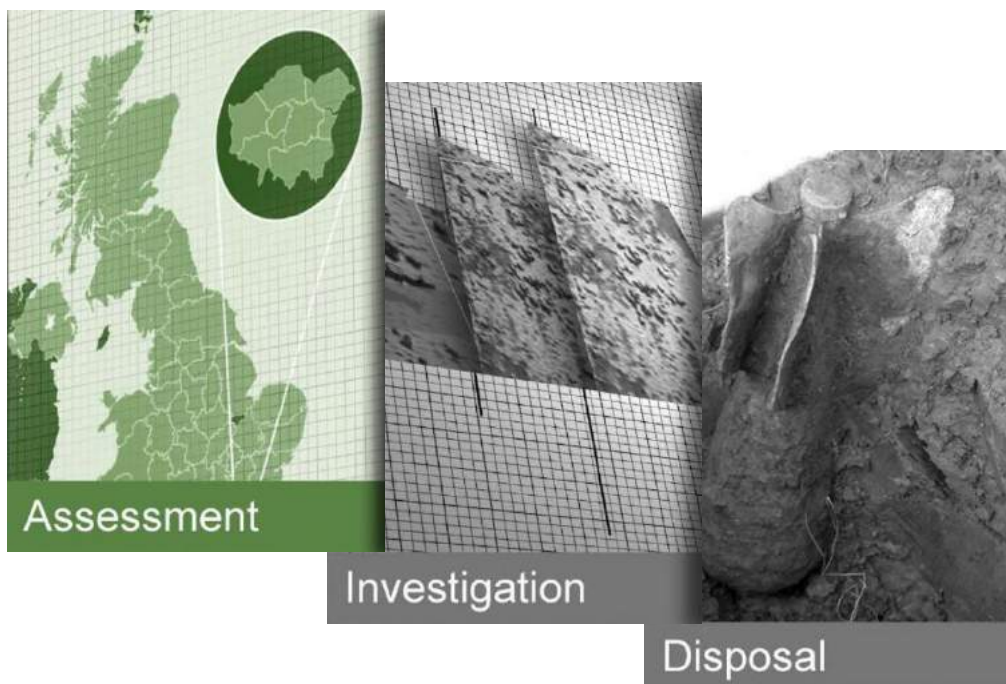




## Swansea Tidal Lagoon - UXO Desk Study & Risk Assessment

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Checked by Stefan Lang  
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**Document Title** UXO Desk Study & Risk Assessment  
**Document Ref.** P6436-16-R1  
**Revision** A  
**Project Location** Swansea Tidal Lagoon, Wales  
**Client** WYG  
**Date** 4<sup>th</sup> November 2016

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## UXO DESK STUDY & RISK ASSESSMENT

### Swansea Tidal Lagoon, Wales

#### EXECUTIVE SUMMARY

Zetica Ltd was commissioned by WYG to carry out an Unexploded Ordnance (UXO) Desk Study and Risk Assessment for an area approximately 8 kilometres (km) in length between Swansea and Baglan Bay ('the Site').

The aim of this report is to gain a fair and representative view of the UXO hazard for the Site and its immediate surrounding area in accordance with the Construction Industry Research and Information Association (CIRIA) C681 'Unexploded Ordnance (UXO), a Guide for the Construction Industry' and C754 'Assessment and Management of Unexploded Ordnance (UXO) Risk in the Marine Environment'.

#### Western part of the Site

During World War Two (WWII), 3No. heavy raids were recorded in the vicinity of the western part of the Site at Swansea Docks, with at least 11No. High Explosive (HE) bombs falling in the immediate vicinity. Given that this Site part of the Site comprised important dock infrastructure and hardstanding, it is considered unlikely that an Unexploded Bomb (UXB) impact would have been missed.

No other significant sources of UXO hazard have been identified on this part of the Site, which is assigned a low UXO hazard level.

#### Central part of the Site

Records indicate that at least 30No. HE bombs fell in the immediate vicinity of the central part of the Site during heavy raids in WWII.

Given the high localised bombing density, and that this part of the Site mostly comprised sand dunes, it is considered that a UXB may have fallen unnoticed and remained in situ.

It is considered prudent to assign this part of the Site a moderate UXO hazard level.

#### Eastern part of the Site

No records have been found indicating that the eastern part of the Site was bombed, which was in an area with a low localised bombing density during WWII.

No other significant sources of UXO hazard have been identified on this part of the Site, which is assigned a low UXO hazard level.

#### Offshore UXO Hazard

No significant sources of marine UXO hazard have been identified in the immediate vicinity of the Site, although offshore firing ranges were located along the South Wales coast during WWII.

Given the tidal streams, wave action and pattern of sediment movement in the vicinity of the Site, it is considered that the largest items of UXO in the marine environment could not be transported. It is considered that small items of UXO and small arms ammunition could roll as bed load particles during high wave energy storm conditions. Such conditions may provide a pathway for UXO migration onto the Site, which provides part of the background risk to any similar site in the United Kingdom.

It is therefore considered that the UXO hazard level on the Site can be zoned from low to moderate, as shown in the following Figures, reproduced as Figures 14, 15 and 16 in the main report.

**Figure** UXO hazard zone plan of the Site (western part of the Site)



Source: Bing Maps

Not to Scale

|               |          |                                                                                     |           |                                                                                     |               |                                                                                       |
|---------------|----------|-------------------------------------------------------------------------------------|-----------|-------------------------------------------------------------------------------------|---------------|---------------------------------------------------------------------------------------|
| <b>Legend</b> | Very Low |  | Low       |  | Moderate      |  |
|               | High     |  | Very High |  | Site boundary |  |

**Figure** UXO hazard zone plan of the Site (central part of the Site)

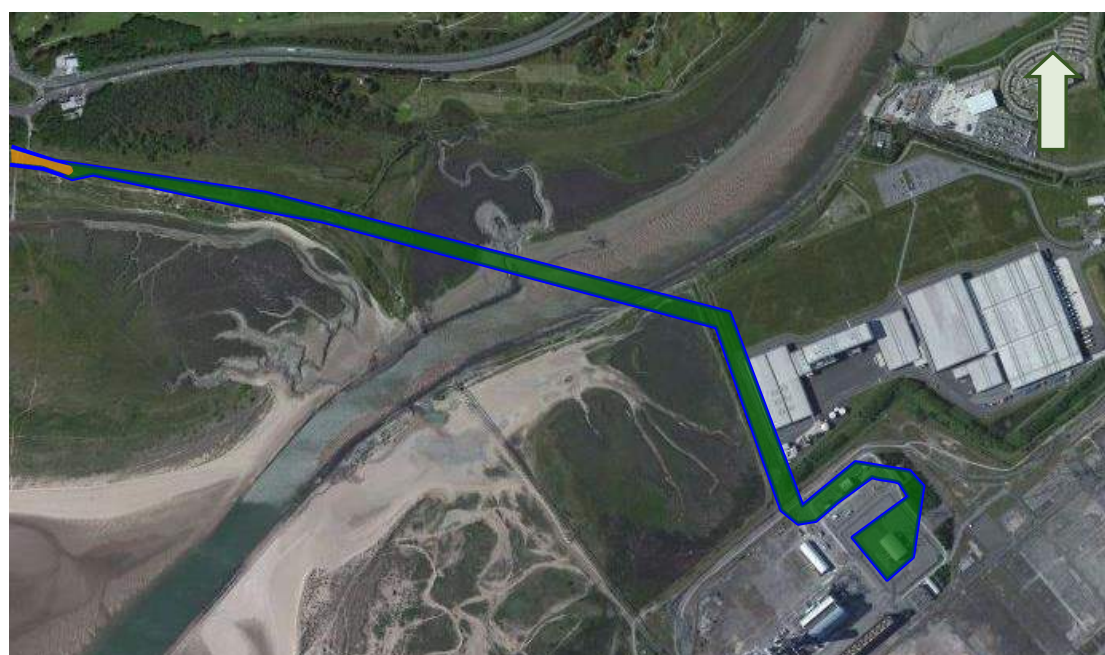


Source: Bing Maps

Not to Scale

|               |          |                                                                                     |           |                                                                                     |               |                                                                                       |
|---------------|----------|-------------------------------------------------------------------------------------|-----------|-------------------------------------------------------------------------------------|---------------|---------------------------------------------------------------------------------------|
| <b>Legend</b> | Very Low |  | Low       |  | Moderate      |  |
|               | High     |  | Very High |  | Site boundary |  |

**Figure** UXO hazard zone plan of the Site (eastern part of the Site)



|               |          |                                                                                     |           |                                                                                     |               |                                                                                       |
|---------------|----------|-------------------------------------------------------------------------------------|-----------|-------------------------------------------------------------------------------------|---------------|---------------------------------------------------------------------------------------|
| <b>Legend</b> | Very Low |  | Low       |  | Moderate      |  |
|               | High     |  | Very High |  | Site boundary |  |

The extents of the UXO hazard level zoning on the Site are summarised in the following Table, reproduced as Table 4 in the main report.

|                          |                                          |                     |                   |
|--------------------------|------------------------------------------|---------------------|-------------------|
| <b>Table</b>             | UXO hazard assessment for the Site       |                     |                   |
| <b>Hazard Assessment</b> | <b>Potential Hazard</b>                  | <b>OSNGR (from)</b> | <b>OSNGR (to)</b> |
| <b>Low</b>               | No significant sources of UXO identified | SS 66909200         | SS 69399297       |
| <b>Moderate</b>          | UXB from WWII bombing                    | SS 69399297         | SS 71719323       |
| <b>Low</b>               | No significant sources of UXO identified | SS 71719323         | SS 73309250       |

The main findings of the report are summarised below.

- No records of bombing or military activity on the Site during World War One (WWI) have been found.
- During WWII, the main strategic targets in the vicinity of the Site included the Swansea Docks and associated infrastructure, concentrations of heavy industry, military camps and the National Oil Refinery at Llandarcy.
- Records have been found indicating that at least 40 No. HE bombs fell in the immediate vicinity of the Site during WWII. The bombing was concentrated on the central part of the Site.
- Anti-invasion defences and minefields were established on and in close proximity to the Site during WWII have subsequently been removed.

The Table below, reproduced as Table 5 in the main report, provides a UXO risk assessment for potential work on the Site.

Further details on the methodology for the risk assessment are provided in Section 14.1 of the main report.

| Table                                                                                                                                                                                                                                                                                   |                      | UXO risk assessment for the Site |    |    |             |            |          |             |          |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|----------------------------------|----|----|-------------|------------|----------|-------------|----------|
| Hazard Zone                                                                                                                                                                                                                                                                             | Potential UXO Hazard | Anticipated Works                | PE | PD | P = PE x PD | Likelihood | Severity | Risk Rating | UXO Risk |
| Mod                                                                                                                                                                                                                                                                                     | UXB                  | Shallow Excavations              | 3  | 2  | 6           | 3          | 5        | 15          | Moderate |
|                                                                                                                                                                                                                                                                                         |                      | Deep Excavations                 | 4  | 3  | 12          | 3          | 5        | 15          | Moderate |
|                                                                                                                                                                                                                                                                                         |                      | Piling/boreholes                 | 2  | 4  | 8           | 3          | 4        | 12          | Moderate |
|                                                                                                                                                                                                                                                                                         | Other UXO            | Shallow Excavations              | 1  | 1  | 1           | 1          | 4        | 4           | Low      |
|                                                                                                                                                                                                                                                                                         |                      | Deep Excavations                 | 1  | 1  | 1           | 1          | 4        | 4           | Low      |
|                                                                                                                                                                                                                                                                                         |                      | Piling/boreholes                 | 1  | 1  | 1           | 1          | 3        | 3           | Low      |
| Low                                                                                                                                                                                                                                                                                     | UXB                  | Shallow Excavations              | 1  | 1  | 1           | 1          | 5        | 5           | Low      |
|                                                                                                                                                                                                                                                                                         |                      | Deep Excavations                 | 1  | 1  | 1           | 1          | 5        | 5           | Low      |
|                                                                                                                                                                                                                                                                                         |                      | Piling/boreholes                 | 1  | 1  | 1           | 1          | 4        | 4           | Low      |
|                                                                                                                                                                                                                                                                                         | Other UXO            | Shallow Excavations              | 1  | 1  | 1           | 1          | 4        | 4           | Low      |
|                                                                                                                                                                                                                                                                                         |                      | Deep Excavations                 | 1  | 1  | 1           | 1          | 4        | 4           | Low      |
|                                                                                                                                                                                                                                                                                         |                      | Piling/boreholes                 | 1  | 1  | 1           | 1          | 3        | 3           | Low      |
| PE (Probability of Encounter), PD (Probability of Detonation), P (Overall Probability)                                                                                                                                                                                                  |                      |                                  |    |    |             |            |          |             |          |
| Shallow excavations defined as <1.0m below ground level (bgl).                                                                                                                                                                                                                          |                      |                                  |    |    |             |            |          |             |          |
| Risk Mitigation Recommendations                                                                                                                                                                                                                                                         |                      |                                  |    |    |             |            |          |             |          |
| To ensure that the UXO risk is reduced to As Low As Reasonably Practicable (ALARP) the following mitigation is advised:                                                                                                                                                                 |                      |                                  |    |    |             |            |          |             |          |
| Low Risk                                                                                                                                                                                                                                                                                |                      |                                  |    |    |             |            |          |             |          |
| Excavations                                                                                                                                                                                                                                                                             |                      |                                  |    |    |             |            |          |             |          |
| To ensure that the UXO risk is reduced to As Low As Reasonably Practicable (ALARP) the following mitigation is advised:                                                                                                                                                                 |                      |                                  |    |    |             |            |          |             |          |
| UXO Awareness Induction                                                                                                                                                                                                                                                                 |                      |                                  |    |    |             |            |          |             |          |
| All staff should have an awareness of the UXO hazard through the site induction process. It is important to ensure that any persons undertaking intrusive works, such as excavation, are made aware of the potential of uncovering UXO and what to do if a suspect item is encountered. |                      |                                  |    |    |             |            |          |             |          |
| This awareness is to be provided through formal UXO awareness inductions. Typically ~1hour in duration, these briefings will be expected to provide site workers with:-                                                                                                                 |                      |                                  |    |    |             |            |          |             |          |
| • Background to the potential UXO hazards that could be encountered.                                                                                                                                                                                                                    |                      |                                  |    |    |             |            |          |             |          |
| • Awareness of how the UXO hazard could present a risk.                                                                                                                                                                                                                                 |                      |                                  |    |    |             |            |          |             |          |
| • Knowledge of what to do in the event that a suspect item is encountered.                                                                                                                                                                                                              |                      |                                  |    |    |             |            |          |             |          |

The UXO awareness induction is to be provided along with back-up materials such as UXO awareness posters, emergency contacts numbers and other background information to assist site workers in becoming familiar with what potential UXO can look like. The materials can also be used by key staff to cascade out the salient points of the induction to others who visit or work on the Site.

By providing the UXO awareness induction, it ensures that in the unlikely event that UXO is encountered:

- All site staff take appropriate action.
- The likelihood of harm to persons or property is reduced.
- Delays in works can be minimised.

It is the responsibility of the contractor to ensure that all staff have received an appropriate UXO awareness induction. A combination of identification badges and helmet stickers can be used to provide confirmation that staff onsite have undergone such an induction.

#### **Boreholes/Piling**

Clearance certification for borehole or pile locations is considered prudent only if a zero tolerance to risk is adopted. Zero tolerance is commonly adopted for sites that have safety critical infrastructure such as nuclear establishments and oil refineries.

### **Moderate Risk**

#### **Excavations**

For those involved in excavations, the raising of awareness (as per low risk) is considered essential.

Non-intrusive UXO detection methods and intrusive investigation of identified targets is recommended where practical.

Where UXO detection is not feasible due to ground conditions, restricted access or programme, an Explosive Ordnance Clearance (EOC) Engineer can be used to supervise during excavation works.

The EOC Engineer will carry out a visual assessment on any suspect items uncovered and classify them as potential UXO or other material.

#### **Boreholes/Piling**

Clearance certification for any borehole or pile locations is considered essential. This can be achieved by advancing a magnetometer into the ground at the borehole or pile location in order to provide detection of ferrous metal targets such as UXB.

Assuming no objects comparable to the UXB detection range are identified, then the borehole or pile position can be considered clear of UXB.

Table 6 in the main report gives recommended actions in relation to the potential UXO risk level and the anticipated Site activity.

Further advice on the mitigation methods can be provided by Zetica on request.

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## UXO DESK STUDY & RISK ASSESSMENT

### Swansea Tidal Lagoon, Wales

**Note:** To aid the reader of this report, Zetica has colour coded each paragraph. Paragraphs with black text on a white background are paragraphs that provide site-specific information or information specifically researched as part of this project.

Paragraphs in a dark green text with a green background are paragraphs containing background information or explanations which may appear as standard text in all similar reports.

## 1 INTRODUCTION

### 1.1 Project Outline

Zetica Ltd was commissioned by WYG to carry out an Unexploded Ordnance (UXO) Desk Study and Risk Assessment for an area approximately 8 kilometres (km) in length between Swansea and Baglan Bay ('the Site').

The aim of this report is to gain a fair and representative view of the UXO hazard for the Site and its immediate surrounding area in accordance with the Construction Industry Research and Information Association (CIRIA) C681 'Unexploded Ordnance (UXO), a Guide for the Construction Industry' and C754 'Assessment and Management of Unexploded Ordnance (UXO) Risk in the Marine Environment'.

This hazard assessment includes:

- Likelihood of ordnance being present.
- Type of ordnance (size, filling, fuze mechanisms).
- Quantity of ordnance.
- Potential for live ordnance (UXO)Swine2016!.
- Probable location.
- Ordnance condition.

It is essential to note that the effects of military activity will often extend beyond the source of the activity. For example, a base for armed forces may use surrounding areas of open land outside the official or recorded military boundaries for practice and military related activities.

In addition, World War One (WWI) and World War Two (WWII) aerial bombardment was not discrete. 'Pinpoint' targeting did not exist in WWI or WWII. The effects of bombardment would be apparent in areas around the intended target.

It is for these reasons that it is important to address military activity both on the Site and in the relevant surrounding areas.

It should be noted that some military activity providing a source of UXO hazard may not be readily identifiable and therefore there cannot be any guarantee that all UXO hazards on the Site have been identified in this report.

## 1.2 The Site

The Site runs from Queen's Dock at Ordnance Survey National Grid Reference (OSNGR) SS 669920 to the Baglan Bay CCGT Power Plant (SS 733925). It is located on Swansea Bay, approximately 2.2km east of Swansea city centre and 4.2km northwest of Port Talbot town centre.

The Site has been divided into 3No. sections.

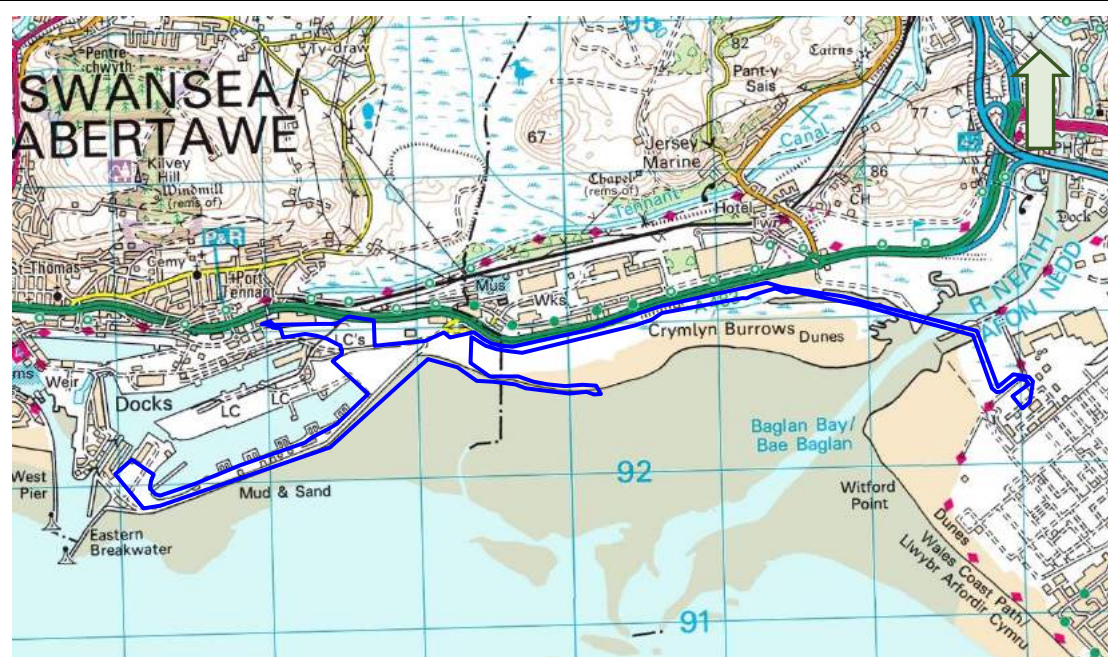
The western part of the Site (SS 669920 to SS 690928) comprises an area of dockland, consisting of existing seawall and vacant ground. The central part of the Site (SS 690928 to SS 718932) mostly comprises undeveloped sand dunes and an area of beach. The eastern part of the Site (SS 718932 to SS 733925) comprises the River Neath, mudflats and part of a power plant.

The Site is bounded throughout most of its course by Swansea bay to the south and by Fabian Way (A483) to the north, in addition to areas of hardstanding and dockland.

It is understood that planned works on the Site may include intrusive ground investigations, excavations and piling associated with the Swansea Tidal Lagoon project.

Figure 1 is a Site location map and Plate 1 is a recent aerial photograph of the Site.

**Figure 1** Site location map



Source: © Crown Copyright 2016. Reproduced by permission of Ordnance Survey

Not to Scale

### Legend

Site boundary



**Plate 1**

Recent aerial photograph of the Site



Source: Google Earth

Not to Scale

**Legend**

Site boundary



## 2 SOURCES OF INFORMATION

### 2.1 Historical Information

With most locations, the potential presence of UXO as a result of enemy action, unauthorised disposal or unrecorded military activity can never be totally discounted.

Detailed records of military activity are rarely released into the public domain. Even when military information is made public there may be gaps in the records because files have been lost or destroyed.

Records for periods such as WWII are only as detailed and accurate as the resources and working conditions would allow at the time. Densely populated areas tend to have a greater number of records than rural areas. Such records may be inaccurate due to the confusion surrounding continuous air raids.

Press records can supplement local information, although this source of information must be treated with caution, as inaccuracies do exist, either inadvertently or intentionally in order to confuse enemy intelligence. Classified official records can sometimes be considered inaccurate for the same reason.

Recent research indicates that England alone had 17,434No. recorded defence sites, of which 12,464No. were classified as defensive anti-invasion sites. The precise locations of many of these sites are still to be identified, illustrating the scale of the problem when establishing potential risks from limited historical data.

Zetica Ltd researched the military history of the Site and its surrounding area utilising a range of information sources. The main sources of information are detailed in the following sections and referenced at the end of this report.

### 2.2 Zetica Ltd Defence Related Site Records

Zetica Ltd's in-house records were consulted, including reference books and archived materials from past work in the region. Relevant documents have been cited within the bibliography of this report.

### 2.3 Zetica Ltd Bombing Density Records and Maps

Reference has been made to the Zetica Ltd bomb risk maps located on ZeticaUXO's website (<http://zeticauxo.com/guidance/uxb-risk-maps/>).

### 2.4 Ministry of Defence and Government Records

Various government departments and units within the Ministry of Defence (MoD) were approached for information of past and present military activity in the area. These included the Home Office records of abandoned bombs.

### 2.5 Other Historical Records, Maps and Drawings

Numerous reference documents including historical maps, aerial photographs and drawings have been consulted from sources such as the National Archives, Royal Commission of the Ancient and Historic Monuments of Wales (RCAHMW), the Central Register of Aerial Photographs for Wales and the Defence of Britain Project.

The British Geological Survey (BGS) was consulted for borehole information.

## 2.6 Local Authority Records

Information has been obtained from the City & County of Swansea Council and Neath Port Talbot County Council.

## 2.7 Local Record Offices and Libraries

West Glamorgan Archives and Swansea Central Library were consulted for information.

## 2.8 Local Historical and Other Groups

Local history groups and archaeological bodies were consulted.

## 2.9 Data Confidence Level

In general, there is a high level of confidence in the researched information sources used for this report. Any exceptions to this are specifically detailed in the text of this report.

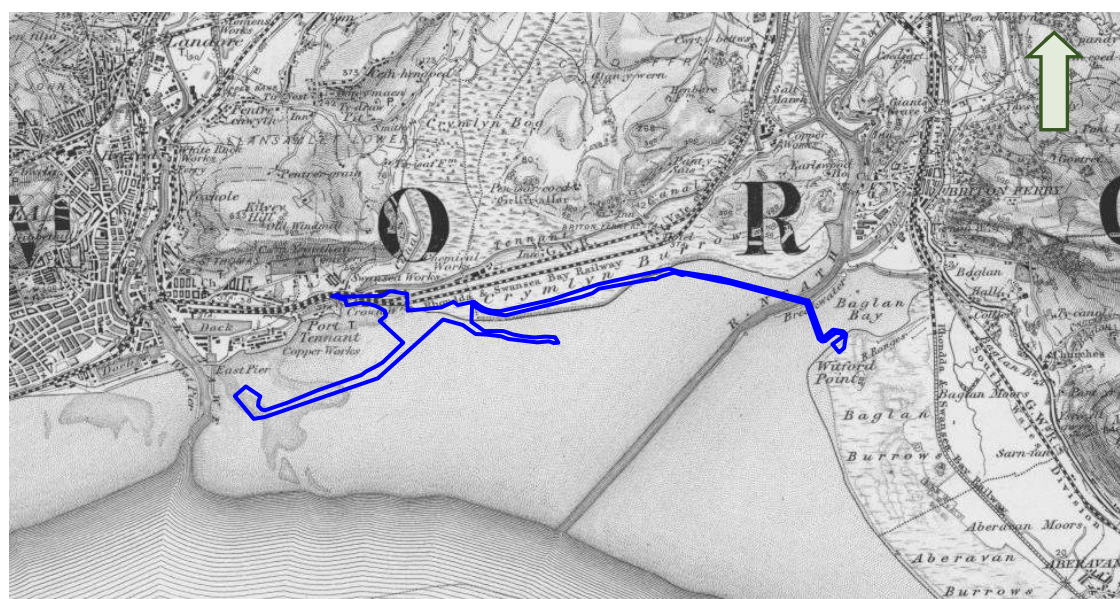
### 3 SITE HISTORY

#### 3.1 General History

The historical map of 1897 (Figure 2) shows that at the end of the 19<sup>th</sup> century the Site mainly comprised mudflats and open sea in Swansea Bay. The north-western part of the Site encroached upon industrial works and the Great Western Railway (GWR) Swansea & Neath mainline.

Swansea Docks were located approximately 0.8km north of the western end of the Site.

**Figure 2** Historical map, 1897



Source: © Crown Copyright 2016. Reproduced by permission of Ordnance Survey

Not to Scale

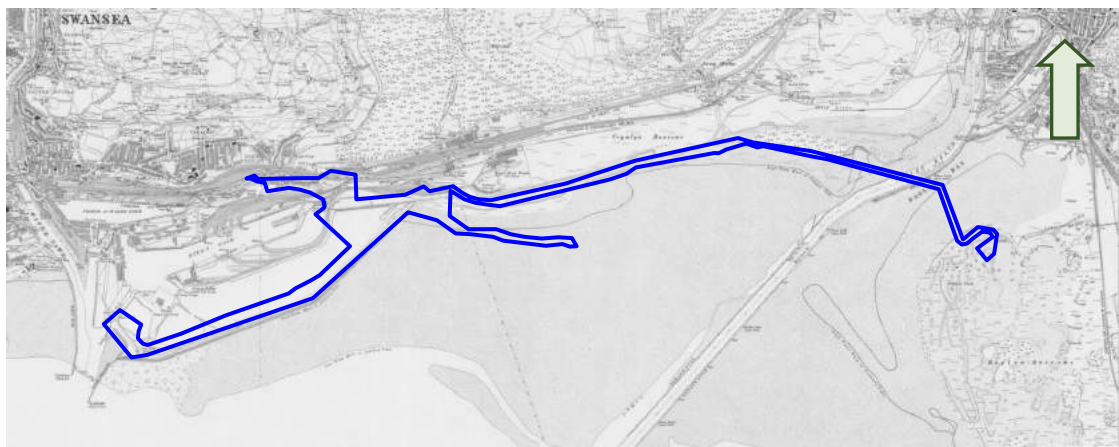
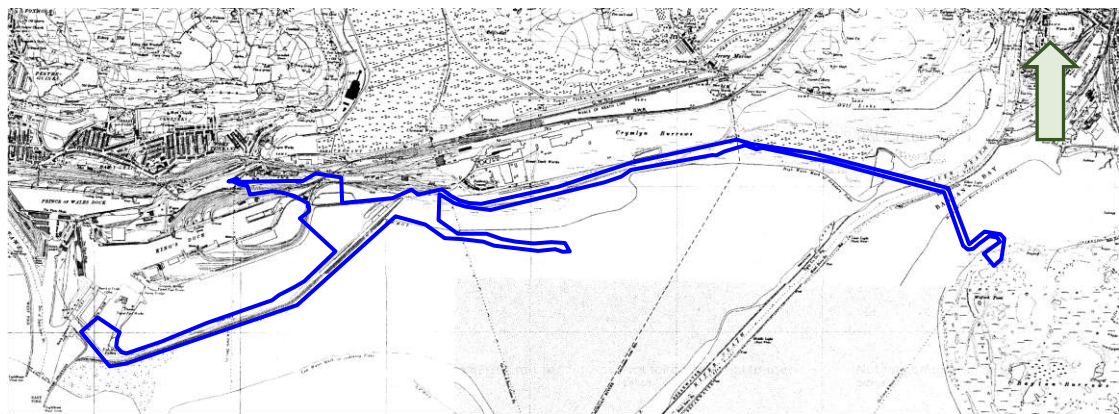
#### Legend

Site boundary —

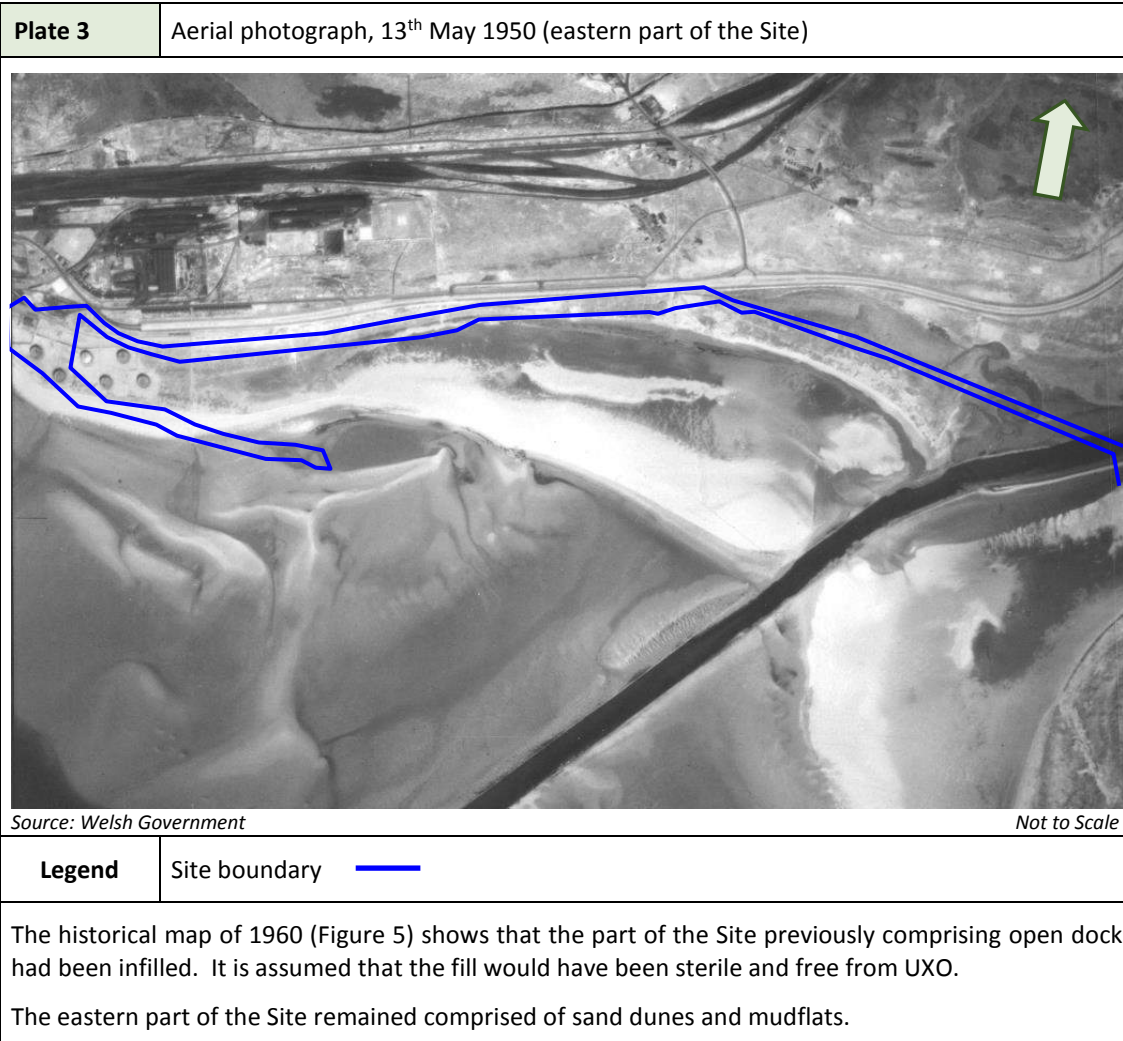
In the early 20<sup>th</sup> century the Swansea Docks were expanded, which included the establishment of a seawall on the western end of the Site to form Queen's Dock. This is shown on the historical map of 1921 (Figure 3).

Transport infrastructure on the north-western part of the Site was also expanded to service the docks, which included the construction of additional sidings and goods yards.

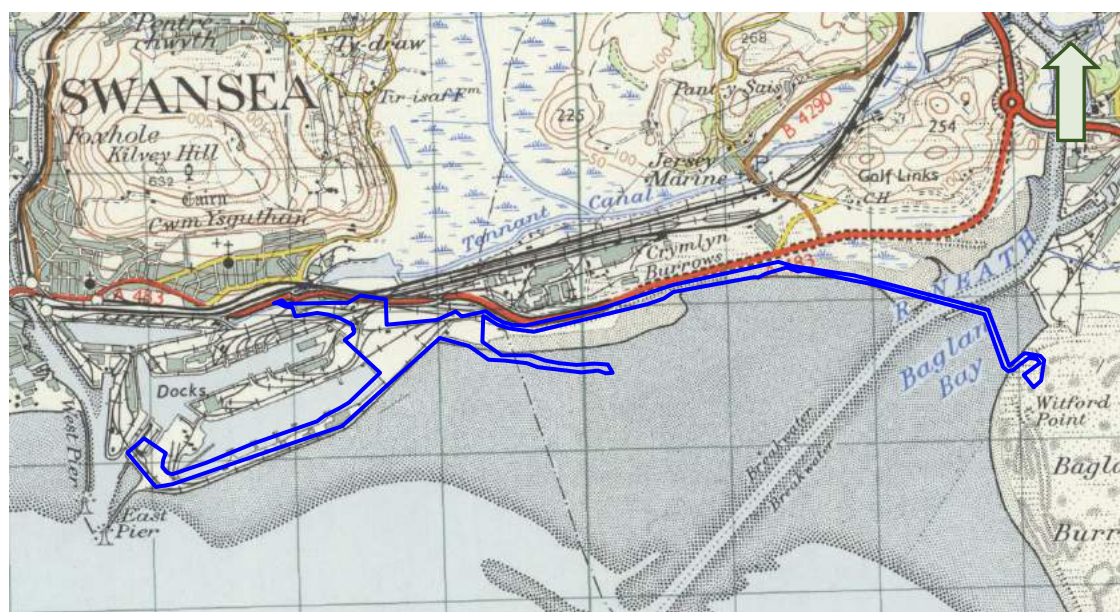
The majority of the Site remained open mudflats.

|                                                                                                                                                                                                                                                                                                             |                      |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|
| <b>Figure 3</b>                                                                                                                                                                                                                                                                                             | Historical map, 1921 |
|  <p>Source: © Crown Copyright 2016. Reproduced by permission of Ordnance Survey</p> <p>Not to Scale</p>                                                                                                                   |                      |
| <b>Legend</b>                                                                                                                                                                                                                                                                                               | Site boundary —      |
| <p>The historical map of 1938 (Figure 4) shows that the Site remained largely unchanged prior to WWII. An engineering works had been constructed adjacent to the northern boundary of the central part of the Site.</p>                                                                                     |                      |
| <b>Figure 4</b>                                                                                                                                                                                                                                                                                             | Historical map, 1938 |
|  <p>Source: © Crown Copyright 2016. Reproduced by permission of Ordnance Survey</p> <p>Not to Scale</p>                                                                                                                 |                      |
| <b>Legend</b>                                                                                                                                                                                                                                                                                               | Site boundary —      |
| <p>Plate 2, an aerial photograph dated the 13<sup>th</sup> May 1950, shows that the dock and railway infrastructure on the western part of the Site remained largely unchanged after WWII.</p> <p>Oil storage drums, previously omitted from OS mapping for security purposes, can be seen on the Site.</p> |                      |

|                                                                                                                                                                                                                                                                            |                                                                         |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| <b>Plate 2</b>                                                                                                                                                                                                                                                             | Aerial photograph, 13 <sup>th</sup> May 1950 (western part of the Site) |
|                                                                                                                                                                                         |                                                                         |
| <p>Source: Welsh Government</p> <p>Not to Scale</p>                                                                                                                                                                                                                        |                                                                         |
| <b>Legend</b>                                                                                                                                                                                                                                                              | Site boundary —                                                         |
| <p>In the late 1940s Fabian Way (A483) was constructed adjacent to the northern boundary of the eastern part of the Site, as is shown in Plate 3, an aerial photograph dated the 13<sup>th</sup> May 1950.</p> <p>No significant development had occurred on the Site.</p> |                                                                         |



**Figure 5** Historical map, 1960



Source: © Crown Copyright 2016. Reproduced by permission of Ordnance Survey

Not to scale

**Legend** Site boundary —

During the late 20<sup>th</sup> century, land reclamation occurred in the vicinity of the eastern half of the Site. The Baglan Bay CCGT Power Plant was established on reclaimed land on the eastern end of the Site.

Additionally, much of the railway and dock infrastructure on the western part of the Site was removed, as is shown in Plate 4, an aerial photograph dating from 2002.

|                                                                                                                                                                                                                                                                                                                                                                                                                 |                         |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| <b>Plate 4</b>                                                                                                                                                                                                                                                                                                                                                                                                  | Aerial photograph, 2002 |
|                                                                                                                                                                                                                                                                                                                              |                         |
| <p>Source: Google Earth <span style="float: right;">Not to scale</span></p>                                                                                                                                                                                                                                                                                                                                     |                         |
| <b>Legend</b>                                                                                                                                                                                                                                                                                                                                                                                                   | Site boundary —         |
| <p>There has been no significant development on the Site since 2002. The Swansea University Bay Campus has been established adjacent to the central part of the Site (see Plate 1).</p>                                                                                                                                                                                                                         |                         |
| <h3>3.2 Pre-WWI Military Activity</h3>                                                                                                                                                                                                                                                                                                                                                                          |                         |
| <p>No records of any significant pre-WWI military activity on the Site have been found.</p> <p>Records have been found indicating that during the 19<sup>th</sup> century several rifle ranges were established in Baglan Bay, within approximately 1km of the eastern end of the Site (see Section 8.1).</p> <p>Pre-WWI military activity is not considered to provide a source of UXO hazard to the Site.</p> |                         |
| <h3>3.3 WWI Military Activity</h3>                                                                                                                                                                                                                                                                                                                                                                              |                         |
| <p>During WWI, Swansea Docks, encompassing the western end of the Site, were used to process military supplies, primarily comprised of coal and munitions.</p>                                                                                                                                                                                                                                                  |                         |
| <p>During WWI an estimated 9,000 No. German bombs were dropped over Britain. It was the first time that strategic aerial bombing had been used.</p>                                                                                                                                                                                                                                                             |                         |
| <p>Given the range limitations of aircraft and airships during WWI there were no recorded air raids on Wales. No records have been found indicating that AA guns were positioned in the region.</p>                                                                                                                                                                                                             |                         |
| <p>In response to the air raids, Anti-Aircraft (AA) guns were established. These were potential sources of Unexploded AA (UXAA) shells which could land up to 13km from the firing point, although more typically fell within 10km during WWI.</p>                                                                                                                                                              |                         |

No records have been found indicating that there were any static AA guns within 10km of the Site.  
WWI military activity is not considered to provide a source of UXO hazard to the Site.

### 3.4 WWII Military Activity

Swansea and its surrounding area were of significant industrial and military importance and recorded several heavy bombing raids. Details of air raid incidents in the vicinity of the Site are provided in Section 4 and Appendix 1.

Defensive and offensive military establishments were built during WWII. These included lines of defences (Stop Lines), pillboxes, AA guns, bombing decoys and minefields. Details for those nearest to the Site are provided in Section 5.

Other military establishments in the vicinity of the Site, including military camps and ranges, are described in Sections 6 to 10.

### 3.5 Post-WWII Military Activity

No records of any significant post-WWII military activity on or in close proximity to the Site have been found.

Records have been found indicating that ordnance demilitarisation (Demil) occurred in the vicinity of the eastern end of the Site. This is described in further detail in Section 9.3.

## 4 WWII BOMBING

Bombing raids began in the summer of 1940 and continued until the end of WWII. Bombing densities generally increased towards major cities or strategic targets such as docks, industrial premises, power stations and airfields.

The German bombing campaign saw the extensive use of both High Explosive (HE) bombs and Incendiary Bombs (IBs). The most common HE bombs were the 50kg and 250kg bombs, although 500kg were also used to a lesser extent. More rarely 1,000kg, 1,400kg and 1,800kg bombs were dropped.

The HE bombs tended to contain about half of their weight in explosives and were fitted with one or sometimes two fuzes. Not all HE bombs were intended to explode on impact. Some contained timing mechanisms where detonation could occur more than 70 hours after impact.

Incendiary devices ranged from small 1kg thermite filled, magnesium bodied bombs to a 250kg 'Oil Bomb' (OB) and a 500kg 'C300' IB. In some cases the IBs were fitted with a bursting charge. This exploded after the bomb had been alight for a few minutes causing burning debris to be scattered over a greater area. The C300 bombs were similar in appearance to 500kg HE bombs, although their design was sufficiently different to warrant a specially trained unit of the Royal Engineers to deal with their disposal.

Anti-Personnel (AP) bombs and Parachute Mines (PMs) were also deployed. 2No. types of anti-personnel bombs were in common use, the 2kg and the 12kg bomb. The 2kg bomb could inflict injury across an area up to 150m away from the impact, within 25m of this, death or fatal injury could occur.

PMs (which were up to 4m in length) could be detonated either magnetically or by noise/vibration. Anti-shipping parachute mines were commonly dropped over navigable rivers, dockland areas and coastlines. The Royal Navy was responsible for ensuring that the bombs were made safe. Removal and disposal was still the responsibility of the Bomb Disposal Unit of the Royal Engineers.

WWII bomb targeting was inaccurate, especially in the first year of the war. A typical bomb load of 50kg HE bombs mixed with IBs which was aimed at a specific location might not just miss the intended target but fall some considerable distance away.

It is understood that the local Civil Defence authorities in urban areas had a comprehensive system for reporting bomb incidents and dealing with any UXO. In more rural areas, fewer bombing raids occurred. It is known that Air Raid Precaution (ARP) records under-represent the number and frequency of bombs falling in rural and coastal areas.

Bombs were either released over targets or as part of 'tip and run' raids where bomber crews would drop their bombs to avoid Anti-Aircraft fire or Allied fighter aircraft on the route to and from other strategic targets. Bombs dropped as a result of poor targeting or 'tip and run' raids on rural, river, marsh or coastal areas were often unrecorded or entered as 'fell in open country', 'fell in the sea' or 'fell in the river' and left little evidence of the fall.

### 4.1 Bombing in Swansea and Glamorganshire

From prior to the declaration of war in 1939, Britain was subjected to reconnaissance flights by the Luftwaffe which was building up a photographic record of potential targets.

From the onset of WWII, mine laying by the Luftwaffe along coasts and in estuaries became increasingly frequent.

The Neath Estuary, Swansea Bay and the coast to the southwest and east of the Site were heavily mined during WWII. This included both defensive mines on beaches in order to prevent enemy landings, as well as marine mines laid at sea by both the British and the German forces to destroy ships entering the bay and the estuary.

In 1940, the docks, oil depots, steelworks and other manufacturing industries based in the Swansea area were important strategic targets for the Luftwaffe. The town was raided more than 44No. times during WWII.

Bombing raids began in the summer of 1940 and continued until the end of WWII. Bombing was generally heavier in the vicinity of Swansea Docks, in the city centre and along the eastern side of Swansea Bay.

The most significant raids took place between the 19<sup>th</sup> and 21<sup>st</sup> of February 1941 during the 'Swansea Blitz'. Following these raids, more than 15ha of the town centre and the surrounding area had been destroyed.

The final raid took place on the 16<sup>th</sup> February 1943.

## 4.2 Strategic Targets

The presence of strategic targets significantly increased the likelihood of bombing within the local area. Airfields, docks, industrial facilities, transport infrastructure and anti-invasion defences were all targeted by Luftwaffe bombers. The inherent bombing inaccuracies at the time meant that areas surrounding the targets were often subjected to bombing.

The main strategic targets in the vicinity of the Site are described below.

### 4.2.1 Docklands

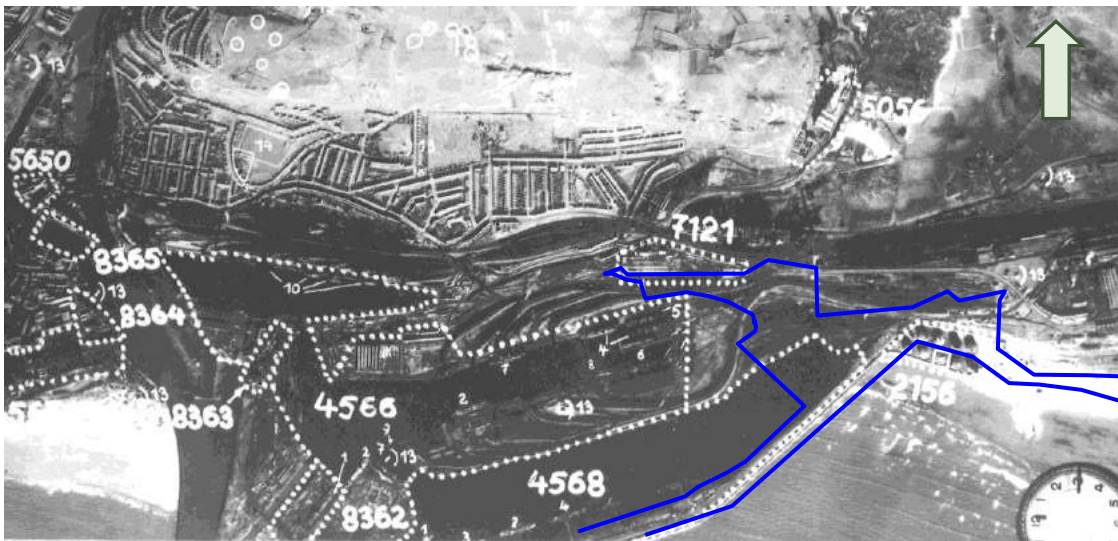
The Swansea Docks, encompassing the western end of the Site, were a major Luftwaffe target. They were a vital importation point for coal, foodstuffs and munitions.

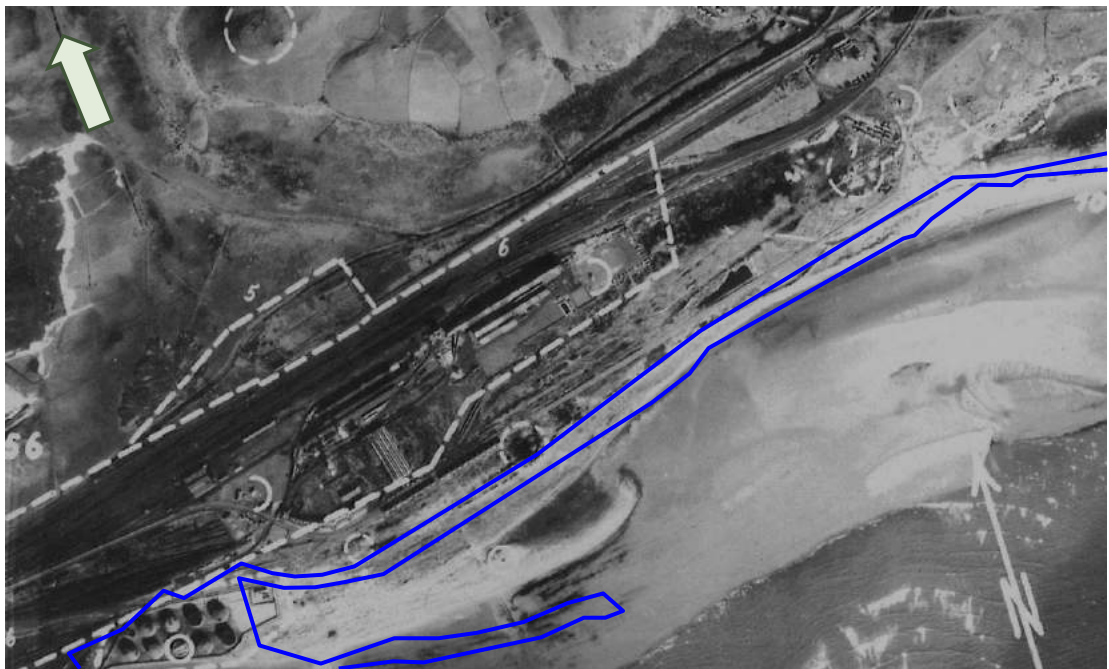
The docks were also heavily used by the supply convoys from America during WWII and Swansea Bay was used during the build-up to D-Day to amass convoys and invasion forces.

Plate 5 is a Luftwaffe reconnaissance photograph dated the 15<sup>th</sup> February 1941 (prior to the 'Swansea Blitz') on which the docks are clearly delineated as targets. Queen's Dock (Target GB 4566) encompassed the western end of the Site.

Targets labelled '1' are AA batteries and semi-circles indicate the position of a barrage balloon. Individual ships and tankers moored in the docks are also numbered (2-10).

The solid white outlined areas, small circles and squares indicate areas of identified bomb damage from earlier air raids.

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                              |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|
| <b>Plate 5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Luftwaffe target photograph of Swansea Docks, 15 <sup>th</sup> February 1941 |
|  <p>Source: Robins</p> <p>Not to scale</p>                                                                                                                                                                                                                                                                                                                                                                 |                                                                              |
| <b>Legend</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Site boundary —                                                              |
| <p>The Briton Ferry Floating Dock, which also handled commercial goods, was located approximately 1km northeast of the eastern end of the Site.</p>                                                                                                                                                                                                                                                                                                                                          |                                                                              |
| <b>4.2.2 Military Targets</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                              |
| <p>A concentration of military targets were located adjacent to the central part of the Site. These included a HAA gun batteries (Section 5.2), the adjoining Jersey Marine Camp (Section 9.1), and Jersey Marine airfield (Section 6.1).</p> <p>These can be identified on the right of the frame in Plate 5.</p>                                                                                                                                                                           |                                                                              |
| <b>4.2.3 Transport Infrastructure</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                              |
| <p>The north-western part of the Site comprised railway sidings, which were connected to various berths and wharves with the Swansea Docks. These were used to process and distribute goods in conjunction with a series of goods yards and warehouses located in the surrounding area.</p> <p>The Great Western Railway (GWR) Vale of Neath mainline was located approximately 0.5km north of the central part of the Site.</p>                                                             |                                                                              |
| <b>4.2.4 Industrial Targets</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                              |
| <p>A concentration of industrial works were located in the Swansea Docklands, in close proximity to the western end of the Site. These included the United Kingdom Chemical Works and Port Tennant Aluminium Works.</p> <p>Several large tinplate works, including the King's Dock Works and Elba Works, were located within approximately 0.1km north of the west-central part of the Site. These can be identified on Plate 6, a Luftwaffe photograph of the central part of the Site.</p> |                                                                              |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                         |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| <b>Plate 6</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Luftwaffe target photograph of central part of the Site, 15 <sup>th</sup> February 1941 |
|  <p>Source: Robins</p> <p>Not to scale</p>                                                                                                                                                                                                                                                                                                                                                            |                                                                                         |
| <b>Legend</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Site boundary —                                                                         |
| <p>Briton Ferry, approximately 1.1km northeast of the eastern end of the Site, contained a concentration of metal works, including the expansive Albion Steel Works.</p> <p>The National Oil Refinery at Llandarcy, approximately 1.6km north of the Site, was a major strategic target and was identified by the Luftwaffe.</p>                                                                                                                                                         |                                                                                         |
| <b>4.2.5 Public Utilities</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                         |
| <p>Public utilities were frequently targeted to disrupt power supplies to local industries.</p> <p>The Tir John Power Station was located approximately 0.4km north of the north-western part of the Site.</p> <p>The Swansea Gas Works were located approximately 1.6km west-northwest of the western end of the Site. The Briton Ferry Gas Works were located approximately 1.7km northeast of the eastern end of the Site.</p>                                                        |                                                                                         |
| <b>4.3 Bombing Density and Incidents</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                         |
| <p>Table 1 gives details of the overall bombing statistics recorded for the Local Authority Districts of the Site and surrounding districts. These were categorised as Rural Districts (RD), Urban Districts (UD), Municipal Boroughs (MB) and Country Boroughs (CB). The Site was located in Swansea CB, Neath RD, Neath MB and Port Talbot MB.</p> <p>The figures for West Ham CB, generally considered to represent a high regional bombing density, are included for comparison.</p> |                                                                                         |

| Table 1        | Bombing Statistics |                 |       |       |                               |
|----------------|--------------------|-----------------|-------|-------|-------------------------------|
| Area           | Bombs Recorded     |                 |       |       |                               |
|                | High Explosive     | Parachute Mines | Other | Total | Bombs per 405ha (1,000 acres) |
| Swansea CB     | 1,496              | 4               | 0     | 1,500 | 69.4                          |
| Neath MB       | 58                 | 0               | 1     | 59    | 13.6                          |
| Neath RD       | 202                | 0               | 3     | 205   | 3.9                           |
| Port Talbot MB | 87                 | 1               | 3     | 91    | 3.9                           |
| Pontardawe RD  | 91                 | 0               | 0     | 91    | 2.6                           |
| West Ham CB    | 1,498              | 45              | 47    | 1,590 | 334.0                         |

Note that Table 1 excludes the figures for AA shells and IBs. Discrepancies between this list and other records, such as bomb clearance records, demonstrate that this data is likely to under-represent actual bombing.

The nearest recorded incidents to the Site are described below. Appendix 1 provides details of further air raid incidents in the vicinity of the Site.

**20<sup>th</sup> July 1940**

6No. HE bombs fell near Elba Crescent, approximately 50m north of the central part of the Site.

1No. HE bomb fell on sand dunes near Jersey Marine, within approximately 0.1km of the central part of the Site.

**27<sup>th</sup> July 1940**

2No. HE bombs fell near the Swansea Dock breakwater, approximately 0.2km southwest of the western end of the Site.

**1<sup>st</sup> September 1940**

251No. HE bombs and 1,000No. IBs fell across Swansea, including over Swansea Dock, in the vicinity of the western part of the Site. The exact locations for most of these incidents were not recorded.

**2<sup>nd</sup> September 1940**

1No. UXB was discovered near Elba Crescent, approximately 50m north of the central part of the Site.

**17<sup>th</sup> January 1941**

178No. HE bombs and 7,000No. IBs fell across Swansea, including over Swansea Dock, in the vicinity of the western part of the Site. The exact locations for most of these incidents were not recorded.

18No. HE bombs fell on the beach south of Elba Crescent, in the immediate vicinity of the west-central part of the Site.

**19<sup>th</sup> – 21<sup>st</sup> February 1941**

The Swansea ‘Three Night Blitz’ took place. During these raids, 896No. HE bombs and more than 30,000No. IBs fell on the town. Approximately 112,000No. properties in the town were damaged or destroyed, mostly located in the town centre.

Due to the large numbers of bombs that fell during this raid, and the widespread fires caused by IBs, many incidents went unrecorded by the ARP wardens. The nearest recorded incidents are included below.

4No. HE bombs fell near the southern jetties in Queen's Dock, in the immediate vicinity of the western end of the Site.

9No. HE bombs and large numbers of IBs fell between the King's Dock Works approximately 0.2km north of the west-central part of the Site, and Jersey Marine Airfield, approximately 0.4km south of the central part of the Site. The exact locations of these bombs was not recorded, and may have included the central part of the Site.

#### 16<sup>th</sup> February 1943

3No. 500kg HE bombs fell on and damaged railway sidings northeast of Queen's Dock, adjacent to the north-western part of the Site. 1No. bomb was recorded as UXB and removed.

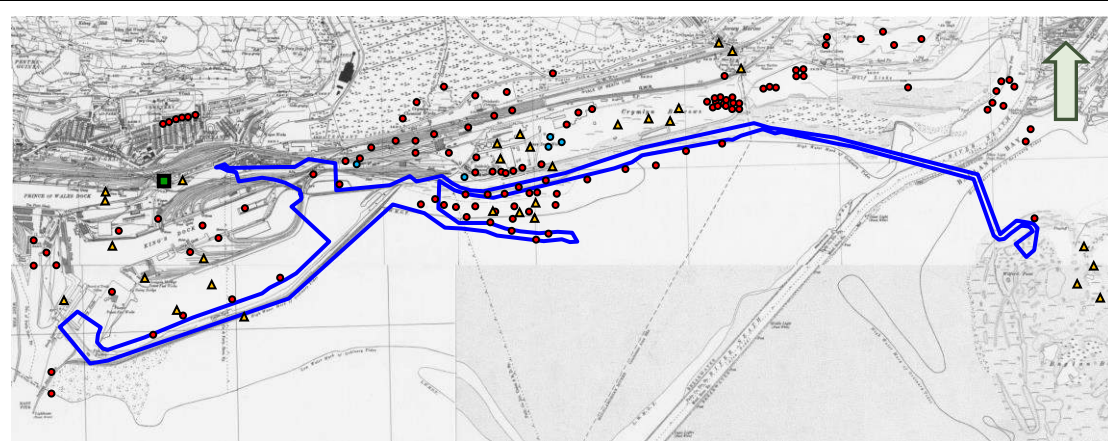
It should be noted that during WWII, many UXB were mapped and subsequently removed as and when conditions and demands on Bomb Disposal teams allowed. Their removal was not always accurately recorded and sometimes records were later destroyed. In practice, most UXB were probably removed and only a much smaller number were actually registered as officially abandoned bombs.

Figure 6 is a map showing the approximate locations of bomb impacts in the immediate vicinity of the Site. IBs shown are indicative of larger numbers of similar devices that fell within the given area. The map has been compiled from a number of different sources, including air raid incident reports, bomb census maps and historical aerial photographs. The map demonstrates that the main Luftwaffe flight path was over Swansea Docks, and that bombing was concentrated in its vicinity and towards the military facilities adjacent to the central part of the Site.

Note that air raid incident reports did not always record precise locations, often only indicating on which street, area or farm a bomb fell.

It is known that exact bomb locations were not usually recorded at the Swansea Docks, and that the incidents displayed below are not fully representative of the bombing density in the area.

**Figure 6** Compiled bomb impact map for the vicinity of the Site



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Not to scale

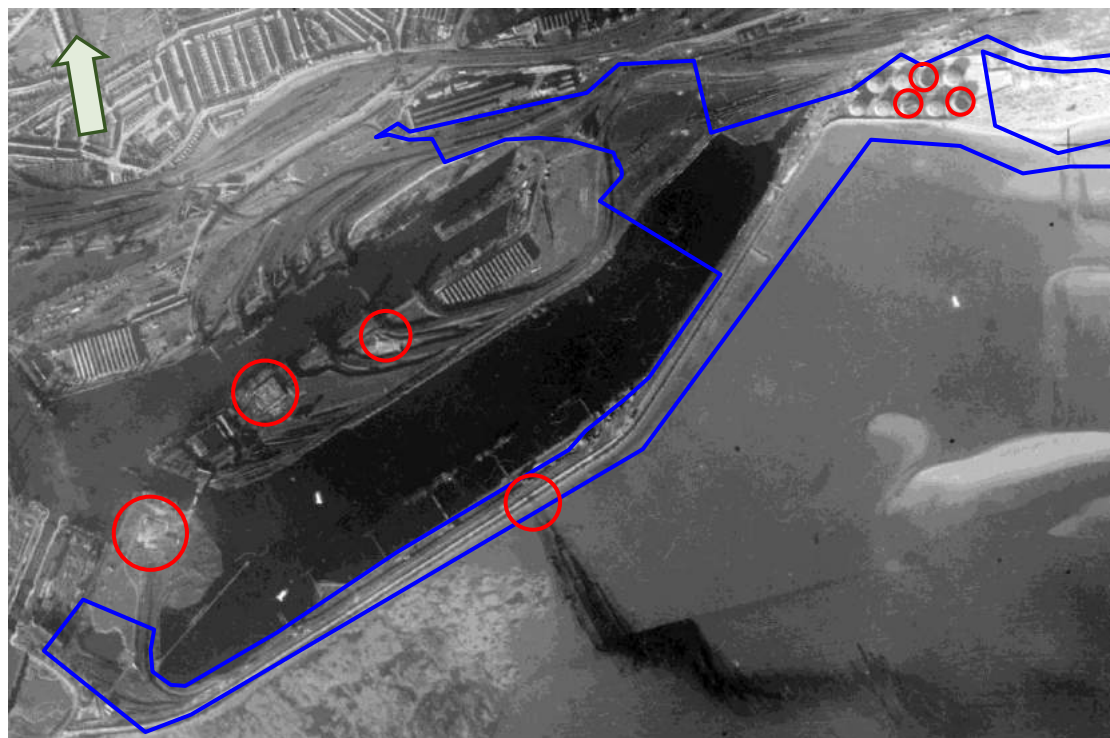
| Legend | Site boundary | HE bomb | UXB | PM | IBs |
|--------|---------------|---------|-----|----|-----|
|        | —             | ●       | ●   | ■  | ▲   |

Plate 7 and 8 are aerial photographs of the western part of the Site, dated the 22<sup>nd</sup> October 1941 and 21<sup>st</sup> April 1945, respectively.

Potential bomb damage has been identified on and in close proximity to the Site, although there is no evidence of any extensive damage at the docks.

In Plate 7, an oil leak can be identified originating from the Site, which may be an indicator of bomb damage.

**Plate 7** Aerial photograph, 22<sup>nd</sup> October 1941



Source: Welsh Government

Not to Scale

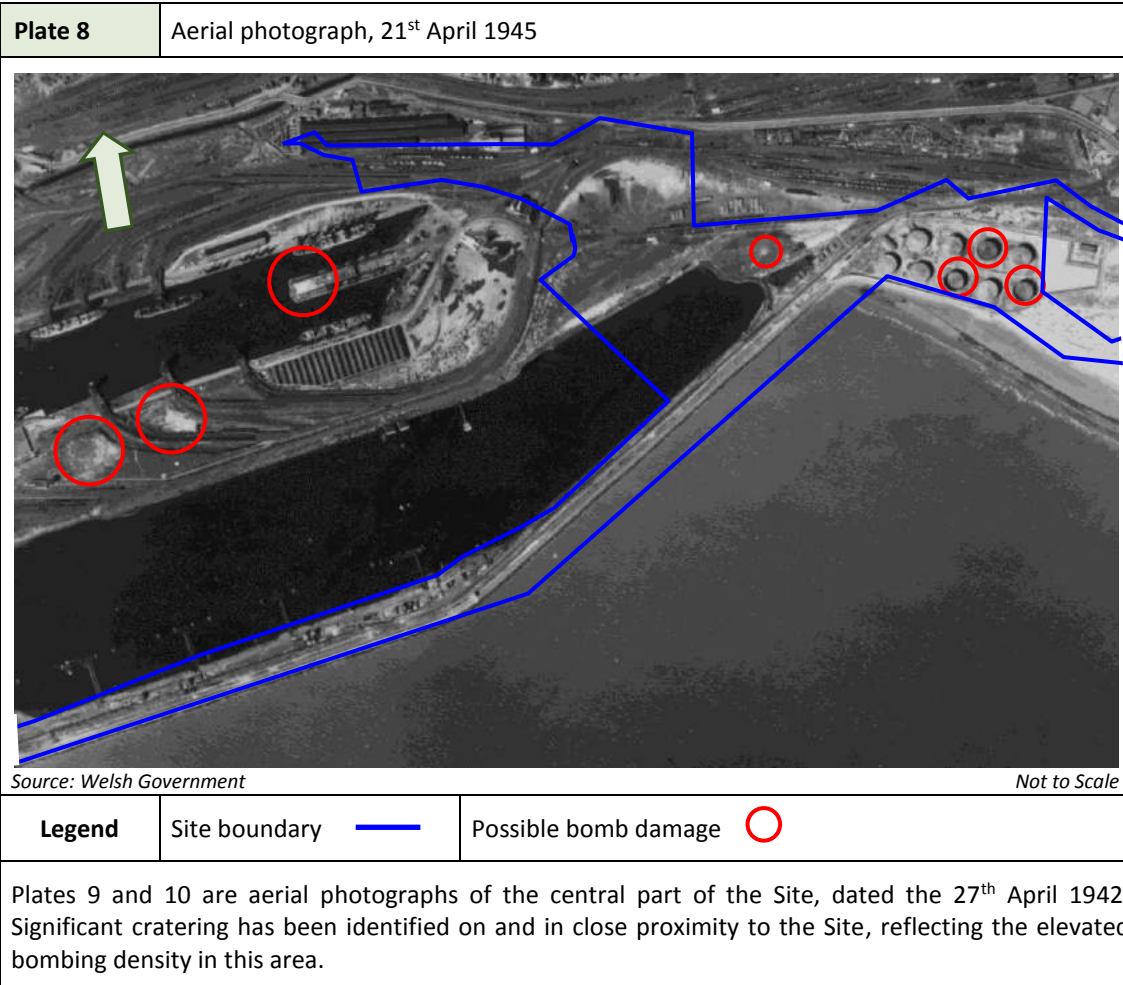
**Legend**

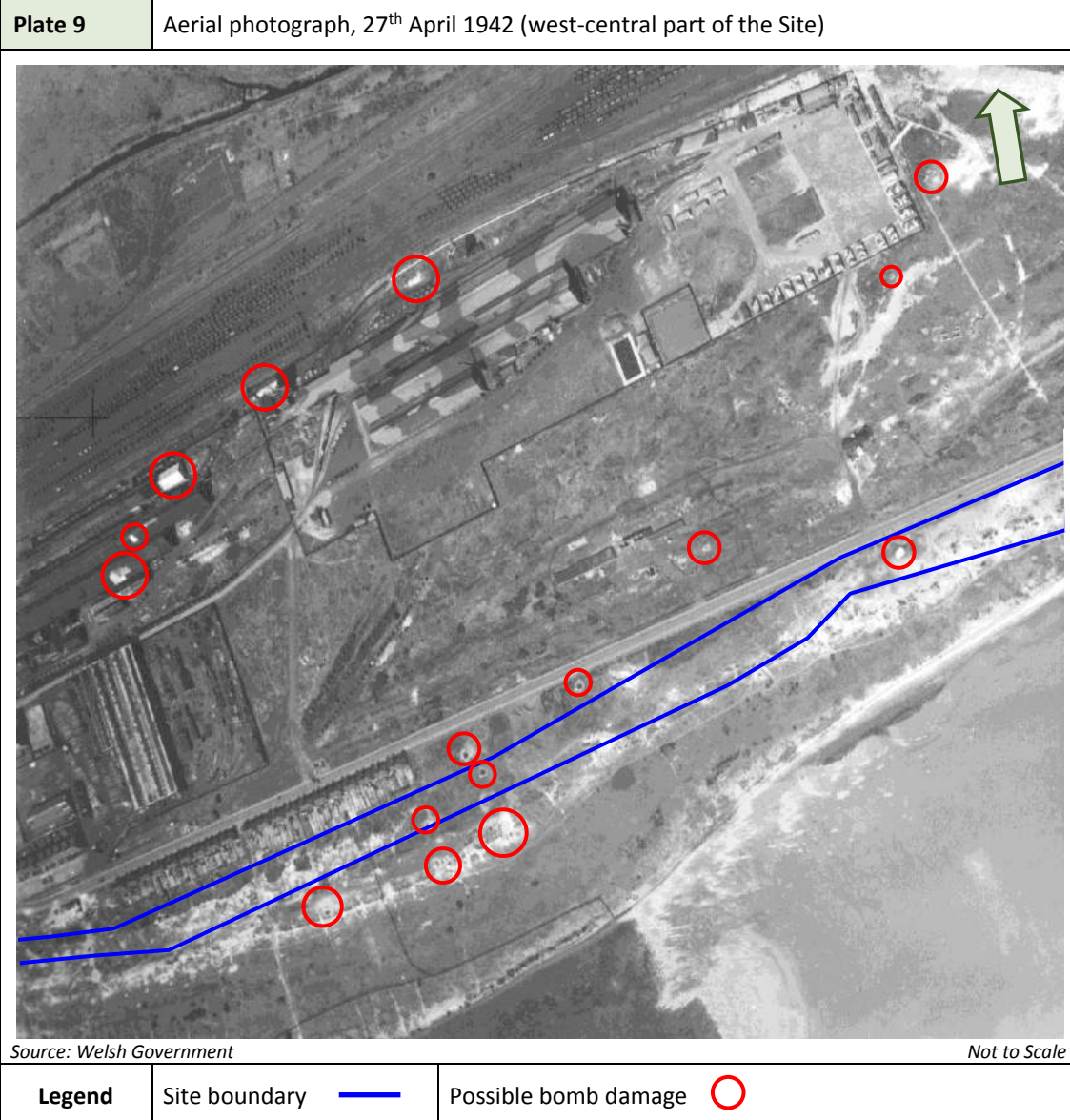
Site boundary



Possible bomb damage







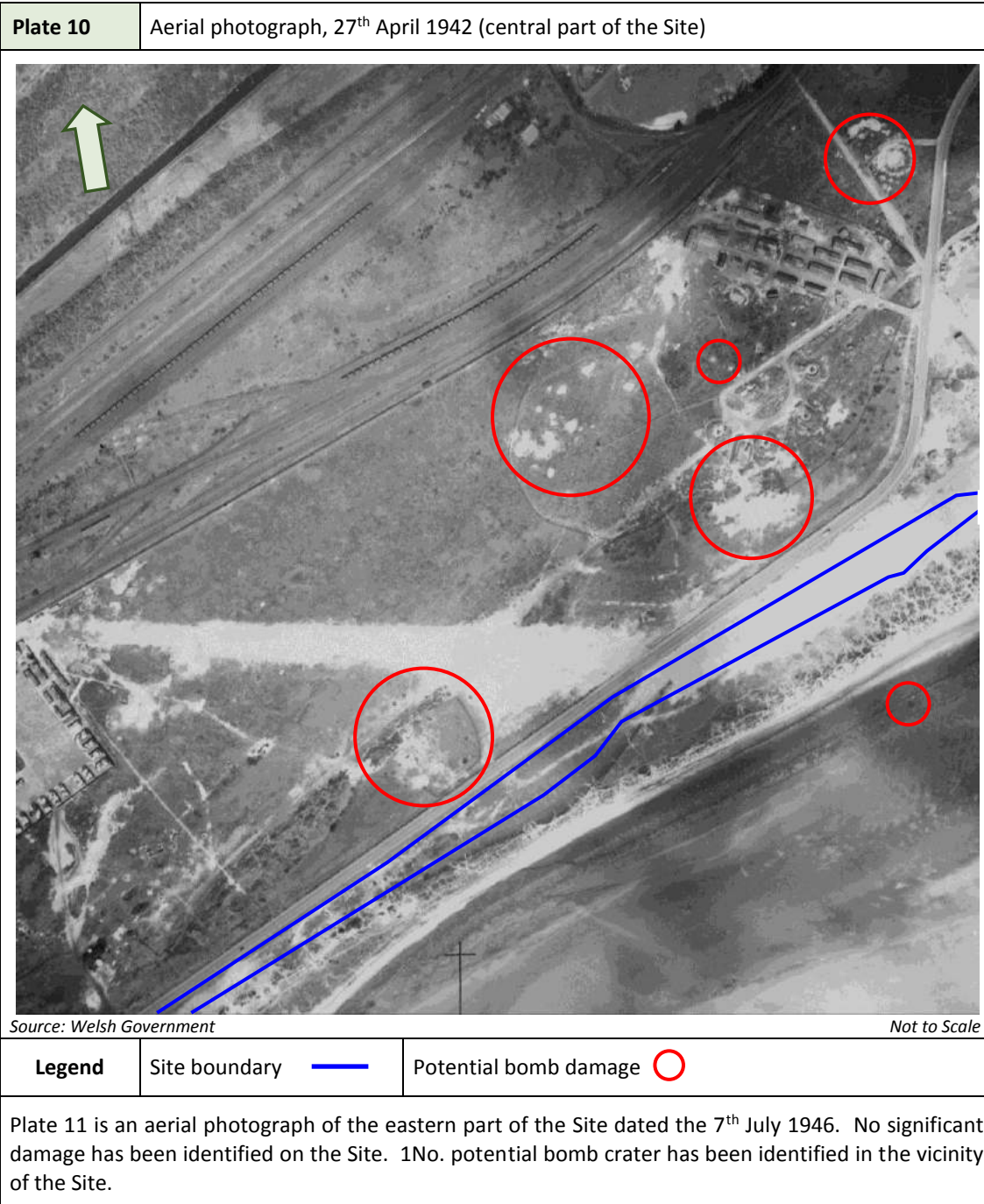
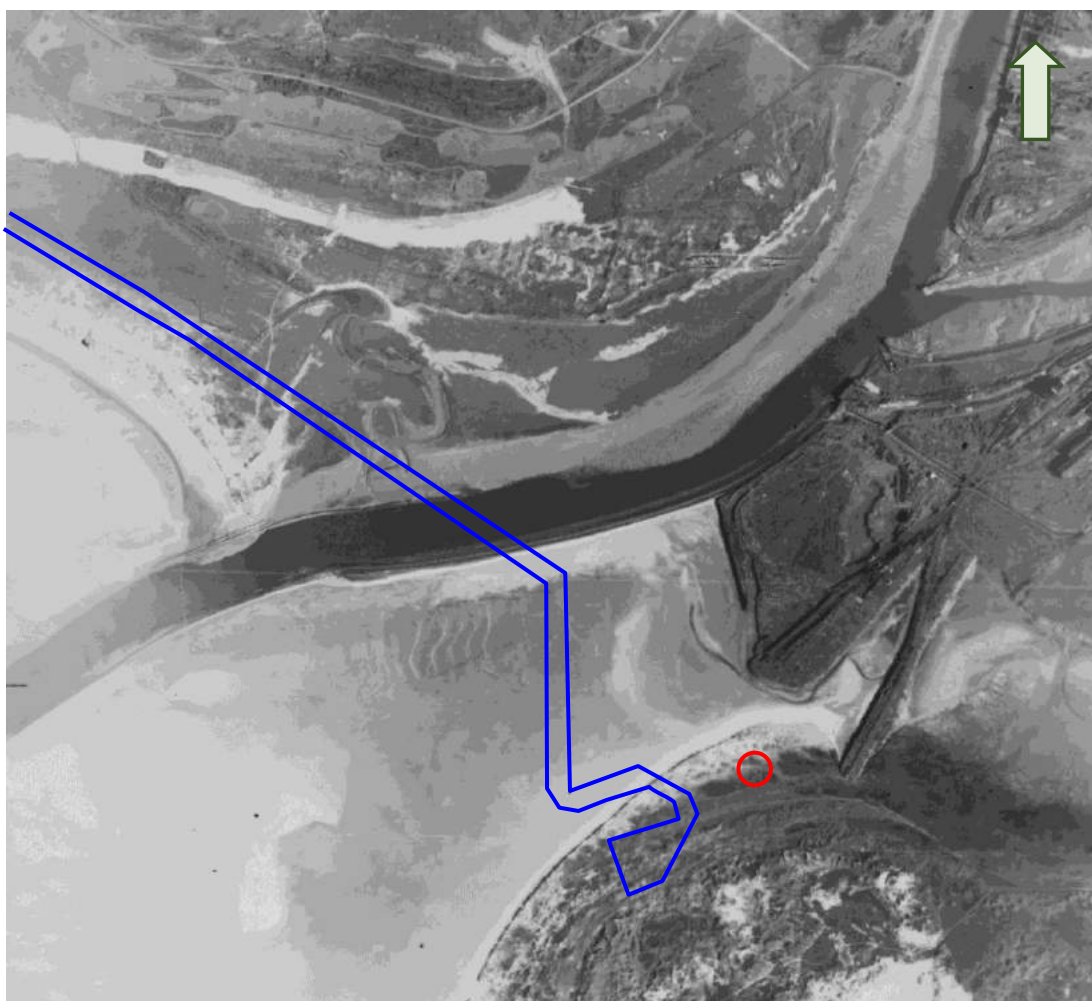


Plate 11

Aerial photograph, 7<sup>th</sup> July 1946



Source: Welsh Government

Not to Scale

**Legend**

Site boundary



Potential bomb damage



During WWII several major raids occurred over Swansea, targeting the docklands and industrial works that bounded the western half of the Site. This resulted in large numbers of HE bombs falling in the vicinity of the Site.

Given that the western part of the Site comprised important dockland and railway infrastructure, which was regularly checked for UXB after each air raid, it is considered unlikely that a UXB would have fallen unnoticed on the Site at this location.

The central part of the Site recorded a high localised bombing density, with at least 30No. HE bombs falling in its immediate vicinity. Given this, and that it mostly comprised unoccupied sand dunes, it is considered that a UXB falling on this part of the Site may have been missed.

No records have been found indicating that the eastern part of the Site was bombed, which was in area with a low localised bombing density.

WWII bombing is considered to provide a possible source of UXO hazard to the central part of the Site.

#### 4.4 Geology and Bomb Penetration Depths

It is important to consider the geological materials present on the Site at the time that a bomb was dropped in order to establish its maximum penetration depth. The BGS 1:50,000 Sheet 247, Swansea (Drift) and BGS borehole records were consulted.

Table 2 provide a summary of the anticipated geology from the published BGS records in the vicinity of the Site and indicative average maximum bomb penetration depths based on empirical evidence and MoD data.

**Table 2** Estimated average maximum bomb penetration depths

| Section | OSNGR     |           | Bomb Weight |       |         | Summary Geology                       |
|---------|-----------|-----------|-------------|-------|---------|---------------------------------------|
|         | From      | To        | 50kg        | 500kg | 1,000kg | Indicative Lithologies                |
| W       | SS 669920 | SS 693929 | 2.5m        | 6.0m  | 7.0m    | Made Ground/Sand/Stiff Clay/Weak Rock |
| C       | SS 693929 | SS 723931 | 3.0m        | 6.5m  | 7.5m    | Soft Clay/Sand/Stiff Clay/Weak Rock   |
| E       | SS 723931 | SS 733925 | 2.5m        | 11.0m | 12.0m   | Sand/Soft Clay/Stiff Clay/Weak Rock   |

The estimated bomb penetration depths given in Table 2 are from the WWII ground level and are based on the following assumptions:

- a) High level release of the bomb resulting in an impact velocity of 260m/s (>5,000m altitude).
- b) A strike angle of 10 to 15 degrees to the vertical.
- c) That the bomb is stable, both in flight and on penetration.
- d) That no retarding units are fitted to the bomb.
- e) That the soil type is homogenous.

A high altitude release of a bomb will result in ground entry at between 10° and 15° to the vertical with the bomb travelling on this trajectory until momentum is nearly lost. The bomb will then turn abruptly to the horizontal before coming to rest. The distance between the centre of the entry hole and the centre of the bomb at rest is known as the 'offset'. A marked lateral movement from the original line of entry is common.

Low-level attacks may have an impact angle of 45° or more, which will frequently lead to a much greater amount of offset movement during soil penetration.

The average offset is one third of the penetration depth, i.e. an offset of 2m may be expected for a 50kg bomb in dry silts and clays. If hard standings or Made Ground were present during WWII, bomb penetration depths would have been significantly reduced but offset distances may have been up to four times greater.

In low level attacks over deep water bodies, the offset distances from the point of entry at the water surface may be considerably enhanced due to hydrodynamic effects before the bomb penetrates or settles on the sea bed. Shallow water has little effect on bomb penetration depths during high level attacks.

## 5 WWII DEFENCES

### 5.1 Bombing Decoys

In order to draw enemy aircraft away from towns and other strategically important targets, a series of decoys were developed between 1940 and 1941.

They were estimated to have drawn at least 5% of the total weight of bombs away from their intended targets. Approximately 792No. static decoy sites were built at 593No. locations in England. In addition, numerous temporary and mobile decoys were deployed.

Several different types of decoy were devised:

- Night time dummy airfields (Q sites).
- Daytime dummy airfields (K sites).
- Diversionary fires to simulate successful bombing raids on airfields (QF sites), petroleum depots (P sites) and major towns and cities (Starfish or SF sites).
- Simulated urban lighting (QL sites).
- Dummy Heavy Anti-Aircraft (HAA) batteries, factories and buildings (C series).
- Mobile decoys representing 'hards' for troop embarkation (MQLs), tanks and other vehicles.

Machine gun emplacements and Light Anti-Aircraft (LAA) guns were used to prevent possible enemy landings at decoy airfields.

By their nature, decoy sites provide a potential risk from Unexploded Bombs (UXB), both within the decoy site boundary and in the surrounding areas.

The nearest recorded bombing decoy was located on the Baglan Higher (SS 775939), approximately 4.5km northeast of the eastern end of the Site.

This decoy is not considered to provide a source of UXO hazard to the Site.

### 5.2 Anti-Aircraft Defences

Anti-Aircraft (AA) gun batteries were targeted by the Luftwaffe. They were also a source of Unexploded AA (UXAA) shells which could land up to 27km from the firing point during WWII, although more typically fell within 15km. These could be distributed over a wide area.

AA batteries present a potential source of UXO hazard as a result of the storage, use and disposal of ordnance associated with the armaments used. They may have a risk from small caches of ammunition buried locally to them. 3No. types of AA batteries existed:

- Heavy Anti-Aircraft (HAA) batteries of large guns designed to engage high flying bomber aircraft. These tended to be relatively permanent gun emplacements.
- Light Anti-Aircraft (LAA) weaponry, designed to counter low flying aircraft. These were often mobile and were moved periodically to new locations around strategic targets such as airfields.
- Rocket batteries (ZAA) firing 3" or 3.7" AA rockets with a maximum altitude of 5,800m and a ground range of 9km were also relatively permanent emplacements.

Many AA batteries were associated with searchlights and consequently 'visible' at night, providing clear targets to the Luftwaffe bombers and a potential for UXB.

During WWII the Site was within the range of guns deployed in the Swansea Gun Defended Area (GDA).

Table 3 is a list of recorded HAA and ZAA batteries within 10km of the Site.

| <b>Table 3</b>        |                   | WWII HAA gun batteries and ZAA rocket batteries within 10km of the Site |                 |                                                     |
|-----------------------|-------------------|-------------------------------------------------------------------------|-----------------|-----------------------------------------------------|
| <b>Grid Reference</b> | <b>Serial No.</b> | <b>Location</b>                                                         | <b>Armament</b> | <b>Approximate Distance and Direction from Site</b> |
| SS 712934             | N3                | Jersey Marine                                                           | 3.7" guns       | 0.1km N                                             |
| SS 716934             | K.74              | Jersey Marine                                                           | UP launchers    | 0.1km N                                             |
| SS 668920             | K.71              | King's Dock                                                             | UP launchers    | 0.1km NNW                                           |
| SS719935              | N25               | Jersey Marine Golf Course                                               | 3.7" guns       | 0.2km N                                             |
| SS 756927             | N7                | Briton Ferry                                                            | 3.7" guns       | 2.1km E                                             |
| SS 643950             | N4                | Raven Hill                                                              | 3.7" guns       | 4.2km NW                                            |
| SS 625916             | N6                | Sketty                                                                  | 3.7" guns       | 4.5km W                                             |
| SS 625916             | N26               | Sketty                                                                  | 3.7" guns       | 4.6km WSW                                           |
| SS 622920             | T                 | Sketty                                                                  | 3.7" guns       | 4.6km WSW                                           |
| SS 721920             | Q                 | Witford Point                                                           | 3.7" guns       | 1.1km S                                             |
| SS 680977             | U                 | Morrison                                                                | 3.7" guns       | 4.7km N                                             |
| SS 627873             | S                 | Mumbles                                                                 | 3.7" guns       | 6.3km SW                                            |
| SS 695984             | N1                | Birchgrove                                                              | 3.7" guns       | 5.6km N                                             |
| SS 745975             | N2                | Neath                                                                   | 3.7" guns       | 5km NNE                                             |
| SS 748976             | V                 | Neath                                                                   | 3.7" guns       | 5.1km NNE                                           |

It should be noted that the lack of official records of HAA batteries or armaments cannot be taken to imply their absence because many units were mobile and were moved around as operational requirements dictated.

In addition to HAA and ZAA batteries, there were LAA guns in the area surrounding the Site, some of which were located at Jersey Marine and the Swansea Docks. These included Oerlikon Cannon, Lewis Machine Guns, Vickers Machine Guns and 40mm Bofors Guns on both mobile and static mountings.

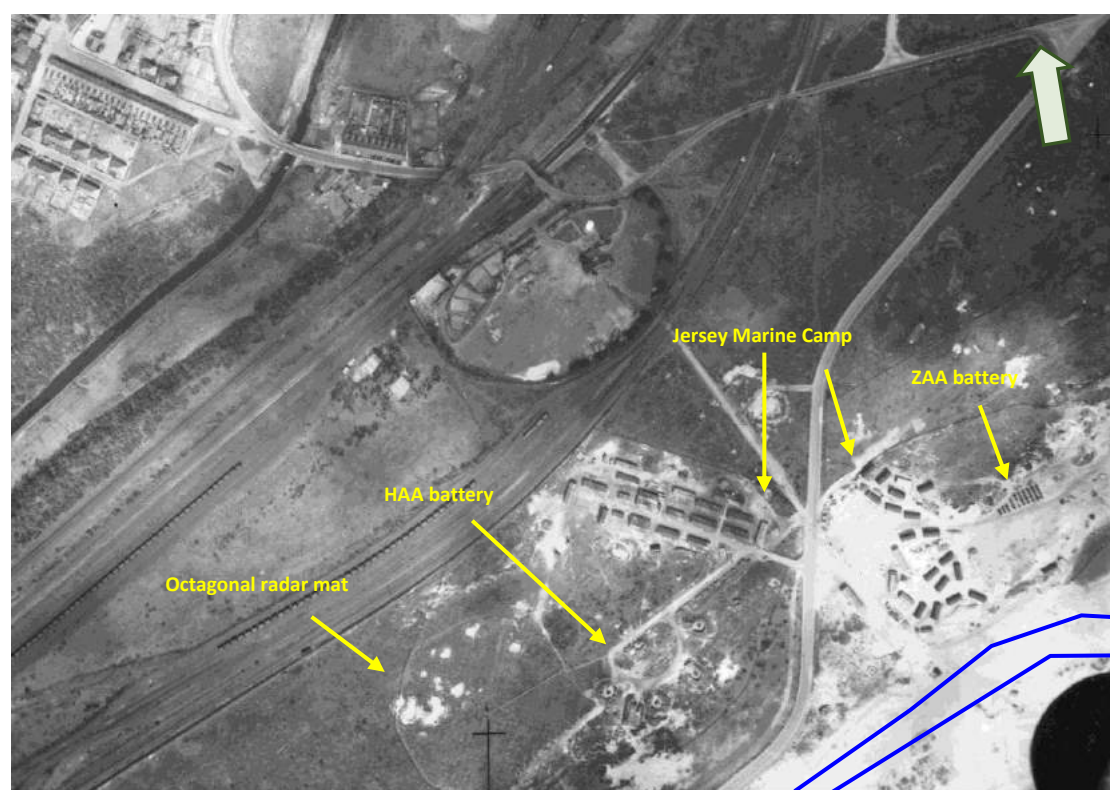
### 5.2.1 Jersey Marine HAA and ZAA Battery

HAA battery N3 was established in July 1940 approximately 0.1km north of the Site (SS 712934). It was augmented by an octagonal radar mat and a ZAA rocket battery. Jersey Marine Camp, located adjacent to the HAA battery, was used to accommodate personnel (see Section 9.1).

Plate 12, an aerial photograph dated the 27<sup>th</sup> April 1942, shows the layout of Jersey Marine HAA and ZAA battery. Potential bomb cratering can also be identified.

**Plate 12**

Aerial photograph of Jersey Marine HAA battery, 27<sup>th</sup> April 1942



Source: Welsh Government

Not to scale

**Legend**

Site boundary —

Plate 13, an aerial photograph dated the 10<sup>th</sup> August 1948, further demonstrates the layout of the HAA gun battery.

Each of the gun emplacements had inbuilt ammunition recesses and there was a control bunker (including command post, height finder and predictor) at the centre of the battery.

Plate 13

Aerial photograph of Jersey Marine HAA battery, 10<sup>th</sup> August 1948



Source: Britain from Above

Not to scale

#### Legend

Site boundary —

The battery remained in use until 1945 when it was closed. It was demolished in the 1950s and has subsequently been partially developed into a warehouse.

The gun emplacement included munitions stores, which would likely have been removed and transferred to ammunition depots at the end of WWII, although the possibility that munitions were disposed of locally cannot be completely discounted.

Additionally, given the number of gun batteries in the surrounding area, the potential for a UXAA shell to have fallen unnoticed on the Site, whilst unlikely, cannot be totally discounted.

### 5.3 Barrage Balloons and Anti-Landing Obstacles

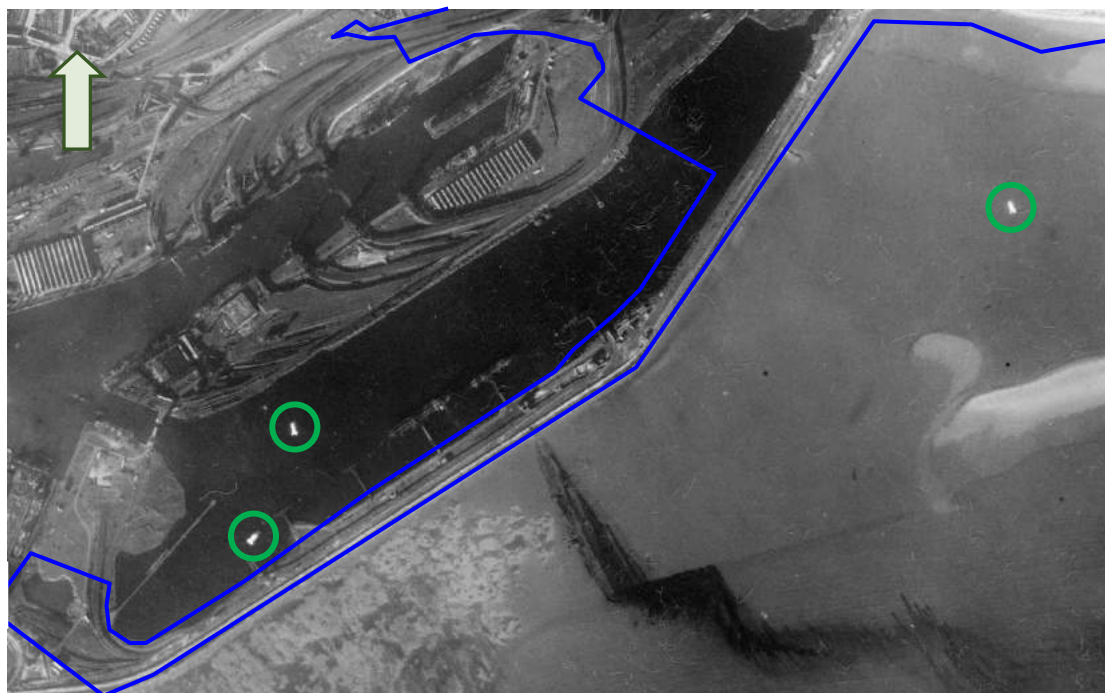
Balloon barrages were flown in many British towns and cities to protect against air raids. Their presence deterred low flying aircraft, making it more difficult for bombs to reach their intended targets. Barrage balloon sites can be a source of UXO as they were targeted by the Luftwaffe. They also often had a small explosive charge fitted with tilt fuzes attached approximately 50m from each end of the balloon cables and designed to detonate if the cables were hit by an aircraft.

Measures were also taken to prevent enemy aircraft landing in the event of invasion. Obstructions were constructed around airfields and on other open sites deemed fit for use as landing grounds. Solid obstructions (such as concrete blocks), posts or stakes, felled trees, haystacks, scaffolding with wire and trenching were the main measures used.

Due to the strategic importance of the Swansea Docks and the National Oil Refinery at Llandarcy, extensive barrage balloons defences were established across the region.

Several barrage balloons were located in the immediate vicinity of the western end of the Site, as can be seen in Plate 14, an aerial photograph dated the 22<sup>nd</sup> October 1941.

**Plate 14** Aerial photograph showing barrage balloons at Swansea Docks, 22<sup>nd</sup> October 1941



Source: Welsh Government

Not to scale

**Legend** Site boundary — Barrage balloon ○

Records have been found indicating that anti-landing obstacles were placed on Jersey Marine Airfield, which encroached upon the east-central part of the Site (see Section 6.2).

Barrage balloons and anti-landing obstacles are not considered to provide a source of UXO hazard to the Site.

#### 5.4 Anti-Invasion Defences

Defence structures are a potential source of UXB as they were especially targeted by low flying enemy aircraft, particularly during 'tip and run' raids which were common in industrialised regions. These defences may also be associated with small caches of UXO in the form of small arms, used by the troops manning the emplacement.

The rapid advance of German Troops into France, Holland and Belgium after the start of WWII prompted the War Office to review the vulnerability of the UK to invasion and a decision was taken to begin work on a national plan of anti-invasion defences. Static defences were built to interrupt and delay the progress of any invading force.

Coastal defences were strengthened (the 'Coastal Crust'). These defences included barbed wire entanglements and minefields, which were often combined to give defence in depth.

Inland, lines of defence structures were constructed along 'Stop Lines' in order to impede enemy progress for long enough to allow mobile defending forces to counter-attack.

Stop Lines included the fortification of key 'centres of resistance', such as river crossings and important road or rail junctions that could seriously hamper the enemy's advance across country. Bridges were mined for demolition and tank traps installed.

Stop Lines were further integrated into a network of fortified nodal points and 'Anti-Tank (AT) Islands'.

Due to fears of an enemy amphibious landing in South Wales, various anti-invasion defences, including pillboxes, minefields and artillery positions, were established in the vicinity of the Site. This included a defensive point on Jersey Marine beach, in the immediate vicinity of the east-central part of the Site.

These defences are described in the sections below.

## 5.5 Pillboxes, Mortar and Gun Emplacements

Defences also included spigot mortar positions and gun emplacements.

Spigot mortars, also known as Blacker Bombards, were used primarily in an anti-tank role at road blocks or to defend airfields. Typically they fired a 20 pound (lb) HE mortar bomb. The fixed positions, in weapons pits with ammunition lockers, were frequently positioned near pillboxes.

Spigot mortar positions could be either fixed or mobile.

1No. machine gun emplacement was established on the seawall at the western end of the Site.

Records have been found indicating that during 1942 29mm Spigot Mortars were established near Jersey Marine beach, in the immediate vicinity of the east-central part of the Site (SS 718933).

960 Defence Battery RA operated a 4" artillery gun emplacement on the beach, adjacent to the west-central part of the Site (SS 694927). Several 13-pdr anti-tank guns were also recorded as being positioned in the Swansea Docks, in the vicinity of the western end of the Site.

Pillboxes provide a potential UXO hazard both from the storage, use and disposal of ordnance associated with them and from UXB because they were targeted by enemy aircraft.

Pillboxes were common along Stop Lines, perimeters of airfields, potential land invasion sites and around important civil sites. Several different designs existed including Seagull Trenches (semi-buried structures), Alan Williams and Tett Turrets (small prefabricated pillboxes). Fortified sites, buildings or loop-holed walls also functioned as pillboxes.

Records have been found indicating that 119No. pillboxes were established in the Swansea Defence Area. 32No. of these were established in and around the Swansea Docks, including 4No. pillboxes constructed on the seawall comprising the western end of the Site.

Records have also been found indicating that 4No. pillboxes were located at the Elba Works, approximately 0.3km north of the west-central part of the Site.

Pillboxes and gun emplacements are not considered to provide a source of UXO hazard to the Site.

## 5.6 Home Guard and Auxiliary Units

Local Defence Volunteers (LDV) units, later known as the Home Guard, were located in all cities, towns and large villages.

Anti-invasion defences were to be defended by the Home Guard and regular Army troops for as long as possible in the event of an invasion. The troops were issued with 'No Withdrawal' orders.

Important elements of the ordnance supply for the use of the Home Guard included substantial supplies of Mills bombs (fragmentation grenades) and Self Igniting Phosphorus (SIP) grenades as well as machine gun and small arms ammunition.

In October 2006 a cache of 76No. SIP grenades was found in a garden at Seend, Wiltshire. In October 2008, a further 26No. SIP grenades were discovered in a garden in Wimborne, Dorset. Similar caches were discovered in October 2009 in Hove, Sussex and during May 2010 in Halesowen in the West Midlands, and a further cache of 20No. was uncovered on a construction site at Birdlip, Gloucestershire, in July 2010. Also in July 2010, a box of 24No. SIP grenades was found on Cogden Beach, Dorset. In April 2012, more than 8No. SIP grenades were found on a construction site in Banbury and destroyed by members of the Army Royal Logistic Corps (RLC).

In March 2015, 80No. SIP grenades were found at a building site in Eastbourne, some of which exploded before they could be made safe by a Bomb Disposal unit. In all 8No. cases, the bottles were in good condition and exploded in flames when broken.

Most recently, in May 2016, 1No. No. 76 SIP grenade was found during excavation at Chapel Point, Lincolnshire forcing works to be delayed. During WWII, the site was occupied by a pillbox and gun emplacement associated with the heavily-defended 'Coastal Crust', manned by Home Guard units. The device was removed safely.

In addition to the regular Home Guard, Auxiliary Units existed which were made up of guerrilla troops trained in sabotage and assassination in case of invasion. Sites used by these Units were Top Secret and many locations are still unknown.

No Home Guard activity has been identified on or in close proximity to the Site.

The 4<sup>th</sup> Glamorganshire (Neath) and 12<sup>th</sup> Glamorganshire (Swansea) battalions operated in the local area, patrolling local transport infrastructure, industrial works and docklands.

Records have been found indicating that 'H' Company of the 4<sup>th</sup> Glamorganshire (Neath) battalion were Head Quarters (HQ) in Jersey Marine Camp (see Section 9.1) within approximately 0.2km north of the Site. They were primarily tasked with the defence of the adjacent HAA gun battery.

Records of Home Guard activities and related sites are rarely preserved. Storage and disposal of munitions by the Home Guard was poorly documented and surplus supplies were either buried or dumped in lakes and ponds. Given the irregular nature of this activity, the possibility of items of UXO being discovered at any locations occupied or used for training by the Home Guard can never be totally discounted.

## 5.7 Minefields and Mined Locations

Minefields were laid along the coast, in estuaries and along the banks of major rivers to deter infantry invasion. Strategic points such as bridges and gaps in cliffs were mined to impede enemy advance. Most of the mined locations in the UK have been cleared and the risk of finding UXO in these areas is considered to be low.

Records have been found indicating that during October 1940 anti-tank and anti-personnel mushroom mines were emplaced along Jersey Marine Beach, between SS 702927 and SS 720927. This partly encompassed the Site.

Additionally, during 1942 a Flame Barrage, designed to pump burning oil over enemy troops, was constructed by 179 Tunnelling Company Royal Engineers (RE) on Jersey Marine beach, in the immediate vicinity of the Site.

Marine mines, both British and German, were laid in the surrounding area. These are discussed in further detail in Section 10.2.

The minefields and Flame Barrage would likely have been removed after WWII. It should be noted, however, that WWII-era mine-clearance operations were not always comprehensive, and mines have been known to be missed in remoter locations.

Given that no records of mines being found on Jersey Marine beach since WWII have been uncovered it is considered likely that they were all removed and only provides a background risk as with other similar sites in the UK.

## 6 MILITARY AIRFIELDS

Military airfields offer the potential for significant UXO hazards due to the use, storage and disposal of ordnance and as a result of enemy bombing during WWI and WWII.

Airfields active during WWII were targeted by the Luftwaffe, providing a potential source of UXB on the airfield.

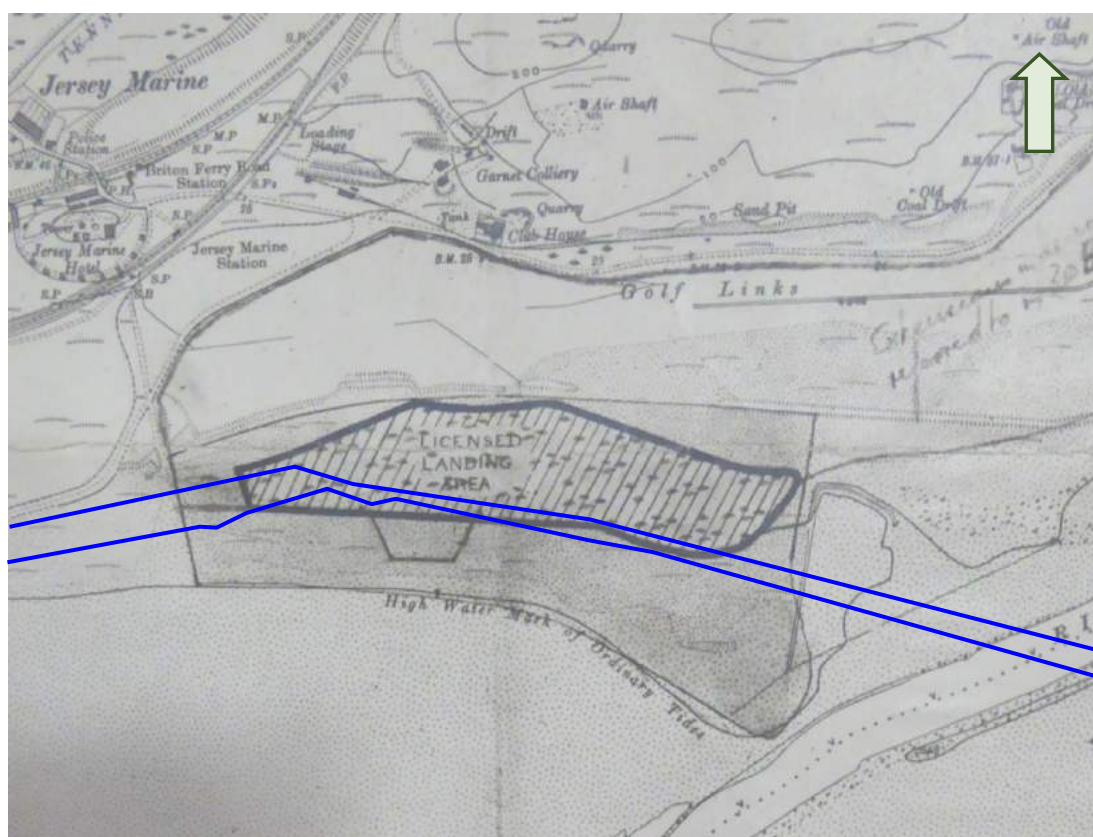
As bombing accuracy was so poor during WWII, it is likely to find UXB in the surrounding areas. Aircraft crashes are also associated with operational airfields.

The nearest identified airfield to the Site is described below.

### 6.1 Jersey Marine Airfield

In July 1938 a landing strip was established on flattened sand dunes, which encroached on the east-central part of the Site (SS 720931). Figure 7 is a plan showing the extent of the airfield.

**Figure 7** Plan of Jersey Marine Airfield, 1939



Source: National Archive

Not to scale

#### Legend

Site boundary



The airfield was used as a terminus for Western Airways until 1939 when the aircraft stationed there were requisitioned by the Royal Air Force (RAF).

No records have been found indicating that the RAF used the airfield, or that military aircraft were stationed there.

The airfield was recorded as abandoned by 1941 and was covered with anti-landing obstacles to prevent use by the enemy.

Jersey Marine Airfield is not considered to provide a source of UXO hazard to the Site.

## 6.2 Aircraft Crashes

Aircraft crash sites are a known UXO hazard. The MoD advises that if crashed aircraft are found, the safest policy is to leave them alone where possible. Unless disturbed there is no statutory requirement for the MoD to clear such sites.

No records of military aircraft crashes on or in close proximity to the Site have been found.

## 7 EXPLOSIVES AND MUNITIONS ESTABLISHMENTS AND DEPOTS

Explosives and munitions manufacturing or storage sites offer a particularly high risk from both explosive substances and UXO. Standard procedures of explosive/ordnance disposal through burial or burning means that explosive and UXO hazards will be present in some areas of such establishments.

In addition, UXB hazards may be present as a result of enemy bombing during WWI and WWII.

### 7.1 Explosives and Ordnance Factories

No records of any explosives or ordnance factories on or in close proximity to the Site have been found.

### 7.2 Munitions Stores

Local ammunition caches would have been present near to defended road blocks, pillboxes, HAA and LAA sites. Most of those associated with the anti-invasion sites are understood to have been cleared.

During WWII Swansea Dock was a key handling point for military supplies, which included munitions. These munitions were often stored in warehouses in the vicinity of the docks before being transported elsewhere. No records have been found indicating that munitions were stored on the Site itself.

Plate 15 is a photograph of munitions stored in N 'Shed' King's Dock, within approximately 1km of the Site.

**Plate 15**

US general-purpose bombs stored in 'N' Shed, King's Dock, 16<sup>th</sup> June 1944



Source: Arthur

There would also have been small munitions caches and ammunition shelters associated with the anti-invasion defences and Jersey Marine Camp located on and in close proximity to the Site.

These would typically have been removed to ammunition depots at the end of WWII, although the possibility of localised disposal can never be fully discounted.

### 7.3 Informal Munitions Depots

Informal munitions depots, often made by requisitioning roadside lay-bys or parks. Other informal munitions depots were commonly located in areas of woodland or on train wagons along sidings in marshalling yards.

No records of any informal munitions depots on or in close proximity to the Site have been found.

### 7.4 Munitions Disposal Areas and Bomb Cemeteries

Munitions disposal areas were often made by requisitioning open areas of land, usually away from habitation. Marshland, beaches or sand dunes were frequently used for this purpose. Disposal of munitions was carried out in many different ways, ranging from destruction to burial. Full records were not necessarily maintained for these locations, and so they can potentially be a source of UXO.

No records of any official munitions disposal areas on or in close proximity to the Site have been found.

Records have been found indicating that ordnance demilitarisation was undertaken in the vicinity of the eastern end of the Site. See Section 9.3 for further details.

## 8 FIRING RANGES AND MILITARY TRAINING AREAS

By their nature, firing ranges and military training areas represent a potential source of UXO due to associated training activities. The training will involve both practice and live munitions and will offer a significant risk from a very wide range of potential UXO.

### 8.1 Small Arms Ranges

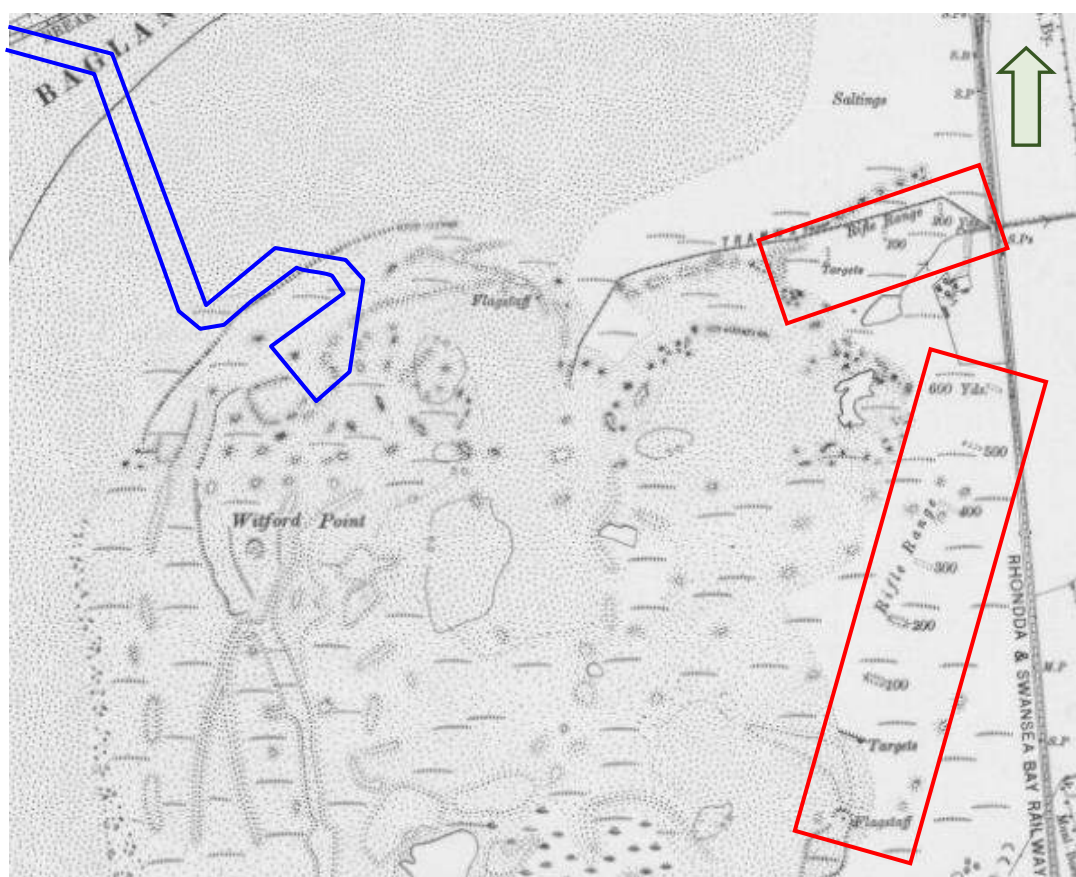
Small arms ranges (such as rifle ranges) and close combat ranges (such as mortar and grenade ranges) are likely to provide a significant source of UXO. It should be noted that even on small arms ranges, larger munitions such as mortars or grenades cannot be discounted.

No records of any small arms ranges on the Site have been found.

During the 19<sup>th</sup> century, several rifle ranges were established on sand dunes in the vicinity of the eastern end of the Site.

Figure 8 is a historical map from 1921 showing the location of these rifle ranges.

**Figure 8** Historical map of 1921 showing the location of the Baglan Bay rifle ranges



Source: © Crown Copyright 2016. Reproduced by permission of Ordnance Survey

Not to scale

#### Legend

Site boundary



Rifle range



Records have been found indicating that during WWII a mortar range was established on sand dunes within approximately 1.5km of the eastern end of the Site. No records have been found indicating the exact location of the range, although it is likely that it was located in the vicinity of the small arms ranges

Anecdotal evidence has been found indicating that a rifle range was located in the vicinity of the Jersey Marine camp, in the vicinity of the east-central part of the Site. No records have been found to corroborate the presence and location of the range.

It is likely that any such range would have been temporary and would have only been used for small arms practice. Small arms ammunition is not considered to provide a significant source of UXO hazard (see Appendix A2.1).

Small arms ranges are not considered to provide a source of UXO hazard to the Site.

## 8.2 Artillery Ranges

Artillery ranges will have utilised a wide range of munitions, predominantly shells, although close combat munitions such as mortars, or larger munitions such as bombs, cannot be discounted.

No records of any artillery ranges on or in close proximity to the Site have been found.

## 8.3 Bombing Ranges

Bombing ranges will have primarily used bombs, although other munitions such as shells and close combat munitions such as mortars cannot be totally discounted.

No records of any bombing ranges on or in close proximity to the Site have been found.

## 8.4 Training Areas

Training areas will have primarily used blank ammunition or practice shells in 'dry' areas, although live munitions such as shells and close combat munitions such as mortars cannot be discounted in any training area.

No records of any military training areas on or in close proximity to the Site have been found.

## 9 OTHER ESTABLISHMENTS, MILITARY BASES AND BARRACKS

Several military establishments directly linked to the armed forces exist or have existed in the region surrounding the Site. These can provide a source of UXO hazard, although the level of risk from such hazards will depend on the nature of operations carried out.

The nearest additional military establishment to the Site is described below.

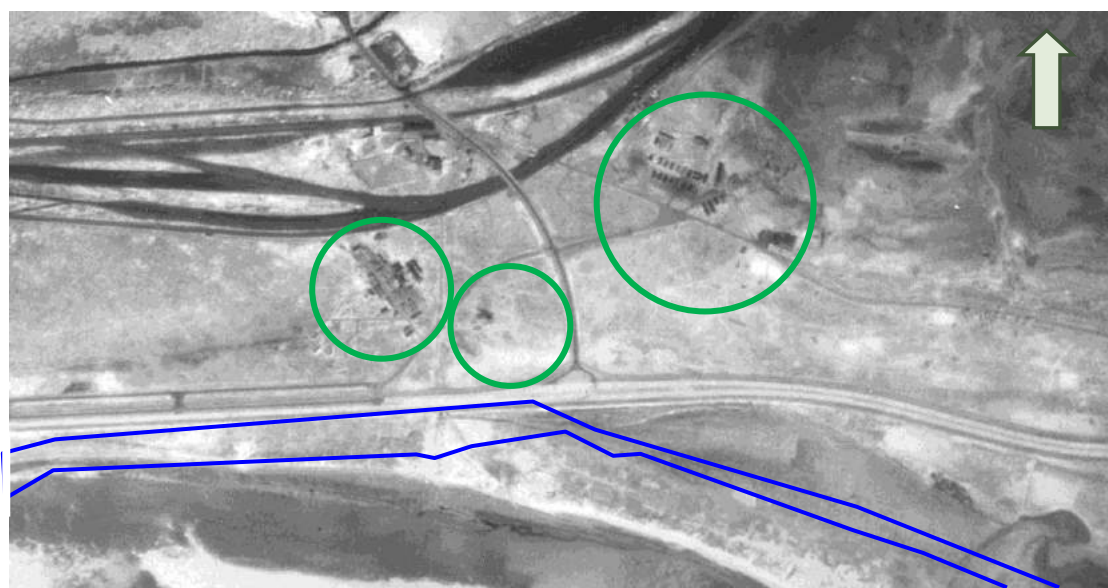
### 9.1 Jersey Marine Camp

During WWII, military personnel were stationed at a camps located south of Jersey Marine, including 1No. located approximately 0.1km north of the east-central part of the Site.

In addition to accommodating personnel stationed at the Jersey Marine HAA and ZAA batteries (see Section 4.2.5), the camps were used to a billet Home Guard and regular army units, tasked with undertaking patrols and manning anti-invasion defences. 285 and 318 Company Pioneer Corps were also stationed at the camps and were involved in the construction and maintenance of anti-invasion defences in the region.

Plate 16 is an aerial photograph, dated the 13<sup>th</sup> May 1950, showing the locations occupied by the camps.

**Plate 16** Aerial photograph showing the location of Jersey Marine camps, 13<sup>th</sup> May 1950



Source: Welsh Government

Not to Scale

#### Legend

Site boundary



Military camp location



It is likely, given its role within the Swansea Defence Scheme, that munitions stores would have been located at the camp.

No records have been found indicating that activity associated with the camps encroached upon the Site. Whilst the possibility of the localised disposal of munitions cannot be fully discounted, these camps are not considered to provide a significant source of UXO hazard to the Site.

## 10 MARINE ORDNANCE HAZARDS

Both wartime and peace time military and naval activities provide numerous sources of UXO within the marine environment. The principal sources of UXO hazards are from ordnance disposal at sea, WWII aerial laid mines, mines laid as beach defences, crashed aircraft and wrecks containing ordnance.

Clearance certification for UXO within a marine environment may be valid only for a limited period as storms, tides and general current movement can cause UXO to migrate into an area that may have been cleared of UXO only hours before. This also makes it very difficult to accurately predict where UXO may be found.

UXO is most likely to be concentrated on and immediately around the principal sources of the UXO hazard. These are typically ordnance disposal sites at sea, WWII mines, marine ranges and wrecks containing ordnance.

### 10.1 Marine Ranges

The nearest marine ranges to the Site are described below.

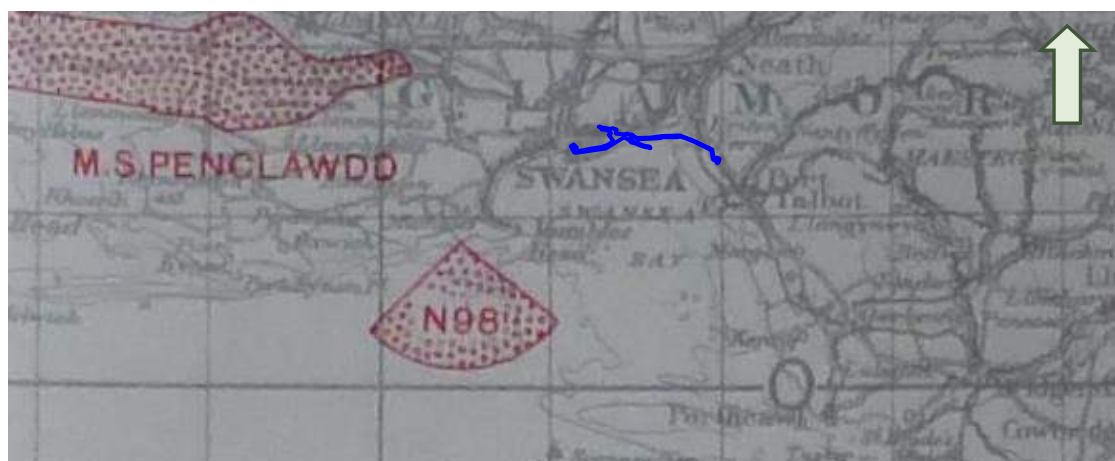
#### 10.1.1 Langland Bay AA Range N98

During WWII a range was established for Defensively Equipped Merchant Ships (DEMS) at Langland Bay, approximately 9.8km southwest of the Site.

This was used by merchant vessels, which had been converted for military use with the addition of LAA guns. The range was used to train crews in the use of these weapons, which were fired out to sea, away from the Site.

Figure 9 is an extract of a plan of WWII ranges located in the region, showing the location of Langland Bay Range.

**Figure 9** Extract of plan showing Langland Bay Range N98, 1945



Source: National Archives

Not to Scale

#### Legend

Site boundary ———

Langland Bay Range is not considered to provide a significant source of UXO hazard to the Site, although it may contribute to the general background risk of UXO in the marine environment.

### 10.1.2 Margam Bombing Range

In April 1939, an air-to-ground bombing range was established on Margam Sands, approximately 12.1km south-southeast of the eastern end of the Site.

The range consisted of 4No. targets located on sand dunes, which were used by No. 9 Armament Training Station, equipped with de Havilland Mosquito fighter-bomber aircraft.

Figure 10 is a plan showing the extent of the range.

**Figure 10** Plan of Margam Sands Bombing Range, WWII



Source: Glamorgan-Gwent Archaeological Trust

Not to Scale

The range was closed after WWII.

Margam Bombing Range is not considered to provide a significant source of UXO hazard to the Site, although it may contribute to the general background risk of UXO in the marine environment.

## 10.2 Marine Mines

During WWI, approximately 128,000No. mines were laid in the sea around the coast of the UK. At the beginning of WWII, the Admiralty ordered the laying of further extensive minefields around the coast of England. This included both defensive mines on beaches in order to prevent enemy landings, as well as approximately 100,000No. marine mines laid at sea to destroy enemy ships.

Known marine minefields were cleared at the end of WWII using the original layout plans, although less than 30% of the total number of sea mines were cleared as many were moved from their original positions by tidal currents. As a result there is a possibility that some remain in the marine environment and a mine can be washed up on a beach or found drifting in the water around any part of the UK's coastline.

Marine mines typically carried 100 to 500lbs (50 to 250kg) of explosive. The initiating mechanisms in these mines have often deteriorated but the explosive charges will not have significantly altered unless the mine has split and the explosives have migrated and dispersed in the marine environment.

No records have been found indicating that marine mines were present on the Site.

Records indicate that more than 20No. marine mines have been discovered in Swansea Bay since the beginning of WWII, mostly between 1942 and 1943. The most recent incident is described below.

#### **26<sup>th</sup> October 2006**

1No. UX WWII sea mine was caught in fishing nets in Swansea Bay, within approximately 5km south of the Site. This was destroyed the next day in a controlled explosion.

Mines are not considered to provide a source of UXO hazard to the Site with the possible, albeit unlikely exception, of buoyant marine mines migrating onto the Site.

### **10.3 Wrecks Containing UXO**

No records have been found indicating that any wrecks are located on the Site.

The nearest recorded WWII wreck is the SS Foremost 49 (Wreck No. 69929) which sank with a cargo of waste on the 19<sup>th</sup> September 1942, approximately 0.2km west of the Site. The wreck has since been removed from the dredged channel at the entrance to Swansea Docks.

Wrecks are not considered to provide a source of UXO hazard to the Site.

### **10.4 Munitions Disposal at Sea**

No records have been found indicating that munitions disposal occurred on or in close proximity to the Site.

An offshore spoil ground, approximately 3km south of the Site, was used during WWII. There is a possibility, albeit very unlikely, that rubble from the bomb-damaged areas of Swansea was disposed of at this location. This could potentially contain UXO.

Offshore munitions disposal is not considered to provide a source of UXO hazard to the Site.

## 11 OFFSHORE CURRENTS AND UXO

In most cases, because of mass, the largest items of UXO are unlikely to be transported very far from their original locations in the majority of marine environments. It is more likely that any large UXO on the seabed will be periodically exposed by scour and then reburied by migrating sediment.

An exception to this would be buoyant or semi-buoyant UXO, as may be the case with some marine mines; smaller, lighter items of UXO, such as small shells and Small Arms Ammunition (SAA); or UXO with neutral buoyancy which could roll as bed load particles.

The following factors influence the likely migration of UXO in the marine environment in the proximity of the Site.

### 11.1 Tidal Currents

Swansea Bay has a high tidal range of approximately 8.5m to 10.2m during spring tides and up to 8.3m during neap tides, with correspondingly strong tidal currents.

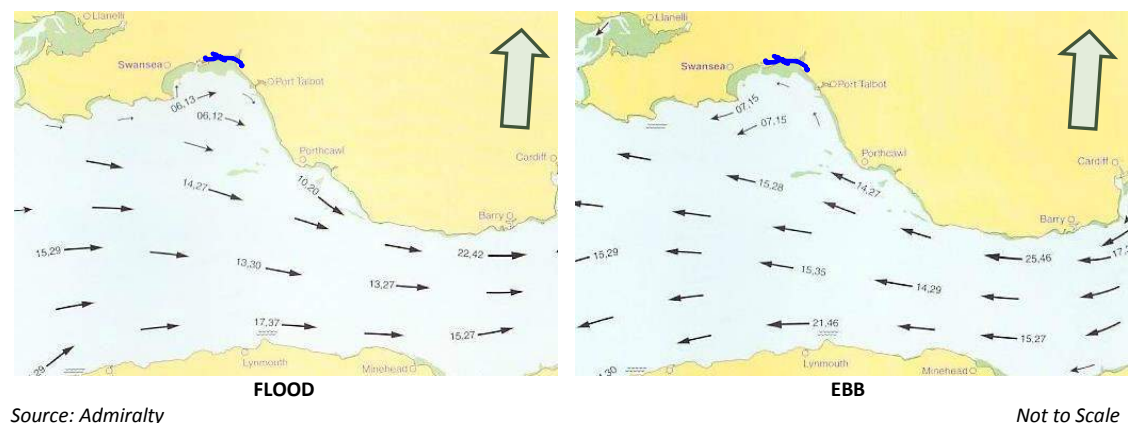
The Swansea Bay coastal tidal current pattern is controlled by the main currents along the northern Bristol Channel. There is a general clockwise residual current and suspended sediment transport circulation pattern around Swansea Bay, which operates as a semi-closed system.

Ebb flow is predominantly west or south-westward, with a northern stream near Port Talbot. Flood flow is east or north-eastwards in the west, becoming south-eastward towards Port Talbot.

Some of the deeper parts of the bay show ebb tide dominance but flood dominance is characteristic over many of the shallow sub-tidal and intertidal areas.

Typical tidal streams are shown in Figure 11.

**Figure 11** Typical tidal streams in the vicinity of the Site

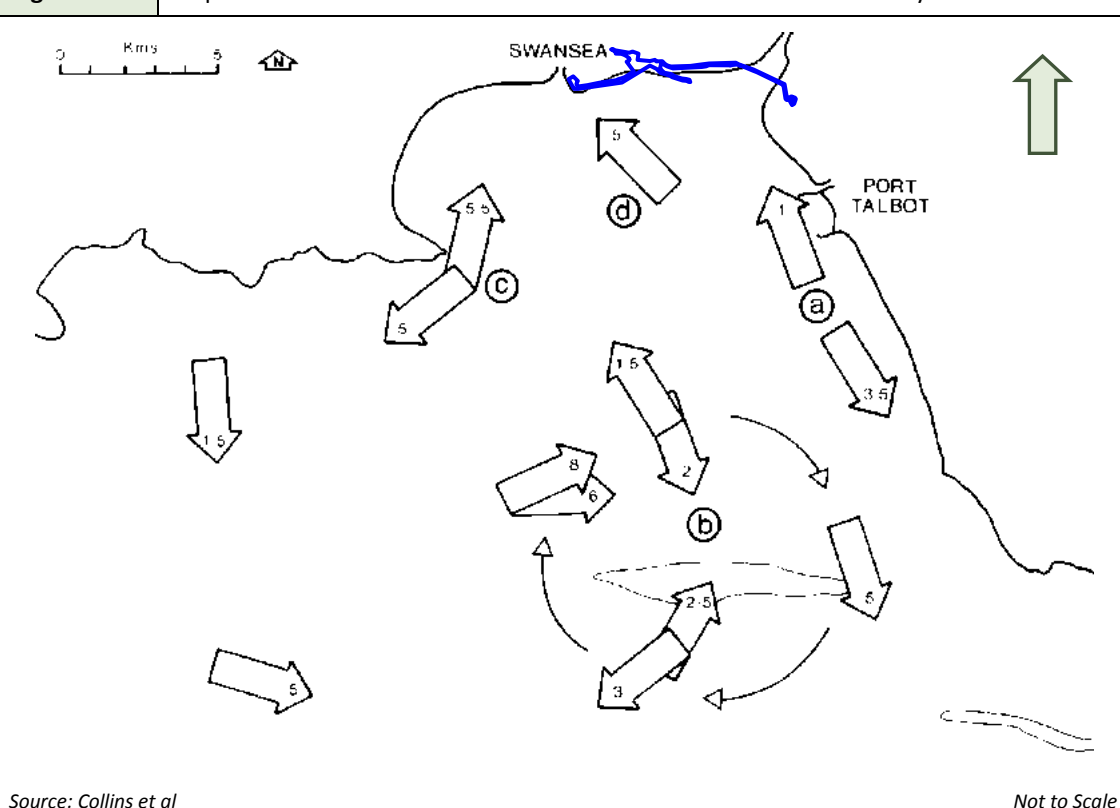


**Legend** Site boundary —

Offshore tidal streams may exceed  $2.4\text{ms}^{-1}$  in the extreme southern part of the bay. Elsewhere the currents are controlled mostly by channel geomorphology and water depth. Peak near and offshore velocities are highest in deeper water, but for spring tides they are generally less than  $1.5\text{ms}^{-1}$ .

Figure 12 is a schematic map of the mean tidal and residual current circulation in Swansea Bay. The upper arrows show mid-depth and the lower arrows show bed currents, both in  $\text{cms}^{-1}$ .

**Figure 12** Map of the mean tidal and residual current circulation in Swansea Bay



**Legend** Site boundary 

Bed stresses created by these tidal currents alone are sufficient to entrain sand and fine gravel, but they act in conjunction with waves to transport other material both onshore and offshore, as described in the following sections.

## 11.2 Wave Action

Wave data demonstrates that high energy wave conditions prevail in Swansea Bay.

Prevailing wave direction offshore is from the southwest which also coincides with the longest fetch.

Short-term observations along the eastern Swansea Bay shoreline have recorded extreme wave heights of >7m and 5m to 6 m is not uncommon during storms. Extreme near shore wave heights generally decrease westwards, in the lee of Mumbles Head.

Severe storms are capable of moving significant quantities from deeper water in the outer parts of Swansea Bay towards the shoreline on the eastern side of the Bay, where it becomes available for re-distribution by 'normal' wave and longshore current processes.

The wave action dominates the near shore sediment transport and littoral drift in Swansea Bay which may influence UXO migration, as detailed in the following section.

### 11.3 Sediment Pathways

Swansea Bay operates as a partially enclosed sediment circulation system with limited input of new sediment from deeper parts of the Bristol Channel or from the Rivers Taw, Afan and Neath.

Sediment distribution and transport in Swansea Bay are controlled by tidally and wave-induced current patterns, but are also related to bathymetry and the exposure of seabed deposits.

The seabed sediments in the Bristol Channel consist mainly of sands, muddy sands and gravelly sands, although much of the Inner Bristol Channel sea floor is swept bare of significant sediment accumulations by strong tidal currents. Areas of slightly muddy sands occur in the northern Swansea Bay. The thickness of sediments exceeds 20m in some places but is generally <10 m.

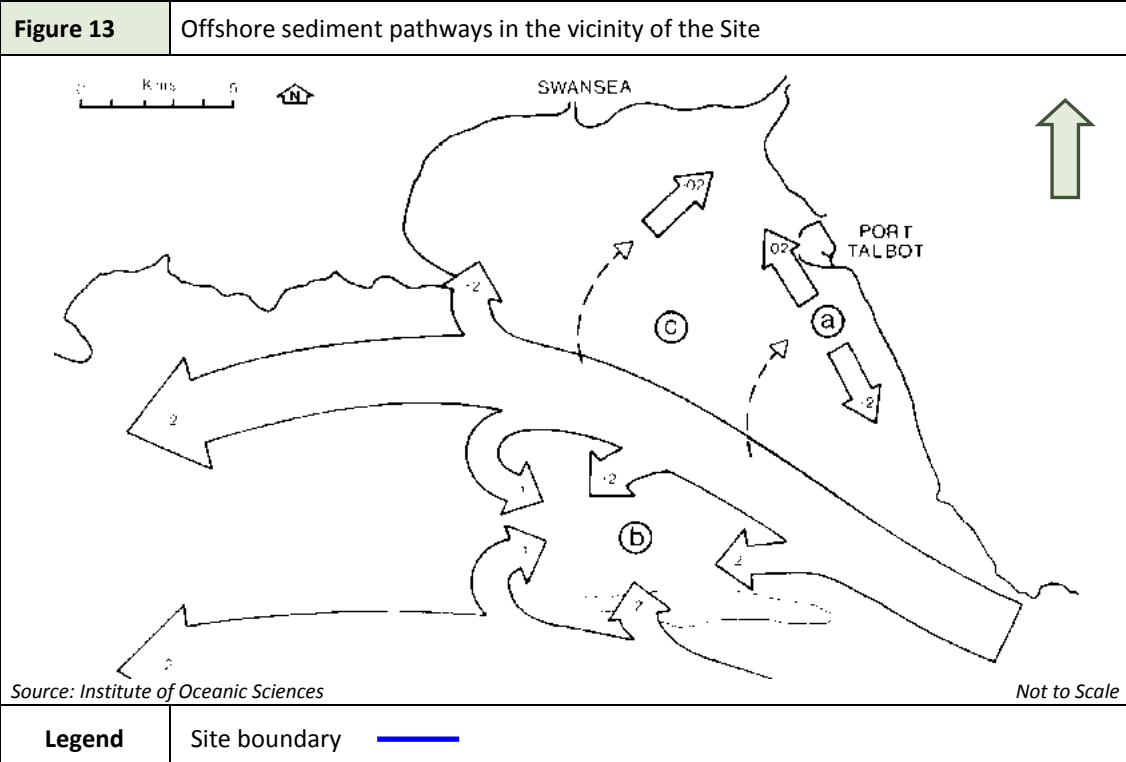
Net littoral drift operates from west to east within Swansea Bay and across the Site, although the sheltering effects of Mumbles Head, together with strong tidal currents, result in a complex transport regime in the bay.

South westerly waves and storm tides transport sand from south of Mumbles Head to the northern and eastern parts of the bay.

For loosely consolidated seabed material, bed load transport under spring tidal conditions with little wave action is towards the west, but it is towards the east under neap tides with superimposed wave action. Net long term near bottom sediment transport is landwards in the shallower water closer to the coast.

It has been estimated that the bed load and near bottom sediment movement across the mouth of the bay approaches 2 tonnes  $m^{-1} d^{-1}$ . This decreases to 0.2 tonnes  $m^{-1} d^{-1}$  towards the central and northern part of Swansea Bay where tidal currents are weaker.

Figure 13 shows the offshore sediment pathways in the vicinity of the Site.



It should be noted that local dredging activities influence the sedimentation processes. The proposed works include using 7.3 million m<sup>3</sup> of sediment abstracted from the lagoon seabed in Swansea Bay as a core fill. It is considered unlikely, given the use of modern dredging techniques, that this dredged material will provide a source of UXO hazard to the Site.

#### 11.4 UXO Migration

Given the tidal streams, wave action and pattern of sediment movement in the vicinity of the Site, as detailed above, it is considered that the largest items of UXO in the marine environment could not be transported.

Most common for large UXO, which are too heavy for the long shore drift, waves and near shore currents to move, is for them to be exposed by scour around them and then be left proud of the sediments.

It is possible that onshore UXO sources have been liberated into the marine environment by coastal erosion after WWII and before post-WWII sea defences were put in place. If small or buoyant enough, such UXO could migrate across the Site.

It is considered that buoyant UXO (as may be the case with some marine mines), smaller, lighter items of UXO (such as small and medium sized shells) and SAA could roll as bed load particles during high wave energy storm conditions. Such conditions may provide a pathway for UXO migration onto the Site.

No significant sources of UXO hazard have been identified in the marine environment in the immediate vicinity of the Site.

The potential migration of marine UXO onto the Site forms part of the low background risk of encountering UXO on any similar site in the UK.

## 12 EXPLOSIVE ORDNANCE CLEARANCE ACTIVITIES

Official UK bombing statistics have been compiled from both British and German sources. There were differences in the way the figures were originally reported and collated which has led to discrepancies in the summary data.

Based on data from 1939 to 1945, War Office statistics indicate that 200,195No. HE bombs exploded within Great Britain. Additionally, 25,195No. HE bombs (representing 11%) were recorded as UXBs. However, records from the Royal Engineers who were responsible for bomb disposal at the time indicate that as of 27<sup>th</sup> February 1946 upwards of 45,000No. UXBs were disposed of.

On average 8.5% UXBs later self-exploded. In some cases the bombs had delayed action fuzes or were never intended to explode, their purpose being to cause inconvenience and fear.

Given the discrepancy in records and the fact that UXBs are still being found unexpectedly, it is clear that the original figures are understated and provide only an approximation of the number of potential UXBs in the UK.

War Office statistics also show that between October 1940 and May 1941 most of the UXBs (93%) were either 50kg or 250kg. It should be noted that details of the recovery and the size of the UXB were not always accurately reported.

The larger WWII UXBs are often difficult to recover due to both penetration depths and the presence of two or more fuzes, combined with more sensitive fillings of explosive mixtures including Amatol and Trialen.

### 12.1 Abandoned Bombs

No records of any officially abandoned bombs on the Site have been found.

### 12.2 EOC Tasks

The MoD has provided information of the following official EOC tasks in the vicinity of the Site. These incidents are believed to be associated with ordnance disposal at smelting works located in the area, discussed in Section 9.3.

#### July 1967

3No. empty British 500lb HE bombs were discovered approximately 0.5km north of the Site. They were all destroyed in situ.

#### May 2000

During the landscaping of the Baglan Energy Park, within 1km of the Site, several items of UXO were discovered. These include 1No. empty 250lb HE bomb, 1No. LIVENS container and 1No. suspected HE Bomb. These were all destroyed in situ.

#### 25<sup>th</sup> July 2001

1No. 4.5" naval shell was discovered in the immediate vicinity of the eastern area of the Site. It was removed and destroyed.

### 12.3 Demilitarisation Activities

In South Wales, it was common for Demilitarised (Demil) ordnance to be sold off for scrap to local steel merchants and smelting works which would use the high-grade steels from the ordnance casing.

This has led to EOC tasks at several smelting works in the region when UXO was occasionally discovered amongst the scrap metal. This is believed to account for the EOC tasks described above.

No evidence has been found to indicate that any smelting works or alike have ever been present on the Site. No records of Demil activity on the Site have been found.

It is known that waste from Demil activity was dumped at Baglan Bay in the immediate vicinity of the eastern end of the Site. Therefore the possibility of such items being dumped on the Site in this location cannot be totally discounted.

The construction of the power station buildings on the eastern end of the Site will have mitigated the risk of UXO within the depths and extents of any intrusive works.

Ordnance related with Demil activity is usually inert and in the unlikely event that ordnance is found in proximity of the eastern end of the Site it must be treated as live until positively identified otherwise.

## 13 UXO HAZARD ASSESSMENT

### 13.1 UXO Hazard Level

The definitions for the levels of UXO hazard are provided below.

#### Definitions of UXO Hazard Level for a Site

| Hazard Level     | Definition                                                                                                    |
|------------------|---------------------------------------------------------------------------------------------------------------|
| <b>Very Low</b>  | There is positive evidence that UXO is not present, e.g. through physical constraints or removal.             |
| <b>Low</b>       | There is no positive evidence that UXO is present, but its occurrence cannot be totally discounted.           |
| <b>Moderate</b>  | There is positive evidence that ordnance was present and that other uncharted ordnance may be present as UXO. |
| <b>High</b>      | There is positive evidence that UXO is present.                                                               |
| <b>Very High</b> | As high, but requires immediate or special attention due to the potential hazard.                             |

#### Western part of the Site

During WWII, 3No. heavy raids were recorded in the vicinity of the western part of the Site at Swansea Docks, with at least 11No. HE bombs falling in the immediate vicinity. Given that this Site part of the Site comprised important dock infrastructure and hardstanding, it is considered unlikely that a UXB impact would have been missed.

No other significant sources of UXO hazard have been identified on this part of the Site, which is assigned a low UXO hazard level.

#### Central part of the Site

Records indicate that at least 30No. HE bombs fell in the immediate vicinity of the central part of the Site during heavy raids in WWII.

Given the high localised bombing density, and that this part of the Site mostly comprised sand dunes, it is considered that a UXB may have fallen unnoticed and remained in situ.

It is considered prudent to assign this part of the Site a moderate UXO hazard level.

#### Eastern part of the Site

No records have been found indicating that the eastern part of the Site was bombed, which was in an area with a low localised bombing density during WWII.

No other significant sources of UXO hazard have been identified on this part of the Site, which is assigned a low UXO hazard level.

#### Offshore UXO Hazard

No significant sources of marine UXO hazard have been identified in the immediate vicinity of the Site, although offshore firing ranges were located along the South Wales coast during WWII.

Given the tidal streams, wave action and pattern of sediment movement in the vicinity of the Site, it is considered that the largest items of UXO in the marine environment could not be transported. It is considered that small items of UXO and small arms ammunition could roll as bed load particles during high wave energy storm conditions. Such conditions may provide a pathway for UXO migration onto the Site, which provides part of the background risk to any similar site in the United Kingdom.

It is therefore considered that the UXO hazard level on the Site can be zoned from low to moderate, as shown in Figures 14, 15 and 16.

**Figure 14** UXO hazard zone plan of the Site (western part of the Site)



Source: Bing Maps

Not to Scale

|        |          |                                                                                     |           |                                                                                     |               |                                                                                       |
|--------|----------|-------------------------------------------------------------------------------------|-----------|-------------------------------------------------------------------------------------|---------------|---------------------------------------------------------------------------------------|
| Legend | Very Low |  | Low       |  | Moderate      |  |
|        | High     |  | Very High |  | Site boundary |  |

**Figure 15** UXO hazard zone plan of the Site (central part of the Site)



Source: Bing Maps

Not to Scale

|               |          |                                                                                   |           |                                                                                   |               |                                                                                     |
|---------------|----------|-----------------------------------------------------------------------------------|-----------|-----------------------------------------------------------------------------------|---------------|-------------------------------------------------------------------------------------|
| <b>Legend</b> | Very Low |  | Low       |  | Moderate      |  |
|               | High     |  | Very High |  | Site boundary |  |

**Figure 16** UXO hazard zone plan of the Site (eastern part of the Site)



Source: Bing Maps

Not to Scale

|               |          |                                                                                     |           |                                                                                     |               |                                                                                       |
|---------------|----------|-------------------------------------------------------------------------------------|-----------|-------------------------------------------------------------------------------------|---------------|---------------------------------------------------------------------------------------|
| <b>Legend</b> | Very Low |  | Low       |  | Moderate      |  |
|               | High     |  | Very High |  | Site boundary |  |

The extents of the UXO hazard level zoning on the Site are summarised in Table 4.

| <b>Table 4</b>    | UXO hazard assessment for the Site       |              |             |
|-------------------|------------------------------------------|--------------|-------------|
| Hazard Assessment | Potential Hazard                         | OSNGR (from) | OSNGR (to)  |
| Low               | No significant sources of UXO identified | SS 66909200  | SS 69399297 |
| Moderate          | UXB from WWII bombing                    | SS 69399297  | SS 71719323 |
| Low               | No significant sources of UXO identified | SS 71719323  | SS 73309250 |

## 14 UXO RISK ASSESSMENT

### 14.1 UXO Risk Level

A UXO risk assessment has been undertaken for the proposed works, taking into consideration the identified UXO hazard.

Firstly, the probability of encountering UXO (PE) has been considered and rated for the different construction techniques, as detailed below.

| Probability of Encounter (PE)                | Rating |
|----------------------------------------------|--------|
| Frequent, highly likely, almost certain.     | 5      |
| Probable, more likely to happen than not.    | 4      |
| Occasional, increased chance or probability. | 3      |
| Remote, unlikely to happen but could.        | 2      |
| Improbable, highly unlikely.                 | 1      |
| Impossible                                   | 0      |

Secondly, the probability of detonating a UXO (PD) has been considered and rated for the different construction techniques, as detailed below.

| Probability of Detonation (PD)               | Rating |
|----------------------------------------------|--------|
| Frequent, highly likely, almost certain.     | 5      |
| Probable, more likely to happen than not.    | 4      |
| Occasional, increased chance or probability. | 3      |
| Remote, unlikely to happen but could.        | 2      |
| Improbable, highly unlikely.                 | 1      |
| Impossible                                   | 0      |

Next, the probability of encountering and detonating the UXO (PE x PD) have been used to generate an overall likelihood rating (P).

| P = PE x PD | LIKELIHOOD of Encounter and Detonation       | Rating |
|-------------|----------------------------------------------|--------|
| 20 to 25    | Frequent, highly likely, almost certain.     | 5      |
| 13 to 19    | Probable, more likely to happen than not.    | 4      |
| 6 to 12     | Occasional, increased chance or probability. | 3      |
| 2 to 5      | Remote, unlikely to happen but could.        | 2      |
| 1           | Improbable, highly unlikely.                 | 1      |
| 0           | Impossible                                   | 0      |

**P ranges from 25, a certainty of UXO being encountered and detonated on the Site by engineering activity, to 0, a certainty that UXO does not occur on the Site and will not be detonated by engineering activity.**

The likelihood of encountering and detonating UXO during site works is multiplied by the severity of such an event occurring ( $P \times S$ ), in order to provide a risk level using the following matrix.

| Severity (S)                                            | Rating |
|---------------------------------------------------------|--------|
| Multiple fatalities                                     | 5      |
| Major injury, long term health issues, single fatality. | 4      |
| Minor injury, short term health issues, no fatalities.  | 3      |
| First aid case but no lost time or ill health.          | 2      |
| Minor injuries, no first aid.                           | 1      |
| No injuries.                                            | 0      |

| UXO Risk Matrix |              |    |    |    |    |   |   |
|-----------------|--------------|----|----|----|----|---|---|
| LIKELIHOOD (P)  | SEVERITY (S) |    |    |    |    |   |   |
|                 |              | 5  | 4  | 3  | 2  | 1 | 0 |
|                 | 5            | 25 | 20 | 15 | 10 | 5 | 0 |
|                 | 4            | 20 | 16 | 12 | 8  | 4 | 0 |
|                 | 3            | 15 | 12 | 9  | 6  | 3 | 0 |
|                 | 2            | 10 | 8  | 6  | 4  | 2 | 0 |
|                 | 1            | 5  | 4  | 3  | 2  | 1 | 0 |
|                 | 0            | 0  | 0  | 0  | 0  | 0 | 0 |

The final risk assessment for the Site is given in Table 5.

| Table 5                                                                                | UXO risk assessment for the Site |                     |    |    |             |            |          |             |          |
|----------------------------------------------------------------------------------------|----------------------------------|---------------------|----|----|-------------|------------|----------|-------------|----------|
| Hazard Zone                                                                            | Potential UXO Hazard             | Anticipated Works   | PE | PD | P = PE x PD | Likelihood | Severity | Risk Rating | UXO Risk |
| Mod                                                                                    | UXB                              | Shallow Excavations | 3  | 2  | 6           | 3          | 5        | 15          | Moderate |
|                                                                                        |                                  | Deep Excavations    | 4  | 3  | 12          | 3          | 5        | 15          | Moderate |
|                                                                                        |                                  | Piling/boreholes    | 2  | 4  | 8           | 3          | 4        | 12          | Moderate |
|                                                                                        | Other UXO                        | Shallow Excavations | 1  | 1  | 1           | 1          | 4        | 4           | Low      |
|                                                                                        |                                  | Deep Excavations    | 1  | 1  | 1           | 1          | 4        | 4           | Low      |
|                                                                                        |                                  | Piling/boreholes    | 1  | 1  | 1           | 1          | 3        | 3           | Low      |
| Low                                                                                    | UXB                              | Shallow Excavations | 1  | 1  | 1           | 1          | 5        | 5           | Low      |
|                                                                                        |                                  | Deep Excavations    | 1  | 1  | 1           | 1          | 5        | 5           | Low      |
|                                                                                        |                                  | Piling/boreholes    | 1  | 1  | 1           | 1          | 4        | 4           | Low      |
|                                                                                        | Other UXO                        | Shallow Excavations | 1  | 1  | 1           | 1          | 4        | 4           | Low      |
|                                                                                        |                                  | Deep Excavations    | 1  | 1  | 1           | 1          | 4        | 4           | Low      |
|                                                                                        |                                  | Piling/boreholes    | 1  | 1  | 1           | 1          | 3        | 3           | Low      |
| PE (Probability of Encounter), PD (Probability of Detonation), P (Overall Probability) |                                  |                     |    |    |             |            |          |             |          |
| Shallow excavations defined as <1.0m below ground level (bgl).                         |                                  |                     |    |    |             |            |          |             |          |

| UXO Risk  | Matrix Rating | Definition                                                                                                                                                                                          |
|-----------|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Very Low  | 0-1           | Little action is required by the client provided that suitable records and procedures are in place to ensure appropriate action is undertaken should the UXO risk level change.                     |
| Low       | 2-5           | Tolerable to the client as engineering activity need not alter if UXO related procedures and controls are strictly adhered to.                                                                      |
| Moderate  | 6-15          | May be tolerable for the client, but it is prudent to reduce the risk where cost effective and reasonably practicable.                                                                              |
| High      | 16-20         | Tolerable to the client only where further risk reduction is impracticable or disproportionate to the risk involved. Essential that all practicable measures are taken to reduce the level of risk. |
| Very High | 21-25         | Unacceptable to the client except in extraordinary circumstances. Imperative that all control measures are taken.                                                                                   |

## 14.2 Risk Mitigation Recommendations

To ensure that the UXO risk is reduced to As Low As Reasonably Practicable (ALARP) the following mitigation is advised:

### Low Risk

#### Excavations

To ensure that the UXO risk is reduced to As Low As Reasonably Practicable (ALARP) the following mitigation is advised:

#### UXO Awareness Induction

All staff should have an awareness of the UXO hazard through the site induction process. It is important to ensure that any persons undertaking intrusive works, such as excavation, are made aware of the potential of uncovering UXO and what to do if a suspect item is encountered.

This awareness is to be provided through formal UXO awareness inductions. Typically ~1hour in duration, these briefings will be expected to provide site workers with:-

- Background to the potential UXO hazards that could be encountered.
- Awareness of how the UXO hazard could present a risk.
- Knowledge of what to do in the event that a suspect item is encountered.

The UXO awareness induction is to be provided along with back-up materials such as UXO awareness posters, emergency contacts numbers and other background information to assist site workers in becoming familiar with what potential UXO can look like. The materials can also be used by key staff to cascade out the salient points of the induction to others who visit or work on the Site.

By providing the UXO awareness induction, it ensures that in the unlikely event that UXO is encountered:

- All site staff take appropriate action.
- The likelihood of harm to persons or property is reduced.
- Delays in works can be minimised.

It is the responsibility of the contractor to ensure that all staff have received an appropriate UXO awareness induction. A combination of identification badges and helmet stickers can be used to provide confirmation that staff onsite have undergone such an induction.

Where a low risk of UXO encounter is anticipated, industry good practice is simply to raise the awareness of those involved in excavations so that in the unlikely event that a suspect item is discovered, appropriate action is taken. This can be achieved through UXO awareness briefings to site staff.

#### **Boreholes/Piling**

Clearance certification for borehole or pile locations is considered prudent only if a zero tolerance to risk is adopted. Zero tolerance is commonly adopted for sites that have safety critical infrastructure such as nuclear establishments and oil refineries.

### **Moderate Risk**

#### **Excavations**

For those involved in excavations, the raising of awareness (as per low risk) is considered essential.

Non-intrusive UXO detection methods and intrusive investigation of identified targets is recommended where practical.

Where UXO detection is not feasible due to ground conditions, restricted access or programme, an Explosive Ordnance Clearance (EOC) Engineer can be used to supervise during excavation works.

The EOC Engineer will carry out a visual assessment on any suspect items uncovered and classify them as potential UXO or other material.

#### **Boreholes/Piling**

Clearance certification for any borehole or pile locations is considered essential. This can be achieved by advancing a magnetometer into the ground at the borehole or pile location in order to provide detection of ferrous metal targets such as UXB.

Table 6 gives recommended actions in relation to the potential UXO risk level and the anticipated Site activity.

Further advice on the mitigation methods can be provided by Zetica on request.

| Table 6                               |                                                                                                                 | Risk mitigation for assumed Site activities                                                                                                                                                                |                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                      |  |
|---------------------------------------|-----------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| Risk Level                            | Typical Future Activity on the Site                                                                             |                                                                                                                                                                                                            |                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                      |  |
|                                       | None                                                                                                            | Shallow Excavations (<1.0m)                                                                                                                                                                                | Deep Excavations (>1.0m)                                                                                                                                                                                   | Boreholes or Pile Construction                                                                                                                                                                                                                                                                       |  |
| Very low                              | Ensure suitable records and procedures are in place to highlight the risk should future development be planned. | Ensure site staff, are informed as part of the site safety induction that the potential presence of UXO cannot be discounted.<br><br>Appropriate action is required to be detailed within site procedures. | Ensure site staff, are informed as part of the site safety induction that the potential presence of UXO cannot be discounted.<br><br>Appropriate action is required to be detailed within site procedures. | Ensure site staff, are informed as part of the site safety induction that the potential presence of UXO cannot be discounted.<br><br>Appropriate action is required to be detailed within site procedures.                                                                                           |  |
| Low                                   | As very low.                                                                                                    | As very low.<br><br>+ It is considered prudent to include some UXO awareness training in site inductions.                                                                                                  | As very low.<br><br>+ It is considered prudent to include some UXO awareness training in site inductions.                                                                                                  | As very low.<br><br>+Clearance certification for borehole or pile locations would be considered prudent only if a zero tolerance to risk is adopted.<br><br>Zero tolerance is commonly adopted for sites that have safety critical infrastructure such as nuclear establishments and oil refineries. |  |
| Moderate                              | As very low.                                                                                                    | As low.<br><br>+Non-intrusive investigation methods considered prudent where practical.<br><br>+Alternatively, EOC Engineer supervision is considered prudent.                                             | As low.<br><br>+Non-intrusive investigation methods considered prudent where practical.<br><br>+Alternatively, EOC Engineer supervision is considered prudent.                                             | As low.<br><br>+Clearance certification for borehole or pile locations is considered essential.                                                                                                                                                                                                      |  |
| High                                  | As very low.                                                                                                    | As moderate.<br><br>+Non-intrusive investigation methods considered essential where practical.<br><br>+ Alternatively, EOC Engineer supervision is considered essential.                                   | As moderate.<br><br>+Non-intrusive investigation methods considered essential where practical.<br><br>+ Alternatively, EOC Engineer supervision is considered essential.                                   | As moderate.                                                                                                                                                                                                                                                                                         |  |
| Very High                             | Requires immediate or special attention.                                                                        | Requires immediate or special attention.                                                                                                                                                                   | Requires immediate or special attention.                                                                                                                                                                   | Requires immediate or special attention.                                                                                                                                                                                                                                                             |  |
| The above table is for guidance only. |                                                                                                                 |                                                                                                                                                                                                            |                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                      |  |

## Appendices

### Appendix 1 WWII Bombing Incident List

#### 27<sup>th</sup> June 1940

6No. HE bombs fell near Danygraig Road, approximately 0.5km northwest of the north-western part of the Site.

#### 10<sup>th</sup> July 1940

4No. HE bombs fell near King's Dock, approximately 0.4km north-northwest of the western end of the Site. These caused serious damage to several goods sheds.

#### 18<sup>th</sup> July 1940

9No. HE bombs fell on and adjacent to the railway sidings near the Elba Works, within approximately 0.3km north of the west-central part of the Site.

1No. HE bomb fell adjacent to the railway south of Jersey Marine, approximately 0.4km north of the central part of the Site.

2No. HE bombs fell on the south bank of the River Nairn, approximately 0.4km northeast of the eastern end of the Site.

4No. HE bombs fell on Jersey Marine Golf Course, approximately 0.5km north of the east-central part of the Site.

#### 20<sup>th</sup> July 1940

6No. HE bombs fell near Elba Crescent, approximately 50m north of the west-central part of the Site.

1No. HE bomb fell on sand dunes near Jersey Marine, within approximately 0.1km of the central part of the Site.

#### 27<sup>th</sup> July 1940

2No. HE bombs fell near the Swansea Dock breakwater, approximately 0.2km southwest of the western end of the Site.

#### 30<sup>th</sup> July 1940

3No. HE bombs fell on the Elba Works, within approximately 0.3km north of the west-central part of the Site.

#### 28<sup>th</sup> August 1940

HE bombs (number unspecified) fell on the beach, within approximately 0.3km of the southern section of the central part of the Site.

#### 1<sup>st</sup> September 1940

251No. HE bombs and 1,000No. IBs fell across Swansea, including over Swansea Dock, in the vicinity of the western part of the Site. The exact locations for most of these incidents were not recorded.

IBs fell over the Ella Works, within approximately 50m north of the west-central part of the Site.

#### 2<sup>nd</sup> September 1940

1No. HE bomb fell near Elba Crescent, approximately 50m north of the central part of the Site. It was recorded as UXB.

2No. HE bombs fell near the Elba Football Ground, approximately 0.2km north of the central part of the Site. These were both recorded as UXB.

Several HE bombs fell on the beach in Baglan Bay, within approximately 0.3km of the eastern end of the Site.

Several craters were recorded on Jersey Marine Golf Course, approximately 0.3km north of the east-central part of the Site.

#### **14<sup>th</sup> September 1940**

100No. IBs fell on sand dunes south of Jersey Marine, within approximately 0.5km of the central part of the Site.

#### **24<sup>th</sup> September 1940**

1No. HE bomb fell in King's Dock, approximately 0.5km west-southwest of the north-western part of the Site.

#### **29<sup>th</sup> October 1940**

1No. HE bomb fell near the Elba Works, approximately 0.3km north of the west-central part of the Site. It was recorded as UXB.

#### **13<sup>th</sup> January 1941**

2No. HE bombs fell near King's Dock, within approximately 0.7km of the north-western part of the Site.

#### **17<sup>th</sup> January 1941**

178No. HE bombs and 7,000No. IBs fell across Swansea, including over Swansea Dock, in the vicinity of the western part of the Site. The exact locations for most of these incidents were not recorded.

18No. HE bombs fell on the beach south of Elba Crescent, in the immediate vicinity of the west-central part of the Site.

IBs fell across Ashleigh Terrace, approximately 0.4km north of the central part of the Site, starting several fires.

#### **28<sup>th</sup> February 1941**

1No. PM fell near Burrows Inn, north of King's Dock, approximately 0.5km west of the north-western part of the Site.

#### **19<sup>th</sup> – 21<sup>st</sup> February 1941**

The Swansea 'Three Night Blitz' took place. During these raids, 896No. HE bombs and more than 30,000No. IBs fell on the town. Approximately 112,000No. properties in the town were damaged or destroyed, mostly located in the town centre.

Due to the large numbers of bombs that fell during this raid, and the widespread fires caused by IBs, many incidents went unrecorded by the ARP wardens. The nearest recorded incidents are included below.

4No. HE bombs fell near the southern jetties in Queen's Dock, in the immediate vicinity of the western end of the Site.

IBs fell across the beach south of Elba Crescent, in the immediate vicinity of the west-central part of the Site

9No. HE bombs and large numbers of IBs fell between the King's Dock Works approximately 0.2km north of the west-central part of the Site, and Jersey Marine Airfield, approximately 0.4km south of the central part of the Site. The exact locations of these bombs was not recorded, and may have included the central part of the Site.

7No. HE bombs fell on the bank of the River Neath, approximately 0.5km north of the eastern part of the Site.

**17<sup>th</sup> March 1941**

IBs fell across Baglan Moors, in the vicinity of the eastern end of the Site.

**24<sup>th</sup> March 1941**

6No. HE bombs fell north of the Elba Works, approximately 0.5km north of the west-central part of the Site.

**22<sup>nd</sup> April 1941**

1No. HE bomb fell in the sea near Jersey Marine, approximately 0.3km south of the central part of the Site.

**16<sup>th</sup> February 1943**

3No. 500kg HE bombs fell on and damaged railway sidings northeast of Queen's Dock, adjacent to the north-western part of the Site. 1No. bomb was recorded as UXB and removed.

## Appendix 2 UXO Hazard and Ordnance Types

When assessing the risk from UXO including UXB, it is important to be aware of ordnance type and function. The following Section briefly describes the more common types of UXO. More data on these can be found at <http://zeticauxo.com/guidance/ordnance-data-sheets/>.

### A2.1 Small Arms Ammunition

Small Arms Ammunition (SAA) is one of the more recognisable categories of ordnance which is primarily designed for anti-personnel use. SAA include items such as bullets, generally up to a calibre (diameter) of 20mm.

Larger calibre small arms munitions can contain fuze mechanisms and high explosives or pyrotechnic fillings and may have been used for anti-aircraft or anti-vehicle purposes.

Generally small arms ordnance has a relatively low risk as UXO, although the larger calibre categories may have the same detonation risk as larger high explosive ordnance. SAA is often associated with discarded ammunition boxes around firing practice ranges. The Plate below illustrates some common SAA.

**Plate** Photograph of typical WWII small arms ammunition



Source: Google Images

## A2.2 Hand Grenades

Hand grenades can be filled with explosives or chemicals and have 3No. main parts, a body, a fuze with a pull ring and a safety-clip assembly. Fragmentation grenades are the most common and have a metal or plastic body filled with an explosive. Most use a burning delay fuze that functions for 3 to 5 seconds after the safety lever is released.

Some, such as smoke grenades, are activated instantly when the lever is released. The Plate below illustrates the typical character and condition of No. 36 hand grenades (Mills Bombs) that have been excavated from a site.

|              |                                                                     |
|--------------|---------------------------------------------------------------------|
| <b>Plate</b> | Photographs of a typical and an excavated WWII No. 36 hand grenades |
|--------------|---------------------------------------------------------------------|



Source: Google Images



Source: Zetica Ltd

## A2.3 Projected Grenades

Projected grenades are among the most commonly found UXO items, particularly the 40mm type. These contain high explosives and use a variety of fuzes, including some of the most sensitive internal impact-fuzing systems. They are extremely dangerous and can explode if moved or handled.

## A2.4 Mortars

A mortar is a short tube designed to fire a projectile at a steep angle. Mortars can range from approximately 50mm to 280mm in diameter and can be filled with explosives, toxic chemicals, white phosphorous or illumination flares. They generally have a thinner metal casing than projectiles, but use the same types of fuzing and stabilisation.

During WWII there are records that the target areas of RAF practice bombing ranges were occasionally used for mortar training.

The Plate below shows a typical 2-inch mortar bomb found (left) and a demonstration 3-inch mortar bomb (right).

|              |                                               |
|--------------|-----------------------------------------------|
| <b>Plate</b> | Photographs of WWII 2-inch and 3-inch mortars |
|--------------|-----------------------------------------------|



Source: Daily Mail



Source: Zetica Ltd

## A2.5 Shells

Shells are a projectile containing an explosive charge designed to burst the casing that can contain High Explosives, pyrotechnic compounds or other chemicals.

Shells can be found in a range of sizes, from <20mm to several times this size. The most likely shells to be found on the Site are Small Arms Ammunition (SAA) or UXAA shells that have fallen back to the ground unexploded.

Most commonly used anti-aircraft shells were 2" and 3.7" HE shells.

If fired and found as UXO, shells can offer a particular hazard from accidental detonation as they can have sensitive fuze mechanisms. A fuze is a device which incorporates mechanical, electrical, chemical or hydrostatic components to initiate a train of fire or detonation.

The Plate below is a photograph of a 3.7" UXAA shell found in Camberwell, London.

|              |                                                  |
|--------------|--------------------------------------------------|
| <b>Plate</b> | Photograph of a recently excavated 3.7" AA shell |
|--------------|--------------------------------------------------|



Source: Zetica Ltd

## A2.6 Incendiary Bombs

Incendiary Bombs (IBs) ranged from small 1kg thermite filled, magnesium bodied bombs to a 250kg 'Oil Bomb' (OB) and a 500kg 'C300' IB. By far the most common air dropped devices across the UK during WWII were small 1kg to 2kg IBs.

In some cases the IBs were fitted with a very small High Explosive (HE) bursting charge. This exploded after the bomb had been alight for a few minutes causing burning debris to be scattered over a greater area. The C300 bombs were similar in appearance to 500kg HE bombs.

The small amount of HE, if any, and the almost negligible potential for IBs to remain active after more than 65 years in the ground means that these items have very little prospect of causing damage. In the majority of cases if IBs are found in the ground, the incendiary materials have deteriorated to such an extent that they are considered to provide a low UXO hazard level.

However, since magnesium and phosphorus were common components in IBs, some localised chemical contamination may occur where the contents have leached out of the IB into the surrounding soil.

The Plate below shows a typical variety of fragmentary remains of IBs and 2No. IBs recovered by the Civil Defence during WWII.

### Plate

Photographs of typical fragmentary remains of IBs and a UXIB



Source: Swansea Museum



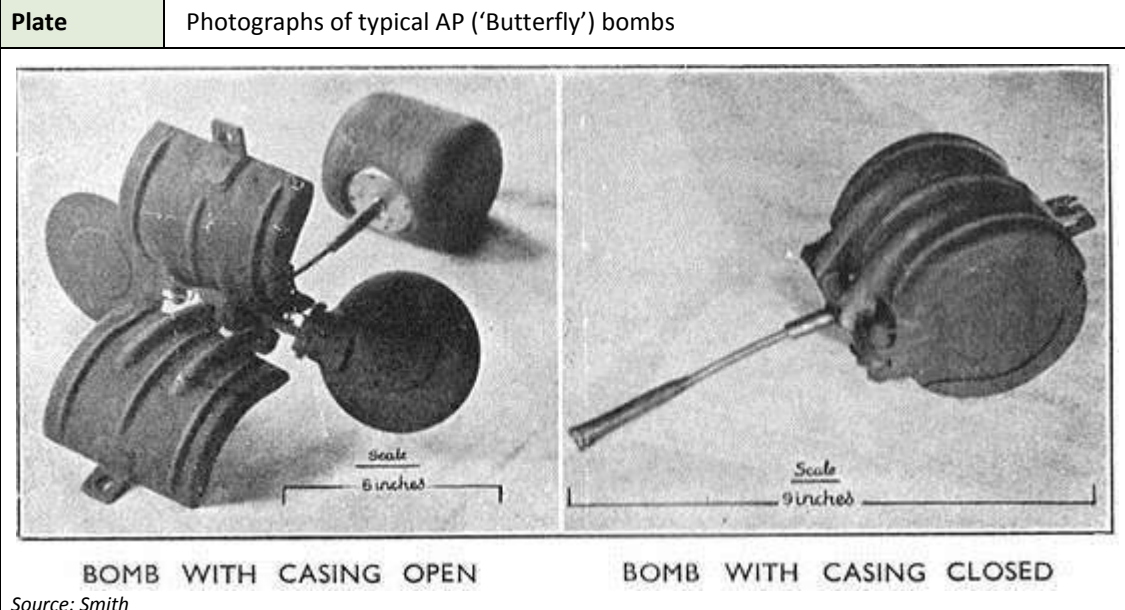
Source: Museum of London

## A2.7 Anti-Personnel Bombs

2No. types of Anti-Personnel (AP) bombs were in common use, the 2kg and the 12kg bomb. The 2kg bomb could inflict injury across an area up to 150m away from the impact, within 25m of this, death or fatal injury could occur.

In the majority of cases WWII AP bombs were so sensitive to disturbance that none have been found since WWII as UXAPB and it is considered very unlikely that such an item would be found buried as an UXAPB

The Plate below shows typical AP ('Butterfly') bombs recovered by the Civil Defence during WWII.



Source: Smith

## A2.8 German High Explosive Bombs

Probably the most common and certainly most publicised UXOs to be found in the UK are bombs. Air dropped bombs, as a result of WWII enemy action, are found on a relatively frequent basis as UXO. They tend to be highly publicised (at least on a local basis) due to the common disruption where an evacuation of the potentially affected area is put in place.

The amount of High Explosive and the potential for a fuze to still be activated means that these devices have the prospect of causing some of the most widespread damage. WWII bombs were particularly sophisticated for their time, with anti-tamper fuzes.

Many German bombs were designed to not explode on impact and instead to cause disruption as a UXB. Some fuzes were set with a delay time of over 70 hours. During this time, an anti-tamper fuze could also be activated to detonate should it be disturbed.

The most commonly used bombs during WWII were the 50kg and 250kg sized general purpose bombs. Less frequently, the 500kg bomb was also used. Larger bombs were used, but so infrequently that any assessment of hazard is more typically based on bombs ranging up to 500kg only.

It should be noted that the June 2008 find of a 1000kg bomb in London, does demonstrate that larger bombs can be found and any risk mitigation measures should consider this.

The Plate below shows the variety of UXB recovered by the Civil Defence during WWII.

|       |                                                                           |
|-------|---------------------------------------------------------------------------|
| Plate | Photograph of a variety of UXB recovered by the Civil Defence during WWII |
|-------|---------------------------------------------------------------------------|



Source: Imperial War Museum

## A2.9 Practice Bombs

Practice bombs were typically used on inland bombing ranges. 11.5lb practice bombs contained a small explosive charge and produced a coloured powder plume for daylight operations and a light flash for night operations. The Plate below shows a recovered 25lb practice bomb head and a complete 25lb WWII practice bomb.

|       |                                                               |
|-------|---------------------------------------------------------------|
| Plate | Photographs of 25lb WWII practice bomb head and practice bomb |
|-------|---------------------------------------------------------------|



Source: Zetica Ltd



Source: BOCN

## A2.10 Magnetic Mines

Magnetic mines are designed to lie at the bottom of relatively shallow water and explode when the earth's magnetic field become distorted by any large metal object such as a ship coming within range.

Luftwaffe aircraft laying mines on tidal rivers are known to have accidentally dropped magnetic mines on to land. It is unlikely that magnetic mines would remain in the ground as unexploded ordnance as they were approximately 2m long, normally dropped by parachute and were unlikely to penetrate the ground because of this. The same is true for other parachute mines.

The Plate below is a photograph of a typical WWII buoyant marine mine.

**Plate**

Photograph of buoyant marine mine



Source: [www.warhistoryonline](http://www.warhistoryonline)

### A2.11 Land Mines

Wartime activities provide numerous sources of UXO within the land environment. Whilst efforts have been made to clear the known British minefields, it was common for mines to become lost for a variety of reasons and so not recovered. Additionally, such munitions might have been disposed of on an unofficial basis and so no records were kept.

Most of the mined beaches and other land areas in the UK have been cleared by the MoD. Occasionally, wave action or activities such as bombing caused mines to become displaced and these were missed as part of any past clearance activities.

### A2.12 Canadian Pipe Mines

Often crudely made, pipe mines were pipes approximately 100mm in diameter and up to 55m long bored roughly horizontal beneath critical infrastructure such as airfield run ways, or angled between ten and thirty degrees into river banks in places where invasion forces may land.

The pipes were filled with explosives and usually a sensitive fuzing mechanism. With nitro-glycerine or Polar Blasting Gelignite (PBG) being the primary component, over time, these devices can become increasingly unstable.

### A2.13 Flame Barrels (Flame Fougasse)

Flame barrels were 40 gallon oil drums concealed by roadsides with built-in explosive charges designed to blast the flaming barrel onto the road in the path of oncoming enemy vehicles. The barrels were filled with oil and petrol, and a fulminate of mercury detonator was placed in the explosive charge.

#### A2.14 UXO Migration

It is possible for explosive material, UXO or ordnance scrap to migrate to a site during landfill or dredging operations or other ground works which import Made Ground or natural materials already containing UXO. It is important to understand the nature and age of such landfill or dredging operations when assessing the potential UXO hazard level on the site.

#### A2.15 Fluvial, Marine and Coastal UXO Hazards

Wartime activities provide numerous sources of UXO within the fluvial and marine environment. There were extensive minefields laid by the British to protect the approaches to the ports around the coast and convoys using the shipping lanes, as well as offshore anti-invasion barriers. There were also many German air and ship raids to lay mines in the coastal shipping lanes.

Clearance certification for UXO within a marine or fluvial environment may be valid only for a limited period because storms, tides and general current movement can cause UXO to migrate into an area that may have been cleared of UXO only hours before. This also makes it very difficult to accurately predict where UXO may be found.

#### A2.16 Effects and Consequences

There have been a limited number of recorded incidents in the UK since WWII where bombs have detonated during engineering works, though a significant number of bombs have been discovered. Incidents involving smaller ordnance are, however, relatively common in the UK.

In the UK, there are no recorded incidents since the decade after WWII, of a UXB accidentally detonating. In recent years, bombs have been found that have fuze mechanisms that have started to operate indicating that given the right conditions a UXB may still function.

In June 2008 the UXB uncovered in the Lea Valley caused difficulty to No. 33 Regiment (Explosive Ordnance Disposal) Royal Engineers because the fuze mechanism started to operate.

The 1,000kg 'Hermann' bomb, the first of this size to be found in over 30 years, took 5 days to deactivate. This demonstrates that larger bombs can be found and any risk mitigation measures should provide the option to deal with this size of device. Since WWII, UXBs have been found on a regular basis in London.

Since WWII, UXBs have been found on a regular basis throughout Britain. Some of the most recent cases are described below.

In May 2009 1No. 50kg WWII bomb was found on a building site in Bexhill-on-Sea, Sussex, and on the 16<sup>th</sup> August 2009, 1No. 250kg WWII bomb was found near Ebberston, North Yorkshire. Both of these were destroyed in controlled explosions by Bomb Disposal Units.

On the 8<sup>th</sup> March 2010 1No. 500kg WWII bomb was found at Bowers Marsh in Essex by Zetica EOC operatives following a Zetica desk study concluding a high risk of UXB on the site. The bomb was demolished in situ by members of the Army Royal Logistics Corps (RLC).

The Plate below is a photograph of the bomb in situ.

|              |                                                                              |
|--------------|------------------------------------------------------------------------------|
| <b>Plate</b> | Photograph of the 500kg WWII UXB at Bowers Marsh, 8 <sup>th</sup> March 2010 |
|--------------|------------------------------------------------------------------------------|



Source: Zetica Ltd

On the 23<sup>rd</sup> February 2011, 1No. WWII UXB was found on a building site in Notte Street in Plymouth City centre. The bomb was removed by EOD personnel and demolished at sea.

On the 22<sup>nd</sup> July 2012, a landslip in the cliffs at Mappleton in the East Riding of Yorkshire exposed over 1,000No. UXO items, including practice bombs, mortars, rockets, shells and grenades. The cliff was part of a former bombing and artillery range, used during WWII and until the 1970s.

UXO items were removed by Explosive Ordnance Disposal (EOD) officers from Catterick and MoD staff from Leconfield. 15No. controlled explosions were undertaken by the Royal Engineers (RE) to detonate the more volatile items in situ, while other less hazardous UXO devices were left in place to be dealt with at a later date.

1No. WWI bomb (shown in the Plate below) was found on the Isle of Sheppey on the 2<sup>nd</sup> August 2012 during a geophysical survey following desk study research by Zetica Ltd which had established that a previously unknown WWI bombing range existed on the site. A further WWI bomb was found in the same location in August 2015.

|              |                                                                      |
|--------------|----------------------------------------------------------------------|
| <b>Plate</b> | Photograph of WWI bomb, Isle of Sheppey, 2 <sup>nd</sup> August 2012 |
|--------------|----------------------------------------------------------------------|



Source: Zetica Ltd

On the 23<sup>rd</sup> March 2015, 1No. WWII 500kg UXB was found on a building site in The Grange, Bermondsey. The bomb was made safe by EOD personnel and removed for demolition.

On the 21<sup>st</sup> May 2015, 1No. 50kg UXB was found on a building site near Wembley Stadium, London Borough of Brent. The bomb was made safe by EOD personnel and removed for demolition.

On the 10<sup>th</sup> August 2015, 1No. 250kg UXB was found under the basement of a building site at Bethnal Green, London Borough of Tower Hamlets. It was made safe and removed by an EOD team from the RLC.

On the 21<sup>st</sup> September 2015, 1No. UXB was uncovered on a construction site in Cheylesmore, Coventry, by the operator of a mechanical digger. It was destroyed in situ by an EOD team from the RLC.

In January 2016, Zetica discovered 3No. 500lb British UXB at a former airfield in Cambridgeshire. These were destroyed in controlled explosions. The Plate below is a photograph of one of the bombs.

|              |                                                               |
|--------------|---------------------------------------------------------------|
| <b>Plate</b> | Photograph of a recently excavated WWII British 500lb GP bomb |
|--------------|---------------------------------------------------------------|



Source: Zetica Ltd

There is a long list of incidents during construction work in Germany that in some cases have led to the deaths of workers.

In June 2010, 3No. members of a bomb disposal team were killed, and 6No. others injured, whilst attempting to defuze an unexploded WWII bomb in Goettingen, Central Germany.

The bomb, the second found in Goettingen in the space of a few days, was unearthed at a depth of 7.5m during excavations for a sports stadium.

In September 2008, 17No. people were injured and considerable damage occurred to adjacent buildings when a bomb exploded on a construction site in Hattingen, Germany.

In October 2006 during road works on a motorway near Aschaffenburg in Bavaria, southern Germany, a bomb was struck by a machine and detonated. The plant driver was killed and 5No. others injured, including passing motorists.

In a similar incident in October 2004 in Linz, Austria a bomb exploded injuring 3No. workers and causing considerable damage to plant. In the same month, a WWII bomb under a back garden in Vienna, Austria, was detonated without warning by a minor earth tremor, after remaining undiscovered for over 60 years.

Incidents involving UXO are also reported from the marine areas around the North Sea. For example, on 6<sup>th</sup> April 2005, 3No. Dutch fishermen were killed when they accidentally trawled up a WWII UX bomb which exploded when it hit the deck.

More recently, an unexploded HE bomb was trawled from the sea floor off South Shields on the 25<sup>th</sup> February 2015 but caused no damage.

Further details of similar finds can be found at <http://zeticauxo.com/news/>.

The effects of a partial or full detonation of ordnance are usually shock, blast, heat and shrapnel damage. A 50kg buried bomb can damage brick / concrete structures up to a distance of approximately 16m away. Unprotected personnel on the surface up to 70m away from the blast could also be seriously injured. Larger ordnance would obviously be more destructive.

Explosives rarely lose effectiveness with age, although over time mechanisms such as fuzes and gaines can become more sensitive and therefore more prone to detonation, regardless of whether the device has been submersed in water or embedded in silt, clay or similar materials.

The effects of a detonation of explosive ordnance are usually extremely fast, often catastrophic and invariably traumatic to any personnel involved.

| Appendix 3 Abbreviations |                                                |
|--------------------------|------------------------------------------------|
| AA                       | Anti-Aircraft                                  |
| ACPO                     | Association of Chief Police Officers           |
| ALARP                    | As Low As Reasonably Practicable               |
| ARP                      | Air Raid Precaution                            |
| ASACS                    | Air Surveillance and Control System            |
| AXO                      | Abandoned Explosive Ordnance                   |
| BD                       | Bomb Disposal                                  |
| BDO                      | Bomb Disposal Officer                          |
| BDU                      | Bomb Disposal Unit                             |
| CBRN                     | Chemical, Biological, Radiological and Nuclear |
| CMD                      | Conventional Munitions Disposal                |
| DCLG                     | Department of Communities and Local Government |
| EO                       | Explosive Ordnance                             |
| EOC                      | Explosive Ordnance Clearance                   |
| EOR                      | Explosive Ordnance Reconnaissance              |
| ERW                      | Explosive Remnants of War                      |
| ESA                      | Explosive Substances and Articles              |
| FFE                      | Free From Explosives                           |
| HAA                      | Heavy Anti-Aircraft                            |
| HE                       | High Explosive                                 |
| HSE                      | Health and Safety Executive                    |
| JSEODOC                  | Joint Services EOD Operations Centre           |
| IB                       | Incendiary Bomb                                |
| IED                      | Improvised Explosive Device                    |

|       |                                      |
|-------|--------------------------------------|
| IEDD  | Improvised Explosive Device Disposal |
| LAA   | Light Anti-Aircraft                  |
| MoD   | Ministry of Defence                  |
| PUCA  | Pick Up and Carry Away               |
| RAF   | Royal Air Force                      |
| SIP   | Self-Igniting Phosphorous            |
| TEP   | Time Expired Pyrotechnics            |
| USAAF | United States Army Air Forces        |
| UXB   | Unexploded Bomb                      |
| UXO   | Unexploded Ordnance                  |

| Appendix 4 Glossary & Definitions              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Abandoned Explosive Ordnance (AXO)</b>      | Abandoned Explosive Ordnance is explosive ordnance that has not been used during an armed conflict, that has been left behind or disposed of by a party to an armed conflict, and which is no longer under control of that party. Abandoned explosive ordnance may or may not have been primed, fuzed, armed or otherwise prepared for use.                                                                                                                                                                          |
| <b>Camouflet</b>                               | The type of cavity produced when a charge explodes underground without breaking the surface of the earth to form a crater.                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Demil</b>                                   | Derived from the term 'Demilitarisation', it refers to the break down and the recycling or disposal of ordnance components.                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Detonation</b>                              | The high-speed chemical breakdown of an energetic material producing heat, pressure, flame and a shock wave.                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Device</b>                                  | This term is used for any component, sub-assembly or completed ordnance, which may or may not have an explosive risk. It can apply to detonators, primers, gaines, fuzes, shells or bombs.                                                                                                                                                                                                                                                                                                                           |
| <b>Explosive</b>                               | The term explosive refers to compounds forming energetic materials that under certain conditions chemically react, rapidly producing gas, heat and pressure. Obviously, these are extremely dangerous and should only be handled by qualified professionals.                                                                                                                                                                                                                                                         |
| <b>Explosive Ordnance (EO)</b>                 | Explosive Ordnance is all munitions containing explosives, nuclear fission or fusion materials and biological and chemical agents. This includes bombs and warheads, guided and ballistic missiles, artillery, mortar, rocket, small arms ammunition, mines, torpedoes, depth charges, pyrotechnics, cluster bombs & dispensers, cartridge & propellant actuated devices, electro-explosive devices, clandestine & improvised explosive devices, and all similar or related items or components explosive in nature. |
| <b>Explosive Ordnance Clearance (EOC)</b>      | Explosive Ordnance Clearance is a term used to describe the operation of ordnance detection, investigation, identification and removal, with EOD being a separate operation.                                                                                                                                                                                                                                                                                                                                         |
| <b>Explosive Ordnance Disposal (EOD)</b>       | Explosive Ordnance Disposal is the detection, identification, on-site evaluation, rendering safe, recovery and final disposal of unexploded explosive ordnance.                                                                                                                                                                                                                                                                                                                                                      |
| <b>Explosive Ordnance Reconnaissance (EOR)</b> | Explosive Ordnance Reconnaissance is the detection, identification and on-site evaluation of unexploded explosive ordnance before Explosive Ordnance Disposal.                                                                                                                                                                                                                                                                                                                                                       |

|                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Explosive Remnants of War (ERW)</b>         | Explosive Remnants of War are Unexploded Ordnance (UXO) and Abandoned Explosive Ordnance (AXO), excluding landmines.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Explosive Substances and Articles (ESA)</b> | <p>Explosive substance are solid or liquid substance (or a mixture of substances), which is either:</p> <ul style="list-style-type: none"> <li>capable by chemical reaction in itself of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings.</li> <li>designed to produce an effect by heat, light, sound, gas or smoke, or a combination of these as a result of a non-detonative, self-sustaining, exothermic reaction.</li> </ul> <p>Explosive article is an article containing one or more explosive substances.</p>                                     |
| <b>Fuze</b>                                    | A fuze is the part of an explosive device that initiates the main explosive charge to function. In common usage, the word fuze is used indiscriminately, but when being specific (and in particular in a military context), fuze is used to mean a more complicated device, such as a device within military ordnance.                                                                                                                                                                                                                                                                                                |
| <b>Gaine</b>                                   | Small explosive charge that is sometimes placed between the detonator and the main charge to ensure ignition.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>High Explosive</b>                          | Secondary explosives (commonly known as High Explosives (HE)) make up the main charge or filling of an ordnance device. They are usually less sensitive than primary explosives. Examples of secondary explosives are: Nitro glycerine (NG), Trinitrotoluene (TNT), AMATOL (Ammonia nitrate + TNT), Gunpowder (GP), and Cyclotrimethylenetrinitramine (RDX).                                                                                                                                                                                                                                                          |
| <b>Munition</b>                                | <p>Munition is the complete device charged with explosives, propellants, pyrotechnics, initiating composition, or nuclear, biological or chemical material for use in military operations, including demolitions. This includes those munitions that have been suitably modified for use in training, ceremonial or non-operational purposes. These fall into three distinct categories:-</p> <ul style="list-style-type: none"> <li>inert - contain no explosives whatsoever.</li> <li>live - contain explosives and have not been fired.</li> <li>blind - have fired but failed to function as intended.</li> </ul> |
| <b>Primary Explosive</b>                       | Primary explosives are usually extremely sensitive to friction, heat, and pressure. These are used to initiate less sensitive explosives. Examples of primary explosives are: Lead Azide, Lead Styphnate, and Mercury Fulminate. Primary explosive are commonly found in detonators.                                                                                                                                                                                                                                                                                                                                  |

|                                  |                                                                                                                                                                                                                                                                                                                                                                                   |
|----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Propellants</b>               | Propellants provide ordnance with the ability to travel in a controlled manner and deliver the ordnance to a predetermined target. Propellants burn rapidly producing gas, pressure and flame. Although usually in solid form they can be produced in liquid form. Examples of propellants are: Ballistite often found in a flake form and Cordite used in small arms ammunition. |
| <b>Pyrotechnic</b>               | A pyrotechnic is an explosive article or substance designed to produce an effect by heat, light, sound, gas or smoke, or a combination of any of these, as a result of non-detonative, self-sustaining, exothermic chemical reactions.                                                                                                                                            |
| <b>Unexploded Ordnance (UXO)</b> | UXO is explosive ordnance that has been either primed, fused, armed or prepared for use and has been subsequently fired, dropped, launched, projected or placed in such a manner as to present a hazard to operations, persons or objects and remains unexploded either by malfunction or design.                                                                                 |

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