

Characterisation and Preparation for the Demolition of an Explosives Facility Major Project Report

by Jordan Hayston

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**CHARACTERISATION AND
PREPARATION FOR THE DEMOLITION
OF AN EXPLOSIVES FACILITY by
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Project submitted as part of the requirements for
the award of BEng (Hons) OME

March 2024

Declaration of Originality

I, Jordan Hayston, declare that I am the sole author of this Project; that all references cited have been consulted; that I have conducted all work of which this is a record, and that the finished work lies within the prescribed word limits.

This work has not previously been accepted as part of any other degree submission.

21/03/2024

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Abstract

The purpose of this research was to identify a suitable method for the removal of one of AWE's legacy explosives facilities. The building has been declared unfit for use due to cracks forming in its roof across the two main rooms. The structural defects were analysed following multiple scans of its interior and exterior, resulting in the decision to demolish it rather than refurbish.

A wide range of legislation, guidance, internal databases, and staff knowledge has been explored to develop a basis of supporting information, ensuring that each stage of the project complies with the law, and is carried out using industry-approved methods.

Each step of the process has been carefully selected based on the knowledge gathered in the literature review, and carried out in a specific order based on the information they provide; the outcome of each activity influences the subsequent tasks, and in turn the outcome of the whole project.

3D scanning, a topographical survey, and visits to the location first allowed the decision to demolish to be made. Following this, a history file was produced which identifies details of the building fabric and past operations, subsequently determining the likelihood of contamination and requirement for FFEH, Free From Explosives Hazard. Hazard identification and operability studies highlighted prominent hazards within the explosives area, proposing management and engineering controls to mitigate the risks. Finally, a high-level risk assessment known as a Scaled Distance Assessment was produced to safely deploy non-explosives workers within Class D Separation distance.

The project successfully collated areas of legislation and industry guidance to develop a process for the safe demolition of an explosives facility residing within the Class D Separation Distance of other explosives locations.

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Chapter 1 Introduction

Multiple building condition surveys and inspections have identified that a building within AWE's explosives area is unfit for the safe storage and manufacture of explosives. The location has a foam slag arched roof, spanning over two main rooms, which has visible cracking extending beyond the surface. The cracking traverses the full length and width of the roof in both rooms, one of which is much worse than the other. This poses a significant hazard, with the potential to cause harm to both personnel and explosives in the vicinity. As a result, the facility has been condemned, all explosives have been removed, and its Explosives Safety Order (XSO)¹ reduced to NIL explosives quantity until further investigation has been carried out. The Explosives Site Licence Building Schedule (ESLBS)² has not yet been amended, as this will be a part of the building works associated with this project.

Most of the AWE's buildings are old and outdated, with the majority of explosives buildings having been built between the 1950s and the 1980s. As part of a larger plan to uplift AWE's explosives estate, it has been identified that a suitable method for refurbishment or demolition is investigated and established, whilst considering the impact on surrounding explosives facilities, and ensuring explosives workers and non-explosives workers are able to be kept safe.

Initially, the replacement of the facility's roof was considered however, this would require extensive research taking into consideration appropriate materials, methods of modifying the building fabric, blast modelling and explosives licence substantiation, and time/cost requirements. As a result of the lack of viable options for restructuring of the explosives building, it was determined that demolishing the building would prove to be the ALARP approach.

In order to safely manage the demolition of the building, legislation and guidance both internal and external to the company has been explored to ensure each activity carried out meets the requirements set out in said legislation and guidance documentation.

It is hoped that the procedure for works of this nature can be replicated over the next 10-15 years with other locations, in order to revitalise the company's explosives areas. This is to provide ample space for new and improved buildings, ensuring an increased capability within the company for the storage, manufacture and testing of explosives.

One of the major issues faced in the project was a result of poor communication and resource allocation. The 3D scanning and topographical surveying of the facility were the first activities, which allowed the blast and structure SME (Subject Matter Expert) to analyse the extent of the cracking in the roof. The scan results took 7 months to be returned, and the subsequent soil depth analysis took a further 3 months. As an alternative, multiple physical inspections were carried out with the blast and structure SME until the scans were available for analysis.

The deployment of personnel within Class D Separation distance was another challenge faced. The building in question is sited within the quantity distances of a number of other explosives facilities as defined in Explosives Regulations 2014 Regulation 27 [1], and considers the guidance of DSA.03 OME Part 2 Chapter 18. These facilities vary between

¹ An XSO is AWE's simplified version of the ESLBS, which clarifies a location's explosives limits, permitted operations and hazard categories, and the building plan.

² An ESLBS is given to each explosives-licensed location as part of AWE's Explosives Site Licence issued by the HSE on behalf of the ONR.

explosives storage and/or explosives manufacture. The result being that physical and managerial constraints are required to be placed on these facilities, which has the potential to put significant strain on storage and operational capabilities.

Chapter 2 Research and Review of Literature

2.1 Identification of the Problem

A contracted company, Ridge, have raised concerns to facility management over the cracking in the building's roof in recent years through their building condition surveys. The issue is assigned a grade 'D'³, in the survey, requiring that the area in fault is either replaced or major rebuild works go ahead, and is further clarified by stating that there is a serious risk of breakdown or failure of the asset. The building closure has been traced back to 2011, when the issue was first raised, although it is possible that the cracking may have gone unnoticed for a period before this. As a result, the building has been condemned and isolated, removing all explosives until further investigation has taken place. The outcome of this assessment is supported by multiple pieces of legislation.

Section 2 of the Health and Safety at Work Act 1974 [2] explains that the employer must take all actions necessary to control and maintain the work environment to ensure there are no risks to health. Regulation 26 of the Explosives Regulations 2014 [3] requires that any person manufacturing or storing explosives must take measures to prevent unplanned fire or explosion, limit the extent of fire or explosion and protect persons from the effect of fire or explosion. The cracking observed on the building's roof indicates that its structure may no longer meet the standards under which it was licenced, meaning the efforts to comply with Regulation 26's 'prevent', 'limit' and 'protect' [3] may be compromised. Consequently, AWE's Acquire and Keep certificate [4], as well as the Explosives Site Licence Building Schedule (ESLBS) [5] would be void and it should remain at NIL explosives limit until resolved. The Acquire and Keep certificate [4], issued by Thames Valley Police, authorises AWE to 'keep' explosives in an approved storage location whilst the ESLBS [5] identifies the manufacture and storage requirements of the Explosives Site Licence.

Section 11 of the Explosives Industry Group Structural Justification Guide [6] details how legacy explosives facilities can be justified. Modification and enhancement methods are described within 11.8 but would come at great difficulty given the geometry of the roofing. 11.9 explains that if the structure cannot be justified to provide adequate protection, the building's explosives limit should be reduced to NIL, as AWE is unable to substantiate the facility against the licensing intent.

Due to the push for the uplift of AWEs explosives estate, there is demand for the development of a process to allow for the removal of legacy facilities. There is currently no consolidation of the different aspects of this process, which is why this research is required.

2.2 Hazard Identification and FFEH

The Explosives Industry Group has published guidance on the Safe Decommissioning of Explosives Sites [7], which begins by explaining the high level of risk associated with decommissioning and decontamination activities, emphasizing the importance of effective planning, health and safety policies, and risk assessment. It is crucial that explosives are evaluated appropriately, for both the risks posed to the explosives, and the risk posed to personnel. It may be required for the building to be declared FFEH, Free From Explosives Hazard. Until confirmation of FFEH, the associated hazards must be addressed by Hazard Identification (HAZID) and Hazard Operability (HAZOP) studies. Using the principles outlined in the ERICPD hierarchy of controls, the risk levels can be managed to achieve an ALARP (As Low As Reasonably Practicable) status.

³ Grade A = No readily observable defects, Grade B = Minor repairs required, Grade C = Major repairs required, Grade D = Replacement or significant major rebuild works required.

2.3 The Safe Deployment of Contractors within Explosives Areas

A programme of works must be identified, factoring in the prominent hazards from the HAZID and HAZOP studies. This is to be arranged between a project team and a contracting company, with input from facility management and the Explosives Safety and Licensing Team (XS&LT). The XS&LT are tasked with the safe deployment of contractors within Class D Separation distance. Chapter 6 of DSA 03.OME Part 2 (JSP482) [8], Section 5 outlines the expected injury to personnel at different quantity distances, specifically Process building Distance (PBD, Class H), Public Traffic Route Distance (PTRD, Class B and C), Inhabited Building Distance (IBD, Class D) and Vulnerable Building Distance (VBD, Class E). Injury is unlikely to occur at Class E Separation Distance, and so protective measures are focused on contractors working within Class D. Personnel working within Class D and PTRD will not likely be injured by blast effects but could be injured or killed by fragmentation thrown from an explosion site. Fragments are considered to be lethal if their impact energy exceeds 80J, and the density of such lethal fragments is not expected to exceed 1 per 56m² within Class D. Within Class H, there is a small risk of injury from blast effects, and an increased risk of injury or fatality from debris and fragments. The human body has a higher tolerance to blast, and the level of harm is proportional to the amount of blast overpressure a person is exposed to as seen in Table 1.

Table 1, Level of harm compared to blast overpressure.

Serial No	Injury Level	Maximum Blast Pressure
		kPa
1	<u>Eardrum Rupture</u> Threshold 50% Rupture	35 100
2	<u>Lung Damage</u> Threshold 50% Lethality	70 250
3	<u>Body Translation</u> Threshold of Lethality 50% Lethality	100-150 400-750

Adequate control of any plant, equipment and vehicles entering the explosives area is a requirement outlined in AWE's Explosives Safety Manual (XSM) Section 8.3 [9]. ER2014 Safety Provisions (L150) [10] drives the segregation of explosives from other activities, including storing other goods such as flammable liquids separately. Where dangerous goods are stored in bulk, they must be located outside of Class D Separation Distance. The Health & Safety Executive (HSE) Explosives Licensing Handbook expands on this, stating that bulk quantities of dangerous goods are identified as being over 400Kg or 450L of substances liable to spontaneous ignition [11].

Although the contractor is responsible for the safe practices relating to the nature of their work, the duty holder is responsible for any special hazard which may affect the contractors' staff. A Safe System of Work (SSoW) must be established, which outlines the following:

- A description of the task
- Safety requirements
- Equipment and materials
- Associated processes
- Method of work

By understanding and acknowledging the hazards present in explosives areas, a higher-level risk assessment can be carried out. AWE's Scaled Distance Deployment Assessment Process has been developed based on Chapter 18 of DSA03.OME Part 2 [12], which details the requirements for controlling and protecting contractors working within Class D Separation Distance. This assessment is specific to major works which will take over 400 person-hours and/or requires over 10 persons. Major works can include the creation of new structures and infrastructure or the alterations and modifications to current infrastructure. Annex C of Chapter 18 describes the initial scaled distance calculation for work locations affected by one PES (Potential Explosion Site), which can be used to determine the permitted number of contractors for different project timeframes. Further calculations are described within Annex D, for work locations affected by multiple PES. The outcome of these sums is binary and determines whether the base level of input data (number of contractors, timeframe of project and key PES information) is permissible.

Where the outcome of a Scaled Distance Assessment (SDA) determines the cumulative risk to be unacceptable, conditions and restrictions must be placed on surrounding explosives facilities to reduce their explosives limits and operations to protect persons from the effects of fire or explosion, in compliance with ER2014 Regulation 26 [3]. Other controls must be put in place to prevent the unauthorised access of explosives, in order to meet requirements, set out in Regulation 30 [13].

Regulation 30 dictates that the licensee must ensure that no person gains access to explosives stores or places of explosives manufacture. ER2014 Security Provisions (L151) expands on Regulation 30 [14], identifying both management and physical security standards for explosives licenced locations. To manage security-related hazards, nominated personnel from contracting companies must undertake AWE's Explosives Workplace Rules course, which covers unauthorised access and acquisition of explosives. The Work Coordination Centre (WCC) also manage access to explosives buildings by ensuring personnel are suitably trained, have an adequate business need to be in the area and confirming the correct levels of protection are in place. To ensure physical security standards are met, a Traka key system is in place which requires system authorisation to withdraw keys. Furthermore, intruder detection systems are installed in every building which alert the onsite police of any unauthorised or unplanned access.

2.4 Research Methodology

A number of regulations and industry guidance documents have been analysed in depth in order to identify a safe and appropriate method for the demolition of one of AWE's explosives facilities. The aim of the research is to ensure each task is carried out in compliance with its respective area of the law and guidance. This will aid in the production of a safe and secure method for similar projects, in the support of AWE's uplift of the explosives estate and has the potential to further inform the wider industry.

The Explosives Regulations 2014 (ER2014) and the Health and Safety at Work Act 1974 form the base level of safety requirements to which the company must comply with legally. Industry guidance produced by the likes of the HSE, and the Explosives Industry Group expand on these regulations, identifying how those in the explosives business should operate in order to abide by the law.

When researching for the history file, several databases and information services were explored to find various documents and data relating to the building. The BlueCielo Meridian database holds all facility and project related documentation. This provided the original building plans and building condition surveys, allowing for the analysis of the facility's design and structure, as well as issues raised regarding its structural compliance. AWE's event

tracking system provided information on any incidents and near misses that have occurred in or around the building, which may have had an impact on its current state. The Geographic Information System (GIS) features map overlays which show all utility services to the location, including water, electric, steam and gas supply which allows for appropriate planning for isolation. The Asset Management System (AMS) records all of the installed equipment in the location, including the Lightning Protection System (LPS), hot water system and ventilation system. It also manages any taskings associated with the building, such as maintenance and repair activities.

Discussions with several AWE staff members from a variety of different teams were held to support and clarify any findings during the research. Facility staff, both current and previous, helped to build a history of the facility due to a lack of historical data, whilst structural SMEs supported the decision to demolish it rather than refurbish.

3 Design Requirements

3.1 Introduction

This chapter aims to identify the requirements associated with each activity in the project, to ensure that they are completed to an acceptable standard. The order of the tasks has been determined based on the information they each provide; the results produced in each step support the decision process further down the line.

3.2 Design Requirements

3.2.1 3D Scanning and Topographical Survey

As the first task in the project, the 3D scans are required to produce suitable imaging of the building's interior to allow for the remote analysis of the structure's cracking. 360-degree camera technology can capture images of entire rooms and corridors, eliminating the need to deploy non-explosives workers into Class D Separation Distance for physical analysis.

The topographical survey is required to determine the soil depth of the earth over-mounding using drone imaging to compare the current shape and size of the mound to a model of the facility which conforms to the standards set out in Chapter 6 of DSA 03.OME Part 2 [15].

The scans are required to aid Subject Matter Experts (SMEs) in determining the level of legal compliance with regards to both structural and explosives regulations and will be the deciding point on whether the building should be renovated or demolished.

3.2.2 History File

The history file must be able to determine the design and structure of the building, outlining materials used in the building fabric to support the environmental team in selecting appropriate waste streams. Utility services should also be identified to allow for the proper isolation of the building.

The history file must also determine all past activities that have taken place in the facility, including explosives operations and any events or maintenance activities which may have affected the building structure. The type of explosives operations will allow for the estimation of potential contamination levels within the building, informing the Explosives Operations Support (XOS) team in how best to certify the location as FFEH.

3.2.3 Hazard Identification and Operability Studies

The HAZID and HAZOP studies is required to identify any dangers present in and around the work location, which are not associated with the specific construction tasks. These hazardous events or scenarios must be related to the building and its location within the explosives area, such as threats to and from explosives. Methods of managing these dangers should then be identified in alignment with the ERICPD hierarchy of controls, including both physical and management measures.

3.2.4 Scaled Distance Assessment and Deployment Strategy

First, the tasks associated with the building works must be identified, including a suitable enclave for the contractors to safely operate in. This will inform the next step of estimating the total number of required personnel and length of the project, whilst also highlighting any specialist plant and equipment that may be required.

Information about surrounding explosives facilities must be collated, including their operational explosives limit and their distance to the work site. This data, in addition to the maximum number of personnel and timescale of the project allows for the Scaled Distance calculations to determine whether the cumulative risk of any surrounding explosives facilities is tolerable.

Where the SDA determines the exposed risk to be above the permitted level, appropriate conditions and restrictions must be imposed on the affecting locations and the project to ensure that the contractors can work safely within Class D Separation Distance.

Any restrictions and controls must be outlined and agreed with stakeholders within the Deployment Strategy before construction works commence.

Chapter 4 Results and Discussion

4.1 Introduction

This chapter defines the results produced in each stage of the project and determines the relevance of the key findings to the wider scope of works; each task influences the overall outcome for the damaged building and its associated demotion works, demonstrating a structured process for the removal of an explosives-licensed facility residing within the Class D Separation Distance of several other locations.

4.2 3D Scan and Topographical Survey

The Geographical Information System (GIS) Team was initially contacted in May 2023 to carry out a topographical mound survey, and to 3D scan the interior of the building. A quote was returned at the end of June 2023 [16], estimating a tasking of 26.5 hours and a cost of £1369.42 which was agreed and signed off by AWE's explosives area facility management team. Due to a lack of effective communication within this team and with the explosives area WCC (Work Coordination Centre), the scanning tasks fell severely behind schedule despite continuous prompts. The scans were returned by mid-December, providing manoeuvrable imaging to analyse the current state of the building. The 3D scans were taken at the points seen in Figure 1 to develop a full map of the facility.

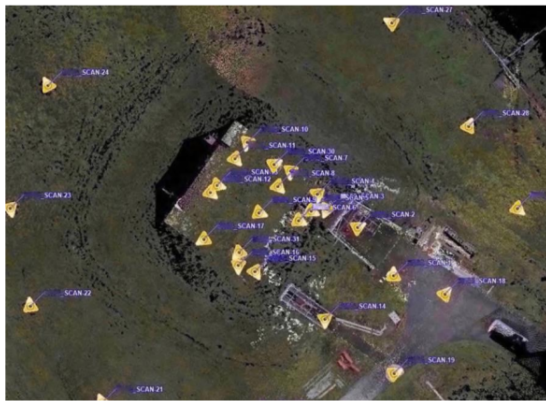


Figure 1, Map of 3D Scan Points

The earth over-mounding, visualised in Figure 2, appears to have maintained its shape however, the soil depth analysis is yet to be provided due to a lack of staffing and resources.

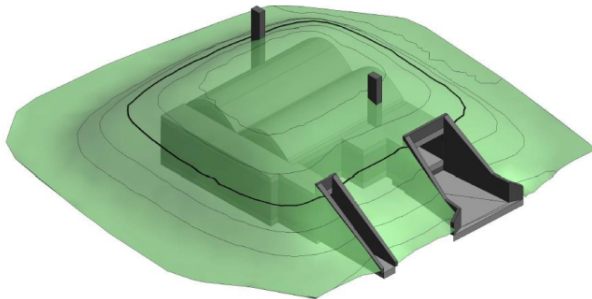


Figure 2, 3D Model of the facility.

The 3D scan of the interior provides an insight into the condition of the building and has enabled the partial mapping of the cracking across the roof (see Figure 5). Due to insufficient lighting, only the first room is visible in the scans; the data from the second room proved to be unhelpful. As a result, further building visits had to be arranged to photograph the cracking. Figures 3 and 4 demonstrate the cracks in both rooms from images taken through 3D scanning and with a digital camera. The crack in the first room is indicated within the blue lines, as it is not fully clear in the screenshot of the 3D scan.



Figure 3, Cracking in Room 1 (taken from 3D Scan)



Figure 4, Core Sample Cracking in Room 2 (taken with digital camera)

The extent of the damage looks to be severe and seems to extend beyond the surface of the concrete. The first room has two cracks in the ceiling spanning across its full length and width, intersecting at the middle. The second room has evidence of 5 core samples which have been taken in the past, unlike the first room, each around 50mm in diameter and 50mm in depth. The cracking has formed between each cut-out, creating a complex map of splits in the arched roof. The cause of the cracking is still unknown, and so it is suggested that further investigation is carried out after the removal of the earth over-mounding.

Ground Penetrating Radar (GPR) was considered whilst assessing the roof, to aid the decision process of demolishing or refurbishing. GPR can provide useful information on the depth of cracking in structures. Once the extent of the cracking was identified, GPR was disregarded for this stage of the project.

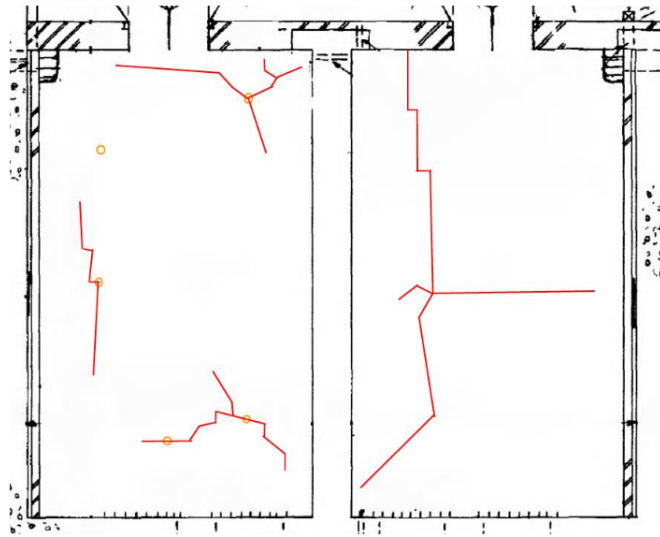


Figure 5, Estimated Map of Roof Cracking

4.2 History of the Building

The facility was built as an explosives storage magazine in 1953, shortly after the business was founded as AWRE (Atomic Weapons Research Establishment). The facility was used for the bulk storage of explosives, featuring a side room for inspection and repacking. Several legacy documents have been collated and analysed to better understand the building structure, an example of the original building drawing can be seen in Figure 6. It comprises of a concrete frame with reinforced concrete walls, floors and a foam slag arched roof, all of which is encased in a mound of earth.

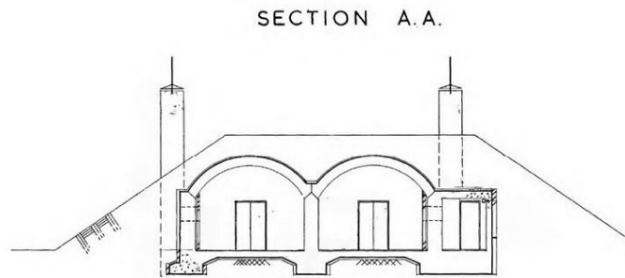


Figure 6, Sample of Original Building Plan [17]

The cracked ceiling issue was raised with facility management in 2011, triggering an initial investigation and the subsequent closure of the building. There are no incidents involving the building recorded on AWE's event tracking system, however a record of all job taskings are recorded on the Asset Management System (AMS). Concerns have been raised by one of AWE's structural engineers regarding the use of heavy machinery and vehicles to backfill burrows in the mound. This worry has been eliminated by facility management, as these operations do not allow any plant or equipment to operate on top of the mound.

Each asset and system within the facility is also identified in AMS, along with maintenance records. There is currently still mains electric and water supply to the building, seen in Figure 7, however some internal electrics have been disconnected from the distribution system such as the lighting and hot water heating system.

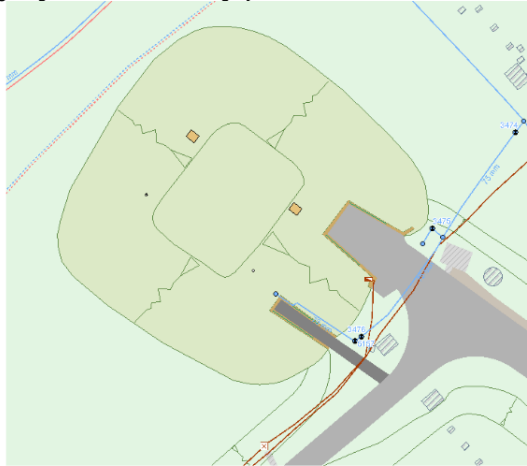


Figure 7, Electrical Supply (Red) and Water Supply (Blue) to facility

The history of the facility's use has been determined through discussions with facility staff and historical documents dictating the permitted explosives operations. As a result, the location is recognised as having a low probability of contamination although it cannot be ruled out.

4.3 Environmental Considerations and FFEH

In alignment with AWE's Explosives Safety Manual (XSM) Section 14.11 [18], any building undergoing a life stage change (e.g., refurbishment, decommissioning, demolition etc.) must be surveyed in advance by facility and clearance personnel with suitable and sufficient records. Prior to any excavation in the explosives area, the location must be assessed by a member of the Explosives Safety & Licensing Team, and a member of the environmental team.

The area has been part of a continuous groundwater monitoring programme to provide an understanding of AWE's environmental impact on the land. There has been no record of any chemical (including explosives), radioactive or asbestos contamination in the ground in the 2022/23 groundwater tests.

The building is designated 'LOW' in accordance with XSM Section 14.11 [18], meaning it is an area where explosives contamination is possible but not likely. As a result, it is required that the facility is sampled and decontaminated as necessary. One swab must be used for up to 1m² and must return less than 0.2mg per swap for the building to be certified as Free From Explosives Hazard (FFEH). If the location is heavily contaminated, intrusive sampling must be carried out once a suitable risk assessment has been completed.

Due to the nature of operations in the facility, it is highly unlikely any explosives contamination will be found however, FFEH certification must be obtained before any works are permitted.

Where any controlled waste may be produced as part of the demolition process, AWE's MSP1604 (Management System Procedure for Waste Management) [19] must be followed and planned to ensure the correct disposal methods are understood. It has been identified that the mounding can be recycled and can be used to repair other buildings which may have been affected by weather or burrowing animals. Other construction and demolition waste must be transported offsite by an approved waste company.

4.4 Explosives Site Licence Variation

Once the building has been certified as FFEH, the process of removing the licence can begin. Contact must be made with the Health & Safety Executive (HSE) prior to making changes to the Explosives Site Licence. The first licence variation must be submitted to the HSE via AWE's RICC (Regulatory Interface Co-ordination Centre) office, with the intent of reducing the buildings Explosives Site Licence Building Schedule to NIL explosives quantity. Once a regulatory agreement has been reached and the new site licence implemented, works to remove the building can commence.

A second variation to AWE's Explosive Site Licence must be initiated following the successful removal of the facility. This will be an agreement to remove the building from the licence altogether, with an updated map of the whole site and its estate.

At the time of this report, it takes on average up to 18 months for a licence variation to come to a final agreement with the HSE, who act on behalf of the Office for Nuclear Regulation ONR to issue explosives licences. This must be factored into the project scope to ensure no works proceed until there is confirmation of the facility obtaining its new licence schedule.

4.5 Hazard Operability

A Hazard Identification (HAZID) and subsequent Hazard Operability (HAZOP) study have been carried out in consultation with one of AWE's Principal Safety Assessment Specialists, in order to clarify and understand the prominent dangers of working within an explosives area and carrying out major building works. Any specific task-related hazards associated with the constructions works are managed within the contractor's risk assessment, and do not require any additional input.

Table 2, Identification of Hazards

ID	Hazardous Event or Scenario	Caused By
1	Electrocution	Building services not isolated
2	Loss of explosives	Unauthorised personnel gain access to explosives
3	External fire/explosion	Improper handling of explosives
		Ongoing explosives processing
		Road transport of explosives nearby

4	Local fire/explosion	Explosive material subject to impact/friction
		Bulk storage of fuel or refuelling of plant/equipment
		Prohibited items within the explosives area

Firstly, isolation of building services will be one of the hold points for the demolition works; a mandatory verification point to ensure the hazard of electrocution is eliminated.

For AWE to comply with Regulation 30 of ER2014, several security measures must be in place to ensure explosives are protected from unauthorised personnel within AWE's explosives area. Each building containing explosives is fitted with an intruder detection system, which alerts the Ministry of Defence Police (MDP) on site in the event of unsanctioned entry. Furthermore, building keys are kept in a Traka key system, which can only be accessed by building managers and facility staff with authorisation to do so.

The Scaled Distance Assessment (SDA) identifies any explosives-licensed location which has an effect on the work location, and restricts explosives operations, be that storage or processing, to ensure that the business conforms to the principles in the ERICPD hierarchy of controls to achieve an ALARP status. Any external hazard relating to explosives will be suitably assessed and controlled in order to guarantee the Non-Explosives Area Support Workers are afforded the highest level of protection.

With regards to the hazard of local fire/explosion, the building must first be certified as FFEH before any works are permitted to go ahead. This eliminates the threat of an explosives-related incident within the facility. The use of plant, equipment and any vehicles, however, requires stringent controls to reduce the risk of fire or explosion caused by fuel; there must be no storage of bulk hazardous goods (450L or 400Kg), and no refuelling of any plant or vehicle within the explosives area.

4.6 Deployment of Non-Explosives Area Support Workers (NXASW)

In order to safely plan for the deployment of NXASW within Class D Separation Distance, the associated tasks must first be understood. The activities listed below have been collated in discussion with construction project managers, ensuring human factors are considered when identifying the correct supply of equipment and personnel for each task.

Table 3, Identification of Associated Tasks

Task	Required No. of Personnel	Contractor	Required Plant / Equipment
Isolation of electrical supply	2	AWE Services	
Isolation of water supply	2	AWE Services	
Removal of Lightning Protection System and internal electrical systems	4	Electrical Specialist	
Removal of earth over-mounding	4	Construction Specialist	2 x excavators
Scanning of foam slag arched roof	2	Survey Specialist	Ground penetrating radar
Demolition of foam slag arched roof	4	Construction Specialist	1 x bulldozer
Dismantling of reinforced concrete structure	4	Construction Specialist	1 x high pressure water jet

Removal of construction waste	2	Approved Waste Management Company	1 x small crane 1 x tipper
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Overall, 12 workers will require deployment into AWE's explosives area for a period of 1 month. AWE's direct labour workforce are able to isolate building services prior to any construction activities, 2 persons for the electrical supply and 2 persons for the water supply. A team of 4 construction specialists will be contracted to carry out all tasks associated with the dismantling of the building, one of which will be the site supervisor. A further 2 persons will be required from an approved waste management company to correctly dispose of construction waste, and a final 2 survey specialists to carry out GPR scans of the roof before removal.

A provisional work enclave has been established (see Figure 8), taking into account the spatial requirements for any plant, equipment, and temporary stored construction waste.

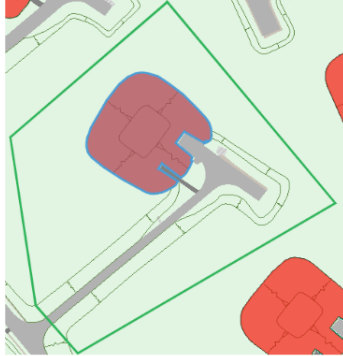


Figure 8, Provisional Work Enclave

Due to the total number of personnel and the estimated number of person-hours required for the task, an SDA is required to determine if the cumulative risk from surrounding Potential Explosion Sites (PES) is tolerable for the period of the works. The maximum number of personnel at the location at any one time can be reduced to 6 in accordance with the ERICPD hierarchy of controls.

Figure 9 outlines the formula used to calculate the scaled distance for a PES containing HD 1.1, taken from Chapter 18 of DSA 03.OME Part 2 [12]. This formula has been transferred into a calculation spreadsheet (see Figure 10) and adapted to factor in multiple affecting PES.

$$\text{Scaled Distance} = \frac{\text{Actual Distance}}{\text{NEQ}^{1/3}}$$

Figure 9, Scaled Distance Formula [12]

	1	2	3	4	5	6	7	8	9
	Building	Explosive Safe Order Limit (TON)	Distance from PES to Work Site	Scaled Distance	NXASW Explosive Month Average	Conversion Factor	Number of Personnel	Period (months)	Calculated NXASW Explosive Month
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
									Calculated NEM Total

Figure 10, Scaled Distance Calculation Spreadsheet for Multiple Affecting PES

The work enclave is affected by a total of 18 Class D Separation Distances from other explosives facilities in the area. The initial SDA calculated that the NEQ (Net Explosives Quantity) and the distance from each of these locations to the work site, in conjunction with the number of personnel and period of works, poses a level of risk that is not tolerable. In order to manage this risk, a number of building limits must be reduced, and operations restricted across all affecting locations.

Class D Separations Distances can be calculated specifically for different building types and explosives hazard types. By identifying the PES which have a greater effect on the work location, the explosives limits can be reduced to a point at which their Class D Separation Distance falls outside of the enclave and therefore no longer needs to be considered within the calculations.

To further control works within the explosives area, continuous communication between the project team, the WCC and any nearby operators must be maintained. The demolition works must come to a stop and contractors exit to a safe location if explosive are to be transited past the enclave, or if any explosives operations are required to take place.

The control measures are captured within a Deployment Strategy document, which includes actions on all project stakeholders to ensure full understanding and compliance. Table 4 describes which actions will be put in place for the duration of the demolition project.

Table 4, Table of Actions for Deployment Strategy

ID	Stakeholder	Action
1	XOS ⁴	Identified buildings must have their XSO explosives limits reduced for duration of the demolition project, and explosives relocated if necessary.
2	XOS	Inform WCC of any explosives moves which may transit past the work enclave or moves to/from any location in the immediate area.

⁴ XOS, Explosives Operations Support

3	WCC	To maintain communications with the project and inform them of any upcoming explosives moves or operations in the area, allowing sufficient time for contractors to exit to a safe location.
4	Project Manager	To brief all contractors on the associated hazards within the area of work, control measures required to mitigate the risks, accident and evacuation procedures, and contraband rules.

On the completion of the actions, the Deployment Strategy will be signed off by the originator and the Head of Explosives Safety allowing the demolition project to commence.

Chapter 5 Conclusions and Recommendations

5.1 Introduction

This chapter concludes the study by summarising the methods and limitations of each task, to ensure they conform to industry standards and comply with legal requirements. It will also provide recommendations for further work, based on any constraints found.

5.2 Summary and Conclusions

The aim of this project was to develop an understanding and process for the demolition of an explosives facility which has become damaged beyond repair. The building is potentially contaminated with explosives and is surrounded by several other explosives licenced locations, making the task difficult to carry out safely.

The first task to 3D scan and carry out a topographical mound survey of the building experienced some communication and staffing issues which caused a severe delay to the results being published. Building visits were carried out as an alternative until the scans were made available, which imposed time constraints on the analysis of the roof's cracking. Once received, the 3D scan of the building interior proved to be inadequate as a result of poor lighting. Although this task did not meet expectations, the decision to demolish the building was confirmed which allowed for accurate planning further down the line.

The building history file was developed based on a series of documents, ranging from the initial 1953 drawings to the most recent building condition survey from 2023. This study outlined the construction and the processes which have been carried out within the facility since it was commissioned 70 years ago. From this, it was determined that the likelihood of explosives contamination was low however, it could not be ruled out. The building must be sampled and cleaned as required in order to certify it as FFEH before any further works are permitted. The history file also highlighted that electric and water services still supply the building, which influenced the tasking carried out when planning the works for the Scaled Distance Assessment (SDA).

The hazard identification and operability studies highlighted explosives and project-related hazards which affect the work location, including scenarios associated with fire and explosion. Any risk of an external fire/explosion is controlled within the deployment strategy for the Non-Explosives-Area Support Workers (NXASW) operating within the explosives area by applying conditions and restrictions to surrounding facilities. To reduce and eliminate the risk of fire/explosion internal to the work enclave, strict controls on plant and equipment will be imposed, as well as FFEH certification.

An SDA was carried out to determine whether the cumulative risk posed by surrounding explosives locations was acceptable based on the number of NXASW and the length of time they are exposed. The outcome of the assessment determined that a number of nearby explosives facilities would require significant reductions in their holdings and operations. With an increase in major projects across AWE's explosives area, this will put a significant strain on the operability of the business.

This project successfully consolidated specific areas of legislation and guidance relating to explosives, to inform the process of safely demolishing legacy buildings within AWE's explosives area. This research and subsequent process is valuable to the business as the buildings are reaching an age where they are failing to meet current requirements for the manufacture, processing and storage of explosives. The rejuvenation of the explosives estate is essential to AWE, and the process for carrying out major structural works to legacy buildings will be factored into the forward planning for the next 10-15 years.

5.3 Recommendations for Further Research

Discussions with AWE's blast and structure SME determined that there were no viable options for replacing the cracked roof. The University of Sheffield is in the process of setting up a 'Centre of Excellence' with AWE, and it has been recommended that the replacement of foam slag arched roofs is investigated on behalf of the company. Many buildings in AWE's explosives area are constructed with these roofs, so this research will prove beneficial for the development of the estate by reducing the amount of required work for each location. It has been suggested that GRP (glass-reinforced plastic) is explored, as it is a strong and versatile material.

With regards to the 3D scanning, it is recommended that sufficient lighting is established prior to any imaging or scans in future, particularly for buildings which may have been out of use for an extended period as they may not have functioning interior electrics. Strict instructions should be provided if any specific areas require capturing. Also, this stage should only be considered for investigative purposes, and not for the straight demolition of a building. In this scenario, analysis of the building condition was required before a definitive outcome was produced. It may be considered for renovation works to allow for digital re-design of the structure, or to be kept as historical data before the building is altered or removed.

Due to issues faced within the SDA, it is suggested that a reduction in overall holdings on site is investigated, be that disposal of unnecessary stock or moving it to an off-site storage location. This would alleviate the dangers from AWE's explosives facilities for any upcoming projects associated with the uplift of the explosives estate.

Chapter 6 Reflections

6.1 Introduction

This chapter reflects on how well the project met the design requirements set out in Chapter 3, including any lessons learnt and how the project could be improved. The project started out with some issues, however the remainder of the tasks were completed with satisfaction.

6.2 Reflections

6.2.1 3D Scanning and Topographical Survey

The initial communications with the GIS team were prompt and clear between both parties, with the quote being returned and accepted within two weeks of the request. The results took 6 months to be returned due to poor communication between the GIS team and the explosives area WCC, which imposed significant time restraints on the project.

The results were also passed on to a separate team to carry out the soil depth analysis, which had not been returned at the time of this report. Investigation into this issue determined that a lack of staff and resources had caused the delays to this task.

Consequently, the analysis of the building's compliance with structural and explosives regulations, and determination of its future was based on several visits to the location. Fortunately, this proved to be the better option as the 3D scans were not able to demonstrate the full extent of the cracks because of poor lighting; the building's lighting system has been disconnected from the distribution board, and the team did not supply sufficient lighting for the 360-degree camera to effectively capture the cracks in the roof. A digital camera was taken down to the facility, however the surfaces are decorated with a glossy paint and the reflection of the flash also made it difficult to capture the cracks.

To improve this step, a catalogue of closed buildings and other locations with future interest should be collated, excluding any which are guaranteed for demolition, and a request for scans put in. Special instructions should be included to capture known defects and ensure suitable lighting is provided.

6.2.2 History File

The history file was successful in determining the building design, structure, and active utility services to support the identification of construction tasks further on in the project. Relevant documentation detailing the building fabric was readily available however, this would not be the case had the relevant training and access to AWE's facility database not been established prior to the project.

Information regarding the building's assets, past maintenance tasks and events was also easily obtained, again due to having the correct access and training for the separate record systems. Determining the explosives operations that had taken place in the facility since its commissioning was more challenging, however its design and Explosives Site Licence Building Schedule (ESLBS) provided a useful insight which was confirmed by a member of staff who has worked at AWE for a number of years.

6.2.3 Hazard Identification and Operability Studies

The hazard identification and operability studies identified some of the prominent dangers associated with the demolition works, mostly focused on explosives-related hazards. Methods of mitigating the risk from each hazard were determined with the aid of The Explosives Regulations 2014 Safety Provisions (L150) [20] and Security Provisions (L151) [14].

This task was carried out in consultation with one of AWE's Principal Safety Assessment Specialists which provided an insight into hazard management for large-scale projects. To improve this step, a full-scale Hazard Operability activity should be arranged with various stakeholders from different disciplines. This would ensure there are no gaps in the study and that the appropriate controls are in place to 'prevent', 'limit' and 'protect' in accordance with ER 2014 Regulation 26 [3].

6.2.4 Scaled Distance Assessment and Deployment Strategy

Based on the details uncovered in the history file research, the relevant construction activities were outlined including the number of personnel and any specialist equipment they each require. Subsequently, an appropriate work enclave was created to allow room for these activities to operate effectively.

An excessive number of explosives facilities were found to have a Class D Separation Distance affecting the work enclave, with the closest being only 6m away. As a result, the outcome of the Scaled Distance Assessment (SDA) determined that the cumulative risk was not acceptable and that restrictions must be put in place to better protect the non-explosives workers.

The top five locations which presented the highest risk were further analysed in hopes of reducing their separation distance to a point where it no longer affected the work location. Formulae provided by the HSE allowed for the calculation of specific Class D Separation Distances for different constructions and explosives hazard types, permitting the locations to operate outside of the ER 2014 standard separation distance tables. By amending the Scaled Distance calculations, the SDA determined that the new outcome was tolerable given that the proposed explosives limit changes can be agreed with building managers.

A number of actions were drafted for the stakeholders of the project to ensure that all requirements are met, and sufficient controls are in place prior to any works going ahead.

6.3 Summary

Overall, the project successfully met most of the requirements set out in Chapter 3 with the exception of a minority. The unforeseen circumstances encountered during the 3D scanning and topographical survey activities proved to be a setback with regards to the project timeline as the building future could not be decided without appropriate analysis of the cracking. Aside from this, the remainder of the tasks were completed smoothly and in compliance with the regulations and guidance discussed in Chapter 2.

The hazard operability study would have benefited from additional time and resource allocation however, this can be improved in future works.

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Characterisation and Preparation for the Demolition of an Explosives Facility Major Project Report

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