Medmerry Islands

RSPB

Detailed Unexploded Ordnance (UXO) Threat and Risk Assessment with Risk Mitigation Strategy

Meeting the requirements of the United Kingdom's Construction Industry Research and Information Association's Unexploded Ordnance Risk Management Framework: "Unexploded Ordnance (UXO) – A Guide for the Construction Industry" (C681) and in compliance with the Construction (Design and Management) Regulations 2015

6 Alpha Associates Ltd

Project No.: 11444

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V1.0

Using This Report

This Detailed UXO Threat and Risk Assessment with Risk Mitigation Strategy is designed to inform the reader whether military related Unexploded Ordnance (UXO) is likely to pose a hazard at the Study Site and if so, calculate the level of risk generated by proposed or likely ground intrusive operations at the Site. The assessment is intended to meet with the requirement of Stages 2 and 3 of the *Health and Safety Executive* endorsed *CIRIA C681 UXO Risk Management Framework* – for which *6 Alpha* were the lead technical author.

There are two prospective outcomes of this report; either the risk level requires a Risk Mitigation Strategy (Stage 3 of the *CIRIA C681* framework) aimed at reducing UXO risks As Low As Reasonably Practicable (ALARP) in accordance with the Project's minimum legal responsibility; or that no further action is required. In the former instance *6 Alpha* will provide a Risk Mitigation Strategy consisting of proactive and/or reactive risk mitigation measures aimed at reducing the identified risks to ALARP.

Document Control

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Executive Summary

Document Scope

6 Alpha Associates Limited (6 Alpha) has been commissioned by *RSPB* to provide a UXO Threat and Risk Assessment with Risk Mitigation Strategy, for the Site described as "Medmerry Seabird Islands, Sussex". The Study Site is centred on *British National Grid Reference* 483139, 95055.

UXO Threat Assessment Summary

The output of *6 Alpha*'s UXO Threat Assessment is summarised at Table I:

UXO Threat Assessment Summary			
Threat Source		**Result**	**Comments**
	Was the Site or its vicinity considered a primary bombing target during WWII?	✗	*Luftwaffe* aerial photography did not identify any primary bombing targets on-site or within 1,000m of the Study Site boundary.
	Was the Site or its vicinity bombed during WWII?	✓	There is a lack of official bombing records for the Study Site due to its remote location. Nonetheless, there is evidence of *German* bombing in the vicinity as well as *British* bombing associated with *Selsely Range*.
	Was the Site or its vicinity damaged by bombing during WWII?	✓	Multiple bomb craters were reportedly generated around *Broad Rife* – potentially on-site/nearby.
	Has any *British* military activity been identified in the area?	✓	An *RAF* bombing practice area *Selsey Range* (designation *26A*) was partially located on-site. The range was extensively used for numerous military training activities until as late as 1964.
	Has ordnance been manufactured and/or stored at the Site or its vicinity?	✓	
	Does UXO contamination pose a potential hazard at the Study Site?	✓	Given that extensive bombing and military activity were recorded on-site and in the wider area, it is possible that UXO may have been generated.

Table I: UXO Threat Assessment Summary

UXO Threat Items

Given the evidence presented at Table I, *6 Alpha* consider it reasonably foreseeable that UXO may have been generated at the Site. The most probable UXO threat items are *British* and *German* aerial bombs and *British* AXO/LSA/SAA.

Potential UXO Burial Depth

Given the likely ground conditions at the Study Site, the average WWII bomb penetration depth has been calculated as 5m below WWII ground level at this Study Site. Although larger UXBs could be present below this depth (potentially up to 14m), they were deployed infrequently during WWII and are highly unlikely to be encountered.

British AXO/LSA/SAA also poses a potential UXO threat at this Site but is much more likely to be shallow buried, up to 2m below the WWII ground level.

UXO Risk Pathways

The Study Site has not undergone significant post-WWII development, although the Client has informed *6 Alpha* that a layer of shingle was deposited in 2012/2013. Given that the proposed works are limited only to areas of shingle deposited in 2012/2013 (to between 20cm and 50cm in depth), they are not expected to generate a viable UXO risk pathway. However, any intrusive works extending below the post-war shingle layer may generate a significant risk pathway to a depth of 5m bgl.

Therefore, it is crucial that if the proposed works are changed, then *6 Alpha* are to be contacted to review and update the risk assessment if necessary.

UXO Risk Assessment

A Semi-Quantitative UXO Risk Assessment has been undertaken and the UXO risk rating is assessed to be:

LOW

The SRQA has determined that the proposed intrusive works may generate, as a reasonable worst-case scenario, a ***LOW*** level of risk at the Study Site because they are expected to intrude only within the post-war shingle deposits.

Whilst the level of risk to site personnel is limited, *6 Alpha* recommend that the identified UXO risks are mitigated in accordance with the ALARP risk reduction principle (see below, and Part III of the report).

Risk Mitigation Strategy

Whilst the proposed works are limited to within post-war shingle deposits, given the extensive military use of the Study Site and its vicinity, a limited suite of reactive UXO risk mitigation measures ought to be implemented to reduce the UXO risk to ALARP.

Recommended UXO Risk Mitigation Measures

There following risk mitigation measures summarised at Table II, are recommended as a minimum in order to reduce risks ALARP during intrusive works.

UXO Risk Mitigation Measures Overview							
Proposed Intrusive Works		Emergency Response Plan	Safety and Awareness Briefings	On-Call EOD Engineer	UXO Watching Brief	Non-Intrusive UXO Survey	Intrusive UXO Survey
Open Works	Excavations	✔	✔	✔	✘	✘	✘
Blind Works	Fence Post Installation	✔	✔	✔	✘	✘	✘
Residual UXO Risk Rating		ALARP					

Table II: UXO Risk Mitigation Measures Overview

Recommended Next Steps

We recommend that the Client's next steps are focused upon phase four of the UXO Risk Management Framework namely, the planning and organisation of the recommended UXO risk mitigation measures as outlined above.

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List of Appendices

Acronyms and Abbreviations

AAA	Anti-Aircraft Artillery
ALARP	As Low As Reasonably Practicable
ARP	Air Raid Precaution
AXO	Abandoned Explosive Ordnance
BDO	Bomb Disposal Officer
bgl	Below Ground Level
BGS	British Geological Survey
BH	Borehole
BPD	Bomb Penetration Depth
CIRIA	Construction Industry Research and Information Association
CS	County Series
EOD	Explosive Ordnance Disposal
HE	High Explosive
HSE	Health and Safety Executive
IB	Incendiary Bomb
kg	Kilogram
km	Kilometre
LCC	London County Council
LSA	Land Service Ammunition
m	Metre
NEQ	Net Explosive Quantity
NGR	National Grid Reference
OS	Ordnance Survey
PoW	Prisoner of War
RAF	Royal Air Force
RMS	Risk Mitigation Strategy
RN	Royal Navy
SAA	Small Arms Ammunition
SQRA	Semi-Quantitative Risk Assessment
TA	Territorial Army
TARA	Threat and Risk Assessment
TNT	Trinitrotoluene
UK	United Kingdom
UN	United Nations
USAAF	United States Army Air Force
UXB	Unexploded Bomb
UXO	Unexploded Ordnance
V Weapons	*Vergeltungswaffen* – Vengeance Weapons
WWI	World War One
WWII	World War Two

Part I: Introduction

1 Document Overview

1.1 Scope of Work

6 Alpha Associates Limited (6 Alpha) has been commissioned by the *RSPB* to provide an Unexploded Ordnance (UXO) Threat and Risk Assessment with Risk Mitigation Strategy, for the Site described as "Medmerry Seabird Islands, Sussex".

1.2 Study Site Location

The Study Site is situated within *Medmerry Nature Reserve,* north-west of the *Town of Selsey,* and totals an area of 0.6ha. The Study Site is centred on *British National Grid Reference* 483139, 95055 and consists of four parcels of undeveloped ground overlaid with shingle.

The Site's Location and Site Boundary is depicted at Appendices 1 and 2, with aerial photography of the Study Site presented at Appendix 3.

1.3 Aims and Objectives

This document has the following aims and objectives:

1.3.1 Aims

The document aims to assess and evidence the nature and scope of the UXO risks to people, plant, equipment and/or the environment at this Study Site. In the event that an intolerable UXO risk is identified, a recommended UXO risk mitigation strategy will also be articulated.

1.3.2 Objectives

The document has the following objectives:

- To assess the nature and scope of potential UXO contamination at the Study Site;
- To assess whether any UXO contamination generated at the Site is likely to remain extant;
- To consider whether the proposed intrusive works will generate a viable UXO risk pathway;
- To identify those sensitive receptors likely to be impacted by an inadvertent UXO encounter during the proposed intrusive works;
- To assess the UXO risk to those sensitive risk receptors during intrusive works;
- To outline proportional risk mitigation measures that are consistent with a coherent overarching risk mitigation strategy, in order to effectively manage the UXO risk ALARP.

2 Introduction to UXO Risk Management

2.1 Definition of UXO

For the purposes of this risk assessment, *6 Alpha* have adopted the definition of UXO outlined in the undermentioned *CIRIA C681* guide, as follows:

"*Explosive ordnance that has been primed, fuzed, armed, or otherwise prepared for use and used in an armed conflict. It may have been fired, dropped, launched or projected and should have exploded but failed to do so…UXO also refers to explosive ordnance that has not been used during an armed conflict, that has been left behind or dumped by a party to an armed conflict, and which is no longer under control of the party that left it behind or dumped it...*"

2.2 Generic UXO Threats

There are multiple factors which may have contributed to the UXO contamination of a construction site in the *UK* but generally, UXO contamination is likely to result from the warfighting activity associated with WWI and WWII, the military occupation and use of land such as airfields, camps and training areas; and the manufacture of munitions to support the armed forces.

For example, *WWII Bomb Census* data from the *Ministry of Home Security* calculated that approximately 10% of bombs dropped on *Britain* during WWII failed to function as designed. If the bomb did not detonate when it was dropped, the force of impact enabled the Unexploded Bomb (UXB) to penetrate the ground. Whilst efforts were made to locate and render safe those UXBs that were observed entering the ground (or left behind clear evidence of having done so) during WWII, evidence of such UXBs was readily obscured by bomb damage debris, vegetation and a lack of footfall in some settings – thus, ensuring that an unquantifiable number of UXBs were left *in situ* below the surface of the ground.

Additionally, it has been estimated that at least 20% of the *UK's* land surface area has been used for military training activities or has otherwise been requisitioned for military use historically. Therefore, *British* Abandoned Explosive Ordnance (AXO), Land Service Ammunition (LSA), Small Arms Ammunition (SAA) and aerially delivered ordnance is also commonly encountered in areas that were formerly occupied by military forces (such as *Royal Air Force* (RAF) airfields, military camps and/or military training areas). Conventional and chemical munitions dumping was also prevalent in these periods with little consideration given to future safety implications. There was also widespread unrecorded dumping of LSA and SAA below the ground that was rarely recorded because the activity was often perceived to be inconsequential.

2.3 Generic UXO Risks

The explosive or chemical fill within UXO rarely becomes inert or loses its effectiveness with age, but the explosive fill may change or crystallise over time – increasing the high explosive's sensitivity to a physical shock or an impact. Trigger mechanisms and fuses, which may have failed, may corrode and deteriorate over time, becoming more sensitive to detonation. It is therefore possible that a significant impact on the UXO case, and the resultant effect upon the fuse, may cause its inadvertent detonation.

2.4 UXO Industry Best Practice

In the absence of specific legislation concerning the management of UXO risks during construction projects, the *UK*'s *Construction Industry Research and Information Association* (CIRIA) has published a best practice guide for the assessment and management of UXO risk in the construction industry (*CIRIA* document reference C681). The *CIRIA C681* guide has been judged and recognised by the *Health and Safety Executive* (HSE) as a minimum standard of good practice, that satisfies the law when applied in an appropriate manner.

6 Alpha were *CIRIA's* lead technical author for their *C681* publication and as such, are in a unique position to ensure that Client's manage UXO risk in a safe, cost-effective and time-efficient manner.

2.5 UXO Risk Management Strategic Framework

At Section 5 of *CIRIA's* C681 guide, a framework for the management of UXO risk is articulated and consists of four key stages. These correspond with the framework employed by *6 Alpha*, as presented at Table 1.

6 Alpha Risk Management Framework	UXO Risk Management Phase	CIRIA C681 Risk Management Framework	Delivered within Report? (✔/✘)
UXO Threat Assessment	**STAGE ONE**	Preliminary Risk Assessment	✔
UXO Risk Assessment	**STAGE TWO**	Detailed Risk Assessment	✔
Risk Mitigation Strategy	**STAGE THREE**	Risk Mitigation	✔
Implementation	**STAGE FOUR**	Implementation	✘

Table 1: 6 Alpha and CIRIA UXO Risk Management Frameworks

3 UXO Threat and Risk Assessment Methodology

3.1 Source – Pathway – Receptor Risk Model

The source-pathway-receptor model is a conceptual risk model employed by *6 Alpha* across all projects that informs how UXO risks are assessed. The model also helps to explain the link between the separate sections of this report and the UXO risk assessment at Section 7. The components of the model are as follows:

3.1.1 UXO Sources

The nature and scope of the UXO threat is summarised in the UXO threat assessment (at Section 4) and it forms the source element of the source-pathway-receptor model.

3.1.2 UXO Pathways

The UXO pathways are the routes by which the sources can reach the receptors. UXO pathways are likely to be either by contact and/or through soil energy transfer, through which the resulting shock wave (generated by a UXO source, or sources) may reach potential receptors. Nonetheless, surface events may also generate a through-air risk pathway in which blast and fragmentation from the UXO sources may also reach the receptors.

UXO risk pathways may be generated by a variety of operations that interact with the ground. Therefore, likely operations have been assessed and summarised (at Section 6), to demonstrate the potential risk pathway elements of the model.

3.1.3 UXO Receptors

Receptors are defined as anything which might be adversely affected by the consequences of an inadvertent detonation of any UXO source through an identified pathway. The proximity, robustness, and sensitivity of such receptors is essential in determining their capacity to withstand such high explosive effects and defining what degree of UXO risk might be tolerated (if any).

3.2 Semi-Quantitative Risk Assessment Methodology

The assessment of UXO risk is a semi-quantitative measure of the probability of UXO encounter and initiation and the consequence of an inadvertent UXO initiation; the former being a function of the identified hazard and proposed development methodology and the latter being a function of the type of hazard and the proximity of personnel (and/or other sensitive receptors) to the hazard.

UXO risk is calculated using the following formula:

Risk **(R)** = Probability **(P)** x Consequence **(C)**

3.3 Information Sources

Significant archive research associated with the Study Site has been undertaken to corroborate and to highlight, any and all potential sources of UXO contamination as well as to assess their likelihood of encounter. For the production of this report, *6 Alpha* have reviewed information from the following sources:

- Information gathered from the *National Archives* at *Kew*, including but not limited to:
  - *Ministry of National Security WWII Bomb Census* statistics;
  - *Air Raid Precaution* (ARP) written records and associated bomb strike mapping;
  - Official WWII bomb damage mapping;
- *Ministry of Defence* (MoD) *Abandoned Bomb Register*;
- *Former 33 Engineer Regiment* (Explosive Ordnance Disposal) records at *Carver Barracks, Wimbish*;
- Post-WWII *RAF* aerial photography;
- *County Series* (CS) and *Ordnance Survey* (OS) mapping.

3.3.1 Azimuth© UXO Threat Database

The above list is not exhaustive, and *6 Alpha's Azimuth*© database has also been heavily drawn upon to deliver the UXO threat assessment element of this report. The *Azimuth*© database contains digitised historic charts, aerial photographs and other extensive analogue records from an exhaustive range of additional national, regional and global archives and/or data sets that have been digitised.

3.4 Constraints

This UXO threat and risk assessment is constrained and limited by that information which is reasonably available to *6 Alpha* at the time of writing, as well as that UXO information that is reasonably accessible in a variety of archives, which *6 Alpha* have digitised and georeferenced or have otherwise summarised in written form.

This document may also require updates and changes, especially wherever and whenever the circumstances and factors associated with assessing UXO risk change. For example, if UXO threats are subsequently discovered and they are different from those that have been anticipated, and/or if proposed intrusive operations are significantly changed.

In such circumstances, risks may require re-evaluation and any such changes are to be made by *6 Alpha*, to ensure the continued technical veracity and risk management efficacy of this document.

Part II: UXO Threat & Risk Assessment

4 UXO Threat Assessment

4.1 WWII Aerial Bombing

The county of *West Sussex* was home to numerous targets that were of interest to the *Luftwaffe*, including its port installations and numerous airfields. As such, numerous areas across the county were bombed, especially around *Bognor Regis, Littlehampton,* and *Worthing.* In addition, the flat beaches made *West Sussex* a potential landing site for *German* invasion and consequently, intensive defensive fortifications were erected along the coastline including anti-tank blocks, minefields, and pillboxes, in addition to anti-aircraft artillery installations spread across the county.

West Sussex was crucial to the preparations for the *D-Day* landings on the 6th June 1944, as the beach areas at *Climping*, *Bracklesham* and the *Witterings* were used for mock landings, whilst *Shoreham* was used as an embarkation port and *Littlehampton* served as an ammunition supply port.

4.1.1 WWII HE Bomb Density

The Study Site was located within *Chichester Rural District,* as presented at Appendix 4. This region recorded one HE bomb strike per 100 hectares, a "very low" level of bombing. However, further site-specific data has been considered regarding the potential bombing of the Site during WWII.

4.1.2 WWII Luftwaffe Bombing Targets

Luftwaffe aerial reconnaissance photography did not identify the Study Site or any areas within 1,000m of it as a primary bombing target.

4.1.3 WWII HE Bomb Strikes

During WWII, *ARP* wardens and other local officials compiled detailed logs of bomb strikes across their respective districts that were then often consolidated and mapped at the end of WWII. These records were not available for the Study Site and this is likely due to the Site's remote nature. Nonetheless, an extensive search of historical records did not identify any direct evidence of bomb strikes on-site or nearby – although further research did note that a *German Junker 88A* aircraft was shot down and crash landed at *Greatham Farm* - 500m to the east of the Site. It is plausible that this aircraft jettisoned its bombload prior to this as a safety procedure when making a forced landing.

Moreover, the nearby town of *Selsey* was also bombed repeatedly, and reportedly endured more air raids than any other location in *Sussex* – likely as a result of its vulnerable location on the south coast. This put it on the flightpath of both *Luftwaffe* bombers flying inland, as well as those returning back to base, who would often jettison any remaining bombs to lighten their loads before flying home – colloquially known as *"tip and run"* raids. Furthermore, whilst IBs may have fallen within the Study

Site, they were dropped in large clusters and accurate record keeping was often either non-existent or perfunctory.

In addition to IBs and HE bomb strikes, during the latter stage of WWII, when more conventional aerial bombardment of the *UK* had significantly declined, the main threat came from *V* type weapons. *V1* and *V2* rockets were thin-skinned, unmanned and inaccurate weapons and generally exploded upon impact and thus, are less likely to pose a UXO threat. There is also no evidence to suggest that the Study Site (or its immediate vicinity) was subjected to rockets strikes during WWII.

British aerial bombs may also have been deployed on-site and in the immediate vicinity as part of the historic military training undertaken at *Selsey Range,* which is elaborated on in section 4.2.1.

4.1.4 WWII Bomb Damage

Official bomb damage mapping associated with the Study Site was not available. Nonetheless, further research of historical records and an analysis of 1945 aerial photography noted that numerous bomb craters were present on and around *Broad Rife* – potentially on-site or in the immediate vicinity of the Study Site boundary. Further research indicates these were likely caused by *British* practice bombing within the undermentioned *Selsey Range*.

4.1.5 UXB Entry Holes

The CS mapping prior to WWII (1938) and aerial photography (1945) shows that the Study Site was located within an undeveloped coastal area during WWII, with the Study Site itself consisting of undeveloped ground. Therefore, it is considered unlikely that any UXB entry holes caused by *German* wartime bombing would have been noticed and dealt with at the time.

However, it is possible local military personnel observing the undermentioned military range would have inspected the area following any *British* training exercises to check the accuracy of the bombing crews operating within it. However, these inspections may not have been comprehensive in all areas, and therefore, they do not preclude the possibility that UXB entry holes could have been missed - especially given the fact that they could be as small as 20cm in diameter and therefore, easily obscured by vegetation or other natural features.

4.2 *British* Military Activity

There is evidence to suggest that military activity has occurred at the Study Site and/or its immediate area previously, as detailed below:

4.2.1 Historic Military Activity

The Study Site was partially located within the *Selsey Range* (designated as *A26)* during WWII. Originally developed in 1941, the range was first operated as an *RAF* (and potentially a *Fleet Air Arm,* the *Royal Navy's* flying contingent) air-to-air firing range. However, it was expanded in 1943 to include air-to-ground bombing practice, including low-level and dive-bombing practice, with an additional extension in 1944, when rocket projectile training was added. By the end of 1944, the following ranges were documented at *Selsey:* live bombing, dive bombing, rocket projectile, live fire against tank targets, a tactical range against convoy targets, and air-to-ground gunnery targets.

In October 1945 the range was closed but was then reopened in 1949 – although after local opposition the practice bombing targets were moved offshore. Nonetheless, the onshore area, which had been renamed *Manhood Range,* was retained for gunnery training and rocket projectiles. Further research notes that the range was in-use until at least 1954, and possibly as late as 1964.

In addition, other military activity has been noted in the wider area – including extensive WWII-era defensive installation. This includes four machine gun emplacements (located 50m to the north-east, 60m to the north-east, 120m to the south-west and 210m to the south-west of the Site), eight pillboxes (the closest located 440m to the south-west), and two onshore minefields (situated 535m to the south-west and 610m to the south-west).

Given the extensive military activity on-site and nearby is considered likely that munitions were stored, located and/or fired from this Study Site historically. It was also common for munitions to be buried at former military facilities and these were often abandoned at the end of the war – the remnants of which are known as Abandoned Explosive Ordnance (AXO).

The location of the former *Selsey Range* and the WWII-era defensive installations are presented at Appendix 5.

4.3 Previous UXO Encounters

An analysis of historic records noted several UXO encounters within the vicinity of the Study Site, as follows:

4.3.1 Abandoned Bombs

The Abandoned Bomb register was compiled from wartime records and was published in the form of a written answer to the *House of Commons* in 1996. The list initially only covered abandoned bombs in *London* but has since been released for the rest of the UK.

An examination of the *MoD*'s official abandoned bomb records has not identified any abandoned bombs on-site or within 1,000m of the Study Site boundary.

4.3.2 WWII UXO Disposal Tasks

An examination of pertinent historical records associated with the Study Site has identified any WWII-era UXO disposal tasks within 1,000m of the Study Site.

4.3.3 Post-WWII UXO Encounters

Large quantities of UXO, ranging from *British* practice bombs to a *"500 lb depth charge",* have been recovered from *Medmerry Beach* (located approximately 900m to the south-east) since the closure of the military range. Most of these UXO have either been washed up onshore or exposed during heavy storms. At least 60 pieces of ordnance were recovered in 2024 alone.

4.4 UXO Threat Summary

Given the evidence presented above, *6 Alpha* consider it reasonably foreseeable that a UXO encounter could occur at this Site. The most probable UXO threat items are *British* and *German* aerial bombs and *British* AXO/LSA/SAA.

5 UXO Burial Depths

5.1 Overview

It is important to establish the likely burial depth for threat spectrum UXO at the Study Site. The potential penetration depth of an UXB was dependent on a number of factors including but not restricted to those prior to striking the ground (e.g. velocity and orientation of the UXB), which in turn will be influenced on factors such as the release altitude from the aircraft and encounters with infrastructure during its fall; those encountered at the point of impact (i.e. was the impact on concrete, grass, water etc.) and finally, the below ground level conditions (e.g. infrastructure/services, basements, foundations, and geology).

Accordingly, the ground conditions at the Study Site must be understood in order to determine the average and maximum *German* UXB penetration depths, as well as the potential for other types of munitions to be buried. The provenance of made ground must also be considered in order to accurately determine the ground levels at the time when UXO contamination may have occurred (so as to accurately determine the average/maximum bomb penetration depths) and subsequently to inform any further recommendations.

5.1.1 Ground Conditions

BGS borehole log "*SZ89SW9 – CEGB Nuclear Power 2*" (located approximately 50m to the east), recorded the following strata:

Depth bgl (m)	Strata	Description
0.00m to 0.60m	**Topsoil**	Hard brown clayey TOPSOIL.
0.60m to 3.10m	**Sand**	Loose brown, becoming grey, silty fine SAND with shell fragments.
3.10m to 3.90m	**Gravel**	Medium dense, fine medium and coarse sand silty GRAVEL shell fragments.
3.90m to 5.80m	**Sand/Clay**	Medium dense brown and green clayey fine and medium SAND, with occasional layers of sandy CLAY
5.80m to 24.40m	**Sand/Silt**	Alternating layers of medium to dense grey-green silty fine and medium SAND and grey clayey sandy SILT with shell fragments

Table 2: Ground Conditions Summary

In addition, an analysis of *BGS* mapping associated with the Study Site suggests that the Site is likely to be underlain by a bedrock of "*Marsh Farm Formation - Clay, silt and sand*" and *"Earnley Sand Formation - Sand, silt and clay"*.

5.2 UXB Burial Depths

Based on the ground conditions described above, the average BPD for a 250kg *German* HE bomb is assessed to be approximately 5m bgl, with the maximum BPD considered to be approximately 14m bgl.

Although it is possible that the *Luftwaffe* deployed larger bombs in the area, an analysis of WWII bomb census data clearly evidences that their deployment was infrequent. Therefore, to use such larger bombs for BPD calculations **are not justifiable under the ALARP principle and thus, CIRIA C681 guidance**.

WWII *German* bombs have a greater penetration depth when compared to IBs and AAA projectiles, which are unlikely to be encountered at depths greater than 1m bgl.

5.2.1 The J-Curve Effect

As a UXB penetrated the ground, it's velocity naturally slowed where it either came to an abrupt stop (e.g., against foundations) or would continue along a route of least resistance – which often resulted in a curving of the trajectory back towards the surface. This is known as the "J Curve" effect and often resulted in a considerable horizontal off-set from the point of entry. This explains why UXBs have been discovered against or under the foundations of buildings which were present during WWII, or many meters from their entry holes. A diagrammatical representation of the "J Curve" effect is presented at Figure 1.

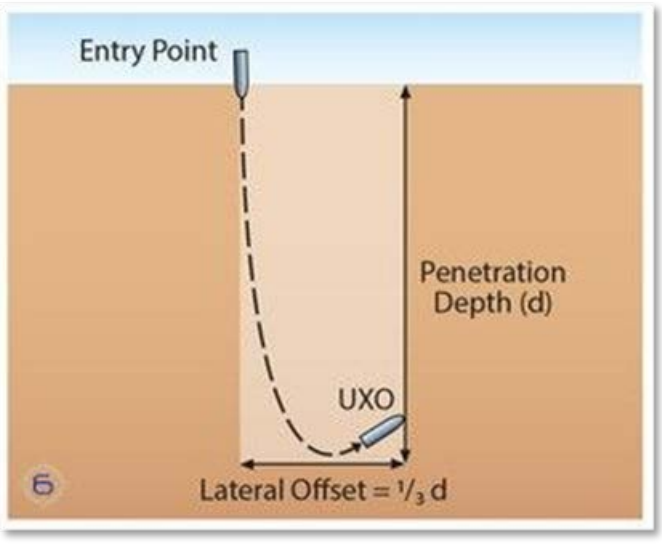


Figure 1: The "J Curve" Effect

5.3 AXO/LSA/SAA Burial Depths

If present, *British* AXO/LSA/SAA are likely to be encountered in previously undisturbed ground to depths of circa 2.0m.

6 UXO Risk Pathways

6.1 Overview

In order to assess whether a viable UXO risk pathway might exist at the Study Site, potential UXO contamination sources must be assessed (and have been at Section 4 of the report) and the likely depth of UXO contamination ought to be established (as per Section 5 of the report). Additionally, the Site's construction history ought to be considered to assess whether any previous intrusive works will have encountered and removed any UXO contamination present at the Site.

6.2 Study Site Construction History

From an analysis of CS and OS mapping, together with aerial photography, the following site history can be deduced:

Year	Development History
1938 CS Map	The Study Site was situated in an undeveloped coastal area and comprised undeveloped ground.
1945 Aerial Photography	Changes were not recorded at the Study Site.
1969 OS Map	A *Drain* was labelled on-site.
1983 OS Map	Changes were not recorded at the Study Site.
1991 OS Map	Changes were not recorded at the Study Site.
2003 Aerial Photography	Changes were not recorded at the Study Site.
2015 Aerial Photography	Shingle was visible on-site.
2023 OS Map	Changes were not recorded at the Study Site.

Table 3: Study Site Development History

As per Table 3, it is apparent that the Study Site has not undergone significant post-WWII development, although the Client has informed *6 Alpha* that a layer of shingle was deposited in 2012/2013. Consequently, it is considered likely that any UXO contamination within ground that has

been disturbed since WWII would likely have been discovered and removed. Nonetheless, it is apparent that the previous intrusive works have not disturbed the ground in all areas of the Study Site down to the likely average UXO burial depth of 5m bgl.

6.3 Proposed Works

An outline of the proposed intrusive works is also presented in order to evidence the potential UXO risk pathways that may be generated, should such work encounter those threat spectrum UXO that have been identified in Section 4.

The Client has provided *6 Alpha* with the document *"Description of works - Medmerry Islands"* which outlines a general overview of the scope of works:

"The primary aim of this project is to restore 0.8ha of shingle on a series of four islands within our Medmerry nature reserve by mechanical clearance and redepositing the top 20cm of shingle to form fresh, bare substrate. This will be accompanied by the cutting of a buffer layer of vegetation next to the shingle, the cutting of patches in a further area beyond this, and installation of fence posts for a seasonal predator exclusion fence".

Moreover, *6 Alpha* has been informed that *"We expect to excavate to circa 20cm depth into (but not beyond) the shingle placed in 2012/13, with a series of posts needing to be driven in to circa 50cm (again, through the shingle and material placed in 2012/13)".*

Consequently, any works into the shingle deposited in 2012/2013 are highly unlikely to generate a UXO risk pathway. However, if the planned methods are changed, then the risk assessment is to be reviewed and updated if necessary. This is crucial as any works beyond the post-war shingle deposits may generate a UXO risk pathway to a depth of 5m bgl.

7 UXO Risk Assessment

7.1 Threat Items

The most probable sources of UXO risk at this Study Site are *British* and *German* aerial bombs and *British* AXO/LSA/SAA. The consequences of initiating *German* HE bombs are generally more severe than initiating AXO/LSA/SAA< IBs or AAA projectiles, and thus they pose the greatest prospective risk to intrusive works.

7.2 Risk Pathways

Given that the proposed works are limited only to areas of shingle deposited in 2012/2013 (to between 20cm and 50cm in depth), they are not expected to generate a viable UXO risk pathway. However, any intrusive works extending below the post-war shingle layer may generate a significant risk pathway to a depth of 5m bgl.

7.3 Risk Receptors

The likely risk receptors include:

- Site personnel;
- Plant and equipment;
- Third-party infrastructure (utilities/services) and buildings;
- The natural environment.

Consequences of UXO initiation include:

- Injuries and/or fatalities to personnel;
- Damage to plant and equipment, nearby buildings and infrastructure;
- Rupture and damage underground utilities/services and the natural environment.

Consequences of an unexpected and unplanned UXO discovery include:

- Incurring delays and additional costs through the expenditure of additional risk mitigation resources and EOD clearance;
- Disruption to local community;
- Negative publicity.

7.4 Semi-Quantitative Risk Assessment

A semi-quantitative risk assessment has been undertaken and the results are presented at Table 4.

Activity	UXO Threat Item	Probability (SH+EM=P)	Consequence (D+PSR=C)	Risk (PxC=R)
Excavations (within post-war shingle deposits)	Aerial Bombs	1+1=2	3+3=6	**2x6=12**
	AXO/LSA/SAA	2+1=3	3+2=5	**3x5=15**
	AAA Projectiles	1+1=2	3+1=4	**2x4=8**
Fence Post Installation (within post-war shingle deposits)	Aerial Bombs	1+1=2	3+3=6	**2x6=12**
	AXO/LSA/SAA	2+1=3	3+2=5	**3x5=15**
	AAA Projectiles	1+1=2	3+1=4	**2x4=8**

Table 4: UXO SQRA Results

7.4.1 SQRA Conclusions

The SRQA has determined that the proposed intrusive works may generate, as a reasonable worst-case scenario, a ***LOW*** level of risk at the Study Site because they are expected to stay within the post-war shingle deposits. Whilst the level of risk to site personnel is limited, *6 Alpha* recommend that they are mitigated in accordance with the ALARP risk reduction principle, as per Part III of this report.

Part III: UXO Risk Mitigation Strategy

8 UXO Risk Mitigation Strategy

8.1 Strategic Overview

As per *CIRIA* C681 guidance, *6 Alpha* recommended that the identified UXO risks are reduced ALARP. Crucially, the ALARP principle states that if the cost of reducing a risk significantly outweighs the benefit, then the risk may be considered tolerable. This does not mean that there is never a requirement for UXO risk mitigation, but that any mitigation must demonstrate that it is beneficial. Any additional mitigation that delivers diminishing benefits and that consumes disproportionate time, money and effort are considered *de minimis* and thus unnecessary. Because of this principle, UXO risks will rarely be reduced to zero (nor need they be).

Consequently, whilst the proposed works are limited to within post-war shingle deposits, given the extensive military use of the Study Site and its vicinity, a limited suite of reactive UXO risk mitigation measures ought to be implemented ahead of proposed intrusive operations at the Study Site in order to reduce the identified UXO risks to ALARP.

8.2 Proactive UXO Risk Mitigation Measures

The level of risk to the proposed works at this Study Site does not warrant the implementation of proactive UXO risk mitigation measures in the form of a geophysical UXO survey or UXO Watching Brief. The implementation of such measures at this Site would be beyond what is required under the ALARP risk reduction principle.

8.3 Reactive UXO Risk Mitigation Measures

The following reactive risk mitigation measures should be undertaken for all activities in all areas:

8.3.1 Operational UXO Emergency Response Plan

Appropriate site management documentation should be held on-site to guide and plan for the actions which should be undertaken in the event of a suspected or real UXO discovery (this plan can be supplied by *6 Alpha*).

8.3.2 UXO Safety and Awareness Briefings

The briefings are essential when there is a possibility of an explosive ordnance encounter and are a vital part of the general safety requirement. All personnel working on the Site should receive a briefing on the following:

- The identification of threat spectrum UXO;
- What actions they should take to keep people and equipment away from such a hazard and to alert site management.

Information concerning the nature of the UXO threat should also be held in the site office and displayed for general information on noticeboards - both for reference and as a reminder for ground workers.

The safety awareness briefing is an essential part of the *Health & Safety Plan* for the site and helps to evidence conformity with the appropriate health and safety standards and legislation.

8.3.3 On-Call EOD Engineer

An on-call EOD Engineer will be able to identify and/or advise on the appropriate course of action in the event of any suspicious and/or real UXO finds and should be implemented at this Site to mitigate the residual UXO risk associated with the proposed works. *6 Alpha* offer three tiers of immediate telephone and/or email response.

8.4 ALARP Safety Sign Off Certification

ALARP safety sign-off certification provides an independent source of evidence that a Client has followed industry best practice and has successfully managed and reduced UXO risks to ALARP. Following the execution of *6 Alpha's* UXO risk mitigation measures, we can deliver ALARP safety sign-off certification, in advance of the proposed operations.

In such circumstances the project will be able to certify for the benefit of all of its stakeholders, that all reasonably practicable measures have been taken to protect contractors from UXO hazards and that the commissioning Client will have acted in compliance with industry best practice as well as the national safety legislation.

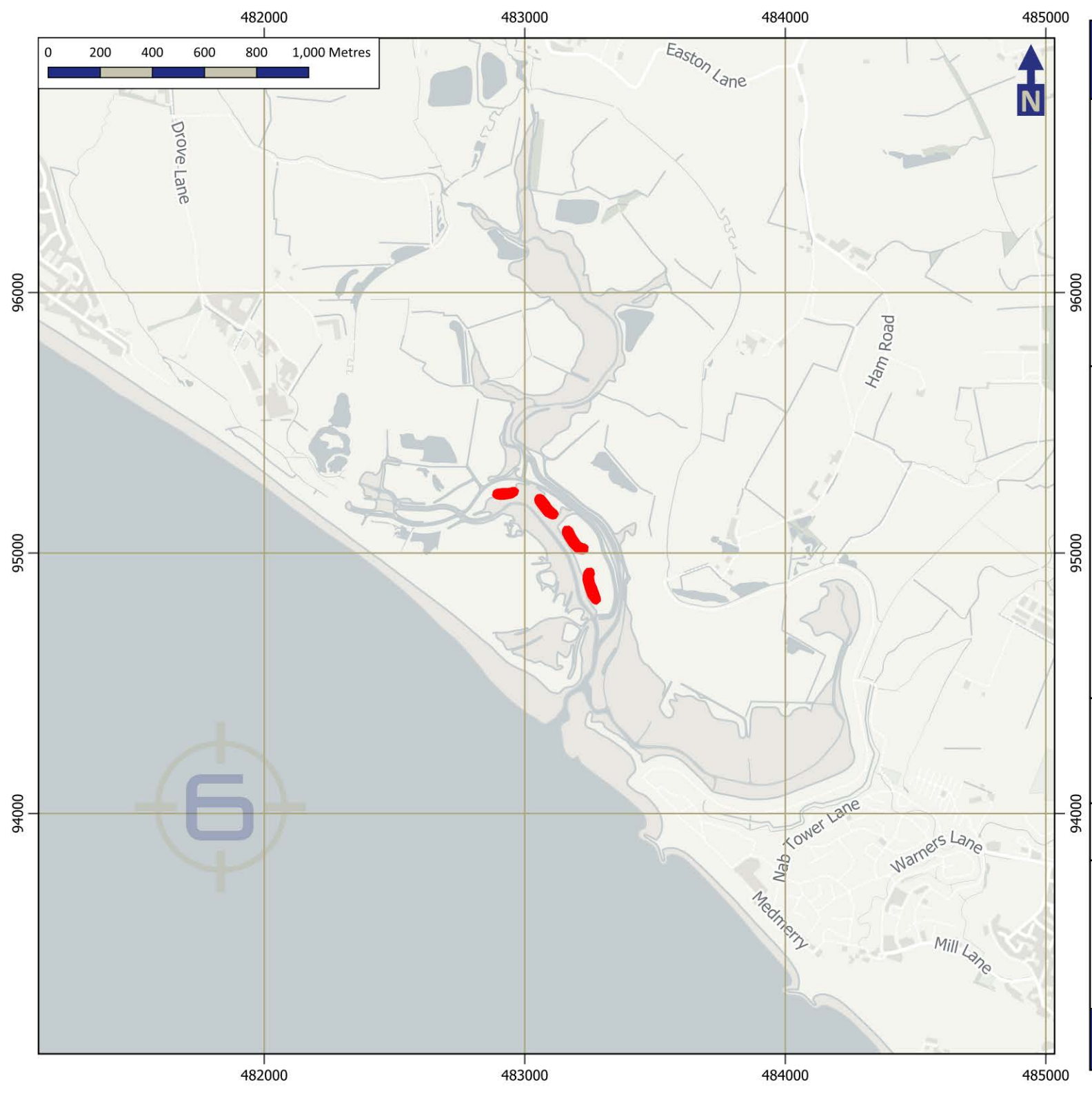
In accordance with best practice therefore, *6 Alpha* ALARP safety sign-off certification does not imply that any site is free from UXO, rather, that the necessary and appropriate UXO risk mitigation measures have been appropriately applied to evidence that UXO risks have been reduced ALARP.

8.5 Recommended Next Steps

We recommend that the Client's next steps are focused upon phase four of the UXO Risk Management Framework namely, the detailed designs of the recommended UXO risk mitigation measures as outlined above. The specifications are to be delivered and the UXO risk mitigation measures are to be executed in advance of the GI and construction phases of work, in order to warrant and to evidence that UXO risks can be mitigated and reduced to ALARP.

Appendices

Appendix 1 – Site Location



Site Location

BOMB SEARCH

LEGEND

Site Boundary

British National Grid

Address

MEDMERRY SEABIRD ISLANDS, SUSSEX

PROJECT NO.	FIGURE	DRAWN	CHECKED	DATE
11444	1	DB	LG	04/09/2024

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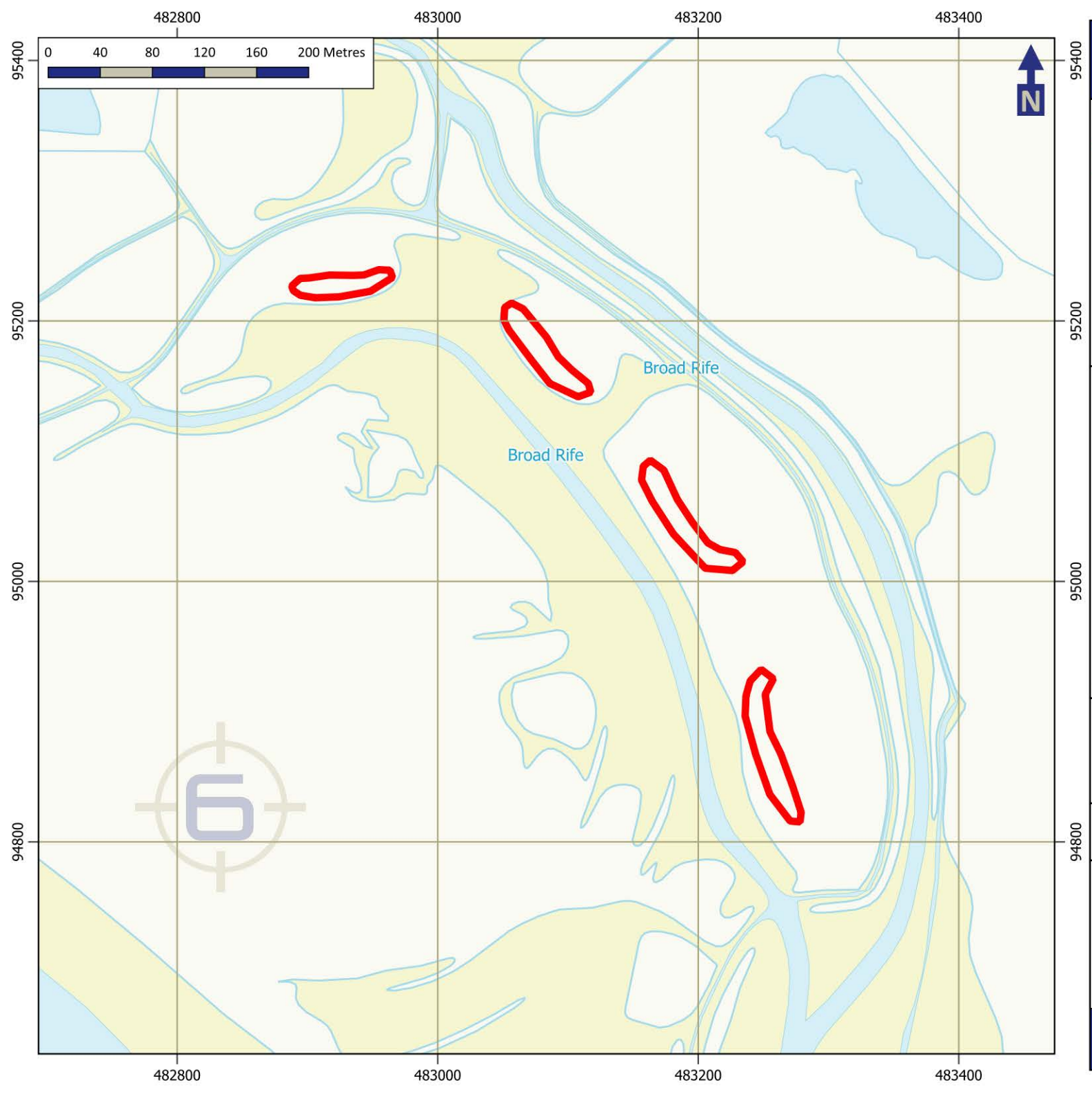
Appendix 2 – Site Boundary



Site Boundary

BOMB SEARCH

LEGEND

Site Boundary

British National Grid

Address

MEDMERRY SEABIRD ISLANDS, SUSSEX

PROJECT NO.	FIGURE	DRAWN	CHECKED	DATE
11444	2	DB	LG	04/09/2024

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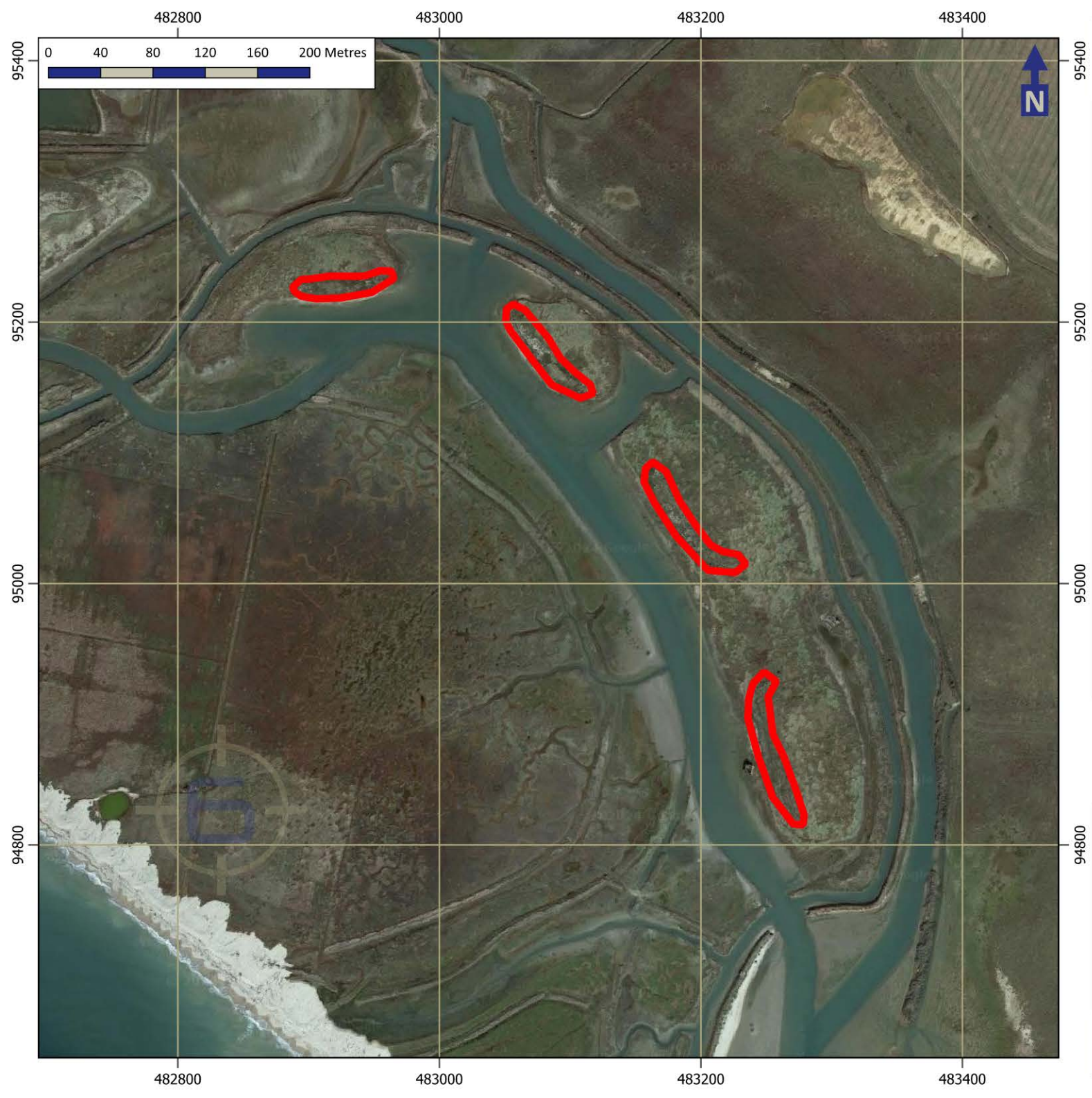
Appendix 3 – Modern Aerial Photography



Modern Aerial Photography

BOMB SEARCH

LEGEND

Site Boundary

British National Grid

Address

MEDMERRY SEABIRD ISLANDS, SUSSEX

PROJECT NO.	FIGURE	DRAWN	CHECKED	DATE
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Map data: Google, Maxar Technologies

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Appendix 4 – WWII High Explosive Bomb Density

WWII High Explosive Bomb Density

BOMB SEARCH

LEGEND

Site Boundary

High Explosive Bomb Density

- Less than 15 bombs per 100 hectares
- 16-25 bombs per 100 hectares
- 26-35 bombs per 100 hectares
- 36-45 bombs per 100 hectares
- Over 46 bombs per 100 hectares

British National Grid

Address

MEDMERRY SEABIRD ISLANDS, SUSSEX

PROJECT NO.	FIGURE	DRAWN	CHECKED	DATE
11444	4	DB	LG	04/09/2024

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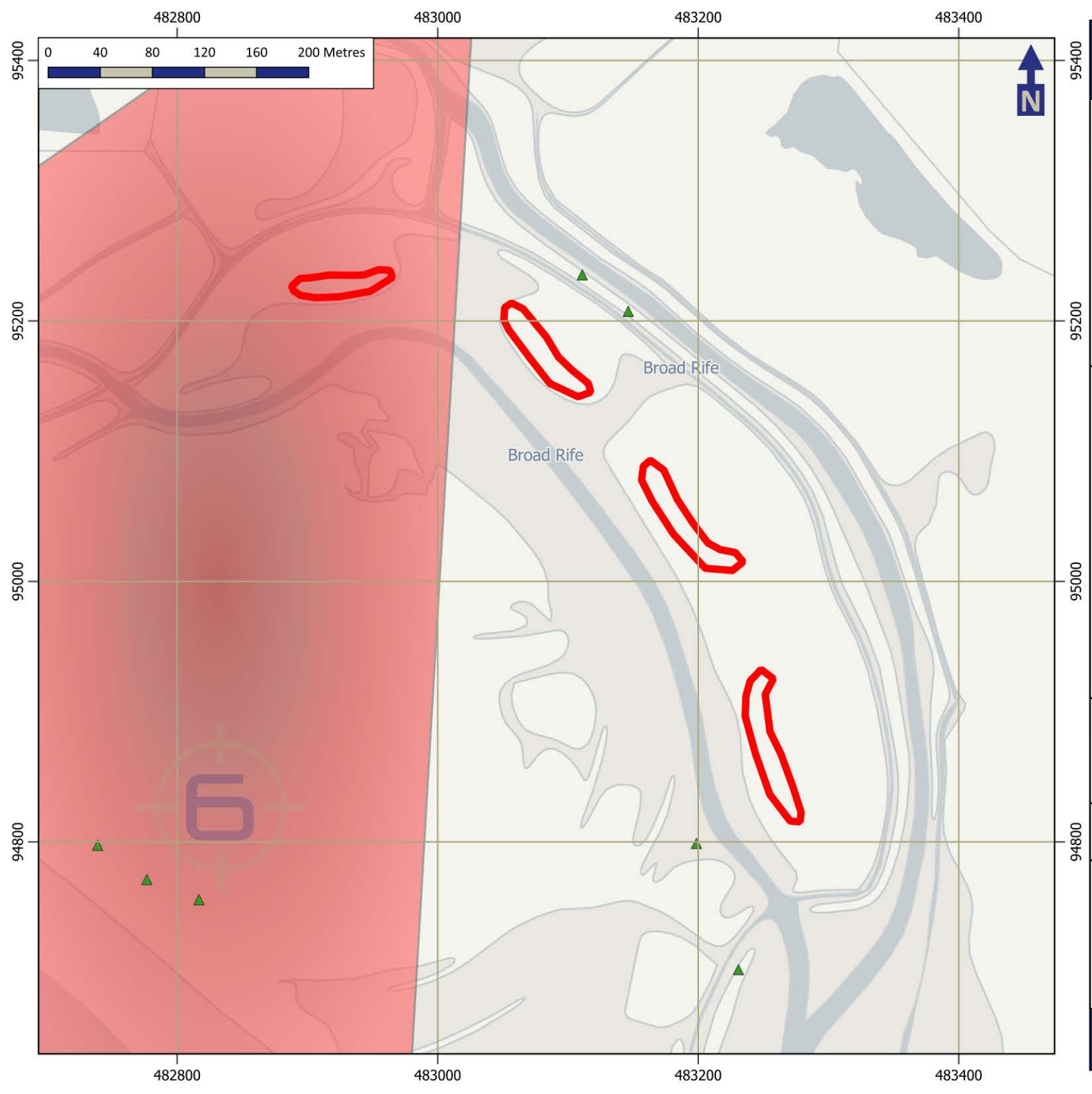
Appendix 5 – Historical Military Activity



Historical Military Activity

BOMB SEARCH

LEGEND

- Site Boundary
- Defensive Structures
- Historic Military Training Areas

British National Grid

Address

MEDMERRY SEABIRD ISLANDS, SUSSEX

PROJECT NO.	FIGURE	DRAWN	CHECKED	DATE
11444	5	DB	LG	04/09/2024

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Feedback

As a valued client, your feedback is important to us. *6 Alpha* have therefore created a *Customer Satisfaction Survey* to provide a platform for comments and feedback to reach us directly and help us to continue improving the way in which our services are delivered.

The survey would take approximately two minutes to complete and your assistance in this would be greatly appreciated. All data is collected and stored directly by 6 Alpha and will not be shared with any third parties, nor used for any other purpose.

The survey can be accessed by scanning the below QR code, or else clicking on the hyperlink.

https://forms.office.com/e/fPBZMQn5CR