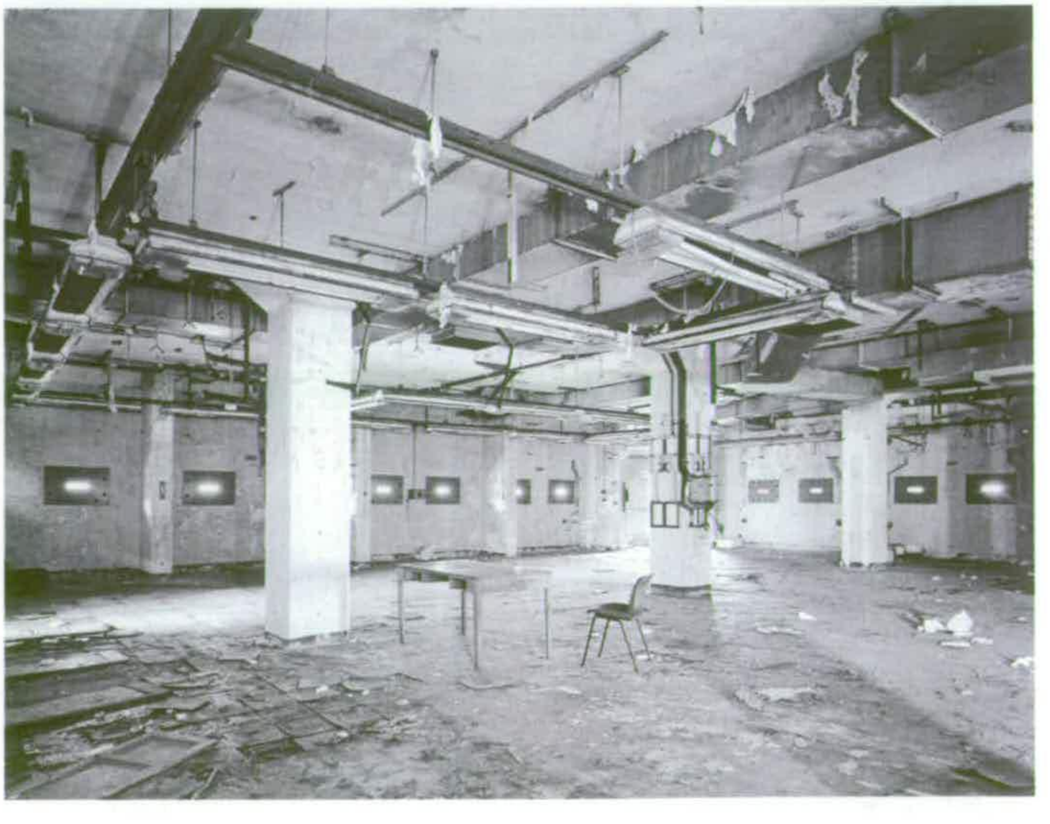

Figure 100
Derelict interior of the Control Room B1
© Crown copyright NMR (AA94/2945)

layers of armoured glass steel held between red painted mounting plates bolted to either side of the walls allowed the direct observation from the Control Room interior of experiments being conducted in the test cells (Fig 101). Six armoured windows in the southern wall allowed viewing of the adjacent Pump Test Cells B1.1; eight windows in the west wall looked across to the detached Turbo Pump Test Cells B2, and in the northern wall a further eight windows (two of which are sealed by steel plates) provided visual access to the Gas Generator Cells B1.4-1.6. The majority of the Control Room's services, including air conditioning ducting, fluorescent lighting and cable trays, were suspended from the ceiling.

Figure 101
Steel mounting plates are bolted to either side of observation windows in the Control Room B1
© English Heritage NMR (DP003959)

Figure 102
Pump Test House B1.1 comprised two brick test cells - one for kerosene pump callibration and the other for liquid oxygen pumps
© Crown copyright NMR (AA94/2941)

Figure 103
Interior of the derelict Pump Test Cells B1.1
© Crown copyright NMR (AA94/1936)

Adjoining the Control Room to the south was the **Pump Test House B1.1** (Fig 102). Measuring 11.0m x 5.4m this comprised two brick built test cells – one for kerosene pump calibration and the other for testing liquid oxygen pumps. The two cells were essentially identical but the liquid oxygen test cell had an additional catch-tank. Currently open to the sky, the cells were originally covered by steel framework and reinforced concrete towers holding stainless steel kerosene and LOX tanks, the lower portions of which survive within the cells (Fig 103). The remains of cabling and fixing brackets survive in both test cells and in the western cell is mounting formed from steel plate and an instrumentation panel. Experiments conducted within the cells were monitored from the Control Room through six armoured windows.

Directly to the south of the Pump Test House was the **Gas Turbine House B1.2** (Fig 104). This consisted of two interconnected plant rooms accessed by two large entrances in their southern walls that are closed by steel 'concertina shutters. The plant rooms have overall dimensions of 11.0m x 10.8m and a flat concrete roof with circular openings that were originally topped by cylindrical ventilation shafts. The building contains concrete machinery plinths and originally housed a pair of Avon RA.7 turbojets geared to provide 14,000 shaft horsepower for turbo-pump testing in the two adjacent pump calibration test cells (Technical Editor 1960, 477).

Figure 104
Interior of the derelict Gas Turbine House B1.2
© Crown copyright NMR (AA94/2942)

In the western angle between B1 and B1.1 was the **Gaseous Nitrogen Test Facility B1.7**. Measuring 3.6m x 4.5m, this had five channels set into the floor for mounting and securing test rigs and two armoured windows which allowed tests to be viewed from the Control Room. Its floor sloped gently to the south to allow unspent fuel to be washed into a sunken drainage channel and thereby enter the effluent system of the Component Test Area. The cell was equipped with pressure regulation flow meters and filters and, uniquely, it had a 0.46m (18in) thick concrete blast wall to the south.

To the north of the Control Room, in a free-standing two storey structure of reinforced concrete, were three further ground floor test cells. These **Gas Generator Test Cells B1.4, B1.5 and B1.6** had channels for the securing of test rigs and sloping floors that drained into effluent channels to the north (Fig 105). Internally, the cells measured 3.2m x 5.5m and were equipped with an exhaust burning system. Above these, were a further six open cells: three faced to the north and three to the south (Fig 106). These were possibly for the high pressure storage of liquid oxygen and kerosene in stainless steel tanks. The upper east cell has since been bricked up but it is not clear whether this was done at the time of operation or as a later alteration perhaps in association with the introduction of the Liquid Hydrogen - Liquid Oxygen test stand in 1967.

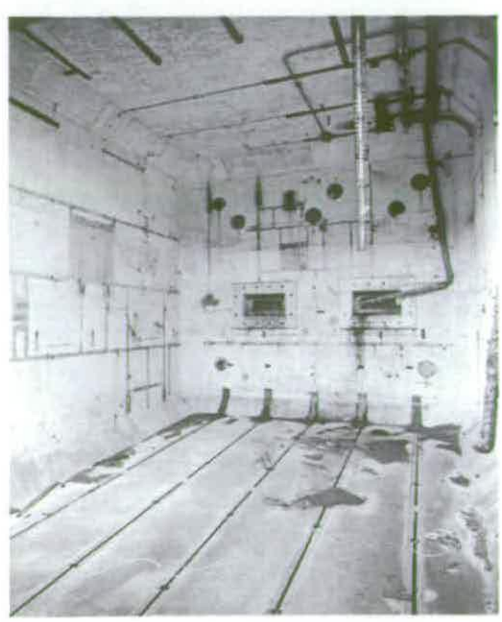

Figure 105
Interior of the Gas Generator Test Cells
© Crown copyright NMR (AA94/1935)

Figure 106
Gas Generator Test Cells B1.4, B1.5 and B1.6 looking south-east. Above these were further cells one of which has been bricked up
© Crown copyright NMR (AA94/2943)

To the east of the Control Room was a steel-framed brick built **Workshop B1.3** (Fig 107). This structure measures 23.4m x 19.2m, has a flat concrete roof and is entered either through the adjoining Control Room or from the east via a concrete ramp. Internally, it has a grid of 6 by 4 bays with a row of steel columns down the centre of the building and offices and stores along its north and south walls. Some fittings, including electrical fittings and ducting for the central heating system, remain attached to the ceiling; most of the interior is fire-blackened. A self-contained switch room retains some racking and cable ducts and to its west is a plant room that projects into the workshop area. Presumably reflecting the staff profile, the Workshop included a gents' washroom but no ladies' washroom. North of the Workshop is a small free-standing brick building with a flat concrete roof. Measuring 1.2m x 2.3m and standing 2.6m in height, this building is similar in construction to B2.3 and may also have functioned as a switch house.

Figure 107
Workshop B1.3 looking north
© Crown copyright NMR (AA94/1938)

Figure 108
Liquid Oxygen Storage Facility B8 looking south-west
© Crown copyright NMR (AA94/1939)

In the angle between B1.3 and B1.1/1.2 was the main **Liquid Oxygen Storage Facility B8** (Fig 108). In common with similar tanks elsewhere in the establishment, it was supported on a thick circular brick wall, 1.45m in height, which had an octagonal concrete pier at its core. Just south of this, concrete walls survive that originally supported a horizontal tank and to the east, in an area that is partially covered in surface rubble and debris, is the concrete floor of a former building associated with LOX storage that is now demolished.

Figure 109
Turbo Pump Test Cells B2 looking north-east
© Crown copyright NMR (AA94/1929)

Some 30m west of the main Control Room was a large concrete structure of rectangular plan. This housed the **Turbo-Pump Test Cells B2** (Fig 109). These three single storey test cells were virtually identical in design: open to the east and west but with steel concertina doors, internal measurements of 7.0m x 7.8m and with a large square hole in the roof. Their floors have six metal-lined channels for securing test equipment and slope to the east to facilitate the drainage of unspent fuel into the effluent system (Fig 110). The northernmost cell, **B2.1,** was referred to as Turbo-Pump Cell T1 whilst that to the south, **B2.2** was known as Turbo-Pump Cell T2. The roofs above these test cells originally supported two steel framework towers located

Figure 110
The floors of the test cells sloped to the east draining unspent fuel into the effluent system
© Crown copyright NMR (AA94/1931)

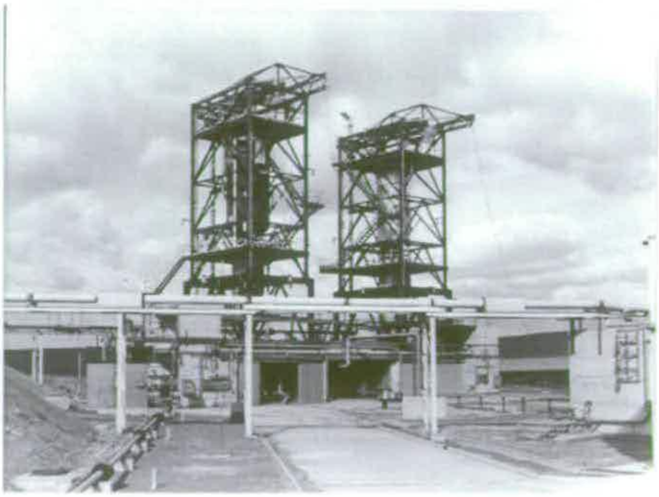

Figure 111
Contemporary photograph showing steel framework towers above the test cells
© Rolls-Royce plc

over the square holes (Fig 111). These towers held, respectively, a stainless steel 5,000 gallon kerosene tank and a stainless steel 8,500 gallon liquid oxygen tank. There is a further similar cell, **B2.6** (also known as T3), between B1 and B2. At either end of building B2 were further concrete cells. At the south is a single storey cell with an open side facing west and two cells in a two storey configuration with open sides facing south. This arrangement was mirrored at the north end of the main building (*see* Fig 109). These cells may have contained pressurized fuel vessels and pumps and their design - facing outwards away from the main structural body - was probably indicative of the need to mutually isolate the storage cells from the tests cells to limit damage in the event of an explosion. The whole structure was overlooked from the Control Room through eight armoured windows in the west wall across an area that is blank with the exception of drainage channels and low-lying concrete plinths and drain covers.

Immediately to the west of the turbo-pump test cells is an area of concrete hardstanding. This is intersected by shallow channels, square in cross-section that carried cabling to the cells. By the north-west corner of this hardstanding are the remains of the **Battery House B2.4** (Fig 112). Traces of the lowest courses of its demolished brick walls are still discernable and a flat concrete roof slab, measuring 2.2m x 2.9m, lies at ground level, intact. To the north-east of the turbo-pump test cells, beside a deep effluent drainage channel, is a valve pit 1.5m square and two identical sub-rectangular concrete footings with dimensions of 1.8m x 2.2m. On the other side of the effluent channel are a series of sunken metal electrodes.

Figure 112
Remains of the Battery House B2.4
© English Heritage AF00134/B2.4

Figure 113
Contemporary aerial photogtraph showing a hut, back right
© Rolls-Royce plc

Other associated building activity includes a rectangular hardstanding measuring approximately 12m x 6m to the north of B2.4. A hut is show in this position on an early aerial photograph of the Component Test Area under construction (Blue Streak Collection, Tullie House Museum) .

To the east of B1.3 were a number of technical service structures. Arranged linearly, from north to south, the first of these was the **LOX Evaporation Pit B18** (Fig 114). This survives as a sub-rectangular hole currently made safe with a sheet metal cover, 1.5m x 1.9m, and a surrounding tubular steel fence. Adjacent to B18 is a brick valve pit measuring 1.5m square. The second numbered structure in this line is a **Sub-Station and Transformer B7** (*see* Fig 114). This single storey brick building has a flat concrete roof and measures 5.9m x 8.7m. At the northern end are two transformer bays separated by a central brick

Figure 114
The LOX Evaporation Pit is visible in the foreground with the Sub-station and Transformer B7 behind
© Crown copyright NMR (AA94/2938)

wall, though the transformer has been removed from the eastern bay. To the south of here, and some 14m due directly east of the workshop B1.3, is the **Boiler House B4 and Compressor House B4.1 and Fuel Oil Storage** (Fig 115). Housed in a single, solidly built brick building with a flat concrete roof measuring 8.0m x 9.8m these comprise two self-contained internal bays. The southern bay, formerly the Compressor House, has been fire damaged. Adjoining B4 to the north is a concrete bund originally for horizontal tanks that have since been removed. It has maximum external dimensions of 6.6m x 4.8m and four internal concrete supports. Adjoining B4 to the east are the remains of the concrete footings for a **High Level Storage Tank Q2.105**. A series of low concrete supports runs at a slight angle between the site of this storage tank and the adjacent building B3 (described below p.77).

Figure 115
A single brick structure housed the Boiler House B4 and Compressor House and Fuel Oil Storage B4.1
© Crown copyright NMR (AA94/1941)

To the south of B4/4.1 is a sub-rectangular area terraced into the general gradient; this was the location of the **High Pressure Gaseous Nitrogen Store B10** (Fig 116). The store is a rectangular building of reinforced concrete and brick measuring 17.3m x 5.5m. Its east side is open apart from four supporting pillars and faces a series of concrete blocks, 2.0m x 0.6m and 0.5m in height. These were mounting blocks and they supported five horizontal cylinders 40ft (12.19m) in length and 4ft (1.22m) in diameter in which gaseous nitrogen was stored.

Figure 116
The High Pressure Gaseous Nitrogen Store B10 was open to the east. Blocks in front supported five horizontal gas cylinders
© Crown copyright NMR (AA94/2939)

Due south of B10 was the **Pump House and Kerosene Store B11** (Fig 117). Its purpose was the storage and distribution of kerosene within the Component Test Area and the structure currently still functions as a store. It is a rectangular single storey building constructed from brick with a flat concrete roof. Below ground immediately to the south of the store were three 5,000 gallon (22,730 litre) tanks with pumps, filters and distribution mains. This area is now covered by a large modern concrete hardstanding.

Figure 117
Pump House and Kerosene Store B11
© Crown copyright NMR (AA94/2940)

A large brick structure towards the east end of the Component Test Area compound is the former **Water Flow Bench Laboratory B3** (Fig 118). Its purpose was to provide a variable pressure, calibrated water flow for component testing, including turbo-pumps, thrust chambers, and injector plates. When it was in operation it was the most powerful test cell of its type in the country, with test capacities of 2,000 gallons (9,092 litres) per minute at

Figure 118
Water Flow Bench Laboratory B3
© Crown copyright NMR (AA94/2937)

950lb per square inch, and 6,000 gallons (27,276 litres) at 300 pounds per square inch (Technical Editor 1960, 477). The main building, 22.4m x 36.2m, is a brick-clad steel-framed structure with a large central bay and a row of offices to the west. It originally contained a large water filled pit used in the testing process; this had been in-filled and the building is now used as a vehicle maintenance garage. To the rear of the building is a concrete hardstanding, 9.5m x 3.5m, that may originally have supported machinery. Some 100m to the north-west of B3 is a small hardstanding, 2.89m x 2.35m, which probably represents the footings of a former structure. The ground to the rear of B3 has been recently disturbed and some dumped material has been deposited in the Effluent Channel immediately north of the building.

Unspent fuel from the Gas Turbine House B1.2, from the Gaseous Nitrogen Test Facility B1.7, from the Turbo-Pump Test Cells B2, and from the Gas Generator Test Cells B1.4, B1.5 and B1.6 along with contaminated cooling water discharged during firings all drained into the Component Test Area effluent system (Fig 119). The floors of these features are all

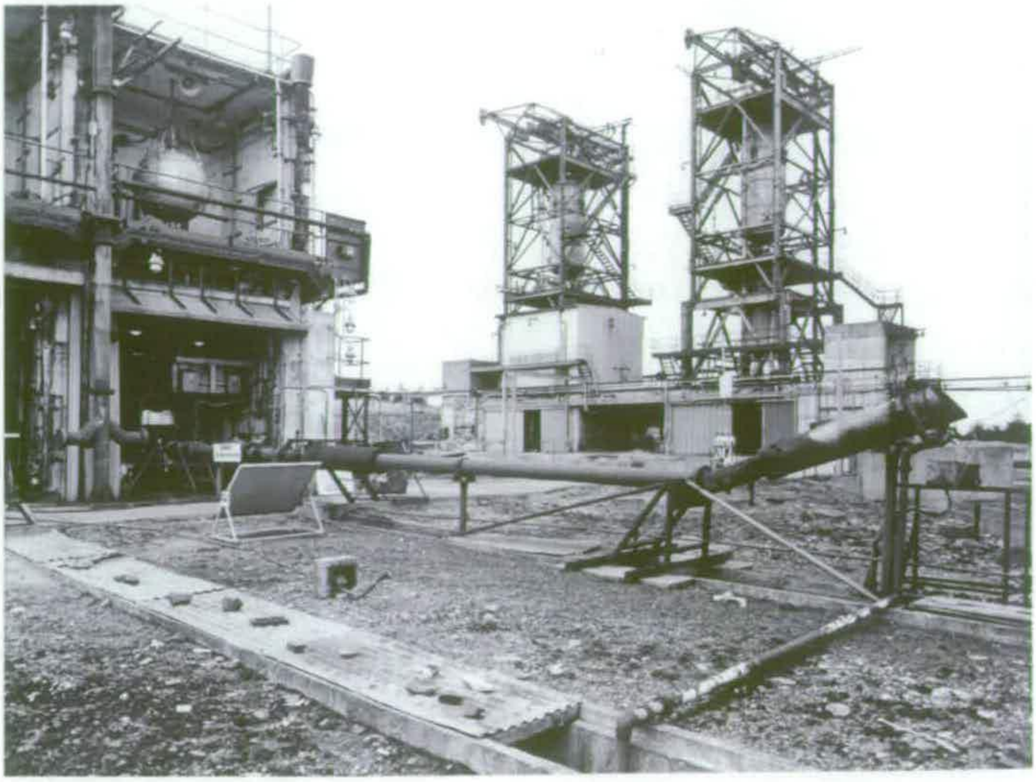

Figure 119
A contemporary photograph shows corrugated iron-covered drainage channels which carried unspent fuel and effluent from the test cells to the Settling Tank B6
© Rolls-Royce plc

sloping to facilitate drainage into sunken concrete channels in front of the open cells. From here, waste fuel was carried in a network of below ground conduits to the north side of the enclosure where they fed into a single main **Effluent Channel B6** (Fig 120). Rainwater from a limited area around the test cells plus any fire service water used was also collected and run into the effluent channel. This substantial concrete sluice is 0.5m in width with 0.2m thick walls and of varying depth; a groove along each side of the channel indicates that they were covered by metal grills. To the north of the gas generator test cells the conduit turns a sharp angle and rises above ground as a visible structure extending eastward in a straight line for some 135m. To the north of the former Water Flow

Figure 120
A network of channels that were originally covered fed into a single main Effluent Channel B6
© Crown copyright NMR (AA94/2935)

Figure 121
The main drainage conduit is supported on concrete stanchions as it approaches the Settling Tank B6 © Crown copyright NMR (AA94/2933)

Bench Laboratory B3 the ground level drops away steeply and here the conduit is supported on concrete stanchions (Fig 121). Unspent fuel was conveyed via this conduit to a large concrete lagoon or **Settling Tank B6** and entered its north end through a series of four metal sluice gates (Fig 122). This rectangular tank measures 17.1m x 31.2m. Internally it is divided into two equal halves

Figure 122
A series of four metal sluice gates controlled the flow of effluent from the main channel into the Settling Tank B6 © English Heritage (AF00134/B6 sluice)

Figure 123
The Settling Tank B6 is divided internally down its length by a concrete wall. The south-west side is further subdivided by cross walls © English Heritage NMR (17802/05)

down its length by a substantial concrete wall (Fig 123). The south-west side is sub-divided laterally into three sections by two brick cross walls. Although corresponding walls no longer exist in the north-east half of the tank, traces are visible on aerial photographs suggesting they were previously in place. The tank was equipped with facilities for separating kerosene for re-use and for filtering water for return to supply tanks.

To the discharge end or south-east of the lagoon is a **Pump House and Effluent Treatment Plant B6.1** (*see* Fig 123 above). This formed part of the effluent treatment system and contained a de-oiling and pressure filtration plant. The building, a single storey brick structure with a flat concrete roof, measures 15.2m x 15.6m. Unusually, the Pump House is a two-phase construction. The earlier structure lies to the south-east and at the southern end of the eastern elevation there is a small brick out-shot building. The original building was enlarged to the north by a taller extension which overlies the roof of the earlier structure (Fig 124). Machine bases are still visible within the Pump House but its floor is now partially flooded.

Figure 124
Pump House and Effluent Treatment Plant B6.1 (middle distance) and the Process Water and Firewater Storage Tanks B6.3 (foreground)
© Crown copyright NMR (AA94/2934)

The plant consisted of two pressure filters with transfer pumps and a chemical dosing plant, housed along with the fire and cooling water pumps. Transfer pumps delivered effluent from the lagoon to the pair of de-oiling filter units at a controlled rate. Each filter contained graded anthracite with special pre-formed floc on top; the filter bed floc was prepared in chemical mixing tanks and pumped to the filters. The chemical mixing tanks and pumps were interchangeable as conditions required. A high speed mixer prepared the chemicals for the floc which was settled and washed free of sulphate before delivery to the filters as ferric hydroxide and sorbocel. Ferric hydroxide was the main agent for removal of kerosene from the effluent and sorbocel formed a bulk filter aid. Each filter can process 5000 gallons per hour and a venturi flow controller could be set to a desired figure up to a maximum of 10 000 gallons per hour if both filters were used together. Backwash to the filters was provided from the domestic water supply system. A motorised agitator at the head of each filter assisted the removal of the pre-coated filter floc during backwash. After each backwash the pre-coated floc had to be re-made by pumping from the chemical mixing tanks. The backwash water was passed to conical-bottomed tanks and the sludge was drawn off from the base of the tanks for transfer by tanker for disposal to the central kerosene storage and incinerator area. The clear liquid was returned by gravity to the storage tanks. Waste Kerosene was then collected and removed from site.

To the south-east of the Pump House and Effluent Treatment Plant, and connected to it by heavy gauge lagged pipes, are the **Process Water and Firewater Storage Tanks B6.3**. This comprises a rectangular concrete tank divided in two with maximum external dimensions of 16.5m x 8.4m. At the centre of each tank is a column supporting a cruciform arrangement of roof supports. From modern aerial photographs it is apparent that whilst the eastern half of the tank retains most of its original cover, the western portion is now entirely open.

Process water entered the area via a 12in (0.3m) branch from the 18in (0.46m) gravity main and a 3in (0.08m) branch fed the process water storage tank via a sand pressure filter. Solids were removed in this filter and backwash was provided from the domestic supply. Filtered water was then delivered to a 50,000 gallon (227,300 litre) concrete storage tank. Water from the fire fighting system was drawn on a 9in (0.23m) branch from the common 12in (0.3m) main and taken direct to a separate, similar, 50,000 gallon (227,300 litre) concrete storage tank. In the event of heavy requirements within the area, additional fresh water could be provided to the storage tank from the borehole and domestic water system. Water for fire fighting could also be delivered direct to the area main by-passing the Pump House and storage tank via a non-return valve when the fire pumps were not running.

Process water was drawn from the storage tank by two similar pumps each with rated duties of 500 gallons (2,273 litres) per minute against a total head of 170ft (51.82m). It was then delivered by two main duty pumps each with a rated duty of 1,000 gallons (4,546 litres) per minute against a total head of 170ft (51.82m) and one pressurising pump. Manual control was provided in the Pump House itself and remote operation in the area Control Room B1. Pumps for fire water were designed for fully automatic operation to be able to start up under all conditions of head.

Distribution of process water was through a 6in (0.15m) cast iron main of Stanton pipes. The principal requirements were a 6in (0.15m) branch to the turbo-pump test cells and to the LOX and kerosene pump test cells. Subsidiary branches from these mains provided services to the gas generator test cells and the gas turbine house. Delivery of process water to the water Flow Lab was via direct line from the Pump House. Fire Pumps in the Pump House discharged to a 10in (0.25m) main and then to a 10in (0.25m) ring main around the area. Water could be drawn off at hydrant points around the site and also to installations within the test cells.

10m west of the Pump House, in an area of otherwise open ground between B3 and the B6 range, is a sunken rectangular concrete bund. This was constructed to hold two **Waste Kerosene Tanks B6.6** but the tanks have since been removed and the bund is now water-filled (Fig 125). A small brick building measuring 2.53m x 1.94m stands on a concrete plinth 3.06m x 2.9m immediately north-east of, and at an angle to, the bund. Although partly demolished it survives to a height of 1.95m and may represent the remains of an earlier pump house. To the south of the bund are three rectangular sunken tanks all with dimensions of approximately 1.5m x 2.5m and protected with either a sheet metal cover or tubular steel

Figure 125
A water filled concrete bund which formerly held the Waste Kerosene Tanks B6.6
© English Heritage (AF00134/B6.6)

railings. The function of this area as the effluent treatment site is reflected in the large number of drain access covers on the ground to the west of B6.1 and B6.3. An area of tarmac here, although now discontinuous, indicates the line of the original fence at the entrance to the former effluent treatment site.

To the south of the main test area, but still within the perimeter fence, were a number of other features. To the west of the Pump House and Kerosene Store B11 a pathway leads to a flight of concrete stairs. These climb a steep scarp 2.5m in height at the top of which was located an **Explosives Locker B25**. Its position is now marked by an overgrown floor slab 1.1m square and a small pile of bricks. Along the bottom of the scarp runs a line of regular concrete stanchions, 0.9m x 0.3m with attached metal fittings, which originally supported service pipes and cabling. Evenly spaced along this line are three brick valve pits, 1.5m square and at its western end, immediately south of the Turbo-Pump Test Cells B2, is a **Switch House B2.3** (Fig 126). Bricks stamped 'Stephenson 1962' may suggest that construction work continued in this area despite the facility being put on hold in 1961. A small single storey building on a concrete base with a flat concrete roof, it measures 2.74m x 2.04m and stands 2.06m in height. Although the switch house is derelict, some switch gear remains inside. Adjacent to the north and west of the switch house are several concrete plinths and drain covers. B2.3 stands at the foot of a steep slope, on the crest of which are four concrete posts – probably former cable supports – measuring 1.24m x 0.26m.

Figure 126
Switch House B2.3
© Crown copyright NMR (AA94/1940)

Liquid Hydrogen-Liquid Oxygen Thrust Chamber Facility

As described above, during the early 1960s a number of organisations were interested in investigating the use of Liquid Hydrogen-Liquid Oxygen fuel combination in rocket engines. After protracted discussions Spadeadam was chosen as the location for a small trials stand. Within the range it was decided to place the stand, termed the Liquid Hydrogen-Liquid Oxygen Thrust Chamber Facility, to the north of the Component Test Area, which had lain largely idle since 1961. The stand was built in 1967 on open ground about 30m to the north of the Turbo Pump Test Cells B2 (Fig 127). One of the reasons for locating the stand here was to reduce the expenditure required. It was able to make use of existing gaseous nitrogen pipes, electricity cables and fire fighting mains that were extended down to the new stand. Full use was also made of other surplus items in the stores at Spadeadam. To further reduce costs the facility reused the stainless steel liquid oxygen tank from the Turbo

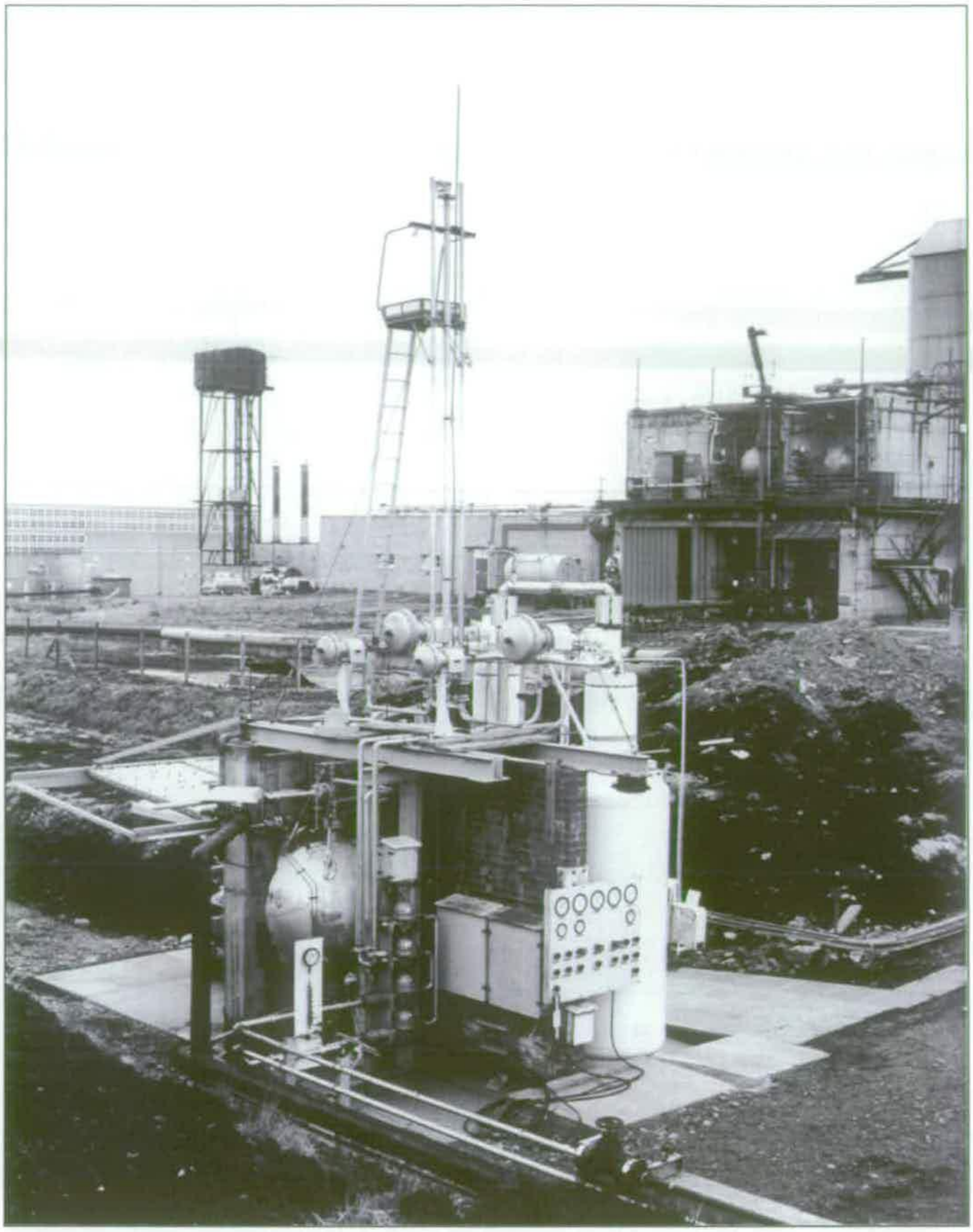

Figure 127
The Liquid Hydrogen-Liquid Oxygen Thrust Chamber Facility
© Rolls-Royce plc

Pump Test Cell T1. It was perhaps also at this time that one of the upper cells of the Control Building B1 was bricked up to create an office or control room for these experiments.

The siting of the stand made full use of the local topography and it was set into the gently northwards falling slope to provide some protection against accidental explosion. This required removing the local peat, up to 7ft (2.13m) in depth down to the underlying clay. A rough track, 6.4m in width, was cut roughly from the northern end of the Turbo Pump Test Cells B2 and surfaced with tarmac to provide access to the test stand. The remains of the stand comprise a T-shaped wall; oriented east to west is a brick wall that separated the two tanks. Draft plans dating to 1967 show the liquid-hydrogen storage tanks situated to the north of the dividing wall with the liquid oxygen to the south (TNA: PRO AVIA 92/232) (Fig 128). A photograph of the thrust chamber facility in use shows that this plan was superceded and two liquid-hydrogen tanks were positioned to the south with a single liquid oxygen tank

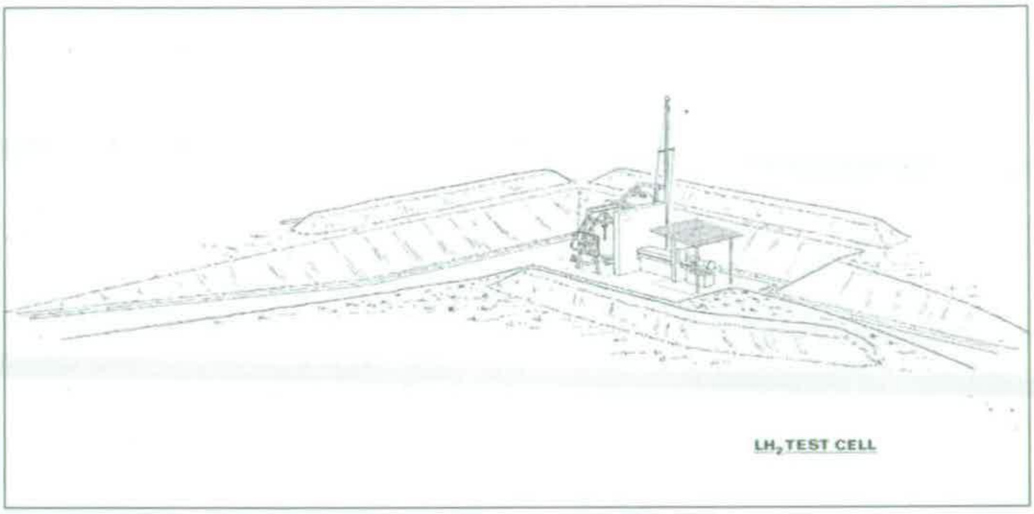

Fig 128
Diagram of the Liquid Hydrogen-Liquid Oxygen Thrust Chamber Facility
© National Archives TNA:PRO AVIA92/232

to the north (see Hill 2001, 37). A concrete north to south cross wall (Fig 129) then separated the tanks from the engine test area to the east where there are the earthwork remains of the flameway. The total cost of the stand was £81,000, the most expensive components of which were the two liquid hydrogen vessels supplied by Air Liquide, Paris, at a cost of £15,000 each (TNA: PRO AVIA 92/232). The test stand was used for one test firing in 1967, when the test chamber was successfully fired twice. Immediately afterwards funding for the project was withdrawn (Hill 2001, 37; Jeffs 2002).

Figure 129
Remains of the Liquid Hydrogen-Liquid Oxygen Thrust Chamber Facility
© English Heritage (AF00134/Thrust Chamber)

Following the cancellation of the ELDO project in the mid-1970s, most of the fittings within the Component Test Area were systematically stripped from the buildings. Some metal fixtures, such as gratings and doors, survived and are still in place today as rusted and derelict remains.

RAF alterations

A number of elements have subsequently been added to the Component Test Area. A Plant Room has been built to rear of B3.1 (formerly the Police Post B5). This brick structure with a flat concrete roof measures 6.0m x 4.3m and was probably constructed when B3 was refurbished in 1994. To the south-east is a brick bund, 7.0m x 4.5m and 0.9m high. This supports a fuel tank and may be of a similar date. On the opposite side of the access road from B3.1 is an area of hardstanding with dimensions of 27.4m x 19.3m now used for car parking. No specific reference was made to this in association with the function of this area either for Blue Streak component testing or for the later testing of RZ-2 rocket engines, suggesting that it may be a later addition to the site.

Waste Kerosene Central Storage

Kerosene that was un-burned after test firings at the Component Test Area, Engine Test Area and Missile Test Area, had to be collected and disposed of. This was separated from cooling water in the effluent lagoons by being drawn from the surface over a weir. After collection, waste kerosene was stored and settled in Waste Kerosene Storage Tanks such as C32.3. It was then transferred by road tanker to the **Waste Kerosene Central Storage Q31** located opposite the entrance to the Component Test Area. Its site is entered via a short track off the main spine road. The position of the building is marked by a sub-rectangular platform which has traces of broken concrete protruding through the surface.

Waste kerosene brought here from the test areas was held in two 12,000 gallon (54,552 litre) waste kerosene holding tanks that were situated within a concrete bund. Waste kerosene was then burned in an oil burning furnace, supplied and installed by the Wallsend Slipway Engineering Company. This was equipped with a fuel pump and had a normal capacity of 70 gallons (318 litres) per hour. There were no residual products from the waste kerosene incineration; all were discharged into the atmosphere. In addition to the two 12,000 gallon (54,552 litres) waste kerosene tanks the site housed another tank of 500 gallon (2,273 litre) capacity for the storage of clean kerosene used for burner starting. In addition to the disposal of waste kerosene the facility also dealt with sludge arising from effluent treatment plants in the three main test areas. This was compressed in special presses at the treatment plants to form filter cakes which were transferred to a holding pit at the Waste Kerosene and Central Storage facility. The cakes were then transferred to a rotary incinerator, supplied and installed by the Incinerator Company. This kiln comprised a loading skip, feeding chamber, drying unit, firing chamber, centrifugal dry dust catcher and ash trolleys. It took a normal charge of 5 cwts (255kg) and required 2 hours for the process to be completed. Ashes from the filter cake burning consisted of calcium compounds and ferric oxide and could be spread locally over the site.

Junction Area

To the north-west of the Waste Kerosene Central Storage facility Q31 the road climbs to a junction some 750m distant at NY 6103 7141. The main arterial road diverges here; to the west one branch leads to the Engine Test Area at Priorlancy Rigg whilst the other continues

Figure 130
General Post Office telephone box at the junction between Priorlancy Rigg and Greymare Hill
© English Heritage NMR (DP003941)

north. Rather incongruously at the junction is a standard 1950s General Post Office red telephone box (Fig 130). 25m to its north is a former **Police Control Post Q29** controlling access to the western road (Fig 131). Measuring 5.95m x 4.34m and standing to a height of around 3m, this rectangular brick building is no longer in use. At the end of a short track some 70m south-west of the telephone box is a **Magazine Q28** (Fig 132). This sub-square brick building measuring 7.30m x 6.71m and standing 2.7m in height has a mass concrete slab floor, no windows and a flat roof designed to blow off in the event of an explosion. To the north of this group of buildings is the Central Reservoirs area Q25 (described below p.173).

Figure 131
Police Control Post Q29
© Crown copyright NMR (AA94/1943)

Figure 132
Magazine Q28
© English Heritage (AF00134/Q28)

Priorlancy Rigg Engine Test Area

Just over 1.8km to the north-west of the Component Test Area is the Engine Test Area known as Priorlancy Rigg. The ground at Priorlancy Rigg rises gently from the south forming an east-west ridge that broadly lies between the 270m and 285m contours. It was below the crest line of this ridge on its southern side that emplacements were built for the test firing of individual propulsion units (Fig 133).

Figure 133
Modern aerial photograph of the Engine Test Area at Priorlancy Rigg © English Heritage NMR (17819/03)

The height differential offered by the natural ridge provided numerous advantages as a location for this test facility. The vertical design of the stands mimicked as closely as possible the configuration of the engines and tanks within the Blue Streak missile. Building them into the side of the natural escarpment resulted in an immediate clearance between the top and bottom of approximately 40ft (12.19m) without the need for extensive excavations. Both the top and base of the stands could be accessed from their respective ground levels. This meant that service areas were more accessible and engines could be manoeuvred into position with minimal lifting. The difference in height also ensured a natural gravitational flow-line from the upper, 'clean', area where vehicles were supplied with cryogenics and propellant to the area below in which waste water and unspent fuel flowed away from the engine to be collected in an effluent lagoon.

Power for the Blue Streak missile was provided by two Rolls-Royce RZ-2 engines developed from a design of the Rocketdyne Division of North American Aviation Inc (see Fig 6). The RZ-2 engine was a bi-propellant, pump-fed propulsion system with a nominal thrust of 137,000 lb per engine. Two of these would be mounted side by side in a missile propulsion bay, the resulting power unit being known as an RZ-12. Each engine consisted of two main functional units: the turbo-pumps that were rigidly mounted in the propulsion bay and a separately mounted thrust chamber which was gimballed for guidance. The turbo pumps were driven by gas generators which burnt a very fuel-rich mixture of LOX and kerosene. The gas generator was a small chamber which converted the engine propellants into high pressure, high temperature gas. The gas was then passed through a turbine to drive the propellant pumps via a gear train. These pumps were centrifugal units mounted on the same shaft. The separately mounted thrust chamber was a convergent-divergent design in which combustion and expansion of the propellant occurred. Propellant was injected into the thrust chamber through small holes in an injector plate; the chamber walls were cooled regeneratively by the fuel (Cleaver 1964).

Exhaust gases from each turbine were fed to an outlet duct in the plane of the main engine exhaust via a heat exchanger which formed part of the vehicle internal pressurisation system. Each engine was controlled by three primary valves: the main LOX and kerosene valves adjacent to the thrust chamber and a gas generator blade valve which isolated LOX and kerosene from the gas generator. These valves were each supported by gaseous nitrogen fed by pairs of solenoid-operated stop-valves. The sequencing of signals to the solenoid valves was done by ground electrical equipment. Ignition of the gas generator and main thrust chambers was initiated by pyrotechnic lighters. Engine starting was accomplished by supplying high pressure LOX and kerosene to gas generators from start tanks on the launcher beam close to the vehicle.

Three test stands, comprising massive concrete and steel structures spaced 250ft (76.2m) apart, were built during the original construction phase. All three were near replicas of Rocketdyne stands at the Santa Susana Field Laboratory, California and permitted full 3 minute firings of complete rocket engines. During test runs, engines were placed in the same configuration - vertical and in a gimballing frame - as they would be assembled in a rocket but anchored to the ground to prevent take off. Above the stands was the infrastructure to provide engines with fuel, water for cooling and maintenance facilities. The stream of hot efflux gases from the engines were directed into a water-cooled flame deflector. The deflector surface was angled at a 45° to turn the flow of hot efflux gases from the vertical to the horizontal plane and along the spillway that was shared by cooling water and unspent fuel. Many aspects of the test facilities at Priorlancy Rigg were similar to those at Greymare Hill described below. The first stand, known as A1, was capable of hosting not only engine firings but full vehicle firings and, initially, it was used for this role prior to the construction of the Greymare Hill Missile Test Area. In addition, Test Stand A2 could support two engines in a double configuration as used in the rocket itself. A fourth stand of innovative British design was later added to the west. Engine tests were controlled remotely from a Control Room A11 to the east that was also used for visual monitoring of experiments (Fig 134).

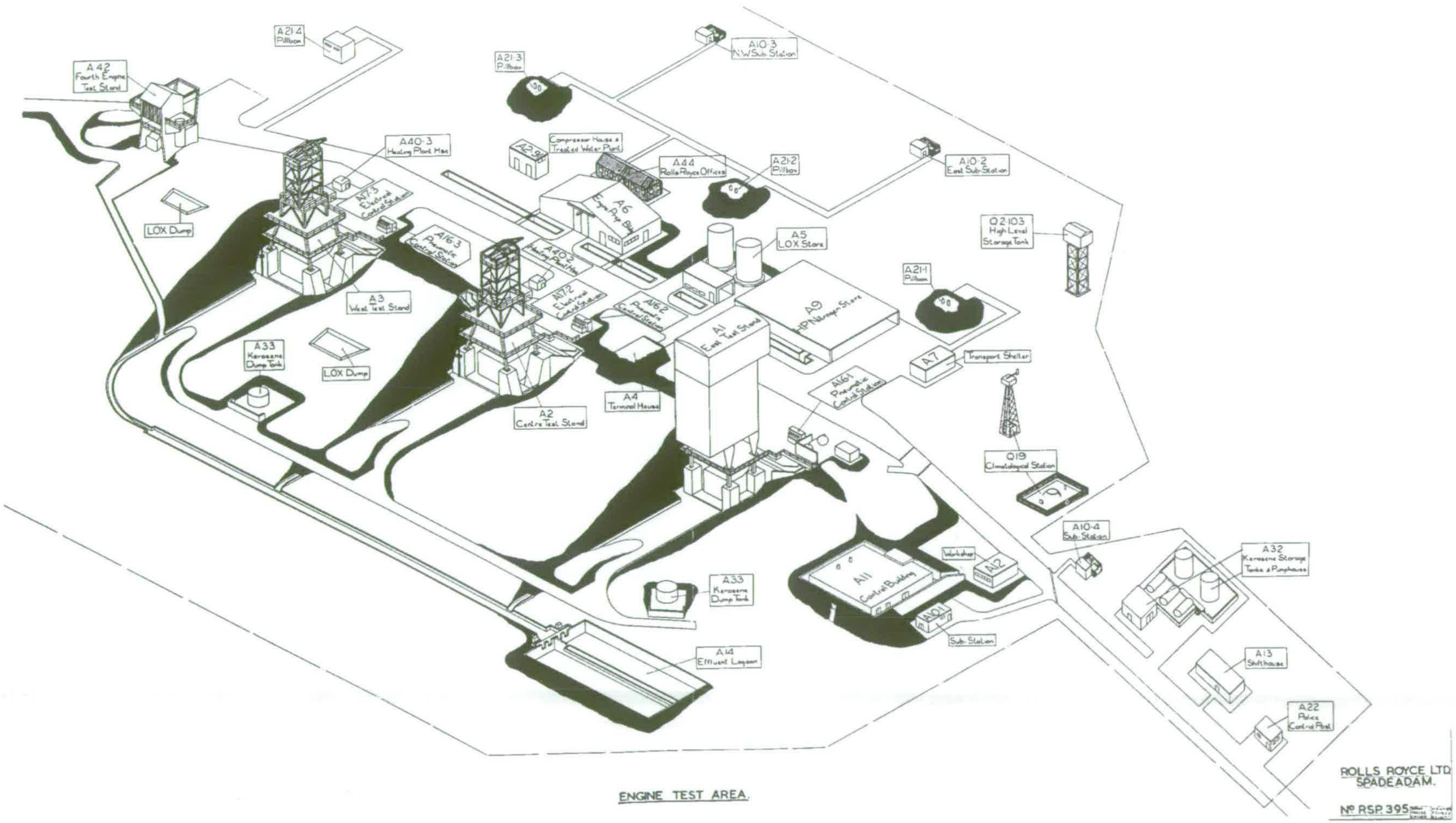

Figure 134
Diagram of the Engine Test Area at Priolancy Rigg
© Rolls-Royce plc

The noise levels on the test stands reached during firings was recorded at 165db and all frequencies. Inside the Control Room 170m from Test Stand A1 the noise levels initially reached 60-65db and measures were taken to introduce further noise reduction material on the filler panels (TNA: PRO 65/350).

Figure 135
Aerial photograph of the Engine Test Area taken in 1959 during the construction phase
© Rolls-Royce plc

An aerial photograph taken in 1957 shows that work had barely begun at Priorlancy Rigg at this date beyond the laying of an access road. An aerial image taken two years later, in 1959, shows that building work was well under way (Fig 135). Despite the use of the natural slope, significant earth moving was undertaken during construction at Priorlancy Rigg in the late 1950s. Dumped material created a vast artificial mound in the far south-west of the site. With maximum dimensions of approximately 140m x 145m the top of this mound is encircled by a loop of the lower access road. To the south of test stands A1 and A2 is a D-shaped platform of dumped material (Fig 136). With maximum dimensions of 70m x 45m its surface is concrete covered and slopes slightly to the south. At its centre is a T-shaped area of grass within which is a rectangular concrete hardstanding with eight concrete piers. From the south of the T-shape two lines of flat head rails cut off flush with the ground surface project diagonally for a distance of 14.15m. From each of the northern corners a further similar rail projects for a distance of 16.15m. This feature is not shown on contemporary diagrams of the

Figure 136
Modern aerial photograph of a D-shaped platform of dumped material and site of former aggregate grader, looking north
© English Heritage NMR (17797/00)

Figure 137
Aerial photograph taken in1959 during the construction phase showing the position of the aggregate grader, looking west
© Rolls-Royce plc

Blue Streak test stands but a structure is visible in this position on aerial photographs taken during construction of the engine test area in 1959 (Fig 137). A corrugated iron building, **Aggregate Grading Plant EH5**, is shown surrounded by mounds of dumped material contained by shuttering that corresponds to the diagonal lines of flat head rails. On later photographs of the test firings no structure is visible here suggesting that this feature represents the remains of a structure built for the construction of the test area that was subsequently demolished once construction work was complete.

The **East Engine Test Stand A1** was the largest of the stands at Priorlancy Rigg. Designed for full engine firings it was capable of resisting 1 million lbs (453,600kg) of thrust (TNA: PRO AVIA 65/1906) and was used for full rocket firings before the Missile Test Area was completed at Greymare Hill. The stand comprised a concrete base on top of which was mounted a steel-framed tower approximately 90ft (27.43m) in height. The tower, designed to withstand 300,000lbs (136,080kg) of thrust (TNA: PRO AVIA 65/1906), supported

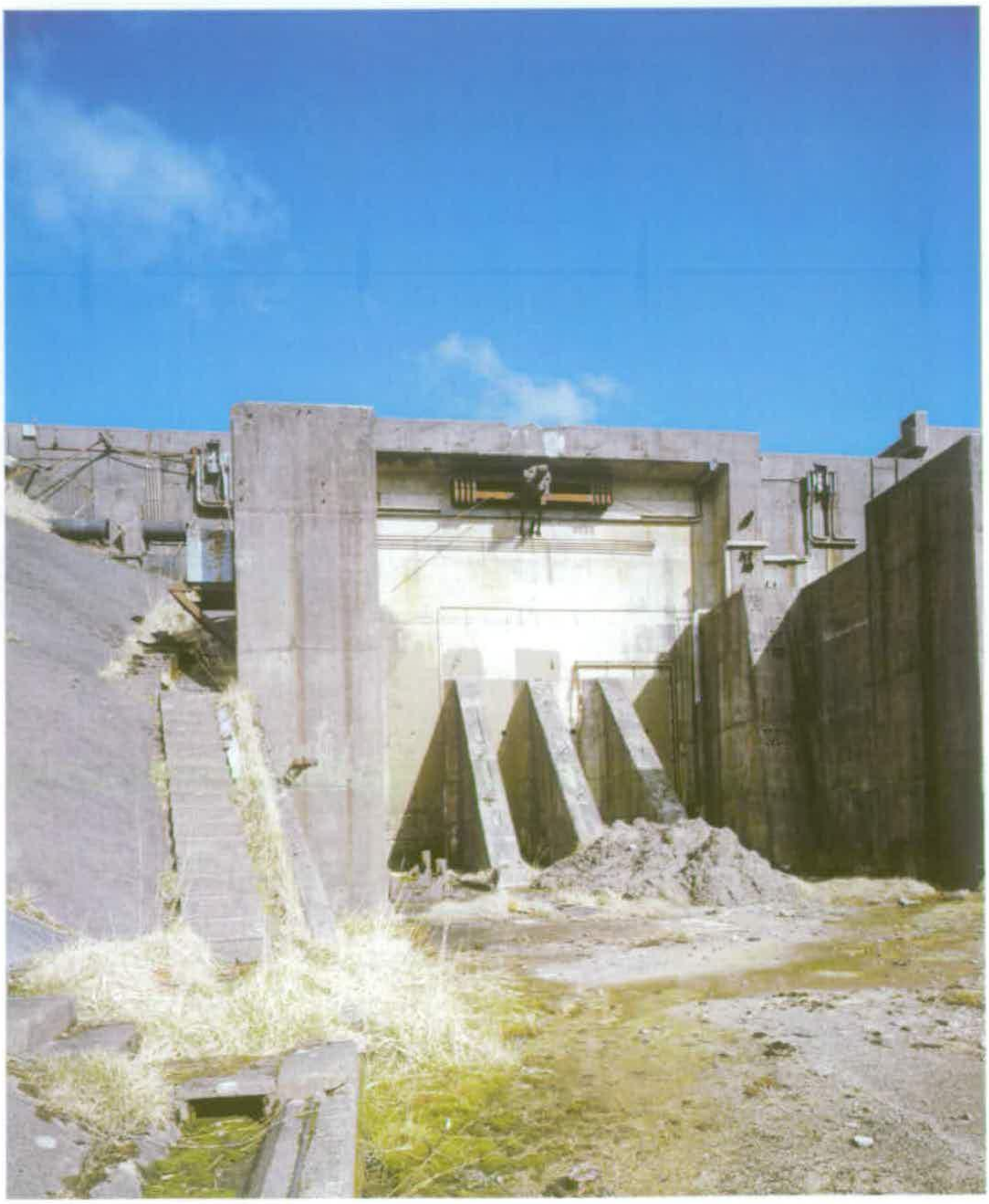

Figure 138
Remains of Engine Test Stand A1
© Crown copyright NMR (AA94/2956)

pressurised liquid oxygen and kerosene tanks to simulate their configuration within the missile. The stand also comprised control and instrumentation systems, engine thrust measuring systems, engine flushing systems, engine erecting and positioning and associated fire fighting equipment.

A vertical concrete wall 38ft 6in (11.73m) in height forms the rear of the stand. Projecting from either side at right angles is a concrete wall each incorporating two columns that together supported the stand superstructure (Fig 138). Just below the lip of the stand a

Figure 139
Rear wall of Engine Test Stand A1 with a gimballed mounting for the efflux deflector still in place
© Crown copyright NMR (AA94/1957)

gimballed mounting survives *in situ* above three sloping concrete ramps at the base of the rear wall that are now partly covered by dumped rubble (Fig 139). Together these originally supported an 18ft (5.49m) square steel efflux bucket. Although the test stands at both Priorlancy Rigg and Greymare Hill were built to project from the sides of shallow escarpments, the resultant heights of the launcher emplacements reached only a maximum of 40-50ft

(12-15m) above local ground level. The problem faced in site design, therefore, was to safely deflect a supersonic gas stream close to its source with a flow rate of 0.5 ton (0.508 tonnes)/sec and a source temperature of 2500°K. It was also essential to be able to carry out repeated firings without the need to reface the deflecting surface at regular intervals. The solution was to build a mild-steel flame-deflecting bucket into the emplacements that deflected flames from the rocket engines through 90° and down a concrete flameway (Fig 140). Exhaust would be carried away from the stand by its own momentum and disperse at a safe distance. To prevent the flame deflectors from melting during firings they were film cooled on the inner surface by large quantities of water. From a 1 million gallon (4,546,000 litre) Reservoir Q23.1 situated to the east of the test areas water was pumped to the stand and supplied through two large bore pipes with diameters of 18in (0.46m) and 36in (0.92m) located to the west of the stand. The flow of water to these pipes was regulated by an adjacent concrete framed brick lined valve pit, 4.74m x 4.35m, accessed via a concrete stairway from near the base of the stand. A second flight of concrete stairs up the west side of the stand leads to a small platform adjacent to which, mounted on a steel bracket, is a galvanised metal tank of uncertain function. On the slope above this is a square concrete box of similarly unknown function measuring 1.69m x 1.69m with sloping sides.

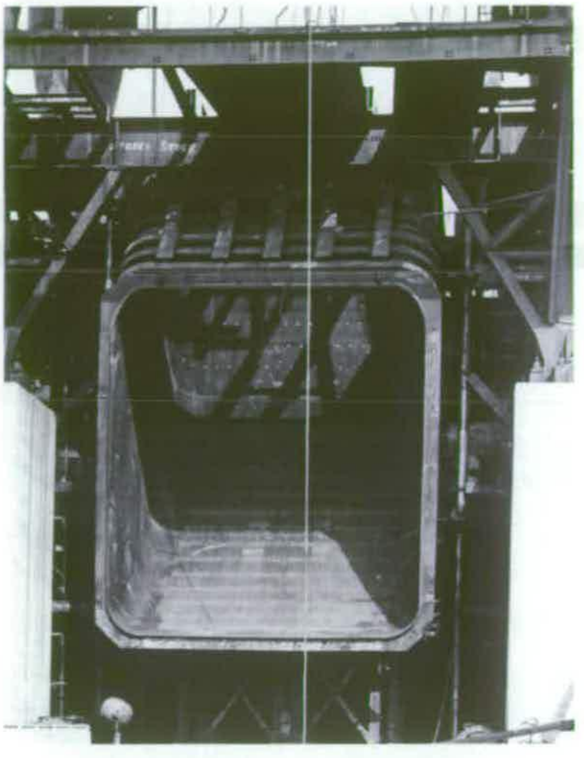

Figure 140
Contemporary photograph of a steel deflector bucket at the Priorlancy Engine Test Stands
© BAe Systems

Immediately above the test stand is a hardstanding or causeway area (Fig 141). Two rails here set into the concrete were used for manoeuvring the rocket engines into place. Originally these extended 40ft 10in (12.46m) at a right angle from the front of the stand at a width of 21ft 9in (6.63m) but the surviving sections now measure 34ft (10.38m) in length. A number of ancilliary buildings associated with the A1 stand were also located here.

Figure 141
Concrete hardstanding above Test Stand A1
© Crown copyright NMR (AA94/1958)

In the south-east corner of the hardstanding is a square concrete structure **EH10** measuring 4.93m x 4.97m (Fig 142). A stainless steel pipe projects from the sides of this structure suggesting that it may have been associated with the supply of liquid oxygen to the Test Stand A1. To the north of this was the **Pneumatic Control Station A16.1**. Formerly a small single storey brick structure measuring 13ft 3in x 12ft 9in (4.04m x 3.89m), this had a flat concrete roof and stood to a height of 12ft (3.66m). Its position is indicated by a raised concrete floor slab. This control unit regulated the pressures and flow rates of all gaseous services required by the engine. From the storage bottles located immediately north-west of stand A1, gaseous nitrogen was fed through a low pressure main to a series of control valves grouped together within the Pneumatic Control Station. This gaseous nitrogen was needed for valve actuation, purges and propellant tank pressurisation prior to launch but most important was the pressurising supply for the main liquid oxygen and kerosene tanks. Immediately west of the rails was the **Electrical Control Station A17.1** (Fig 143). This contained the main switch and distribution gear for the A1 test stand as well as instrumentation and control gear for engines undergoing tests; it was pressurised during operation. The building had dimensions of 26ft 6in x 14ft 6in (7.47m x 4.45m) and low brick walls to a height of 2ft (0.61m). Above these low walls was a steel-framed structure clad in aluminium with a roof of steel decking which stood to a maximum height of 10ft 6in (3.2m). The station has been demolished and its position is marked by a concrete floor slab where some internal details, including a floor level cable conduit, are still discernible. Behind this, to the north, is the concrete floor slab of the **Terminal and Power House A35**. This was a temporary timber-framed structure measuring 22ft 3in x 13ft 3in (6.78m x 4.04m). Its walls were of corrugated iron as was the roof which stood to a maximum ridge height of 12ft 6in (3.81m) above ground. Immediately to the west of the terminal and power house was the **Heating Plant House A40.1** (Fig 144). This was a single storey structure

Figure 142
Concrete structure (EH10) possibly associated with the supply of liquid oxygen to Test Stand A1
© Crown copyright NMR (AA94/1959)

Figure 143
Concrete footing of the Electrical Control Station A17.1
© English Heritage (AF00134/A17.1)

Figure 144
Remains of the Heating Plant House A40.1
© English Heritage (AF00134/A40.1)

measuring 17ft 3in x 12ft 6 in (5.26m x 3.81m) built from reinforced brick with a flat concrete roof. It had electric tubular heating and a 110 volt AC power supply. The structure has now been demolished but a conduit in the floor marks the line of a former internal cable duct. Immediately to the south of the Heating Plant House, in the south-west corner of the hardstanding are two tripartite features **EH9**. A diagram of the area (Martin 2002, 126) describes two **LOX Run Tanks** in this position. The tanks, which would have supplied liquid oxygen to Test Stand A1, have evidently been removed and the tripartite features are the remains of their stands. To the east of the hardstanding, at a distance of some 7.5m from it, is a square concrete tank measuring 5.7m x 5.8m. It is now water filled but is shown on a diagram of the stand (Martin 2002) as a **Kerosene Run Tank EH11**. As the tank has evidently been removed, this feature would appear to represent a bund or support for the tank that supplied kerosene to the Test Stand A1. There is a Valve Pit to the west of the test stand, measuring 4.5m x 4.1m, which pumped water up to the stand for cooling the efflux deflector bucket during firings.

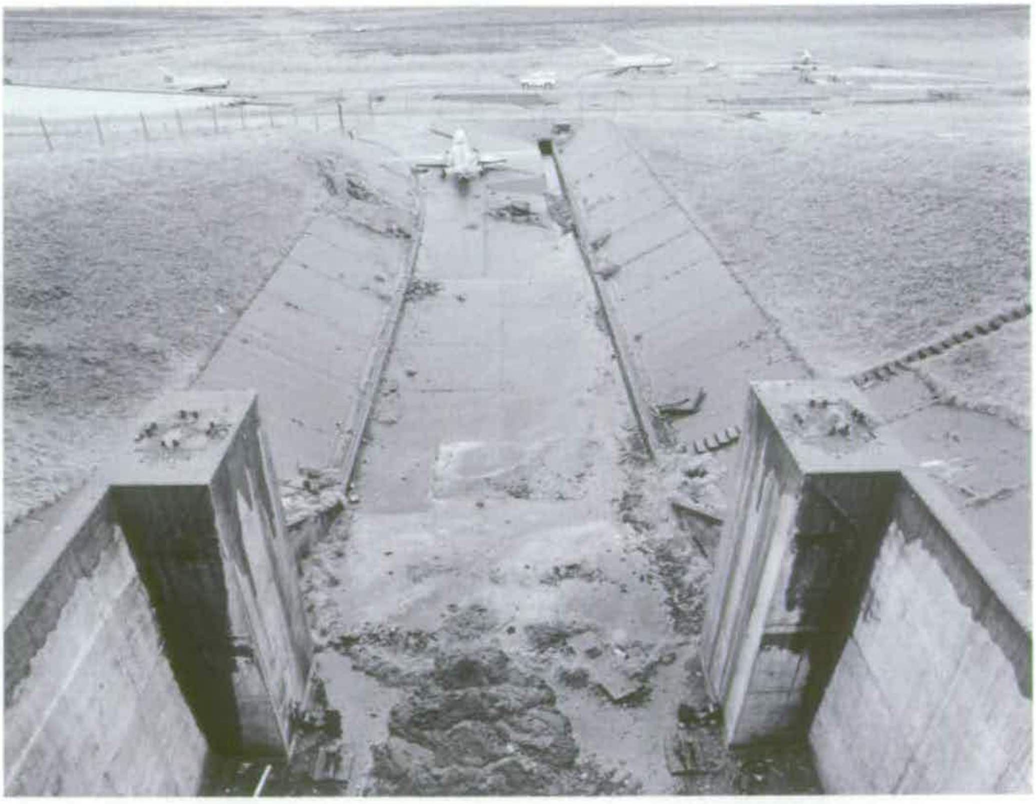

Figure 145
Concrete spillway of Test Stand A1 which channelled cooling water and unspent fuel into drainage conduits to the south
© Crown copyright NMR (AA94/1960)

Below the stand is a sloping concrete flameway or spillway which channelled unspent fuel and cooling water away from the stand into an effluent conduit to the south (Fig 145). At a width of 29ft 10in (9.10m) the lower parts of the channel are lined with sloping concrete panels at the base of which further channels drain away from the test stand.

In the event of an emergency abort during firing, highly volatile liquid oxygen and kerosene could be rapidly dumped at a safe distance from the rocket engine. Kerosene was piped down to a **Kerosene Dump Tank A33.1** some 60m to the south-east of the stand. This flameproof feature originally comprised a 10,000 gallon (4,546 litre) tank supported on an octagonal concrete base 6.6m in diameter with a surrounding concrete bund measuring 9.79m square (Fig 146). Although the connecting piping has now been removed the concrete

Figure 146
Support for a Kerosene Dump Tank A33.1 that received fuel from Engine Test Stand A1 in an emergency
© Crown copyright NMR (AA94/1967)

foundations still survive. Liquid oxygen was conveyed to a **LOX Dump Tank** situated a similar distance downhill on the west side of the spillway (Fig 147). A pipe was carried on a series of 1.5m square concrete supports to a square platform measuring 5.29m x 4.53m, on which contemporary photographs show a storage tank. Below this was a trapezoidal concrete reservoir with sloping sides and maximum dimensions of 12.32m x 9.39m; on its southern side is a 0.38m sliding metal sluice plate.

Figure 147
To the west of Test Stand A1 a line of concrete stanchions supported a pipeline leading down to the emergency LOX Dump Tank
© English Heritage NMR (17818/17)

After the completion of the Test Stand C3 at Greymare Hill, stand A1 was no longer required for full vehicle firings and the facility was mothballed. In the late 1960s, British Gas were beginning to investigate laying long distance gas pipelines across the country but were concerned about a number of explosions that had taken place in North American pipelines. To assess the strengths of pipelines at different pressures and temperatures a number of experiments were conducted in the flameway of Test Stand A1. These involved pressurising (probably with gaseous nitrogen) 30m sections of 1m diameter pipes, with a thickness of between ¼ and ½ in. Copper coils were then placed at 1m intervals to measure how quickly a crack travelled down a pipe when an explosive charge was detonated. Instrumentation, which was provided by Rolls-Royce staff, was run back to tape recorders in the Control Centre A11 and the Terminal House A4; the tests were also recorded using high speed cameras set at the end of the flameway (Godfrey Moy *pers. comm.*). Traces of this activity survive about two thirds down the flameway comprising two large 48in (1.22m) diameter steel pipes with cut off steel channels 8in x 3in (0.2m x 0.08m) set into the concrete close by, both of which appear to have been demolished using explosives.

To the west of A1 is the **Engine Test Stand A2**. Its layout was essentially similar to A1 though this stand was capable of supporting a double engine (RZ-12) firing. It comprises a concrete emplacement on which was mounted a steel-framed tower approximately 90ft (27.43m) in height designed to resist 1 million (453,600kg) and 300,000 lbs (136,080kg) of thrust respectively (Fig 148). At the rear of the test stand is a vertical concrete wall 38ft 6in (11.73m) in height from which two concrete walls project for a distance of 11.7m. Measuring 0.41m at their narrowest point, these walls widen to 1.86m where they once supported four columns which in turn supported the feet of a tower. During firing, engines were mounted within the tower which also supported pressurised liquid oxygen and kerosene tanks to simulate their configuration within the missile. The main tower supports were formed of

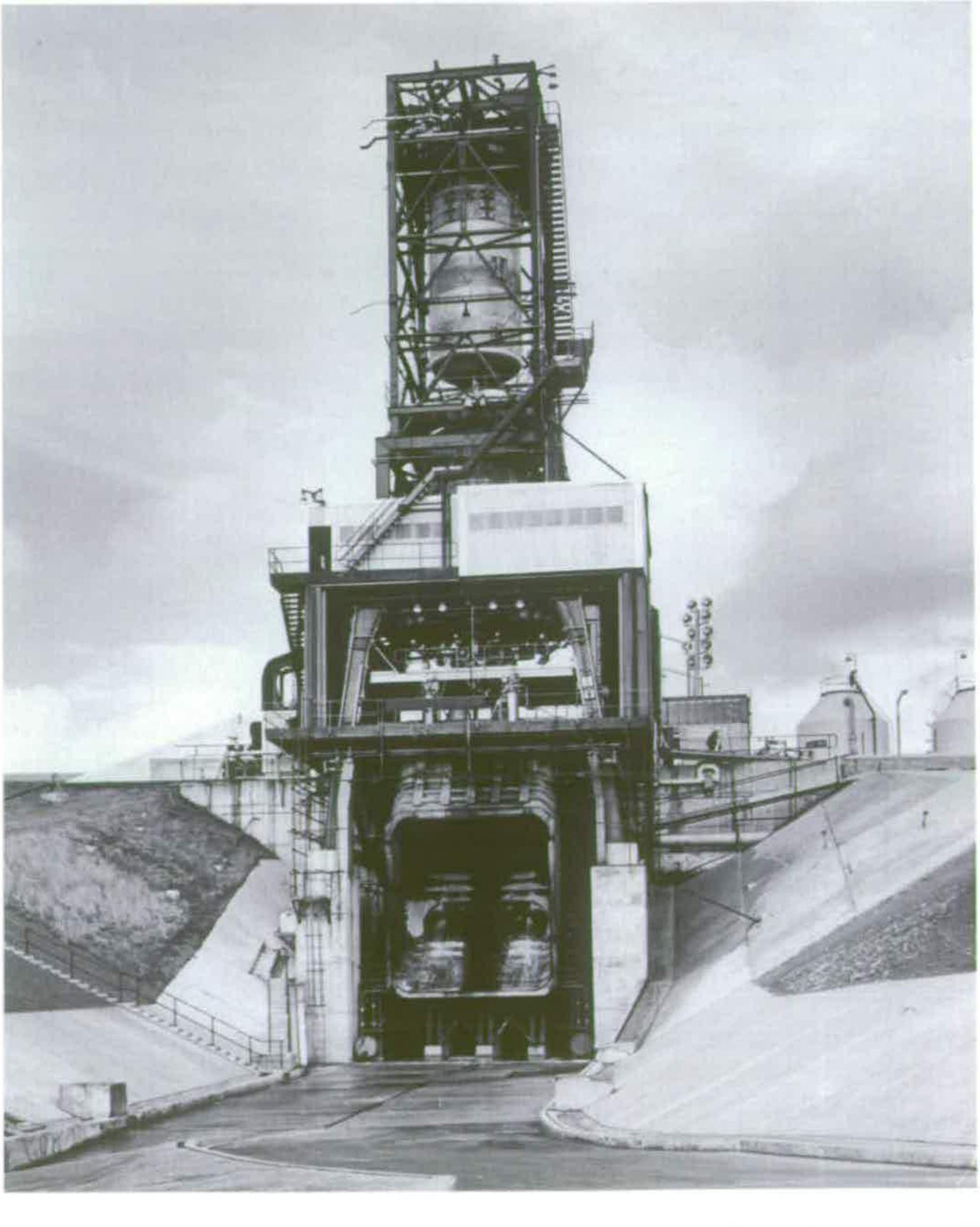

Figure 148
Contemporary photograph of Engine Test Stand A2 showing fuel tanks suspended in a steel framework tower above the engine and the efflux deflector bucket below. The liquid oxygen storage tanks of A5 are visible in the background © Rolls-Royce plc

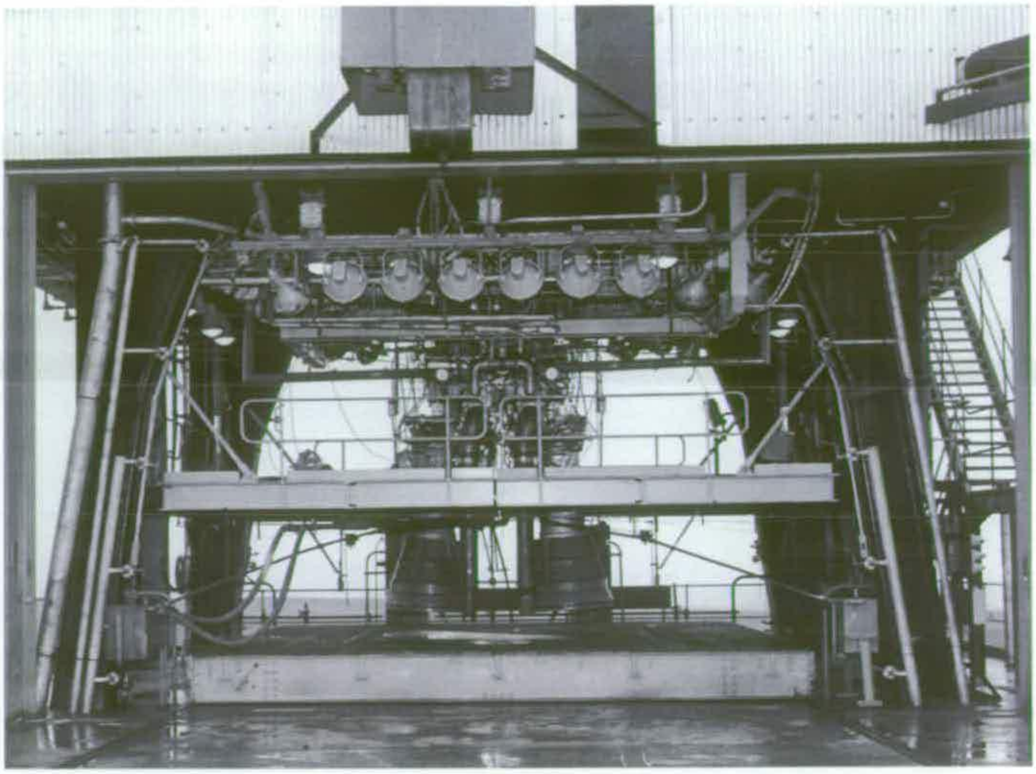

Figure 149 *Contemporary photograph showing rocket engine in position for firing*
© Rolls-Royce plc

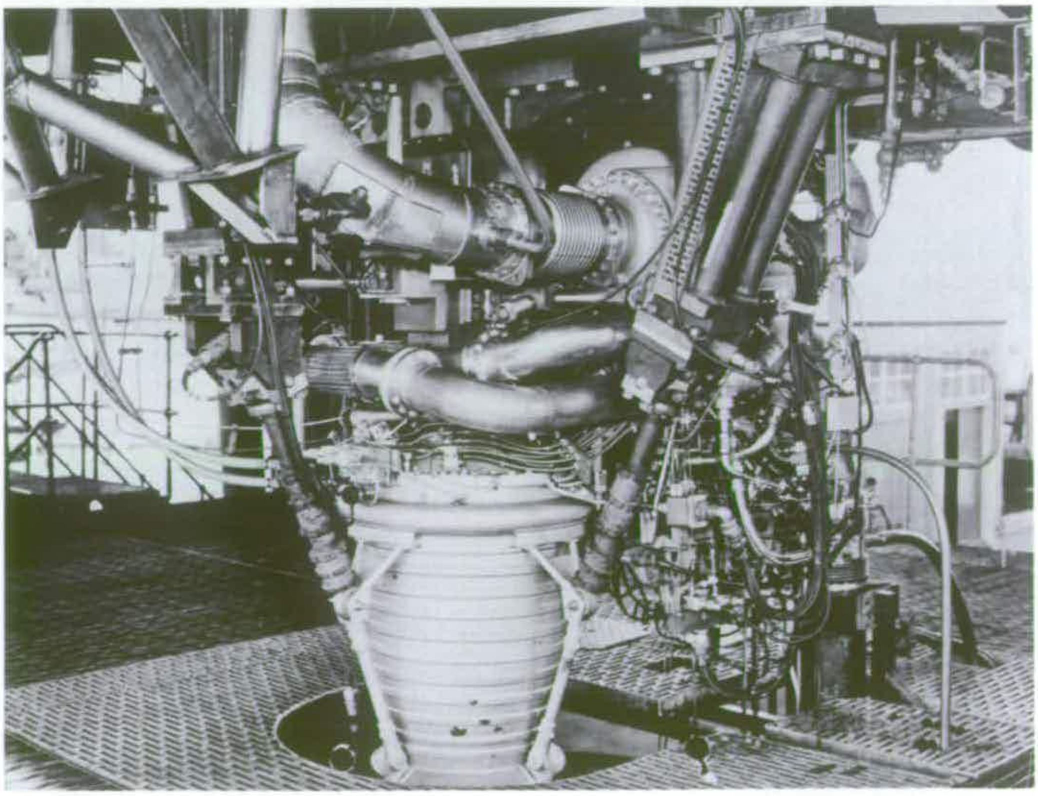

Figure 150 *Contemporary photograph showing detail of rocket engine in position for firing*
© Rolls-Royce plc

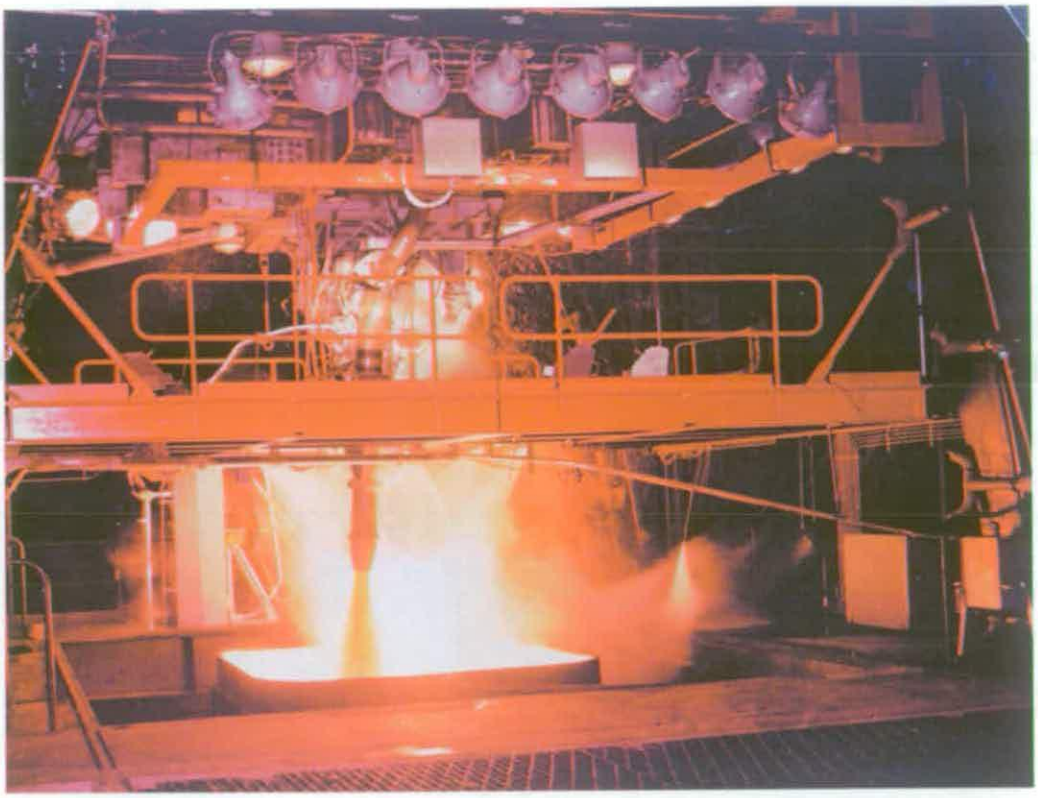

Figure 151
Contemporary photograph of rocket engine during night time test firing
© Rolls-Royce plc

Figure 152
Contemporary photograph of Priorlancy Rigg during test firing on Engine Test Stand A2
© Rolls-Royce plc

square section hollow steel legs that were filled with reinforced concrete. This prevented the legs from failing in the event that they came into contact with liquid oxygen vapour which could cause them to become brittle. The legs were removed during demolition and have been dumped at the foor of the stands below the LOX dump. Each of the four legs is about 9m in length and 0.54m wide (21in) in cross section, their tops expanding to 1.2m (46in).

They are reinforced by four 1½in and two ½in steel rods. Each of the legs is encased by a welded steel sheath. Similar columns are found between Test stands A2 and A3. Virtually all of the stand's other metal components were also removed after decommissioning.

Figure 153
Modern aerial photograph of Engine Test Stand A2 showing the spillway and sloping concrete walls that supported the deflector bucket © English Heritage NMR (17818/22)

Projecting at right angles from the base of the rear wall are a further three concrete walls (Fig 153). These are steeply sloping and they supported the steel efflux bucket that deflected fames from the engine through 90° down the flameway. At the base of the sloping walls are cut-off steel channels indicating the positions of further supports for the efflux bucket. This bucket was also attached to the back of the vertical concrete stand by means of a metal bracket which survives *in situ*. To the east of the stand is sub-square Valve Pit. This measures 4.m x 4.2m and it pumped water up to the test stand for cooling the efflux deflector bucket during firings. Two large bore steel pipes which fed the cooling water are visible to the east of the stand (Fig 154). These were accessed via a flight of concrete steps close to the rear wall of the stand and were controlled by a square brick valve pit some 18m to the east. Two steel channels are attached to either side of the front face of the stand, linked by a guide rail across the front of the stand which indicates the position of a sliding door or shutter. Historic photographs suggest that this is a secondary feature.

Figure 154
Large bore steel pipes on the east side of Engine Test Stand A2 poured vast quantities of cooling water onto the hot steel deflector bucket to prevent it from melting during test firings © English Heritage NMR (DP003884)

Areas of this stand were accessed by a series of stairways. A flight of concrete steps leads up the west side of the stand to a small platform on which is a metal tank, the function of which is unknown (Fig 155). Above this is a lagged galvanised metal pipe. On the opposite side of the flameway a flight of steps leads to the crest of a slope and an expanse of concrete – these may be secondary.

Figure 155
On the west side of Engine Test Stand A2 is a metal tank of unknown function. This is located adjacent to one of the concrete supports which held the steel framework tower © English Heritage NMR (DP003894)

Figure 156
Hardstanding above Test Stand A2
© English Heritage NMR (17797/03)

Above the test stand is the hardstanding which was used for manoeuvring the engines into position (Fig 156). Set into the concrete of this causeway are two steel rails 21ft 10in (6.65m) apart that extend at right angles to the stand face for a distance of 41ft (12.5m). Immediately east of the rails was the **Pneumatic Control Station A16.2**. Traceable as a raised concrete floor slab measuring 13ft 3in x 12ft 9in (4.04m x 3.89m) this was a single storey brick built structure with a flat concrete roof 12ft (3.66m) in height. It was similar in form and function to the Pneumatic Control Station at stand A1; from here the pressures and flow rates of all gaseous services required by the engine were regulated.

Figure 157
Concrete footings of the Electrical Control Station A17.2
© English Heritage (AF00134/A17.2)

On the opposite side of the rails from the Pneumatic Control Station was the **Electrical Control Station A17.2** (Fig 157). Although the control station has now been demolished, some internal details, including a cable conduit, are visible in its concrete floor slab. The building measured 26ft 6in x 14ft 6in (8.08m x 4.45m) and 10ft 6in (3.2m) in height. It was steel-framed with low brick walls to a height of 2ft (0.61m) above which the walls were clad in corrugated aluminium. This contained the main switch and distribution gear for the test stand; it also contained instrumentation and control gear for engines undergoing tests and was pressurised during operation.

To the north of the Electrical Control Station was the **Heating Plant House A40.2**. This has been demolished and concrete footings with a conduit in the floor for a cable duct mark its position. A single storey structure measuring 17ft 3in x 12ft 6in (5.26m x 3.81m) it stood to a height of 9ft 6in (2.9m) with walls of reinforced brick and a flat roof of reinforced concrete.

As at A1, below the stand is a sloping concrete flameway or spillway which channelled unspent fuel and cooling water away from the stand into an effluent conduit to the south (Fig 158). At a width of 29ft 10in (9.10m) the lower parts of the channel are lined with sloping concrete panels at the base of which further channels drain away from the test stand.

From close to the western foot of the stand a flight of concrete steps provides access to a **LOX Dump Tank**. Two lines of 0.9m square concrete supports lead from the west side of the test stand to the tank which comprises a sunken concrete feature, trapezoidal in plan and with maximum dimensions of 16.6m x 7.98m. Beneath this feature, some 19m down

Figure 158
The concrete spillway of Engine Test Stand A2 drained into a conduit to the south
© Crown copyright NMR (AA94/1961)

the slope, was the **Kerosene Dump Tank A33.2** (Fig 159). The remains consist of an octagonal concrete base, 8.1m in diameter, with a central hollow that is now in-filled with sand. This is surrounded by a square concrete bund, accessed by steps at its south-east corner and capped by a low brick wall, 9.9m in diameter and 1.5m in height. This foundation originally supported a 10,000 gallon (45,460 litre) storage tank that could safely receive kerosene drained from tanks in the test stand in the event of an emergency during firing. This kerosene dump tank also serviced the adjacent test stand A3.

Figure 159
Kerosene Dump Tank A33.2
© English Heritage NMR (DP003897)

The **Engine Test Stand A3** was designed for the test firing of single rocket engines designated RZ-2A and RZ-2B which together formed an RZ-12. Its layout was essentially similar to A1 and A2 (Fig 160), comprising a concrete base on top of which was mounted a steel-framed tower (Fig 161) approximately 90ft (27.43m) in height designed to resist up to 1 million lbs (453,600kg) and 300,000 lbs (136,080kg) of thrust respectively (TNA: PRO AVIA 65/1906). At the rear of the test stand is a vertical concrete wall 38ft 6in (11.73m) in height but this differs from stands A1 and A2 in that it is partly brick built. From the rear wall two concrete walls project for a distance of 11.7m. Measuring 0.41m at their narrowest point, these walls widen to 1.86m where they

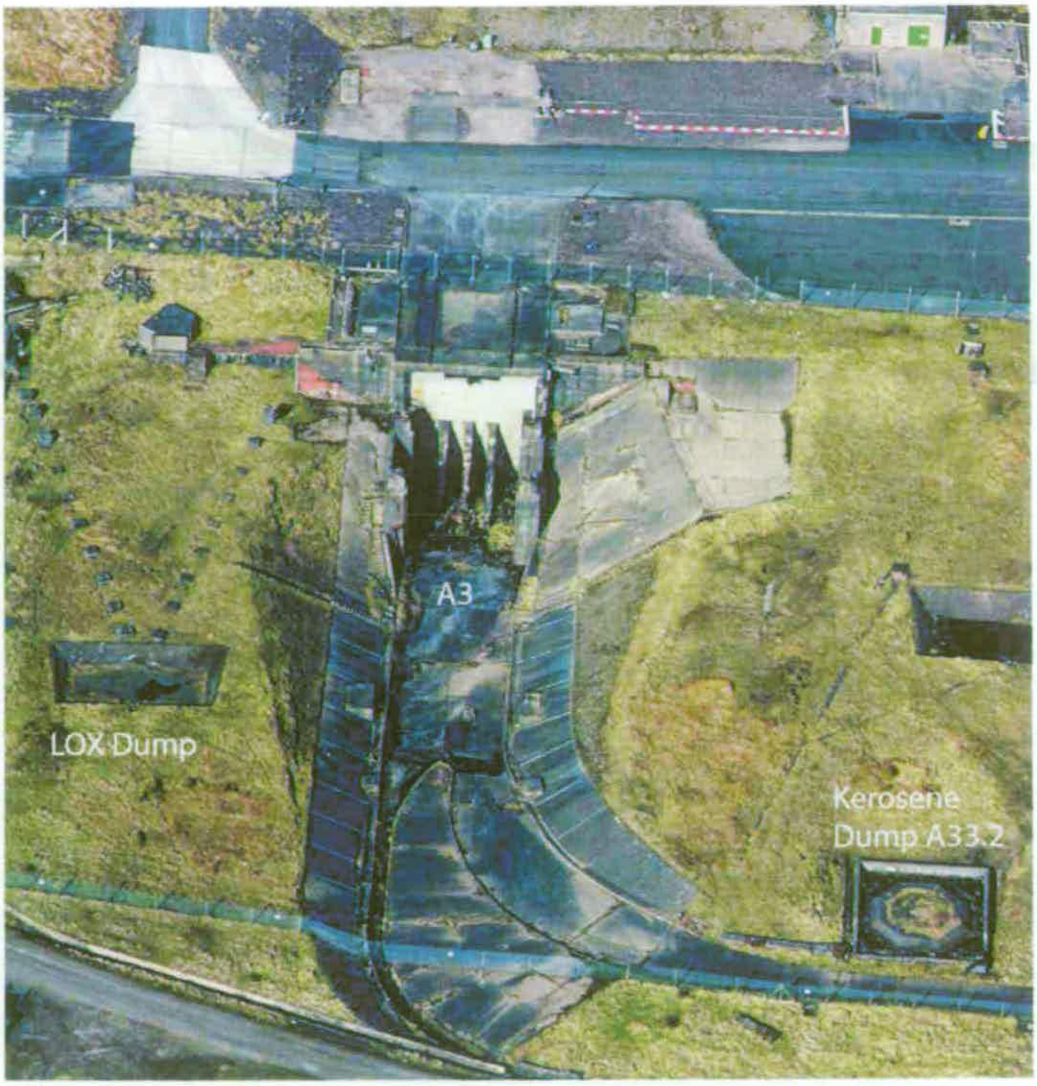

Figure 160
Modern aerial photograph of Engine Test Stand A3 with associated emergency LOX and kerosene dumps © English Heritage NMR (17797/01)

Figure 161
Engine Test Stand A3 during firing © Rolls-Royce plc

once supported four columns which in turn supported the feet of a tower. This tower supported pressurised liquid oxygen and kerosene tanks to simulate their configuration within the missile. The main tower supports were formed of square section hollow steel legs that were filled with reinforced concrete. This prevented the legs from failing in the event that they came into contact with liquid oxygen vapour which could cause them to become brittle. Various fittings remain attached to the rear wall of the test stand including small bore pipes that carried electrical wires, galvanised metal cable channels and junction boxes. The stand was also earthed against static and lightning; brass attachments for lightning straps are also still visible on the rear wall. Virtually all of the stand's other metal components were removed during decommissioning.

Figure 162
Remains of Engine Test Stand A3 showing the sloping walls and bracket that supported the deflector bucket and concrete walls that supported the steel framework tower above
© English Heritage NMR (DP003895)

Projecting at right angles from the base of the rear wall are a further three concrete walls (Fig 162). These are steeply sloping and they supported the steel efflux bucket that deflected fames from the engine through 90° down the flameway. At the base of the sloping walls are cut-off steel channels indicating the positions of further supports for the efflux bucket. During firing, to prevent the efflux bucket from melting, the deflector was continuously cooled by water. Two large bore steel pipes which supplied this cooling water are visible to the east of the stand. In front of the lower pipe is a horizontal roller that supported the pipe while allowing for some horizontal movement. The pipes were accessed via a flight of concrete steps on the east side of the stand. Another flight of concrete steps leads up the west side of the stand to a small platform. On the east side of the flameway is another flight of steps, which may be secondary, leading to the crest of the slope and a small expanse of concrete. Five square blocks, probably used for earthing, also project from the slope.

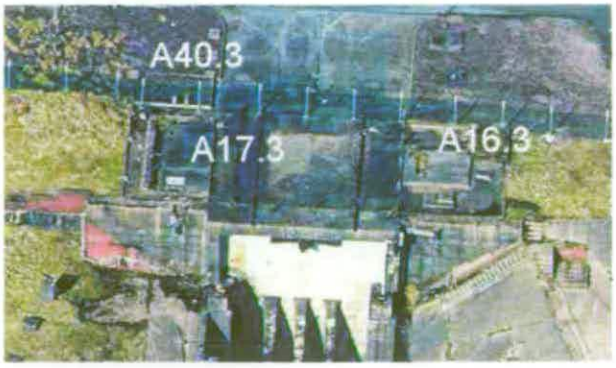

Figure 163
Hardstanding above Engine Test Stand A3 where service buildings were located
© English Heritage NMR (17797/01)

Above the test stand is a hardstanding which was used for manoeuvring the engines into position (Fig 163). Set into the concrete of this causeway are two steel rails 6.65m apart that extend at right angles to the stand face for a distance of 11.6m. Immediately east of the rails was the **Pneumatic Control Station A16.3** (Fig 164). This was a small single storey brick built structure with a flat reinforced concrete roof measuring 13ft 3in x 12ft 9in (4.04m x 3.89m) and 12ft (3.66m) in height. It was similar in form and function to the Pneumatic Control

Figure 164
Concrete floor slab of the former Pneumatic Control Station A16.3 © English Heritage (AF00134/A16.3)

Station at stands A1 and A2. From here the pressures and flow rates of all gaseous services required by the engine were regulated. The building now only survives as a raised concrete floor slab.

Figure 165
Concrete floor slab of the former Electrical Control Station A17.3 © English Heritage (AF00134/A17.3)

On the west side of the rails was the **Electrical Control Station A17.3** (Fig 165). This contained the main switch and distribution gear for the test stand; it also contained instrumentation and control gear for engines undergoing tests and was pressurised during operation. The building measured 26ft 6in x 14ft 6in (8.08m x 4.45m) and 10ft 6in (3.2m) in height. It was steel-framed with low brick walls to a height of 2ft (0.61m) above which the walls were clad in corrugated aluminium. Although the control station has been demolished, some internal details, including a cable conduit, are visible in its concrete floor slab.

To the north of the Electrical Control Station was the **Heating Plant House A40.3**. Although the building has been demolished, its concrete footings mark its position and a conduit in the floor for a cable duct is still visible. This single storey structure measured 17ft 3in x 12ft 6in (5.26m x 3.81m) and stood to a height of 9ft 6in (2.9m). Its walls were of reinforced brick and the roof was flat reinforced concrete.

As at A1 and A2, below the stand is a sloping concrete flameway or spillway (Fig 166). At a width of 29ft 10in (9.10m) the lower parts of the channel are lined with sloping concrete

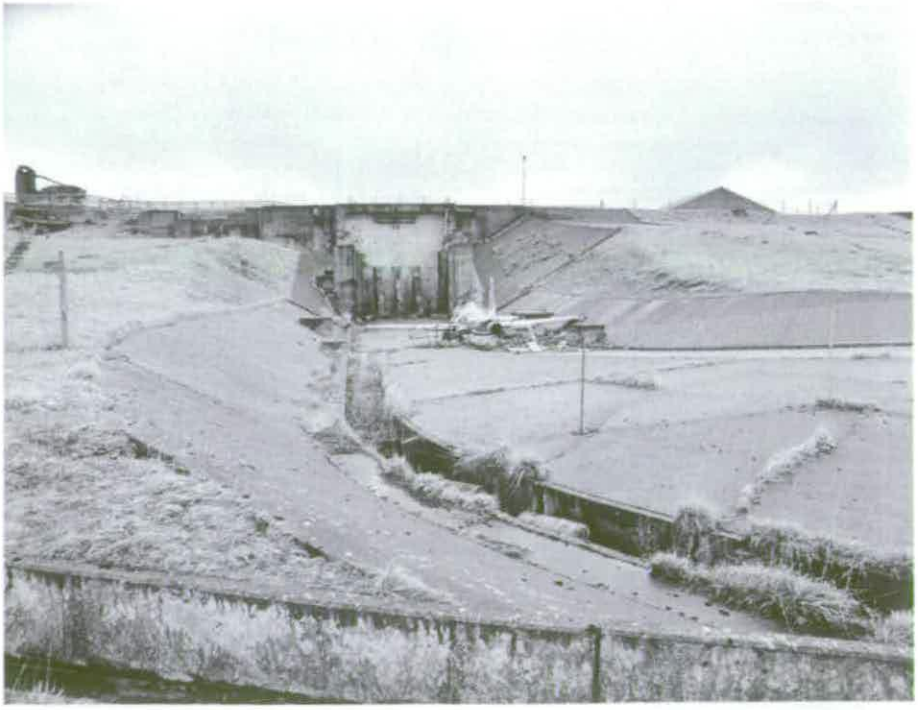

Figure 166
Derelict remains of the sloping concrete spillway below Engine Test Stand A3 that channelled cooling water and unspent fuel into drains to the south of the stand © Crown copyright NMR (AA94/2927)

panels at the base of which there are further channels 0.5m in width that drain away from the test stand. This channelled unspent fuel and cooling water away from the stand into an effluent conduit to the south.

Stand A3 shared a Kerosene Dump Tank A33.2 with stand A2 and this is visible, as already described, as a concrete footing at the base of the slope between the two stands. Close to the west foot of the stand a flight of concrete steps leads to two converging rows of concrete blocks, measuring 0.95m x 0.78m, that once supported pipes carrying liquid oxygen from the stand to an emergency **LOX dump tank** (Fig 167). The dump tank survives as a sunken concrete feature, trapezoidal in plan and with maximum dimensions of 12.5m x 6.55m. Its base is filled with hard-core and there is a sluice on its south side. The dump tank was also shared by the adjacent test stand A42 to the west.

Figure 167
Remains of an Emergency LOX dump tank located to the west of Engine Test Stand A3
© Crown copyright NMR (AA94/2926)

Engine Test Stand A42 (also referred to as A4) is the westernmost stand at Priorlancy Rigg (Fig 168). It was the last to be constructed and, unlike stands A1, 2 and 3 which were built to an American design, was designed by British engineers to address many of the problems encountered with the earlier stands (Walley 1966). The result was an innovative test stand (Fig 169) which, although smaller than the others (being designed to test only a single engine), could resist a static thrust of 200,000 lbs (90,720kg) (TNA: PRO AVIA 65/1906).

Figure 168
Modern aerial photograph of Engine Test Stand A42 with emergency dump systems for liquid oxygen (LOX) and kerosene
© English Heritage NMR (17818/15)

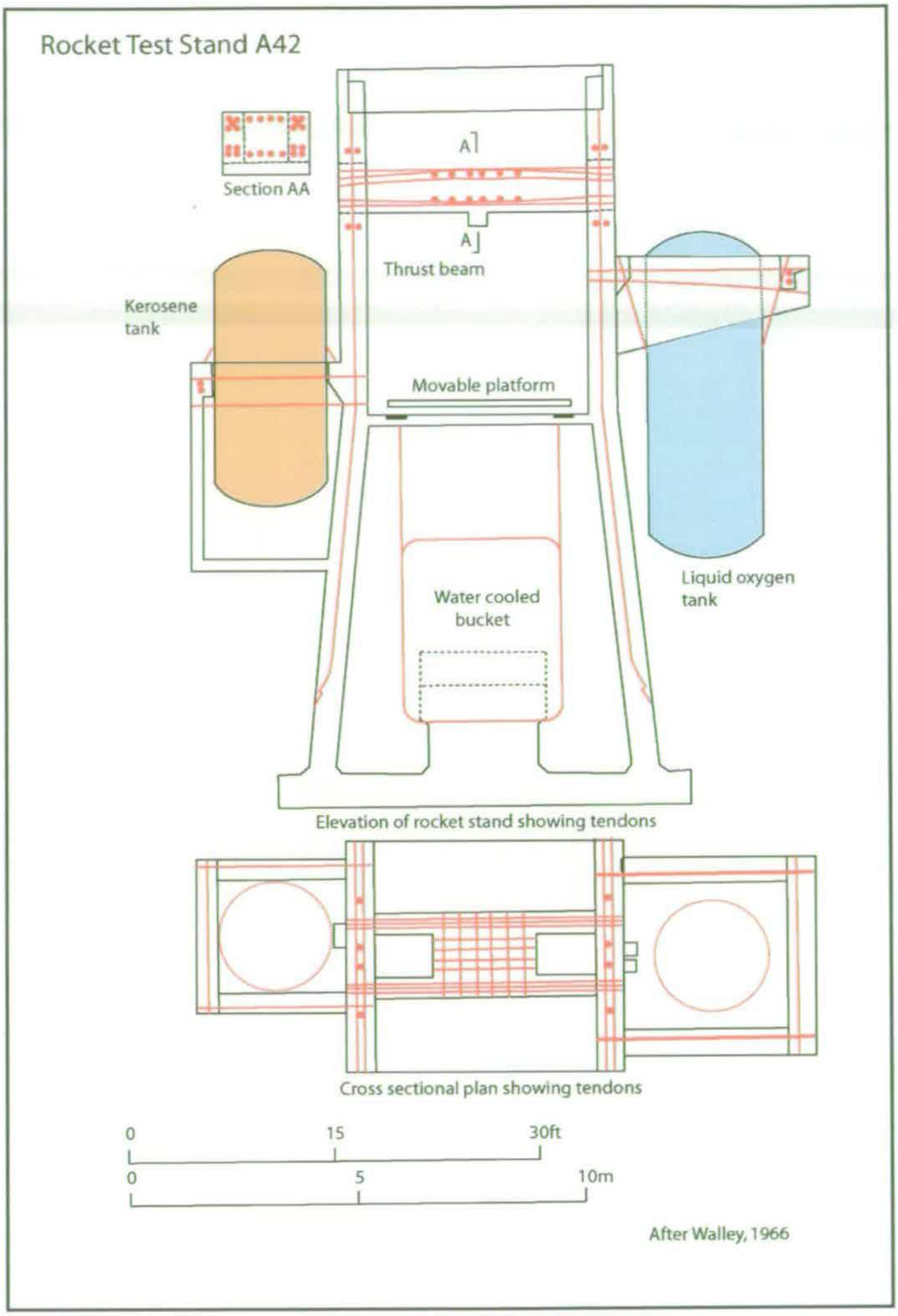

Figure 169
Diagram of Engine Test Stand A42. After Walley 1966

It comprised two pre-stressed walls tied to a base to counter the thrust of the engine, two sets of pre-stressed concrete brackets and two pre-stressed concrete hangars for the LOX tank. The thrust was taken by a pre-stressed concrete beam which was stuck to a stainless steel plate bearing the engine mountings with epoxy resin. This was probably the earliest use of epoxy to bond steel and concrete together (Walley 2001, 19). To the rear of the tower was a steel-framed lifting gantry which handled the rocket engines. The super-structure was roofed with aluminium sheeting designed to blow off in the event of an explosion; the front was covered in translucent cladding and the rear had a roller shutter (Fig 170). The efflux deflector on stand A42 was a 19ft 6in square steel bucket.

Figure 170
Contemporary photograph of Engine Test Stand A42
© Rolls-Royce plc

On the platformed mound in the south-west of the Engine Test Area is a concrete standing measuring 24.65m x 6.20m, the remains of a former **Hut EH4**. A second, smaller, concrete plinth, 4.75m x 3.66m, lies nearly 30m to the south-east. These may have been temporary structures associated with the construction phase of this later stand.

Few features survive on the hardstanding above the test stand. At the south-east corner are the foundations of a small brick building measuring 17ft 3in x 12ft 5in (5.26m x 3.78m). A channel, 1.3m in width and filled with hardcore, survives at the north end along with the footing for an electrical junction box and the remnants of a lagged metal pipe. Midway along the northern edge of the concrete standing is the footing for another electrical junction box. Originally the stand housed an **Electrical Control Station A42.1** which contained the main switch and distributive gear as well as instrumentation and control gear for use during firings and was pressurised during operation. There was also a **Junction Room A42.2** for instrumentation and control cabling that was pressurised during operation and a **Draw in Chamber A42.3**. The latter was a single storey pentagonal building of reinforced concrete and brick with a concrete floor and roof. It measured 13ft 6in (4.11m) by a maximum of 12ft (3.66m) and stood to a height of 11ft (3.35m). Adjoining the Draw in Chamber was a **Pressurisation Chamber/Plant Room A42.6**. This single storey building had brick walls, a concrete roof and a floor of reinforced concrete. It measured 12ft 3in x 7ft 3in (4.04m x 2.21m) and was 8ft 6in (2.59m) in height. The remains of only one building survive above the stand and it is not possible to identify which of the above these represent. The dimensions listed, however, suggest that it is neither the Draw in Chamber A42.3 nor the Pressurisation Chamber/Plant Room A42.6.

Figure 171
Derelict concrete spillway of Engine Test Stand A42
© Crown copyright NMR (AA94/2925)

As at the stands to the east, below Test Stand A42 is a sloping concrete flameway or spillway (Fig 171) which channelled unspent fuel and cooling water away from the stand into an effluent conduit to the south-east (Fig 172). At a maximum width of around 7.1m the lower parts of the channel are lined with sloping concrete panels.

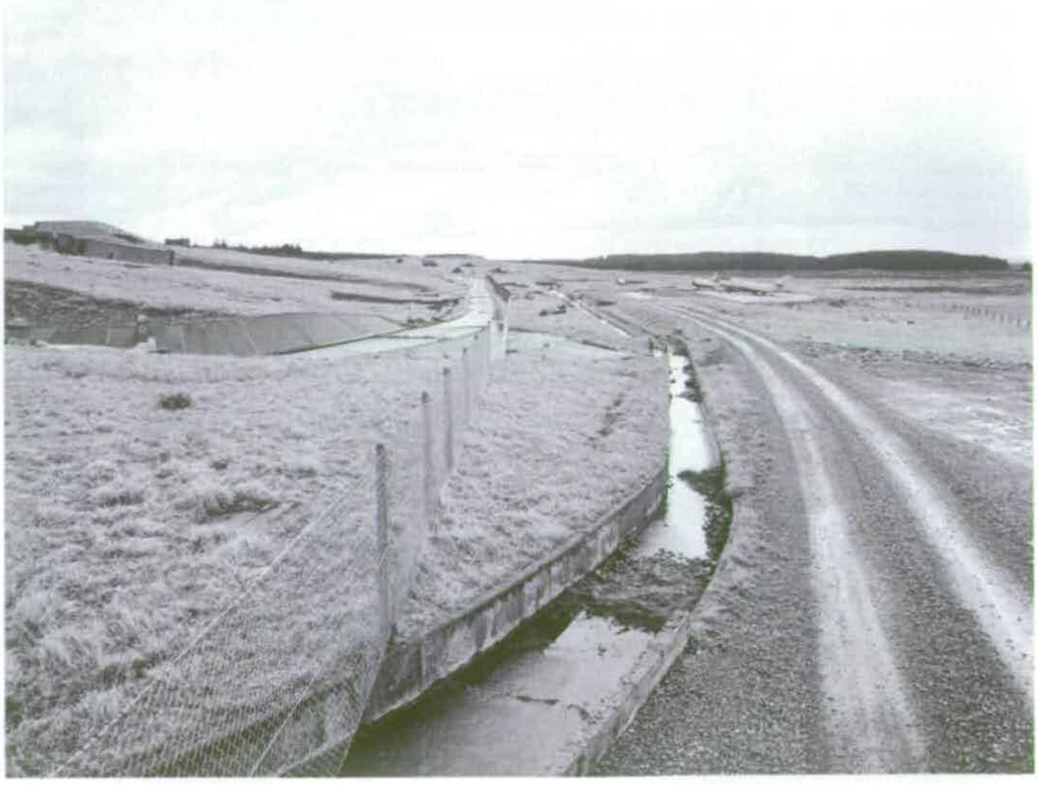

Figure 172
Cooling water and inspent fuel from Engine Test Stand A42 drained into a channel that flanked the south side of the test stands
© Crown copyright NMR (AA94/2929)

Figure 173
Kerosene Dump Tank to the west of Engine Test Stand A42 © Crown copyright NMR (AA94/2930)

Figure 174
Engine Test Stand A42 was demolished with explosives after being decommissioned © English Heritage (AF00134/A42)

Stand A42 shared a **LOX Dump Tank** with stand A3 and this survives as a sunken concrete feature, trapezoidal in plan and with maximum dimensions of 13.2m x 6.3m. A line of concrete support blocks 0.9m square that once supported pipes carrying liquid oxygen from the stand are still visible. A second line of concrete support blocks also leads from the west side of the stand down the slope to a **Kerosene Dump Tank** (Fig 173). With external dimensions of 11.12m x 5.0m and standing to a height of 1.1m, the kerosene tank comprised a concrete bund with three internal tank supports. The interior of the bund was accessed by five steps at its eastern end. After decommissioning, the stand was apparently demolished using explosives and it remains as a pile of concrete rubble with metal fittings (Fig 174).

Power Supply

From the main overhead electricity supply Priorlancy Rigg Engine Test Area power was distributed to a series of Sub-Stations equipped with transformers for stepping down the voltage of the electricity supply. **Electricity Sub-Station A10.1** (Fig 175) is situated to the

Figure 175
Electricity Sub-station A10.1 © Crown copyright NMR (AA94/1945)

east of the Control Centre A11. This single story brick building with a flat concrete roof measures a total of 5.97 x 10.87m including two transformer bays that are separated by a central brick dividing wall and are open to the north. Some 16m south-east of the Sub-Station is a former **Electro-Flow Meter House EH1** (Fig 176). This small brick kiosk measures 1.26 x 1.28m and originally had a shallowly sloping roof though this is now missing. Inside are the remains of two electroflow guages and an amp meter (Fig 177).

Figure 176
Electro-Flow Meter House EH1 (left)
© English Heritage (AF00145/EH1)

Figure 177
Interior of Electro-Flow Meter House (right)
© English Heritage (AF00134/EH1interior)

To the rear of the test stands is the **Electricity Sub-Station A10.2** (Fig 178). This comprises a small single storey brick structure, 3.66 x 2.40m, with a double fenced transformer bay measuring 4.83 x 2.67m to the north. **Electricity Sub-Station A10.3** stands on a raised area in the north-west of Priorlancy (Fig 179). This structure is of similar construction to A10.2 comprising a small single storey brick building 3.65 x 2.40m with a fenced double transformer bay to the rear (north) measuring 2.80 x 5.05m. A fourth **Electricity Sub-Station A10.4** lies outside the main Engine Test Area immediately to the west of the Kerosene Storage Tanks and Pump House A32 (Fig 180). It comprises a similar brick structure measuring 3.67m x 2.42m and there is a fenced transformer bay to the north with dimensions of 5.14m x 2.89m. As part of the power supply system a **Terminal and Power House A35** was erected on the causeway above Test Stand A1. Recorded as measuring 22 ft 3 in x 13ft 3in (6.78m x 4.04m) and standing to a height of (minimum) 9ft 6in (2.9m) and (maximum) 12ft 6in (3.81m), this timber-framed building with corrugated iron walls and roof was a temporary structure for de Havilland. A screeded concrete floor survives marking its former location.

Figure 178
Electricity Sub-Station A10.2
© English Heritage (AF00134/A10.2)

Figure 179
Electricity Sub-Station A10.3
© English Heritage (AF00134/A10.3)

Figure 180
Electricity Sub-Station A10.4
© English Heritage (AF00134/A10.4)

Gas and Liquid Supply

The primary systems were those supplying liquid oxygen, kerosene, liquid nitrogen and gaseous nitrogen. Liquid oxygen and liquid nitrogen were produced in the air separation plant situated within the BOC Compound some 2.3km to the south-east of the engine test area. Gaseous nitrogen for use on site was produced from liquid nitrogen. These were all supplied to the missile via fly-off probe connections so as to be available for supply or dumping right up to the moment of launch. At Priorlancy Rigg, as at the Component Test Area, the oxidant systems formed part of the test facility. The fuel and oxidant tanks of the A1 test stand were supported within the steel framed service tower; elsewhere, storage tanks were slung in steel towers directly above the test platforms (Fig 181). Lubricating oil, trichloroethylene for engine flushing, and demineralised water for the engine water lead start were also required.

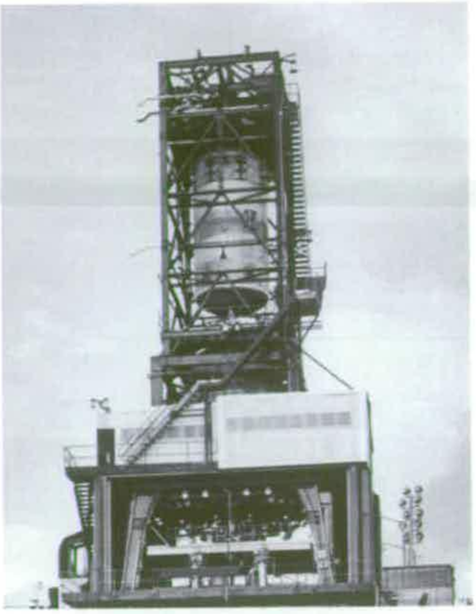

Figure 181
Fuel and oxidant tanks were supported in a steel framed tower above the engine test stands
© Rolls-Royce plc

Liquid Oxygen (LOX) Supply

Liquid oxygen was supplied to each of the test stands from a common **LOX Store A5** situated to the north of the stands at NY 59653 71969. Brought from the BOC compound by tanker, the LOX was stored in two large cylindrical tanks supported on bases. These bases are visible as octagonal raised, turf covered areas with an internal dimension of 1.44m, an external dimension of 2.67m and 5.6m apart (Fig 182). These may have originally been surrounded by a circular supporting brick wall as at LOX storage tanks elsewhere on site. The bases currently stand within a rectangular earth mound that is 5.4m wide and oriented roughly east-west. Diagrams of the Engine Test Area show a rectangular building immediately to the south of the tank bases in a location that is now covered in a low bank of rubble. In the south-east corner of the upper emplacement of test stand A1 is a square concrete bund measuring 4.97m x 4.92m and standing 2.01m in height. This originally supported a LOX tank; stainless steel piping, 10in (0.25m) in diameter, for the supply of stand A1 is visible on the south face of the bund. The LOX tank has subsequently been removed. Liquid oxygen was conveyed under pressure in stainless steel pipes to each of the engine stands where it was burnt as a mixture as a fuel-rich mixture of LOX and kerosene to power gas generators which in turn drove the engine turbo pumps.

Figure 182
The site of the LOX Store A5
© English Heritage (AF00134/A5)

Kerosene Supply

The **Kerosene Storage Tanks and Pump House A32** that supplied the Engine Test Area were located some 530m to the east of the test stands. Plans of the former test area show a structure comprising a sub-square single storey building to the north of which were three horizontal cylindrical tanks and a further two larger cylindrical tanks placed vertically. These provided kerosene for burning in combination with liquid oxygen during engine test firings and it was certainly deliberate that the respective stores for each material were located a safe distance (around 600m) from one another. Although the Kerosene Storage Tanks and Pump House have been demolished, the platform on which they stood is identifiable as an earthwork terrace with visible pieces of broken concrete.

Nitrogen Supply

The gaseous nitrogen system was the most extensive system on the test stand. At Priorlancy Rigg it included a separate main and emergency supply derived from a **High Pressure Nitrogen Store A9** located some 20m behind the test stands. This was a partly steel-framed structure with brick walls on its south and west sides which provided cover for a battery of 4ft (1.22m) diameter by 44 ft long (13.41m) gaseous nitrogen storage bottles. The store measured approximately 29m x 25.5m and contained six pairs of concrete blocks upon which was mounted a frame that secured the nitrogen tanks. From these, gaseous nitrogen was fed through a low pressure main to a series of control valves grouped together within the test stand Pneumatic Control Station. At its east side is a hardstanding measuring 23.5m x 16.0m which probably represents a former loading area.

Water Supply

Vast amounts of water were required at Priorlancy Rigg as coolant for the efflux deflectors on the four stands and for fire-fighting facilities. A **Reservoir Q23.1** located over 700m to the east of the main test area at NY 60617 71726 provided storage capacity for 1,000,000 gallons (4,546,000 litres) and supplied the water for the entire engine test area. Water was pumped to Priorlancy Rigg by the adjacent **Pump House Q23.2**, power for which was supplied by the nearby **Troutbeck Electrical Sub-Station Q23.8** (formerly Q23.3). These features are described fully in the Water Storage and Supply section below. Part of the

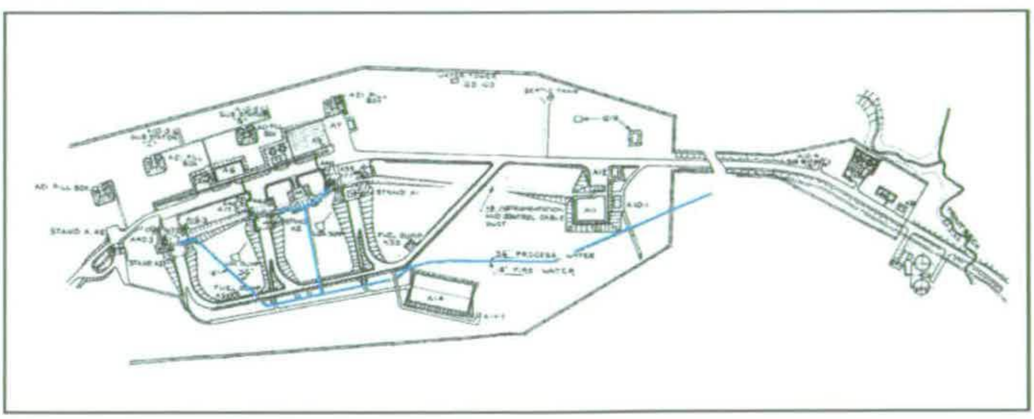

Figure 183
Diagram showing the water supply to test stands at Priorlancy Rigg
© National Archives TNA:PRO AVIA 65/ 1906

route of the water main to the test stands can still be traced as a linear earthwork mound to the east of the Control Room A11 (Fig 183). South of the control room the water main turned

Figure 184
Valve Pit to the west of Engine Test Stand A1 (left)
© Crown copyright NMR (AA94/1962)

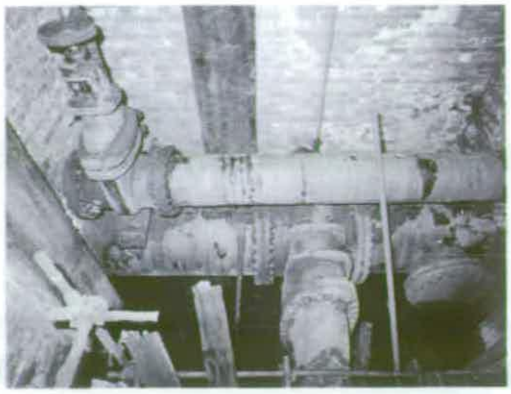

Figure 185
Inside of Valve Pit to the west of Engine Test Stand A1 (right)
© Crown copyright NMR (AA94/1963)

an angle and headed west, passing to the north of the Effluent Lagoon A14 and flanking the southern end of the test stand spillways. From here it was pumped up to each of the stands. Two square Valve Pits, each measuring around 4.4m wide, are located on the slope between Test Stands A1 and A2 (Figs 184 and 185). Large bore pipes emerge at the sides of each of the test stands and these supplied water for cooling the efflux bucket during firings.

Figure 186
Steel Braithwaite water tank A29
© English Heritage (AF00134/A29)

To the north of the test stand causeways was a **Treated Water Plant and Compressor House A29.1** (now A6.1). This brick building measuring 8.25m x 4.05m has a flat concrete roof and originally contained a mixed bed plant comprising booster pump, acid mixing tank, soda mixing tank, compressor and a 2,000 gallon (9,092 litres) treated water storage tank. Also associated with this facility was a rubber bulking tank. A steel Braithwaite **Water Tank A29** measuring 5.09m x 2.89m was supported on five brick piers at NY 59798 72005 (Fig 186). It is currently labelled 'Priorlancy Domestic Water Reservoir'. To the north of the tank is a possible **Pump House A29.1** (Fig 187). This small hut of pink-grey brick measures 2.39m x 2.40m and has a flat concrete roof. A **Water Tower Q2.103** that also once stood in this area has been demolished.

Figure 187
Possible Pump House A 29.1
© English Heritage (AF00134/A29.1)

Test Observation and Monitoring

Engine tests were remotely controlled and visually monitored from a **Control Room A11** to the east of the test stands (Fig 188). During the development and trials stage a great deal of instrumentation was needed to provide information on the functioning of various engine components and systems. Associated with each test facility was an extensive system of control and data-recording instrumentation. A large number of chart recording instruments were installed to obtain the maximum amount of technical data during the short duration of the test. The Control Room was situated some 170m (600ft) to the east of the nearest

Figure 188
Control Centre A11
© English Heritage
NMR (17797/04)

engine test stand at a distance that was deemed advisable by the Chief Safety Officer of the Ministry of Supply (TNA: PRO AVIA 65/1906). This single storey bunker, constructed from 2ft (0.61m) thick reinforced concrete is rectangular in plan. It is protected on three sides by an earthwork traverse (Fig 189) revetted internally by a vertical concrete wall, the fourth and eastern side - that away from potential blast sources – being protected by a vertical concrete wall (Fig 190). It was equipped with 130 recording units, 24 channel oscillographs and eight control consoles for the remote control of the test equipment and the rocket engine during test (Aircraft Engineering, 1960). Visual monitoring of the stands was made from five observation ports in the western wall of the building through five episcopes fixed to the building's exterior. Alternatively the firings could be watched through four submarine type periscopes set behind the observation posts. These passed through the building's roof where four mounting

Figure 189
Control Centre A11 is protected on three sides by an earthwork traverse
© Crown copyright
NMR (AA94/1946)

Figure 190
The western side of the Control Centre A11 is protected by a concrete wall
© Crown copyright
NMR (AA94/1946)

Figure 191
Visual monitoring of tests was done from five observation ports in the west wall of the Control Centre A11
© Crown copyright NMR (AA94/1950)

Figure 192
Submarine type periscopes in the roof of Control Centre A11
© Crown copyright NMR (AA94/1948)

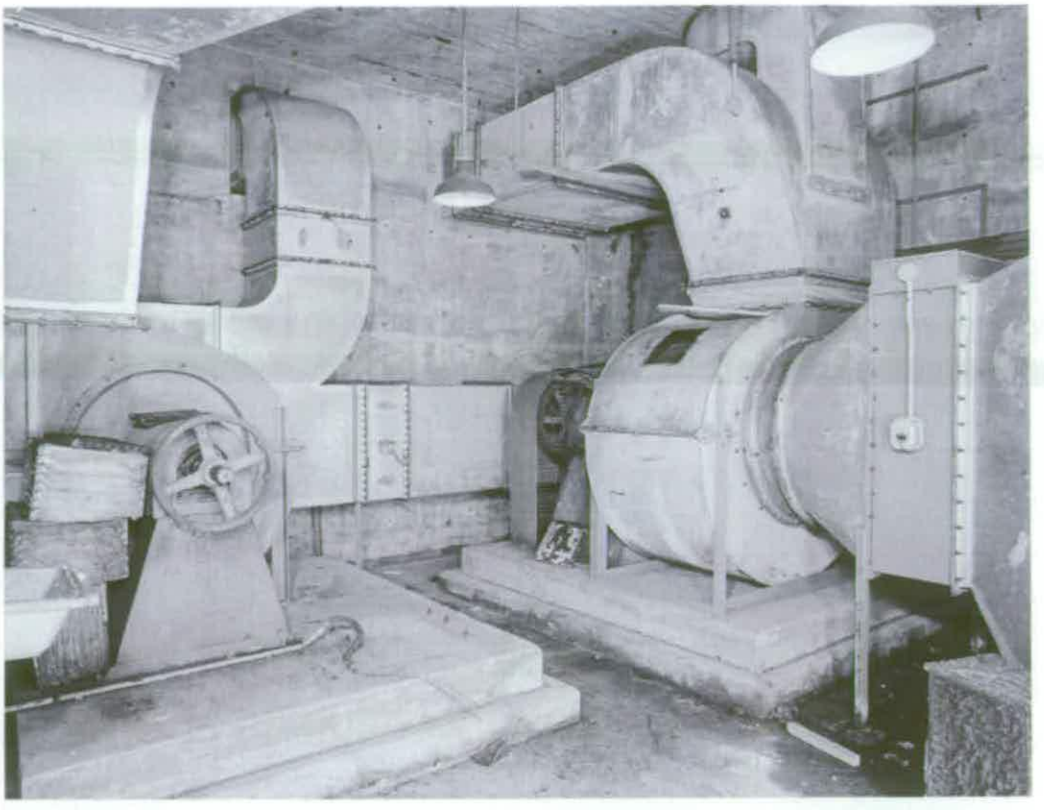

Figure 193
Air conditioning plant to the east of the Control Room © Crown copyright NMR (AA94/2921)

plates survive and the openings could be covered to create a weather tight interior. Air conditioning for the Control Room was provided by machinery located in plant rooms in the east portion of A11, now sealed. Air was supplied from here via metal conduits (Fig 193). Electrical supplies were provided by the adjacent Electrical Sub-Station A10.1.

The Control Room was linked to the test stands by an underground **Instrumentation Duct A8** containing over 8,000 instrumentation and control cables. Comprising a tunnel, 2.9m square in cross section and around 381.0m (1,100 ft) in length, the tunnel survives intact although much of it is now flooded (Fig 194). Internally, some metal cable racks survive in place. It is visible to the east of the road as a linear earthwork mound. Its function was to carry cables on wire racks to avoid the need for above ground cable stands which would have obscured the view of test firings. The design of the tunnel was evidently a contentious one. The plan was an expensive one and problems were encountered with waterproofing. An alternative system of cluster ducts buried in concrete was explored but Rolls-Royce engineers were not satisfied with this as a solution (TNA: PRO AVIA 65/350). A Treasury official considered the tunnel to be one of the few extravagances in the design of the establishment, believing that

Figure 194
Inside the Instrumentation Duct A8 © English Heritage NMR (DP003916)

Figure 195
The Terminal House A4 was protected by an earthen mound © Crown copyright NMR (AA94/1965)

the cables could have been run above ground and only placed in tunnels as they approached the stands (TNA: PRO T225/1424). The Instrumentation Duct led to a **Terminal House A4** between test stands A1 and A2 (Fig 195). This reinforced concrete structure is covered by an earthen mound with maximum dimensions of 21m x 22.5m. Its function was to distribute control and monitoring circuits from the Control Centre to the test stands. It also contained local recorders for high impedance parameters and instrument reference points (Fig 196).

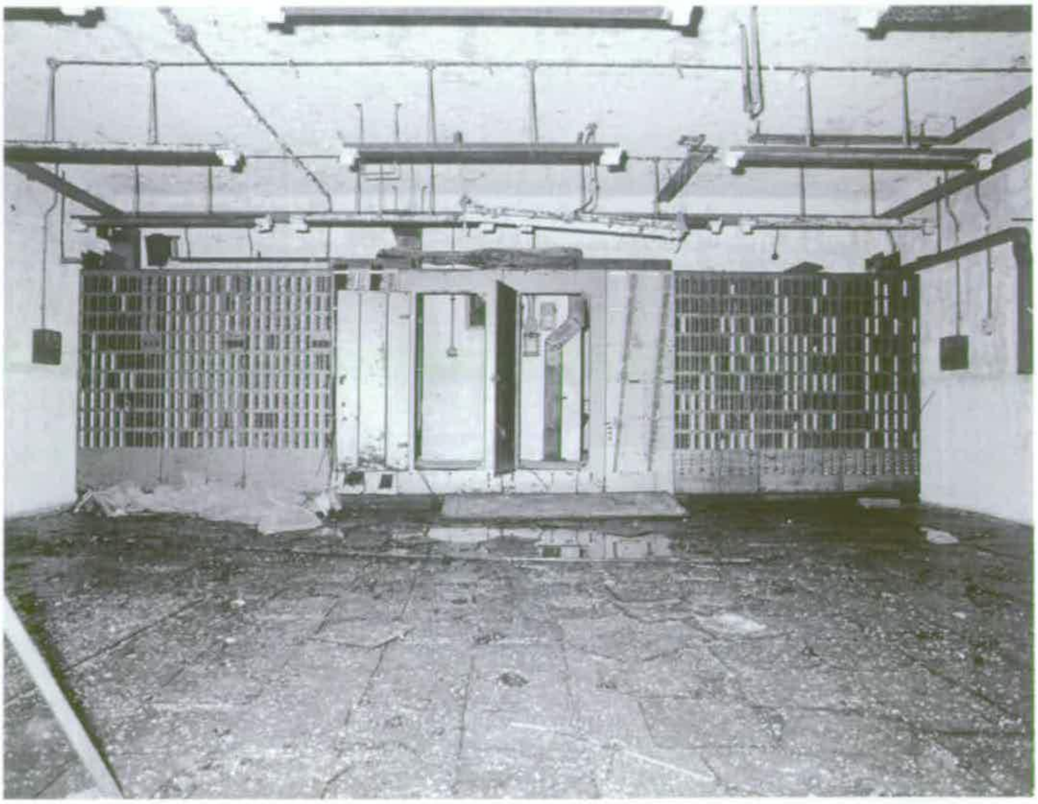

Figure 196
Interior of the Terminal House A4 © Crown copyright NMR (AA94/1966)

The Instrumentation Duct terminated at a small polygonal structure to the east of test stand A42 (Fig 197). With maximum measurements of 3.92m x 4.06m this concrete-framed with brick infill building has a flat concrete roof and internally contains the remains of electrical cable racks. It is lit by an 8-pane metal window and is entered through a single door on the north-west side.

Figure 197
The Instrumentation Duct A8 terminated at a small polygonal structure to the east of Test Stand A42
© English Heritage (AF00134/polygonal)

The test firings were also recorded by cine-cameras from various locations around the test stands – the cameras being remotely controlled form the control room. To the north of the test stands, at a distance of some 50m-65m, is a line of four Observations Posts. These so-called pill-boxes comprise a reinforced concrete structure covered by an earthen mound. They were accessed from the north – the side facing away from the potential blast zone of the test stands – via a small revetted passageway and a steel door with an escape hatch. **Observation Post A21.1**, located to the rear of Test Stand A1, comprises a single internal

Figure 198
Observation Post A21.2
© English Heritage (AF00134/A21.2)

compartment measuring 2.58m x 1.85m with a roof at a height of 2.26m (Fig 198). It is covered in a mound with maximum dimensions of 20.4m x 17.4m that stands to a height of around 3.5m. Projecting vertically from the roof are two steel pipes in which a pair of periscopes were originally fitted though these have since been removed. **Observation Post A21.2** is located behind test stand A2. It is similar in form to A21.1 with a single reinforced concrete box and mound measuring 19m x 18.7m. The periscopes have also been removed from this structure. **Observation Post A21.3** lies behind test stand A3 and is of similar construction to the others. Its earthen mound measures 19.7m x 17m at its widest points and a pronounced earthwork slope leads down to its entrance. Just under

Figure 199
Observation Post A21.4
© English Heritage (AF00134/A21.4)

30m to its west is **Observation Post A21.4** (Fig 199). Again, it is similar in construction with a mound 20.7m x 18.m and 3.5m in height.

Effluent Collection and Treatment

Vast quantities of effluent were generated during test firings, a combination of contaminated cooling water, used fire service water, and unspent fuel. Storm water was also collected as a combined effluent. From the test stands this ran down concrete spillways and into a

Figure 200
A concrete lined drain that flanks the south side of the test stands carried cooling water and unspent fuel to an Effluent Lagoon A14
© Crown copyright NMR (AA94/1968)

series of concrete drainage channels. The channels flow south through conduits under the access road to a common concrete lined drain that runs east-west some 80m below the stands (Fig 200). This drain empties into a 200,000 gallon (909,200 litre) **Effluent Lagoon A14** to the south-east of the test area (Fig 201). Constructed from reinforced concrete this

Figure 201
Storm water, cooling water and unspent fuel were collected in an Effluent Lagoon A14 to the south-east of the test stands
© Crown copyright NMR (AA94/1971)

is rectangular in plan measuring 49.54m x 22.25m with a longitudinally central dividing wall. This wall was topped by a central channel so that any floating kerosene, lubricating oil or scum could be skimmed off. Immediately to the east of the lagoon was the **Waste Kerosene System A14.1** (Fig 202). This functioned as a storage and pumping system and comprised a small square brick built kiosk, 2.20m x 2.22m, and adjacent electrical switch gear. To the west of this stood a concrete bund. Measuring 11.12m x 8.2m and standing to a height of 1.1m, this contains six similar concrete plinths arranged in two lines of three. These originally supported two horizontal tanks, 32ft (9.75m) long and 9ft (2.74m) wide. These stored waste kerosene until it was taken away by tanker for disposal. The twin effluent lagoons enabled not only the bulk storage of waste liquid but also its subsequent emptying for treatment at a controlled rate. Other effluent was drawn off from either lagoon by valve connections at low level and discharged through a 12in (0.3m) cast iron concrete-lined gravity main to the main effluent treatment plant. In normal operation, one lagoon was used for collecting effluent and storm water while the other discharged to the treatment plant.

Figure 202
Immediately east of the Effluent Lagoon is the Waste Kerosene System A14.1
© English Heritage NMR (17819/01)

The Effluent Treatment Plant was located some 500m to the east of the main engine test area. Originally comprising two large circular storage tanks with a small building, probably a pump house, in between; this has since been demolished. The site is identifiable as a level earthwork platform with a pronounced curving scarp describing the arc of the northernmost storage tank. This comprised an **Effluent Pump House Q17.2** and a **Post Treatment Reservoir Q17.3**. The Effluent Pump House, located on the south side of the approach road to Priorlancy at approximately NY 60276 71894, contained three main elements: a plant house and chemical store, a second chemical store and a tank. It has since been demolished but the site is marked by an earthwork platform and one surviving ground level building corner. Immediately to the east of this, at approximately NY 60310 71864, was the Post Treatment Reservoir.

Processing of effluent at the treatment plant was carried out as a series of stages. Preliminary Treatment involved the discharge of effluent through a palatine flow controller in the gravity main into an open channel. From there effluent entered a 45ft diameter clarifloculator at a rate of flow that ranged from 0-25,000 gallons (0-113,650 litres) per hour but with a designed through-put of 12,000 gallons (54,552 litres) for normal operation. Ferrous sulphate and injected chlorine were added in two chemical mixing chambers each of which was fitted with Dorr Oliver turbo mixers. Effluent and chemical that entered through a pipe passed under the clarifloculator and discharged in a central chamber just below the surface. Floc was formed in the central chamber and was gently agitated. Residual kerosene was entrained with the floc and, together with any solid materials, settled on the base of the tank. This sludge was delivered to a filter press in the adjacent sludge handling house. The cakes were ultimately removed to the central waste kerosene incinerators. Remaining effluent, free of sludge, was returned to the clarifloculator feed chamber for re-circulation through the tank. The bulk of the effluent rose in the clarifloculator outer chamber and discharged over a weir into a channel around the periphery. This liquid was then pumped to a series of three de-oiling filters each measuring 6ft 6in diameter by 3ft (1.98m x 0.91m). Any free kerosene, lubrication oil or scum on the surface was skimmed by rotating blades and discharged into a disposal trough. Self-priming pumps delivered the clarified discharge to any of three Permutit pre-floc de-oiling filters. Each filter contained graded anthracite with special pre-formed floc on top. The filter floc, comprising ferrous sulphate, caustic soda, solkafloc, and sodium hypochlorite was prepared in chemical mixing tanks and pumped to the filters. Kerosene, oils and any foreign matter were retained in the filter bed floc and disposed of by back wash into the main clarifloculator entry channel. During normal operation the three filters were worked in parallel with any two of the three pumps installed. Full instrumentation, flow indication, chemical control, metering and pressure gauges were provided at all required stages throughout the plant. Plans to add a further clarifloculator and additional pressure filters to increase capacity may never have been realised. Filtered discharge was then piped through a 10in (0.25m) cast iron main to the Engine Test Area Pump House Q23.2. From the Pump House recycled water was returned to the adjacent 1,000,000 gallon (4,546,000 litre) water storage Reservoir Q23.1.

Ancilliary Features

Immediately to the north-east of the Control Room is a former **Workshop A12** (Fig 203). This single storey building, measuring 9.63m x 6.72m, is steel-framed with low brick walls above which is aluminium cladding and a steel decking roof. It currently functions as a store. To the north of test stand A1 three hardstandings mark the position of a former group of buildings. The **Transport Shelter A7** was a steel-framed structure measuring 9.55m x 5.5m and clad in aluminium sheeting but open to the west. The building has been demolished but its concrete floor slab survives. Immediately south of here a concrete floor slab measuring 4.6m x 3.2m indicates the position of a former **Hut EH3**. A second floor slab measuring 15.45m x 6.11m just 13m to the east is all that remains of former **Hut EH2**. This is not shown on early plans of the area dating to the 1950s, though, these may both have been constructed during the later phase of work at Spadeadam associated with ELDO.

Figure 203
Workshop A12
© Crown copyright
NMR (AA94/1944)

To the north of test stand A2 is the former **Engine Preparation Building A6** (Fig 204). Measuring 24.7m x 11.7m this was built on low brick walls with a steel frame construction. It was originally clad in aluminium sheeting but has been re-clad in pressed steel.

Figure 204
The Engine Preparation Building A6 has been re-clad in pressed steel
© English Heritage
NMR (DP003902)

The Engine Preparation Building stands on a platform cut into the natural slope and this sharpened scarp flanks the rear wall of the building. The scarp describes a dog-leg around A6.1 and continues to the west for a distance of around 40m. The level area immediately to the south of the scarp is occupied by the remains of a former hardstanding with associated features including an access ramp to the south, raised concrete plinths and two electrical junction boxes to the rear. No building is shown here on early plans of the test area and it is now empty except for a partial cover of gravel. A linear kerbed feature flanks the southern side of this area and extends in sections to the east as far as the High Pressure Nitrogen Store A9. This has the appearance, on an early site diagram (TNA: PRO AVIA 65/1906), of a sunken channel or drain that is bridged in places to give access to buildings A5, A6 and A9 to the north. It has been filled with hard-core to ground level. On a level area above the slope was the former **Rolls-Royce Office A44**. This was a temporary building and nothing now survives of this structure.

A **Climatological Station Q19** was located in the east of the site some 50m due north-east of the Control Room A11. Its remains comprise a well-defined rectangular earthwork platform 12.0m x 9.7m and about 0.5m in height accessed via four concrete steps at its

Figure 205
Theodolite pillar at the Climatological Station Q19 (left) © English Heritage (AF00134/Q19post)

Figure 206
Steel framework at the Climatological Station Q19 that may have supported meteorological instruments (right) © English Heritage (AF00134/Q19)

south-east corner. On the platform is an embanked oval hole with maximum dimensions of 4.15m x 3.0m and a single step on the east side. Its depth appears to be 0.15m but the bottom of the hole is obscured by tussocky grass. Metal fittings suggest that a mast may originally have been erected here. In the north-east corner of the platform is a triangular-section theodolite pillar (Fig 205) and, in the north-west corner, some steel-frame working that may once have supported meteorological instruments (Fig 206).

A group of structures originally located just inside the engine test area lie outside of the modern perimeter fence. The only surviving building is Electrical Sub-Station A10.4. This is the westernmost feature and adjacent to this were the Kerosene **Storage Tanks and Pump House A32** at approximately NY 60248 71974. As described above, this comprised a single storey building to the north of which were three horizontal cylindrical tanks and a further two larger vertical cylindrical tanks. All that survives of these structures is an earthwork platform measuring 25m x 13.5m. To the south-east of this was a **Shift House A13**. Although this reinforced concrete building has since been demolished its former position is visible as an earthwork platform at approximately NY 60269 71946. Immediately south-east of here was the **Police Control Post A22** that demarcated the original entrance to the engine test area. This has now also been cleared but an earthwork platform on which it stood still survives. On the south side of the road at this point was the Effluent Treatment Plant, comprising Effluent Pump House Q17.2 and a Post Treatment Reservoir Q17.3 as described above.

Post Blue-Streak Features

Some alterations were evidently carried out to the site at Priorlancy Rigg that post-date its use for Blue Streak engine test firings. Two structures, Hut EH2 and Hut EH3, have already been described that are not shown on early plans of the area and which may have been constructed later in association with the ELDO project.

Since 1976 Priorlancy Rigg has been used by the RAF as part of the Electronic Warfare Training Range. To the south a mock airfield was created by cutting a swathe through the vegetation. This was enhanced by positioning derelict aircraft along its length. A number of these were also placed on the remains of the test stands. These remained until the late 1990s when a new dummy airfield was built in the north-east part of the range. The RAF continues to house a variety of mobile simulators and original Soviet-built radar systems at

Figure 207
Modern Garage A13. In the background is a Fitter SU22-M, one of the derelict aircraft positioned on the site for training purposes © English Heritage NMR (DP003881)

Priorlancy Rigg for training purposes. The former Engine Preparation Building A6 is still in use and in 2002 a **Garage A13** measuring 14.0m x 13.03m was constructed some 130m to the east (Fig 207). This steel-framed double bay structure has brick footings and walls that are constructed of breeze block (lower section) and pressed steel sheeting (upper

Greymare Hill Missile Test Area

The principal test area was located at Greymare Hill just over 3km to the north-east of Priorlancy Rigg (Fig 208). The ground here is a shallow natural baisin that drains eastwards into the Cheese Burn. To the north the ground rises towards Greymare Hill and a maximum height of 331m but it is the two concrete test stands that dominate the area. These are the largest on the range and, as at the Engine Test Area, they were deliberately sited to exploit the contours of the hill, being set into a natural scarp along the 310m contour line.

Figure 208
Missile Test Area at Greymare Hill
© English Heritage NMR (17819/05)

The two stands, referred to as the east stand or C3 and west stand or C2, were designed for the full static firing of complete Blue Streak launch vehicles. Static firings allowed the maximum amount of information on both the vehicle and the ground system performance to be obtained with a minimum expenditure of time and money. Additionally, should a system malfunction during firing then the test could be terminated. The test stands at Greymare Hill were initially equipped for the erection and support of an entire missile and, later, the first stage of the ELDO rocket. In terms of development of ground support equipment and operational procedures, it was essential that the Greymare Hill static test facilities were as similar as possible to the ultimate launch site at Woomera in Australia. Initially known as the Missile Test Area, subsequent to the cancellation of the missile project this facility was referred to as the Rocket Test Area. They also shared common features including a supply infrastructure, a Control Centre to the south, and a number of service buildings along the northerly road connecting the two stands. The east test stand C3 was finished in June 1961 but that to the west was evidently never completed.

Construction work at Greymare Hill began in 1958-9. Early aerial photographs of the site (F21 543/RAF/1429 frame 149) show seven or eight labourers' huts to the west of the approach road at approximately NY 61981 74133 (Fig 209). Erected to accommodate a

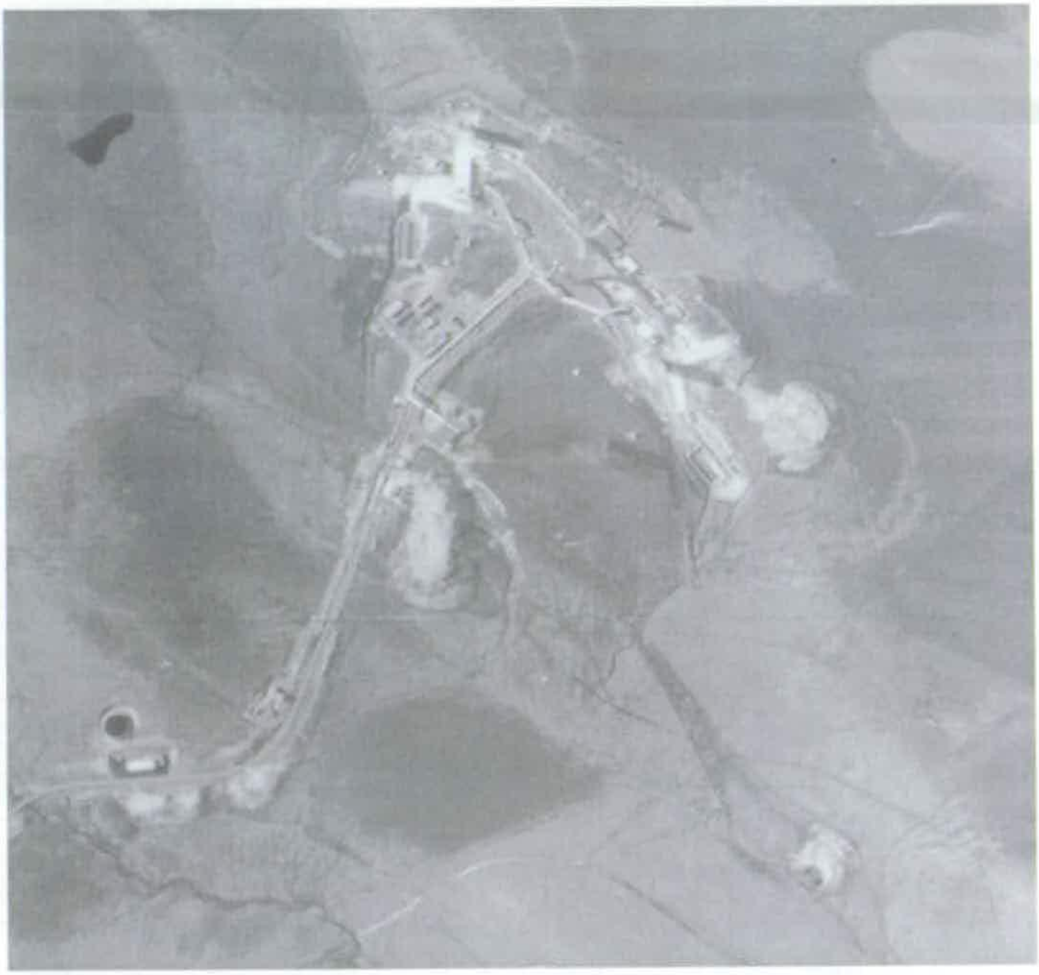

Figure 209
Aerial photograph of the Missile Test Area at Greymare Hill in August 1961
© Crown copyright F21 543 RAF/1429 Frame 149

temporary workforce, they were subsequently demolished. The area is overgrown with vegetation but although tussocky grass covers some of the concrete hut bases others are still visible (Fig 210). **Hut EH3** survives as a concrete floor slab measuring 12.2m x 6.0m. To the south-east of this is a second, much smaller, concrete floor slab for **Hut EH4** with dimensions of 3.6m x 2.3m. Some 26m further to the south-west was **Hut EH5**. This is now only visible as a concrete base measuring 7.0m x 3.8m. The remains of **Hut EH6** comprise a concrete floor slab, 26.0m x 7.0m, located 18m to the north-west of Hut 5 which slopes gently to the north and has a possible entrance in its south-east corner.

Figure 210
Concrete floor slabs survive where temporary construction huts were erected at the Missile Test Area
© English Heritage (AF00134/greymare huts)

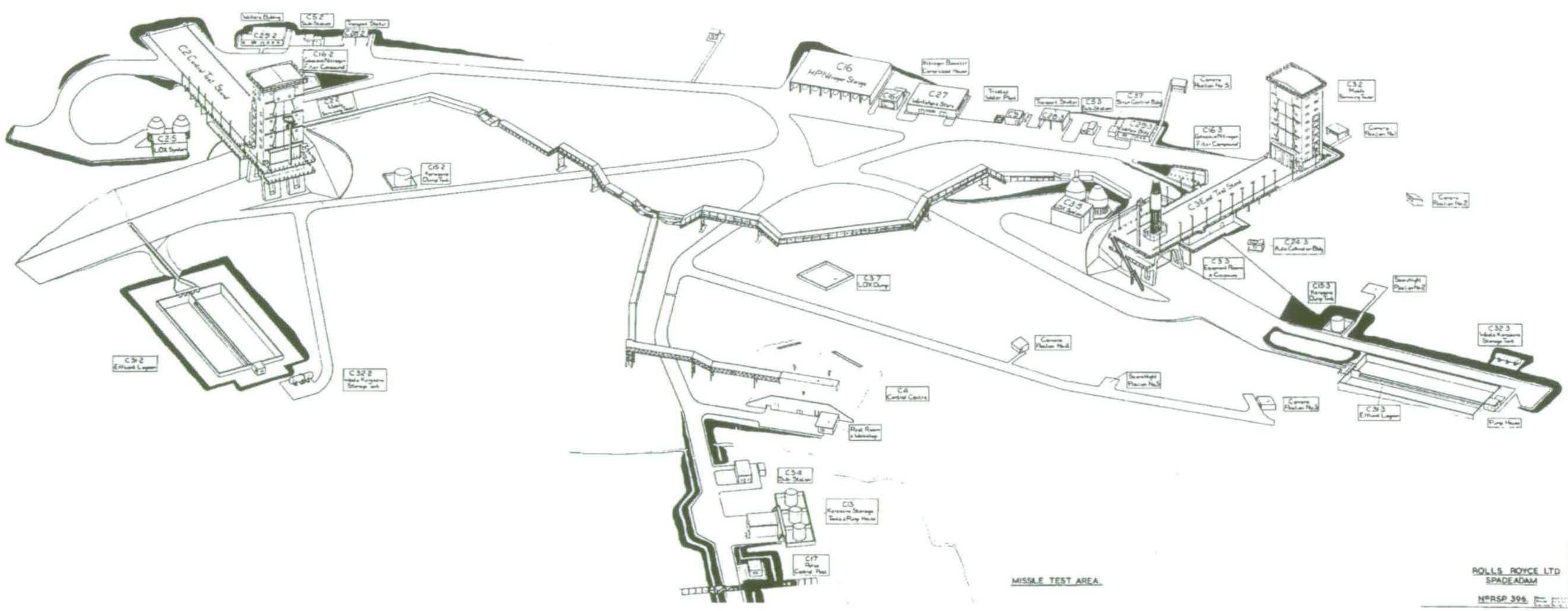

Figure 211
Diagram of the Missile Test Area at Greymare Hill
© Rolls-Royce plc

The Missile Test Area at Gremare Hill was extensive, comprising two test stands and an observation system (Fig 211). Large mounds of earth were also created at Greymare Hill during the construction phase. One of these, in the extreme north-east of the site, has maximum dimensions of approximately 70m x 100m and is surrounded, on its north-east side, by a low-lying area of marshy ground. A second mound lies at the extreme south of the site. Measuring approximately 75m x 120m the form of this irregularly-shaped mound appears, to some extent, to have been dictated by line of the nearby stream. The Greymare Hill test site is also extensively covered in earthwork drainage channels. In particular these flank the east side of the approach road and the area to the north of test stand C3. Typically channels are 2-3m wide and around 1m deep. These are shown on aerial photographs dating to 1961 (F21 543/RAF/1429 frame 149) and were created during the construction phase.

Figure 212
Police Control Post C17
© Crown copyright NMR (AA94/1988)

Access to the Greymare Hill test site was regulated at the southern end of the facility by a **Police Control Post C17** located to the east of the approach road (Fig 212). This is a rectangular single storey brick building with a flat concrete roof measuring 5.96m x 4.35m, and standing to a height of around 3m. It was entered through a porch on the west side that has subsequently been enclosed by wooden panelling. Internally there is a single large room and outside, a small 'serving hatch' in the west elevation (now bricked up) is visible through which passes could be issued.

The **Test Stand C3** lies in the eastern half of the site (Fig 213). For safety reasons a wire mesh fence surrounds most of the stand and its associated features. Each stand consisted of two main elements: a concrete causeway at the end of which was a free-standing thrust pad on which the rocket was fired. The vehicle was transported to the test stand by road in the handling frame and was then transferred into a mobile servicing tower. This ran on rails embedded in the causeway and carried the rocket to the thrust pad at the end of the causeway (Fig 214). This tower was not only used to erect but also to service the vehicle and could be moved back to a safe distance when firing was imminent. The launcher, which physically supported the vehicle once it was in position and then released it for flight, was also mounted on the emplacement. Test firings produced vast amounts of flames and efflux gases that had to be safely deflected away from the stand. A massive steel bucket, or efflux deflector, beneath the stand provided the escape path for the hot gases. Large concrete rooms beneath the causeway provided safe housing for those items such as hydraulic supplies, pneumatic and electrical control systems which needed to be close to the vehicle.

Figure 213
Modern aerial photograph of Missile Test Stand C3
© English Heritage NMR (17819/16)

Figure 214
Missile Test Stand C3
© Crown copyright NMR (AA94/2970)

The concrete **Causeway** of test stand C3 measures a total length of 76.2m and is 19.9m wide (Fig 215). Two channels, 0.62m wide, run the length of the causeway set 14.65m apart. Within these channels were a pair of metal rails which guided the **Mobile Servicing Tower C3.2** which originally stood to a height of 120ft (36.58m) (Fig 216). It weighed 400 tons (406.4 tonnes) but this was increased to 600 tons (609.6 tonnes) by a later extension

Figure 215
Contemporary photograph of the causeway of Missile Test Stand C3 showing a vehicle in place on the thrust pad
© Rolls-Royce plc

and was fitted with a crane that could winch the vehicle from a horizontal to a vertical position still within its handling frame (Fig 217). The servicing tower was self-propelled, moving on four electrically driven bogies - one at each corner - powered from batteries stored at the top of the tower. At either end of the channels are concrete blocks - buffers for the mobile servicing tower. Those to the north measure 1.6m x 0.9m, stand 0.6m in height and are chamfered to the rear. Two buffers on the thrust pad are slightly smaller measuring 0.93m x 0.9m and 0.62m high; they are also chamfered to the rear. The edge of the causeway is protected by a tubular steel handrail which is severely corroded and missing in

Figure 216
Missile Test Stand C3 showing a vehicle in position on the thrust pad and the Mobile Service Tower behind © Rolls-Royce plc

Figure 217
The Mobile Servicing Tower was fitted with a crane for winching the rocket from its transporter into a vertical position © Rolls-Royce plc

places. Contemporary photographs (SP/092/CL; SP/095/CL.BW) show high-level lighting along each side of the platform, and the remains of metal light standards and electrical junction boxes are still visible (Fig 218). The photographs show that additional lighting was supplied by mobile searchlights on the causeway and in the area around it (described below p.155) of which nothing remains. The tower also had folding platforms which, in the vertical position, encircled the vehicle and provided working floors at approximately 10ft vertical intervals. A lift was installed for carrying personnel and equipment to platform levels in addition to emergency external stairs. A tension device applied the necessary constant tensioning to the first stage regardless of possible movement of the tower due to windage or slight changes in the vehicle dimensions resulting from upper stage loading or propellant filling. The servicing tower was equipped with lighting, heating, fire-fighting facilities, and local power points and external cladding protected the vehicle and personnel from the elements. Prior to firings the mobile servicing tower would withdraw a safe distance back along the rails to the opposite end of the causeway (Williams and Hume, 1963-4). A modern Garage C31 (described below p.167) has been recently constructed at the north end of the causeway. In line with the front of this building and to either side of it are steel plates, 1.17m x 0.46m, which probably mark where the front of the tower came to rest. At this point during preparations for a static firing or launch the vehicle was most vulnerable to ground winds. With 5psi in the LOX tank and 2psi in the kerosene tank, a wind velocity of up to 45mph could be withstood. Winds were most problematical during the later ELDO project when all threes stages were erected and the vehicle was fully fuelled just prior to a static firing test.

Figure 218
Missile Test Stand C3 was illuminated by high level lighting and by mobile searchlights on the causeway and in the surrounding area © Rolls-Royce plc

At the end of the causeway is the **Thrust Pad** (Fig 219). This free standing concrete structure supported by four inclined legs, each set at an angle of 7°, originally held the launcher and vehicle. The top of the thrust pad measures around 19m x 19m. In the centre is a large square hole, 6.2m x 5.9m over which the vehicle was suspended for firings. A tubular steel link gantry incorporated in the servicing tower and hinged at the bottom by two pivots lifted the vehicle from the handling frame. Four metal plates, one situated some 5m from each of the hole corners, probably indicate the resting position of the mobile tower while the vehicle was being mounted onto the thrust pad. The thrust pad was designed to resist a pull of up to 1,000,000 lbs (453,600kg) and during test firings the rocket was held down on top of the thrust pad by the heavy steel **Launcher**. The launcher was a steel component weighing about 70 tons (71.12 tonnes) and it had four basic functions. It supported the erect vehicle when the propulsion system was inoperative; it rotated the vehicle on its stand to allow for changes in flight path azimuth; it held the vehicle down against the full thrust of the propulsion system; and it effected a controlled release of the vehicle.

Figure 219
Thrust pad of the Missile Test Stand C3
© Crown copyright NMR (AA94/2028)

Each launch platform consisted of two massive main box beams 26ft (7.92m) long, 5ft (1.52m) wide, 7ft (2.13m) high and weighing 24 tons (24.38 tonnes) connected by a lighter vee-gate structure. At each end of the box beams, attached to the corners by a yoke bracket supported on a pivot pin, was a large wheeled bogie assembly. In order to allow for changes in the flight path azimuth the complete structure was mounted on four such bogie wheels. These were 20in (0.5m) in diameter and fabricated from 1in (0.03m) thick flame cut Conlo special steel plate. They were set at an angle 32.5° and driven by Strateline gear units on arcs of rail sunk into the concrete emplacement allowing the platform to be rotated as required. The complete structure weighed a total of 70 tons. To position the platform, the bogies were lowered on 6 inch diameter guide rods into engagement with the azimuth rails, thus lifting the launching platform feet clear of the ground. Radial movement was then obtained, allowing the entire launcher to be rotated. At the correct radial position the bogies were hydraulically raised and the launcher rested on the main beams of the track. The rocket was held in position at its base by four articulated hydraulically operated arms of the release gear. To prevent the launcher lifting under full thrust it was secured at each corner by a 4in bolt screwed into slippers which slide on guide rails in the emplacement. The first platform built was a mild steel prototype with development work done by Morfax Ltd. Subsequent platforms were made of Conlo 1 notch ductile steel (which is a low carbon high manganese steel) from the Consett Iron Co. Ltd. Low carbon content greatly reduces difficulties in welding whilst risk of cracking in heat affected zones of weld is negligible. This necessitates strengthening by high manganese content with no increase risk in welding. This steel has an appreciable increase in yield point value for same tensile strength range mild steel, increasing safety margins. All the release gear was tested extensively at Hatfield. Additional design work was carried out by Morfax Ltd on design and installation of the circular rails and the tracks on which the platform rotated. They produced set of mild steel rails in 15ft (4.57m) long segments with a 3in x 3in (0.08m x 0.08m) section. A controlled release was effected over a period of 100 milliseconds through release jaws that were hydraulically damped to avoid any sudden and destructive impulse loading being imposed on the vehicle (Vernon, 1960, 86-96).

Set into the concrete surface of the thrust pad are the remains of a circular steel rail. The launcher was set on this to allow the rocket to be accurately rotated in azimuth prior to firing. To the east side of the main hole are two rectangular holes, one smaller measuring 0.95m x 0.6m and one larger measuring 2.77m x 0.93m; all are steel lined. This lay-out is mirrored to the west. To the south is a circular steel plate, 1.3m in diameter, with an inner bore of 0.65m which probably marks the position of a slender **Servicing Mast** (Fig 220). Between the main hole and this feature is a narrow steel channel set at right angles to the

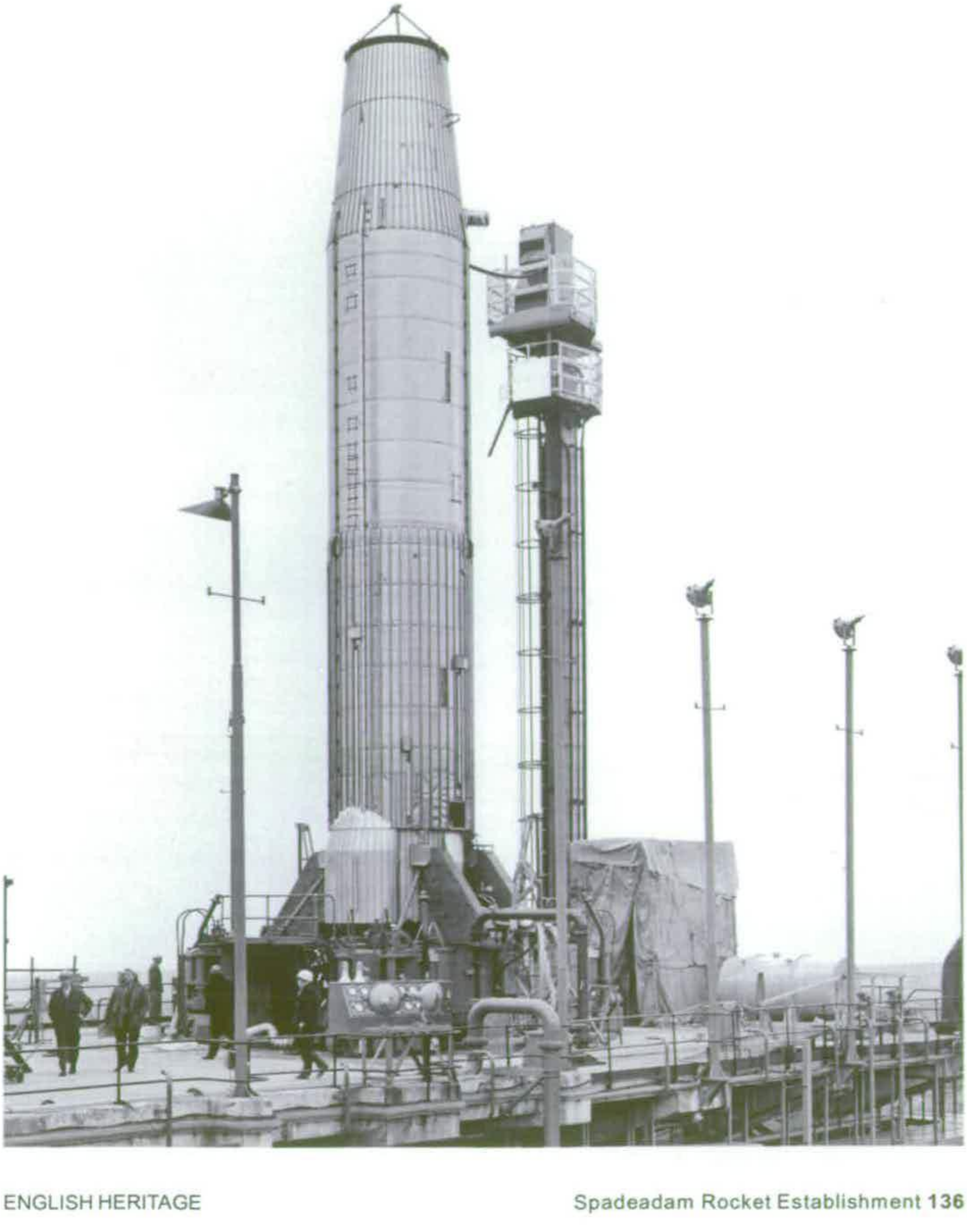

Figure 220
Contemporary photograph showing a vehicle in position on Missile Test Stand C3 with the Service Mast to the right
© Rolls-Royce plc

rails. 22.4m to its north is another narrow steel channel beyond which is a third channel 0.7m in width. Immediately to the west of the feature is a series of metal fixtures set into the concrete; these may mark the position of a low structure that is shown on contemporary photographs (SP/098/CL) next to the servicing mast.

Efflux Deflectors

Efflux from the rocket was directed through the hole in the thrust pad into a steel deflector beneath that was similar to those installed at Priorlancy Rigg. The deflector was an 18ft square steel bucket weighing approximately 70 tons (71.12 tonnes) and was the largest of its type at the time. It was held on three concrete sloping supports (Fig221)and to produce a 90° deflection of the efflux, the deflector surface was at a 45° slope. To prevent over-heating during firings the deflector was water-cooled. Cooling water was pumped to the test stands in 3ft diameter pipelines and entered through holes in the deflector surface at a rate of 20,000 gallons (90,920 litres) per minute (Fig 222). As a result the surface of the deflectors encountered temperatures of around 120-140°C (Williams and Hume 1963-4). As at Priorlancy Rigg, waste water, together with any unspent fuel, flowed down a spillway that extended to the east. At a width of 16m this concrete sluice ran down to an effluent lagoon to the east.

Figure 221
Three sloping concrete walls supported the efflux deflector bucket at Missile Test Stand C3
© Crown copyright NMR (AA94/2892)

Figure 222
Contemporary photograph of Missile Test Stand C3 showing cooling water pouring from the efflux defelector bucket
© Rolls-Royce plc

The test stand also has an intermediate level. A concrete walkway 3.1m wide runs around three outer sides of the thrust pad at this level and could be accessed from the sides of the stand. The length of the walkway was enclosed by a tubular steel handrail though this is now in disrepair. On the surface of the walkway are a number of plinths upon which machinery and gas storage tanks were originally mounted. A contemporary photograph (RR95.1117.11) shows an external steel staircase fixed to the south side of the stand giving access from the lower ground level to the top of the thrust pad and to an intermediate level (*see* Fig 222).

For maximum strength the causeway was constructed as a hollow rectangular concrete girder (Walley 2000, 19). The space inside was divided into eight bays and was used as **Equipment Rooms** containing equipment that needed to be close to, but also protected from, the vehicle during firings. Housed within the bays were electronic rectifiers, batteries and switchgear as well as hydraulic equipment including high and low pressure gaseous

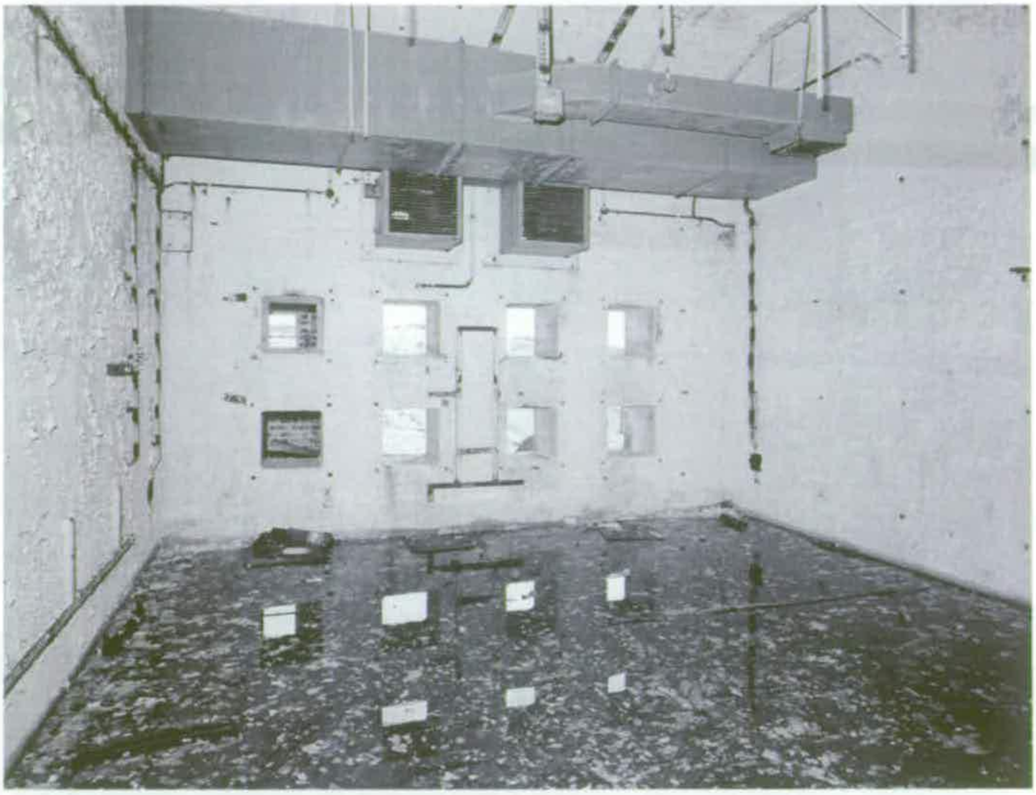

Figure 223
Equipment Rooms beneath the causeway of Missile Test Stands C3 housed electrical and hydraulic equipment
© Crown copyright NMR (AA94/2893)

Figure 224
Galvanised metal roof ducting within the Equipment Rooms of Missile Test Stand C3
© Crown copyright NMR (AA94/2895)

nitrogen pipe-work, compressed air and an air conditioning plant. Most of the internal walls are pierced by rectangular openings for ventilation ducts and cabling (Fig 223). The equipment has been removed and although some galvanised metal roof ducting survives, the rooms are derelict and much of the floor surface is water covered (Fig 224). A central corridor runs through these rooms from the rear of the stand to the steel door which provided access to the walkway.

On the west side of the equipment rooms is a small brick out-shot measuring 6.15m x 2.56m with a double entrance on its western elevation (Fig 225). Internally, some electrical fittings survive and building covers four square openings which open into the air conditioning plant room behind. The eastern wall of the equipment rooms is similarly pierced by square

Figure 225
West side of Missile Test Stand C3 showing walkway level and brick outshot
© Crown copyright NMR (AA94/2891)

openings and ventilation holes. Also attached to this wall face are the remains of cable ducting. Two brick out-shots here are protected by the overhang of the causeway. The southerly building measures 1.30m x 5.58m and the remains of cable ducts within the building probably indicate that it held instrumentation equipment. The building to its north measures 4.01m x 2.14m and it, too, has large ventilation holes in its eastern elevation. To the north of the rear passage providing access to the equipment rooms is a concrete retaining wall. Beyond it, to the north, are two small brick instrumentation rooms placed beneath the overhanging causeway. The first room, measuring 4.27m x 2.2m, stands to a height of 2.6m. Some electrical fittings remain in here. The northernmost room with dimensions of 4.15m x 2.2m and a height of 1.96m is slightly smaller. On the slope in front of these rooms are three heavily lagged pipes.

Auxilliary Supply Systems

Essential to the operation of the Blue Streak vehicle was its closely integrated ground system. The primary liquid transfer systems (described below p.142) supplied the vehicle with propellants - liquid oxygen and kerosene, whilst the auxiliary transfer systems supplied nitrogen, water and lubricating oil. Pressurised propellant was also supplied for engine starting from two small tanks mounted on the launcher. The gaseous nitrogen system was the most extensive system on the test stand. At Greymare Hill, as at Priorlancy Rigg, it included a separate main and emergency supply, derived from a battery of 4ft (1.22m) diameter by 44ft (13.41m) long gaseous nitrogen storage bottles located behind, and some distance from, the test stands. From these, gaseous nitrogen was fed through a low pressure main to a series of control valves grouped together within the Pneumatic Control Unit. This control unit, housed in one of the concrete rooms beneath the causeway, regulated the pressures and flow rates of all gaseous services required by the vehicle up to the moment of launch. This gaseous nitrogen was needed for valve actuation, purges and propellant tank pressurisation prior to launch but most important was the pressurising supply for the main liquid oxygen and kerosene tanks. This both effected the filling of the vehicle bottles and maintained a constant pressure within the ground liquid storage tanks. Valves controlling the wider gaseous nitrogen supplies to the ground support equipment could not be conveniently grouped together – each valve was mounted on or close to the piece of equipment it served. The missile (or first stage of the rocket) carried a bottle of liquid nitrogen in flight to provide a source of gas for the purpose of maintaining tank pressurisation. This was supplied from an insulated liquid nitrogen tank under the test stand emplacement. The first stage also required a supply of lubricating oil for the propellant turbo-pump gear boxes during engine operation, a supply of de-mineralised water for filling the thrust chamber regenerative cooling jackets to reduce thrust build-up rate during start, and a supply of trichloroethylene for flushing parts of the propulsion system before and after firing. Oil and water were supplied from tanks mounted on trolleys with hand pumps being used for the transfers.

Ground Hydraulic System

The rocket autopilot hydraulic pumps were powered by an auxiliary drive on the propellant turbo-pump gearboxes. A ground supply of hydraulics was therefore required to carry out autopilot checks and to hold the engines in a central position during thrust build-up before the vehicle hydraulic pumps took over. The ground hydraulics consisted of a trolley on which were mounted four electronically driven pumps housed in one of the equipment rooms beneath the causeway (Williams and Hume 1963-4).

To the east of the test stand a concrete path leads down to the **Auto Collimator Building C24.3** (Fig 226). This is a small L-shaped building, single storey and constructed from brick, that measures 5.16m x 5.14m. It is entered through a porch, 1.75m x 1.49m, on the north side and internally, against the north wall, are two ceramic pipes that retain some cabling though the Auto Collimator Building is derelict.

Figure 226
Auto Collimator Building C24.3
© Crown copyright NMR (AA94/2896)

Primary Supply Systems

Ground Electrical Supply

As described above, all site power supplies were derived from the grid as a 415-volt supply. A single storey **Electrical Sub-Station C5.4** is located in the south of the test site (Fig 227). Measuring 10.85m x 5.96m this is a brick structure open to the south with double

Figure 227
Electrical Sub-Station C5.4
© Crown copyright NMR (AA94/1989)

bays separated by brick wall. A further high voltage **Electrical Sub-Station C5.3** was situated to the west of the test stand - a small brick building with a flat concrete roof, this measures 3.66m x 2.40m (Fig 228). Immediately to its west is a wire mesh enclosure which still houses a 750kVA transformer. The ground electrical supply system provided power to the ground support equipment and was derived from a unit housed in the equipment rooms beneath the causeway. It also supplied the vehicle until 30 seconds before firing at which time the vehicle systems were switched to internal battery supplies. All site power supplies were derived from the grid as a 415-volt supply fed straight to the large items of electrically driven equipment such as the liquid oxygen and kerosene transfer pumps. The majority of equipment was fed with 240-volt single-phase current; a limited amount of equipment required a 50-volt dc current fed by rectification of the 240-volt supply. In the event of a power failure batteries connected on a float charging system supplied essential services. Power was fed directly to large items of electrically driven equipment such as the liquid oxygen and kerosene transfer pumps.

Figure 228
Electrical Sub-Station C5.3
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Liquid Oxygen (LOX) Supply

The **LOX System C3.5** is located to the west of the test stand (Fig 229). It comprised two principal structures: the LOX store tanks and Pump House, and its function was to pump stored liquid oxygen into the vehicle under testing. Two circular walls supported the LOX storage tanks that are no longer in position. These identical bases comprise an outer brick wall that is 7.08m in diameter, 1.43m high and 0.77m thick with a low entrance, 0.92m tall and 0.53m wide, on the north side which provides access to the interior. On top of the walls are the remains of sixteen plates which supported the tank superstructures. The interior consists of an octagonal concrete base, 2.8m in diameter, 0.55m thick and 1.45m high. Contemporary photographs (SP098CL; SP099CL) show these bases each supporting a single large yellow LOX tank that would have been filled by tanker from the supply manufactured at the LOX plant in the BOC site (Fig 230).

Figure 229
Liquid Oxygen (LOX) Store Tanks and Pump House C3.5 © English Heritage NMR (DP003888)

Figure 230
Contemporary photograph of Missile Test Stand C3 showing two large yellow LOX storage tanks to the west of the causeway © Rolls-Royce plc

Adjacent to the tanks is the Pump House. This tall single storey building is constructed from brick with a concrete floor and flat roof supported by three concrete beams. It measures 12.12m x 7.33m and has large openings in its east and west elevations. Adjoining the southern elevation is a small brick out-shot, measuring 2.42m x 2.12m, with a flat concrete roof. The Pump House originally housed two Missile Charging Pumps rated at 500gpm; inside are nine plinths with mounting bolts for the pumps and associated equipment. Some fittings survive, including the remains of cables and an electrical switch box. A line of four rectangular concrete stanchions, each 0.8m x 2.3m, runs between the pump house and test stand. These probably supported stainless steel piping through which the LOX would have been transferred.

Unlike the transfer of kerosene which was a well-tested procedure, the transfer of a cryogenic (liquid oxygen) at a rate of 250 gallons per minute had never before been attempted in the United Kingdom. Liquid oxygen and kerosene were transported to the launch site in tankers and were then held in storage tanks with sufficient capacity for a vehicle launch preceded by several hours of hold time - approximately 60 tons (60.96 tonnes) of oxidant and 27 tons (27.43 tonnes) of fuel. A two-pump system pumped liquid oxygen from the launcher storage tanks into the vehicle tanks at two distinct rates: one for main filling at 500 gallons (2,273 litres) per minute and a topping flow of 10 gallons (45.46 litres) per minute for final fill. Vehicle and ground LOX transfer lines had to be pre-cooled to the low boiling point of LOX (-183°c) to prevent the production of high gas pressures resulting from boil off in the pipes when transferring the liquid. This was done by pumping liquid oxygen through the supply system which was then dumped. For this reason, supply lines were kept as short possible by locating the LOX storage tanks adjacent to the test stand.

Once the vehicle had been supplied with LOX, this could be returned to storage for a later refill via remotely operated valves in the event that the firing had to be aborted. Alternatively, in an emergency, LOX could be dumped quickly and safely away from the test stand. From the four rectangular concrete stanchions between the Pump House C3.5 and test stand another line of four rectangular concrete stanchions, each measuring 0.9m x 1.8m, continues to the south-west for a distance of 30m (Fig 231). After turning through another right angle, the line continues for some 53m as series of concrete blocks measuring 0.6m square. As shown on early photographs of the test stand (95.1117; 099CL) (*see* Fig 230), these originally

Figure 231
Concrete stanchions to the west of Missile Test Stand C3 carried a pipeline from the test stand to an emergency LOX dump Area
© Crown copyright NMR (AA94/2023)

carried stainless piping that conveyed liquid oxygen to the LOX Dump Area in an emergency. The **LOX Dump Area C3.7** consisted of an almost square tank measuring 8.95m x 8.85m with 0.2m wide walls standing to a height of 0.46m (Fig 232). Its base is featureless but in the south-east corner is a sluice leading into a concrete drain.

Figure 232
LOX Dump Area C3.7
© Crown copyright NMR (AA94/2002)

Kerosene Supply

Kerosene was also transported to the launch site by tankers. It was stored in the **Kerosene Storage Tanks and Pump House C13** which, in contrast to the LOX tanks, were located 1,000ft (304.8m) to the south of the test stand for safety reasons. Now demolished, its remains are partly obscured by dumping and demolition rubble but some features may still be discerned. One hardstanding measuring 11.6m x 10.8m hosts a raised concrete plinth, 3.10m x 1.55m. To its south is a T-shaped footing – a possible base for pumping or recording equipment. The main stem of this measures 3.30m x 2.07m and at right angles to it is an area measuring 6.4m x 0.6m. Further south is another concrete surface, 2.75m x 1.50m, with two metal pipes set into its floor. The kerosene store originally consisted of three 15,000 gallon (68,190 litre) mild steel tanks which supplied kerosene to the whole Greymare Hill site. Fuel was transferred by mild steel pipeline up to the two test stands and **Delivery Mains C2.4** and **C3.4** respectively. There were filters situated close to vehicle and remotely operated valves for pre-cooling, filling operations or for returning the liquids to storage for a later refill of the vehicle in an abort situation.

In the event of an emergency, kerosene could be discharged via an 18in (0.46m) main from the rocket to the **Kerosene Dump Tank C15.3** (Fig 233). This 10,000 gallon (45,460 litre) tank was supported on a raised circular base, 4.85m in diameter, to the south-east of the stand. This was surrounded by a square concrete wall measuring 7.17m square, 1.38m

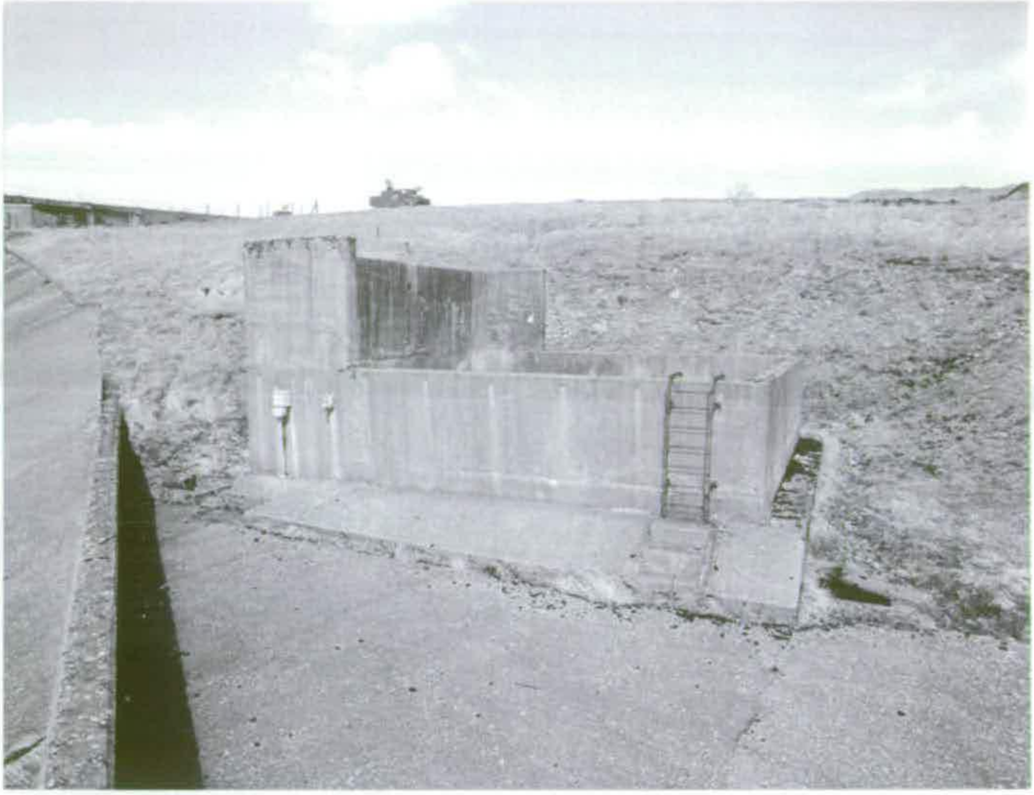

Figure 233
Kerosene Dump Tank C15.3
© Crown copyright NMR (AA94/2034)

high and 0.22m wide. The west side of this wall – that closest to the test stand - was taller for added blast protection.

Nitrogen Supply

The gaseous nitrogen system was the most extensive system on the test stand. It included a main supply derived from **High Pressure Nitrogen Storage Tanks C16** located behind, and some distance from, the test stand which comprised seven gaseous nitrogen storage bottles and separate emergency supply of one cylinder (Fig 234). Each cylinder measured 4ft (1.22m) in diameter and 44ft (13.41m) long with a capacity of 530 cubic feet (14.9m^3). These have now been removed but a hardstanding survives on which there are eight pairs of rectangular concrete blocks. Each block measures 1.91m x 0.60m and stands to a height of 0.65m and on the top of each are four metal mounting bolts.

Figure 234
High Pressure Nitrogen Booster Storage Tanks C16
© Crown copyright NMR (AA94/2041)

Figure 235
Gaseous Nitrogen Booster Compression House C16.1
© Crown copyright NMR (AA94/2040)

Immediately to the east was the **Gaseous Nitrogen Booster Compression House C16.1** (now C16) (Fig 235). This building, measuring 6.98m x 5.60m, housed two parallel auxiliary gaseous nitrogen booster compressors and associated features. Constructed from brick with a flat concrete roof it has a wide concertina steel door in the south elevation. To the rear is a small brick out-shot – possibly a washroom – measuring 3.30m x 4.23m.

To the west of the test stand, adjacent to the access road, was the **Gaseous Nitrogen Filter Compound C16.3**. The surface of this irregularly shaped enclosure is above the level of the lower roadway and was accessed via a set of metal stairs on the southern face. It formerly housed the filters and pressure regulators incorporated in the high pressure gaseous nitrogen, main gaseous nitrogen and emergency gaseous nitrogen line running from beneath the storage cylinders. Gaseous nitrogen was fed through a low pressure main to a series of control valves grouped together within the Pneumatic Control Unit housed beneath the causeway. These regulated the pressures and flow rates of nitrogen and, indeed, all gaseous services required by the vehicle up to the moment of launch.

Water Supply

Water was piped to both test stands from the Pump House at Midhill, some 1.5km north of the Administration Area (described below p177). Cooling water was pumped to the test stands in 3ft (0.91m) diameter pipelines and entered through holes in the deflector surface at a rate of 20,000 gallons (90,920 litres) per minute. Immediately to the south-west of the test stand is a series of valve pits and sunken water tanks that would have been part of the water supply system for the test stand. Two further valve pits of similar function, each measuring 3.2m x 4.9m, lie some 160m to the north-west where the Greymare Hill access road bifurcates to service the two test stands (Fig 236). To the south-east of the Control Centre are further valve pits and pumps which may also have been associated with the supply of water to the stands.

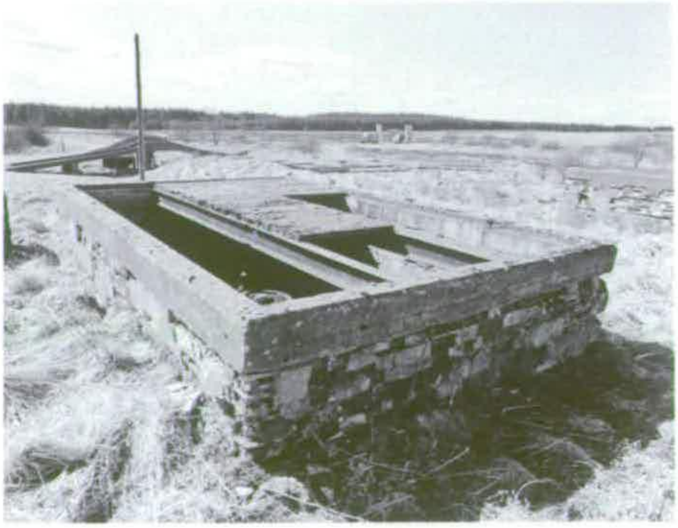

Figure 236
Two Valve Pits are located at the bifurcation of the access road between the two test stands
© Crown copyright NMR (AA94/2000)

Figure 237
A broad concrete lined spillway extends eastward from Missile Test Stand C3 to an Effluent Lagoon C31.3
© Crown copyright NMR (AA94/2029)

Figure 238
Eight sluice gates at the west end of the Effluent Lagoon controlled the flow of waste water and unspent fuel
© Crown copyright NMR (AA94/2032)

Figure 239
Pump House to the east of Effluent Lagoon C31.3
© Crown copyright NMR (AA94/2033)

Effluent Treatment

Waste cooling water from the east test stand, along with any unspent fuel, was washed down a broad concrete sluice to the **Effluent Lagoon C31.3** to the east (Fig 237).

This comprises a rectangular concrete tank with dimensions of 49.62m x 22.48m divided into two by a central concrete wall 0.39m thick. With a capacity of 200,000 gallons (909,200 litres) there are eight sluice gates at its western end that would have controlled the flow of effluent into the tanks (Fig 238). Just beyond the eastern end is a small brick building measuring 4.14m x 4.12m (Fig 239). It is a well-constructed single storey structure with a flat concrete roof and was the pump house for the lagoon. Internally there are two red painted concrete plinths with three pump bases.

Immediately to the north of the lagoon is the **Waste Kerosene Storage Tank C32.3** (Fig 240). The tank, now removed, was supported on three concrete plinths which were in turn surrounded by a continuous retaining wall or bund, measuring 11.18m x 5.04m. This wall is 0.15m thick and stands to a height of 1.52m. Access to the base of the tank was via a set of concrete steps at the south-west corner.

Figure 240
Waste Kerosene Storage Tank C32.3
© Crown copyright NMR (AA94/2035)

As at the Component Test Area and the Engine Test Area, waste kerosene from the missile test stands was drawn over a weir from the surface of the effluent lagoon. After collection, waste kerosene was stored and settled in this tank. The bulk of the liquid was returned to the lagoon while waste kerosene was removed by road tanker to the Waste Kerosene Central Storage and Incinerators Q31 located opposite the Component Test Area.

To the south-west of the lagoon and kerosene tank, a rectangular platform measuring 15m x 70m has been cut from the natural ground level and is defined by well-formed scarps on three sides. The feature is visible on an aerial photograph of the site dating to 1961 (F21 543/RAF/1429 frame 149) and appears to have been constructed in association with the Blue Streak project. Its position in reference to test stand C3 closely mirrors that for the lagoon associated with stand C2, suggesting that a site was prepared for this Lagoon C31.3 before being abandoned in favour of the present location.

Remote Control of Tests

The prepared test vehicle was filled with a mixture of 27 tons (27.43 tonnes) of liquid oxygen and 60 tons (60.96 tonnes) of kerosene. Such a ratio potentially forms an explosive gel that is temperature and impact-sensitive and equivalent to 1-3 times its weight in Trinitrotoluene (TNT). For safety reasons, once the rocket was filled with propellants, approach to the vehicle and much of the ground equipment was precluded; it was vital, therefore, that each of the ground and vehicle systems could be remotely controlled. At Greymare Hill both test stands were connected via landline cabling carried in an Instrumentation Duct (described below p.152) to a remote control centre in the Control Room C4 located some 250m to the south, a distance deemed advisable by the Chief Safety Officer of the Ministry of Supply (TNA: PRO AVIA 65/1906).

Countdown

After a vehicle was taken to site it reqired approximately three weeks of preparation before firing. It took five days to erect and connect-up the vehicle on the stand and the rest was divided equally between setting-up and checking the site and vehicle systems. A few days before firing there was a simulated countdown to minus two seconds. Countdown itself lasted six hours and fell into three distinct phases. The first phase was a check of the entire vehicle and stand with free access to the rocket and launch area. The second phase involved the transfer of liquid oxygen to the stand when access was restricted and there was a 'hold' period before the more dangerous phase began when liquid oxygen was fed into vehicle tanks. From then on all personnel were evacuated from the launch area and the countdown was controlled remotely from consoles in the Control Room from where the firings could be observed by means of periscopes, episcopes and closed-circuit television. If the vehicle needed to be approached for any reason the liquid oxygen had to be returned to the storage tank. Provision was also made for the emergency dumping of propellants (Pollock, 1962). A test firing of forty seconds duration made on the 20 September 1962 produced a recorded 275,000lb (124,740kg) thrust (Pollock, 1962) (Fig 241).

Figure 241
Full rocket firing at Missile Test Stand C3, Greymare Hill
© Rolls-Royce plc

Observation and Monitoring of Tests

Missile tests were not only remotely controlled but also visually monitored from the **Control Centre C4**. This single storey bunker constructed from 2ft (0.61m) thick reinforced concrete is Y-shaped in plan (Fig 242). It is protected on three sides by an earthwork mound (Fig 243) with maximum dimensions of 47m (north-south) x 53m (east-west); the south side – that away from possible blasts allowed access to the bunker (Fig 244).

Figure 242
Modern aerial photograph of the Control Centre C4 which is Y-shaped in plan
© English Heritage NMR (17801/01)

Figure 243
An earthen mound covers the concrete bunker but observation ports remain exposed
© Crown copyright NMR (AA94/1992)

Figure 244
The Control Centre C4 was accessed via entrances in the south wall
© Crown copyright NMR (AA94/1990)

The entrances led to passageways running down either side of the central Recording Room C4.1. This contained a range of equipment including 14 consoles, 27 pen/chart recorders and 4 types magnetic-tape recorders (Aircraft Engineering, 1960) (Fig 245). At the northern end of the Control Centre, in the arms of the 'Y', were two control room from which the tests were controlled and monitored. That to the west - Control Room No.1 C4.2 – looked toward test stand C2 whilst Control Room C4.3 looked east towards test stand C3. Visual monitoring

Figure 245
The interior of the Control Centre contained a range of recording equipment
© Crown copyright NMR (AA94/2897)

of each stand was made through observation ports in the north walls of the building through three episcopes. These were housed in a concrete gully measuring 10.4m x 1.5m and consisted of a steel box housing the episcope mirrors bolted to the exterior of the building (Fig 246). Armoured windows at their bases permitted direct viewing. Alternatively firings could be watched through four submarine type periscopes in the building's roof. Although no longer in place their positions are marked by four small protruding pipes. Air conditioning in the Control Centre was provided by a self-contained plant room located at the southern end of the building.

Figure 246
Test Stands could be observed during firings through four submarine type periscopes that protruded from the roof of the Control Centre C4
© Crown copyright NMR (AA94/1994)

Figure 247
A sub-circular steel plate lies to the east of the Control Centre mound. A socket at its centre probably held a post
© Crown copyright NMR (AA94/1995)

At the foot of the east slope of the Control Centre is a sub-circular steel plate, 3.07m in diameter (Fig 247). It has a concrete socket, 0.12m in diameter, at its centre which probably held a post.

Associated with each test stand was an extensive system of control and data-recording instrumentation. 3,500 wires ran between the Control Room and the test stands along a raised **Instrumentation Duct C22**. The remains of this duct are visible on the roof of the Control Centre as a raised cable tunnel 4.95m wide and 25.15m in length (Fig 248). To the west of the Control Centre the Instrumentation Duct emerged as a covered steel-framed cable-way. It no longer survives here but its line is marked by concrete stanchions 1.21m square that cross the access road. The duct then ran parallel to the west side of the road for a distance of 250m. It survives as concrete path 2.6m in width with a retaining wall, 0.37m high and capped with hard grey engineering bricks, to the east. Along its inner face is a channel or gutter 0.15m in width. To the west of the causeway are concrete blocks, 0.75m square; to the east are rectangular

Figure 248
A raised cable tunnel on the roof of the Control Centre C4 connects to the test stands via an Instrumentation Duct C22
© Crown copyright NMR (AA94/1993)

Figure 249
The Instrumentation Duct C22 was carried on a concrete runway
© Crown copyright NMR (AA94/2959)

Figure 250
Two concrete blocks to the east of the access road supported the Instrumentation Duct gantry. Missile Test Stand C3 is in the background
© Crown copyright NMR (AA94/2001)

blocks measuring 0.77m x 0.55m that are presumably the foundations for cable racks and other service lines. South of here runs a line of concrete posts, 0.9m in height with galvanised metal brackets which may have carried power cables. 250m to the north the Instrumentation Duct divided into two to serve the east and west test stands. To the east, towards C3, the line of the walkway is continued by two concrete ramps that formerly gave access to the gantry that carried the duct over the approach road (Fig 249). On the eastern side of the road is a pair of concrete blocks, 3.36m x 2.0m, that supported the gantry (Fig 250). Further east, the line of the duct is marked by pairs of concrete posts, 0.75m square. A polygonal concrete footing with five mounting positions marks a northward change of direction. To its north is a pair of concrete blocks measuring 3.35m x 2.0m beyond which the duct turned eastwards towards the test stand C3. Close to the stand the duct entered a concrete tunnel that is now sealed. From the main Instrumentation Duct junction, a second similar arm ran westwards towards test stand C2. Close to this stand the duct also entered a cable tunnel, now sealed (Fig 251).

Figure 251
Close to Missile Test Stand C3 the Instrumentation Duct entered a cable tunnel, photographed in 1994 but sealed at the time of survey
© Crown copyright NMR (AA94/2888)

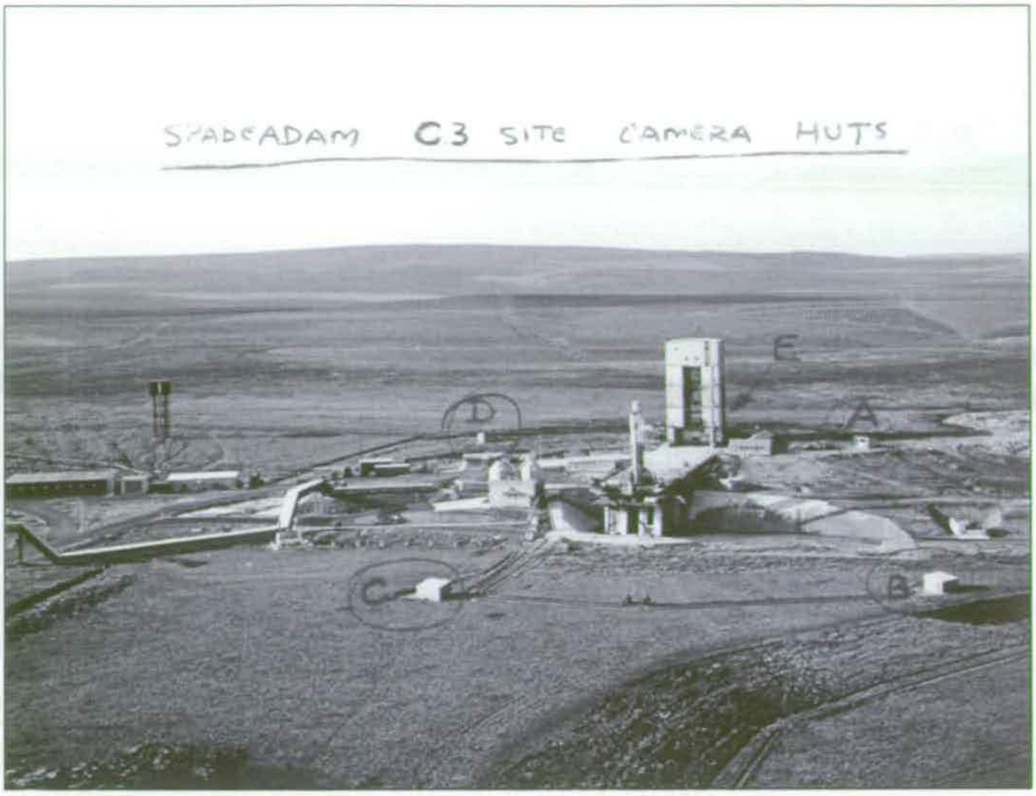

Figure 252
Contemporary aerial photograph annotated with the locations of Camera Huts around Missile Test Stand C3
© Rolls-Royce plc

As well as being observed from the Control Centre, test firings were recorded by cine-cameras that were remotely controlled from the Control Centre and positioned at various locations around the test stands (Fig 252). **Camera Position No.1** was at the rear of test stand C3. Its remains comprise a concrete floor slab measuring 5.40m x 4.51m around the edge of which is a low concrete kerb (Fig 253). Threaded bolts set into the kerb originally secured the hut walls. Internally there is a sub-division where glazing was positioned. The site of **Camera Position No.2** has been destroyed by the later addition of a road giving access to the mound in the north-east of the site. **Camera Position No.3** is located some 97m to the south-east of the test stand. Its remains are similar to those of Camera Position No.1 though it is now almost completely covered in vegetation. To the west of here and, again, 97m from the test stand are the remains of an identical **Camera Position No.4**. The fifth location, **Camera Position No.5**, lies to the north-west of the test stand at a distance of just under 100m.

Figure 253
Remains of Camera Position 1 to the rear of Missile Test Stand C3
© English Heritage (AF00134/camera1)

In addition to the camera positions, direct viewing of test stand C3 was also undertaken from two remote locations some 0.5km to the east. **Observation Post EH6** is sited on the south side of the Cheese Burn Valley to the south-west of the Underground Firing Facility (described below) though its view of the test stand is now impeded by a modern forestry

Figure 254
Observation Post (EH6)
© English Heritage (AF00134/EH6)

plantation (Fig 254). Constructed from re-used railway sleepers covered in roofing felt, the post measures 2.01m x 1.84m and stands to a height of 2.2m. It is protected on the roof and north-west elevation (the blast-side facing the test stand) by ½ inch (0.013m) thick steel plating. Two observation ports in this wall, each measuring 0.45m x 0.24m, were originally covered by hinged doors that have since fallen off. The north-west side of the post was further protected by a bank of earth which extended round its northern and southern sides. It was entered via a doorway on its southern side.

A second viewing position, **Observation Post EH7**, is located some 530m to the east of test stand C3 (Fig 255). It has a concrete floor base measuring 3.8m square and measures 2.2m in height but two of its walls are sloping giving a trapezoidal appearance. Its construction is similar to Observation Post EH6. Re-used railway sleepers form walls that were covered in roofing felt. The west side is protected by ½ inch (0.013m) thick steel plating and has two narrow observation slots, 0.1m x 0.3m. The steel plating also extends over the roof. It is entered via a doorway in the south side.

Figure 255
Observation Post (EH7)
© English Heritage (AF00134/EH7)

In order to aid observation the stands were well-illuminated. From contemporary photographs it is evident that mobile searchlights were positioned on the stands themselves. Additional lighting was evidently located around the stand at a distance from it (Fig 256).

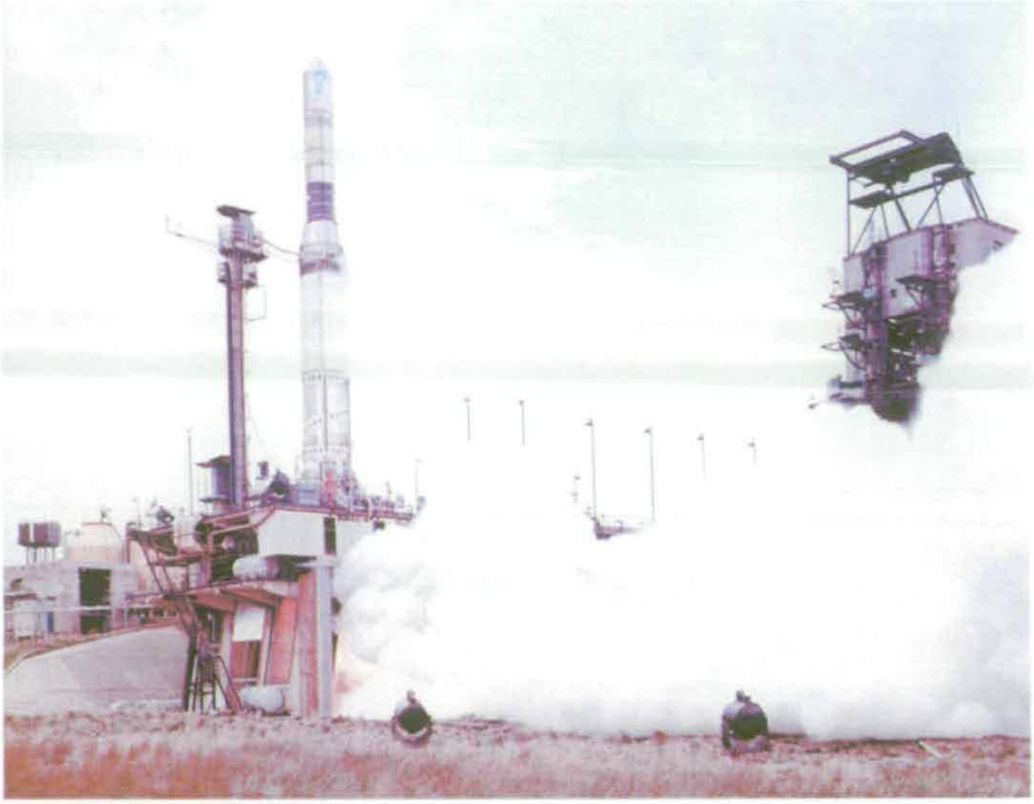

Figure 356
Missile Test Stand C3 was illuminated by mobile searchlights on wooden rails some distance from the stand
© Rolls-Royce plc

Searchlight Position 2 lay to the north of the Kerosene Dump Tank C15.3, although no trace of this now survives. **Searchlight Position 3** lay midway between Camera Positions 3 and 4. These searchlights were mobile units on small caterpillar tracks that could be moved on narrow runways formed of railway sleepers. Sections of the runways survive between Camera Positions 3 and 4 with a further track surviving within vegetation to the east and west of Camera Position 5.

Figure 257
Staff Welfare Buiding C29.3
© Crown copyright NMR (AA94/2037)

Staff working at the C3 test stand had access to a **Welfare Building C29.3** (now C30) (Fig 257). This single storey brick structure measuring 13.03m x 3.45m, has a flat concrete roof and was entered from the south through a single porch door.

Also associated with the test stand was a **Transport Shelter C28.3**. Although now demolished, a hardstanding measuring 9.65m x 5.38m survives marking its former position. This was a double-bay steel-framed structure and cut off girders can still be seen.

C3 was the only test stand at Greymare Hill to be completed and fully operational under the later ELDO project, but a second stand **Test Stand C2** was also begun as part of the original Blue Streak missile project (Fig 258). It lies in the western half of the site and

Figure 258
Missile Test Stand C2 was similar to Test Stand C3 but was never completed © English Heritage NMR (17801/04)

although the reinforced concrete elements of the stand were finished, fitting out work had barely commenced before the abandonment of the Blue Streak missile project in April 1960. In contrast to test stand C3, C2 was never finished and its remains are therefore incomplete. It also has a number of design differences. The ground surface immediately to the south and west of the stand is markedly uneven in appearance. An area of irregular earthwork scarps west of the LOX plant C2.5, massive spoil dumps in the spillway and irregular scarping around the Effluent Lagoon C31.2 are all indicative of the unfinished nature of this part of the site. For safety reasons a wire mesh fence surrounds most of the stand and its associated features.

The concrete causeway measures 101.7m in length and 19.3m wide (Fig 259). Although channels, 0.41m wide, run the length of the causeway the metal rails upon which the **Mobile Servicing Tower C2.2** would run are not *in situ*, presumably having been removed during decommissioning. Where the modern road passes over the causeway, these channels have been in-filled. At either end are concrete buffers. Those at the north measure 1.75m x 0.9m, stand 0.61m high and are chamfered to the rear. Those on the thrust pad to the south are slightly smaller measuring 0.93m x 0.9m and standing 0.62m in height; these are

Figure 259
Missile Test Stand C2
© Crown copyright
NMR (AA94/2010)

also chamfered to the rear. The edge of the causeway is protected by a tubular steel handrail which is severely corroded and missing in places. A concrete walkway at the stand's intermediate level runs around three outer sides of the thrust pad and could have been accessed from the sides of the stand. At a width of 3.1m it was protected by a tubular steel handrail though this is now in disrepair.

At the end of the causeway is the **Thrust Pad**. As at C3, this free-standing concrete structure supported by four inclined legs, each set at an angle of 7°, was designed to hold the launcher and vehicle. The top of the thrust pad measures around 19m x 19m. In the centre is a large square hole, 6.2m x 5.9m, over which the vehicle was suspended for firings (Fig 260). The launcher was set on a circular steel rail that allowed the rocket to be accurately rotated in azimuth prior to firing and the remains of these rails set into the concrete surface of the thrust pad are still visible. To the east side of the main aperture are two rectangular holes, one smaller measuring 0.95m x 0.6m and one larger measuring 2.77m x 0.93m. This layout is mirrored to the west. Efflux from the rocket was designed to be directed through the hole

Figure 260
Thrust pad of Missile Test Stand C2
© Crown copyright
NMR (AA94/2013)

in the thrust pad into an 18ft (5.49m) square steel deflector beneath. Three concrete supports that slope at an angle of approximately 45° were installed below to hold a deflector which was probably never fitted (Fig 261). As at C3, waste water, together with any unspent fuel, would flow down a spillway that extended to the west. The concrete lining of the spillway was not completed and the feature is now largely obscured by areas of dumping.

Figure 261
Sloping concrete walls were designed to support an efflux deflector that was probably never fitted © Crown copyright NMR (AA94/2015)

This causeway was constructed as a hollow rectangular concrete girder. The main entrance is on the eastern side which gave access to a passageway along the rear of the stand. In contrast to C3 the western end of the rear passageway is blocked by a concrete wall which is pierced by a 48in (1.22m) wide rectangular air vent and a single door. Another design difference is four self-contained compartments which extend northwards beneath the causeway. These are on two levels joined by stairs but are otherwise featureless and may have been intended for use as storage areas. To the south of the rear passageway the Equipment Rooms are entered via double doors. Internally there are eight bays with a central corridor leading from the rear of the stand to a steel door that gives access to the external walkway beneath the causeway. Evidently some fitting out had begun in the Equipment Rooms. The first pair of bays to the north was occupied by an air conditioning plant and sections of its galvanised metal ducting remain in place. Other bays housed electronic and hydraulic equipment required for test firings. A man-hole in the floor of the south-west bay gives access to the Instrumentation Duct. Most of the internal walls are pierced by rectangular openings for ventilation ducts and cabling. The equipment was either never installed or has since been removed and although some galvanised metal roof ducting survives, the rooms are derelict and much of the floor surface is water covered.

To the east of the test stand is the (possibly unfinished) **Auto Collimator Building C24.2**. This is a small L-shaped building, single storey and constructed from brick, measuring 5.04m x 3.85m. It is entered through a porch, 1.76m x 1.41m, on the east side.

Power Supply

As described above, all site power supplies were derived from the grid as a 415-volt supply. A high voltage **Sub-Station C5.2** was situated to the east of the test stand and consisted of a small brick building with a flat concrete roof which measures 3.66m x 2.40m (Fig 262). Immediately to its east is a wire mesh enclosure which still houses the remains of a 750kVA transformer. The ground electrical supply system provided power to the ground support equipment and was derived from a unit housed in the Equipment Rooms beneath

Figure 262
High voltage electrical Sub-Station C5.2
© Crown copyright NMR (AA94/2886)

the causeway. Power was fed directly to large items of electrically driven equipment such as the liquid oxygen and kerosene transfer pumps.

Liquid Oxygen (LOX) Supply

The **LOX System C2.5** is located to the west of the test stand (Fig 263). It comprised two principal structures: the Pump House and LOX store tanks and its function was to pump liquid oxygen into the vehicle under testing. On the north side of the Pump House are two brick supports for LOX storage tanks. These are identical comprising an outer brick wall 7.03m in diameter, 1.48m high and 0.73m thick with a low entrance, 0.92m tall and 0.53m wide, on the north side which provides access to the interior. On top of the walls are the

Figure 263
Liquid Oxygen supply C2.5
© Crown copyright NMR (AA94/2017)

remains of sixteen plates which supported the tank superstructures. The interior consists of an octagonal concrete base, 2.8m in diameter, 0.55m wide and 1.45m high. No LOX Dump Area was constructed at stand C2 for use in an emergency. The Pump House is a tall single storey building constructed from brick with a concrete floor and flat roof supported by three concrete beams. It measures 12.12m x 7.33m and has large openings in its east and west elevations. Internally are five plinths with mounting bolts for the pumps and associated equipment as well as conduits for cabling. Surviving fittings include the remains of cable fixtures, smashed electrical switch boxes and stainless steel liquid oxygen valves. On the southern side, set into the corners, are two pairs of ceramic pipes that probably held electrical cabling. Two rectangular concrete stanchions, measuring 0.9m x 2.6m, survive between the pump house and test stand. These probably supported stainless steel piping through which the LOX would have been transferred. No provision was built for the emergency dumping of liquid oxygen before construction work was halted.

Kerosene Supply

Kerosene was stored in the **Kerosene Storage Tanks and Pump House C13** located over 1,000 ft to the south of the test stand for safety reasons (see page xx). It was transferred by pipeline up to stand C2 via a **Delivery Main C2.4**. In the event of an emergency, kerosene could be discharged from the rocket to the **Kerosene Dump Tank C15.2** (Fig

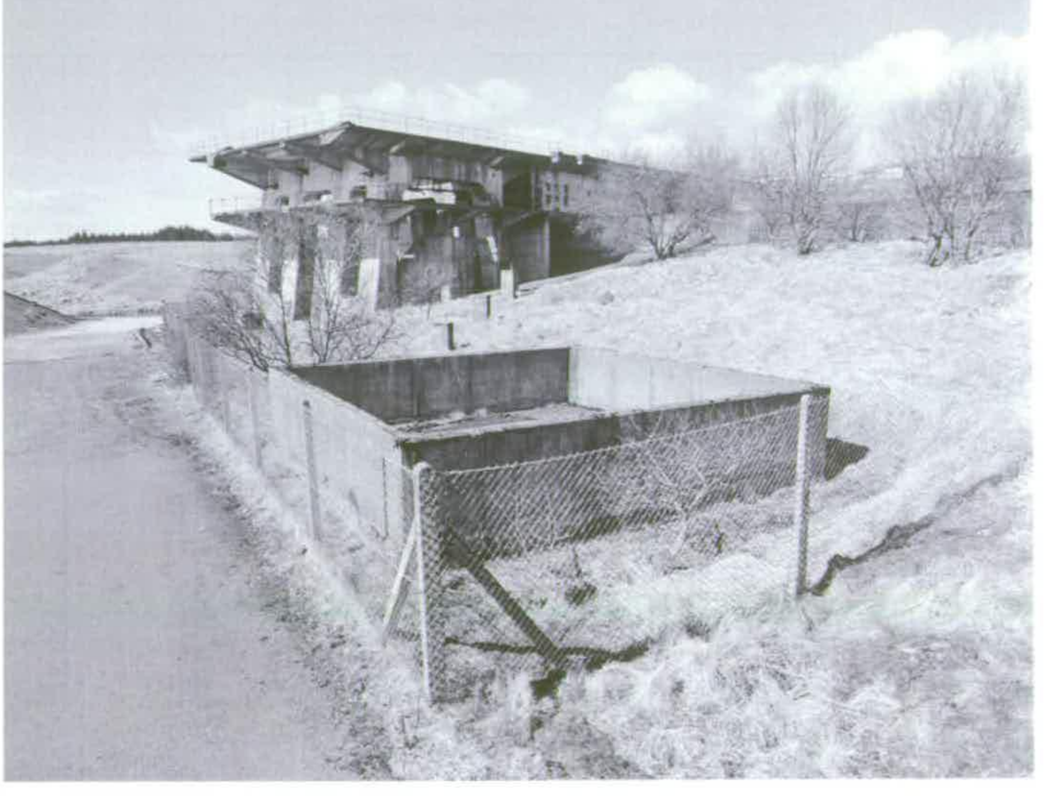

Figure 264
Kerosene Dump Tank C15.2
© Crown copyright NMR (AA94/2005)

264). A square concrete wall measuring 7.20m x 7.12m and 1.24m high surrounds a raised circular base on which a tank would have been supported. On the exterior of the wall are fittings to attach lightning straps.

Nitrogen Supply

The gaseous nitrogen supply for C2 was to be derived from the main **High Pressure Nitrogen Storage Tanks C16** (described above) that was located some 180m to the east of the test stand. To the east of the test stand, adjacent to the access road, was the **Gaseous Nitrogen Filter Compound C16.2**. It formerly housed the filters and pressure regulators incorporated in the high pressure gaseous nitrogen, main gaseous nitrogen and emergency gaseous nitrogen line running from beneath the storage cylinders through a low pressure main to a series of control valves grouped together within the Pneumatic Control Unit installed in the Equipment Rooms beneath the Causeway. These would have regulated the pressures and flow rates of nitrogen and, indeed, all gaseous services required by the vehicle up to the moment of launch. Some metal fittings remain in the compound although it is likely that it was never completed when work was halted in 1960.

Water Supply

Water was piped to both test stands from the Pump House at Midhill. As at stand C3, cooling water was to be pumped to the test stand in 3ft (0.91m) diameter pipelines and enter through holes in the deflector surface at a rate of 20,000 gallons (90,920 litres) per minute. No piping is evident, however, at C2.

Effluent Treatment

Waste cooling water from the west test stand, along with any unspent fuel, was designed to wash down a broad concrete spillway (Fig 265) to an **Effluent Lagoon C31.2** to the south (Fig 266). This comprises a rectangular concrete tank with dimensions of 49.63m x 22.45m and a capacity of 200,000 gallons (909,200 litres). It is divided into two by a central concrete wall but the lagoon and the channels leading to it are unfinished. At the northern end are

Figure 265
A concrete lined spillway was designed to carry cooling water and unspent fuel to the Effluent Lagoon C31.2

Figure 266
Effluent Lagoon C31.2
© Crown copyright
NMR (AA94/2966)

projecting steel rods where the sluice gates were to be placed and at its southern end is a concrete footing where the pump house would have been situated. The **Waste Kerosene Storage Tank C32.2** listed in an inventory of site features (TNA: PRO 92/2) appears not to have been installed due to the cancellation of the project.

Observation and Monitoring

As at C3, missile tests were to be remotely controlled and visually monitored from the Control Centre C4 some 300m to the south of the stand. The stand was to be connected to the Control Centre via the Instrumentation Duct. From the main Instrumentation Duct junction, an arm ran westwards towards test stand C2 before entering a cable tunnel, now sealed (Fig 267).

Figure 267
Monitoring and control cables entered a cable tunnel from the Instrumention Duct
© Crown copyright
NMR (AA94/2020)

As well as being observed from the Control Centre, test firings could have been recorded by cine-camera, remotely controlled from the Control Centre. **Camera Position No.EH8** lies

Figure 268
Camera Position (EH8)
© English Heritage (AF00134/EH8)

some 90m to the south of the test stand (Fig 268). Its comprises a concrete floor slab measuring 5.39m x 4.54m around the edge of which is a low concrete kerb. Wooden plates for its timber hut remain in place but it is unlikely that the camera position was ever fully completed.

Ancilliary Buildings

Staff working at the C2 test stand had access to a **Welfare Building C29.2** (now C29). This single storey brick structure measuring 13.03m x 3.45m, has a flat concrete roof and was entered from the south through a single porch door. Also associated with the test stand was a **Transport Shelter C28.2**. Although now demolished, a hardstanding measuring 9.65m x 5.36m survives marking its former position. This was a double-bay steel-framed structure and cut off girders can still be seen.

Numerous health and safety-related features were associated with the test facility. To the west of the Welfare Building C29.3 was the **Siren Control Building C37**. This has been demolished. Further west was the **Warning Tower C37.1**. A 100ft (30.48m) steel pylon equipped with loud speakers the tower has since been removed but at its base stands a small brick building with a flat concrete roof and a single door in its southern elevation. This was photographed but not included in the current survey due to access restrictions.

At the point where the main access road divides to service the two test stands stood the **Workshop Store C27**. Now demolished, this comprised a steel-framed building three bays deep by five bays wide. The overall dimensions of the surviving floor are 19.5m x 11.7m and there is a concrete plinth measuring 1.22m x 0.75m in the second bay from the west. A separate area of hardstanding, 3.5m wide, lies to the east.

Figure 269
Demineralised Water Plant and Storage C9
© Crown copyright NMR (AA94/2039)

There are various features on the site relating to general water supply. A **Demineralised Water Plant and Storage C9** (Fig 269) is located in the middle of the line of communal buildings that flank the northern access road. A well-built single storey structure this brick building measures 5.27m x 3.90m. It has a flat concrete roof and is entered via a single door in the southern elevation. To the west is a low brick extension and adjacent valve pit. On the slope just west of the water plant is a pair of Braithwaite **Drinking Water Tanks C12** (Fig 270). These large tanks are

Figure 270
Braithwaite Water Storage Tanks C12
© English Heritage (AF00134/C12)

each supported on five brick piers and accessed via a metal ladder in the south-east corner. At the opposite end of the site, some 57m to the north of the Police Control Post, is a possible **Valve House C21.1** (Fig 271). With dimensions of 2.34m x 1.80m and at a height of 1.27m this is a small brick structure that has subsequently been covered in a pebble dash render. The building has a flat roof covered by asphalt and is entered through a very low door in its southern elevation.

Figure 271
Possible Valve House C21.1
© English Heritage (AF00134/C21.1)

Some 10m to the north-west of the possible Valve House is a former **Chemical Treatment Plant C30** (now C21) (Fig 272). A small single storey brick building, this has a flat concrete roof. It measures 4.64m x 2.38m and 2.35m in height and has two single doors in its western elevation.

Figure 272
Chemical Treatment Plant C30 (right)
© Crown copyright NMR (AA94/1989)

Post Blue Streak Features

Following the abandonment of the Blue Streak project the test facility at Greymare Hill was used for satellite launcher testing as part of the ELDO project. To the east of the north-east corner of test stand C3 is an area of hardstandings – the remains of huts that were probably constructed during this ELDO phase of activity. **Hut 1** has been demolished but a concrete floor slab, 15.99m x 7.43m, survives. Around its edge are bolts for the mounting of a timber hut and to the rear of the hut are the ground level remains of lavatories. A concrete path runs along the east side of this hut base and at the northern end a small area of concrete connects this hut base to the floor slab to the west, marking the position of a short link corridor. **Hut 2** was originally a truncated H-shape in plan though its south-west end has been cut away by the modern road. The remains comprise a T-shaped concrete hardstanding with maximum dimensions of 24.4m x 12.36m. To the west of this platform and adjacent to the modern Garage C31 is a rectangular area of hardstanding. Cut-off 'I' girders here indicate the former presence of a steel-framed building. In between is a sloping ramp, 2.97m in width, which may indicate an original loading area. The southern edge of Hut 2 is marked by a concrete path.

Jet Noise Fatigue Testing at Greymare Hill

As described above (see section on Jet Noise Fatigue Testing), experiments which involved subjecting sections of aircraft to prolonged periods of exposure to engine noise were conducted in the flameway of the unfinished C2 test stand at Greymare Hill during the 1960s. No fixed infrastructure relating to this activity has been found and the flameway, where tethering hooks for securing aircraft being used as noise sources and other fixtures might be expected, is covered by spoil.

RAF activity at Greymare Hill

Numerous features within the missile test area are associated with later use of the site by the RAF. The two spoil mounds (located in the far north-east of the site and to the east of C17) were evidently levelled and capped with hardstandings. An access road was constructed (obliterating remains of Hut 2 and Camera Position2) to the north-east mound which was surmounted by an area of concrete measuring 12m x 71m. An oval-shaped area of asphalt was added to the mound in the south of the site and this was reached by a new asphalt road (see Fig 208). Both areas are currently in use as locations for mobile radar.

Figure 273
Mock Soviet SA-10 missile system used for training at Greymare Hill © English Heritage (AF00134/simulated threat)

Figure 274
Modern Garage C31 © English Heritage NMR (DP003886)

Figure 275
Water Booster Pump House C18 © English Heritage (AF00134/C18)

A large permanent radar was installed on high ground to the north-west of the test site. Mounted on top of a tall tower this is surrounded by hardstanding and renders the area out-of-bounds on health and safety grounds. In addition to the radars mobile simulated threats are in use around the site (Fig 273). Also installed during this later phase of RAF activity was a modern **Garage C31** (Fig 274). Measuring 13.03m x 7.70m this is a steel-framed structure with brick footings and rendered breeze-block walls. The upper parts of the walls are clad in pressed steel sheeting and the roof is of the same material. There is a large roller shutter door in the south elevation. A **Water Booster Pump House C18** (Fig 275) was constructed between the two test stands by the site of the former Gaseous Nitrogen Store C16. This small brick structure measures 2.74m x 1.8m and has a gently sloping roof with a maximum height of 1.62m.

Underground Launcher Facility

Running in parallel with the development of the missile and its warhead, discussions were also taking place regarding the best method of launching the missile. A number of schemes were proposed including mobile launchers or launchers positioned at sea, either floating platforms or submerged silos (see Cocroft and Thomas 2003, 46-8; 257). By 1958 the preferred option was for an underground launching facility or silo. At this time, underground launching technology was an unexplored field and the studies undertaken in Great Britain were at least as advanced as, or even ahead of, those being carried out by the United States and the Soviet Union.

The Royal Aircraft Establishment at Farnborough, Hampshire, the Rocket Propulsion Establishment at Westcott, Buckinghamshire, and the principal contractor de Havilland Propellors carried out the preliminary design work. To examine the initial design concepts a one-sixtieth model was built at the Rocket Propulsion Establishment and tested using high pressure nitrogen gas. A much larger one-sixth scale silo was later constructed and tested using high test peroxide and kerosene fuelled rockets (Hill 2001, 83-5). To further refine the design of the underground launching facility, it was proposed to construct a full-size model at Spadeadam (Fig 276).

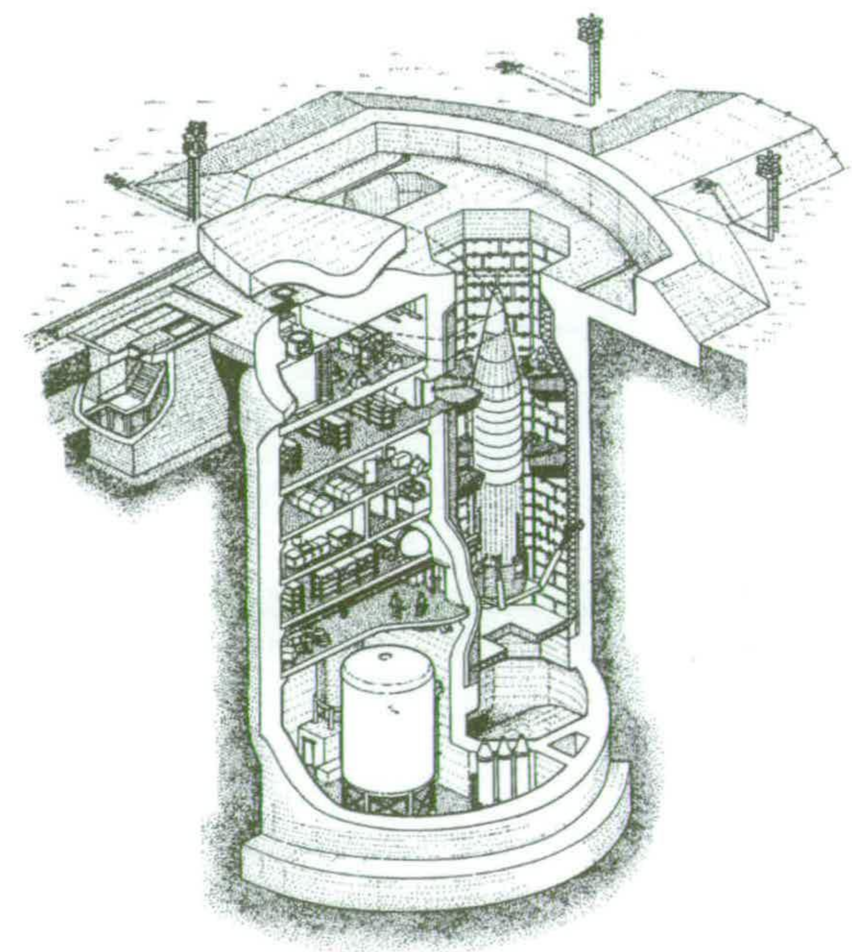

Figure 276
Diagram showing the structure of the proposed Underground Launcher Facility © English Heritage Cocroft and Thomas 2003

One of the key questions that needed to be addressed was whether or not it was feasible to develop a fully underground system where the missile could be 'hot-launched' directly from its silo. One of the principle concerns was whether the acoustic shock produced by the vibration from the engines would destroy the missile before it left the silo. An alternative method was to raise the missile to the surface on a lift system prior to launching.

A letter sent from the Ministry of Supply to the Treasury in September 1958 confirms that by that date plans were well advanced for the construction of an underground launching facility at Spadeadam (TNA: PRO T225/1150). Trial bore holes were evidently drilled during summer 1958 and permission was sought for the expenditure of £690,000 (plus a 15% agency fee) to begin the construction of a full size silo designated U1 (Dommet 1998, 9). Owing to the proximity of the bedrock to the surface and the great expense and time that would be incurred excavating a hole 150ft (45.72m) deep, it was proposed to dig a 30ft (9.14m) hole through the overburden down to the bedrock. The base of the silo would then be placed in the hole while the remainder of the structure would be above ground. It was also planned to place the underground firing facility close to the Greymare Hill Missile Test Area in order to take advantage of existing technical infrastructure.

Figure 277
Contemporary Aerial photograph of the Missile Test Area and site of the Underground Launcher Facility © Crown copyright F21 543 RAF/1429 Frame 149

Personal recollection by a former Rocket Establishment employee, Ron Lake, confirmed that work on the test facility had begun prior to the cancellation of the missile project and that it was located somewhere to the east of Greymare Hill at Whipper Slack (Fig 277). The beginning of an excavation is visible on a contemporary air photograph, taken in August 1961. All major civil engineering work had halted in April 1960 following the cancellation of the ballistic missile project confirming that this excavation had taken place prior to that date. The photograph shows a hole centred at NY 628 738 with disturbed ground to its north with traces of heavy vehicle tracks leading westwards back towards the southern end of the Greymare Hill complex.

Figure 278
Work on the Underground Launcher Facility was started in the bottom of a valley at Whipper Slack © English Heritage (AF00134/launcher silo1)

The hole is situated in the bottom of the valley of a small stream called the Cheese Burn, potentially causing the hole to flood (Figs 278 and 279). This location may probably be explained by the projected design for the silo model, whereby only about one-fifth would be below ground and the remainder would project above the surface. With such an arrangement the top of the silo would be approximately level with the top of the valley and this may have allowed a level causeway to be constructed from the crest of the valley on the north to the top of the silo allowing the rocket to be manoeuvred into position. The hole is water filled and across its surface are pieces of rotten timber or formwork (Fig 280); the excavation for the hole measures about 50m by 30m and has well-formed sides. To the north of the hole is an area of hummocky ground covered by short grass, in contrast to the surrounding heather. This probably represents spoil excavated from the hole.

Figure 279
A sluice gate controlled the flow of stream water into the silo hole
© English Heritage (AF00134/launcher silo2)

Figure 280
Timberwork spans the hole excavated for the Underground Launcher Facility
© English Heritage (AF00134/launcher silo3)

Similarly at Woomera, Australia, it was proposed to construct the test silo on the side of a ravine, again to reduce the need for unnecessary excavation (Hill 2001, 89: TNA: PRO T225/2020). Preparatory excavations into the escarpment of a ravine had begun by March 1960 (Fig 281), but construction work does not appear to have progressed beyond the laying of the foundations (Martin, 2002, 144).

Figure 281
Excavations at Woomera, Australia for an Underground Launcher Facility © Weapons Research Establishment, Salisbury, Australia

Although the underground launcher facility was never adopted by the United Kingdom the United States took a great deal of interest in the design work. Colonel Leonhardt, Deputy Commander for Installations, Ballistic Missile Installations, came to England to assess the work, which resulted, for example, in the construction of a one-sixth scale model in the United States similar to the one built at Westcott (Hill 2001, 85). Dr Barrie Ricketson, Head of Gas Dynamics at the Rocket Propulsion Establishment, Westcott, also visited the United States to brief the Americans on the progress of work in the United Kingdom. The research carried out in Britain undoubtedly contributed to the design of the United States Titan II missile silo. An American historian of that project commented that 'Blue Streak was the free world's first in-silo launch weapon system concept' (Stumpf 2000, 26, see also *Flight* 1961, 889). Titan II missile silos remained in service until 1987 (Hill 2001, 85).

Water Storage and Supply

The large quantity of water required for cooling and for emergency fire-fighting services throughout the Spadeadam establishment could not be met from local bore holes alone. Supplies were therefore pumped from the River Irthing through an **Intake Works Q26** (not surveyed). A metering pump was installed to ensure that the extraction of water for Spadeadam did not to reduce the flow of the river to below 2.75 million gallons (12,501,500 litres) per day (TNA: PRO AVIA 92/1). This comprised an intake channel with sluice gate, one submersible pump capable of pumping 1,900 gallons (8,637 litres) per minute with a 25ft (7.62m) head and two further submersible pumps with a flow rate of 800 gallons (3,637 litres) per minute and 400ft (121.92m) head. The works also included a surge suppressor unit, associated valves, pipe-work and electrical control gear contained in a **Valve Housing Q26.3** and **Electrical Sub-Station Q26.2**. The normal operational rate for the plant was 48,000 gallons (218,208 litres) per hour over a ten hour abstraction. From the Intake Works water was piped 4.8km to a centrally located water storage facility north of the main arterial road junction at NY 60955 71626 known as the **Central Reservoirs Area Q25** (Fig 282).

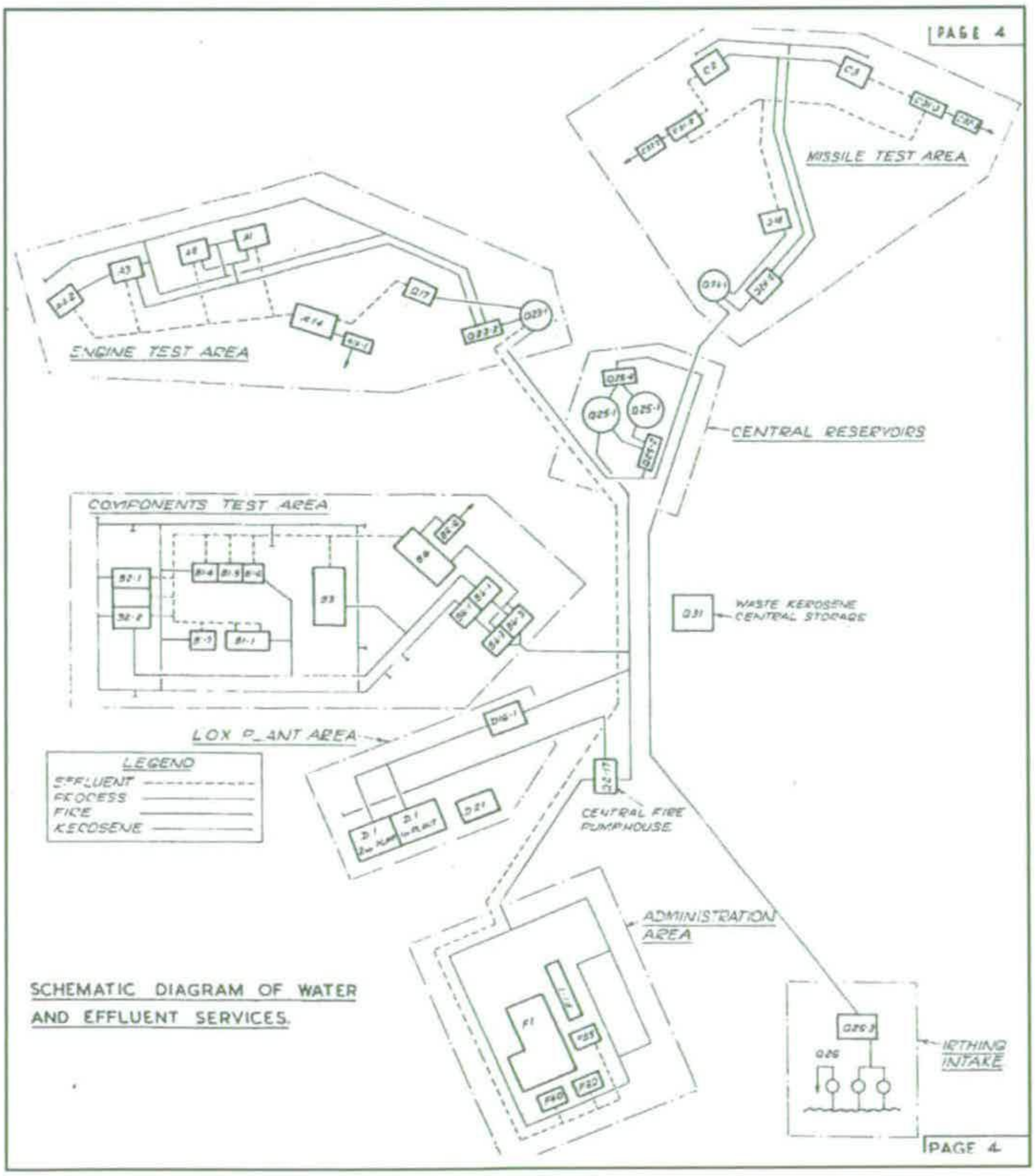

Figure 282
Schematic Diagram of the Water and Effluent Services at Spadeadam
© Rolls-Royce plc

Figure 283
Modern aerial photograph of the Central Reservoirs Area Q25
© English Heritage NMR (17818/20)

This preparation and storage facility is situated on a high plateau of ground some 1.5km to the north of the Aministrative Area (Fig 283). Water pumped up from the main Intake Plant Q26 could flow to many other, lower, parts of the site. Before entering the circulation system, water was filtered through a **Micro Screening Chamber Q25.4** (Fig 284).

Figure 284
Before entering storage tanks, water from the main Intake Plant Q26 was screened through a Micro Screening Chamber
© Crown copyright NMR (AA94/1976)

Measuring 23ft x 20ft (7.01m x 6.1m) and standing to a height of 10ft (3.05m) this brick building has a concrete floor and a flat reinforced concrete roof supported on RSJs. It was accessed via an external steel stairway and contained reinforced concrete filter tanks as a sub-structure. From the screening chamber water was piped 22m via large-bore pipes to two 1,000,000 gallon (4,546,000 litre) capacity **Reservoirs Q25.1** immediately to the south. These circular pre-stressed concrete tanks measure 30.48m in diameter and stand to a height of 7.3m. They differ from others on site (Reservoirs Q23.1 and Q24.1) in that they are covered by a square lattice work of concrete beams. Originally these supported wooden bearers and corrugated sheeting. Water storage tanks elsewhere on the site were replenished from this central source and the fire mains were similarly supplied from here. Water from the western reservoir was piped to the lower-lying Administration Area, the LOX Plant Area and the Component Test Area. Water was also piped from both reservoirs to the nearby **Central Pump House Q25.2** (Fig 285) through a 0.33m diameter large bore pipe. Situated

Figure 285
Central Pump House Q25.2
© Crown copyright NMR (AA94/1972)

some 85m to the south-east of the tanks, this rectangular single storey structure is built of brick with a flat concrete roof and measures 11.35m x 6.4m. Adjacent to the south-east corner of the pump house is a concrete **Transformer Base Q25.3** (Fig 286) which was originally enclosed by a concrete post and chain link fence.

Figure 286
Transformer Base Q25.5
© English Heritage (AF00134/Q25.5)

Figure 287
Reservoir Q23 supplied water to the Engine Test Area at Priorlancy Rigg
© English Heritage NMR (17818/19)

From this pump house water was transferred westwards to a single **Reservoir Q23.1** that supplied the Priorlancy Rigg Engine Test Area (Fig 287). Located over 700m to the east of the main test area at NY 60617 71726 this reservoir provided storage capacity for 1,000,000 gallons (4,546,000 litres) and supplied the water for the entire Engine Test Area. Comprising a roofless circular tank of pre-stressed concrete construction it measures 30.48m in diameter and stands 6.4m in height. To the west is a small brick building with a flat concrete roof measuring 3.58m x 2.65m. From the reservoir water was delivered via a 42in (1.07m) suction main westward to a **Pump House Q23.2**. This structure was built on a platform terraced into the slope some 100m to the south-west. Two covered access pits are visible along this line and a broad-bore pipe emerges at the base of the terrace scarp in its south-east corner. The pump house has since been demolished and the site consists of a level area approximately 23m wide, rubble strewn with an access track. The pump house originally comprised an aluminium clad building with a steel decking roof and reinforced concrete floor. It measured 106ft x 35ft (32.31m x 10.67m) and stood 25ft (7.62m) in height. The Pump House contained six motor driven centrifugal pumps and one engine driven pump, fuel storage tanks, water cooling tanks, a heat exchanger, lubricating oil cooler and exhaust silencers. The pumps had duty ratings of up to 10,000 gallons (45,460 litres) per minute at 425ft (129.54m) total head. Cooling water was pumped to the test area through a 36in (0.92m) welded steel supply main and its flow could be either controlled locally in the pump-house or by remote control from the test area control building (TNA: PRO AVIA92/2). Power for the pump house was provided by the **Troutbeck Electrical Sub-Station Q23.8** (formerly

Q23.3) to the south of the pump house site. This single storey brick building, 8.9m x 5.9m, originally contained circuit breakers and a distribution board. At its east end a double transformer bay with a central brick dividing wall is now empty. Part of the route of the water main to the test stands can still be traced as a linear earthwork mound to the east of the Control Room A11. South of the control room the main turned an angle and headed west, passing to the north of the Effluent Lagoon A14 and flanking the southern end of the test stand spillways. From here it was pumped up to each of the stands. Two square Valve Pits, each measuring around 4.4m across, are located on the slope between Test Stands A1 and A2. Large bore pipes emerge at the sides of each of the test stands and these supplied water for cooling the efflux bucket during firings.

From the Central Pump House Q25.2 water was also transferred northwards to a single **Reservoir Q24.1** at Midhill that supplied the Greymare Hill Missile Test Area (Fig 288).

Figure 288
The Midhill Reservoir supplied the Missile Test Area at Greymare Hill © English Heritage NMR (17819/20)

At 31.70m in diameter and 6.4m in height the single storage Reservoir Q24.1 has a capacity of 1,000,000 gallons (4,546,000 litres). It is a circular pre-stressed concrete tank to the east of which is a small pump- or valve-house constructed of brick with a flat concrete roof and measuring 3.76m x 2.60m. This structure is surrounded by five small covered tanks and valve pits. To the south-east of the reservoir is the site of former Pump House Q24.2. This was a steel-framed building with brick flank walls that stood to a height of 6ft 9in (2.06m) and brick toe walls 9in (0.23m) high at the ends. The walls were clad in aluminium sheeting and the roof was covered in steel decking. This building has been demolished but its pale blue concrete floor slab survives. Concrete plinths are visible within this floor area on which pumps were probably mounted. Numerous other plinths and bolts survive which mark the positions of ancilliary machinery. To the south-west of this floor slab is a **Pump House Q24.4**. This single storey building measuring 4.99m x 13.59m is constructed from breeze block and has a flat concrete roof. It is the modern replacement for Pump House Q24.2. To the north-east of the floor slab is the **Midhill Electrical Sub-Station Q24.3**. This is a rectangular brick building, 5.80m x 8.23m, with an adjacent double transformer bay separated by a central dividing wall at its north end. Some 8m to the south of the Sub-Station is a rectangular concrete bund. This has dimensions of 4.16m x 2.79m and two rectangular internal tank supports. To the west of the blue floor slab is a brick structure, 4.18m x 3.31m, that is probably a covered valve pit. Constructed against the east side of this is a structure of metal sheeting measuring 10.27m x 2.86m with a narrow out-shot on its east side. Water from the Midhill pumping station was moved by large bore pipe to the Missile Test Area at Greymare Hill. Traces of its route along the western side of the approach road are marked by large concrete blocks. Although most of these are damaged, the impression of the pipe is still visible on some of the blocks.

Post Blue Streak Features

As discussed above, even while Blue Streak was being tested the range was used for other trials work, including testing the effects of engine noise on sections of *Concorde's* airframe. The location of this work has not been identified, but may have been conducted in the unfinished flameway of Test Stand C2, Greymare Hill, where it is known that other acoustics trials took place. In the late 1960s facilities were also constructed in the Component Test Area (see p82) for testing a liquid hydrogen/liquid oxygen engine, the RZ-20, developed by Rolls-Royce and the government's Rocket Propulsion Establishment, Westcott (Jeffs lecture 2002).

The most substantial facilities were, however, developed in the early 1970s associated with the proposed relocation of some the activities carried out at the Proof and Experimental Establishment, Foulness, Essex to Spadeadam.

When planning for the new range began in about 1970, it was expected that testing of the Blue Streak rocket might continue for another 10 years. It was therefore predicted that for some time the two establishments might work side-by-side and that the new range would share much of the infrastructure constructed for the Blue Streak project. Nonetheless, the proof establishment would require its own dedicated facilities and these were to be located at four main sites R8 Rowantree Crag, R5 Caud Beck, R7 Green Hill, and R51 Berry Hill. Access to the four sites was to be from the main spine road leading to Greymare Hill with specially constructed side roads leading into the test areas. The establishment also considered reusing sections of the Priorlancy Rigg Engine Test Area and the Greymare Hill Rocket Test Area.

The southermost of the new sites is at Rowantree Crag (NY 628 710). Known as K Site, or R8, this was linked by a new road that was constructed leading eastwards from the main spine road (Fig 289).

Figure 289
Modern aerial photograph of K Site © English Heritage NMR (17801/35)

Figure 290
Police Post at the entrance to K Site © English Heritage NMR (AF00134/ Kpolice)

Its function was to test the effects of mines and entry to the site was controlled at a small concrete **Police Post** (Fig 290). The new road is just over 1km in length from the main road to the entry to the test area; beyond here it continues on its course for a further 500m, a spur road leads off southwards towards Rowantree Crag, a section of which is protected by an earthen bank on its western side. The road then turns eastwards for another 500m before terminating in a dead end. At the entrance to the test area is a concrete splinter-proof **Control Building K1** (Fig 291). Following standard range practice the building is entered from western side, away from the potential

Figure 291
Control Building K1 © English Heritage NMR (DP003988)

firing area. On, its western side are steel windows and doors, while the eastern elevation, facing the range, is blank. At the southern end of the building is the plant room and above it a double storey platform on which equipment could be mounted to monitor the experiments. To the east is a large concrete hardstanding and on this apron, to the rear of the Range Office, are sawn off steel girders marking the position of an open sided barn-like structure. To its east is an electrical **Sub-Station K4.1** (Fig 292). Adjacent to this, on the east side is a reinforced concrete **Protected Garage K4.2** built to house ammunition or instrumentation vans. To its east is another protected structure **K3** of unidentified function. Other minor features within K Site include a small building of unknown function, **K5**, at the eastern end

Figure 292
Sub-Station K4.1 (left), Protected Garage K4.2 (centre) and a third building of unknown function K3 (right)
© Crown copyright NMR (AA94/2915)

of the area and another electrical Sub-station (also identified as **K4.2**) to the south; there are also a number of concrete fire-pools.

About 1km to the north of K Site, another test area, J Site or R5, was laid out along the east-west valley floor of Caud Beck. The site is now occupied by Advantica, whose primary activity is the destructive testing of gas pipelines, this area was not entered during the course of the survey (Fig 293).

Figure 293
J Site or R5 occupied the Valley of the Caud Beck, an area now used by Advantica for destrctive testing of gas pipelines © English Heritage NMR (17801/21)

The valley floor of Caud Beck is fairly level, falling only 10m in over 1km and is approximately 200m in width. To either side two meandering streams, Caud Beck to the south, flow along the foot of each valley side eastwards into the King Water. The test area is entered from the main spine road along a short side road, 250m in length, at the junction of which is a small, single-person, reinforced concrete **Police Post**. It was intended that the primary use of R5 would be for the destructive testing of airframes and aero engines. The range was split into three sections, each of which had large concrete 100m square concrete pads on which the trials were to take place. The range facilities were numbered consecutively from west to east. At the western end was the **Engine Attack Site R5a**, this comprised a concrete pad and to its west a reinforced concrete Control Building. To its east was **R5b Attack of Part Aircraft** and at the western end of the site **R5c Static Site Whole Aircraft**, these two facilities appear to have shared a single Control Building at NY 6260 7241. Air photographs show that the two control buildings constructed for the test facility survive; in addition many other structures have been built to support the work of Advantica.

Figure 294
Reinforced concrete Police Post at the junction of roads leading to Greymare Hill and Berry Hill © English Heritage (AF00134/greypolice)

The longest section of road built for the new establishment extended for 2.5km and stretched from close to the entrance to Greymare Hill eastwards to Berry Hill. In the angle of the road is a small, single-person reinforced concrete **Police Post** (Fig 294), which was constructed at this time to control access eastwards. In common with most roads on the range it was built on a raised embankment, and as it approached Berry Hill it was laid over low-lying boggy ground. This road also gave access to Green Hill, known as H Site or R7 (NY 639 737), which was designed for testing attacks on structures, presumably airframes, and also drop test trials. The road turning to H Site is marked on the southern side by a small, single person reinforced concrete **Police Post** (Fig 295) and on its northern side by an electricity **Sub-Station H1.1 (Fig 296)**. The layout of H site makes full use of the local topography, and the four bays which were required to undertake the trials were excavated into the southern slope of Green Hill, spoil from the excavations being pushed southwards to extend the level areas. On entering the test area the access road bifurcates at a Y-junction with one road leading the west and the other to east, immediately to the west of the junction is a small sewage works. In the first bay to the east is a reinforced concrete **Protected Office H1** which comprises a transformer bay, three equipment rooms and office accommodation (Fig 297). At its western end is an open garage, which was probably intended to house ammunition

Figure 295
Reinforced concrete Police Post at the entrance to H Site © English Heritage (AF00134/Hpolice)

Figure 296
Sub-Station H1.1 at the entrance to H Site © English Heritage (AF00134/H1.1)

Figure 297
Protected Office H1
© Crown copyright
NMR (AA94/1980)

or instrumentation vans. To the west of the Protected Office is a large featureless bay 60m x 50m in area; to the south is a series of man-hole covers and a circular sewage filter bed, 5.1m in diameter (Fig 298).

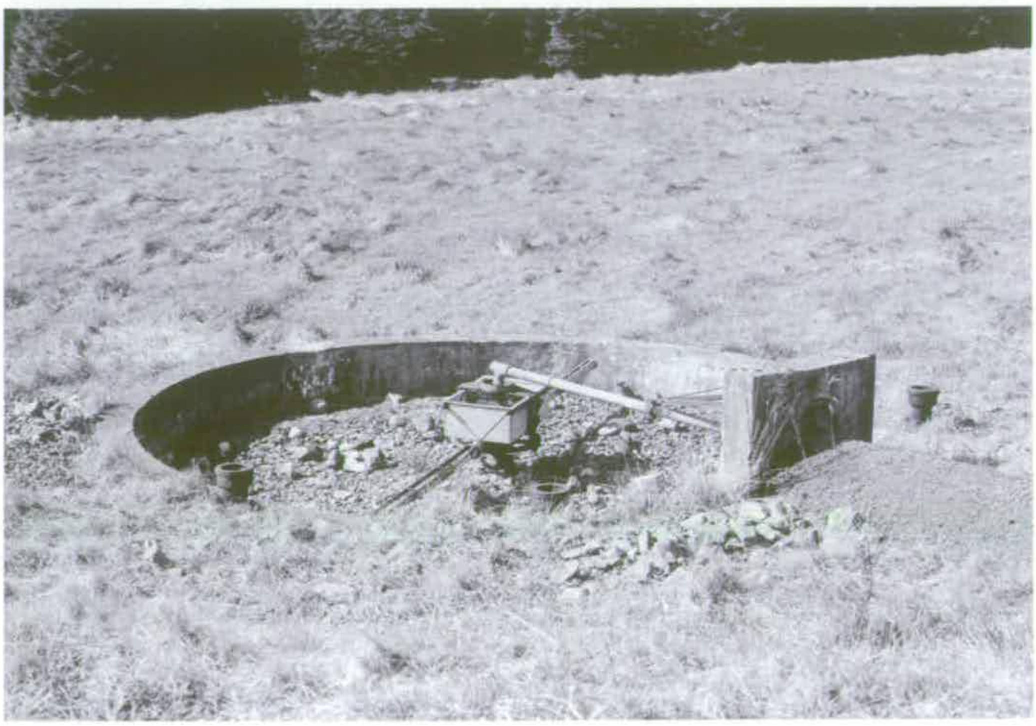

Figure 298
Sewage filter bed at H Site
© Crown copyright
NMR (AA94/1981)

Eastwards of the junction is a large bay 180m x 75m, at its south-western corner is a reinforced concrete **Protected Garage H3.1** (Fig 299), further eastwards the road curves northwards through a shallow cutting to emerge into the northern bay, which is about 35m square. Just before the entrance to the bay on the western side of the road, is a small bay in which is set a reinforced concrete **Protected Garage H3.2** and an **Electricity Distribution**

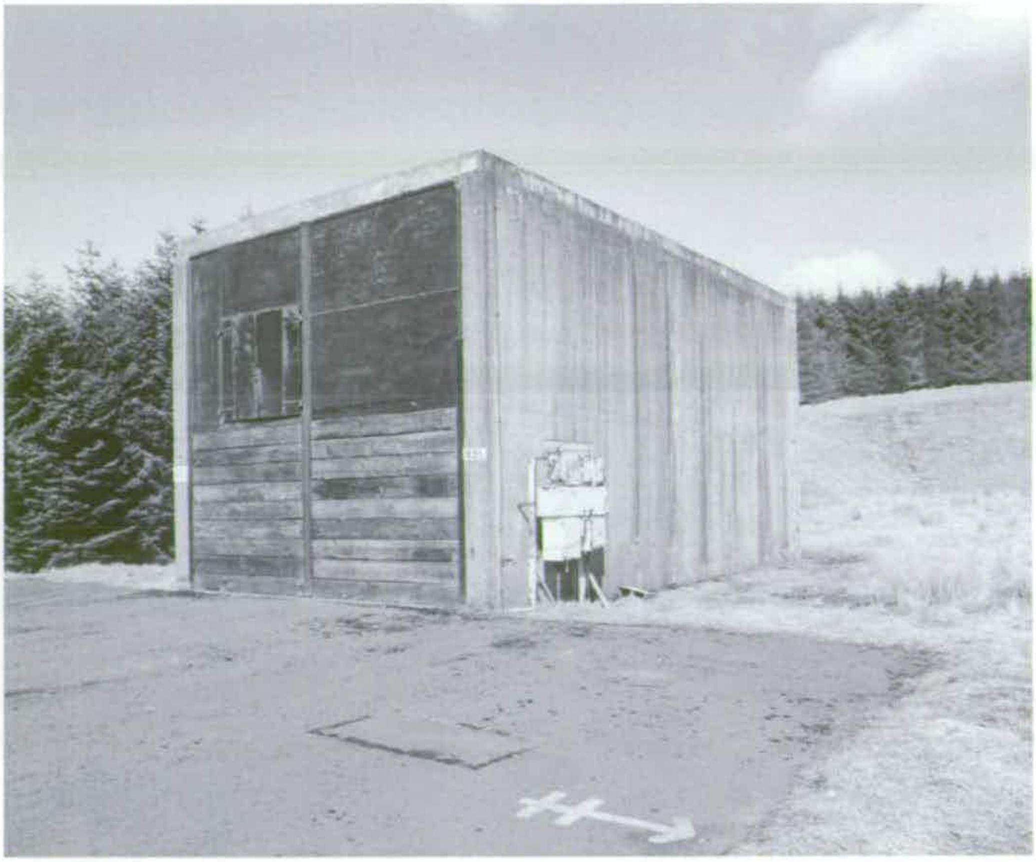

Figure 299
Protected Garage H3.1
© Crown copyright NMR (AA94/1984)

Figure 300
Electricity Distribution Sub-Station H4.2 (left) and Protected Garage H3.2
© Crown copyright NMR (AA94/1986)

Sub-station H4.2 (Fig 300). Within the R7 complex it was also intended to construct a **Dropping Tower R52** (Fig 301). Dropping Towers are used in the certification of explosives and ammunition, whereby they are dropped from a given height on to steel decking or a steel pin, to simulate accidents that might occur during their service life. On the southern side of the bay is a circular arrangement of steel-reinforcing rods; it is possible that this marks the footing of the Dropping Tower. To its south is a rectangular shaped piece of tarmac which may indicate the position of a hut.

Figure 301
Remains of Dropping Tower R52
© Crown copyright NMR (AA94/1987)

Eastwards of Green Hill the test area at Berry Hill (NY 622 725), designated R51, is situated on a local eminence and is almost entirely surrounded by boggy waterlogged ground (Fig 302).

Figure 302
Test Site of Berry Hill or R52 currently in use as the main operations centre for RAF Spadeadam
© English Heritage NMR (17801/27)

Its intended function was the study of the fragmentation patterns produced by exploding munitions used by all of the services. It was envisaged that a variety of munitions would be tested, including 1000lb and 540lb bombs, 155mm, 105mm, 76mm, and 5.5in shells, 8in howitzer shells, and mortar rounds. Activities within the area were to be controlled and monitored from a splinter-proof reinforced concrete blockhouse or **Control Building G1** to the south-east with roof access for the personnel and camera equipment. To the north-east of the Control Building is a contemporary electricity **Sub-Station G1.1**, a square building to the west of the control building **G7** is probably also contemporary and was designed to hold detonators and demolition charges. Tests were to be carried out on three circular sites, with radii of 10m, 15m and 25m, the fourth site was to be defined by its circumferential road.

Three circular areas survive at Berry Hill, there is also a large rectangular helicopter landing pad that may overlie the fourth test area (CM6/286). The total cost of the facilities at Berry Hill was £720,000, of which £68,000 was spent on the Control Building (TNA: PRO CM6/291). In common with the other features built for the projected Proof and Experimental Establishment R51 was never used for its intended purpose. Instead, its protected control centre became the main operations centre for the RAF range, complete with an air traffic control room to monitor flying activity within the range. The complex is also used a target for training sorties and surrounding the operations centre are a number of active radars as well as dummy missile sites. The only building work that appears to have been constructed to serve the RAF range includes a rectangular building at the south-western end of the control centre and a double garage, probably built in or close to 2002, to house mobile radar equipment. Temporary Portakabins are also installed to provide extra accommodation as the need arises.

In addition to the new test facilities a **Meteorological Station** was built to support the work of the range. The siting of this station required careful topographic positioning; it was to be located below the lowest level of the site's operational area and the prevailing windward side of site activity (TNA: PRO CM6/287). The location chosen was to the north-east of the Component Test Area at NY 6133 7090 (Fig 303). Originally facilities included an Office

Figure 303
Modern aerial photograph of the Meteorological Station © English Heritage NMR (17818/09)

Q110, an Anemometer Tower, a large open area for meteorological balloons, a Balloon Filling House Q110.2, and a store area for the hydrogen bottles, which were used to inflate the balloons. The form of the Balloon Filling House was almost identical to the one at

Foulness, Essex, illustrating the close links between these two establishments. The site of the meteorological station sits on a manmade platform excavated into a south-facing valley side, defined by a well-engineered scarp to the north. Today the area, known as F Site, is approached from a short side road that leads off the main spine road. At the entry to the site is a small electrical **Transformer Station L4** (Fig 304) and to its north, just to the west of the main road, is a Braithwaite **Water Tank Q110.3** (Fig 305), which holds the area's domestic water supply.

Figure 304
Transformer Station L4 at the Meteorological Station © English Heritage (AF00134/L4)

Figure 305
Braithwaite Water Tank containing the domestic supply for the Meteorological Station © English Heritage (AF00134/metstation water)

Figure 306
Office Q110 in the Meteorological Station
© English Heritage (AF00134/Q110)

The area still comprises an **Office Q110** (Fig 306), a small **Petrol, Oil and Lubricant Store Q110.1** (Fig 307), and the former **Balloon House Q110.2** (Fig 308), which stands in the centre of the circular concrete hardstanding. To the south of the Balloon House in the rough ground adjacent to the entry track are four concrete blocks, these probably mark the site of the **Anemometer Tower**. On the opposite side of the main road is a turning onto a rectangular-shaped, rubble strewn area that may mark the position of a building, perhaps a temporary hut erected during the construction work.

Figure 307
Petrol, Oil and Lubricant Store Q110.1
© English Heritage (AF00134/Q110.1)

Figure 308
Balloon House Q110.2
© English Heritage
(AF00134/Q110.2)

In addition to these new works, when it was announced that rocket testing was to cease as part of the decommissioning process, evaluations were carried out at Priorlancy Rigg Engine Test Area and Greymare Hill Rocket Test Area to ascertain if any structures might be of use to the new establishment. At Priorlancy Rigg, a scheme known as R50 was to be put in place. Few details are available although it is known that **Test Stand A1**, at a distance of 40yds (36.5m), was regarded as being too close to the centre of activity. They also reserved the **Control Centre A11**, **Workshop A12** and the **Reservoir Q23.1** for possible future use. Project R50 was mentioned in correspondence in 1971 (TNA: PRO CM6/286) when reference was made to the construction of a naval magazine located approximately at NY 634 741 - a considerable distance from Priorlancy Rigg.

At Greymare Hill it was suggested that the **Servicing Tower C2** might be retained for tests requiring elevated platforms or dropping facilities. Interest was also shown in retaining and modifying the **Control Centre C4** for use as part of Project R54. It was also proposed to retain **C13** for storing fuel drums and to maintain the eastern **Effluent Lagoon C31** and the **Waste Kerosene Storage Tank C32.2** (TNA: PRO CM6/291). No evidence was found at Greymare Hill to suggest that any work took place to modify the site for new uses.

Conclusions

A long chronology of activity dating back to Roman times can be identified at Spadeadam but this investigation focused on the archaeological remains associated with the Blue Streak missile project - remains that are of international historical significance. Blue Streak was a hugely ambitious project that aimed to provide Britain with a new generation of nuclear deterrent forces. Spadeadam was developed in the late 1950s in support of this project as Europe's foremost missile technology centre. The place chosen for this state-of-the-art research establishment was an expanse of moorland that has one of the highest annual rainfalls in Great Britain. One of the main features dating to this period of development was a network of roads that provided access onto the moor and connected test areas within it. Many of these roads were laid on waterlogged ground on rafts of birch wood, represented today by rows of bushes that have sprung up along the road sides. Material for construction work was extracted from a quarry located south-east of the main entrance; the quarry has been partly in-filled but remains as a flooded feature. The scale of construction work at Spadeadam required a large labour force. This was provided in part by itinerant Irish workers who were accommodated in a temporary labour camp immediately south of the quarry. Other temporary contractor's huts were also built in the Administration Area, to the north of the BOC compound and at Greymare Hill. Further remnants of this first phase of Blue Streak Missile activity were also recorded during the survey. Large scale earth-moving was undertaken during the construction of test stands at Priorlancy Rigg and at Greymare Hill. This is evidenced by the terracing of stands into the natural slope and by the creation of large earth mounds in the south-west of Priorlancy Rigg and in the north and south of the Missile Test Area. Another mound, to the south of the Engine Test Stands, was identified as the location of an aggregate grader used during the construction of the stands.

The vastness of the moorland and the potentially explosive properties of the materials involved meant that each test facility occupied a geographically distinct area. The location of each test area was dictated by the type of testing carried out there creating a clear correlation between geographical location and position within the processual flow-line. From the archaeological remains of these places it is also possible to detect changes in government policy. The construction work at Spadeadam began when Whitehall's enthusiasm for the project was running high and no expense was spared to develop a missile based nuclear deterrent. The test buildings were constructed of the highest quality concrete with chamfered edges - a symbol of the optimism and confidence embodied in the Spadeadam Rocket Establishment. But even while construction work was underway doubts were being raised in the Ministry over the viability and cost of the missile system. The structural proof supports the documentary evidence that corners started to be cut in an attempt to reduce expenditure.

Running in parallel with the development of the missile and its warhead, discussions had also taken place regarding the best method of launching the missile. By 1958 the preferred option was that of an underground launcher facility or silo. In order to further the design of this facility work began on constructing a full size scale model at Spadeadam. Underground launcher technology was a relatively unexplored field at this time and the studies undertaken in Cumbria were ahead of those being carried out in the United States or the Soviet Union. The silo echoed the design of a launcher also being built at the Weapons Research Establishment at Woomera in Australia. As at Woomera, however, work at Spadeadam was never completed. Nevertheless, the United States took a great interest in progress as far as it went and the research carried out in Britain undoubtedly contributed to their Titan II missile silo.

After the cancellation of Britain's missile project, Blue Streak was adopted by ELDO as the launch vehicle for the Europa 1 rocket. This change of policy is largely unrepresented in the existing site plans but, again, is evidenced by the archaeological record. Additional accommodation for the project was provided in temporary wooden huts, visible as hut bases in the Administration Area, Priorlancy Rigg Engine Test Area and Greymare Hill Missile Test Area. Test stand C3 was completed and used in test firings, and some features (such as test stand A2), originally designed for use in the Californian desert, were adapted to the colder, wetter Cumbrian climate with the addition of corrugated sheeting and metal concertina doors.

By the 1960s Blue Streak technology was becoming obsolescent and ELDO was seeking more efficient propellants for their rocket engines. One combination with potential was a mixture of liquid hydrogen and liquid oxygen. To investigate this further Rolls-Royce constructed the Liquid Hydrogen-Liquid Oxygen Thrust Chamber Facility to the north of the Component Test Area in 1967. This area had lain largely idle since 1961 and use of this location, with its pre-existing infrastructure, significantly reduced the expenditure required for the new facility.

Following the decision to relocate the Proof and Experimental Establishment from Shoeburyness on the Essex coast to Spadeadam, extensive and expensive civil engineering work was undertaken on the range to provide the specialised facilities needed by the new establishment. Specifications for the new work included roads capable of bearing the weight of a tank transporter and with enough clearance for moving aircraft to link the new test facilities to the existing spine road running from the south of the range to Greymare Hill in the north. A road was built to Berry Hill, the control centre for Range 51, and this included difficult ground works to carry the route over Berry Bog. New roads were also laid along Caud Beck to serve Range 5 and to the Rowntree Crag area, R8, which was to be used for mine evaluation. Other work included the laying of a new fire main, drains and cable ducts to link the test areas to the control centres. The overhead electrical power supply was placed in underground channels to protect them from accidental damage. In addition to the new test areas a meteorological station was built to the north-east of the Component Test Area.

Since RAF Spadeadam was established in 1976 some concrete hardstandings have been extended and, in recent years, garages have been erected to house the mobile radar systems but comparatively few new structures have been built. As the result of an evaluation carried out as part of the decommissioning process, existing structures were retained as being of use to the new establishment. Activities are largely accommodated within the structures built for the Blue Streak project or the planned proof establishment. It is perhaps a side effect of the high cost, experimental, nature of the work undertaken at Spadeadam since the 1950s that money invested in the site was largely focused on research and development rather than cosmetic alterations to offices and workshops. As a result, most of the establishment buildings have retained much of their original character.

During the late 1950s the test facilities at Spadeadam were the most advanced of their kind in Europe and reflected Britain's aspirations to superpower status. Their design displays many similarities with Rocketdyne's facilities in Santa Susana, California, illustrating the close collaboration with the United States in the development of large launch vehicles and propulsion systems. Despite their military connotations, projects such as Blue Streak may also be seen as iconic of their age and the optimistic and unquestioning presumption of the benefits of scientific advances that characterised the early post-war period. Today its test stands represent some of the most architecturally impressive remnants of Britain's Cold War research programmes. The wider landscape of Spadeadam Waste may also be viewed as a product of the Cold War, a late 20th century technological landscape created to test one of the most potent weapons developed in the United Kingdom.

Additionally, Spadeadam may be seen as an important monument in international space history for the peaceful exploitation of space. After the cancellation of the Intermediate Range Ballistic Missile (IRBM) project in 1960, Blue Streak was used as the first stage of the European Launcher Development Organisation's (ELDO's) rocket *Europa 1* and the facilities continued in use as part of this project until 1971 when it too was cancelled. The influence of the establishment also reached beyond the boundaries of the range, for example in training the local workforce in high quality engineering skills, many of which were transferred to new businesses in the area. The enduring significance of the *Blue Streak* project to the local community has recently been illustrated by the interest generated by the oral history project run by Tullie House Museum, Carlisle.

Survey and Methodology

Detailed original surveys were undertaken of the Rocket Establishment's technical areas to RCHME Level 3 (RCHME, 1999, 4) standards. These areas comprise the British Oxygen Corporation (BOC) Compound, the Component Test Area, Priorlancy Rigg Engine Test Area and Greymare Hill, Missile Test Area. Detailed surveys were also undertaken of the main reservoirs, range area R7, and the remains of the labour camp to south of the main entrance. The surveys were carried out within Ordnance Survey National Grid co-ordinates using differential Global Positioning System (GPS) equipment. Survey base stations were established on site with the archaeological and topographic detail being plotted by roving GPS receivers. All the GPS data was processed using Trimble Geomatics Office and Geosite Office software and data from the OS National GPS network and National Geodetic Survey websites. Areas of the range that were inaccessible for the GPS equipment were recorded using a combination of total station theodolite (Leica TC805L) and hand taping. The survey was then transferred into an AutoCAD environment via KeyTERRA-FIRMA software. All of the CAD-based drawings included in the report were completed using Adobe Illustrator 10 software. The report was prepared in Adobe PageMaker 7.

Four of the site's principal structures - the Component Test Area's Control Room B.1, the Control Centre A11 and Engine Test Stand A2 at Priorlancy, and the missile Test Stand C.3 at Greymare Hill - were architecturally recorded. This was done using a combination of total station theodolite (Leica TC805L) and hand taping and the results were drawn up in Microstation. In addition to the plans, data record sheets were compiled for all the significant features and buildings associated with the Blue Streak project using Adobe Pagemaker 7.0 software. No original survey was carried out in the Administration Area. The buildings in this area were recorded to RCHME architectural recording Level 1 (RCHME, 1991, 2) comprising a brief description made from external observations supplemented by photography. The Royal Commission on the Historical Monuments of England (RCHME) first photographed the Blue Streak facilities in 1994. This existing photography was supplemented by colour photography taken during the current survey. The Blue Streak facilities were also photographed from the air during March 2003.

All readily accessible secondary historical sources were consulted, including contemporary journal articles and more recent historical accounts of the Blue Streak project. Relevant primary document files were consulted at the National Archives (formerly the Public Record Office), Kew, and these are listed in the Bibliography and Sources section. The project has also benefited from the recollections of the Rocket Establishment veterans, in particular those of Andy Jeffs in a paper given at a British Rocketry Oral History Project conference. The memories of other veterans associated with the Blue Streak oral history project being run by Tullie House Museum, Carlisle have also elucidated many other aspects of the site's history.

The site archive and copies of this report along with all ground and air photographs taken during the survey have been deposited in the archive of English Heritage at the National Monuments Record Centre, Great Western Village, Kemble Drive, Swindon, SN2 2GZ, to where applications for copyright should be made and further enquiries directed.

Acknowledgements

The survey of the remains of the Blue Streak missile test facilities at RAF Spadeadam was carried out in partnership with Defence Estates as part of a wider project to develop a conservation management plan for the range. Niall Hammond, Environmental Advisor (Archaeology) to the Environmental Support Team, oversaw the commissioning and completion of the project for Defence Estates. English Heritage acknowledges the helpful assistance they have received from the RAF during the course of this work through the Commanding Officers Wing Commander Robertson (until 2004) and Wing Commander Goodall. Practical day to day arrangements on the site were facilitated by Squadron Leader Gagen, the range Conservation and Access Officer Charles Miles, and staff of W S Atkins, especially Jon Clarke and Edward McDonald.

In parallel with the survey work, a Heritage Lottery funded project to record the memories of people associated with Blue Streak and RAF Spadeadam was undertaken at the Tullie House Museum, Carlisle. Fiona Deal managed this project and we are grateful to her for the interchange of information between the projects. We particularly appreciate the information given to us by a number of the engineers who worked on the Blue Streak project, notably Ray Hancock, Godfrey Moy, and Ray Ross (formerly of Rolls-Royce) and Ron Lake (formerly of de Havilland). Installation artist Louise K Wilson formed a link between these two projects filming both the test site veterans and the archaeological survey work for a film entitled *Spadeadam* that was premiered in October 2003 at the Blue Streak exhibition in the Tullie House Museum, Carlisle. We also acknowledge the contribution that research carried out by the British Rocketry Oral History Project has made to our knowledge of the Blue Streak project, in particular the work carried out by Roy Dommett, Nicholas Hill, and David Wright. Kerry Dougherty, Curator Space Technology, Powerhouse Museum, Sydney, Australia, provided information on the current condition of the Blue Streak facilities on the Woomera weapons range.

The archaeological ground survey was undertaken by Catherine Tuck, David McOmish, Wayne Cocroft and Moraig Brown of the Cambridge office of English Heritage. Architectural surveys were carried out by Tony Berry and Nigel Fradgley of the York office of English Heritage. Photographs taken by Roger J C Thomas in 1994 were supplemented by ground photographs taken by Keith Buck and Peter Horne was responsible for aerial photography (all English Heritage, York). Site plans were produced by Catherine Tuck and David McOmish, report illustrations were prepared by Catherine Tuck and the report was written and compiled by Catherine Tuck and Wayne Cocroft and edited by David McOmish.

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Appendix 1

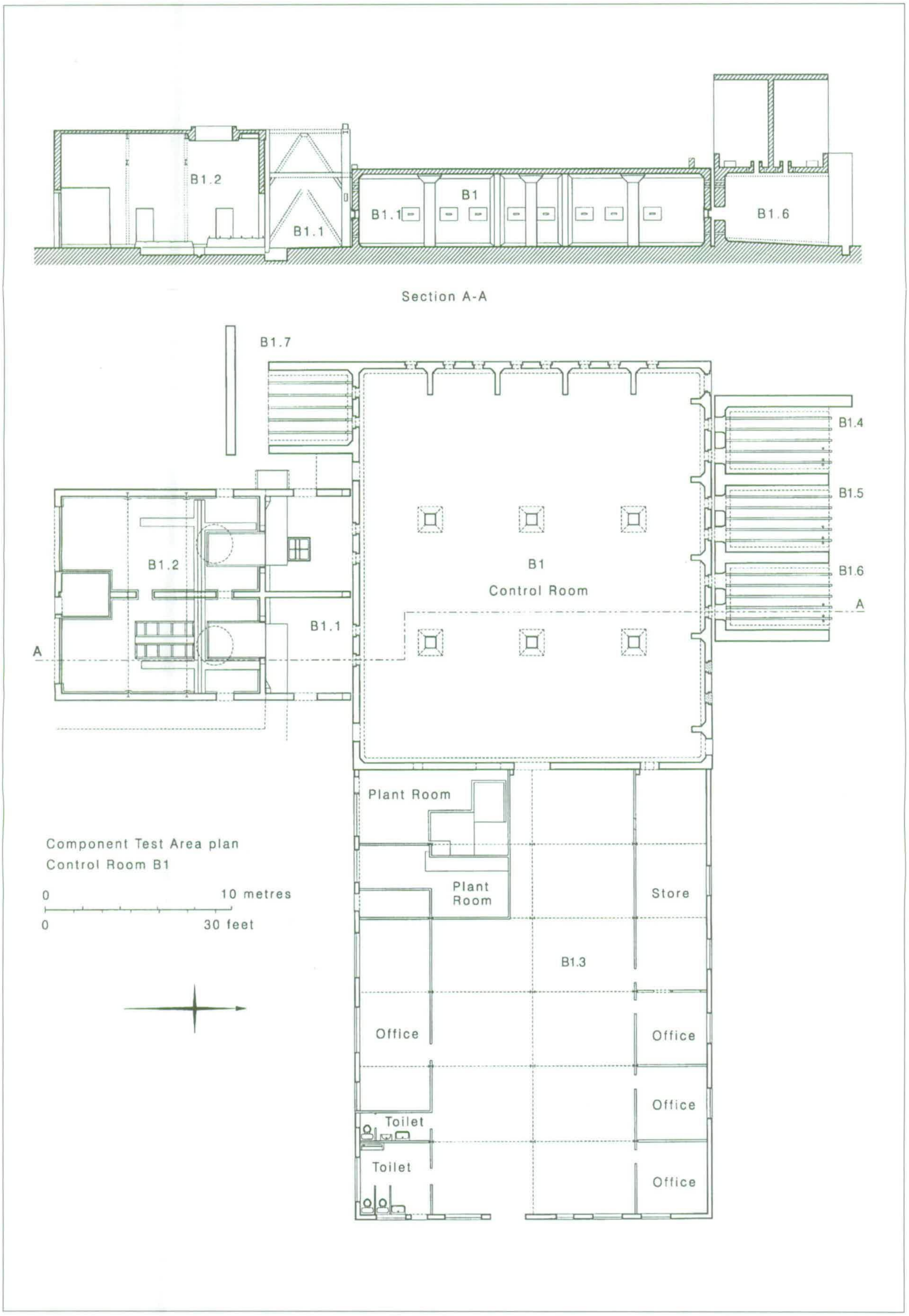
Architectural plans and elevations

Drawing 1 Component Test Area: Control Building B1

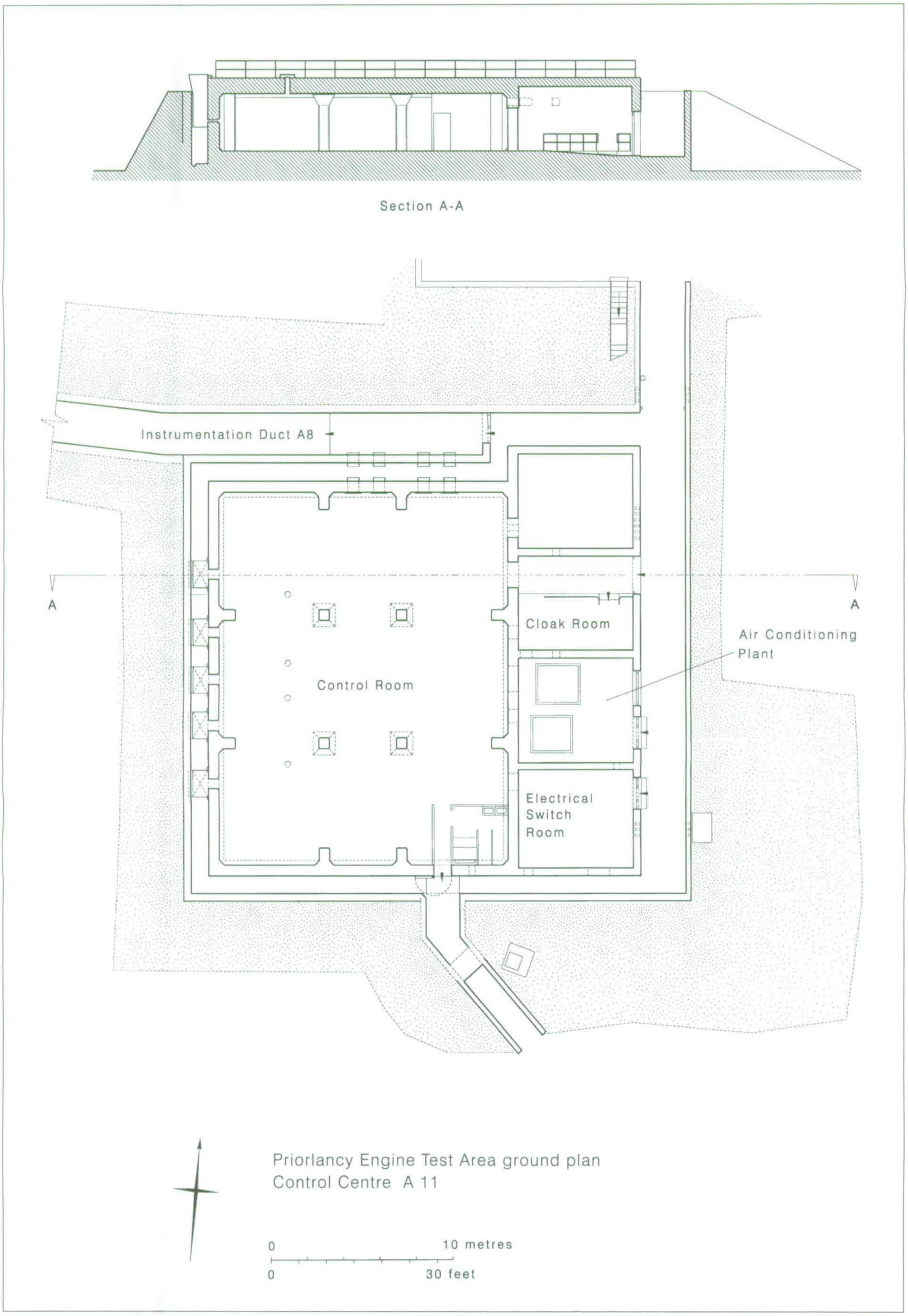
Drawing 2 Engine Test Area, Priorlancy Rigg: Control Centre A11

Drawing 3 Engine Test Area, Priorlancy Rigg: Test Stand A2

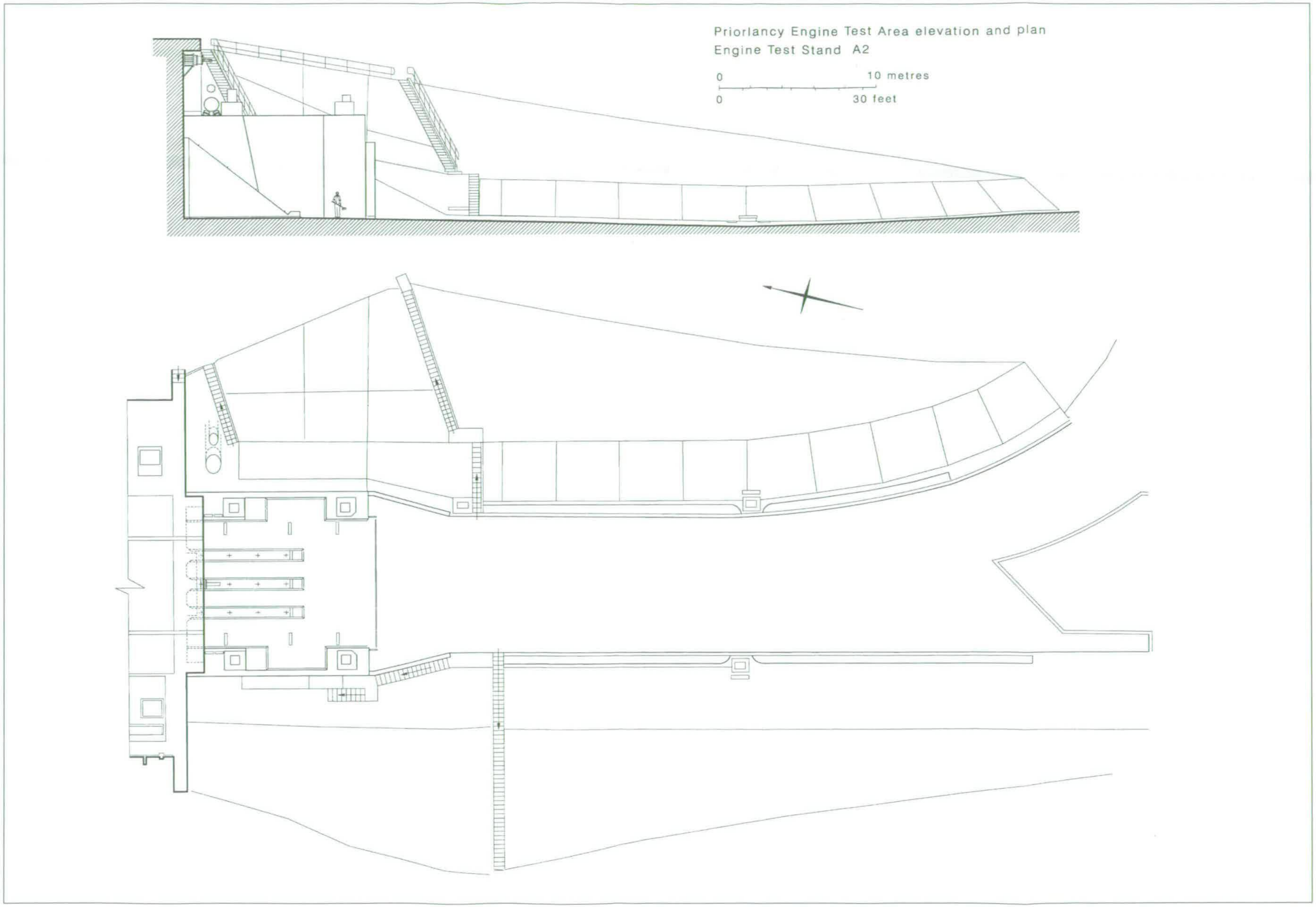
Drawing 4 Missile Test Area, Greymare Hill: Test Stand C2



Architectural Drawing of the Control Room B1 at the Component Test Area



Architectural Drawing of the Control Room A11 at the Engine Test Area



Architectural Drawing
of Test Stand A2 at the
EngineTest Area
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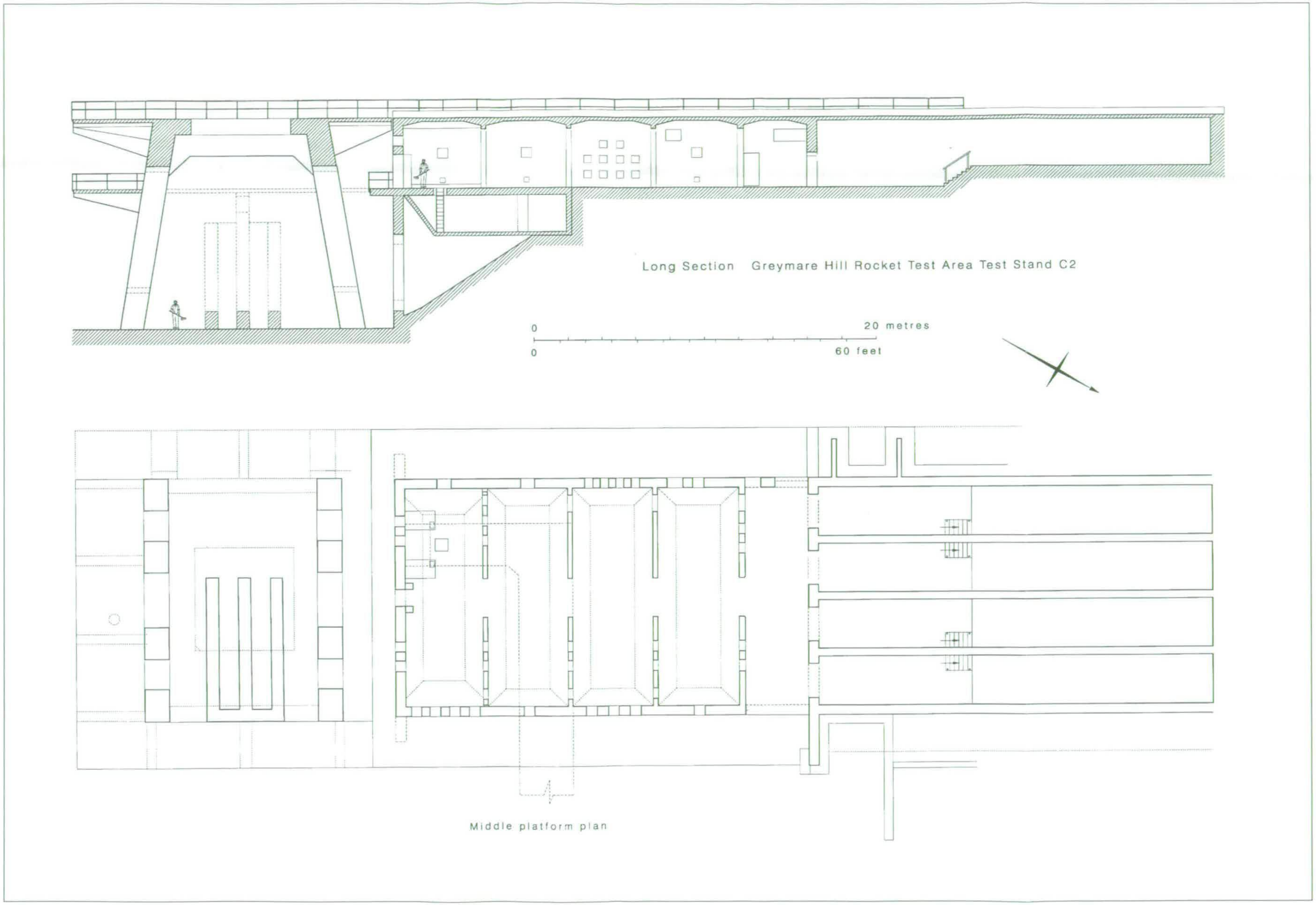

Architectural Drawing of Test Stand C2 at the Missile Test Area © English Heritage

Appendix 2

Outline Chronology for Blue Streak and RAF Spadeadam

1936	Ministry of Agriculture and Fisheries (MAF) begin negotiations to acquire the Spadeadam estate
1950	May Ministry of Agriculture and Fisheries acquires the Spadeadam estate under 999-year lease from the Lord of Carlisle
1953	
November	Royal Aircraft Establishment authorised to begin studies on a long-range missile
1954	
12 June	Document signed by the United States and the United Kingdom to share research into long range missiles - the 'Wilson-Sandys Collaboration Agreement'. Blue Streak project initiated
1955	Spadeadam Waste selected as the test site for Blue Streak
August	Rolls-Royce and the Rocketdyne Division of North American Aviation sign a mutual technical assistance agreement
19 October	Test facilities opened
1956	
17 February	Home Affairs Select Committee discusses the proposal to acquire Spadeadam Waste Survey work begins
December	The Treasury approves construction of Spadeadam Rocket Establishment Contract let to British Oxygen Wimpey Ltd to build Spadeadam
1957	
January	Construction work begins Megaton-sized warhead developed at the Atomic Weapons Research Establishment, Aldermaston, dropped in a live test code named 'Orange Herald' by Valiant bomber onto Christmas Island
4 October	Russian launches the first artificial satellite Sputnik 1
1958	
31 January	First United States artificial satellite Explorer launched May Test firings of the RZ-1 engine begin at the Rocket Propulsion Establishment (RPE), Westcott, Buckinghamshire Test firings begin in the underground launcher facility models at RPE Westcott
1959	March First test firings of the RZ-2 engine at RPE Westcott
August	First engine tests at the Engine Test Area Spadeadam

1960	
January	de Havilland Propellers and de Havilland Aircraft merge to form Hawker Siddeley Aviation
13 April	Official announcement of the cancellation of Blue Streak as a ballistic missile programme
1961	
June	C3 Test Stand at Greymare Hill comes in to operation
1962	March European Launcher Development Organisation (ELDO) formed, Europa I adopted as the first stage satellite launcher
14 June	European Space Research Organisation (ESRO) formed
15 June	First test firing of a complete rocket on Greymare Hill Test Stand C3
November	First flight vehicle F1 tested at Spadeadam
1964	
5 June	First successful launch of Blue Streak F1 at Woomera; Australia A42 Test stand at Priorlancy completed
20 October	F2 launched at Woomera
1965	Trials carried out to investigate the effects of jet noise on sections of Concorde's airframe
22 March	F3 launched at Woomera
1966	
24 May	F4 launched at Woomera
15 November	F5 launched at Woomera
1967	British government announced its decision to pull out of the Europa programme by 1971Liquid Hydrogen/Liquid Oxygen test stand erected in the Component Test Area
4 August	F6/1 launched at Woomera
6 December	F6/2 launched at Woomera
1968	
30 November	F7 launched at Woomera
1969	
3 July	F8 launched at Woomera
8 Sep	Test firings of liquid oxygen/liquid hydrogen RZ-20 engine at Spadeadam
1970	
12 June	F9 launched from Woomera
5 November	F11 launched from Kourou, French Guyana on 5 November 1971
December	The United Kingdom withdraws from ELDO
1972	
August	Contractors begin construction of facilities for the Proof and Experimental Establishment (P&EE) Spadeadam, work begins on the roads
27 April	Europa project cancelled
30 November	Rolls-Royce (1971) Ltd relinquishes control of the range
1 December	Government's Property Services Agency assumes responsibility for the range infrastructure

1973	
28 March	Contract let to Brimms of Newcastle for construction of R5, R51 and the meteorological station
15 June	Rolls-Royce (1971) Ltd redundancy begins
29 June	The Rocket Establishment closes
1975	
14 February	The Government announces that the P&EE Spadeadam is to run down and close over the next two years
April	Site is handed over to the P&EE European Space Agency (ESA) formed
1976	RAF Spadeadam opened
1977	RAF Spadeadam commences work as an Electronic Warfare Tactics Range

Appendix 3

Range inventory, 1960-2 - TNA:PRO AVIA 92/2

Priorlancy

A1	**Engine Test Stand**
A2	**Centre Test Stand**
A3	**West Test Stand**
A4	**Terminal House**
A5	**Lox Store, mains and pumps**
A6	**Engine Preparation Building**
A7	**Transport Shelter**
A8	**Instrumentation and Cable Control Ducts**
A9	**High Pressure Nitrogen Storage and Ducts**
A10.1	**Substation**
A10.2	**Substation**
A10.3	**Substation**
A10.4	**Substation**
A11	**Control Building**
A12	**Workshop to Control Building**
A13	**Shift House**
A14.1	**Waste Kerosene System**
A16.1	**Pneumatic Control Station for Stand A1**
A16.2	**Pneumatic Control Station for Stand A2**
A16.3	**Pneumatic Control Station for Stand A3**
A17.1	**Electrical Control Station** - for Stand 1
A17.2	**Electrical Control Station** - for Stand 2
A17.3	**Electrical Control Station** - for Stand 3
A21.1	**Pillbox** – for Stand 1
A21.2	**Pillbox** – for Stand 2
A21.3	**Pillbox** – for Stand 3
A21.4	**Pillbox** – for Stand A42
A22	**Police Control Post**
A23	**Fencing Area**
A24	**Drainage**
A25	**Roads, Bridges, Culverts, Hardstandings, Paths**
A27	**Cooling Water Mains**
A28	**Fire Water Mains**
A29	**Domestic Water Mains**
A29.1	**Treated Water Plant and Compressor House**
A32	**Kerosene Storage Tanks, Bases of Pumphouse**
A33	**Kerosene Dump Tanks, Bases and Pumps**
A34	***See* Q29**
A35	**Terminal and Power Room**

A37	**Street Lighting**
A38	**Public Address System**
A39	**Telephones**
A40.1	**Heating and Plant House for Stand A1**
A40.2	**Heating and Plant House for Stand A2**
A40.3	**Heating and Plant House for Stand A3**
A42	**Fourth Engine Test Stand**
A42.1	**Electrical Control Station**
A42.2	**Junction Room -**
A42.3	**Draw in Chamber 4th Engine Test Stand**
A42.6	**Pressurisation Plant Room**
A46	**Site Clearance and Grassed Areas**
A80	**Television and Searchlight Equipment**
A82	**Photographic Equipment**
A84	**Warning System**
A85	**Intercom System**
A88	**Storage Vessels**
A90	**Instrumentation for de Havilland**
A100	**Process Proving Equipment**
A101	**Surplus Instruments**

Component Test Area - source TNA:PRO AVIA92/2

B1	**Control Room**
B1.1	**Pump Test Facility**
B1.2	**Gas Turbine House**
B1.3	**Workshop**
B1.4	**Gas Generator Test Facility No.1**
B1.5	**Gas Generator Test Facility No.2**
B1.6	**Gas Generator Test Facility No.3**
B1.7	**Gaseous Nitrogen Test Facility**
B2.1	**Turbo Pump Test Facility No.1**
B2.2	**Turbo Pump Test Facility No.2**
B2.3	**Turbo Pump Test Facility No.3**
B2.4	**Battery House**
B3	**Water Flow Laboratory**
B4.1	**Air Compressor House**
B6	**Effluent System**
B8	**Liquid Oxygen Storage and Distribution**
B10	**High Pressure Gaseous Nitrogen Storage and Distribution**
B11	**Kerosene Storage and Distribution**
B15	**Fire and Process Water Mains**
B16.1	**De-Mineralised Water Plant and Distribution**

Greymare Hill

C2	**Centre Test Stand**
C.2.1	**Base launcher and Deflector System**
C.2.2	**Self Propelled Mobile Missile Servicing Tower**
C.2.3	**Equipment Rooms**
C.2.4	**Kerosene System**
C.2.5	**Lox System**
C.2.6	**Liquid Nitrogen**
C.2.7	**Lox Dump Area**
C.2.8	**Trichlorethylene Flushing System**
C 3	**East Test Stand**
C.3.1	**Base Launcher and Deflector System**
C.3.2	**Self Propelled Mobile Missile Servicing Tower**
C.3.3	**Equipment Rooms**
C.3.4	**Kerosene System**
C.3.5	**Lox System**
C.3.6	**Liquid Nitrogen**
C.3.7	**Lox Dump Area**
C.3.8	**Trichlorethylene Flushing System**
C.4	**Control Centre**
C5.2	**Substation** – adjoining Stand 2
C5.3	**Substation** – adjoining Stand 3
C5.4	**Substation** – south of control centre
C.13	**Kersosene Storage Tanks and Pumphouse**
C.14	**Kerosene Main**
C.15.2	**Kerosene Dump Area** - Stand C2
C.15.3	**Kerosene Dump Area** – Stand C3
C.16	**High Pressure Nitrogen Storage and Distribution**
C.16.1	**Gaseous Nitrogen Booster Compressor House**
C.16.2	**Gaseous Nitrogen Filter Compound** - Stand C2
C.16.3	**Gaseous Nitrogen Filter Compound** - Stand C3
C.22	**Installation and Control, Cables and Ducts**
C.27	**Workshop**
C.29.3	**Offices and Lavatories**
C37.1	**Warning Tower**
C81	**Warning System**

BOC Compound – source TNA:PRO AVIA 92/2

D1	**Main Building**
D1.1	**Cooling and Drying System No.1 Plant**
D1.2	**Compressor Section No.1 Lox Plant**
D1.3	**Caustic Section No.1 Plant**
D1.4	**Air Expansion System No.1 Plant**
D1.5	**Boiler House**
D2	**Main Building**

D2.2	**Compressor Section No.2 Lox Plant**
D2.3	**Caustic Section No.2 Plant**
D2.4	**Air Expansion System No.2 Plant**
D3	**Liquid Oxygen Tank**
D4	**Liquid Nitrogen Tank**
D5.1	**Air Separation Unit No.1 Plant**
D5.2	**Air Separation Plant No.2**
D6.1	**Nitrogen Handling System No.1 Plant**
D6.2	**Nitrogen Handling System No.2 Plant**
D7.1	**Cooling Tank**
D7.2	**Cooling Tank**
D9	**Effluent Drainage**
D10	**Lox Substation and Transformer**
D11	**Tanker Filling Bay**
D12	**External Services, roads, drains**
D13	**Lox Pump House**
D14	**Fire Fighting Water Mains**
D15	**Domestic Water Mains**
D16.1	**Water Treatment Plant Lox Area**
D19	**Fencing**
D22	**Grassed Areas and Site Clearance**
D100	**Process Proving Equipment**

Administrative Area – F prefixes – after AVIA 92/2

F1	**Main Buildings**
F1.1	**Main Office Buildings**
F3	**Boiler House**
F3.1	**Fuel Oil Storage**
F8	**Garage and Workshop**
F8.1	**Additional Garage**
F10	**Equipment Test Laboratory**
F11	**Administration Area Control Building**
F12	**Surgery Block**
F18	**Compressor House and Store Room**
F22	**Weighbridge and Hut**
F23	**Film and Chemical store**
F25	**Police Control Post**
F26	**Oil and Paint Store**
F27	**Petrol Filling Station**
F28	**Roads, Bridges, Culverts, Ducts, Hardstandings, Paths, etc**
F29	**Process and Fire Mains**
F30	**Domestic Water Mains and Treated Water Plant**
F30.1	**Treated Water Plant**
F30.2	**Softened Water Plant**
F33	**Heating and Ventilation**

F36	**Public Address System**
F39	**Surface Water Drainage**
F40	**Treatment Plant from Wash and Pickling Room**
F40.8	**Line Store and Plant Room**
F41	**Soil Drainage**
F42.1	**Sub-station**
F42.2	**Sub-station**
F42.3	**Sub-station**
F42.4	**Sub-station**
F47	**DeHavilland Welding and Machine Shop**
F51	**Fencing and Gates**
F53	**Photographic Effluent Delay Tanks**
F53.1	**ATF Group Test Cell**
F53.2	**High Test peroxide Store Workshop and Degreasing Room**
F55	**Effluent Drainage**
F56	**Vibrator Building**
F58	**Flagpole**
F60.1	**Silver Recovery Building**
F61	**DeHavilland Power and Supplies Building**
F62	**Grassed Area and Site Clearance**
F63	**Dehavilland Drawing Office**
F65	**Spent Hypo Transfer**
F80	**Instrumentation**
F81	**Instrument Workshops**
F82	**Instrument Cabling and Racks**
F83	**Intercoms**
F100	**Process Proving Equipment**
Q sites – AVIA 92/2	
Q1	**Roads, paths, hardstandings, culverts, ducts and bridges** -
Q2.101	**Administration Area High Level Storage Tanks**
Q2.102	**Camp High Level Storage Tanks**
Q2 103	**ETA High Level Storage Tanks**
Q2 104	**MTA High Level Storage Tanks**
Q2.105	**CTA High Level Storage Tanks**
Q2.11	**Domestic Water tank**
Q2.12	**Gravity Water Main for Central Reservoir Q25.1**
Q2.13	**Pumping Mains**
Q2.14	**Pumping Main from Central Reservoir Q25.1**
Q2.15	**Pumping Mains**
Q2.16	**Domestic Water Pump House**
Q2.17	**Fire Mains Pump House**
Q2.18	**Fire Mains** - from Central Pump House Q2.17 to Areas D and F
Q2.19	**Temporary Fire Station**
Q2.20	**Hose Drying Tower**

Q2.21	**Borehole No.1 Administration Area**
Q2.22	**Borehole No.3 Labour Camp**
Q2.23	**Borehole No.2 ETA**
Q2.24	**Borehole No.4 MTA**
Q3.1	**Electrical Distribution and Ducts**
Q3.4	**Telephone Communications**
Q3.5	**132 kV incoming supply**
Q3.7	**Central Electricity Authority Compound**
Q3.8	**CEA Switch and Control Building**
Q3.9	**CEA Auxiliary Plant Building**
Q4.1	**Surface Water Drainage**
Q4.3	**Soil Drainage**
Q4.4	**Sewage Disposal Works**
Q5.1	**Boundary Demarcation and Fencing**
Q11	**M & E Site Workshop Equipment and Temporary Pickling Facilities**
Q14	**High Pressure Gaseous Nitrogen Distribution from D6.1 and D6.2 to local Storage Areas**
Q17	**Effluent Treatment Sludge Beds and Clan Flocculators** - ETA
Q17.1	**Effluent Pipelines** - ETA
Q17.2	**Effluent Pumphouse** - ETA
Q17.3	**Sludge Handling Equipment Tank** - ETA
Q17.4	**Chlorinator Room and Flash Mixing Channels** - ETA
Q18	**Effluent Treatment System** - MTA
Q18.1	**Effluent Pipelines** - MTA
Q18.2	**Effluent Pumphouse** – MTA
Q18.3	**Engine House** - MTA
Q18.4	**Chlorinator and Controller House** - MTA
Q19	**Meteorological Area** - ETA
Q20.1	**Remote Observers Shelter** - ETA
Q20.2	**Remote Observers Shelter** – MTA
Q21	**Refuse Incinerator**
Q23.1	**Process Water Reservoir** - ETA
Q23.2	**Pumphouse** - ETA
Q23.3	**Troutbeck Substation** - ETA
Q24.1	**Process Water Reservoir** - MTA
Q24.2	**Pumphouse** - MTA
Q24.3	**Midhill Substatio**
Q25.1	**Process Water Reservoirs**
Q25.2	**Central Pumphouse**
Q25.3	**Transformer Switching Station**
Q25.4	**Micro-Screening Chamber**
Q26	**River Irthing Water intake Works**
Q26.1	**Weir**
Q26.2	**Substation transformer and Switching Units -**

Q26.3	**Pumphouse**
Q27.1	**Car park** – adjacent to Administration Area
Q27.2	**Bus park and Shelter** - adjacent to Administration Area
Q28	**Magazine**
Q29	**Police Control Post**
Q30.1	**Effluent Pumping Main**
Q31	**Kerosine Waste Disposal Plant**
Q31.1	**Waste Kerosene Storage Tanks**
Q31.2	**Incinerator**
Q31.3	**Incinerator**
Q31.4	**Incinerator**
Q31.5	**Waste Kerosene Pumphouse**
Q34	**Traffic Lights**
Q34.1	**Traffic Lights**
Q35	**Firebreaks**
Q35.1	**Firebreak** – B, D and F areas
Q35.2	**Firebreak** – ETA
Q35.3	**Firebreak** – MTA
Q36	**Notice Boards**
Q36.1	**Notice Boards**
Q39	**12 Month operational spares**
Q41.1	**Small Refuges**
Q41.3	**Large Refuges**
Q42	**12 Months Spares**
Q44	**Kerosene Dump Tanks**
Q45	**Grassed Area and Site Clearance**
Q46	**Street Lighting B, D & F Areas**
Q47	**Safety Precautions**
Q48	**Backwash Settling Tank** – adjacent Q2.16
Q51	**Spare 10ft 6in Flame Deflector Bucket**
Q52	**Spare 18ft Flame Deflector Bucket**
Q56	**Additional Effluent Facilities**

Appendix 4

Range inventory, May 1974 – Sources TNA:PRO CM6/291, DEFE 51/118

Priorlancy	
A1	**Engine Test Stand No.1** - not maintained since 1961, structure is in a corroded condition, recommended that the tanks and auxiliary structures are cleared away.
A2	**Engine Test Stand No.2** - kerosene and lox tanks, and associated pipe work and controls required by the Indian Government, as spares and support for stand A3. Steelwork to be removed.
A3	**Engine Test Stand No.3** - to be dismantled for the Indian Government.
A4	**Terminal House for Instrumentation Cables** - retain main cable entry into A8
A5	**Lox Storage Pumphouse** - plan to be stripped out
A6	**Electrical Switchgear Building** - 5 ton overhead crane to remain
A7	**Store** - to be demolished
A8	**Main Cable Duct** - cabling for A3 to be retained
A9	**High Pressure Liquid Nitrogen Store** - to be demolished
A10.1	**Sub-station** - To be modified to suit R50 project
A10.2	**Sub-station** - to cover A42 and A2 towers and supporting buildings
A10.3	**Sub-station** - to cover A42 and A2 towers and supporting buildings
A10.4	**Sub-station** - entry and Effluent Plant
A11	**Control and Instrument Building** - to be modified for project R50
A11.1	**Control Instrument Equipment** -
A12	**Workshop** - to be modified for project R50
A13	**Rolls Royce Ltd Shift House** - protected building for staff
A14	**Lagoon** - includes pumphouse and supporting pipework
A14.1	**Kero Waste tanks No.1 and No.2**
A15	**Concrete Culverts** - essential for R50 project
A16.1	**Supplies Tower A1 Stand** - Pneumatic Control Building, to be demolished
A16.2	**Supplies Tower A2 Stand** - Pneumatic Control Building, to be demolished
A16.3	**Supplies Tower A3 Stand** - Pneumatic Control Building, to be demolished
A17.1	**Supplies Tower A1 Stand** - Electrical Control Building, to be demolished
A17.2	**Electrical Control Building** - supply to A2
A17.3	**Electrical Control Building** - supply to A3
A21.1	**Observation Post** - recover periscopes
A21.2	**Observation Post** - periscopes bid for
A21.3	**Observation Post** - periscopes bid for
A21.4	**Observation Post** - direct viewing windows
A22	**Police Control Post** -
A23	**Dannert Wire Fence** - perimeter to be modified to suit R50
A24	**Drainage Systems and Service Ducts** -

A25	**Roads, Paths and Hardstandings** -
A27	**Supply Pumps and Valves** - Indian Government to remove equipment
A28	**18-inch Fire Main** - required for R50
A29	**Drinking Water Main** -
A29.1	**Demineralised Water Building** - water used for engine washing
A29.2	**Treated Water Storage and Distribution System to Engine Test Stands**
A30	**Main cables**
A31	**Kerosine Distribution Main** -
A32	**Kerosine Storage and Pumphouse Building**
A33	**Kerosine Dump System** - East clear site for R50 project West leave bund insitu
A34	***See* Q29**
A35	**De Havilland timber shed** - to be demolished
A36	**Not allocated**
A37	**Street lights** -
A38	**Public Address System** -
A39	**Telephones** -
A40.1	**Heating Plant House** - for Stnd A1
A40.2	**Heating Plant House** - for Stand A2
A40.3	**Heating Plant House** - for Stand A3
A40.4	**Heating Plant House** - for Stand A42
A42	**Engine Test Stand No.4** - reinforced concrete construction, to be left intact for possible future use.
A42.1	**Electrical Control Building** - for Stand A4
A42.2	**Cable Junction Room** -
A42.3	**Draw in chamber** -
A43	**Kerosine Tank** - for Stand A1, to be cleared
A44	**Site Office** - timber shed to be cleared
A45-47	Removed and cleared
A48	**Metal Cabinet** - to be cleared
A49	***See* A7**
A50	**Lox Dumps** - at stands A1, A2, A3
A51 to A83	Equipment not applicable
A84	**Warning Klaxon on mast** -
A85 to A101	Equipment not applicable
A102	**Timber Hut** - concrete plinth to remain
A103	**Timber Hut** - to be demolished
A104	**Timber Hut** - concrete plinth to remain
A105	**?**

Component Test Area - source DEFE 51/118

B1	**Control Room**
B1.1	**Pump Test Cells**
B1.2	**Gas Turbine**

B1.3 **Workshop**

B2 **Turbo Pump Test Cells**

B2.3 **Switch House**

B3 **Water Flow Bench Laboratory**

B4 **Boiler House**

B5 **Police Post**

B6.1 **Pump House**

B7 **Sub-station and Transformer**

B8 **Pump House**

B10 **High pressure Gaseous Nitrogen Storage**

B11 **Pump House and Kerosine Storage**

Greymare Hill

C2 **Centre Test Stand** - general layout

C.2.1 **Base launcher and Deflector System** - bucket and pipework to be stripped

C.2.2 **C2 Servicing Tower** - to be retained

C.2.3 **Equipment Rooms and Causeway** - retain electrical switch gear and lighting

C.2.4 **Tank** -

C.2.5 **Lox Pump house and Storage Tanks** -

C.2.6 **?Kerosine Dump System** - remove

C.2.7 **Kerosine Dump System pipework** - remove

C.2.8 **Trichlorethylene** System -

C 3 **East Test Stand** - general layout

C.3.1 **Base Launcher and Deflector System** - to be removed except for stairway access

C.3.2 **C3 Tower** - dismantle and remove

C.3.3 **Causeway** - equipment rooms to be stripped except for some fittings such as lighting and heating

C.3.4 **Unspecified Installation** - to be removed and sealed

C.3.5 **Pumphouse** - remove tanks and pipework, etc

C.3.6 **?Tank** -

C.3.7 **Pipework** -

C.3.8 ?

C.4 **Control Centre** - some equipment required by Indian Government, all remaining section of structure required by Proof and Experimental Establishment.

C.4.1 **Control Room** -

C.4.2 **Control Centre** - part of

C.4.3 **Control Centre** - part of

C.4.4 **Control Centre** - part of

C.5.2 **Sub-station** - C2 stand area

C.5.3 **Sub-station** - C3 stand area

C.5.4 **Sub-station** - main substation for Rocket Test Area

C.6	**Electrical Distribution** - for Rocket Test Area
C.7-C.8	Not allocated
C.9	**Battery Charging Room** -
C.10	**Pipes** - including 36-inch cooling water mains
C.11	**Fire hydrant system** -
C.12	**Domestic Water Supply** - to Rocket Test Area
C.13	**Pumphouse** - switchgear and lighting to be retained
C.14	**Kerosine Piping and Distribution System** -
C.15.1	Not allocated
C.15.2	**C2 Kerosine Dump System** - tank and piping to be removed
C.15.3	**C3 Kerosine Dump System** - remove tank and piping
C.16	**Gaseous Nitrogen Tankerage and Pipes** - to be removed
C.16.1	**Nitrogen Compressor House and Lavatory** -
C.16.2	**Concrete Base** -
C.16.3	**Gaseous Nitrogen Supply Equipment** - for C.3 Stand, to be stripped
C.17	**Police Control Building** - at entrance to Rocket Test Area
C.18	**Drainage System and fencing** -
C.19	**Road** - pipe bridges to be removed
C.20	**Dannert fencing** -
C.21	**Street Light** -
C.22	**Instrumentation** -
C.22.2	**Cabling** - ?from C.2 to C4.1
C.22.3	**Cabling** - from C.3 to C4.1
C.23	Not allocated
C.24.2	**Auto Collimation Building** - For C2 not completed
C.24.3	**Auto Collimation Building** - For C.3 used as heating and ventilation building
C.25	**Public Address System** -
C.26	**Telephone Installation** -
C.27	**Workshop and Store** - steel-framed
C.28.2	**Transport Shelter at C2 Stand** -
C.28.3	**Transport Shelter at C2 Stand** -
C.29.2	
C.29.3	**Offices and Lavatories** - was Welfare Building
C.30	**Chemical Treatment Building** -
C.31.2	**Effluent Lagoon** - unfinished
C.31	**Channel Culverts to Effluent Lagoon** - C.2 and C.3
C.31.3	**?Channel Culverts to Effluent Lagoon** - C.2 and C.3
C.32.3	**Waste Kerosine Storage Tank** - including pipework and pumphouse to be retained for Project R54
C34	**Weather Protection and Heating Installation** - for 36-inch cooling water main, 18-inch fire main, kerosine supply pipeline, domestic water main and sewerage pipeline.
C35	**Former Explosives Store** - brick with concrete roof

C36	**Camera Huts and TV Centres** - 10 in total 5 allocated to each rocket test stand, 7 to be retained
C37	**Warning Tower Equipment Building** - brick with concrete roof
C37.1	**Tower** - steel
C38	**Grassed areas and site clearances** -
C39 to C79	Not applicable details or cancelled items
C80	**Optical Equipment** -
C81	**Warning System** - *see* C37.1
C82 to C84	Equipments dealt with separately
C85	**Direct Current Power Systems** -
C86-C101	Miscellaneous - not applicable
C102	**Hawker Siddeley Dynamics Office** - timber hut at C3
Q Sites	
Q1	All roads, paths, hardstandings, culverts, ducts and bridges -
Q2 103	**High Level Domestic Water Storage Tank** - Engine Test Area, complete with osage building at foot of tower
Q2 104	**High Level Domestic Water Tank** - Rocket Test Area
Q2.12	**Process Gravity Water Mains** - from central reservoirs, Q25.1 as modified to suit development by PSA.
Q2.13	**Pumping Main** - from central reservoir to Engine Test Area reservoir Q25.1
Q2.15	**Pumping Main** - from River Irthing Q26 to central reservoir Q25.1
Q2.23	**Borehole No.2** - Engine Test Area, including pump and controls
Q2.24	**Borehole No.4** - Rocket Test Area, including pumps and controls
Q3	**Electrical Supply and Distribution** - to Engine Test Area and
Q3.1	Rocket Test Area connecting to Administration Area
Q4	**Surface water and soil drainage systems** - as installed in Engine
Q4.1	Test Area and Rocket Test Area connecting to Administration Area
Q4.3	
Q5.1	**Boundary Demarcation Posts** -
Q14	**High Pressure Gas Supply** - to Engine Test Area and Rocket Test Area
Q17	**Effluent Treatment Sludge Beds and Clan Flocculators** - Engine Test Area
Q17.1	**Effluent Pipelines** - Engine Test Area
Q17.2	**Effluent Pumphouse** - Engine Test Area
Q17.3	**Chlorinator Room and Flash Mixing Channels** - Engine Test Area
Q18	**Effluent Treatment System** - Rocket Test Area, *see* C31 and C32.3 for details
Q19	**Meteorological Area** - Engine Test Area, including anemometer tower, receiver hut, enclosed compound for measuring equipment
Q20.1	**Remote Observers Shelter** - Engine Test Area, retain fro use by MoD Police
Q20.2	**Remote Observers Shelter** - Rocket Test Area, retain for use by MoD Police

Q23.1	**Process Water Reservoir** - Engine Test Area, 1 million gallon reservoir and fire mains, required for Project R50
Q23.2	**Pumphouse** - Engine Test Area, required for Project R50
Q23.3	**Troutbeck Substation** - Engine Test Area, serves Pumphouse Q23.2
Q24.1	**Process Water Reservoir** - Rocket Test Area, 1 million gallon reservoir and fire mains, required for Project R54
Q24.2	**Pumphouse** - Rocket Test Area
Q24.3	**Midhill Substation** - serves Pumphouse Q24.2
Q25.1	**Process Water Reservoirs** - Two covered I million gallon reservoirs
Q25.2	**Central Pumphouse** - for Process Water Reservoirs will be modified by PSA
Q25.3	**Transformer Switching Station** - Central Process Water Reservoir
Q25.4	**Micro-Screening Chamber** - for River Irthing intake at the central reservoir
Q26	**River Irthing Water intake Works**
Q26.1	**Weir** - not constructed
Q26.2	**Substation transformer and Switching Units** -
Q26.3	**Pumphouse** - River Irthing water intake
Q28	**Old Magazine** - Brick with concrete roof
Q29	**Police Control Post** - at road junction of Engine Test Area and Rocket Test Area
Q30.1	**Effluent Pumping Main** -
Q31	**Kerosine Waste Disposal Plant** -
Q34	**Traffic Lights** - Greymare Hill road to be removed
Q34.1	**Traffic Lights** - at road junction of Engine Test Area and Rocket Test Area to be removed
Q35	**Firebreaks** -
Q36	**Notice Boards** -
Q36.1	**Notice Boards** - adjacent to Administration Area

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