NSW GOVERNMENT

Transport for NSW

Beaches Link and Gore Hill Freeway Connection

Appendix K

Maritime heritage

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DECEMBER 2020

Transport for NSW

Beaches Link and Gore Hill Freeway Connection

Technical working paper: Maritime heritage

December 2020

Prepared for

Transport for NSW

Prepared by

Cosmos Archaeology

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EXECUTIVE SUMMARY

The Western Harbour Tunnel and Beaches Link is a New South Wales (NSW) Government initiative to provide additional road network capacity across Sydney Harbour and to improve connectivity with Sydney's Northern Beaches. This includes the Beaches Link and Gore Hill Freeway Connection project (the project) comprising a new tolled motorway tunnel connection from the Warringah Freeway to Balgowlah and Frenchs Forest, and upgrade and integration works to connect to the Gore Hill Freeway.

Cosmos Archaeology Pty Ltd was engaged to satisfy the maritime archaeological aspects of the Secretary's Environmental Assessment Requirements for the project.

To achieve this, Cosmos Archaeology Pty Ltd carried out a baseline review and field survey of three areas in Middle Harbour (Area A, Area B and Area C) to identify known sites, establish archaeological potential and assess the cultural heritage sensitivity of maritime heritage sites. This study was restricted to maritime heritage on or under the bed of the harbour below the Highest Astronomical Tide, including the former bed of the harbour under reclamation, as well as sites that have a land/water interface. With the available project design plans, Cosmos Archaeology Pty Ltd then assessed the likely impacts on maritime heritage and described appropriate mitigation measures.

Impacts within Middle Harbour would be concentrated within Area A, which would be the location of a 340 metre immersed tube tunnel between Northbridge and Seaforth. Area A contains known maritime infrastructure, shipwrecks, associated deposits and additional discard from vessels. The cultural heritage sensitivity of the identified and potential maritime heritage in parts of Area A is assessed as medium, because of the likelihood of shipwrecks being present. However maritime cultural heritage sensitivity is low within the limits of where the geophysical survey was carried out with the exception of the shipwreck discovered during the December 2017 field investigation, Clive Park Unidentified No. 1. The impacts identified would have a Negligible to Minor impact on the maritime heritage resource without any further mitigation with the exception of the Clive Park Unidentified No. 1 wreck (and associated magnetic anomaly No. 3), which would be moderately impacted by anchoring activities and construction related vibration.

Area B, on the western side of The Spit, contains shipwrecks with associated deposits. It is very likely that remnant maritime infrastructure and discard from vessels is present in the area, including in and under reclamation fill. There is also a reasonable probability of shipwrecks being present beyond the limits of the geophysical survey. A temporary casting facility with a wharf structure (involving piling and dolphins) is proposed within Area B. It is considered improbable that the shipwreck discovered during the December 2017 field investigation called Pearl Bay Unidentified No. 1 would be impacted by anchoring and/or piling for the wharf and dolphins.

Area C, between Clive Park at Northbridge and Beauty Point at Mosman, very likely contains discard from vessels but is unlikely to contain remains of shipwrecks and is highly unlikely to contain remains of maritime infrastructure. Area C has low sensitivity throughout. A temporary mooring facility is proposed east of Clive Park in Middle Harbour, within Area C, covering an area of about 160 metres by 120 metres. The probability of impacts from anchoring is improbable to highly improbable. If impacts were to occur they would be moderate scale for any shipwrecks and minor for other site types.

The following mitigation measures are presented to ensure that potential impacts on maritime heritage remain either Negligible or Minor and with respect to the Clive Park Unidentified No. 1 wreck they are reduced to Minor.

Mitigation Measure	Mitigated impact
Mitigation measure A – Prepare Maritime Heritage Management Plan	Ensures the impact on known and potential maritime heritage remains such as maritime infrastructure, shipwrecks and discarded objects to Negligible to Minor.
Mitigation measure B – Maritime archaeologist involvement in pre-dredge clearance of the bed of the harbour	Would reduce the impact on potential maritime heritage remains such as maritime infrastructure, shipwrecks and discarded objects to Negligible or Minor.
Mitigation measure C – Establish restricted zones around sites where marine activities can be controlled to ensure potential impacts are minimised	Would reduce the potential impact on these sites to Negligible.

Mitigation measure D – Carry out archival recording and limited excavation of Clive Park Unidentified No. 1	Would reduce the potential impact on this site to Minor.
Mitigation measure E – Carry out archival recording of maritime heritage items	Would reduce the potential impact on these sites to Negligible.
Mitigation measure F – Complete and review the side scan sonar surveys for areas to be affected by project works.	Would reduce the impact on potential maritime heritage remains such as maritime infrastructure, shipwrecks and discarded objects to Negligible or Minor.
Mitigation measure G – Prepare a structural survey of the 'Harbour Foreshore' at Seaforth	Would reduce the potential impact on this site to Negligible.
Mitigation measure H – Carry out requisite steps to minimise settlement impacts for Harbour Foreshore' at Seaforth.	Would reduce the potential impact on this site to Negligible.
Mitigation measure I – Dive inspections for proposed Temporary Mooring Facility east of Clive Park in Middle Harbour.	Would reduce the impact on potential maritime heritage remains such as maritime infrastructure, shipwrecks and discarded objects to Negligible.

1 INTRODUCTION

1.1 Overview

The Greater Sydney Commission's *Greater Sydney Region Plan – A Metropolis of Three Cities* (Greater Sydney Commission, 2018) proposes a vision of three cities where most residents have convenient and easy access to jobs, education and health facilities and services. In addition to this plan, and to accommodate for Sydney's future growth the NSW Government is implementing the *Future Transport Strategy 2056* (Transport for NSW, 2018), that sets the 40 year vision, directions and outcomes framework for customer mobility in NSW. The Western Harbour Tunnel and Beaches Link program of works is proposed to provide additional road network capacity across Sydney Harbour and Middle Harbour and to improve transport connectivity with Sydney's Northern Beaches. The Western Harbour Tunnel and Beaches Link program of works include:

- The Western Harbour Tunnel and Warringah Freeway Upgrade project which comprises a new tolled motorway tunnel connection across Sydney Harbour, and an upgrade of the Warringah Freeway to integrate the new motorway infrastructure with the existing road network and to connect to the Beaches Link and Gore Hill Freeway Connection project
- The Beaches Link and Gore Hill Freeway Connection project which comprises a new tolled motorway tunnel connection across Middle Harbour from the Warringah Freeway and the Gore Hill Freeway to Balgowlah and Killarney Heights and including the surface upgrade of the Wakehurst Parkway from Seaforth to Frenchs Forest and upgrade and integration works to connect to the Gore Hill Freeway at Artarmon.

A combined delivery of the Western Harbour Tunnel and Beaches Link program of works would unlock a range of benefits for freight, public transport and private vehicle users. It would support faster travel times for journeys between the Northern Beaches and areas south, west and north-west of Sydney Harbour. Delivering the program of works would also improve the resilience of the motorway network, given that each project provides an alternative to heavily congested existing harbour crossings.

1.2 The project

Transport for NSW is seeking approval under Part 5, Division 5.2 of the *Environmental Planning and Assessment Act* 1979 to construct and operate the Beaches Link and Gore Hill Freeway Connection project, which would comprise two components:

- Twin tolled motorway tunnels connecting the Warringah Freeway at Cammeray and the Gore Hill Freeway at Artarmon to the Burnt Bridge Creek Deviation at Balgowlah and the Wakehurst Parkway at Killarney Heights, and an upgrade of the Wakehurst Parkway (the Beaches Link)
- Connection and integration works along the existing Gore Hill Freeway and surrounding roads at Artarmon (the Gore Hill Freeway Connection).

A detailed description of the project is provided in Chapter 5 (Project description) and Chapter 6 (Construction work) of the environmental impact statement.

The Gore Hill Freeway Connection component of the project is not relevant to this report and is therefore not discussed further.

1.3 Project location

The project would be located within the North Sydney, Willoughby, Mosman and Northern Beaches local government areas, connecting Cammeray in the south with Killarney Heights, Frenchs Forest and Balgowlah in the north.

Commencing at the Warringah Freeway at Cammeray, the mainline tunnels would pass under Naremburn and Northbridge, then cross Middle Harbour between Northbridge and Seaforth. The mainline tunnels would then split under Seaforth into two ramp tunnels and continue north to the Wakehurst Parkway at Killarney Heights and north-east to Balgowlah, linking directly to the Burnt Bridge Creek Deviation to the south of the existing Kitchener Street bridge.

Surface works would also be carried out at the Gore Hill Freeway in Artarmon, Burnt Bridge Creek Deviation at Balgowlah and along the Wakehurst Parkway between Seaforth and Frenchs Forest to connect the project to the existing arterial and local road networks.

1.4 Key features

Key features of the Beaches Link component of the project are shown in Figure 1-1. The key components which are relevant to this report include:

- Twin mainline tunnels about 5.6 kilometres long and each accommodating three lanes of traffic in each direction, together with entry and exit ramp tunnels to connections at the surface. The crossing of Middle Harbour between Northbridge and Seaforth would involve three lane, twin immersed tube tunnels
- Twin two lane ramp tunnels:
  - Eastbound and westbound connections between the mainline tunnel under Seaforth and the surface at the Burnt Bridge Creek Deviation, Balgowlah (about 1.2 kilometres in length)
  - Northbound and southbound connections between the mainline tunnel under Seaforth and the surface at the Wakehurst Parkway, Killarney Heights (about 2.8 kilometres in length)
  - Eastbound and westbound connections between the mainline tunnel under Northbridge and the surface at the Gore Hill Freeway and Reserve Road, Artarmon (about 2.1 kilometres in length).
- Operational facilities, including a motorway control centre at the Gore Hill Freeway in Artarmon and tunnel support facilities at the Gore Hill Freeway in Artarmon and the Wakehurst Parkway in Frenchs Forest
- Other operational infrastructure including groundwater and tunnel drainage management and treatment systems, surface drainage, signage, tolling infrastructure, fire and life safety systems, roadside furniture, lighting, emergency evacuation and emergency smoke extraction infrastructure, Closed Circuit Television (CCTV) and other traffic management systems.

Subject to obtaining planning approval, construction of the project is anticipated to commence in 2023 and is expected to take around five to six years to complete.

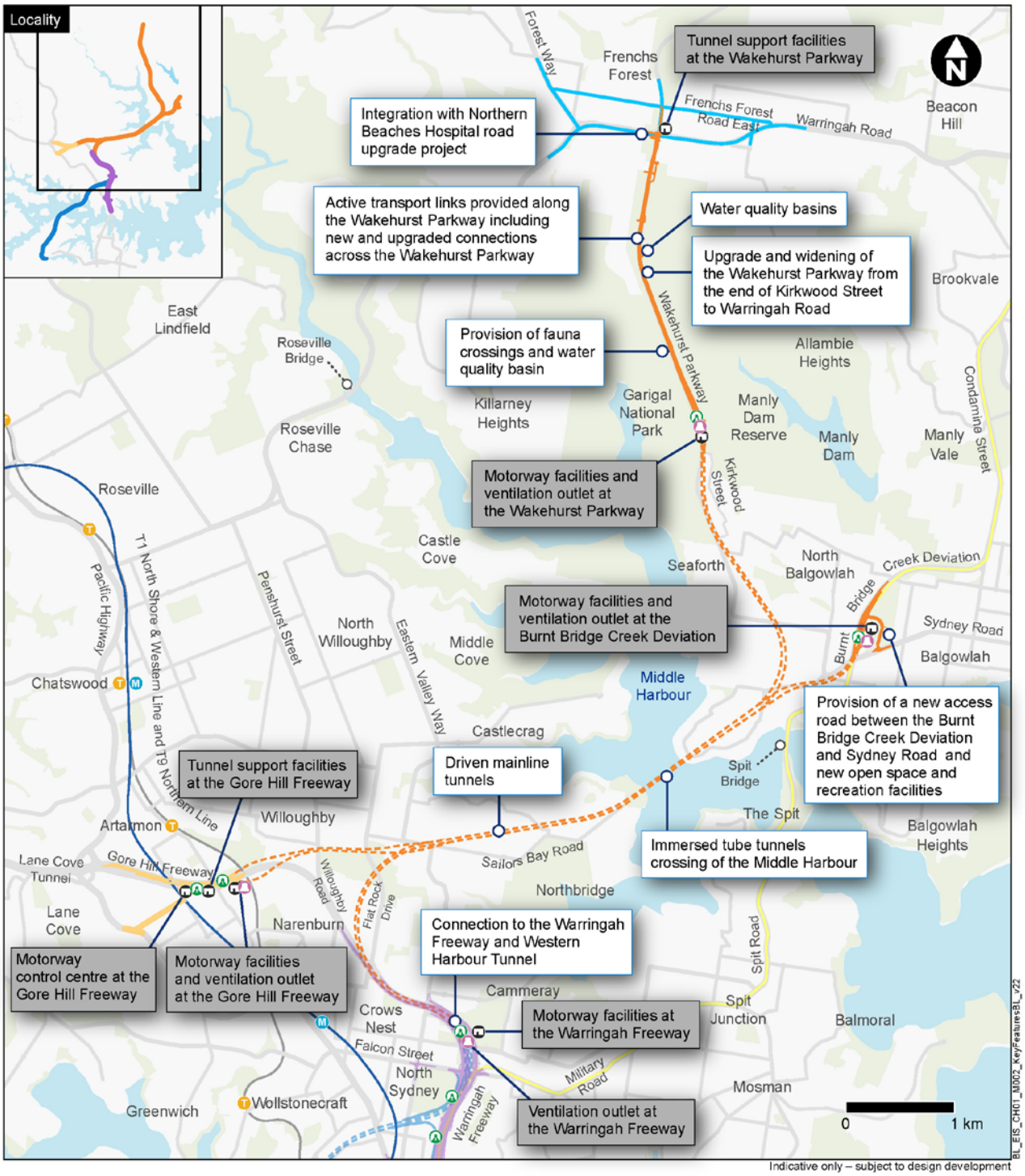


Figure 1-1 Key features of the Beaches Link component of the project

1.4.1 Immersed tube elements

The key feature of the Beaches Link component of the project relevant to this report is the crossing of Middle Harbour between Northbridge and Seaforth, which would be constructed as immersed tube tunnels.

The immersed tube tunnels would connect to the driven mainline tunnels in Middle Harbour offshore from Clive Park, Northbridge, and Seaforth Bluff, Seaforth.

The immersed tube tunnels would be installed as a series of pre-cast units. Due to the profile of the harbour bed, the units would sit both partially within in a trench closer to the shore and above the bed of the harbour towards the centre of the harbour crossing. The middle sections would be placed with the tops of the tunnel units being about 9.2 metres above the existing level of the bed of the harbour.

Given the very soft sediments at the bed of Middle Harbour, supporting piles would be required at discrete locations along the immersed tube crossing. A granular locking fill would be placed around the end sections (closer to the shore) of the immersed tube tunnels for stability and protection.

The water depth above the immersed tube tunnels would vary between 16 metres and 22 metres, depending on the distance from the shore.

The immersion of the tube tunnel elements would be performed by two immersion pontoons. Temporary anchors would be placed into the bed of the harbour prior to the immersion process to securely position the immersion pontoons and the tunnel elements.

Indicative cross sections of the immersed tube tunnel crossing of Middle Harbour are shown in Figure 1-2 (end sections) and Figure 1-3 (middle sections). An indicative long section of the immersed tube tunnels is shown in Figure 1-4.

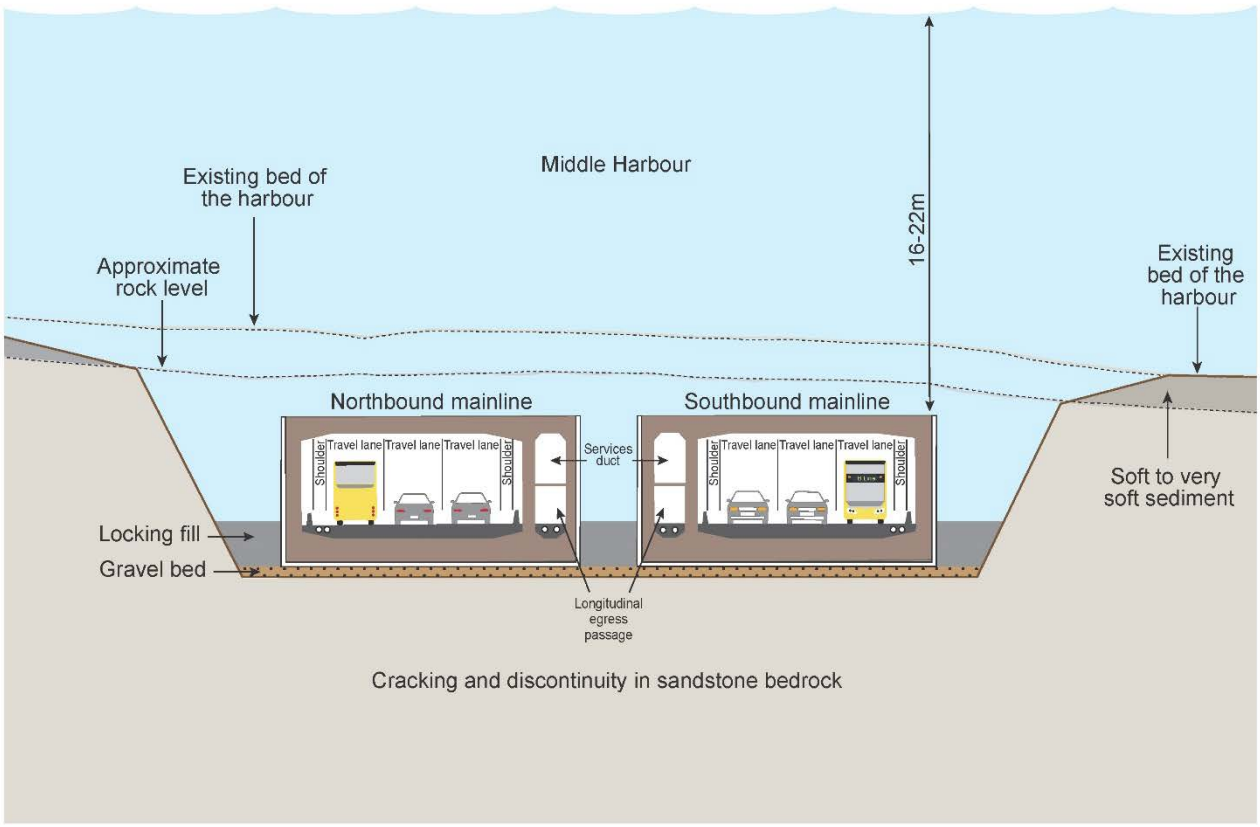


Figure 1-2 Indicative cross-section of the end sections of immersed tube tunnels at Middle Harbour

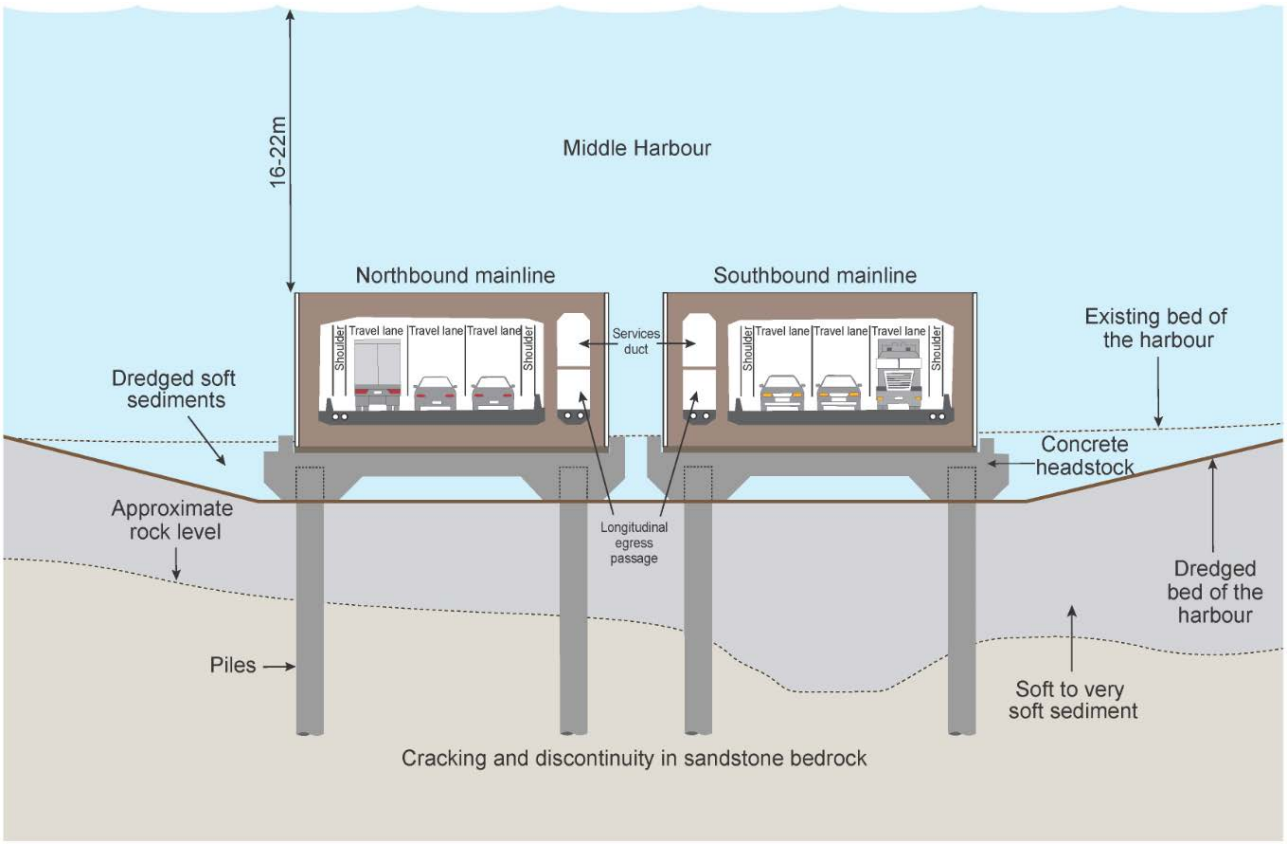


Figure 1-3 Indicative cross section of the immersed tube tunnels, Middle Harbour

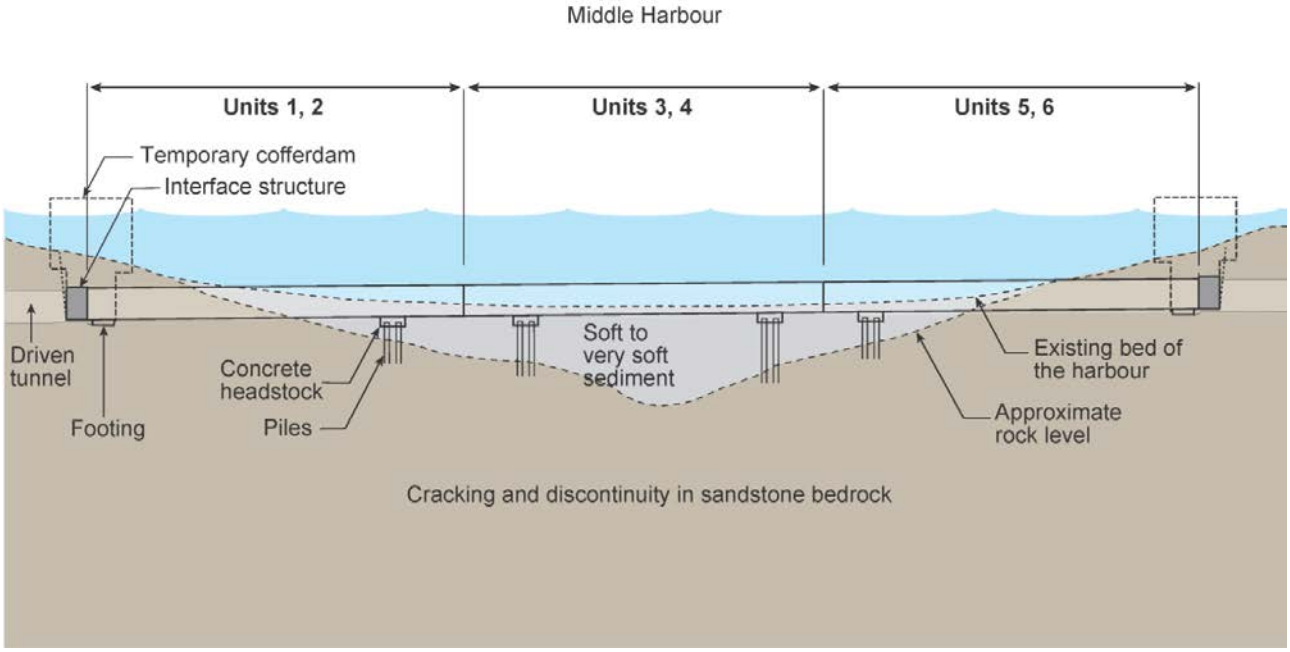


Figure 1-4 Indicative long section of the immersed tube tunnels, Middle Harbour.

1.4.2 Key construction activities

The area required to construct the project is referred to as the construction footprint. The majority of the construction footprint would be located underground within the mainline and ramp tunnels. However, surface areas would also be required to support tunnelling activities and to construct the tunnel connections, tunnel portals, surface road upgrades and operational facilities.

Key construction activities would include:

- Early works and site establishment, with typical activities being property acquisition and condition surveys, utilities installation, protection, adjustments and relocations, installation of site fencing, environmental controls (including noise attenuation and erosion and sediment control), traffic management controls, vegetation clearing, earthworks, demolition of structures, building construction support sites including acoustic sheds and associated access decline acoustic enclosures (where required), construction of minor access roads and the provision of property access, temporary relocation of pedestrian and cycle paths and bus stops, temporary relocation of swing moorings and/or provision of alternative facilities (mooring or marina berth) within Middle Harbour
- Construction of the Beaches Link, with typical activities being excavation of tunnel construction access declines, construction of driven tunnels, cut and cover and trough structures, construction of surface upgrade works, construction of cofferdams, dredging and immersed tube tunnel piled support activities in preparation for the installation of immersed tube tunnels, casting and installation of immersed tube tunnels and civil finishing and tunnel fitout
- Construction of operational facilities comprising:
  - A motorway control centre at the Gore Hill Freeway in Artarmon
  - Tunnel support facilities at the Gore Hill Freeway in Artarmon and at the Wakehurst Parkway in Frenchs Forest
  - Motorway facilities and ventilation outlets at the Warringah Freeway in Cammeray (fitout only of the Beaches Link ventilation outlet at the Warringah Freeway (being constructed by the Western Harbour Tunnel and Warringah Freeway Upgrade project), the Gore Hill Freeway in Artarmon, the Burnt Bridge Creek Deviation in Balgowlah and the Wakehurst Parkway in Killarney Heights
  - A wastewater treatment plant at the Gore Hill Freeway in Artarmon
  - Installation of motorway tolling infrastructure
- Upgrade and integration works at Balgowlah and along the Wakehurst Parkway with typical activities being earthworks, bridgeworks, construction of retaining walls, stormwater drainage, pavement works and linemarking and the installation of roadside furniture, lighting, signage and noise barriers
- Testing of plant and equipment and commissioning of the project, backfill of access declines, removal of construction support sites, landscaping and rehabilitation of disturbed areas and removal of environmental and traffic controls.

Temporary construction support sites would be required as part of the project (refer to Figure 1-5), and would include tunnelling and tunnel support sites, civil surface sites, cofferdams, mooring sites, wharf and berthing facilities, laydown areas, parking and workforce amenities.

Only three construction support sites are relevant to this report. These are:

- Middle Harbour south cofferdam (BL7)
- Middle Harbour north cofferdam (BL8)
- Spit West Reserve (BL9).

A detailed description of construction works for the project is provided in Chapter 6 (Construction work) of the environmental impact statement.

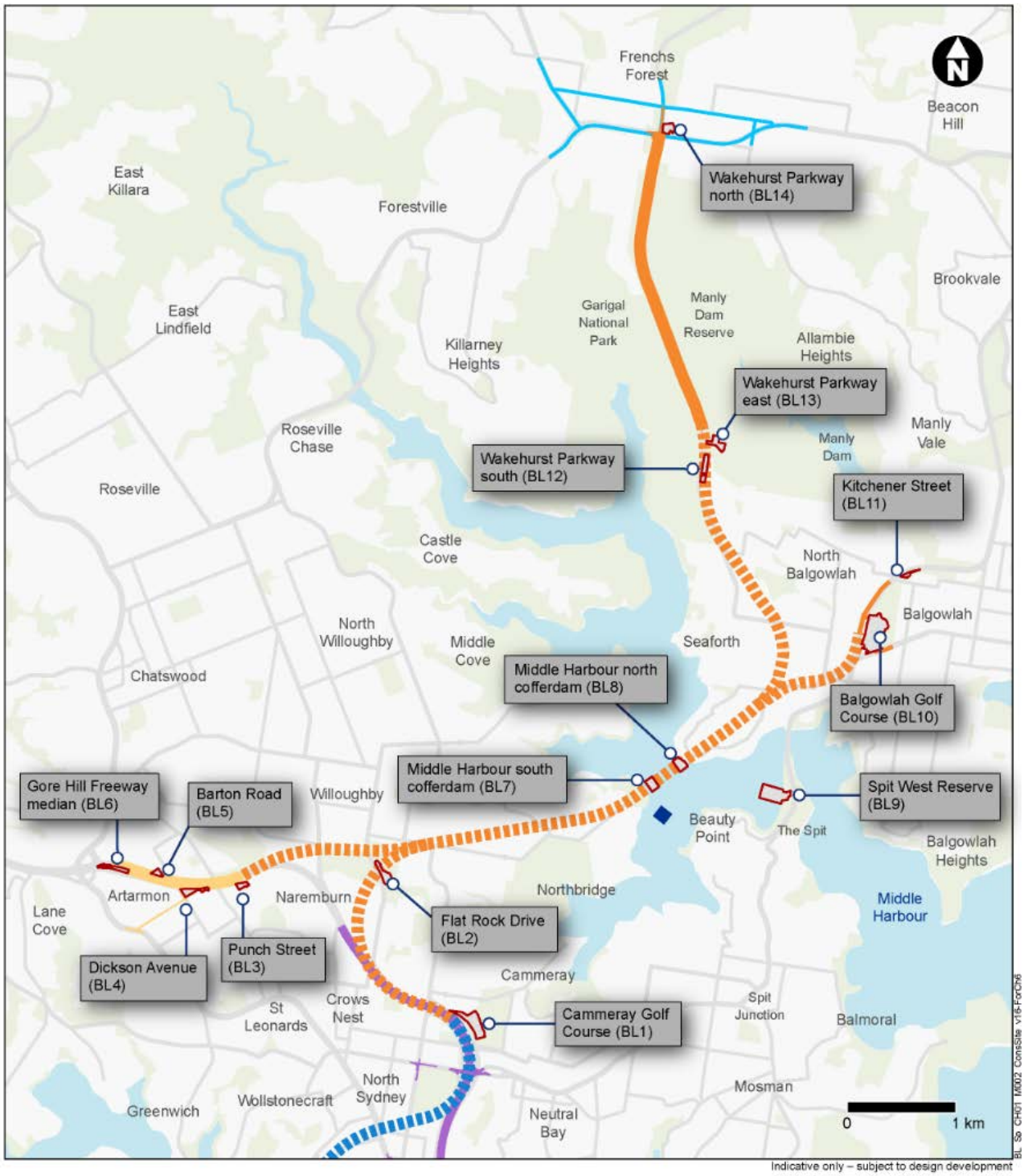


Figure 1-5 Overview of construction support sites.

1.5 Purpose of this report

This report has been prepared to support the assessment of non-Aboriginal maritime heritage for the environmental impact statement for the project. The environmental impact statement has been prepared to accompany the application for approval of the project and address the environmental assessment requirements of the Secretary of the Department of Planning, Industry and Environment ('the Secretary's Environmental Assessment Requirements'). Aboriginal maritime archaeological heritage issues are addressed in Appendix L - Technical working paper: Cultural heritage assessment report (Jacobs, 2020).

Cosmos Archaeology Pty Ltd was engaged to satisfy the maritime archaeological aspects of the Secretary's environmental assessment requirements (SEARs) reproduced in Section 1.6.

This report addresses all aspects of historical underwater cultural heritage, from now referred to as maritime heritage. The potential for submerged Aboriginal archaeological sites has been addressed in a separate document (Cosmos Archaeology Pty Ltd 2019).

This report has been prepared in accordance with the following guidelines:

- *Criteria for the Assessment of Excavation Directors* (NSW Heritage Council 2011)
- *NSW Heritage Manual* (Heritage Office and Department of Urban Affairs and Planning 1994)
- *Assessing Heritage Significance* (NSW Heritage Office 2001)
- *The Australia ICOMOS Burra Charter*

1.6 Secretary's environmental assessment requirements

The Secretary's environmental assessment requirements (SEARs) relating to heritage, which includes maritime heritage, are shown in Table 1.

Table 1: Secretary's Environmental Assessment Requirements for Heritage

SEARs	Where addressed
1. The Proponent must identify and assess any direct and/or indirect impacts (including cumulative, vibration and visual impacts to the heritage significance of listed (and nominated) heritage items inclusive of:	Addressed in Section 8.3 and 8.6.4 for cumulative impacts
(a) Aboriginal places and objects, as defined under the *National Parks and Wildlife Act 1974* and in accordance with the principles and methods of assessment identified in the current guidelines;	Not addressed in this report – see Appendix L - Technical working paper: Cultural heritage assessment report.
(b) Aboriginal places of heritage significance, as defined in the Standard Instrument – Principal Local Environmental Plan;	Not addressed in this report – see Appendix L - Technical working paper: Cultural heritage assessment report.
(c) environmental heritage, as defined under the *Heritage Act 1977* (including potential items of heritage value, conservation areas, open space heritage landscapes, built heritage landscapes and archaeology);	Addressed in Chapters 4 to 6
(d) items listed on the State, National and World Heritage lists;	Addressed in Section 3.1
(e) heritage items and conservation areas identified in local and regional planning environmental instruments covering the project area; and	Addressed in Section 3.1
(f) marine items of potential heritage significance within Middle Harbour, such as any shipwrecks.	Addressed in Chapters 4 to 6
2. Where impacts to State or locally significant heritage items or archaeology are identified, the assessment must:	
(a) include a significance assessment and statement of heritage impact for all heritage items (including any unlisted places that are assessed of heritage value;	Addressed in Chapter 7
(b) provide a discussion of alternative locations and design options that have been considered to reduce heritage impacts;	Addressed in Section 8.2

SEARs	Where addressed
(c) in areas identified as having potential archaeological significance, carry out a comprehensive archaeological assessment and management plan in line with Heritage Council guidelines which includes a methodology and research design to assess the impact of the works on the potential archaeological resource and to guide physical archaeological test excavations and include the results of these excavations. This is to be carried out by a suitably qualified archaeologist and is to discuss the likelihood of historical, maritime and Aboriginal archaeology of heritage significance on the site, how this may be impacted by the project, and includes measures to mitigate any impacts;	Addressed in Chapter 9
(d) consider impacts to the item of significance caused by, but not limited to, vibration, demolition, archaeological disturbance, altered historical arrangements and access, increased traffic, visual amenity, landscape and vistas, curtilage, subsidence and architectural noise treatment (as relevant);	Addressed in Section 8.6
(e) provide a comparative analysis to inform the rarity and representative value of any heritage places proposed for demolition;	Addressed in Section 8.7
(f) outline mitigation measures to avoid and minimise identified impacts in accordance with the current guidelines; and	Addressed in Chapter 9
(g) be carried out by a suitably qualified heritage consultant(s) (note: where archaeological excavations are proposed the relevant consultant must meet the NSW Heritage Council's Excavation Director criteria).	Cosmos Coroneos is an experienced archaeologist of over 25 years who has obtained permits under the Heritage Act for the excavation of Local and State significant sites in NSW
3. Where archaeological investigations of Aboriginal objects are proposed these must be conducted by a suitably qualified archaeologist, in accordance with section 1.6 of the *Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW* (DECCW 2010).	Not addressed in this report – see Appendix L - Technical working paper: Aboriginal cultural heritage assessment report

2 APPROACH TO THIS STUDY

This chapter outlines the methods used to determine the existing conditions of the project area, assess the potential impacts on non-Aboriginal maritime heritage, and formulate focused and appropriate mitigation measures proportionate to the cultural heritage significance of the identified maritime heritage.

2.1 Study area

This maritime heritage assessment is separated into three study areas (Figure 2-1):

- Area A – the proposed tunnel alignment and cofferdams between Northbridge (Middle Harbour south cofferdam (BL7) and Seaforth Middle Harbour north cofferdam (BL8))
- Area B – the proposed construction support site in Pearl Bay and the western side of The Spit (Spit West Reserve (BL9))
- Area C – the proposed temporary mooring facility east of Clive Park in Middle Harbour.

Figure 2-1: Study area for the maritime heritage assessment separated into Area A – Northbridge to Seaforth, Area B – Pearl Bay, including the western side of The Spit, and Area C at the entrance to Long Bay (Base image: Google Earth)

2.2 Assessment process

Cosmos Archaeology Pty Ltd prepared an Issues Paper and Desktop Assessment for the project in 2017 (Cosmos Archaeology Pty Ltd 2018). The assessment drew on the findings of past reports. From this information, two areas were identified in Middle Harbour that formed a focus for initial assessments. The areas were:

- Area A: between Clive Park at Northbridge and Seaforth Bluff at Seaforth
- Area B: on the western side of The Spit, including D'Albora Marina.

The proposed temporary compound to the south-east of Clive Park in Northbridge (Area C) was not included in the 2017 Issues Paper or Desktop Assessment, as information on the use of the area for the project was not available at the time.

The areas primarily cover the bed of the harbour but also include adequate buffers to account for areas of the foreshore that have been reclaimed as part of previous development. Area B is confined to the eastern portion of the proposed disturbance footprint for the project (Figure 2-1).

This impact assessment report was carried out in four stages, as detailed below:

1. Baseline review
2. Field survey

3. Establishing maritime heritage potential, significance and sensitivity
4. Assessing impacts and appropriate mitigation measures.

2.2.1 Baseline review

The start of the assessment process involved reviewing available information to form a basic understanding of the potential extent, variety, condition and significance of maritime heritage within the study area; often referred to as a predictive model. The information obtained during this baseline review guided the direction and conduct of field investigations, which in turn refined the understanding of the maritime heritage resource. This allowed more informed assessments to be prepared on the heritage significance of the resource, potential impacts on that resource, and the formulation of suitable mitigation measures.

The baseline review comprised two main components: a desktop review of archival resources, heritage databases and secondary reports, and an examination of remote sensing data.

2.2.1.1 Desktop literature review

The following archival resources, heritage databases and reports were reviewed:

Resource	Description
Previous Cosmos Archaeology reports	Cosmos Archaeology has previously carried out several maritime archaeological assessments within the project area, particularly around Pearl Bay and The Spit (Cosmos Archaeology Pty Ltd 2006a, 2006b, 2010).
Transport for NSW archives	Transport for NSW has a collection of detailed surveys and plans of the project area shoreline dating back to the late 19th century. These surveys have been annotated over time to keep track of maritime leases and changes to the shoreline such as reclamations and construction of maritime infrastructure.
NSW Maritime Heritage database	The Maritime Heritage Sites database, managed by the Department of Premier and Cabinet (Heritage) ,,contains information on identified maritime heritage sites – mostly shipwrecks – in NSW.
NSW Wrecks Info – Shipwreck Position Database (NSW Wrecks)	The NSW Wrecks Info website is managed by avocational wreck researchers and contains publicly available information on the position of shipwrecks compiled from a number of sources (NSW Wrecks Info 2017). The Shipwreck Position Database is available as a number of Google Earth files under different categories including checked waypoints (shipwrecks found and dived on), unchecked waypoints (possible shipwrecks that have not been inspected), side scan sonar hits, compiled targets from reported sinking positions, World War II echo sounder anomalies, trawler snags and others.
NSW State Heritage Inventory	The NSW State Heritage Inventory is a database managed by the Heritage Division of the Department of Premier and Cabinet (Heritage) and comprises a listing of all heritage places and objects included in state and local statutory registers across NSW.
Australian National Shipwreck Database	The Australian National Shipwreck Database, maintained by the Commonwealth Department of the Environment and Energy, is an online database of known and potential shipwrecks, aircraft wrecks and other maritime heritage sites and objects in Australian waters.
Archival sources and heritage reports	A review of a wide range of primary and secondary historical sources held by NSW libraries and State Records, and various published and unpublished heritage reports and articles, was also carried out.

2.2.1.2 Remote sensing data review

The following remote sensing data was examined to identify potential items of maritime heritage. A summary of the effectiveness of the remote sensing techniques used for the project in provided in Table 2.

Side scan sonar data

A side scan sonar survey was carried out specifically for the project for the purpose of mapping bed of the harbour features and identify any significant features which could impact future drilling or near shore construction activities' (Earth Technology Solution Pty Ltd July 2017a). The survey covered most of the proposed extent of the disturbance footprint for Area A, apart from two northern projections of about 80 by 25 metres and the eastern nearshore portion of Area B (see Figure 2-2). The side scan sonar survey did not cover Area C.

Figure 2-2: Extent of side scan sonar survey in relation to proposed extent of disturbance footprint (in solid blue and solid orange) (Base image: Google Earth, Side scan sonar data provided as .shp files by Adam Podnar Geotechnical Engineer, Douglas Partners, 5 December 2017).

Seismic reflection profiling survey

Seismic or sub-bottom profiling is the marine equivalent of ground penetrating radar. This form of remote sensing technology is primarily used to record geological strata below the bed of the harbour to assist engineers in their design of marine structures as well as assist dredge contractors in understanding the material they will be encountering.

Two seismic reflection profiling surveys were carried out in the study area. The initial survey was carried out during May and June 2017 to 'map subsurface layers across the site to assess geological conditions for tunnel alignment assessment including the depth to top of rock and significant sediment layers, and provide sufficient spatial coverage to allow production of contour plans of these layers' (Figure 2-3) (Earth Technology Solution Pty Ltd, July 2017a: 3). An additional survey was carried out in late October 2017 along the tunnel alignment next to Seaforth (Marine & Earth Sciences, November 2017).

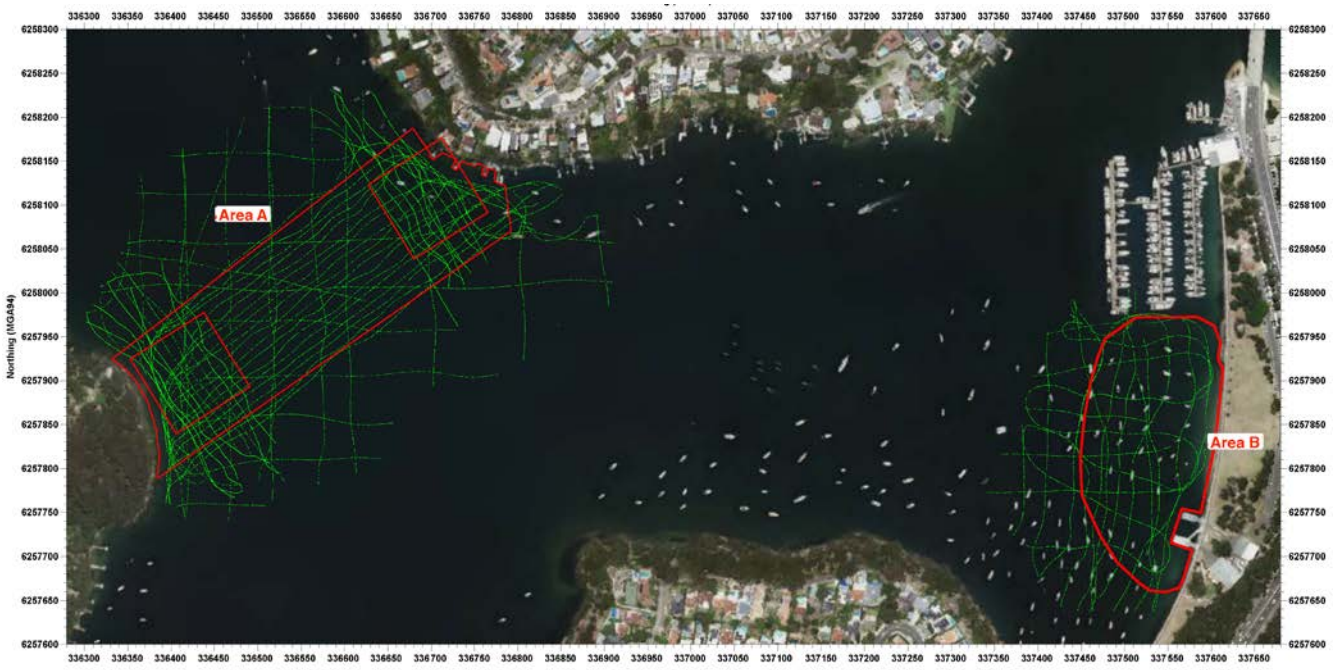


Figure 2-3 Vessel track plot showing extent of seismic reflection survey in Areas A and B (Earth Technology Solution Pty Ltd, July 2017a: Figure MH 4). The green lines show where the survey collected the data. The red boxes show the area of interest around the proposed cofferdams.

The seismic reflection data was examined, however it was determined to be of insufficient resolution to allow the identification of buried anomalies that may indicate the presence of historical cultural material such as the remains of wreckage. This is more so the case with timber-hulled wrecks which are very difficult to identify through seismic reflection survey techniques unless the parameters of the data collection process are specifically calibrated to detect such sites.

Core and non-core drilling

Geotechnical drilling took place within Area A (for purposes other than heritage investigation) throughout May and June 2017. Various techniques were deployed at 74 drilling locations.

The data collected from the drilling did not find any cultural material. However, this was determined to have limited value in identifying historical cultural material. This is because the small diameter (< 300 mm) and the relatively low frequency of the holes would have been very unlikely to intersect significant archaeological material.

Magnetometer survey

A magnetometer survey was conducted in Area A in June 2017 with the 'focus on the nearshore (two potential cofferdams) areas to attempt to delineate potential geological features such as a fault or dykes and also significant sized metal objects such as vessel wrecks and other debris' (Figure 2-4) (Earth Technology Solution Pty Ltd, July 2017a: 2).

Area B was not surveyed, because the number of moored vessels in the area would have had an adverse influence on the magnetic data.

The line spacing for the survey was 10 metres however there was no information on whether the tow-fish was kept at a constant altitude or what that altitude was. The absence of this information does not allow for a determination as to approximate size of ferrous objects that may be present on or under the bed of the harbour. The survey stated that the magnetometer survey was designed to identify 'significant sized metal objects', so it can be expected that the altitude of the tow-fish was not low enough to detect smaller ferrous components and fittings of timber-hulled wrecks.

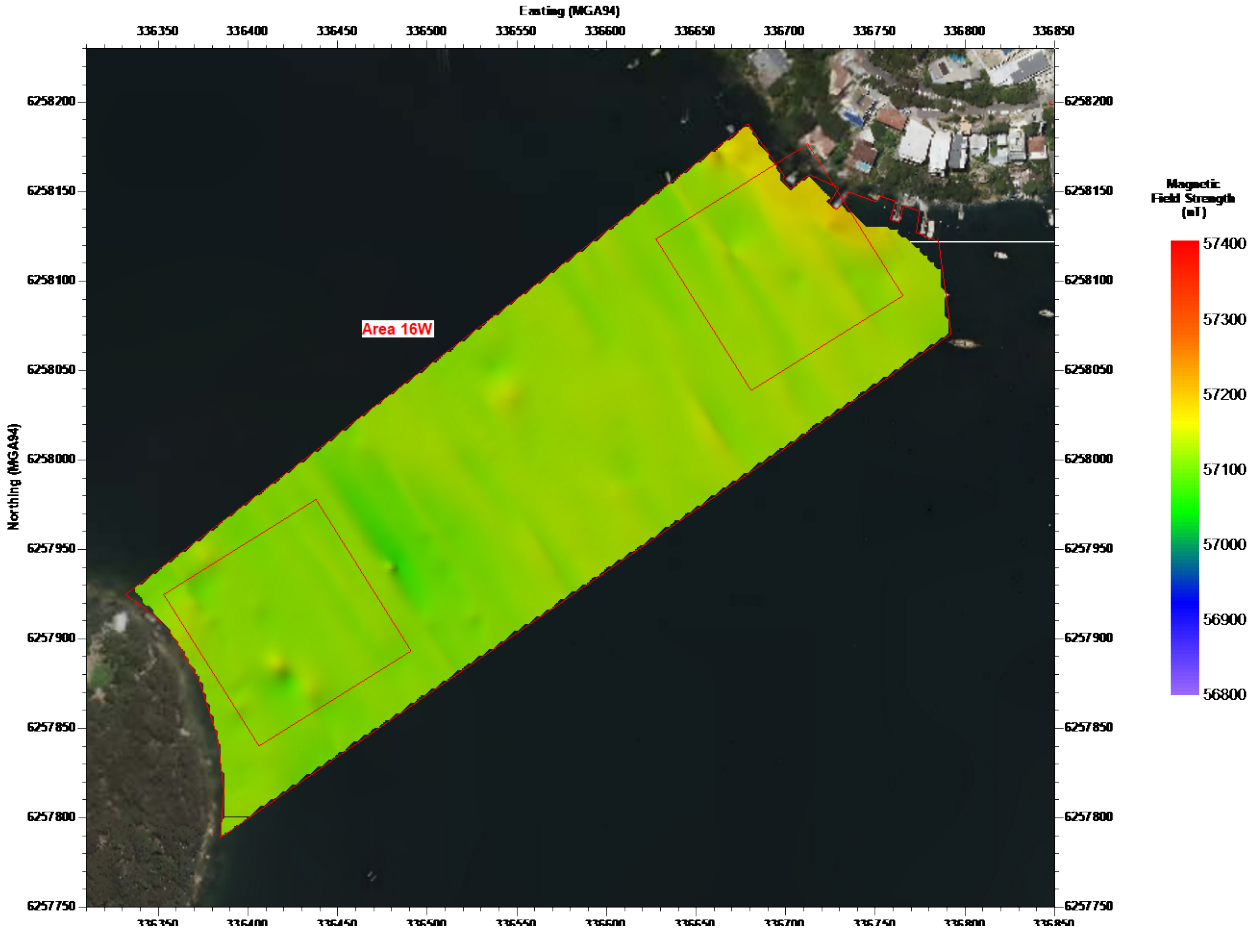


Figure 2-4: Extent of magnetometer survey in Area A (Earth Technology Solution Pty Ltd, July 2017a: Figure MH9A). The red boxes show the area of interest around the proposed cofferdams.

Table 2 Summary table of the effectiveness of remote sensing techniques employed for the detection of maritime heritage

Remote sensing type	Uses	Coverage	Effectiveness for this study
Side Scan Sonar	Excellent for detecting cultural objects on bed of the harbour	95% of bed of the harbour in Areas A and B where disturbance proposed	Optimum. However, 5% of bed of the harbour to be impacted not covered
Seismic profiling	Potential for detecting buried cultural remains	100% of bed of the harbour in Areas A and B where sub-surface disturbance proposed	Limited. Parameters of survey may not have included settings to provide sufficient resolution images for the detection of cultural buried objects closer to bed of the harbour surface
Core drilling	Not very useful for finding buried objects unless looking for large sites such as a wreck, and only when the approximate location of the wreck is known	Carried out in Area A	Very limited although74 bore holes were conducted and no material of potential cultural significance was found
Magnetometer	Excellent for looking for maritime heritage with ferrous components	95% of bed of the harbour in Area A	Limited. Good for looking for larger sites with large ferrous components but not for timber hulled wrecks with limited ferrous content. Could not estimate size of ferrous objects

2.2.2 Field survey

The purpose of the field survey was to test the predictive model formulated in the baseline review as well as to inspect anomalies of potential cultural heritage significance identified from the geophysical surveys. The field survey, in the form of a diving investigation, took place over five days between 13 and 19 December 2017. The investigations were led by maritime archaeologists Cosmos Coroneos (Cosmos Archaeology Pty Ltd) and Matt Carter (archaeologist).

An archaeological review of the remote sensing data available for the study identified 12 anomalies of potential cultural heritage significance. Of these anomalies, nine were inspected while one was assessed to be too deep to be dived on under the diving standards that were being followed and with the equipment available. The remaining two anomalies were not inspected in the time available as they were considered unlikely to be of cultural heritage value.

The findings of the dive investigations are presented in Chapters 4 and 5 of this report. The conduct and the results of the dive investigation are presented in the Cosmos Archaeology January 2018 report *Western Harbour Tunnel and Beaches Link: Maritime Archaeological Dive Inspections December 2017*.

2.2.3 Establishing maritime heritage potential, significance and sensitivity

This report largely assesses maritime heritage that is either submerged or buried. Not all maritime heritage is documented in the historical record, and what is submerged and/or buried is archaeological in nature. Given the size of the study area it was not possible to carry out a complete visual examination of the bed of the harbour.

Maritime heritage potential has been determined through historical and comparative site research augmented with the findings of the field and geotechnical investigations carried out for this project. The conditions of the maritime heritage resource have also been predicted based on the understanding of the site conditions and underwater cultural site formation processes (see Cosmos Archaeology Pty Ltd November 2017). The level of maritime heritage potential is presented for Areas A, B and C in Sections 4.5, 5.5 and 6.5.

Understanding the cultural heritage significance of maritime heritage is critical in determining an appropriate level of impact mitigation. Maritime heritage assessments within the study area are provided in Chapter 7. It is noted that remote sensing anomalies that were not inspected could not have their cultural heritage significance confidently assessed.

Maritime heritage sensitivity combines maritime heritage potential and significance to devise appropriate mitigation measures. Definitions and assessments of sensitivity for Areas A, B and C are provided in Section 7.4.

2.2.4 Assessing impact and appropriate mitigation measures

The identified potential impacts of the proposed development are presented for Areas A, B and C in Chapter 8. Based on the findings of the impact assessments, appropriate mitigation measures are presented in Chapter 9.

2.3 Definitions

In this study, maritime heritage is defined as all material of potential heritage significance on or under the bed of the harbour below the Highest Astronomical Tide (the highest level of water which can be predicted to occur under any combination of astronomical conditions). This includes areas of former bed of the harbour that are under reclamation.

Components of archaeological and heritage listed sites that have a land/water interface, such as slipways, seawalls and wharves, are also addressed.

Built heritage components of such sites, such as roads, gates and buildings built on reclaimed land, are not assessed within this study.

The following definitions are also used throughout this report:

- *Biological damage* includes impacts from biological organisms to organic materials of a site
- *Chemical damage* includes impacts affecting the fabric and structural integrity of a site, such as corrosion
- *Discard* includes items that have been accidentally or deliberately deposited in or on the bed of the harbour or within reclamation and now form an archaeological site
- *Fetch* is the distance travelled by wind or waves across open water, contributing to the generation of waves
- *Foreshore* includes areas in immediate contact with the edge of the harbour
- *Highest Astronomical Tide* refers to the highest tide level which can be predicted to occur under average meteorological conditions and any combination of astronomical conditions
- *Maritime infrastructure* are structures built for industrial or recreational use associated with activities on or near the harbour
- *Mechanical damage* includes impacts affecting the physical integrity of a site
- *Reclaimed land* refers to fill being deposited onto the bed of the harbour usually adjacent to land for the purposes of extending, raising and/or levelling the land. Reclaimed land is usually retained by a seawall
- *Bed of the harbour* includes sediments forming the floor of the harbour
- *Submerged* is used to describe land or archaeological heritage that are currently under water or have become buried by reclamation.

3 HERITAGE LEGISLATION AND POLICY

3.1 Heritage listings in study area

There are four levels of statutory listings for historical cultural heritage sites, objects and places in NSW:

- local listing on the heritage schedule of a council's environmental planning instrument
- state listing on the NSW State Heritage Register
- national listing on the National Heritage List
- world listing on the United Nations Educational Scientific and Cultural Organization (UNESCO) World Heritage List.

Sites and items owned, occupied or managed by the NSW Government can also be included in the Heritage and Conservation Register of the respective agency or corporation under Section 170 of the NSW *Heritage Act 1977.*

Inclusion on such statutory heritage registers provides automatic protection. In NSW, protection for historical heritage sites and items is afforded by the NSW *Heritage Act 1977*, the NSW *Environmental Planning and Assessment (EPA) Act* 1979, the Commonwealth *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* and the UNESCO *Convention Concerning the Protection of the World Cultural and Natural Heritage.*

Additional protection is also afforded to historic shipwrecks and associated relics within NSW waters under the Commonwealth *Historic Shipwrecks Act 1976.* However, this Act does not apply to internal state waters, including the study area.

Cultural heritage sites, objects and places may also be listed on non-statutory registers; most notably, the Register of the National Estate. The act of listing a place on the Register of the National Estate does not constitute automatic legal protection, however the Register is widely recognised as an authoritative compilation of the heritage significance of many of Australia's natural and cultural places and is considered by planning agencies when decisions about development and conservation are being made.

Table 1 provides a summary of the heritage register listings and associated legislative protection within the study area.

Table 3 Summary of heritage register listings within the study area

HERITAGE REGISTER	STATUTORY PROTECTION	LISTED SITES IN AREAS A, B and C
World Heritage List	UNESCO *Convention Concerning the Protection of the World Cultural and Natural Heritage*	There are no sites listed on the World Heritage List in Areas A, B or C, or immediate surrounds
National Heritage List	*Environment Protection and Biodiversity Conservation Act 1999*	There are no sites listed on the National Heritage List in Areas A, B or C, or immediate surrounds
State Heritage Register	NSW *Heritage Act 1977*	There are no sites listed on the State Heritage Register in Areas A, B or C, or immediate surrounds
Transport for NSW S170 Heritage & Conservation Register	NSW *Heritage Act 1977*	There are no sites listed on the Transport for NSW S170 Register in Areas A, B or C, or immediate surrounds
Sydney Regional Environmental Plan 2005	Sydney REP made under the *Environmental Planning and Assessment Act 1979*	There are no sites listed on the Sydney Regional Environmental Plan 2005 in Areas A, B or C, or immediate surrounds
Manly Local Environmental Plan 2013	Manly LEP made under the *Environmental Planning and Assessment Act 1979*	• 'Harbour Foreshore' – Seaforth (Area A)
Willoughby Local Environmental Plan 2012	Willoughby LEP made under the *Environmental Planning and Assessment Act 1979*	• Clive Park Tidal Pool – Clive Park (Area A)
Register of the National Estate	Non-statutory register	There are no sites listed on the Register of the National Estate in Areas A, B or C, or immediate surrounds

3.2 Statutory protection

The following section provides a discussion of the statutory requirements afforded under the NSW *Heritage Act 1977,* as it applies to the current project – an identified State significant infrastructure project and the *Environmental Planning and Assessment Act 1979*.

3.2.1 NSW Heritage Act 1977

The *Heritage Act 1977* (the Heritage Act) provides protection for items of 'environmental heritage' in NSW. 'Environmental heritage' includes places, buildings, works, relics, movable objects or precincts considered significant based on historical, scientific, cultural, social, archaeological, architectural, natural or aesthetic values. Items considered to be significant to the state are listed on the State Heritage Register and cannot be demolished, altered, moved or damaged, or their significance altered without approval from the Heritage Council of NSW.

For the purposes of the Heritage Act, the State of NSW includes the bed of the harbour and the water column up to three nautical miles from the coast. Shipwrecks currently under the jurisdiction of the Heritage Act are identified in the Historic Shipwrecks Register, maintained by the NSW Heritage Council.

The *Heritage Act 1977* also provides protection for 'relics', which includes archaeological material or deposits. Section 4 (1) of the Heritage Act (as amended in 2009) defines a relic as:

'...any deposit, artefact, object or material evidence that:

(a) relates to the settlement of the area that comprises New South Wales, not being Aboriginal settlement, and

(b) is of State or local heritage significance'

Sections 139 to 145 of the *Heritage Act 1977* make it an offence to excavate or disturb land known or likely to contain relics, unless under an excavation permit. Section 139 (1) states:

> *A person must not disturb or excavate any land knowingly or having reasonable cause to suspect that the disturbance or excavation will or is likely to result in a relic being discovered, exposed, damaged or destroyed unless the disturbance is carried out in accordance with an excavation permit.*

Excavation permits are issued by the Heritage Council of NSW, or its Delegate, under Section 140 of the *Heritage Act 1977* for relics not listed on the State Heritage Register, or under Section 60 for relics listed on the State Heritage Register. An application for an excavation permit must be supported by an Archaeological Research Design and Archaeological Assessment prepared in accordance with the NSW Heritage Division archaeological guidelines. Minor works that would have a minimal impact on archaeological relics may be granted an exception under Section 139 (4) or an exemption under Section 57 (2) of the Act.

As the current project is subject to Division 5.2 (State Significant Infrastructure) provisions of the NSW *Environmental Planning & Assessment Act 1979*, excavation or exception permits issued under the *Heritage Act 1977* would not be required. Conditions of approval nonetheless could require the same consideration of the heritage significance of archaeological relics and the management of impacts, including those through archaeological investigation.

Part 3C of the Heritage Act also contains specific provisions for the protection of shipwrecks more than 75 years old. This section is included to provide a link to and consistency with the Commonwealth *Historic Shipwrecks Act 1976*. In NSW the 'relics' provision takes precedence over Part 3C when it comes to determining the legal and protected status of a wreck and associated artefacts. This applies to known and potential relics present on or in the bed of the harbour, even if the sites are not listed on the State Heritage Register.

3.2.2 NSW Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act 1979* (the EP&A Act) establishes the framework for cultural heritage values to be formally assessed in the land use planning and development consent process.

The EP&A Act requires that environmental impacts are considered before land development including impacts on cultural heritage items and places as well as archaeological sites and deposits.

Environmental planning instruments are made under the EP&A Act, and are used to regulate land use, development and environmental impact assessment. They include State Environmental Planning Policies

and Local Environmental Plans. Historically, Regional Environmental Plans were also made, but these instruments are now deemed to be State Environmental Planning Policies.

Sydney Regional Environmental Plan (Sydney Harbour Catchment) (2005)

Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005 aims to protect, enhance and maintain the catchment, foreshores, waterways and islands of Sydney Harbour for existing and future generations.

Clause 52(b) of *Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005* requires public authorities and others to consider the matters listed in the Plan before they carry out activities to which Part 5 of the EP&A Act applies.

Local environmental plans – Manly (2013), Mosman (2012) and Willoughby (2012)

While the majority of the study area is within the water bodies of Sydney Harbour and Middle Harbour, the shoreward extents of the study area cross into three local government areas:

- Northern Beaches Council (Area A)
- Mosman (Area B)
- Willoughby (Area A).

Local environmental plans constitute environmental planning instruments prepared at a state level in accordance with the EP&A Act and provide statutory protection of heritage assets within local government areas.

As indicated above, although these local environmental plans do not apply to the project, their heritage schedules have been checked to identify waterside items that may contribute to the maritime heritage resource.

3.3 Summary of statutory provisions relevant to the study area

Table 4 provides a compilation of all the items listed on heritage registers that are located within the bed of the harbour and foreshore of the study area and included in this study.

Table 4: All identified items with existing statutory protection discussed in this report

Area	Item	SHR (*NSW Heritage Act 1997*)	S170 (*NSW Heritage Act 1997*)	REP (*Environmental Planning and Assessment Act 1979*)	LEP (*Environmental Planning and Assessment Act 1979*)
A	Harbour foreshores –Northern Beaches Council municipalarea boundary adjacent to the harbour, all suburbs	-	-	-	*Manly Local Environmental Plan 2013* (Item I1)
A	Clive Park and Tidal Pool – Sailors Bay Road, Northbridge, Lot 7093, DP 93909, Lot 347, DP 1130320	-	-	-	*Willoughby Local Environmental Plan 2012* (Item I179)

3.4 Heritage policies relevant to maritime heritage

This report adheres to the principles outlined in the following heritage policies and guidelines.

3.4.1 UNESCO *Convention on the Protection of the Underwater Cultural Heritage*

The UNESCO *Convention on the Protection of the Underwater Cultural Heritage*, adopted in 2001, sets out the basic principles for the protection of underwater cultural heritage, provides a detailed cooperation system and provides widely recognised practical rules for the treatment and research of underwater cultural heritage. The main principles are:

- Obligation to preserve underwater cultural heritage
- *In situ* preservation as first option
- No commercial exploitation
- Training and information sharing.

3.4.2 The Burra Charter

The Burra Charter 2013 provides a best practice standard for managing cultural heritage places in Australia. The Burra Charter was first adopted in 1979 and is periodically updated to reflect developing understanding of the theory and practice of cultural heritage management. The current version was adopted in 2013.

The Charter can be applied to all types of places of cultural significance including natural, Indigenous and historic places with cultural values. The Burra Charter advocates a cautious approach to change: do as much as necessary to care for the place and to make it useable, but otherwise change it as little as possible so that its cultural significance is retained. The Charter includes 12 conservation principles which are further developed in the processes and practice sections of the Charter.

3.4.3 Guidelines for the Management of Australia's Shipwrecks

The *Guidelines for the Management of Australia's Shipwrecks* were produced as a combined publication by the Australian Institute for Maritime Archaeology Inc. (now the Australasian Institute for Maritime Archaeology) and the Australian Cultural Development Office (now the Australian Government Department of the Environment and Energy) in 1994.

The guidelines comprise principles and practices that have been adopted by Australia's professional maritime archaeologists and serve as useful modules for other groups. The document includes a Statement of Principles governing the broad approach to be taken when dealing with historic shipwreck sites and related archaeological collections.

3.4.4 NSW Heritage Manual

The *NSW Heritage Manual*, published in 1996 by the NSW Heritage Office and Department of Urban Affairs & Planning, is a comprehensive set of guidelines explaining all aspects of the NSW heritage management system. When the manual was first published, it served as the primary reference for heritage management in NSW. While there have been major amendments to the NSW *Heritage Act 1977* and sections of the manual are now outdated, much of the major principles within the manual remain relevant – in particular, the chapters on Investigating History, Investigating Heritage Significance, Assessing Heritage Significance and Statements of Heritage Impact.

3.4.5 Criteria for the Assessment of Excavation Directors

The *Criteria for the Assessment of Excavation Directors* was published by the NSW Heritage Council in 2011 and outlines the composition of skills required when selecting an archaeological Excavation Director, to be nominated as part of an application under relevant sections – including Sections 60 and 140 – of the NSW *Heritage Act 1977.*

4 AREA A – NORTHBRIDGE TO SEAFORTH, MIDDLE HARBOUR

4.1 Physical setting

Area A is characterised by a narrowing stretch of Middle Harbour, about 500 metres wide, between Northbridge to the south-west and Seaforth Bluff to the north-east (Figure 4-1). The foreshore on both headlands comprises exposed Hawkesbury sandstone, sloping quite steeply down to the water's edge, although minor levels of private reclamation have also occurred along the rocky foreshore of Seaforth Bluff. Cofferdams BL 7 and BL8 would be located within Area A. The cofferdams are further described in Section 8.1.

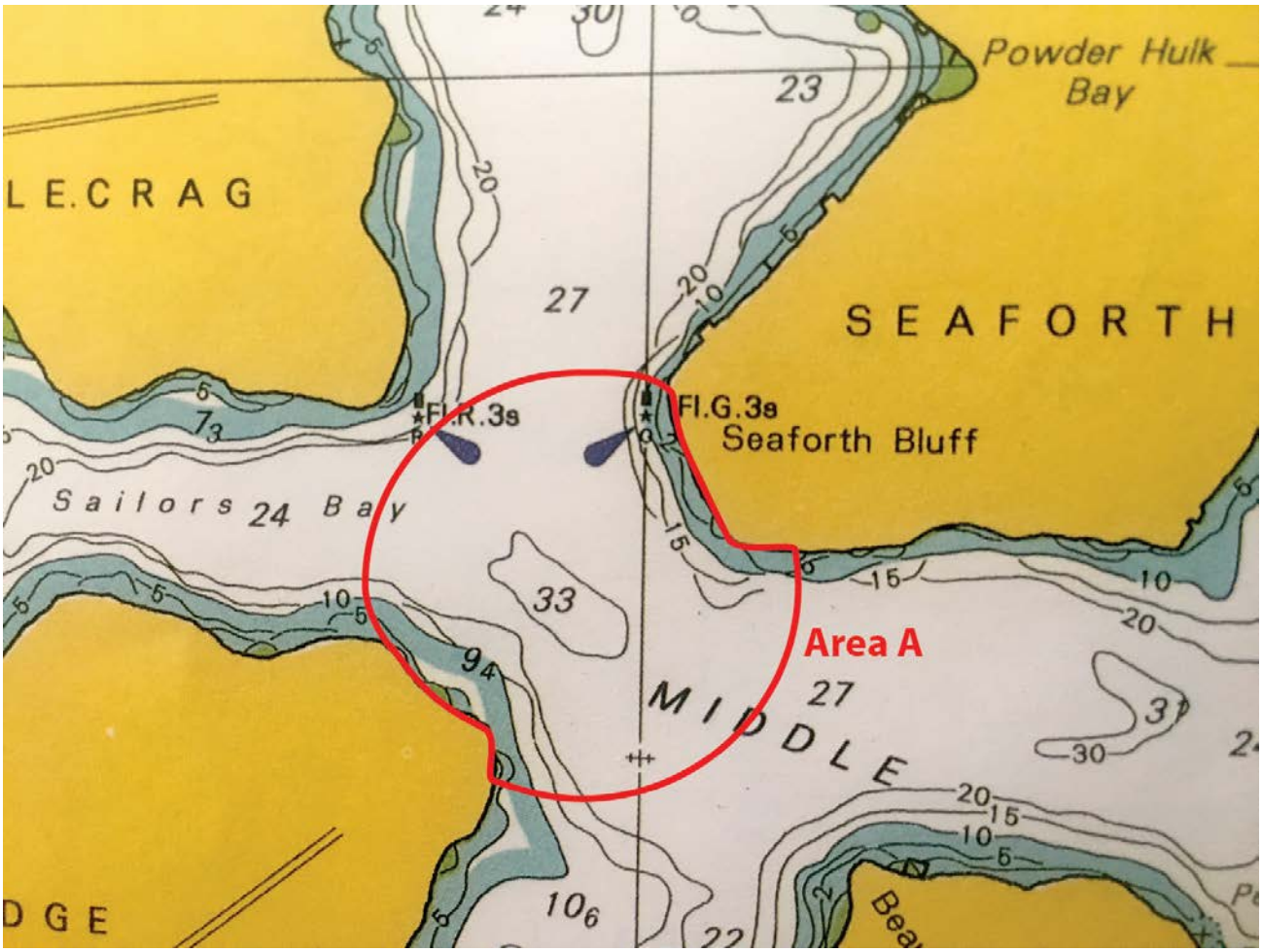


Figure 4-1 Portion of nautical chart showing Area A (Commonwealth of Australia//Crawford House Publishing 1995). Depths are in metres

Bathymetric data shows that the bed of the harbour continues to slope downwards from both shorelines at a gradient similar to which is observed above water. At depths of around 10 metres below Lowest Astronomical Tide, about 60 metres from shore, the gradient becomes gentler, gradually levelling out to a depth of 31 metres below Australian Height Datum midway between the headlands (Figure 4-2). Based on this information, it may be expected that the steep bed of the harbour close to the shorelines on both headlands consists of exposed sandstone bedrock similar to that along the foreshore, gradually sloping down and becoming buried by marine sediments towards the centre of Middle Harbour.

The side scan sonar data obtained for this project showed several sandstone rock outcrops protruding from the steep bed of the harbour close to the shorelines on both headlands, similar to what can be seen above water (Figure 4-3). The most prominent is a near continuous sandstone rock ledge, about 20 metres deep, which runs parallel to the Seaforth Bluff shoreline at a distance of 70 to 80 metres. The other less pronounced and continuous rock outcrop is within 25 metres of the Clive Park shoreline and is in less than 10 metres of water. A number of the smaller sandstone protrusions appear to be isolated boulders which have tumbled down the hillside into the water. The apparent higher frequency of boulders on the Seaforth side could be a by-product of the building activity that has taken place on the slopes above. With depth, these rock outcrops have become gradually buried by eroded silty sand and naturally deposited shell, and the bed of the harbour becomes siltier as the gradient begins to level out. At the

lowest point, midway between Northbridge and Seaforth, the bed of the harbour is composed of silty clay with shell and fibrous plant matter (Douglas Partners & Golder Associates August 2017).

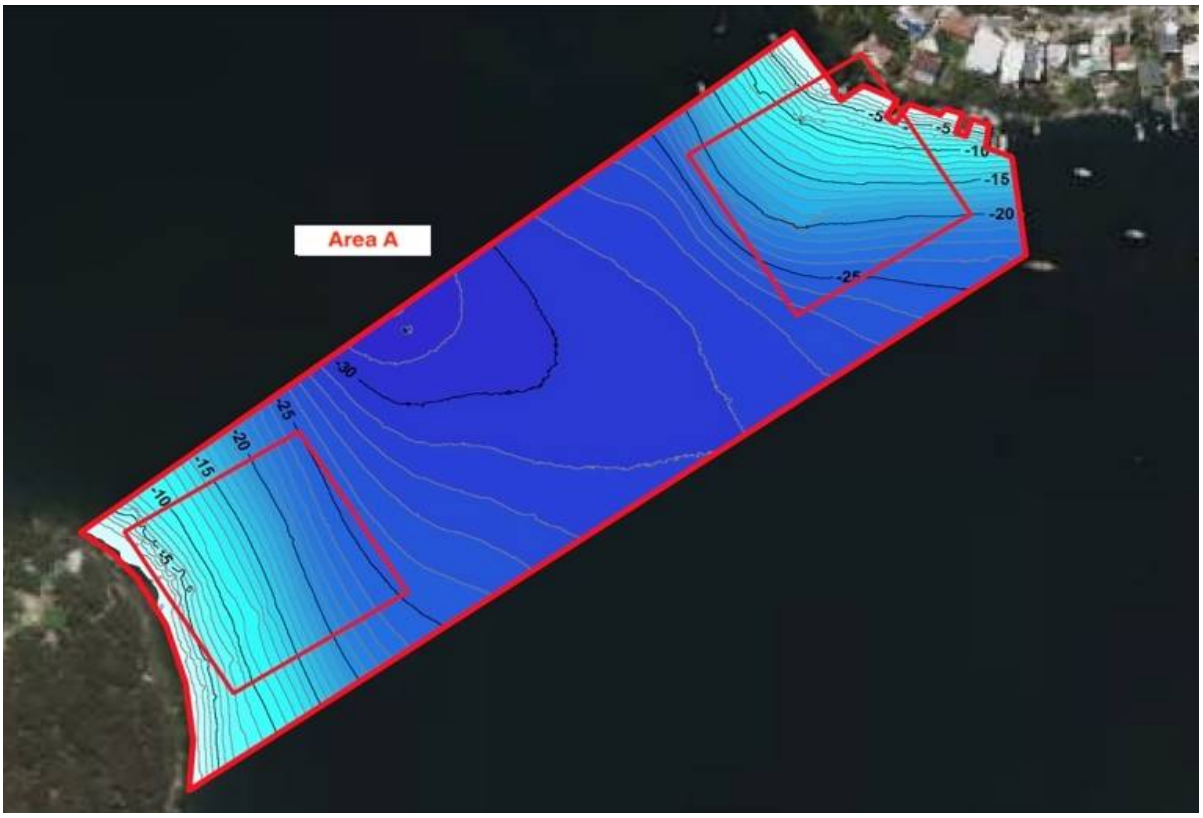


Figure 4-2 Bathymetric contour plan within Area A between Clive Park at Northbridge and Seaforth Bluff at Seaforth, Middle Harbour *Depths are in metres AHD* (Earth Technology Solution Pty Ltd, July 2017a: Figure MH2). The red boxes show the area of interest around the proposed cofferdams.

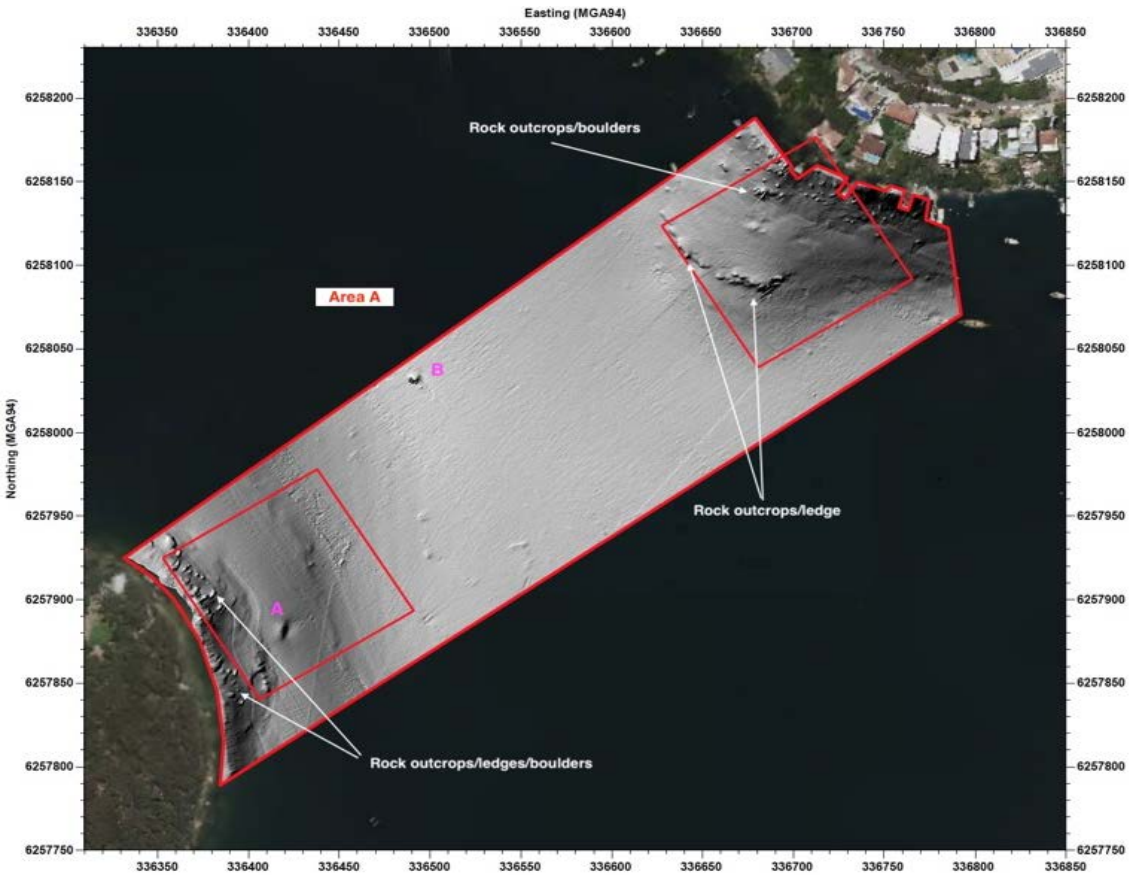


Figure 4-3 Bed of the harbour features within Area A showing rock ledges, outcrops and boulders (Earth Technology Solution Pty Ltd, July 2017a: Figure MH2A). Feature A is a shipwreck and Feature B is an anthropogenic anomaly. The red boxes show the area of interest around the proposed cofferdams.

With regards to cultural modifications, there have been only minor levels of private reclamation along the rocky foreshore of Seaforth Bluff. Generally, Middle Harbour has also had limited dredging activities and there appears to be no evidence dredging has occurred along the foreshore of Seaforth or Northbridge.

4.2 Historical activities in the vicinity of Area A

4.2.1 Northbridge

The Northbridge area was first subject to European occupation in 1837 via the granting of 10 acres of land fronting Middle Harbour – and adjacent to Area A – to solicitor John Lewis Spencer. Three years later, Spencer sold the land to developer Henry Lambert Brabazon, who subdivided the allotment into a proposed residential estate named Albert Town. Only a handful of lots were subsequently sold at auction, however, and the proposed Albert Town village never eventuated (Souter 2004) (Figure 4-4).

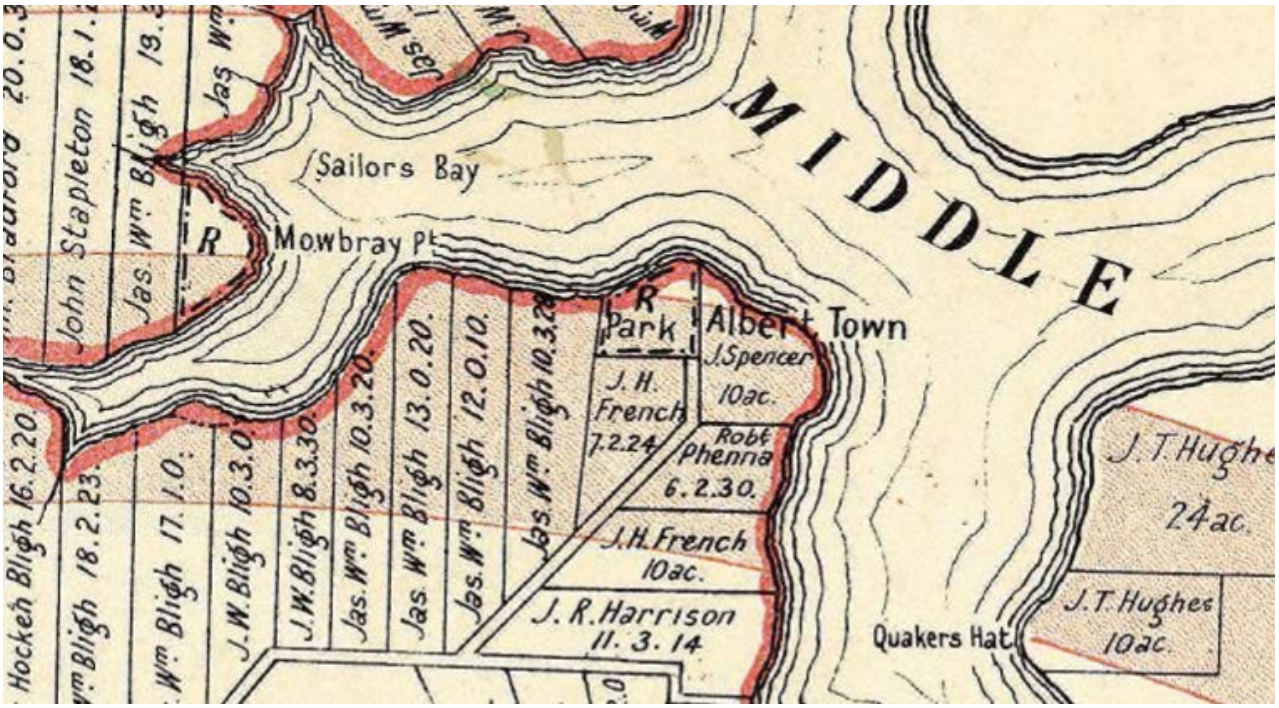


Figure 4-4: 1890 Willoughby parish map, showing Spencer's 10 acres and noting the proposed site of Albert Town (*Liddell & Clarkson 1890****)***

In 1907, the remaining majority of Brabazon's land at the site, including the entire waterfront area, was purchased by Joseph Henry Evans Booker, who utilised the property to operate a public tea garden. In 1911, the land was resumed – along with a section of foreshore to the north-west – by the NSW Government for public recreational purposes and named 'Clive Park' in honour of the then Mayor of Willoughby, Clive Backhouse. The park was gazetted in 1933 and placed under the management of Willoughby City Council (Butler 2016) (Figure 4-5 and Figure 4-6).

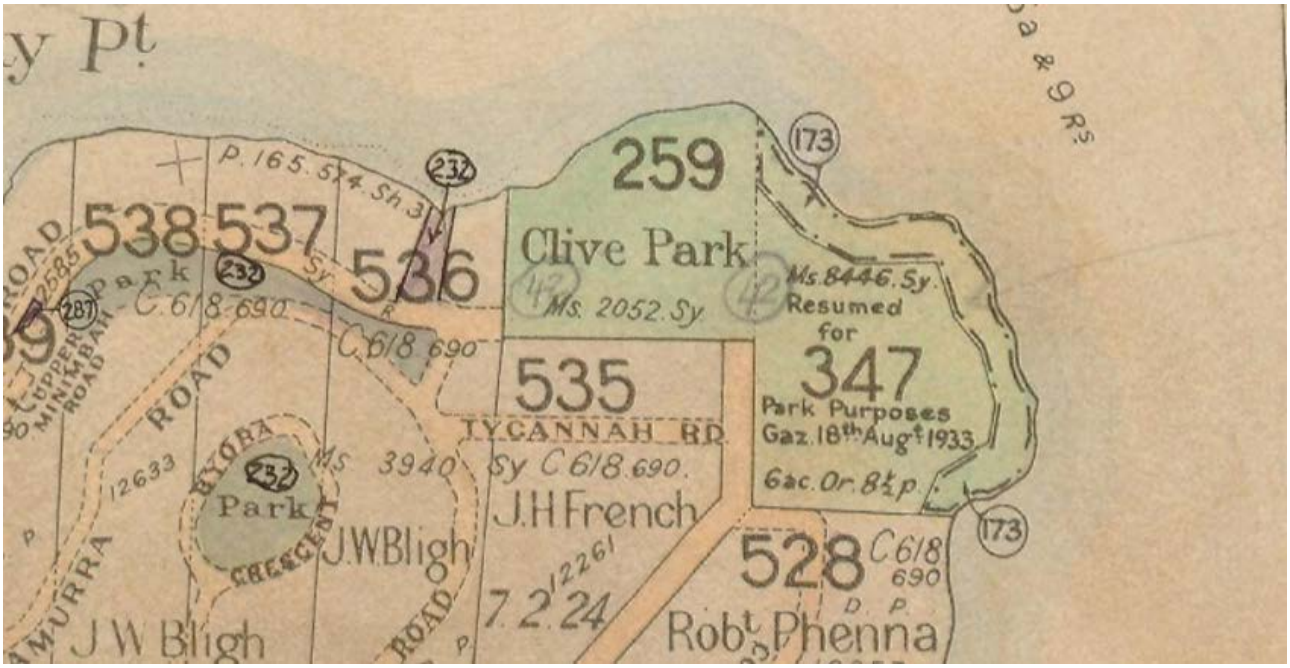


Figure 4-5: 1964 Willoughby parish map showing gazetted area of Clive Park (NSW Department of Lands, 1964).

Figure 4-6: 1943 aerial photograph showing Clive Park (*RTA photography 1943****).***

In 1945, a recreational tidal pool was constructed at Clive Park by the Northbridge Volunteer Defence Corps Association. The pool was formed of two seawalls of large rocks topped with concrete and connected by a screen made of galvanised pipe and steel mesh (NSW Office of Environment and Heritage 2013) (Figure 4-7 to Figure 4-10). The Clive Park foreshore has continued to be used for recreational purposes with no further development since the mid 20th century, with the structural features of the tidal pool surviving largely intact (see Section 4.3).

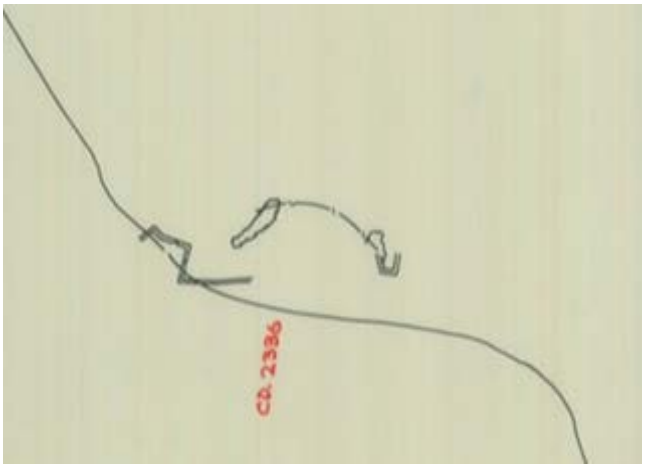


Figure 4-7: ca.1980s Crown plan showing layout of Clive Park tidal pool (left) (Crown Plan, ca.1980s)
Figure 4-8: Clive Park tidal pool under construction, 1945 (Brown 1945) (right)

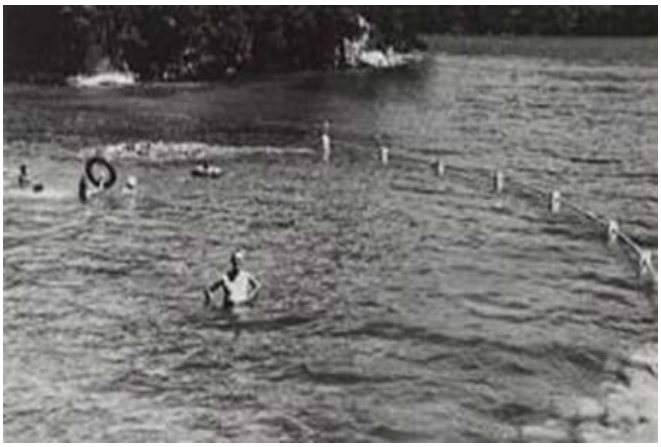


Figure 4-9: 1994 photograph of remains of Clive Park pool (Anon 1994) (left)
Figure 4-10: ca.1940s photograph of swimmers enjoying Clive Park pool (Mitchell ca. 1940s) (right)

4.2.2 Middle Harbour

Although Middle Harbour has served as a waterway since European settlement, the area encompassed by Area A has historically been a quieter part of Port Jackson than Sydney Harbour. The establishment of a wharf at Bantry Bay in the late 1850s saw regular movement of vessels through the study area for the loading of milled timber as well as settlement around Frenchs Forest. Traffic increased towards the end of the 19th century as the secluded bays of Middle Harbour became popular with weekend ferry excursions Godden Mackay July 1991: 43-44).

From the 1880s to around 1900, hulks used to store explosives were moored at Powder Hulk Bay to the immediate north of Seaforth. After 1900, the NSW Government established a storage facility for explosives at Bantry Bay. The explosives were towed to the facility through the study area in lighters, which had taken on their load from the Explosives Wharf at The Spit (see Area B). This facility closed down in 1974 (Godden Mackay July 1991: 46).

From the end of the 19th century, residential development was occurring on the higher ground around Middle Harbour. Because of the steep and rocky nature of the foreshore, residences were initially confined to the flatter tops of the ridges and plateaus inland from the study area, as was the case for most of lower Middle Harbour (Godden Mackay July 1991: 44). However, along the foreshores, timber jetties, slips, boatsheds and even swimming enclosures were erected on those residential properties that had waterfront access. For some properties, minor and localised reclamation would have taken place.

4.2.3 Seaforth Bluff

The earliest documented European occupation of the Seaforth area occurred in 1837 via a 30 acre land grant surrounding Parsley Bay. By 1857, the majority of Seaforth had been divided into large allotments, with Seaforth Bluff – adjacent to Area A – granted to settler Jacob Marks (Figure 4-11). Small scale agricultural and pastoral land use subsequently commenced across the Seaforth area; however, Marks' Seaforth Bluff allotment appears to have remained largely unoccupied (McAteer 2006).

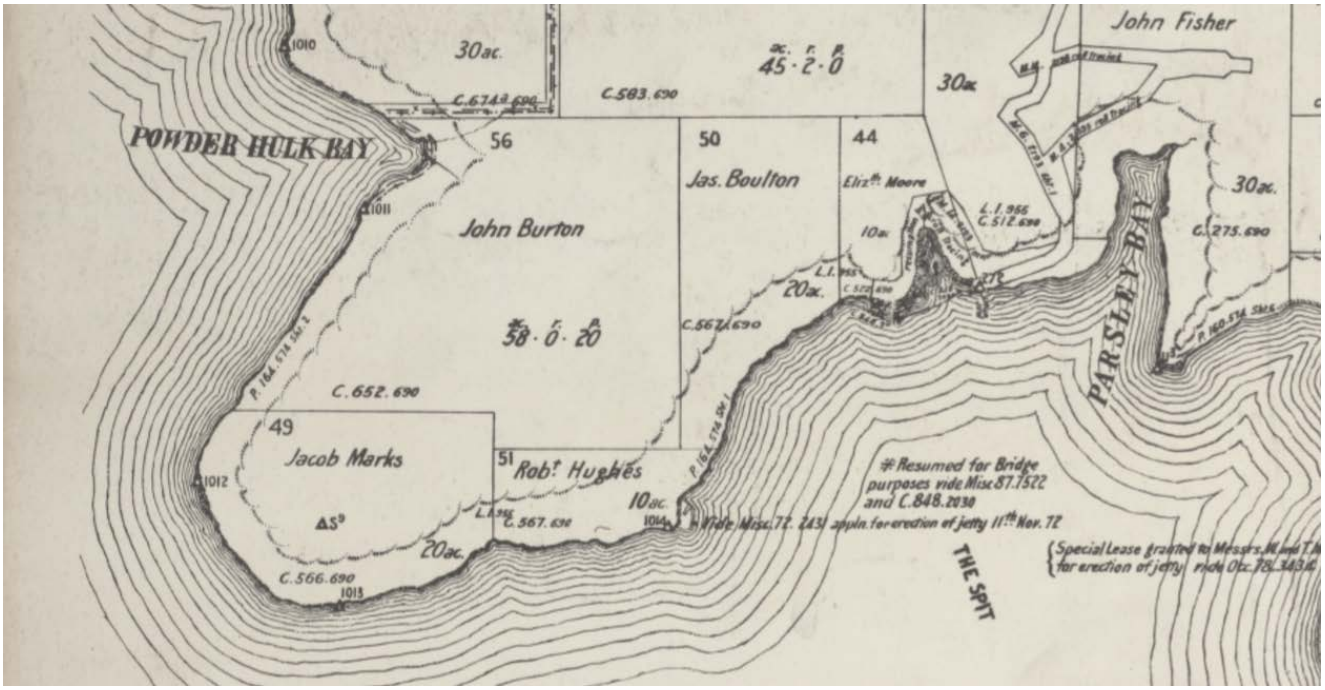


Figure 4-11: 1890 Manly Cove parish map, showing Jacob Marks' Seaforth Bluff allotment **(Anon 1890)**

By the early 1900s, a number of the allotments surrounding Marks' had been purchased by the developer Henry Halloran, who renamed the area the Seaforth Estate. Halloran subdivided the estate into 350 residential allotments and began offering them for sale at public auction in 1906 (McAteer 2006: 15). By 1909, Halloran had also acquired Marks' Seaforth Bluff land, which he then also subdivided and incorporated into the Seaforth Estate, offering a series of steep cliff face waterfront blocks along the newly created Clontarf Crescent for sale (MacRitchie 2008) (Figure 4-12).

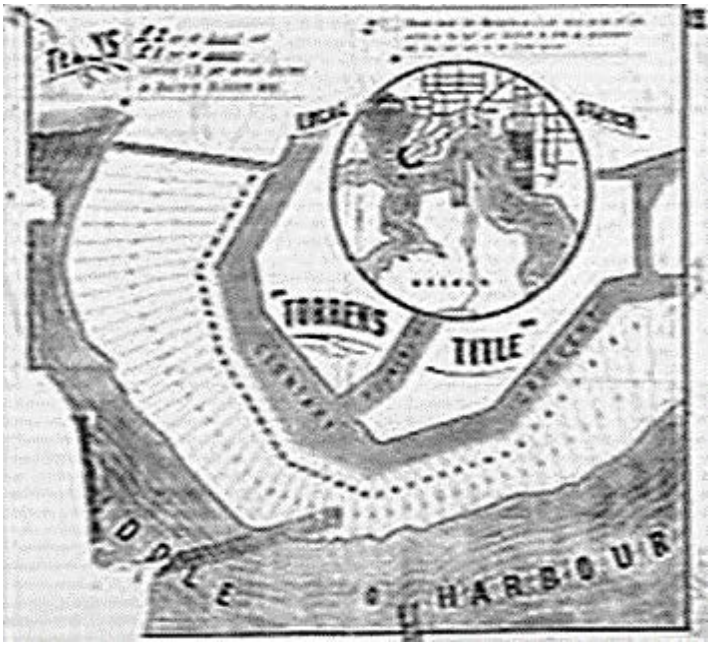


Figure 4-12: Real estate poster for sale of the subdivided land at The Bluff **(Anon 1909).**

Scattered residential development ensued around Seaforth Bluff over the following decades. By the early 1940s, half a dozen private residences had been constructed on the clifftop at the south-western tip of Seaforth Bluff, with associated private waterfront facilities including seawalls, small jetties, boat landings and sheds (Figure 4-13).

***Figure 4-13: 1943 aerial photograph of Seaforth Bluff* (RTA Photography 1943)**

Residential development slowly increased across Seaforth Bluff throughout the mid to late 20th century, with private waterfront facilities upgraded and extended (Figure 4-14 and Figure 4-15). However, the steep cliffs have inevitably prevented the establishment of substantial maritime infrastructure, with only small recreational structures being developed.

***Figure 4-14: Photograph of The Bluff in 1970* (Anon 1970).**

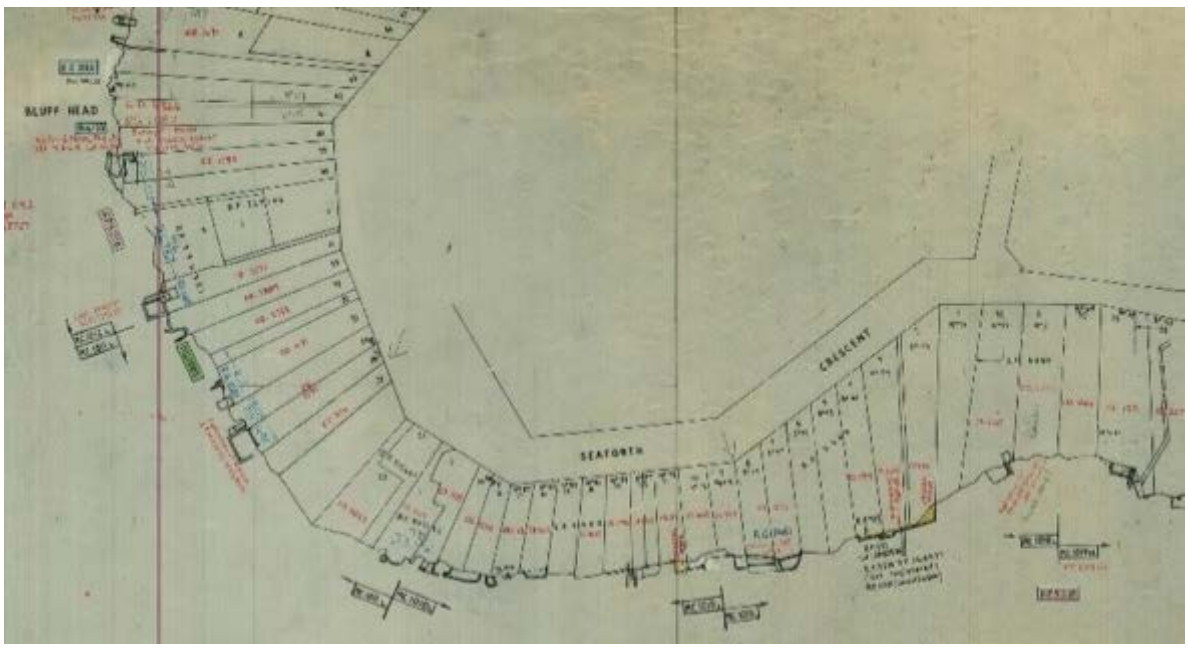


Figure 4-15: ca.1980s Crown plan showing Seaforth Bluff allotments and associated maritime infrastructure
The southern shoreline (lowest edge) is within Area A (Crown Plan ca. 1980s)

4.3 Known maritime heritage sites and items

The following discussion of known maritime heritage sites within Area A has been compiled from historical research, a review of statutory and non-statutory heritage registers, and the findings of field inspection conducted in December 2017.

4.3.1 Maritime heritage infrastructure

4.3.1.1 Harbour Foreshore, Seaforth

The Seaforth foreshore is listed as an item of local heritage significance on the *Manly Local Environmental Plan 2013* (Item No. 11). The foreshore within Area A contains a mixture of small timber or concrete-piled private jetties, sandstone block retaining walls and small slipways for hauling up boats (Figure 4-16). Along the foreshore are sections of exposed sandstone cliffs of low height, which have been shaped by seawater movement in the form of tides and wave action for around 8,000 years (Figure 4-17).

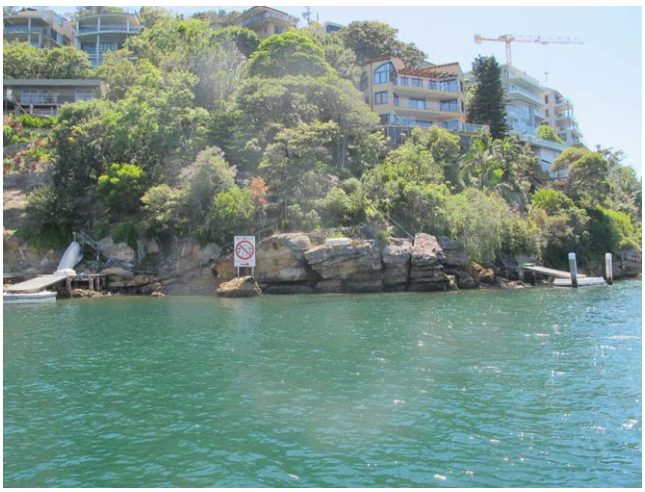


Figure 4-16: Foreshore at Seaforth looking north-west (left) (Image: Cosmos Archaeology, 14 December 2017)
Figure 4-17: Foreshore at Seaforth looking north-east (right) (Image: Cosmos Archaeology, 14 December 2017)

4.3.1.2 Clive Park Tidal Pool

Clive Park Tidal Pool, constructed in 1945, is listed as an item of heritage significance in the *Willoughby Local Environmental Plan 2012* (Item 179). The pool is located in a shallow bay on the northern side of Clive Park. It is a semi-circular enclosure about 20 metres wide and 12 metres across that incorporates natural sandstone outcropping on its eastern side (Figure 4-18). Immediately to the west of the tidal pool is a small sandy beach (Figure 4-19). The depth of the pool was not measured but it would appear to be a few metres at most at high tide. The bed of the harbour is a mix of rock platform, rubble and sand.

Figure 4-18: Clive Park Tidal Pool looking south-east towards the shore (left) (Cosmos Archaeology 18 December 2017)
Figure 4-19: West end of Clive Park Tidal Pool looking south towards shore (right) (Cosmos Archaeology 18 December 2017)

Apart from the natural sandstone outcropping which forms the eastern portion of the pool, the enclosure is composed of two walls of coarsely stacked roughly hewn sandstone blocks bonded with cement with eight reinforced concrete pylons spaced about 2.5 metres apart forming the seaward end of the enclosure (Figure 4-20). The pylons were designed to hold up a net to provide protection from sharks and other animals.

Figure 4-20: Clive Park Tidal Pool looking south towards shore. Row of eight reinforced concrete piles in the centre flanked by low sandstone walls bonded with cement. (Cosmos Archaeology 18 December 2017)

The western sandstone wall is the better preserved of the two. It is about 10 metres long, 1.5 metres wide and about one metre high (Figure 4-21). The eastern wall is poorly preserved and has collapsed in places (Figure 4-22). As of December 2017 the condition of the Clive Park Tidal Pool could generally be considered to be poor, with sections having collapsed or collapsing and the pylons in the process of breaking apart as the steel reinforcing corrodes.

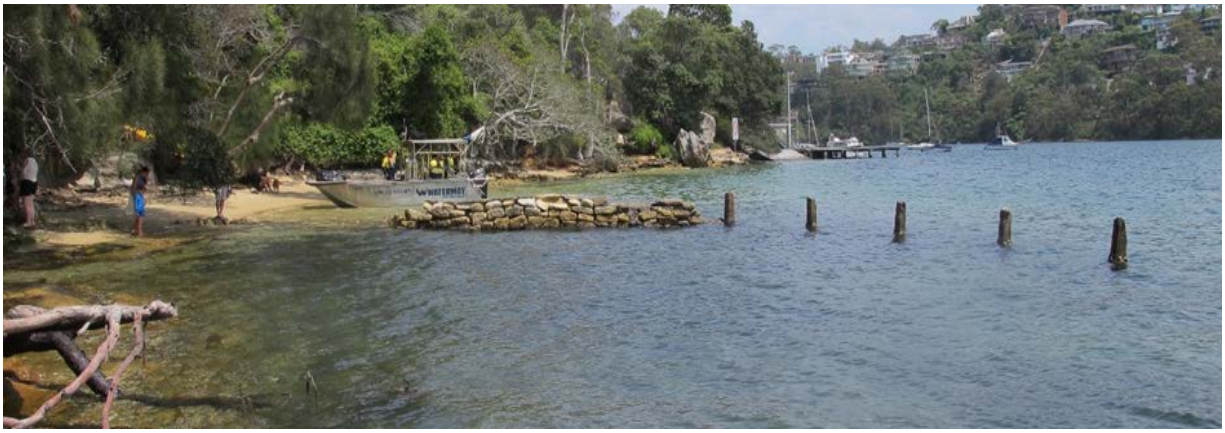


Figure 4-21: West end of Clive Park Tidal Pool showing coarsely stacked sandstone blocks (Cosmos Archaeology 18 December 2017)

Figure 4-22: Eastern end of Clive Park Tidal Pool showing collapsed wall. Seaforth Bluff is in the background (Image: Cosmos Archaeology, 18 December 2017)

4.3.1.3 Submerged remains of maritime infrastructure

The diving carried out during the December 2017 field investigation identified three objects on the bed of the harbour associated with maritime infrastructure: two timber piles and a mooring buoy (Cosmos Archaeology Pty Ltd January 2018). It would appear that the two objects in the vicinity of Clive Park (16W-004 and 16W-005) have floated into the area and sunk, rather than originating from a structure nearby. Item 16W-008 is closer to existing private jetties at Seaforth and could be associated with those structures.

Table 5: Submerged maritime infrastructure remains in Area A

Target ID	Description
16W-004	Timber pile lying on bed of the harbour. About 0.5 metre diameter with remnant length about 7 metres
16W-005	Large plastic mooring buoy 1 metre high and one metre across
16W-008	Timber pile lying on bed of the harbour. About 0.3 metres diameter with remnant length about 7 metres

Figure 4-23 Target 16W-004 – timber pile (left) (Cosmos Archaeology, 18 December 2017)
Figure 4-24 Target 16W-005 – mooring buoy (right) (Cosmos Archaeology, 18 December 2017)

Figure 4-25 Target 16W-008 – timber pile (Cosmos Archaeology, 18 December 2017)

4.3.2 Shipwrecks

A search of the Australian National Shipwreck Database and the Department of Premier and Cabinet (Heritage) maritime heritage sites database revealed no shipwrecks listed within Area A. There are however two known shipwrecks nearby with one located near Clive Park during the December 2017 field investigation, and one marked on navigation charts towards the centre of Middle Harbour.

4.3.2.1 Clive Park Unidentified No. 1 wreck

A ferrous – most likely steel-hulled – shipwreck was identified lying upside down on a sloping sandy bed of the harbour in 13 metres of water about 50 metres from the shoreline. The visible extent of the wreck is 10 metres long by eight metres wide however edges of the hull appear to be buried and/or have broken away and slid down the slope (Cosmos Archaeology Pty Ltd January 2018) (Figure 4-26).

From the initial inspection it would appear that the vessel was a towed punt or barge, as there is no evident means of propulsion. The presence of bucket-sized containers and flexible steel wire rope on the wreck suggests it may have been involved in repairs and/or maintenance of vessels or maritime infrastructure.

A cursory examination of the hull indicated an absence of rivets or similar fastenings. This would suggest that hull plates and frames were welded, a process that did not become popular until the 1930s, though the relatively thick corrosion product on the hull could be obscuring any fastenings (Sapp 2011). From what could be seen of the contents of the wreck, there appeared to be no synthetic materials such as plastics. Flexible steel wire rope has been used in maritime environments since the mid 19th century (Sayenga n.d). The condition of the ferrous structural elements is very poor, with parts of the keel and hull breaking away at the diver's slightest touch.

Based on available information from the site it is likely that the wreck dates to the middle decades of the 20th century, with the poor state of preservation of the ferrous structure suggesting a date of loss before 1950. Given that it had contents on board it was most likely lost accidentally, possibly parting its moorings overnight and drifting with the wind and the tide. Given the location of the wreck – at a point exposed to the north, east and south – it may have originated from the Bantry Bay area, The Spit or the entrance to Long Bay.

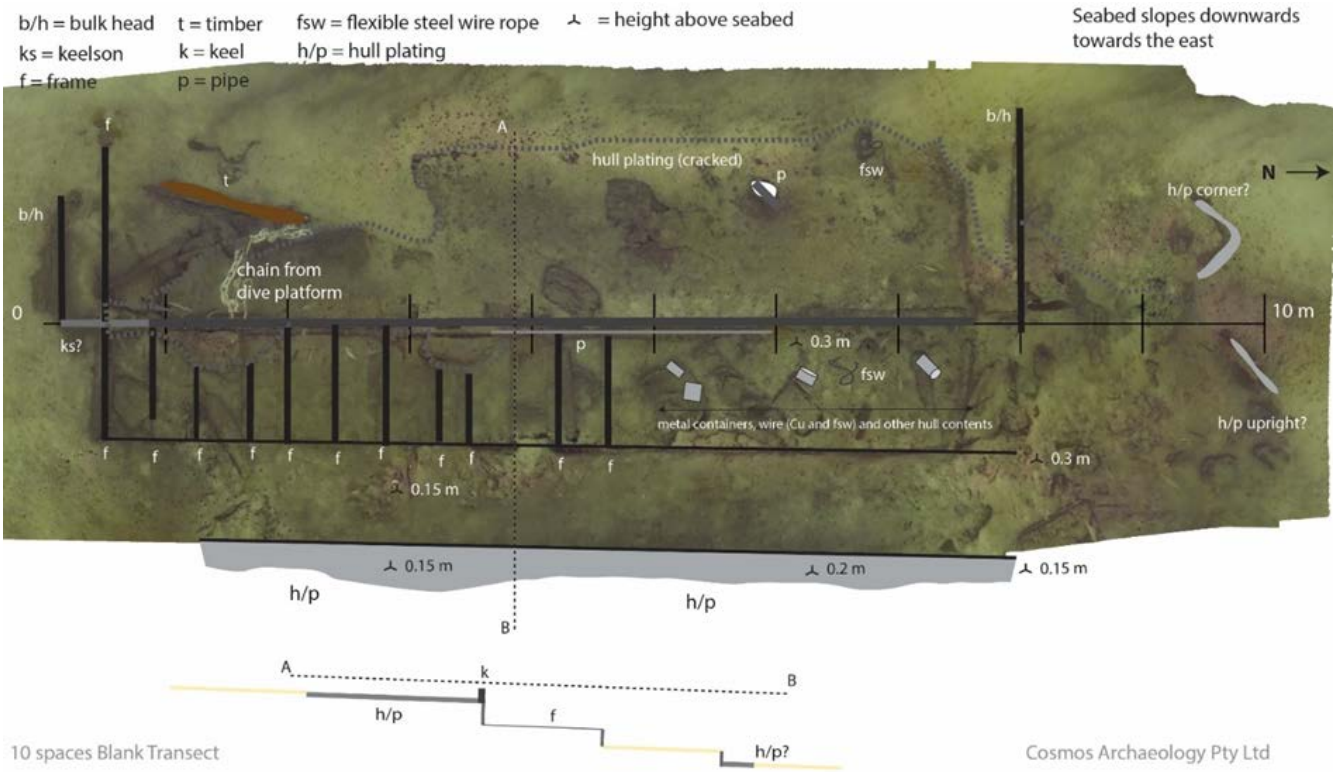


Figure 4-26: Site plan of the Clive Park Unidentified No.1 wreck, located at 16W-003. Composite of a measured site plan and orthophotic image

4.3.2.2 Middle Harbour Unidentified No. 1 wreck

A 1995 mariners' chart shows a shipwreck on the meridian line in the southern part of Area A (Figure 4-27). Details of the shipwreck are not provided in the chart, but the position corresponds with an entry in the NSW Wrecks Info website which refers to the wreck of a wooden barge. However, multi-beam imagery of the location shows a high relief wreck site (Figure 4-28), thus suggesting that either the wreck is relatively recent and the timber structure has not yet broken down, or the wreck is actually made from iron or steel. There is a high likelihood that the vessel was scuttled – that is deliberately sunk and abandoned – in this location because the water is sufficiently deep that the wreck would not pose a danger to navigation.

This wreck was not inspected in the December 2017 field investigation as it is located well outside the proposed disturbance footprint, and the position accuracy based on the charts was not considered sufficient to give confidence that the wreck could be located relatively quickly.

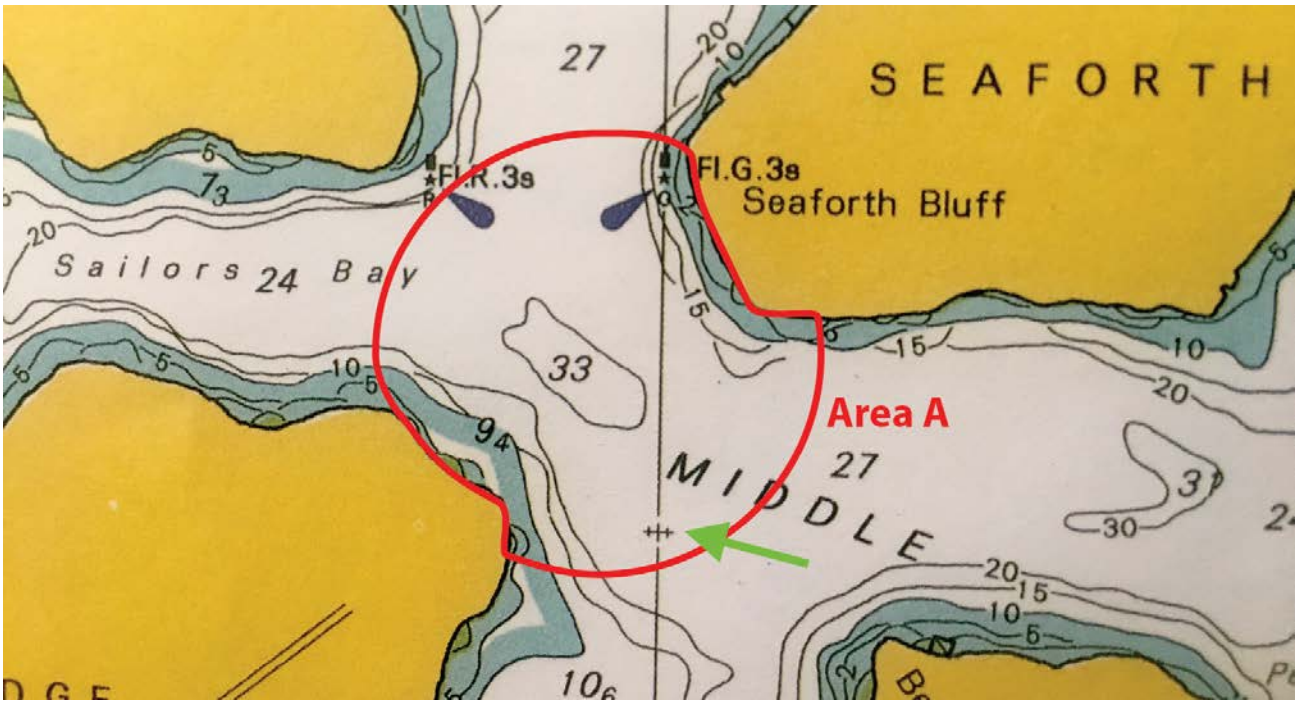


Figure 4-27: 1995 mariners' chart showing the location of a wreck (shown by green arrow) (*Commonwealth of Australia/Crawford House Publishing 1995)*

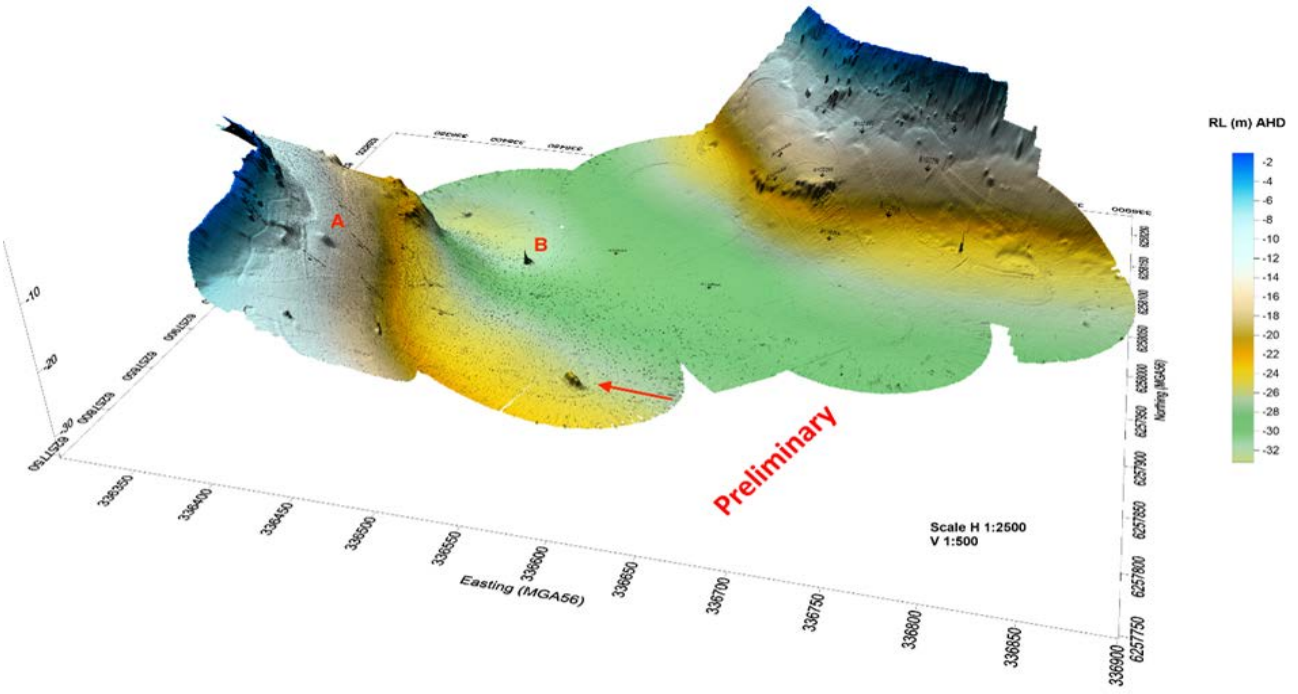


Figure 4-28: Oblique multi-beam image of Area A, looking north-west, with a red arrow indicating what is very likely the Middle Harbour Unidentified No. 1 wreck (ET471.MH.MultiBeam.3DView.jp2 provided by Adam Podnar,

Geotechnical Engineer, Douglas Partners Pty Ltd 28 November 2017). Feature A is a shipwreck (see Section 4.3.2) and Feature B is an anthropogenic anomaly (see Section 4.4.4)

4.3.3 Discard from vessels

The diving carried out during the December 2017 field investigation identified three objects or collections of objects on the bed of the harbour that were discarded from vessels, including a concrete pipe, outboard engine with steel pipe and glass bottles (Cosmos Archaeology Pty Ltd January 2018).

Table 6: Material discarded from vessels in Area A

Target ID	Description
16W-002	Concrete pipe with steel reinforcement
16W-004	Outboard engine and steel pipe
16W-010	Glass beer bottles

These objects are to be expected in waterways with considerable traffic. The outboard engine (16W-004) most likely accidentally fell off the transom of a small boat, which is a common occurrence. It was noted that the bed of the harbour immediately below the sandstone rock outcropping in 16W-010 seems to be a natural flotsam trap for small light objects moving along the bed of the harbour with the current.

Figure 4-29 Target 16W-002 – concrete pipe (Cosmos Archaeology, 18 December 2017)

4.3.4 Summary

Table 7: Known maritime heritage sites and items in Area A

Site/item	Location (WGS84 UTM Zone 56 H)	Heritage Listing
Clive Park Tidal Pool	Sailors Bay Road, Northbridge 336292.00 E 6257940.00 S	Willoughby LEP (2012) I179
Seaforth Harbour Foreshore	Northern Beaches Council municipal area boundary along the harbour	Manly LEP 2013
Clive Park Unidentified Shipwreck No. 1 (Target ID 16W-003)	336417.00 E 6257882.00 S	N/A
Middle Harbour Unidentified Shipwreck No. 1	336569.00 E 6257851.00 S	N/A
Concrete pipe (Target ID 16W-002)	336399.00 E 6257906.00 S	N/A
Timber pile, outboard engine and steel pipe (Target ID 16W-004)	336414.00 m E 6257853.00 m S	N/A
Mooring buoy (Target ID 16W-005)	336416.00 m E 6257844.00 m S	N/A
Timber pile (Target ID 16W-008)	336716.00 m E 6258126.00 m S	N/A

Site/item	Location (WGS84 UTM Zone 56 H)	Heritage Listing
Glass beer bottles (Target ID 16W-010)	336683.00 m E 6258072.00 m S	N/A

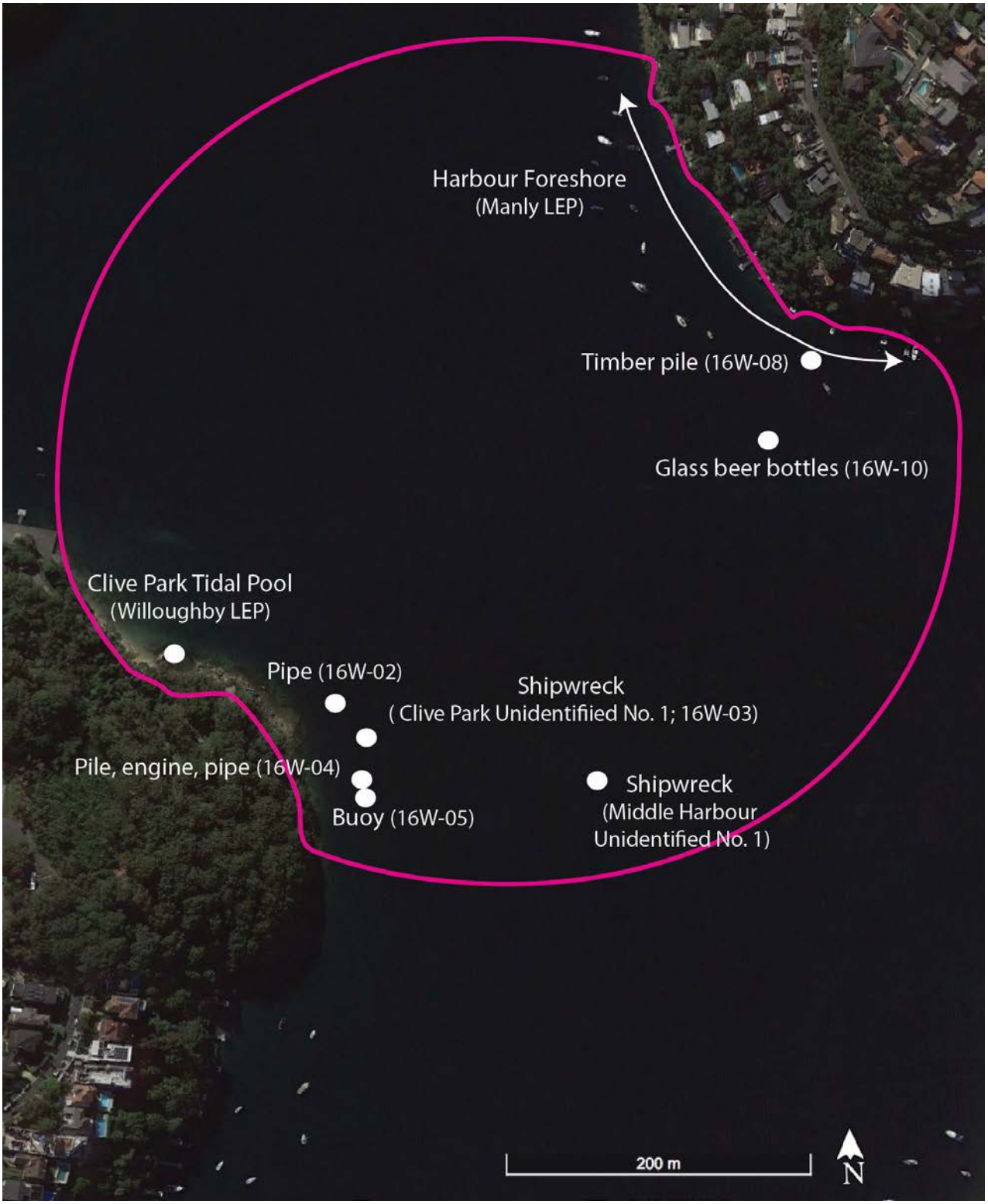


Figure 4-30: Known maritime heritage sites and items in Area A (Base image: Google Earth)

4.4 Potential maritime heritage sites and items

Based on historical information, as summarised in Section 4.2, the following cultural activities have occurred near Northbridge, Seaforth Bluff and surrounds:

- Movement of vessels through Middle Harbour

- Development of foreshore residences and associated private maritime infrastructure
- Recreational boating and competitive sailing
- Recreational use of foreshore areas
- Recreational swimming.

Based on the above and the known sites within the study area, the following types of maritime heritage sites and items may occur in Area A:

- Maritime infrastructure (1910s onwards) – private seawalls, baths, jetties and wharves
- Discard from maritime infrastructure (1910s onwards) – accidental and/or deliberate discard of items such as personal objects, food and drink containers, fishing equipment as well as damaged and removed material from the infrastructure
- Shipwrecks (ca.1830s onwards) – including recreational, commercial and industrial vessels
- Discard from vessels (ca.1850s onwards) – accidental and/or deliberate discard of items such as personal objects, food and drink containers, ship fittings and equipment as well as fishing and boating equipment.

The following sections provide a discussion on the predicted type and condition of these maritime sites within Area A. Detailed discussion of general maritime site formation processes can be found in Annex B of the Cosmos Archaeology November 2017 report, *Western Harbour Tunnel and Beaches Link – Maritime Archaeological Desktop Study*.

4.4.1 Maritime infrastructure and associated deposits

The foreshores of Northbridge and Seaforth Bluff are studded with various maritime structures including jetties, wharves, boatsheds and bathing enclosures, dating from the ca. 1910s along Seaforth Bluff and the 1940s along Northbridge. All of these types of structures would likely have been repaired, upgraded, expanded or replaced over time. Timber-piled maritime structures in particular require constant maintenance and pile replacement due to marine borer attacked and abrasion along the water line. As such, it is likely that remains of earlier phases of maritime infrastructure survive on the bed of the harbour adjacent to the shorelines within Area A, including timber pile stumps associated with jetties, wharves, boatsheds and bathing enclosures. Such remains would be buried and/or masked by rock rubble and hence were not identified by remote sensing.

Deposits associated with maritime infrastructure are also likely to have built up around and beneath the current and former locations of these structures, deposited either from the structures themselves or vessels moored alongside. Such deposits can include accidental and/or deliberate discard of items such as tools, personal objects, food and drink containers and fishing equipment, as well as damaged and removed material from maintenance of the structure.

4.4.2 Shipwrecks and associated deposits

There are two known shipwrecks within Area A and it is quite possible that additional wrecks occur – either due to shipping accidents or intentional scuttling.

There is at least one shipwreck in Middle Harbour listed on the Australian National Shipwreck Database that has not been previously located and which could be within Area A (Anon 28 June 1927). This is the *Mureegar*, a timber motor launch owned and captained by Dr G. E. Manning that burnt on 27 June 1927 (Australian Government Department of the Environment and Energy, 2016). Dr Manning was entertaining a party of Queensland league footballers when an oil stove exploded and flames spread over the vessel. The party swam to shore near Flat Rock and was taken to The Spit by two motor boats. *Mureegar* was burnt to the waterline (Anon 28 June 1927). It is unknown what happened to the rest of the vessel, but it can be assumed that it sunk to the harbour floor. The wrecks that are known to be located within Area A do not fit the description of the *Mureegar*.

The remains of *Mureegar* would most likely consist of the hull and bilge area below the hull's waterline. It is most likely that the wreck of the *Mureegar,* if present in Area A, has settled into the bed of the harbour and/or is partially covered by sedimentation. The wreck is over 80 years old and any exposed timber would have been destroyed by marine borers. However, the engine would likely be protruding above the bed of the harbour and provide a magnetic signature. Associated deposits are likely to be contained within the wreck and may also be scattered over an extensive area depending on how far the vessel moved as it burnt.

All anomalies identified from the remote sensing data as being of potential cultural heritage significance (with the exception of 16W-06; see Section 4.4.4) were examined in the December 2017 field investigation. Should the wreck of the *Mureega* be present in the study area, it would very likely be broken up and almost completely buried, or wreckage would be strewn across exposed rock outcropping. The geophysical surveys conducted in the study area were not optimised to identify the remains of wreckage in such circumstances.

4.4.3 Discard from vessels

Along with shipping and sailing activity, there is inevitably discard from vessels on the water. Discard can be accidental or deliberate, and can include personal objects, food and drink containers, ship fittings and equipment, fishing and boating equipment as well as cargo from vessels passing through Middle Harbour. Such deposits can consist of a range of materials and are mostly single items, but can also occur in scatters created by one event or multiple events. Higher concentrations would be expected closer to shore where vessels were more likely to be moored or anchored.

The December 2017 diving inspection found that discarded objects would pool at certain locations, primarily around rock outcrops. This is due to ‘dead spots’ that form around obstacles that reduce current flow, thereby allowing objects to settle. Also, the rock outcrops act as obstacles that catch objects as they tumble down the relatively steeply sloping terrain within Area A.

4.4.4 Unverified anomalies

Anomalies within Area A have been identified through remote sensing data or online sources and databases. Most of these anomalies were inspected in the December 2017 field investigation but a number were not, as they were either too deep or buried.

Both the multi-beam and side scan sonar surveys identified an anomaly in water more than 30 metres deep, about half way between Seaforth Bluff and Clive Park (see Figure 4-28). This anomaly – target 16W-06 – was not able to be inspected by the dive team in the December 2017 field investigation (Cosmos Archaeology January 2018). The object is about two metres high, seven metres long and 2.5 metres wide (Earth Technology Solution Pty Ltd, July 2017a: 2). It is very likely the wreck of a small boat. The magnetometer survey did not record any anomalous magnetic intensity around this target and so it can be considered to have a non-ferrous hull suggesting the bulk of the objects is composed of aluminium, fibreglass or timber (Figure 4-31). If it is a timber-hulled wreck it would most likely be associated with a relatively recent wrecking event, as a small timber boat would not be sitting two metres proud of the bed of the harbour after a few decades of immersion (see 17W-01 in Section 5.3.2).

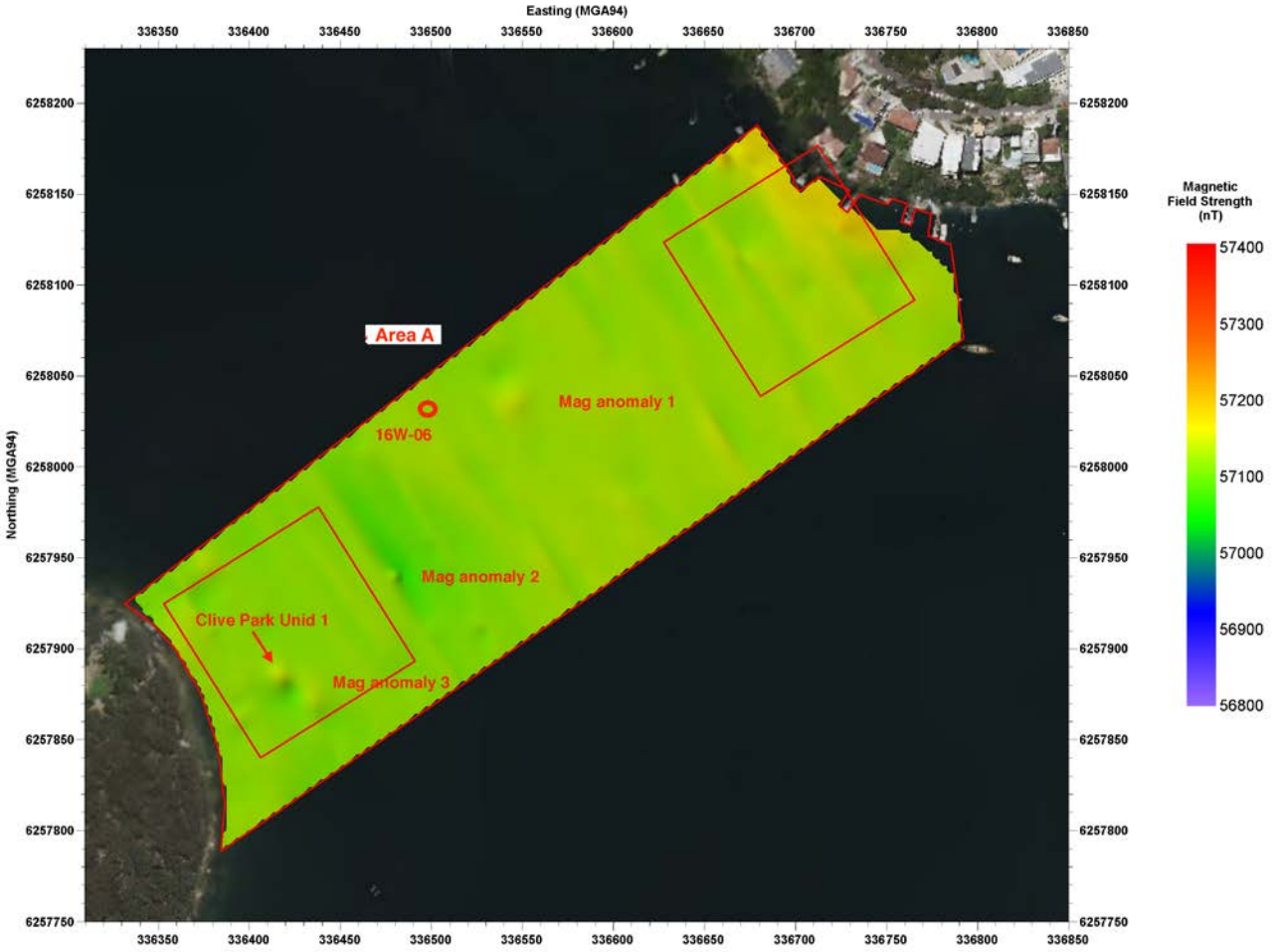


Figure 4-31: Magnetic anomalies in Area A (Earth Technology Solution Pty Ltd, July 2017b: Figure MH9A). Target 16W-06 has been included to show that it displayed no magnetic signature, which means there is little ferrous content associated with it. The red boxes show the area of interest around the proposed cofferdams.

The magnetometer survey showed four magnetic anomalies of an undetermined size (see Figure 4-31). One of these anomalies was the iron-hulled wreck Clive Park Unidentified No. 1. The other three magnetic anomalies appear to be buried as there was not a corresponding bed of the harbour anomaly on the side scan sonar imagery. The depth of burial and size of the objects cannot be determined with the information available. Magnetic Anomaly No. 3 may have some association with Clive Park Unidentified No. 1 wreck, as it is about 25 metres downslope of the wreck site and the formation of the wreck site suggests that some wreckage may have shifted downslope. The relatively higher magnetic responses closer to Seaforth Bluff may be ambient background noise from the moorings, boat hulls and jetty structures along the shoreline.

There is a wreck noted on the NSW Wrecks Info website as a 'Barge' (NSW Wrecks Info, 2010). Its position is given as being about 135 metres north-east of the Middle Harbour Unidentified No. 1 wreck that is shown on charts and multi-beam data (see Figure 4-27 and Figure 4-28). The multi-beam imagery for Area A does not appear to show a bed of the harbour anomaly at the location where the 'Barge' is meant to be. It is likely that the 'Barge' is the same wreck as the Middle Harbour Unidentified No. 1 (see Section 4.3.2.2) and that the position provided is incorrect. Nevertheless, the coordinates of the 'Barge' site and the other unverified anomalies in Area A are provided in Table 8.

Table 8: Unverified anomalies in Area A

Object	Easting (WGS84 UTM Zone 56H)	Northing (WGS84 UTM Zone 56H)	Source
'Barge'	336690	6257909	NSW Wrecks Info
16W-06	336489	6258029	Side scan sonar
Mag anomaly 1	336545	6258038	Magnetometer
Mag anomaly 2	336430	6257939	Magnetometer
Mag anomaly 3	336435	6257872	Magnetometer

4.5 Summary of maritime heritage sites and items in Area A

Area A has areas that have the potential to contain maritime heritage and archaeological remains associated with maritime infrastructure, shipwrecks and vessel activity. Using known sites, the distribution of potential sites and the spread of activities within Area A, these areas have been separated by a rating of 'archaeological potential' as defined in Table 9.

Table 9: Defining archaeological potential

Archaeological Potential	Likelihood of presence
Certain	100%
Very likely	85–99%
Likely	50–84%
Unlikely	16–49%
Very unlikely	1–15%
Remote	< 1%

The December 2017 dive inspection confirmed the presence of a range of cultural materials. The bed of the harbour outside the scanned area has been assessed as also likely to contain items of maritime heritage.

A summary of the maritime archaeological potential within Area A is presented in Table 10 and illustrated in Figure 4-32.

Table 10: Maritime archaeological potential within Area A

Archaeological Potential	Site type	Known or predicted location
Certain	Maritime infrastructure, shipwrecks, associated deposits and discard	Areas immediately adjacent to foreshores of Northbridge and Seaforth Bluff, and isolated locations of known shipwrecks and remains of maritime infrastructure
Very likely	Shipwrecks and discard	Anomaly 16W-03 is very likely a wreck. Discard associated with maritime infrastructure and moored vessels up to 50 metres from shore
Likely	Shipwrecks and discard	Within the study area beyond the limit of the geophysical surveys
Very unlikely	Shipwrecks and discard	Within the limit of the geophysical surveys, and the reported 'Barge' in the south-east quadrant

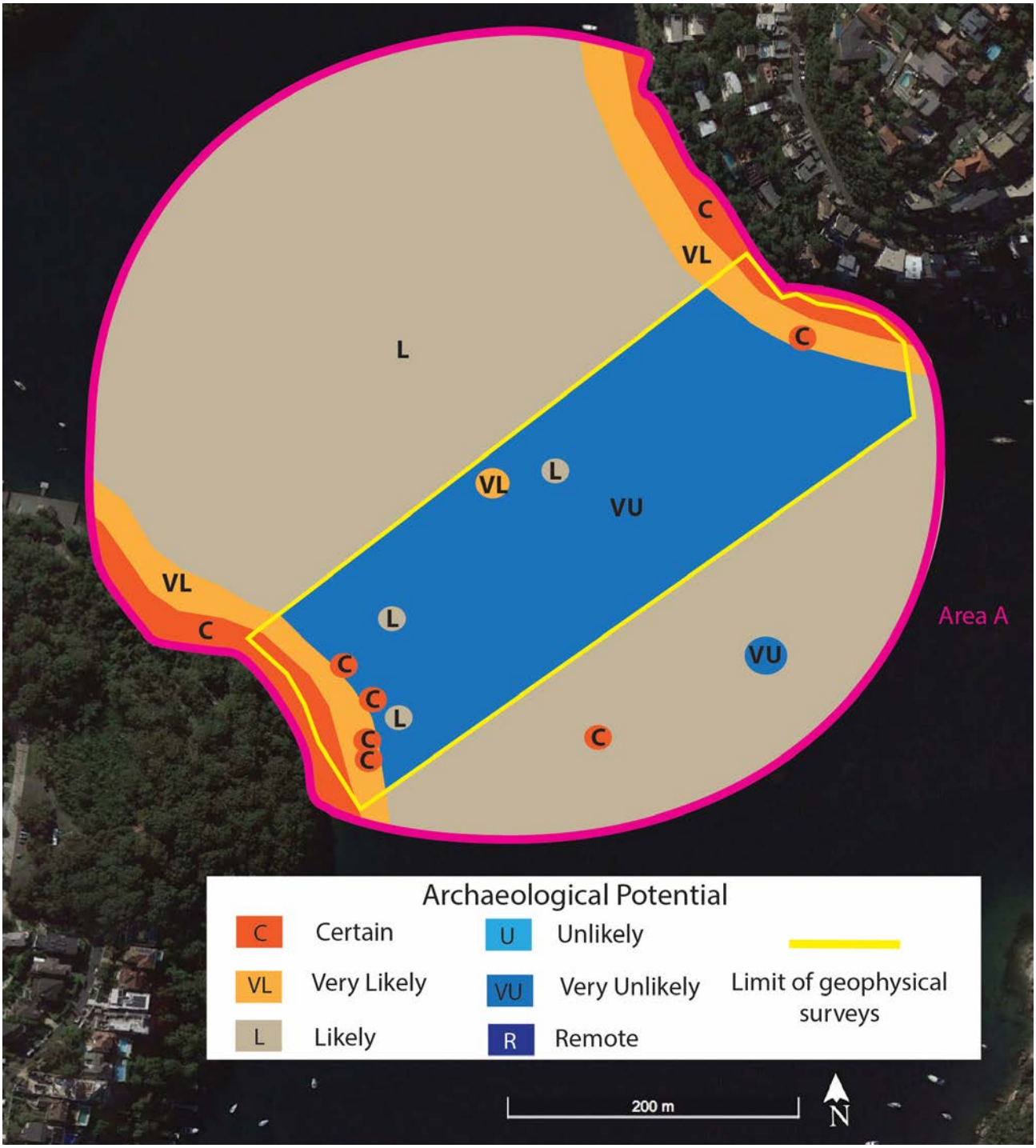


Figure 4-32: Maritime archaeological potential within Area A

5 AREA B – WESTERN SIDE OF THE SPIT, PEARL BAY

5.1 Physical setting

Area B is situated in Pearl Bay on the western side of The Spit, a large sandbar projecting north-north-east from Beauty Point across Middle Harbour (Figure 5-1). Spit West Reserve construction support site (BL 9) would be located within Area B. As described in Section 8.1, support site BL9 would be used as a casting facility for the immersed tube tunnel units and a barge point for construction supplies and the workforce travelling to the Middle Harbour crossing.

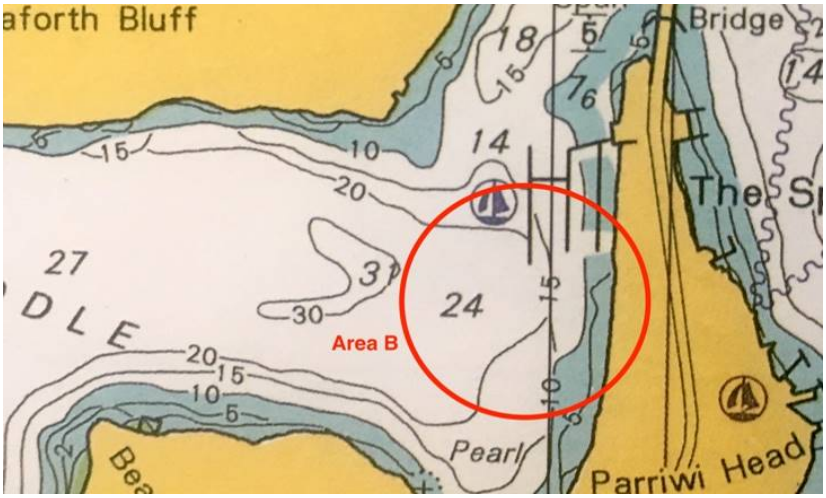


Figure 5-1 Portion of nautical chart showing Area C (Commonwealth of Australia/Crawford House Publishing, 1995: Chart 15). *Depths are in metres*

The Spit originally developed as a result of Pleistocene erosion of the surrounding and upstream Hawkesbury sandstones, episodes of marine flooding and Aeolian sedimentation, and the rising sea levels commencing around 17,000 years Before Present (BP). The bed of the harbour that comprises most of the study area was also created during this period. The natural width of The Spit has been progressively expanded since European settlement through reclamation. The eastern edge of the study area was reclaimed throughout the early to mid 20th century. The bed of the harbour on the western side of The Spit drops away from the shoreline to a depth of 10 metres below Australian Height Datum about 50 to 60 metres from the shore, sloping more gradually to a depth of 22 metres about 150 metres from shore (Figure 5-2).

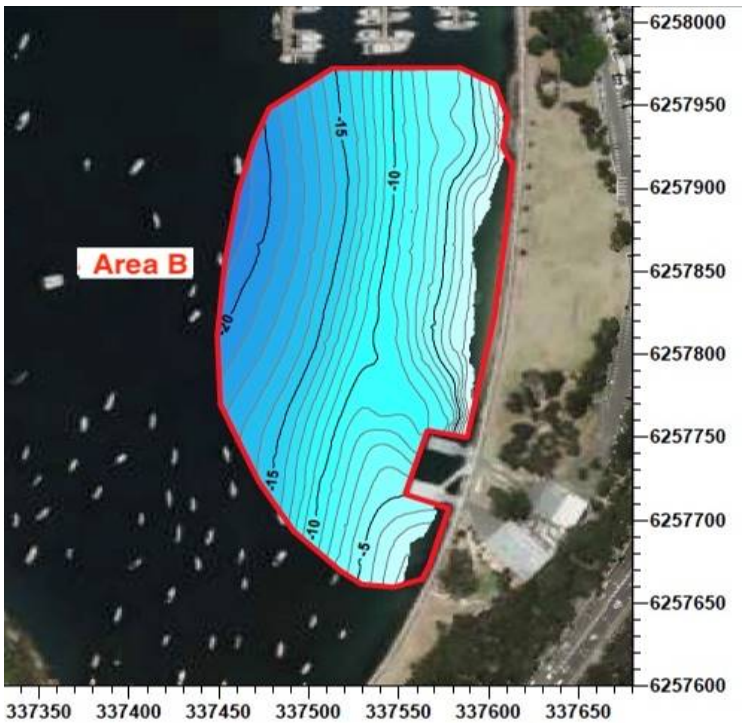


Figure 5-2: Area B – the western side of The Spit, Middle Harbour (Earth TechnologySolution Pty Ltd, July 2017a: Figure MH2). *Depths are in metres*

Based on the nature of the development of The Spit, it is expected that the bed of the harbour sediments within Area B would predominantly comprise a sloping landscape of Holocene marine sediments consisting of gravels and fluvial sands, and fluvial silt/mud and sand (eroded sandstone) derived from fluvial downstream tidal flows (Manly Council and Clontarf / Bantry Bay Estuary Management Working Group 2007).

There are numerous moorings across the bed of the harbour south of the existing marina (Figure 5-3). Some of these moorings are located at water depths of about 20 metres.

Figure 5-3: Bed of the harbour features derived from bathymetric survey within Area B (Earth Technology Solution Pty Ltd, July 2017a: Figure MH2A). *Low circular mounds are moorings for recreational craft*

5.2 Historical activities in the vicinity of Area B

Due to the rugged landscape and relative isolation from the Sydney settlement, little European occupation of Middle Harbour occurred during the early years of the colony. With its steep cliffs and strategic position near the mouth of Port Jackson, Middle Head was selected as an early defensive position. In 1801, the construction of a battery at Georges Head saw the Mosman area develop as one of Sydney's most significant maritime defence installations. Farming activity began to be established in nearby Balmoral, but the area further north in the vicinity of Area B proved unsuitable for cultivation.

Little, if any, European occupation or utilisation of land at The Spit appears to have occurred until 1849, when Peter Ellery, a Seaforth pioneer, established a small ferry service across Middle Harbour, transferring passengers in a rowboat from The Spit to Clontarf. By the 1850s, Ellery had abandoned the rowboat and established a hand punt operation at the same location, running along cables stretched over the harbour. A narrow track formed along The Spit, allowing traffic access to the southern punt landing point. Ellery occupied a house at the western side of The Spit and it appears that he was the only settler in the area at this time (Sturrock 1982) (Figure 5-4).

Figure 5-4: 1870s Willoughby parish map, showing undeveloped nature of The Spit and track to Ellery's southern punt landing point (NSW Surveyor 1870s).

Over the next 20 years, settlement along Middle Harbour in the Mosman to Manly region increased as both water and land transport were improved and expanded. By the late 1880s, the NSW Government had taken over the operation of The Spit hand punt and in 1889, a larger steam punt service was introduced, able to carry eight ordinary sized buggies and several passengers in one trip. New infrastructure was built to support the Government punt service and the area of The Spit – to a line almost as far south as the apex of Pearl Bay – was designated as Government Reserve. Isolated reclamation was conducted to build up and stabilise the roadway running along The Spit providing access to the punt service. A wharf to provide coal to fuel the steam punt was erected at the eastern base of The Spit, and three residences were constructed fronting the western side of the roadway to accommodate punt operators (

Figure 5-5 and Figure 5-6). The western shore of The Spit, however, remained undeveloped.

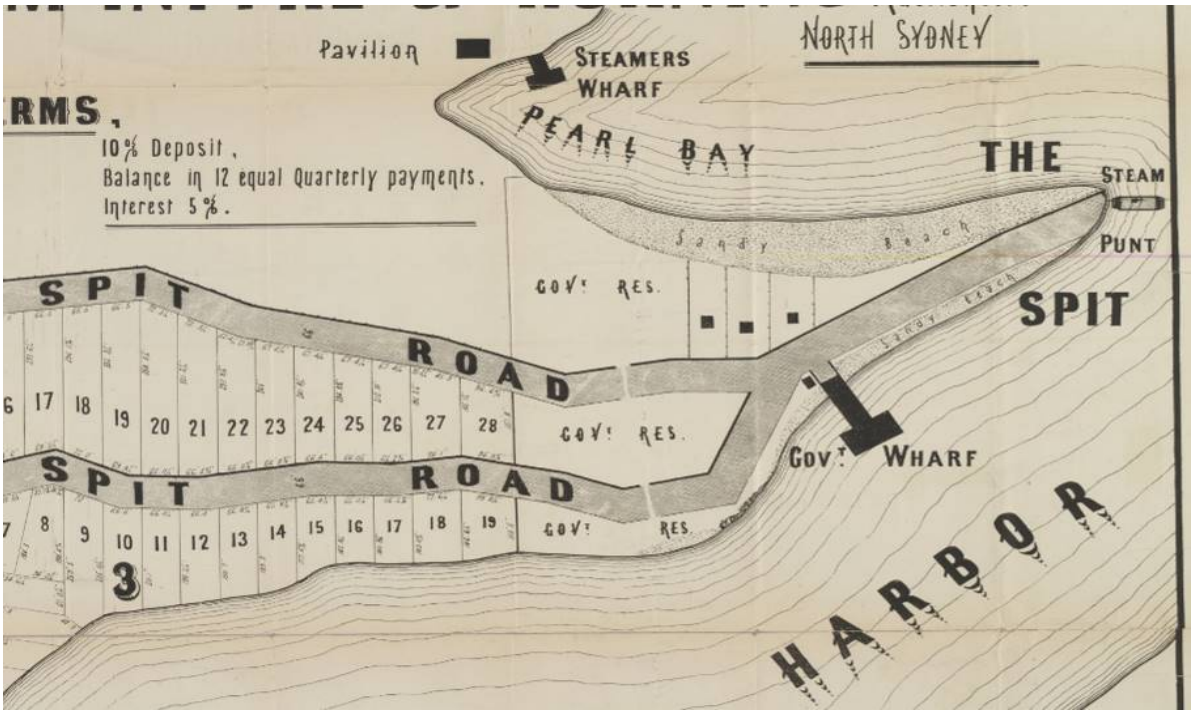


Figure 5-5: 1894 subdivision notice – while largely schematic, this plan shows the general locations of The Spit Government Reserve, roadway, steam punt, coal wharf and houses for punt operators **(**Pile & Allum 1894**).**

Figure 5-6: Late 1880s photograph showing The Spit roadway and coal wharf – the punt landing is visible in the background (Anon ca. late 1880s)

As settlement in the vicinity of The Spit increased, the foreshores of Middle Harbour and Pearl Bay became popular for recreational activities and a public boatshed was erected at the north-western tip of The Spit, adjacent to the steam punt landing. By the late 1890s, the increasing traffic and recreational use of The Spit prompted the NSW Government to construct a tramline along the length of The Spit, linking Spit Junction and North Sydney with the punt services across Middle Harbour. The tramway was cut along the eastern side of Upper Spit ridge, then constructed along the length of The Spit roadway, which was raised and stabilised with small-scale reclamation to accommodate the tram tracks (Gamble & Souter 1976) (Figure 5-7).

Figure 5-7: 1900 photograph of the opening of the tram service to The Spit (Anon 1900)

Shortly after the tramway was completed, the tidal flats at the northern end of The Spit were again raised through land reclamation and a long stone seawall constructed around the north-western extent. Further recreational development followed, including the construction of Lyons Boat Shed, a public large boathouse and refreshment rooms, situated on the north-western side of The Spit. In the early 1910s, public transport services across Middle Harbour at The Spit were also substantially expanded with the

establishment of a second steam passenger punt and a tramcar transfer ferry service connecting The Spit tramline to a newly constructed tramline on the opposite shore of Middle Harbour, ascending up to Clontarf and Manly. Both land and maritime infrastructure was constructed to support these services; however, development was confined to around the northern end of The Spit (Gamble & Souter 1976, Woodside, Chinn & McCarthy 1961).

In 1915, maritime facilities at The Spit were further expanded with the construction of an 'explosives wharf' on the western side of the punt landings at the northern end of The Spit. This 'explosives wharf' was constructed to provide mooring and loading facilities for launches, tugs and workboats operated by the NSW Explosives Department engaged in the transportation of explosives between Bantry Bay, explosives magazines at Newington and the railway at Rozelle Bay (Andrews 2002, Mary Dallas Consulting Archaeologists 2001).

The increased recreational use of Middle Harbour and The Spit during the 1910s led to the establishment of a number of small vessel moorings along the eastern extent of Pearl Bay – within project Area B. The western shoreline of The Spit, however, remained undeveloped throughout this period (Gamble & Souter 1976, McLaren 1978, Woodside, Chinn & McCarthy 1961) (Figure 5-8).

Figure 5-8: ca. 1920 view of The Spit from Seaforth, showing substantial development at the northern end – with undeveloped sand flats and small boats moored along the western side of The Spit beyond (Cazneaux ca. 1920)

In 1924, following growing public agitation, a low-level bascule bridge was constructed over Middle Harbour at The Spit by Manly Council and the Sydney Harbour Trust to replace the passenger punt services. The southern bridge abutment was located at the northern extent of The Spit, with the approach angle necessitating a realignment of the southern approach road (Bickford 1927).

In the late 1920s, the construction of the Northern Suburbs Ocean Outfall Sewer at Bluefish Point, North Head, resulted in large excavations at Clontarf. Spoil from these works was used to reclaim sections of the tidal flats along the western side of The Spit to provide additional public parkland and recreational facilities surrounding the bridge. The reclamation works were carried out in the early to mid 1930s and resulted in the creation of a 12-acre park retained by concrete seawalls and vested in the Sydney Harbour Trust Commissioners (Mosman Municipal Library) (Figure 5-9 to Figure 5-12). This reclamation created the current western shoreline of The Spit – within and adjacent to Area B.

Figure 5-9: ca. early 1930s photograph of Spit Bridge showing reclamation works being carried out on the western side of The Spit (Foster ca. 1930s)

Figure 5-10: Reclamation being carried out at Pearl Bay, 1935 (Anon 1935)

Figure 5-11: Spit Bridge, 1932, showing reclamation (John Hall & Co. 1932)

Figure 5-12: 1943 aerial photograph showing the reclaimed land and seawall on the western side of The Spit (RTA Photography 1943). Note the number of moored vessels in Pearl Bay

The Spit saw continued redevelopment throughout the mid to late 20th century, including the replacement of the bascule bridge with a higher and wider concrete and steel lift bridge in 1958, the demolition of Lyons Boatshed and the establishment of d'Albora Marina in the 1970s in its place (

Figure 5-13). The western shore of The Spit within and adjacent to Area B, however, remained largely unchanged except for a small section of infill reclamation and the construction of recreational boating facilities in the late 1990s to early 2000s, now utilised by the Mosman Rowing Club.

Figure 5-13: 1974 photograph of The Spit, showing the second Spit Bridge, d'Albora Marina and the undeveloped shoreline along the western shore adjacent to Area B (Anon 1974)

5.3 Known maritime heritage sites and items

The following discussion of known maritime heritage sites within Area B has been compiled from historical research, a review of statutory and non-statutory heritage registers, and the findings of field inspection conducted in December 2017.

5.3.1 Maritime infrastructure

A search of the relevant statutory and non-statutory registers indicates that there are no known maritime infrastructure heritage sites within Area B. The site of the late 19th century 'explosives wharf' is located on the western side of the Spit to the north of Area B, between the d'Albora Marina boatsheds and the current bridge. The current seawall in Area B appears to be a late 20th century construction which may have been a rebuild of the earlier 20th century wall bounding the reclamation of the area. Some of the moorings identified in the side scan sonar imagery in Area B could date back to the early 20th century.

5.3.2 Shipwrecks

A search of the Australian National Shipwreck Database and the Department of Premier and Cabinet (Heritage)maritime heritage sites database revealed no shipwrecks listed within Area B. However, the December 2017 field investigation located two shipwrecks within Area B, within 10 metres of each other.

5.3.2.1 Pearl Bay Unidentified No. 1 shipwreck

The Pearl Bay Unidentified No. 1 shipwreck is about 130 metres from the western shore in about 20 metres of water. The wreck comprises the remains of a timber-hulled and copper-sheathed vessel (Figure 5-14), approximately two metres wide by up to 10 metres long, and extends approximately 700 mm above the bed of the harbour. A propeller was visible, indicating that the vessel was most likely a motor launch. A port hole was observed near the bow suggesting there may have been a small below deck cabin space or foredeck cabin (Figure 5-15). The presence of a corrugated plastic hose with a stainless-steel hose clamp attached fitting (Figure 5-16) – probably for pumping out the bilge – indicates that the vessel sank after the middle of the 20th century. However, the very poor condition of the timber hull would suggest that the vessel has been underwater for at least a few decades. The vessel most likely sank at its moorings sometime in the last half of the 20th century (Cosmos Archaeology Pty Ltd January 2018).

Figure 5-14: Close-up of copper/copper alloy sheathing (left) (Cosmos Archaeology Pty Ltd 19 December 2017)

Figure 5-15: Port hole found in the interior of the wreck (right) (Cosmos Archaeology Pty Ltd 19 December 2017)

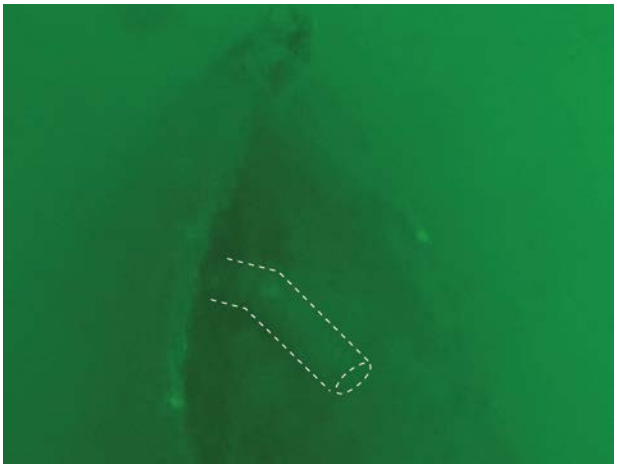


Figure 5-16: Bow of the wreck with the corrugated plastic hose shown in dotted white line (Cosmos Archaeology Pty Ltd 19 December 2017)

5.3.2.2 Wreck of recently sunk yacht

Within 10 metres of the Pearl Bay Unidentified No. 1 shipwreck is the wreck of a 12 metre timber yacht (Figure 5-17). This vessel is known to have sunk sometime during the six months preceding the December 2017 dive inspection, because it did not appear on the side scan sonar imagery obtained earlier in the year and the registration numbers and vessel name were clearly visible. (This information has been withheld from this report on the basis that the vessel may be the subject of an enquiry or investigation). The vessel is not listed on the Australian Register of Historic Vessels (Australian National Maritime Museum).

Figure 5-17: Large intact wooden yacht (Cosmos Archaeology Pty Ltd 19 December 2017)

5.3.3 Summary

Table 11: Known maritime heritage sites and items in Area B

Site/item	Location (WGS84 UTM Zone 56 H)	Heritage listing
Pearl Bay Unidentified No. 1 Shipwreck (18W-001)	337471.865 E 6257848.820 N	N/A
Wreck of recently sunk yacht	337471.865 E 6257848.820 N	N/A
Seawall	Foreshore within study area	N/A

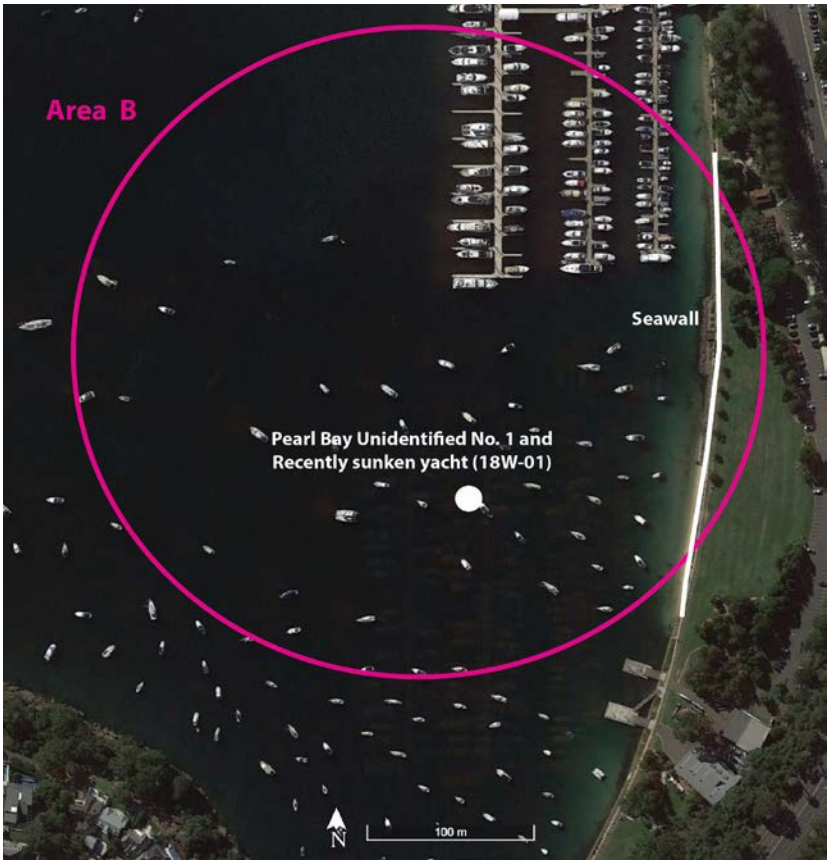


Figure 5-18: Known maritime heritage sites and items in Area B (Base image: Google Earth)

5.4 Potential maritime heritage sites and items

Based on historical information, as summarised in Section 5.2, the following cultural activities have occurred near The Spit and Pearl Bay:

- Recreational boating (1890s onwards)
- Offshore mooring of vessels (1910s onwards)
- Development of transport across Middle Harbour, including punts, tramways, bridges and associated approaches (1850s onwards)
- Potential explosives shipment (early 1910s to 1970s)
- Reclamation (1890s to 1930s).

As such, the following types of maritime heritage sites and items may occur in Area B:

- Maritime infrastructure (1890s onwards) – mooring facilities
- Shipwrecks (1890s onwards) – including recreational and industrial vessels
- Discard from vessels (1890s onwards) – accidental and/or deliberate discard of items such as personal objects, food and drink containers, ships fittings and equipment as well as fishing and boating equipment including potential unexploded ordnance
- Discard in and under reclamation fill (1890s-1930s).

The following sections provide a discussion on the predicted type and condition of these maritime sites within Area B. Detailed discussion of general maritime site formation processes can be found in Annex B of the Cosmos Archaeology November 2017 report, *Western Harbour Tunnel and Beaches Link – Maritime Archaeological Desktop Study*.

5.4.1 Maritime infrastructure and associated deposits

The western side of The Spit has been dotted with small vessel moorings since the 1910s. The regular spacing of the vessels seen in historical photographs suggests that a standard type of mooring was deliberately prepared and placed to create this layout. The type of moorings used is unknown but they were likely anchors or concrete blocks attached to long chains. Although the chains may have been replaced over time, or additional moorings added, it is likely that the original mooring facilities have been

left on the bed of the harbour and are either still used or abandoned. The exception is those moorings located within the vicinity of the d'Albora Marina, as these may have been removed for the marina's development. Those that are still in use are not considered to be maritime archaeological remains; however, those that are not used do form part of the maritime archaeological record. As typically large solid features, the remaining moorings would likely remain intact, either on the surface of the bed of the harbour or buried. The bed of the harbour around moorings could also contain artefacts discarded from vessels, as described further in Section 5.4.3. The 'explosives wharf' is located north of Area B, to the north of the boatshed, and it is unlikely that associated deposits from this wharf would extend into this area.

Concrete seawalls were constructed to retain the most recent phase of reclamation, along with the creation of a 12 acre park. The curved northern end of the seawall and its western edge can be discerned in a 1943 aerial photograph of The Spit, abutting the eastern edge of Area B (Figure 5-12). The current seawall is concrete, faced for the most part with rock armour rubble. There may also be remains of the earlier retaining walls within the reclamation.

5.4.2 Shipwrecks and associated deposits

There are two known shipwrecks within Area B and it is possible there are others – either due to accidents or intentional scuttling.

Boating in Area B was largely recreational, with only the northern end of the area likely to experience the passing of vessels through Middle Harbour. As such, potential shipwrecks would most likely be recreational sailing craft representing small vessels of timber or, later, fibreglass construction.

The waters of Area B are well sheltered and the coastlines are gradual, making it likely that any accidental wrecking events occurred through collision or engine faults. There is also the likelihood that some vessels may have sunk at their moorings for a variety of reasons, for instance the failure of the bilge pumps. It would appear that this is how both known wrecks in Area B ended up on the sea floor.

In the case of collision or engine failure, the vessel would have been abandoned rapidly, with all personal possessions left on board. While some salvaging for equipment and personal items may have occurred, these wreck sites should be expected to contain and be associated with a variety of material. Depending on the wrecking event, this material could also be scattered over a wide area. Vessels sinking in violent circumstances can often sink upside down or break up.

Some wrecks may have been re-floated or broken up if they impeded the movement of vessels or were hazardous to shipping and the use of the marina. The two known wrecks are situated in deep water and, other than potentially fouling the lines of existing mooring chains, they pose no navigation hazard.

For wrecks that were not recovered, over time the larger remains would settle into the bed of the harbour to a certain depth – depending on the size/weight of the wreck and sediment consistency, with mechanical and biological processes largely affecting the exposed areas. Timber-hulled wrecks would break down relatively quickly with little remaining above the bed of the harbour apart from non-organic materials such as engine components or, in the case of Pearl Bay Unidentified No. 1, copper sheathing that once protected the timber hull. Any wreck in Area B would also be subjected to impacts arising from cultural activities such as dragging anchors and swinging mooring chains resulting in the vessel breaking up and being spread across the bed of the harbour. These factors will eventually produce a low-relief site that may appear indistinguishable from a scatter of debris or low-lying reef. However, the buried remains of such a wreck could retain high structural integrity.

5.4.3 Discard from vessels

Recreational boating activity inevitably results in accidental and intentional discard from vessels on the water. Losses and discards from vessels can include personal objects, food and drink containers, ship fittings and equipment, and various types fishing and boating equipment. Such deposits can consist of a range of materials and are mostly single items, but can also occur in scatters created by one event or multiple events. Higher concentrations would be expected in the areas around the vessel moorings on the western side of The Spit. Discard in the northern part of the moorings may have been impacted by the development of D'Albora Marina. However these impacts would largely be confined to the footprint of piles. Use of the marina would increase disturbance of discarded cultural items on the surface of the bed of the harbour or shallowly buried, as well as adding to the cultural deposit.

5.4.4 Discard in and under reclamation fill

Several episodes of land reclamation occurred over the tidal flats west of The Spit, to the east of Area B, from the 1890s to the 1930s. Concrete seawalls were constructed to retain the latest phase of reclamation, along with the creation of a 12 acre park. The curved northern end of the seawall and its western edge can be discerned in a 1943 aerial photograph of The Spit, abutting the eastern edge of Area B (Figure 5-12). Seawalls are periodically repaired and upgraded. Often degraded sections of walls are repaired while for major upgrades a new seawall is often built in front of the one being replace. The remains of earlier seawalls can often be found within a few metres of a current seawall. This Reclamation would have the effect of burying and preserving any potential archaeological remains on and under the bed of the harbour. Reclaimed areas may also contain cultural items from the original source of the fill material, along with opportunistic discard as locals, workers and even local government authorities took advantage of the operation to bury unwanted refuse. The type, material kind, size and extent of these remains cannot be predicted. Regardless, the process of burial generally conserves material and it is likely that any such items are relatively intact.

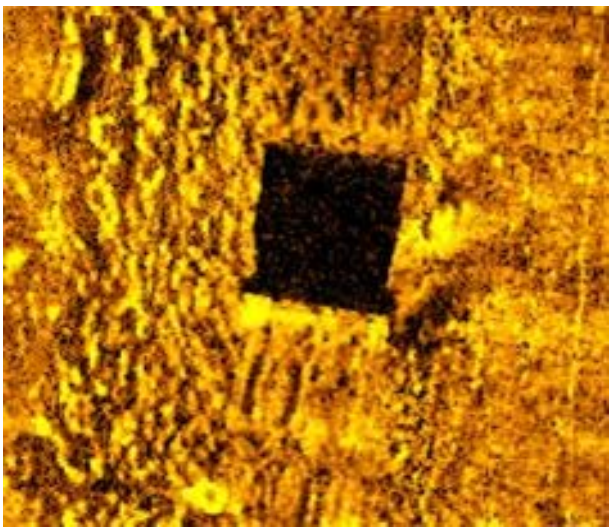
5.4.5 Unverified anomalies

Two anomalies identified from the side scan sonar survey of Area B were not inspected as they appeared to be modern or data 'artefacts', due to their proximity to shore and the shallow water they were in (Cosmos Archaeology Pty Ltd January 2018).

The first, Target 18W-002, is a linear feature measuring approximately 4.5 metres long and one metre wide and casting a long shadow (Figure 5-19). It has the potential to be a pile but is more likely a water pipe or similar, or a data anomaly. The second anomaly, Target 18W-003, consists of two parallel linear features 4.5 metres long, 0.5 metres wide and spaced three metres apart. These lines could represent collapsed piles or a data anomaly due to shallow depths and close proximity of the coastline.

Table 12: Unverified anomalies within Area B

Object	Easting (WGS84 UTM Zone 56 H)	Northing (WGS84 UTM Zone 56 H)	Source
18W-002	337595	6257876	Side scan sonar
18W-003	337550	6257699	Side scan sonar



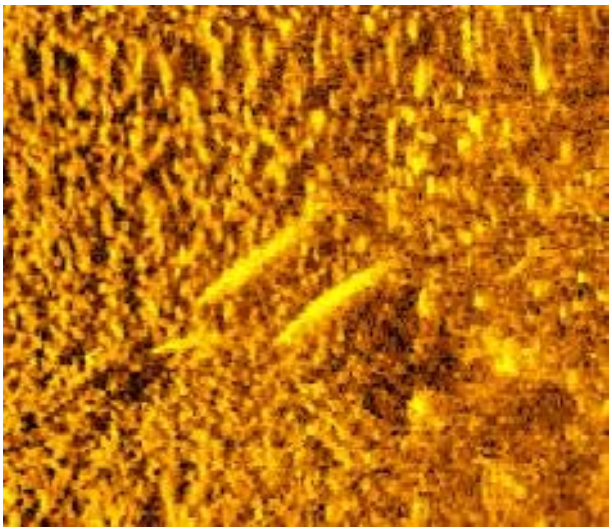


Figure 5-19 Side scan sonar image of Target 18W-002
Figure 5-20 Side scan sonar image of Target 18W-003

5.5 Summary of maritime heritage sites and items in Area B

Within Area B there are areas that have the potential to contain maritime heritage and archaeological remains associated with maritime infrastructure, shipwrecks and vessel activity. Using known sites, the distribution of potential sites and the spread of activities within Area B, these areas have been separated by a rating of 'archaeological potential' (refer Table 9 in Section 4.5 for definitions).

The maritime archaeological potential of Area B is highest around the moorings closest to the western shore of The Spit (Table 13 and Figure 5-21). However, the whole of Area B has experienced vessel

activity and hence has the potential to contain remains such as discarded items. With two wrecks being found almost next to each other, it would be reasonable to assume that wreckage from other small recreational-type wrecks could also be present within Area B.

A summary of the maritime archaeological potential within Area B is presented in Table 13 and illustrated in Figure 4-32.

Table 13 Maritime archaeological potential within Area B

Potential	Site type	Known or predicted location
Certain	Maritime infrastructure, shipwrecks, associated deposits and discard	The current seawall and two wrecks
Very likely	Maritime infrastructure, associated deposits and discard	This would include disused moorings under reclamation and within 200 m of the shoreline
Likely	Shipwrecks and discard	Shipwrecks are likely within the study area and discard throughout
Very unlikely	Two side scan sonar anomalies	Close to the current shoreline. One is outside and to the south of the study area

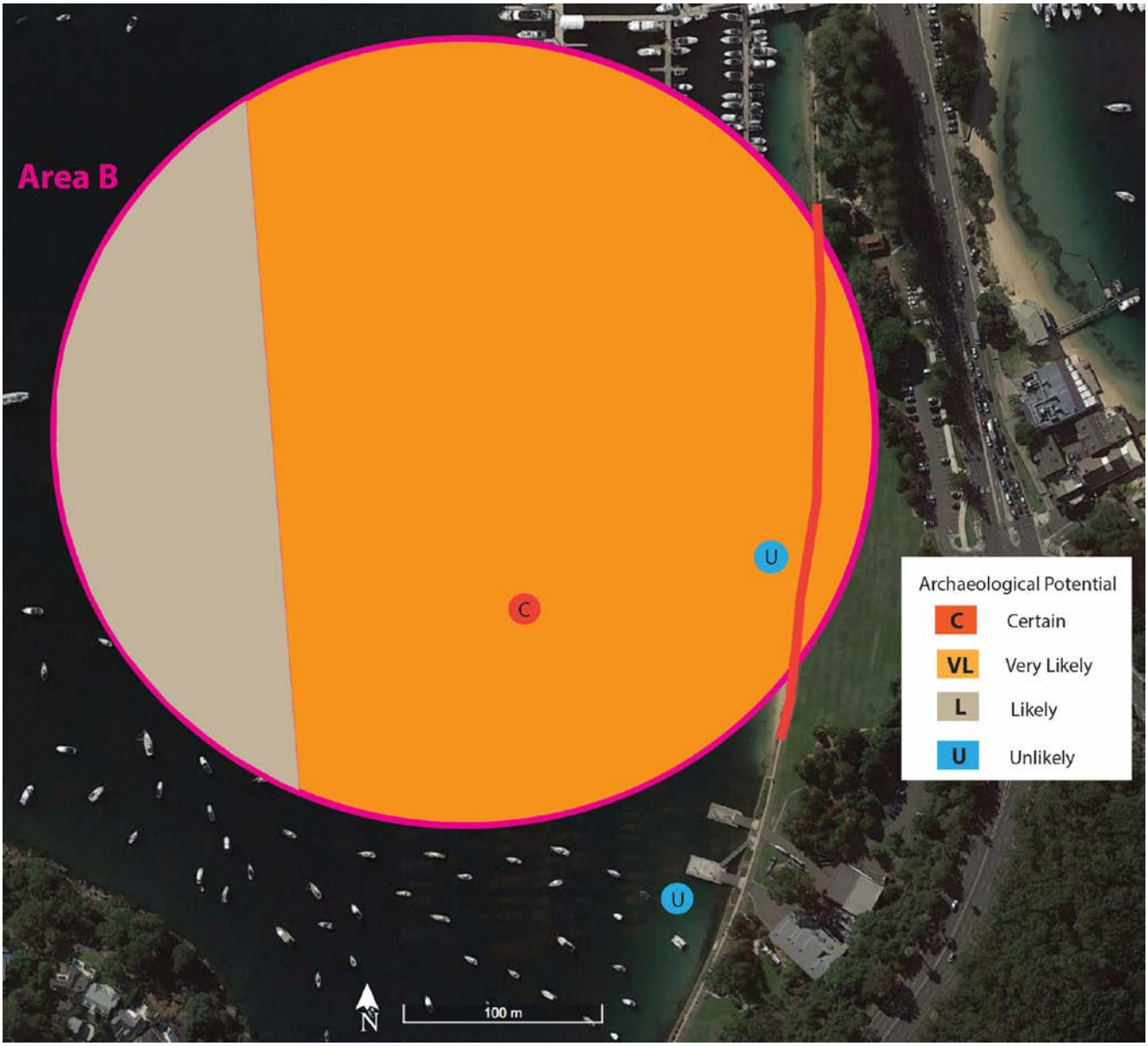


Figure 5-21: Maritime archaeological potential within Area B

6 AREA C – CLIVE PARK TO BEAUTY POINT, MIDDLE HARBOUR

6.1 Physical setting

Area C is situated at the entrance to Long Bay in Middle Harbour between Clive Park at Northbridge and Beauty Point at Mosman (Figure 6-1). Located closer to the western shore, Area C overlays what appears to be an underwater ridge sloping down towards the east.

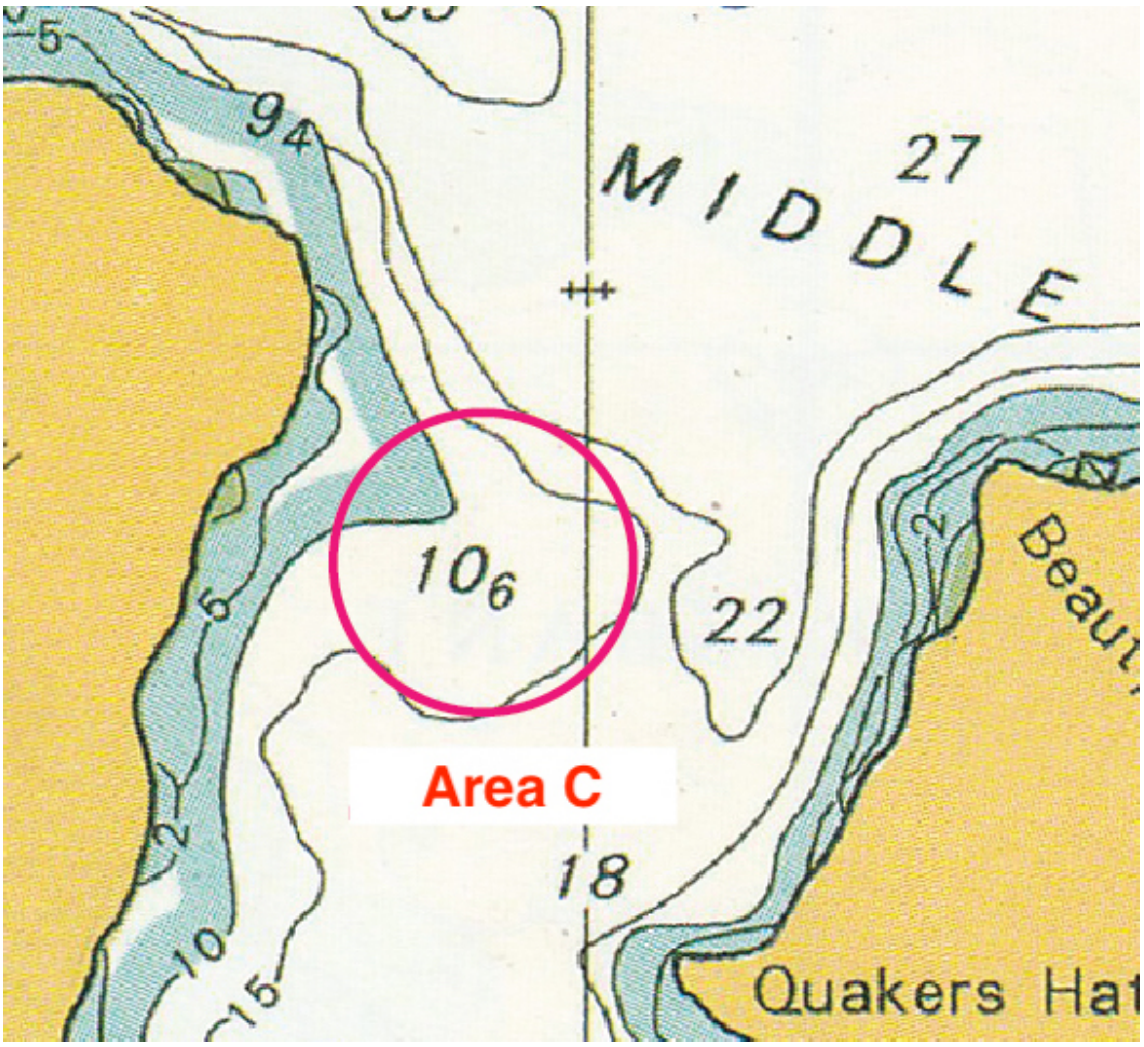


Figure 6-1: Bed of the harbour topography within Area C (pink circle) (Commonwealth of Australia/Crawford House Publishing, 1995: Map 15).

Water depth ranges from about 10 metres below Australian Height Datum at the western end of the area to 20 metres towards the northern and eastern edges. Water depth is between 10 and 15 metres across most of the area.

The bed of the harbour is expected to be composed of silty sand with shell, as has been observed at similar depths in Area A. There may be some rock outcropping at the western fringes of Area C.

No geophysical information for Area C – such as side scan sonar, multi-beam sonar, magnetometer, seismic profiling or borehole data – has been obtained for this project.

6.2 Historical activities in the vicinity of Area C

Since European settlement, the waterway of Middle Harbour has been a quieter part of Port Jackson than Sydney Harbour. Long Bay appears to have been a less frequented part of Middle Harbour until residential development started taking place along its southern shores towards the end of the 19th century. The abandonment of several vessels in Salt Pan Cove, towards the head of Long Bay, including the 61.2 metre long steel barque *Itata* in 1906 (Figure 6-2), and the 38.7 metre long timber vessel *Cobaki* in 1946, would suggest that the Long Bay area was still relatively secluded during the early decades of the 20th century (Australian Government Department of the Environment and Energy 2018).

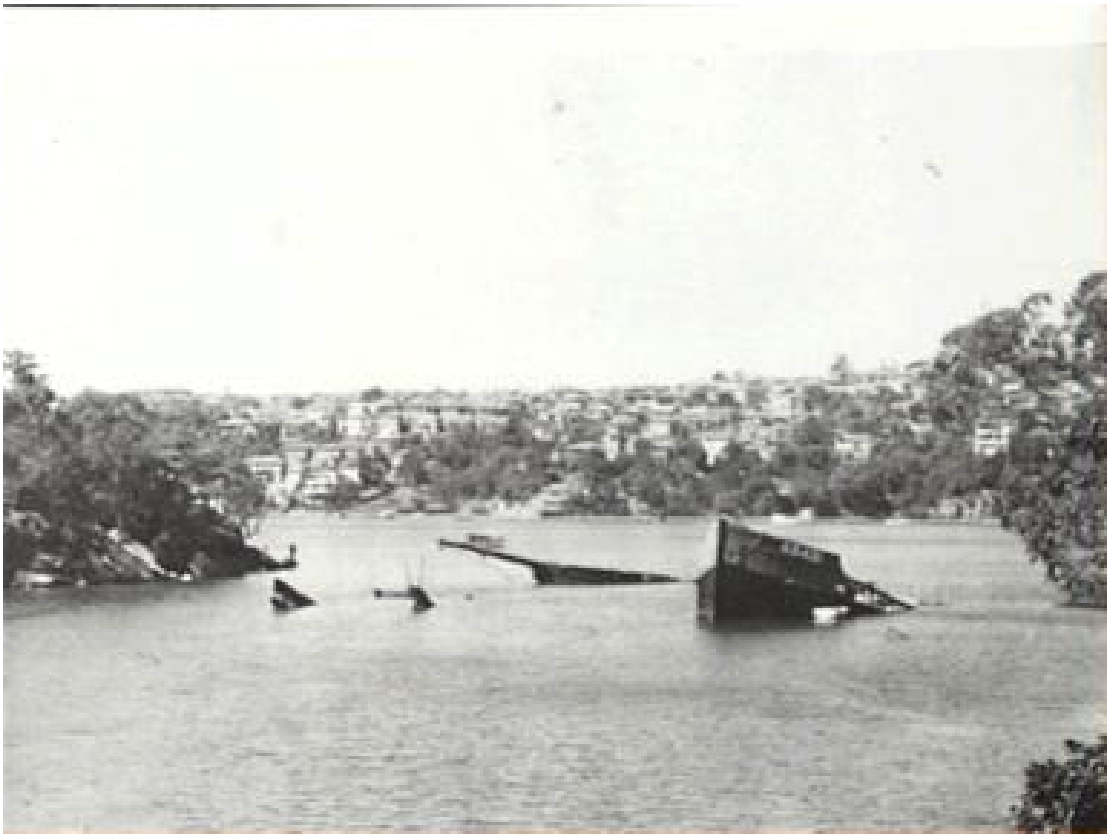


Figure 6-2: Shipwrecks in Salt Pan Cove, 1923 (Mitchell 1923)

By the mid 20th century, however, residential development had expanded along the foreshores of Northbridge and Beauty Point, resulting in a proliferation of recreational watercraft and associated moorings close to shore (Figure 6-1). The stretch of water that Area C encompasses would have become a busy thoroughfare as vessels passed from Long Bay into Middle Harbour and eventually past The Spit into Sydney Harbour.

Figure 6-3: 1943 aerial showing residential foreshore development and scattered small boat moorings along both shorelines of Long Bay (RTA Photography 1943).

6.3 Known maritime heritage sites and items

There are no known maritime heritage sites or items within Area C.

6.4 Potential maritime heritage sites and items

Based on historical information, as summarised in Section 6.2, the following cultural activities have occurred around the entrance to Long Bay between Clive Park and Beauty Point:

- Movement of vessels from Long Bay into Middle Harbour
- Private recreational boating.

Based on these activities, the following maritime heritage and archaeological sites may occur:

- Shipwrecks (ca.1900s onwards) – mostly recreational vessels but possibly scuttled work vessels
- Discard from vessels (ca.1900s onwards) – accidental and/or deliberate discard of items such as personal objects, food and drink containers, ships fittings and equipment as well as fishing and boating equipment.

The following sections provide a discussion on the predicted type and condition of these maritime sites within Area C. Detailed discussion of general maritime site formation processes can be found in Annex B of the Cosmos Archaeology November 2017 report, *Western Harbour Tunnel and Beaches Link – Maritime Archaeological Desktop Study*.

6.4.1 Maritime infrastructure and associated deposits

Given the location of Area C east of Clive Park in Middle Harbour, it is highly unlikely that former moorings will be present and there has been little need for navigation markers like that situated on Fig Tree Point further to the south (see Figure 6-1). The only remains of maritime infrastructure anticipated in Area C may be the remnants of timber piles from maritime structures along the shorelines that have floated into the area and sunk. Such remains could be resting on the bed of the harbour or partially buried and are likely to be in a degraded condition.

6.4.2 Shipwrecks and associated deposits

Boating in Area C has largely been recreational so potential shipwrecks would most likely be recreational sailing craft representing small vessels of timber or later fibreglass construction. The waters of Area C are also well sheltered, making it likely that any accidental wrecking events occurred through collision or engine faults.

While abandonment of several vessels has occurred throughout the 20th century in the sheltered area Salt Pan Cove, it is considered unlikely that intentional scuttling of such large vessels would occur in the open waters within Area C.

In most accidental wrecking situations, the vessel would have been abandoned rapidly, with all personal possessions left on board. While some salvaging for equipment and personal items may have occurred, these wreck sites should be expected to contain and be associated with a variety of material. Depending on the wrecking event, this material could also be scattered over a wide area. Vessels sinking in violent circumstances can often sink upside down or break up.

Over time, the larger remains of any shipwrecks would settle into the bed of the harbour to a certain depth, depending on the size/weight of the wreck and sediment consistency, with mechanical and biological processes largely affecting the exposed areas. Timber-hulled wrecks would break down relatively quickly with little remaining above the bed of the harbour apart from non-organic materials such as engine components. Any wreck in Area C would also be subjected to impacts arising from cultural activities such dragging anchors. These factors will eventually produce a low-relief site that may appear indistinguishable from a scatter of debris or low-lying reef. However, the buried remains of such a wreck could retain high structural integrity.

There is one shipwreck in Long Bay listed on the Australian National Shipwreck Database that has not been located, and which could potentially be within Area C. This is the *Mystery*, a 9.4 metre long timber launch owned by Geoffrey Austin Hill that sank when its engine exploded and the vessel caught fire on 19 January 1935 (Australian Government Department of the Environment and Energy 2018). Hill and two companions had been returning from a fishing trip and stopped in Long Bay, apparently about 90 metres from the shore, to clean their catch. When they restarted the engine, it backfired and exploded. The launch burnt to the waterline and sank. There was apparently a proposal to attempt to recover the engine

however it is not known if this was carried out. The vessel itself was deemed unsalvageable (Anon 30 January 1935).

It is most likely that the wreck of *Mystery*, if present in Area C, has settled into the silty/sandy bed of the harbour and is partially covered by sediment. Due to marine borer action, it is unlikely that the timber hull would survive above the surface of the bed of the harbour. The engine – if it was not recovered – would likely protrude somewhat above the bed of the harbour and would present as a magnetic signature in remote sensing. Any objects associated with the *Mystery* are likely within the wreck or scattered within the immediate vicinity.

6.4.3 Discard from vessels

Recreational boating activity inevitably results in accidental and intentional discard from vessels on the water. Losses and discards from vessels can include personal objects, food and drink containers, ship fittings and equipment, and various types fishing and boating equipment. Such deposits can consist of a range of materials and are mostly single items, but can also occur in scatters created by one event or multiple events.

The December 2017 diving inspection found that discarded objects would pool at certain locations, primarily at around rock outcrops. This is due to 'dead spots' that form around obstacles that reduce current flow thereby allowing objects to settle. Also, the rock outcrops act as obstacles that catch objects as they tumble down the relatively steeply sloping terrain within Area C.

6.5 Summary of maritime heritage sites and items in Area C

The absence of geophysical information for Area C meant that no diving inspection was carried out for this area. There is therefore no map available to display the likelihood of potential maritime heritage sites and items across the area. The likelihood of the presence of maritime heritage site types in Area C is defined in Table 14.

Table 14 Maritime archaeological potential within Area C

Potential	Site type	Known or predicted location
Very likely	Discard from vessels	Across the whole study area, with higher concentrations around rock outcrops
Very unlikely	Maritime infrastructure and associated deposits	Across the whole study area
Unlikely	Shipwrecks and associated deposits	Across the whole study area

7 HERITAGE SIGNIFICANCE

7.1 Introduction

Understanding the cultural heritage significance of a known or potential maritime heritage site is critical in determining an appropriate and proportionate level of mitigation. The significance criteria are detailed below, followed by significance assessments for each of the known maritime heritage sites and potential maritime heritage site types.

7.2 Significance criteria

An assessment of cultural or heritage significance seeks to understand and establish the importance or value that a place, site or item may have to select communities and the general community. The Australian ICOMOS *Charter for the Conservation of Places of Cultural Significance* (the *Burra Charter 1979,* most recently revised in 2013) is the standard adopted by most heritage practitioners in Australia when assessing significance. It defines cultural significance as 'aesthetic, historic, scientific or social value for past, present or future generations' (Australia ICOMOS 1999).

This value may be contained in the fabric of the item, its setting and relationship to other items, the response that the item stimulates in those who value it now, or the meaning of that item to contemporary society.

Accurate assessment of the cultural significance of sites, places and items is an essential component of the NSW heritage assessment and planning process. A clear determination of a site's significance allows informed planning decisions to be made, in addition to ensuring that heritage values are maintained, enhanced, or at least minimally affected by development.

Assessments of significance are made by applying the following standard evaluation criteria provided by the Department of Premier and Cabinet (Heritage) (NSW Heritage Office, 2001) to establish a statement of significance. These criteria are based on the *Burra Charter*:

a. An item is important in the **course or pattern** of NSW's **cultural or natural history** (or the cultural or natural history of the local area)

b. An item has strong or special **associations with** the life or works of **a person, or group of persons, of importance in NSW's cultural or natural history** (or the cultural or natural history of the local area)

c. An item is important in demonstrating **aesthetic characteristics** and/or a high degree of **creative or technical achievement** in NSW (or the local area)

d. An item has strong or special **associations with a particular community or cultural group** in NSW (or the local area) for **social, cultural or spiritual reasons**

e. An item has **potential to yield information** that will contribute to an understanding of NSW's cultural or natural history (or the cultural or natural history of the local area)

f. An item possesses **uncommon, rare or endangered** aspects of NSW's cultural or natural history (or the cultural or natural history of the local area)

g. An item is important in **demonstrating the principal characteristics of a class of NSW's cultural or natural places**; or cultural and natural environments.

In addressing the criteria above, it should be demonstrated whether the site meets the threshold for being of State or Local significance. If it does not meet either threshold it is considered to have minimal significance with respect to that particular criterion. If a site meets the threshold for State significance for at least one the above criteria it is considered to be of State significance.

7.2.1 Historical themes

Historical themes are a way of describing a major force or process which has contributed to our history. Themes provide a context within which the heritage significance of an item can be understood, assessed and compared (NSW Heritage Office and Department of Urban Affairs and Planning, 1996). In the case of this report, historical themes are used to assess the significance of site types by demonstrating how the sites shaped the area in which they are located. This is particularly important as the broad scale of this assessment prevents detailed research into individual items.

Table 15 lists the relevant themes that are used in this assessment, based on the NSW Heritage Council's Historical Themes (Heritage Council of New South Wales, 2001).

Table 15: NSW Historical Themes used in this assessment

Historical Theme	Description	Relevant Examples
9. Environment – natural or modified and shaped	Activities associated with the interactions between humans, human societies and the shaping of their physical surroundings	National park, nature reserve, preservation of open space, place important in arguments for nature or cultural heritage conservation. Could also include seawall
10. Townships	Activities associated with creating, planning and managing urban functions, landscapes and lifestyles in towns, suburbs and villages	Abandoned wharf, village reserve
13. Transport	Activities associated with the moving of people and goods from one place to another, and systems for the provision of such movements	Ferry, wharf, bridge, barge, harbour, shipwreck
15. Utilities	Activities associated with the provision of services, especially on a communal basis	Water pipeline, powerhouse, bridge, culvert
26. Creative endeavour	Activities associated with the production and performance of literary, artistic, architectural and other imaginative or inventive works; and/or associated with the production and expression of cultural phenomena; and/or environments that have inspired such creative activities	Exemplar of an architectural style, bridges, park designs
27. Leisure	Activities associated with recreation and relaxation	Swimming pool, park, beach, clubhouse, fishing spot, picnic place, swimming hole
28. Sport	Activities associated with organised recreational and health promotional activities	Swimming pool
29. Health	Activities associated with preparing and providing medical assistance and/or promoting or maintaining the wellbeing of humans	Landscaped grounds

7.3 Assessment of cultural heritage significance

7.3.1 Cultural heritage significance of known sites

The assessment of the cultural heritage significance of the known maritime heritage sites is presented in Table 16. Where relevant, the assessments for listed sites have been used.

The history and identity of the four known wrecks within Area A and Area B – including the recently sunk 12 metre timber cruiser/yacht (18W-01) – are not currently known. This limits any assessment of their cultural heritage significance. The assessments have been made based on the estimated age of the wrecks and their possible functions. They are currently assessed to be of local significance based on available information. It is possible, though unlikely, that further investigation into these sites may elevate them to State significance.

Items and sites that do not meet the local significance threshold have been assessed to be of Nil significance. These sites and items so assessed will not be further addressed in this study.

Table 16: Cultural heritage significance assessment of known maritime heritage sites

Area	Site	Criterion A (Historical)	Criterion B (Person)	Criterion C (Aesthetic/technical)	Criterion D (Social)	Criterion E (Research)	Criterion F (Rarity)	Criterion G (Representativeness)	Significance level	Themes/sub-themes
A	Clive Park Tidal Pool	The tidal pool was built towards the end of WWII by the Northbridge Volunteer Defence Forces. Local	No known association with well-known person(s). Nil	The pool enclosure does not appear to have any technical merit; however, its rustic appearance and isolated scenic location have considerable visual appeal. Local	Significant for local Willoughby residents as a popular foreshore bushland park. Local	Little new information can be obtained from the study of the remnant pool remains. Nil	Pool reputed to be the smallest tidal pool within the Sydney region. Local	Poorly preserved example of a tidal pool. Nil	Local	27) Leisure/ Swimming, Public parks, Public reserve, Volunteer construction, Park design, Public well-being
A	Harbour foreshores, Seaforth	Seaforth waterfront developed from the early 1900s. Local	The development of Seaforth as a residential area is associated with Henry Halloran. Local	Mixture of timber and sandstone structures as well as natural sandstone outcropping. Local	Contributes to the sense of identity to the residents of Northern Beaches Council LGA. Local	Little new information can be obtained from the study of the private maritime infrastructure in this area other than documenting the phases of development. Nil	Maritime infrastructure associated with residences is common along the foreshore of Middle Harbour. Nil	The Seaforth Bluff foreshore can be considered to typical and not a standout example of residential maritime infrastructure in Middle Harbour. Nil	Local	8) Fishing 27) Leisure 28) Sport,/Sailing, Boating, Swimming
A	Clive Park Unidentified No. 1 shipwreck	Identity of vessel not known, but likely work barge from mid 20th century. Nil	No known association with well-known person(s). Nil	The wreck is of very low relief and has no visually appealing aspects. The build and shape of the hull appears to be unusual but this does not at present indicate any technical merit. Nil	No known association with a particular community. Nil	Further investigation of the hull and its contents would provide more information as to the vessel's historical context. Local.	There is a limited number shipwrecks recorded in NSW and the wrecks of small harbour workboats are under-reported. Local	This is a very poorly preserved example of a mid 20th century work boat. Nil	Local	13) Transport/ shipwreck
A	Middle Harbour Unidentified No. 1 Shipwreck	Nothing is known about this vessel. Wreck event most likely happened in second half of 20th century. Nil	No known association with well-known person(s). Nil	Not assessed as site not inspected.	No known association with a particular community. Nil	Further investigation of the hull and its contents would provide more information as to the vessel's historical context. Local	There is a limited number shipwrecks recorded in NSW and the wrecks of small harbour watercraft are under-reported. Local	Not assessed as site not inspected.	(Likely to be) Local	13) Transport/ shipwreck
A	Concrete pipe, Steel pipe, outboard engine, beer bottles (16W-002, 004, 010)	These are relatively modern objects lost/discarded in recent years. Nil	No known association with well-known person(s). Nil	These objects have no technical or aesthetic merit. Nil	No known association with a particular community. Nil	No new relevant information is likely to be obtained from further study of these objects. Nil	Objects of modern manufacture discarded in Middle Harbour are ubiquitous. Nil	This suite of objects is not a good representative example of material discarded from vessels. Nil	Nil	8) Fishing 27) Leisure/ Boating

Area	Site	Criterion A (Historical)	Criterion B (Person)	Criterion C (Aesthetic/technical)	Criterion D (Social)	Criterion E (Research)	Criterion F (Rarity)	Criterion G (Representativeness)	Significance level	Themes/sub-themes
A	Mooring buoy and timber piles (16W-004, 005, and 008)	These are relatively modern objects discarded in recent years. Nil.	No known association with well-known person(s). Nil	These objects have no technical or aesthetic merit. Nil.	No known association with a particular community. Nil	No new relevant information is likely to be obtained from further study of these objects. Nil.	Remnants of maritime infrastructure of modern manufacture lost in Middle Harbour are common. Nil.	This suite of objects is not a good representative example of remnant maritime infrastructure. Nil.	Nil.	13) Transport/ wharf, moorings
B	Pearl Bay Unidentified No. 1 Shipwreck	Nothing is known about this vessel other than it was a pleasure watercraft. Wreck event most likely happened in second half of 20th century. Nil.	No known association with well-known person(s). Nil	The wreck is a low relief site on a silty bed of the harbour. Visibility is low. Nil.	No known association with a particular community. Nil	Further investigation of the hull and its contents would provide more information as to the vessel's historical context. Local.	There is a limited number shipwrecks recorded in NSW and the wrecks of small recreational watercraft are under-reported. Local	This is a very poorly preserved example of an early to mid 20th century recreational boat. Nil.	Local	8) Fishing 27) Leisure/ Boating,
B	Recent sunken yacht	Nothing is known about this vessel other than it was a pleasure watercraft. May have been converted from a fishing type vessel. Nil.	No known association with well-known person(s). Nil	The wreck is complete and has no aesthetic qualities different from when afloat. Not enough time for marine life to congregate around the wreck. Nil.	No known association with a particular community. Nil	The vessel was wrecked only recently and does not appear to have particularly obsolete or unusual form or construction which would warrant further investigation. Nil.	Though there is a limited number of shipwrecks recorded in NSW and the wrecks of small recreational watercraft are under-reported, vessels sinking at their moorings is very common and they are raised soon after sinking if intact. Nil	This is a very well preserved example of a late 20th century recreational, possibly converted fishing, boat. Nil.	Nil	8) Fishing 27) Leisure/ Boating,
B	Seawall	A relatively modern upgraded seawall which would closely follow the alignment of the original 1930s seawall. Nil	No known association with well-known person(s). Nil	The concrete seawall is faced along most of its length with rock armour. It has little technical or aesthetic merit. Nil.	No known association with a particular community. Nil	This type of seawall has little research significance. Nil.	This type of seawall and associated rock armour is very common within the Sydney region. Nil.	This type of seawall and associated rock armour is not a meritorious example of its type. Nil.	Nil	9) Environment – natural or modified and shaped/seawall

7.3.2 Cultural heritage significance by site type

General statements of cultural significance for potential site types have been prepared in accordance with the principles of the *Burra Charter* (Table 17). The statements incorporate what is known about site types within the three areas of this assessment.

Table 17: Cultural heritage significance assessment of potential maritime heritage sites across areas A, B and C

Site types	Criterion A (Historical)	Criterion B (Person)	Criterion C (Aesthetic/technical)	Criterion D (Social)	Criterion E (Research)	Criterion F (Rarity)	Criterion G (Representativeness)	Significance Level	Themes/sub-themes
Maritime infrastructure (moorings, jetties, slips, pool enclosures) and associated deposits.	Maritime infrastructure within the study area has historic significance for demonstrating the development of leisure activities in the their respective local areas, including sailing, recreational boating, fishing and swimming. Local	No known association with well-known person(s). Nil	The remains of maritime infrastructure would have little technical merit. They would be of the most basic types and forms, as they would have been on a small scale for private use. They would likely have no aesthetic qualities. Nil.	As any remains of maritime infrastructure would be associated with private properties and vessels they would have no significance beyond a small group of individuals who used them. Nil.	It can be expected that, for the majority of remains of maritime infrastructure, little could be learned from their study. However, earlier remains from the 19th century could provide some detail about the development of the area. Nil to Local	Remains of maritime infrastructure are ubiquitous across the Sydney region. Nil	It is very unlikely that the remains of maritime infrastructure within the study area would be a good representative example of its class. Nil.	Local	8) Fishing 10) Townships 27) Leisure 28) Sport/ Boating, Swimming
Shipwrecks	Shipwrecks within the study area would reflect the changing waterborne activities in Middle Harbour, from commercial based fishing, transportation of explosives and recreational boating. Local	No known association with well-known person(s). Nil	Any shipwrecks present within the study area would be of low relief and mostly buried. Coupled with the low visibility in Middle Harbour they would have little aesthetic appeal. Shipwrecks in this area would be expected to be of general construction and display little technical innovation. There is, however, the possibility of the remains of a well-made and technically superior hand crafted timber boat being present in the area. Nil.	No known association with a particular community. Nil	Early (19th to mid 20th century) locally built boats, both commercial and recreational, are rare and the wrecks of such vessels would contribute to our understanding of boat building traditions in the Sydney region. Local	There is a limited number of shipwrecks recorded in NSW and locally built vessels from the 19th and early 20th century, particularly inshore craft like fishing or recreational boats or even work punts and barges, are under-reported. Local	The sandy silt nature of the bed of the harbour in the study area is conducive to the preservation of wrecks; however, the amount of water traffic and associated damage caused by anchors would have a destructive impact on a wreck site. This criterion can only be addressed on a site by site basis.	Local	13) Transport 8) Fishing 27) Leisure /Boating,/work punts, fishing boats

Site types	Criterion A (Historical)	Criterion B (Person)	Criterion C (Aesthetic/technical)	Criterion D (Social)	Criterion E (Research)	Criterion F (Rarity)	Criterion G (Representativeness)	Significance Level	Themes/sub-themes
Discard from vessels	Discard from vessels would reflect the changing habits and material culture of those engaged in waterborne activities in Middle Harbour, particular recreational boating, over time. **Nil**	No known association with well-known person(s). **Nil**	Discard from vessels within the study area would not reach the threshold for Local significance for this criterion. **Nil**	No known association with a particular community. **Nil**	Discard from vessels would generally be of no cultural heritage significance. The exception would unusual items (in character or date of manufacture), which could provide some new understanding of the cultural development of the project area that is not readily available in the historical record. **Nil to Local**	The presence of cultural material on the bed of the harbour within Middle Harbour would be ubiquitous and forms ambient background 'noise' in the underwater landscape. **Nil**	Discard from vessels within the study area would not be a good representative example of its class. **Nil**	**Potentially Local**	13) Transport, 8) Fishing 27) Leisure/ Food and drink, Maintenance, Cargo, Domestic life
Discard in and under reclamation fill.	Reclamation took place in the study area along the western shore of The Spit in the 1930s. Prior to that the area was characterised as intertidal mud flats. **Nil**	No known association with well-known person(s). **Nil**	Discard underneath the reclamation would not reach the threshold for Local significance for this criterion. **Nil.**	No known association with a particular community. **Nil**	The 1930s reclamation has effectively sealed off archaeological deposits formed from the 19th century. Some insight could be obtained from documenting the variety of material culture found under the reclamation. **Nil to Local**	The presence of cultural material on the former bed of the harbour within Middle Harbour would be ubiquitous and forms ambient background 'noise' in the underwater landscape. **Nil**	Discard under and within reclamation in the study area would not be a good representative example of its class. **Nil**	**Potentially Local**	9) Environment 10) Townships 19) Health 35) Persons/ Refuse, Domestic life

7.4 Maritime heritage sensitivity

Maritime heritage *sensitivity* combines maritime heritage *potential* with *significance* and helps to devise appropriate and proportionate mitigation measures. For example, there may be extensive areas with high concentrations of dumped material and these may have high archaeological potential but be of low heritage significance, thereby leading to a grading of low heritage sensitivity. Alternatively, a discrete area such as an early 19th century wreck site could be considered to be of high heritage sensitivity. Definitions of sensitivity used throughout this section are provided in Table 18.

Table 18: Grading of maritime heritage sensitivity

Term	Heritage Sensitivity
High	Site assessed to be of State significance and in good condition
Medium	Site assessed to be State significance in poor or fragmentary condition or of Local significance in poor to good condition or uncommon site type such as a shipwreck
Low	Site of Local significance in very poor or fragmentary condition or isolated object of Local significance
Nil	Cultural material that does not meet the threshold of Local significance

7.4.1 Maritime heritage sensitivity – Area A

Those sites listed on Local Environmental Plans are considered to be of medium sensitivity, as are the two known wrecks (Figure 7-1). These sites are labelled as ‘M’ in Figure 7-1.

Of the four unverified anomalies, three are presently assessed to be of low sensitivity; the assumed small wreck between Seaforth Bluff and Clive Park is very likely to be recent, while two of the magnetic anomalies are likely to be isolated objects of most likely Local significance (see Section 4.4.4). These are marked as ‘L’ in Figure 7-1. The magnetic anomaly downslope to the south-east of the Clive Park Unidentified No. 1 wreck is likely to be associated with that wreck and so is also labelled as ‘M’.

The bed of the harbour within Area A that has been covered by geophysical survey is assessed to have Low heritage sensitivity because while there is archaeological potential for the remains of maritime infrastructure and discarded material to be present, these would in very poor condition/fragmentary condition or would be isolated objects of Local significance.

The bed of the harbour within Area A that was not covered by the geophysical survey is considered to be of Medium heritage sensitivity as it is likely that the remains of a shipwreck may be present.

Items and sites assessed to be of Nil significance have no heritage sensitivity and will not be further addressed in this study.

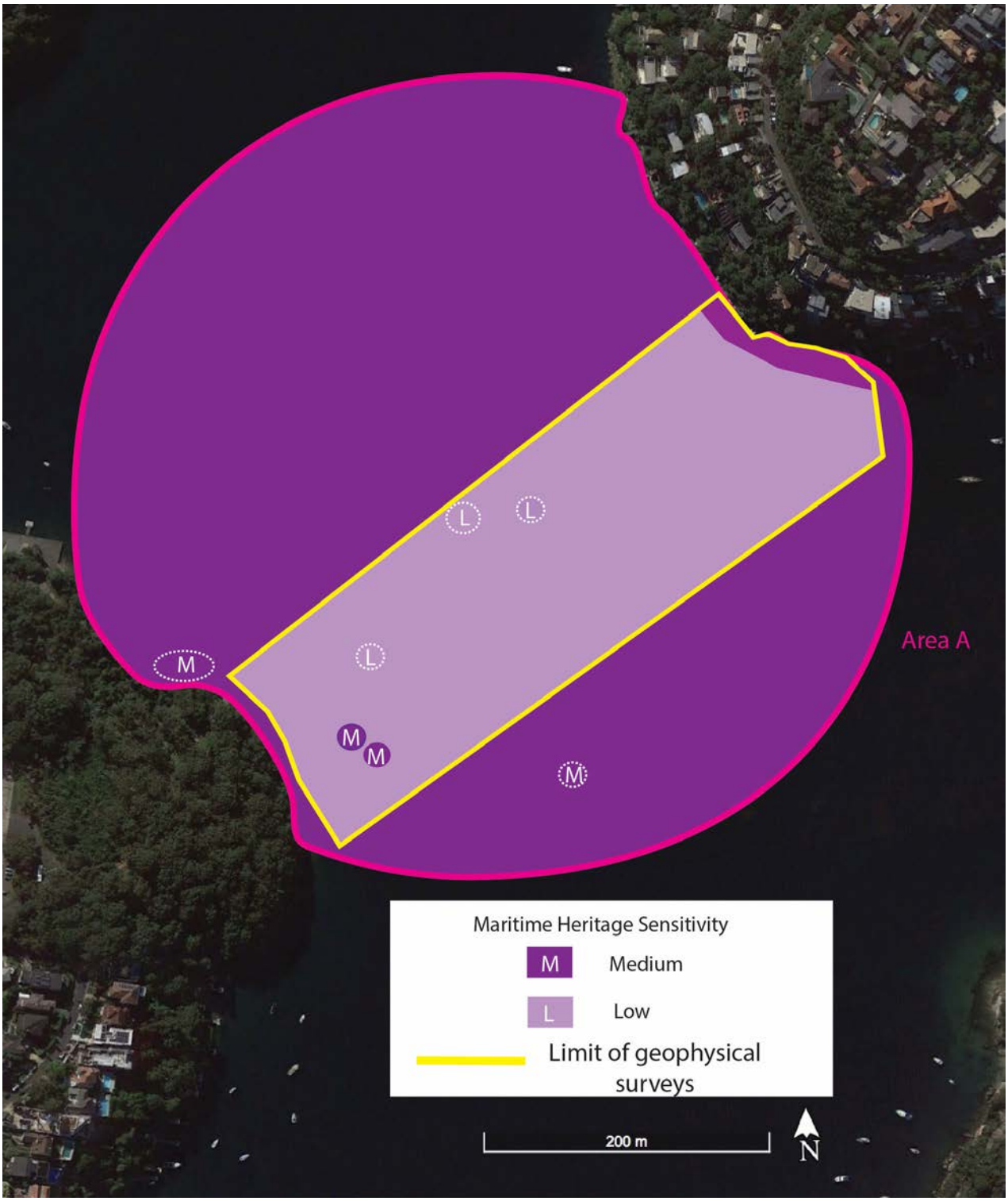


Figure 7-1: Area A – maritime heritage sensitivity

7.4.2 Maritime heritage sensitivity – Area B

Based on available information, the majority of Area B is rated as being of Medium sensitivity (Figure 7-2). This is because there is likely to be one or more wrecks, of the small recreational type, present. Discarded material and disused moorings will form the overwhelming majority of material culture in this area and they can be assessed to be of Nil to Local significance.

The south-east portion of Area B is assessed as being of Low sensitivity. This area was examined by side scan sonar survey and subsequent diving inspection in December 2017, which provides some confidence that the area has been examined carefully for the presence of such sites.

The 'M' inside the low sensitivity zone is Pearl Bay Unidentified No. 1 wreck, which is of Medium sensitivity. The two locations labelled 'L' are side scan sonar anomalies which have been assessed as having Low heritage sensitivity.

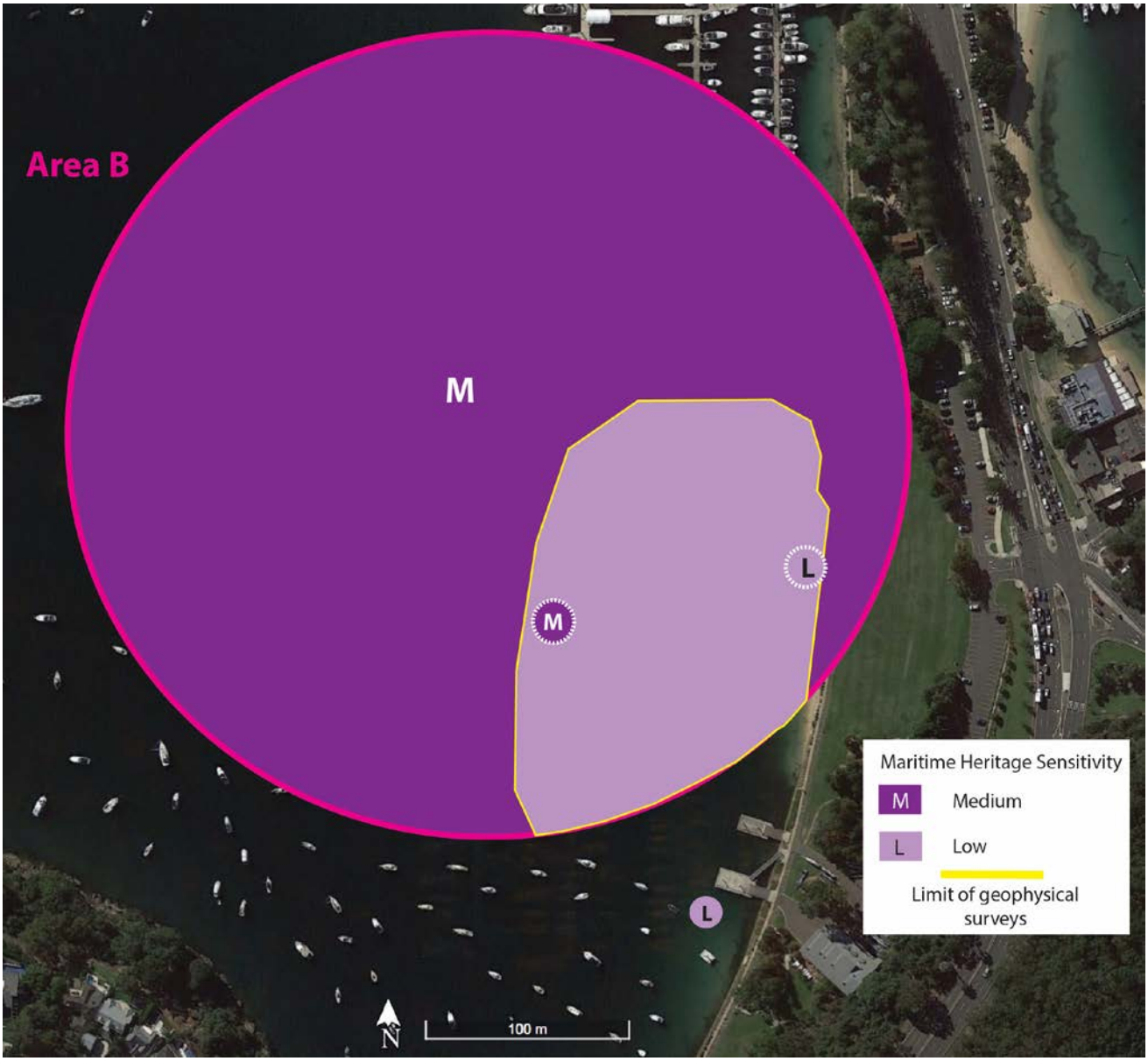


Figure 7-2: Area B – maritime heritage sensitivity

7.4.3 Maritime heritage sensitivity – Area C

Area C is assessed as being of Low sensitivity as it is unlikely that wrecks or remains of maritime infrastructure would be present. Ubiquitous discarded material would be scattered throughout the area.

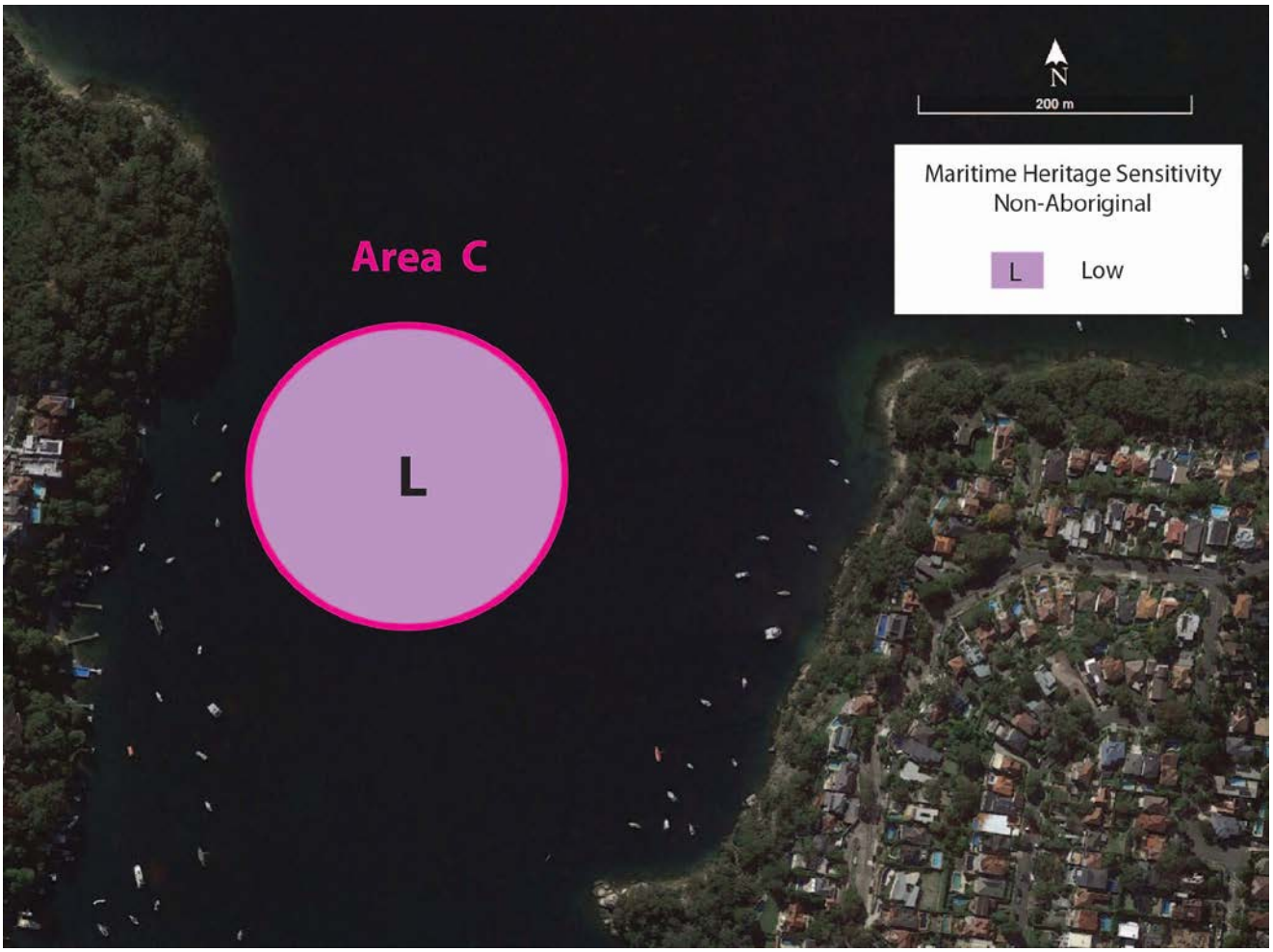


Figure 7-3: Area C – maritime heritage sensitivity

8 IMPACTS ON MARITIME HERITAGE

8.1 Proposed works

All project information detailed in this chapter was obtained from Chapter 5 (project description) and Chapter 6 (Construction work) of the environmental impact statement.

There are three areas where construction activities may impact the bed of the harbour and foreshore:

- Immersed tube tunnel crossing between Northbridge and Seaforth and temporary cofferdams BL 7 and BL 8 used during construction (Area A) Casting facility in Pearl Bay (Spit West Reserve construction support site BL9), on the western side of The Spit (Area B)
- Temporary mooring facility east of Clive Park in Middle Harbour (Area C).

Only those construction activities that could impact all identified areas of known and potential maritime heritage are described in the following sections.

8.1.1 Area A

An immersed tube tunnel, about 340 metres long, is proposed within Area A. Construction activities in Area A would include:

- Construction of two cofferdams (south cofferdam BL7 and north cofferdam BL8)
- Excavation of rock within cofferdams
- Construction of two concrete transition structures to provide a connection between the bored tunnels in work Areas 2 and 4 and the immersed tube tunnel
- Dredging of a trench for the immersed tube tunnel
- Fit out of steel immersed tube tunnel units (these would be fabricated elsewhere and transported by barge)
- Installation of four piled foundations and headstocks
- Installation of immersed tube tunnel units.

The cofferdams would be placed an appropriate distance away from the shoreline at both Northbridge and Seaforth Bluff (Figure 8-1) to avoid impacting these areas.

As described in Chapter 6 of the environmental impact statement, before the construction of the cofferdam can occur, the upper layer of the bed of the harbour would be injected with a permanent grouting material to improve its strength and water-tightness. Ground treatment would be carried out by drilling holes into the bed of the harbour. These holes would then be injected by a grouting machine located on a flat top barge, with either cement or chemical-based grouting.

The cofferdam structure would be made up of a series of interlocking, tubular piles. Each pile would be driven into the underlying sandstone within the areas that were subject to ground treatment. Piling would take place from a flat top barge (or similar barge) using a crane fitted with a hydraulic vibrating hammer, offshore pile driving hammer and/or a similar piece of construction equipment.

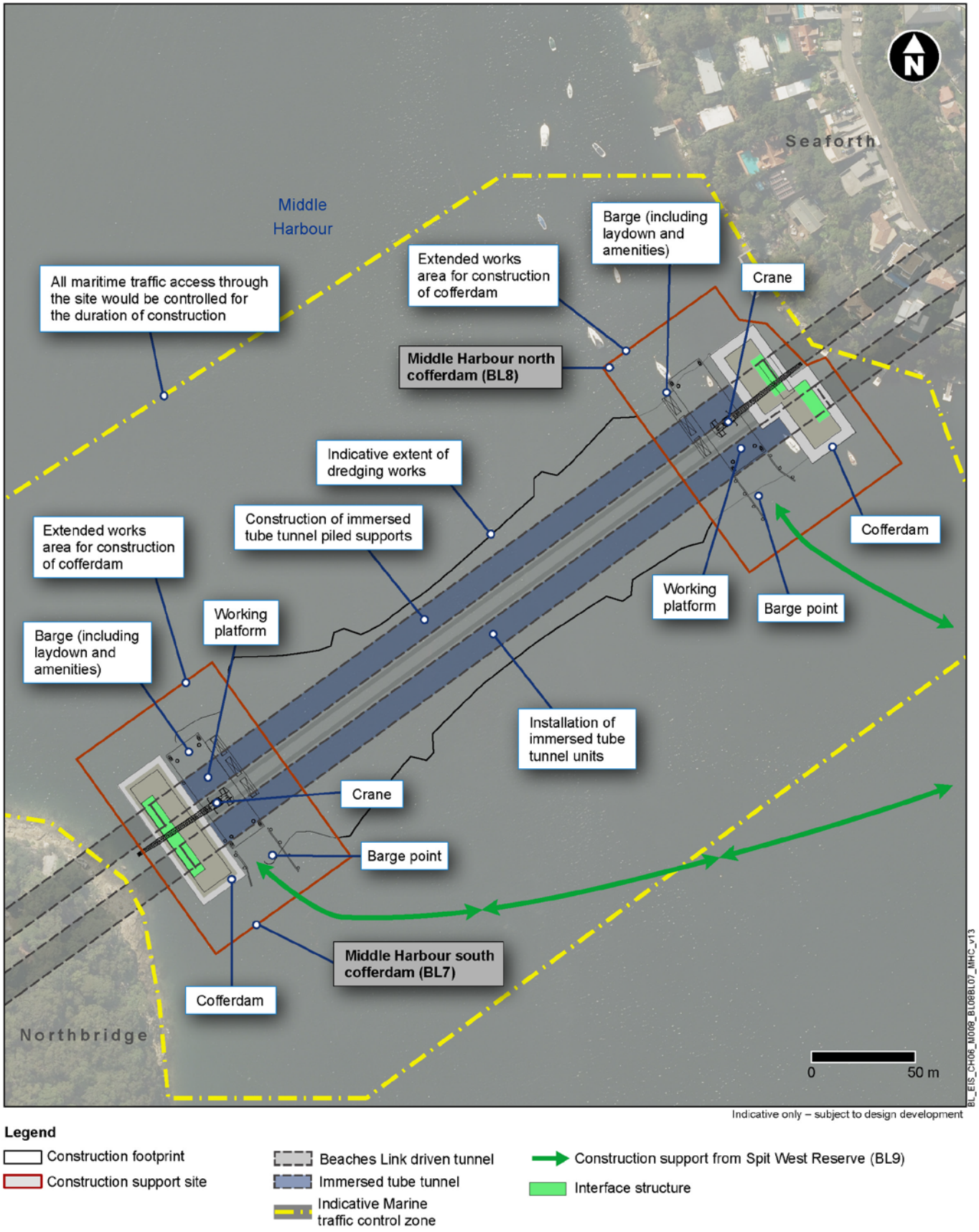


Figure 8-1: Plan showing proposed dredging extent and cofferdams BL7 and BL8

Once all piles have been installed, dewatering of the cofferdam would occur and the water level would be progressively lowered. Structural steel support would be installed within the cofferdams from a flat top barge so the cofferdams remain
structurally sound.

The base of the immersed tube tunnel would be approximately -30 metres AHD (Figure 8-2). As the immersed tube tunnel units would rest on a series of uniformly graded gravel beds, the construction depth of the dredging is likely to be one to two metres deeper than this.

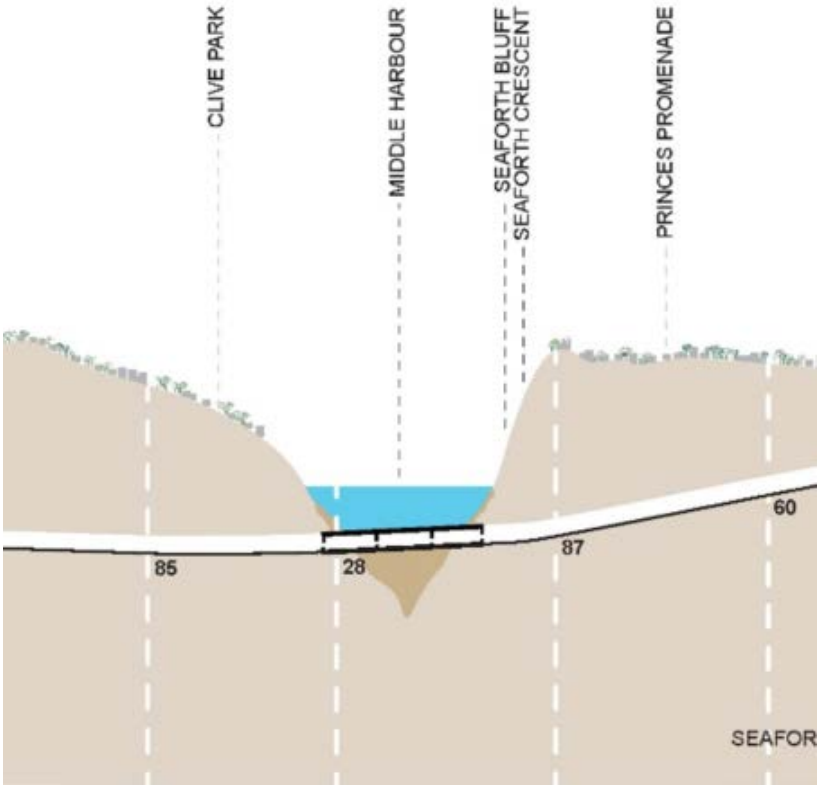


Figure 8-2:Indicative vertical alignment of the mainline tunnel crossing of Middle Harbour.
Note that all measurements are indicative only and in metres to tunnel road surface.

Once all preparations have been finalised, the tunnel element and immersion pontoons would be transported from the temporary mooring facility east of Clive Park in Middle Harbour to the immersion location by tug boats. At the immersion location, the immersion pontoon would be connected to the pre-installed anchors Figure 8-3.

Once the work is completed, the cofferdams would be removed and there would be no visual evidence of the crossing of Middle Harbour above water.

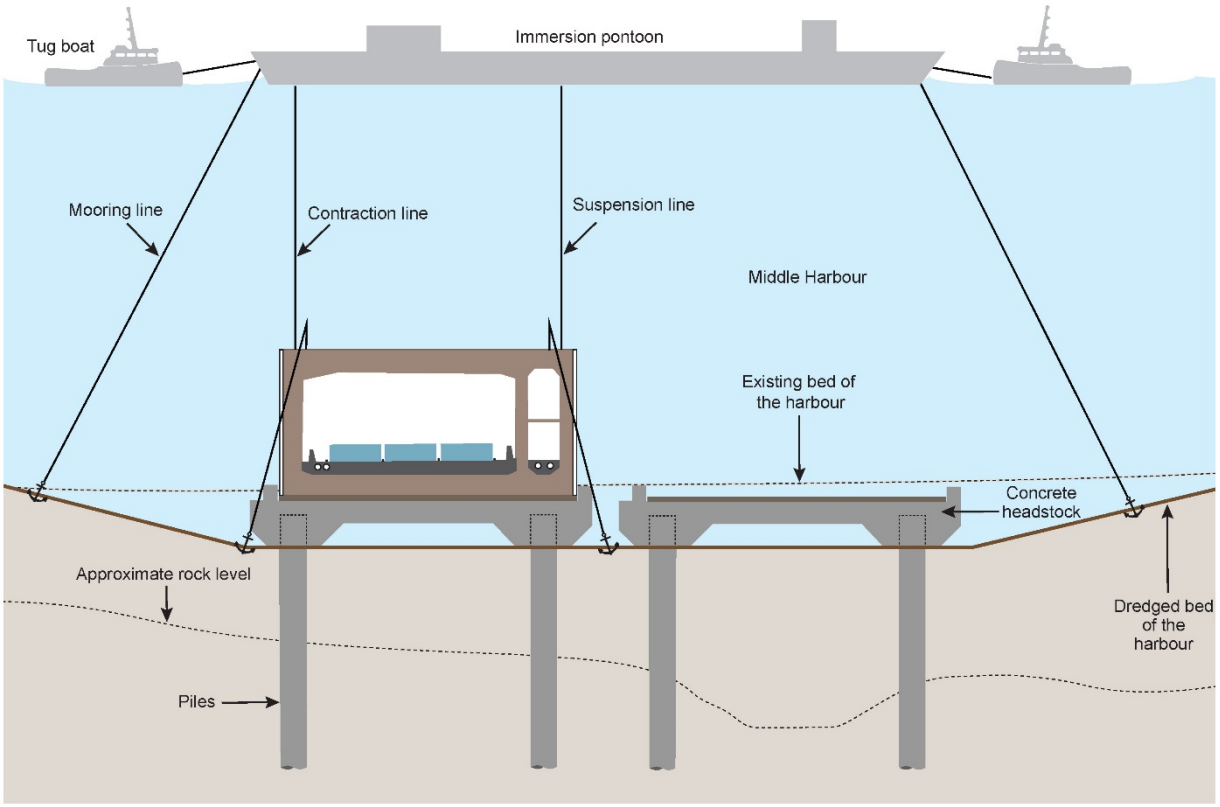


Figure 8-3: Typical immersion configuration – immersion pontoon

8.1.2 Area B

Spit Reserve construction support site (BL9) is located primarily in the water west of Spit West Reserve, with a small adjoining land-based site. The proposed construction works at the site would include a temporary floating immersed tube tunnel casting facility that would be connected to Spit West Reserve by two temporary fixed jetties. The casting facility at the Spit West Reserve within Area B would require piles to be driven for the wharf structure, along with dolphins (which typically consist of a number of piles driven into the marine bed and connected above the water level to provide a platform or fixing point) to steady and tie up the barges (Figure 8-4). It is understood that the wharf and associated facilities would be temporary, and that the Spit West Reserve would be rehabilitated to its original condition after construction is completed.

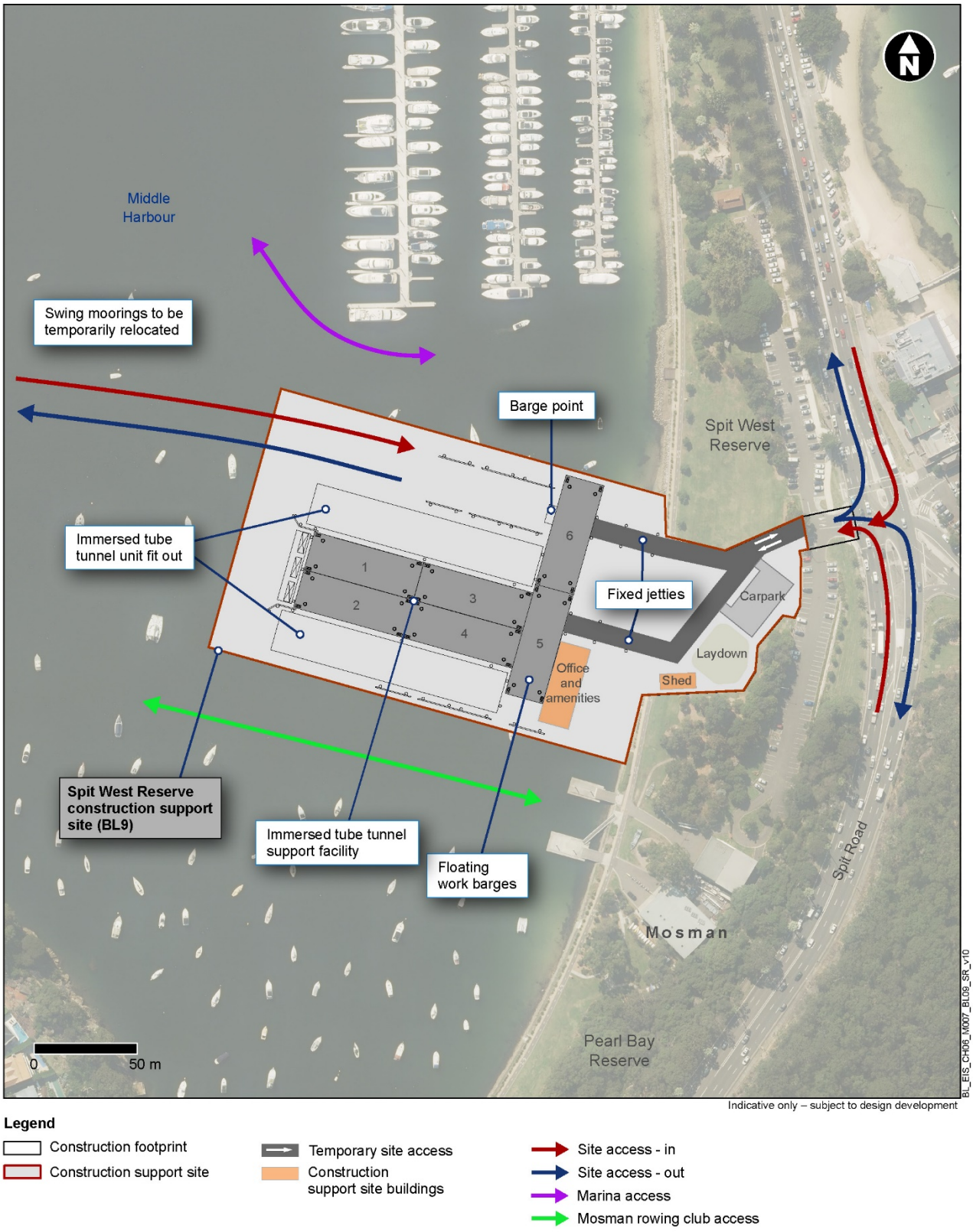


Figure 8-4: Indicative layout – Spit West Reserve construction support site (BL9)

8.1.3 Area C

A temporary mooring facility would be established east of Clive Park in Middle Harbour in Area C to temporarily store constructed elements before they were immersed. About 55 swing moorings would need to be established in an area about 160 metres long and 120 metres wide.

8.2 Alternative design options

Desktop investigations into the potential for maritime heritage in the vicinity of the future crossing of Middle Harbour were completed to inform design development. These investigations did not identify areas

of high heritage sensitivity that would require the consideration of alternative locations or designs for the project. As documented in this report, field work confirmed that no areas of high heritage sensitivity would be impacted by the project.

The immersed tube tunnel construction methodology requires a construction support site (and temporary mooring facility east of Clive Park in Middle Harbour) west of the Spit Bridge to enable the fit-out of the units and to avoid dredging the sand bar at the entrance of Middle Harbour. There is little opportunity to avoid areas of Low to Medium maritime heritage sensitivity in the selection of the construction support site (and temporary mooring facility), given the limited availability of suitable sites close to the project construction footprint at Middle Harbour. A key factor in the design of the construction support site has been to minimise impacts on public open space at the Spit West Reserve, the Mosman Rowers Club and moorings. This has required the site to be predominantly over water. Further detail on alternative design options is provided in Chapter 4 of the environmental impact statement.

8.3 Types of impact

The review of Chapter 6 (Construction) and the identification of known and potential maritime heritage sites has identified a number of potential impacts on the assessed maritime heritage sensitivity within the study area. These impacts can be divided into three broad categories: direct, potential direct and indirect impacts.

Impacts such as altered historical arrangements and access, increased traffic, visual amenity, landscape and vistas, curtilage, subsidence and architectural noise treatment have not been considered in this assessment as they are not relevant to maritime heritage in this study area.

8.3.1 Direct impact

Direct impact is defined as planned, intentional physical change occurring to a maritime heritage site or item from project activities, resulting in the reduction of the cultural heritage values of that heritage site or item. Direct impact may include minor and peripheral changes, or large scale removal, including demolition, archaeological disturbance and the requirement for architectural noise treatment. Direct impacts that may occur to the identified maritime heritage in the study area are described in the following sections.

Dredging and excavation

Dredging and excavation within the cofferdam involves physical removal of the bed of the harbour. This would result in the removal of archaeological remains. This impact can be mitigated by examining and recording cultural material recovered during dredging that may have heritage value.

For this project, a backhoe dredger would be used to break up rock and bring material to the surface to deposit into the skipper vessel for redistribution. It is envisaged that this method could, in the absence of adequate archaeological monitoring procedures, possibly result in the total removal of buried or exposed underwater archaeological sites. This particularly applies to the remains of small vessels, especially if they are of timber construction, and sites consisting mainly of artefact concentrations.

Installation of bed of the harbour structures

The proposed construction would require the installation of structures in the bed of the harbour. These structures could range from single piles (to support the immersed tube tunnel units or for tying up purposes) to continuous tubular piled walls to allow works areas to be de-watered. Impacts would vary according to the size and extent of such structures.

8.3.2 Potential direct impact

Potential direct impact is defined as incidental physical impact and consequences occurring to a maritime heritage site or item from project activities resulting in the reduction of the cultural heritage values of that heritage site or item. Potential direct impacts may include a variety of changes including inappropriate access by vessels, which can be managed or mitigated by appropriate measures. Potential direct impacts that may occur to the identified maritime heritage are described in the following sections.

Anchoring and tilting spuds

Work vessels will be required at times to anchor within the project areas. This anchoring may use anchor/mooring block and chain systems or built-in legs (known as ‘spuds’) which pin the vessel to the

bed of the harbour. Vessel anchors and associated swinging chains can impact underwater archaeological sites by potentially damaging fabric and moving objects around thereby deflating and scrambling a site.

Vessel wake

Work vessels moving to and from the work site and construction facility can generate wakes which could undermine maritime infrastructure and maritime heritage sites in shallow waters, thereby weakening their integrity. Any assessment of the impact of vessel wake on existing maritime infrastructure and shorelines should also consider impacts on cultural heritage sites.

Modelling suggests that marine-based shore wash generated by works would be no greater than current shore wash from present maritime activities. As such, shore wash will not be considered further as it would have no impact upon maritime heritage items. Full details can be found in Technical working paper: Navigation Impact Assessment (RHDHV, 2020) in Annexure A of Technical working paper: Traffic and transport.

Propeller jet scour

Work vessels in shallow waters can create scour trenches, which can impact an underwater archaeological site by exposing a previously buried object to biological, chemical and mechanical impact. These impacts are not confined to dredgers and hopper barges, but also relate to tug vessels which may be picking up and dropping anchors as well as helping manoeuvre larger vessels operating in confined spaces.

Disposal of sediment

The direct impacts associated with the disposal of dredge spoil are outside the scope of this assessment.

8.3.3 Indirect impact

Indirect impact is defined as a secondary impact on a maritime heritage site or item which would reduce the cultural heritage significance of that site or item. The potential for indirect impact varies according to the nature of the heritage item, and its proximity to the project. Indirect impact as it may relate to heritage in general may include vibration, settlement, visual impacts, social impacts, impacts on landscapes and vistas, dust, changes to ongoing use, changed associations or change to access.

Indirect impacts of direct relevance to this study with respects to maritime heritage are described in the following sections.

Sediment erosion and accumulation

Changed conditions on the bed of the harbour may cause sediment disturbance, movement and loss within the vicinity of the dredged areas. This may result in increased exposure of underwater archaeological sites and some previously buried sites may become exposed. Sites buried in stable sediments are protected from damage caused by hydrodynamic processes, marine borers, chemical processes and certain forms of cultural activity.

For littoral sites (close to shore), sediment erosion is likely to be the principal threat. Erosion can remove sediments that have been protecting coastal sites and can directly erode the fabric of the sites themselves. Erosion at the base of cliff lines may also contribute to the destabilisation of the cliffs and potentially be a threat to sites on clifftops as well as those at sea level. As noted below, there is no expected change in sediment dynamics in the area where the tunnel would be located.

The changed conditions on the bed of the harbour may also stimulate sediment accumulation within the vicinity of the dredged areas. The accumulation of sediments around and over underwater archaeological sites is generally seen as a positive impact. However, such accumulation can have a negative aspect by covering sites which renders them invisible and hence more susceptible to accidental damage, as well as inaccessible to the public and researchers.

Hydrodynamic modelling has been carried out to assess the potential operational impacts of the exposed immersed tube tunnels on the hydrodynamics within the study area and in the general vicinity (Royal HaskoningDHV 9 March 2018). There are anticipated small increases in current speeds closer to Seaforth of up to 0.08 m/s and less along the underwater slope rising up to Northbridge (Royal HaskoningDHV 2020). There is no expected change in sediment dynamics in the area where the tunnel would be located (Royal Haskoning DHV 2020).

Vibration

Vibrations from construction work such as piling, dredging and tunnelling can impact the integrity of maritime infrastructure or shipwrecks thereby affecting their cultural heritage significance. Vibrations would have a negligible impact on the cultural heritage significance of archaeological deposits associated with maritime infrastructure, shipwrecks or discard from vessels. This is because the artefacts within the deposits may move from their original position, but not enough to lose any appreciable archaeological context.

The potential impact of vibration from construction activities on the maritime heritage within the study area has been assessed in Technical working paper: Noise and Vibration (Renzo Tonin, 2020).

The report notes that, although heritage structures or items are generally considered on a case by case basis, as a screening test for the purposes of this project all heritage structures are conservatively assumed to be unsound without further investigation being (Technical working paper: Noise and vibration). As such, a vibration level (PPV) of 2.5 mm/s has been adopted as the vibration damage screening level.

This is a conservative approach that will identify heritage items that need further inspection. Any heritage structure or item predicted to exceed the screening level would be investigated, and appropriate vibration criteria for the structure adopted. If a heritage item is found to be structurally unsound (following inspection) the conservative 'cosmetic' damage objective of 2.5 mm/s peak component particle velocity (from DIN 4150) would be considered, and appropriate protections put in place depending on the construction of the heritage item (Technical working paper: Noise and vibration). Cosmetic damage levels for this project are considered 'safe limits' up to which no damage due to vibration effects has been observed for particular building types (Technical working paper: Noise and vibration).

The general approach to manage potential vibration impacts on heritage items would be to:

1. Identify heritage items where the 2.5 mm/s peak component particle velocity objective may be exceeded during specific construction activities
2. Prepare a structural engineering report on identified heritage items, to confirm structural integrity of the building and confirm if item is 'structurally sound'
3. If the item was confirmed as 'structurally sound', adopt the screening criteria from BS7385 Part 2, or
4. If the item was confirmed as 'structurally unsound', adopt the more conservative cosmetic damage objectives of 2.5 mm/s peak component particle velocity (Technical working paper: Noise and vibration).

For this assessment the potential impacts from vibration only apply to Area A. The vibrations caused by piling for the wharf in Area B or the installation of the temporary mooring facility in Area C would be inconsequential to the heritage values of the known and potential maritime heritage in those areas.

Settlement

The proposed driven tunnels that would connect to the IMT units within Area A near Northbridge and Seaforth would pass under the maritime heritage site known as 'Harbour Foreshores (Seaforth)'. The excavation of tunnels below ground stimulates potential settlement at the ground surface within the zone of influence of the tunnel. This can be the result of both stress redistribution in the surrounding ground, and groundwater drawdown around drained tunnels. Settlement modelling for this project for potential impacts to heritage items has been carried out by WSP ARUP (2020).

The WSP ARUP report (2020) states that most of the Western Harbour Tunnel and Beaches Link driven tunnels would be constructed in medium to high strength Hawkesbury Sandstone with a limited thickness of residual soil and fill cover. The majority of the induced settlement along the alignment due to tunnel excavation would therefore be the result of stress redistribution within the rock mass (WSP ARUP, 2020).

For tunnelling projects, predicted impact to structures is assessed according to the level of approximate equivalent ground settlement and trough gradients. The WSP ARUP report (2020) provided a detailed table of criteria commonly used for risk assessments. For the purposes of this assessment an adapted version is presented in Table 19.

Table 19: Summary of damage categories to buildings and structures due to settlement (WSP ARUP 2020: adapted from Table 2).

Max. settlement of building/structure (mm)	Max. slope of ground (angular distortion)	Expected degree of severity	Category of damage	Type of damage
0	0	Negligible	0	Aesthetic
< 10	< 1:500	Very slight	1	Aesthetic
10 to 50	1:500 to 1:200	Slight	2	Aesthetic
50 to 75	1:200 to 1:50	Moderate	3	Serviceability
> 75	1:200 to 1:50	Severe	4	Serviceability
> 75	1:50	Very severe	5	Stability

Buildings and structures assessed as being at 'moderate' risk or higher would require additional assessments to better understand the potential impacts (WSP ARUP 2020).

The initial assessment of buildings, including fixed maritime heritage structures, along the project alignment found that no site reached the 'moderate' threshold that required further assessment (WSP ARUP 2020). The potential impact on individual maritime heritage sites is addressed in Section 8.6.

This study only assessed the potential impacts of settlement on fixed maritime heritage infrastructure because this could have an impact on their structural integrity. For items that are lying on or under the bed of the harbour, ranging in size from an anchor to a shipwreck, the predicted ranges of settlement as they relate to potential impact on heritage values are inconsequential. This is because objects on the bed of the harbour are in a constant state of downwards movements caused by bioturbation and wave action raising sediments into suspension, thereby causing the object to further 'sink' into the sediment. The modelling for this project indicates that the scale of settlement falls within existing conditions for non-fixed maritime heritage.

The WSP ARUP report (2020) recommended a range of management measures before and during construction to ensure that ground movement impacts are managed (WSP ARUP 2020):

- Management of ground settlement to comply with the accepted settlement, angular distortion and limiting tensile strain criteria
- Development of detailed predictive settlement models for areas of concern to guide tunnel design and construction methodology, including the selection of options to minimise settlement where required
- Preparation of building condition surveys for properties within the zone of influence of tunnel settlement (for example within the 5mm predicted surface settlement contour and within 50 metres of surface works)
- Where construction of the project is deemed the cause of cracking or property damage, the damage would be repaired at no cost to the owner
- Establishment of an Independent Property Impact Assessment Panel, comprising geotechnical and engineering experts, before the start of works to independently verify building condition survey reports, resolve any property damage disputes and establish ongoing settlement monitoring requirements
- Preparation of agreements with utility owners and infrastructure owners identifying acceptable limits of settlement, settlement monitoring and actions in the event that settlement limits are exceeded.

Visual Impact

All visual impacts in relation to maritime heritage for this project would be temporary as the cofferdams and temporary wharf would be removed at the completion of the project.

8.4 Approach to assessing impact

For this study there are three components to the assessment of impact:

- Level of impact on a maritime heritage site or item
- Consequence of the impact on the heritage site or item

- Probability of impact on a maritime heritage site or item.

Level of impact

The level of impact on the heritage significance of each heritage item in the study area has been assessed based on the definitions and framework for assessing severity of impacts from the *EPBC Act Significant impact guidelines 1.2* (Department of Sustainability Environment Water Population and Communities 2013). The following criteria were used to assess the level of impact:

- The scale of the proposed works and its impacts
- The intensity of the proposed works and its impacts
- The duration and frequency of the proposed works and its impacts.

The levels of impact used in this study are defined in Table 20. For impacts to meet a certain level they generally need to have two of the three criteria – scale, intensity, duration/frequency – noted in the table. The level of impact assigned to each heritage item is based on the level assessed before the implementation of management or mitigation measures, which are discussed in Chapter 9.

Table 20: Definition of levels of impact

Level of impact	Scale	Intensity	Duration/frequency
Major	Medium – large	Moderate – high	Permanent/irreversible
Moderate	Small – medium	Moderate	Medium – long term
Minor	Small/localised	Low	Short term/reversible

Consequence of impact

The consequence of an impact on a maritime heritage item is a combination of the level of impact and its heritage sensitivity. A Major level of impact on a site or item of Low heritage sensitivity will have a lesser consequence for the maritime heritage resource of NSW than a Major level of impact on a site or item of High heritage sensitivity. For example, dredging could have a Major impact on any maritime heritage site or item within the footprint however if this heritage is assessed to be of Low sensitivity, then the impact could be considered to be Minor. Alternatively, if dredging were to impact a maritime heritage site of High sensitivity, such as a 19th century wreck, then the scale of impact could range from Major or greater depending on whether the site is of State or Local significance.

Table 21 presents a matrix of consequences of the impacts of the proposed works on the heritage values of a site or item.

Table 21: Matrix of consequence of impact on heritage values of a maritime heritage site or item

Level of Impact / Maritime Heritage Sensitivity	Negligible	Minor	Moderate	Major
High	No discernible alterations to existing natural and human processes already impacting on maritime heritage sites.	Detectable impact with maritime heritage values intrinsic to the site remaining largely intact.	Partial reduction in maritime heritage values intrinsic to the site.	Substantial reduction in maritime heritage values intrinsic to the site.
Medium	No discernible alterations to existing natural and human processes already impacting on maritime heritage sites.	Partial reduction in maritime heritage values intrinsic to the site or archaeological deposits.	Substantial reduction in maritime heritage values intrinsic to the site or archaeological deposits.	Complete loss of maritime heritage values intrinsic to the site or archaeological deposits.
Low	No discernible alterations to existing natural and human processes already impacting on maritime heritage sites.	Complete loss of maritime heritage values intrinsic to the site or archaeological deposits.	N/A	N/A

In assessing consequence of impact, The complete loss of maritime heritage values intrinsic to a site of High sensitivity like a well preserved State significant site, would be considered to be an Extreme impact. There are no State significant sites within the study area and such a category therefore does not apply to this study. Any type and level of impact on sites and items assessed to be of Nil significance (see Section 7.3.1) can be considered to have a Negligible impact on their cultural heritage values. These sites and items will not be discussed further in Section 8.6.

Probability of impact

When assessing the potential impacts of a large scale development on maritime or underwater heritage there is always a level of uncertainty that needs to be considered. This is because the understanding of the underwater archaeological/maritime heritage resource is largely reliant on the interpretation of remote sensing data. The limitations of available technologies that obtain such data mean that the presence or absence of underwater maritime heritage sites of significance cannot be stated with complete confidence. In addition, it is difficult to monitor construction activities around underwater sites as the sites themselves are not visible and impacts may not always be noticed at the time they occur. Such uncertainties can be addressed by the design of appropriate mitigation measures to prevent or minimise impacts on known and potential underwater/maritime heritage sites as well as assessing the probability, or risk, of impact.

For example, with regard to the probability of an impact, activities such as dredging would be highly likely to disturb any maritime heritage sites within the footprint of this activity. By contrast, there would be a lower likelihood of the chain of an anchored project vessel potentially damaging a wreck assessed to have maritime heritage significance. The grading system for determining the probability of impact is presented in Table 22.

Table 22: Terms defining probability of impact

Term	Probability
Definite	100%
Highly probable	85–99%
Probable	50–84%
Improbable	25–49%
Highly improbable	1–14%
Almost impossible	< 1%

8.5 Limitations of assessment

As shown in Figure 8-5, the side scan sonar survey did not cover the full extent of the proposed disturbance footprints. As such, no diving inspection for maritime heritage sites could be effectively carried out. This is a limitation of the impact assessment for those areas.

For the area where the crossing of Middle Harbour is proposed, two relatively thin (80 metre by 20 metre) sections of the disturbance footprint were not surveyed. No dredging or piling is proposed in these unsurveyed areas but anchoring is likely. At present it therefore cannot be assessed whether any maritime heritage present would be impacted in these two small areas.

The proposed temporary mooring facility east of Clive Park in Middle Harbour (Area C) was not surveyed. An undefined number of moorings are to be established. At present it therefore cannot be assessed whether any maritime heritage would be impacted.

The side scan sonar survey in Pearl Bay, next to the western side of The Spit, covered the area where direct bed of the harbour impacts would occur due to piling. In the unsurveyed area, no bed of the harbour impacts would occur apart from perhaps the relocation of functioning private moorings, which are not a maritime heritage issue. There would not be any impacts due to propeller jet turbulence, given the deep water the project vessels would traverse in this area.

The mitigation of potential impacts in the unsurveyed areas at the proposed crossing of Middle Harbour (Area A) and temporary mooring faciclity (Area C) are addressed in Chapter 9.

Figure 8-5: Extent of side scan sonar survey in relation to proposed extent of disturbance footprint (Base image: Google Earth; Side scan sonar data provided as .shp files by Adam Podnar, Geotechnical Engineer, Douglas Partners, 5 December 2017)

8.6 Assessed potential impacts on maritime heritage

8.6.1 Area A

The proposed construction activities in Area A that would have or potentially have an impact on maritime heritage sites and items are discussed below under the impact categories of direct, potential direct and indirect.

Direct impacts

Dredging and excavation

The unverified side scan sonar and magnetic anomalies would be impacted by dredging (Figure 8-6 and Table 23). The impact scale has been assessed to be Minor as even though the sites would be removed they have been assessed to be of Low potential heritage sensitivity.

It is probable that dredging and excavation would remove the remains of maritime infrastructure and highly probable that discarded artefacts would be removed. This impact is considered to be Minor.

Given the geophysical surveys that have been carried out in the locations of proposed dredging and excavation, it is highly improbable that the remains of a shipwreck of Medium to High heritage sensitivity would be impacted.

Installation of bed of the harbour structures

It is highly improbable that the installation of piling would impact the remains of potential maritime infrastructure and discarded material, and it is improbable that maritime infrastructure associated with the Manly LEP listed site 'Harbour Foreshores' would be impacted. The impacts on the aforementioned maritime heritage would be considered to be Minor.

Table 23: Assessment of probability and level of direct impacts on known and potential maritime heritage sites in Area A

Site	Sensitivity	Dredging Probability	Dredging Level	Installation Probability	Installation Level
Clive Park Tidal Pool	Medium	None	N/A	None	N/A
'Harbour Foreshores' (Seaforth)	Medium	None	N/A	Improbable	Minor
Clive Park Unid No 1 (16W-03)	Medium	None	N/A	None	N/A
Middle Harbour Unid No. 1 (wreck)	Medium	None	N/A	None	N/A
'Barge' (unverified)	Low	None	N/A	None	N/A
Side scan sonar anomaly 16W - 06	Low	Definite	Minor	None	N/A
Magnetic anomaly 1	Low	Definite	Minor	None	N/A
Magnetic anomaly 2	Low	Definite	Minor	None	N/A
Magnetic anomaly 3	Medium	None	N/A	None	N/A
Potential maritime infrastructure	Low	Probable	Minor	Highly improbable	Minor
Potential shipwrecks	Low	Highly improbable	Moderate	Highly improbable	Minor
Potential discard	Low	Highly probable	Minor	Highly improbable	Minor

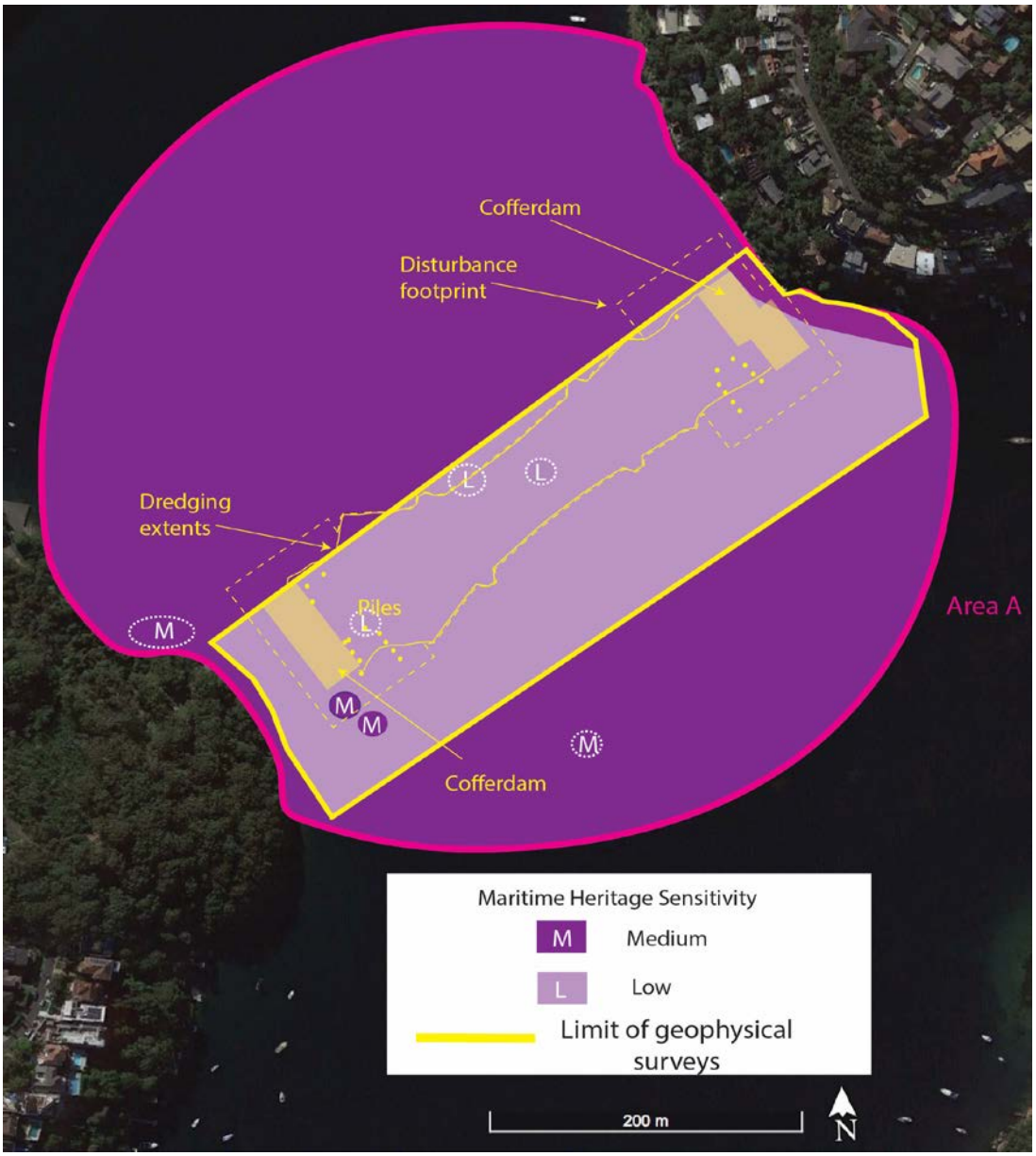


Figure 8-6: Potential impact on maritime heritage sites in Area A (Proposed works outlined in yellow)

Potential direct impacts

Anchoring and tilting spuds

The Clive Park Unidentified No. 1 wreck is located less than 20 metres south of the proposed Clive Park cofferdam (Middle Harbour cofferdam BL7). Because of its proximity to the proposed structure it is highly probable that it would be impacted by anchoring activities during the construction, excavation, operation and dismantling of the cofferdam. Because of the wreck's fragility, any anchor or tilting spud related impacts on the site would have a Moderate impact on its cultural heritage significance. Magnetic anomaly No. 3 is likely associated with the Clive Park Unidentified No. 1 wreck and thus has the same impact assessment.

To mitigate the potential impact on the wreck, a proactive measure has been recommended (see Mitigation Measure D in Section 9.2) to safeguard the likely loss of information resulting from a breakdown of site integrity, in the form of an archival record that would involve limited excavation. The archival recording would have the following objectives or research questions:

- Identifying and recording the extent of the site
- Identifying the type and function of the vessel (which would mean determining its construction)
- Identifying what the vessel was carrying at the time of loss

- Re-assessing the cultural heritage significance of the site.

The purpose of the limited excavation of the site would be to recover and examine its contents. Artefacts recovered from the site would be buried – after analysis – in an approved location nearby.

The option of placing a restricted zone around the site during construction is not considered feasible due to its shallow depth and proximity to the proposed southern cofferdam. From experience, the creation of marine heritage restricted zones close to work sites does not prevent breaches from occurring, as vessels often need to manoeuvre unexpectedly for reasons of safety.

In the very unlikely event that the wreck site is re-assessed as being of State significance the mitigation options for the site would need to be reviewed. Such measures could involve complete archaeological excavation and/or possibly *in situ* burial.

The disturbance footprint extends beyond the limits of area covered by the geophysical survey in two locations (see Figure 8-6). Anchoring is expected to take place within the disturbance footprint. The bed of the harbour outside the area covered by the geophysical surveys has been assessed to be of Medium sensitivity because of the likelihood of shipwrecks being present. However, the potential extent of anchoring within the unsurveyed area is relatively small and it is improbable that a shipwreck would be impacted. Should such an impact occur, the level of impact could be as high as Moderate.

With respect to remains of potential maritime infrastructure and discarded material, any impacts arising from this activity would have a Negligible to Minor impact.

Propeller jet scour

The Clive Park Unidentified No. 1 is at a sufficient depth (between 10 and 15 metres) for it not to be impacted by propeller jet turbulence generated by recreational vessels passing overhead. Project vessels manoeuvring around the proposed Clive Park cofferdam would likely pass over the wreck site. However at lower tides a larger vessel overhead may generate greater and deeper turbulence, which may impact the site. Although the impact could be as high as Moderate, this event is considered improbable. Magnetic anomaly No. 3. which is likely associated with the Clive Park Unidentified No. 1 wreck, is in deeper water and less likely to be impacted.

Potential maritime infrastructure and discarded material in shallow water would probably be impacted by propeller jet turbulence but the impact would be Negligible.

Table 24: Assessment of probability and level of potential direct impacts on known and potential maritime heritage sites in Area A

Site	Sensitivity	Anchoring Probability	Anchoring Level	Propeller jet turbulence Probability	Propeller jet turbulence Level
Clive Park Tidal Pool	Medium	Highly improbable	Minor	N/A	N/A
'Harbour Foreshores' (Seaforth)	Medium	Improbable	Minor	N/A	N/A
Clive Park Unid No 1 (16W-03)	Medium	Highly probable	Moderate	Improbable	Moderate
Middle Harbour Unid No. 1 (wreck)	Medium	N/A	N/A	N/A	N/A
'Barge' (unverified)	Low	N/A	N/A	N/A	N/A
Side scan sonar anomaly 16W - 06	Low	N/A	N/A	N/A	N/A
Magnetic anomaly 1	Low	N/A	N/A	N/A	N/A
Magnetic anomaly 2	Low	N/A	N/A	N/A	N/A
Magnetic anomaly 3	Medium	Highly probable	Moderate	Highly improbable	Moderate
Potential maritime infrastructure	Low	Improbable	Minor	Probable	Negligible
Potential shipwrecks	Low	Highly improbable	Moderate	Highly improbable	Negligible
Potential shipwrecks	Moderate	Improbable	Moderate	Highly improbable	Negligible
Potential discard	Low	Improbable	Negligible	Probable	Negligible

Indirect impacts

Vibration

Technical working paper: Noise and vibration assessed that activity associated with the construction of the cofferdams would reach the threshold for possible cosmetic damage to heritage items, defined as unsound structure, for the 'Harbour Foreshores' site at Seaforth and the Clive Park Tidal Pool. The Clive Park Tidal Pool is a ruin and cosmetic damage caused by vibration may only slightly accelerate the natural processes already affecting an unmaintained, collapsed structure in a marine environment.

Though not directly assessed in the vibrations study the Clive Park Unidentified No.1 wreck is closer to the cofferdam than the Clive Park Tidal Pool and would also be impacted by vibrations (Technical working paper: Noise and vibration). As the site is situated on a sloping sandy bed of the harbour and its structure is badly corroded, vibration would very likely cause a loss of integrity to the structure and/or as a secondary effect from the mobilisation of the bed of the harbour. There is a lesser likelihood that Magnetic Anomaly No. 3, which is likely associated with the Clive Park Unidentified No. 1 wreck, would be affected by vibrations as it is further from the cofferdam.

With respect to remains of potential maritime infrastructure and discarded material, any impacts arising from vibrations would have a negligible impact on the heritage values of these items.

The second vibrations study (Technical working paper: Noise and vibration), which examined the potential impact of vibrations arising from mainline tunnelling, found that no maritime heritage fell with the minimum working distances for cosmetic damage for tunnelling vibration.

Settlement

Settlement and ground movement may cause damage to the maritime heritage components of the Harbour Foreshores (Seaforth) above the driven main alignment tunnel from tunnel excavation. The settlement modelling for this project indicates that the ground settlement levels along the Seaforth foreshore would have a predicted maximum surface settlement of 20-30 mm (WSP ARUP, 2020). As such, the severity of impacts on structures within the heritage item would be 'slight', and aesthetic in character. The potential impact on the maritime heritage values of this site would be Minor at most.

Visual impacts

Temporary visual impact may occur due to the size, form and scale of the proposed works, including the installation of the two cofferdams within Area A. The impacts on the aesthetic values of the Clive Park Tidal Pool site and the 'Harbour Foreshores' site at Seaforth would be considerable during works. The aesthetic significance of these items is Local, and it is assessed that the temporary visual impacts on the heritage values of these sites would be Minor. No underwater maritime heritage site or item would be visually impacted by the proposed works.

Table 25: Assessment of probability and level of indirect impacts on known and potential maritime heritage sites in Area A

Site	Sensitivity	Vibration Probability	Vibration Level	Visual impact Probability	Visual impact Level
Clive Park Tidal Pool	Medium	Highly probable	Negligible	Definite	Minor
'Harbour foreshores' (Seaforth)	Medium	Highly probable	Negligible	Definite	Minor
Clive Park Unid No 1 (16W-03)	Medium	Highly probable	Moderate	None	N/A
Middle Harbour Unid No. 1 (wreck)	Medium	Highly improbable	Negligible	None	N/A
'Barge' (unverified)	Low	Highly improbable	Negligible	None	N/A
Side Scan Sonar anomaly 16W - 06	Low	Highly improbable	Negligible	None	N/A
Magnetic anomaly 1	Low	Highly improbable	Negligible	None	N/A
Magnetic anomaly 2	Low	Highly improbable	Negligible	None	N/A
Magnetic anomaly 3	Medium	Highly probable	Moderate	None	N/A
Potential maritime infrastructure	Low	Probable	Negligible	None	N/A
Potential shipwrecks	Low Moderate	Probable	Negligible	None	N/A
Potential discard	Low	Probable	Negligible	None	N/A

8.6.2 Area B

The proposed construction activities in Area B that would have an impact on maritime heritage sites and items are discussed under the direct, potential direct and indirect categories.

Direct impacts

Installation of bed of the harbour structures

It is highly improbable that the installation of piling within the area covered by the geophysical survey would impact on any potential shipwrecks (Table 26). The probability of impact increases with the westernmost cluster of proposed piles (Figure 8-7). Proposed piling would take place close to Pearl Bay Unidentified No. 1, but is not expected to impact the wreck.

Potential direct impacts

Anchoring and tilting spuds

There is a possibility that Pearl Bay Unidentified No. 1 may be impacted by anchoring during the construction, operation and removal of the wharf.

With respect to remains of potential maritime infrastructure and discarded material, any impacts arising from this activity would have a Negligible to Minor impact.

Propeller jet scour

Pearl Bay Unidentified No. 1 wreck is at a depth of at 20 metres below Australian Height Datum, which would render it immune to the effects of propeller jet turbulence created by the vessels working above it. Potential maritime infrastructure and discarded material in shallow water would be probably be impacted by propeller jet turbulence but the impact would be Negligible.

Indirect impacts

Visual impacts

All maritime heritage areas and items of heritage sensitivity (Low and Medium) in Area B are underwater and would not be visually impacted by the proposed works.

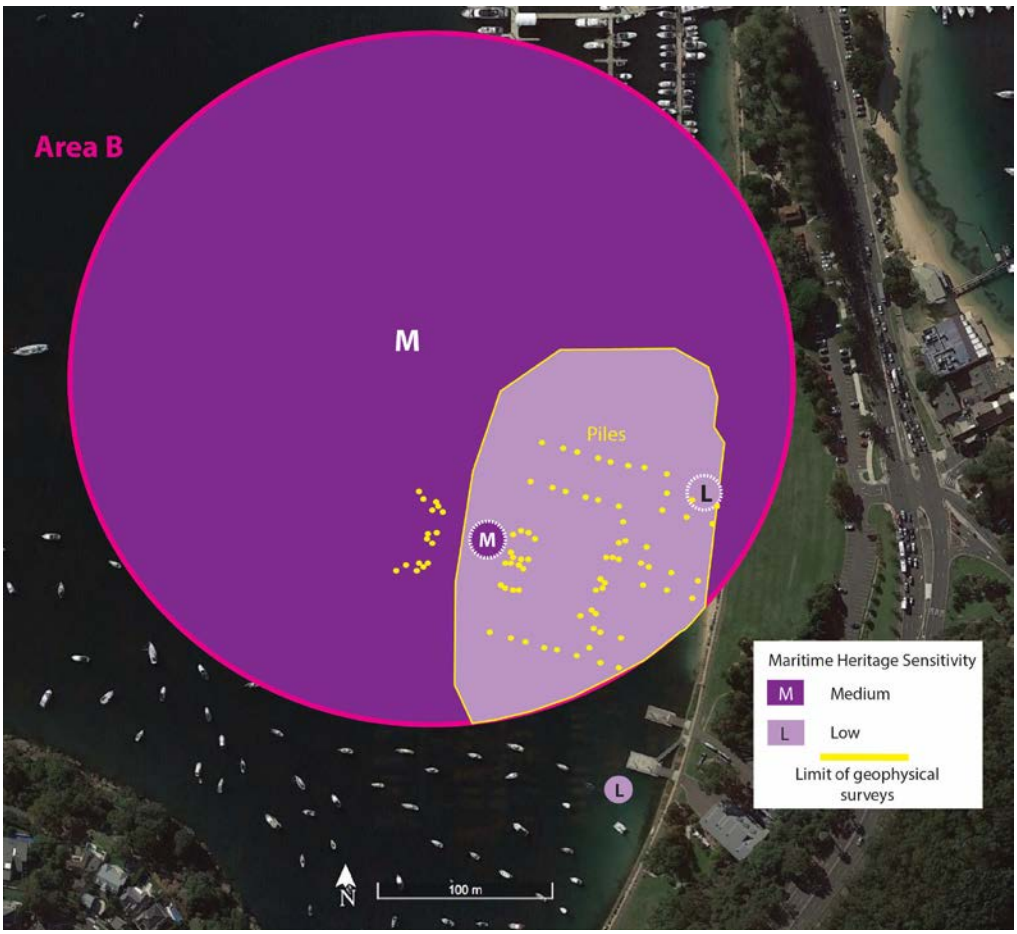


Figure 8-7: Potential impacts on maritime heritage in Area B (Proposed works in yellow)

Table 26: Assessment of probability and level of impacts on known and potential maritime heritage sites in Area B

Site	Sensitivity	Installation Probability	Installation Level	Anchoring Probability	Anchoring Level	Propeller jet turbulence Probability	Propeller jet turbulence Level
Pearl Bay Unidentified No. 1 (18W-01)	Medium	Improbable	Moderate	Improbable	Moderate	None	N/A
Side scan sonar anomaly 18W-02	Low	Improbable	Minor	Improbable	Minor	Probable	Minor
Side scan sonar anomaly 18W-03	Low	N/A	N/A	N/A	N/A	N/A	N/A
Potential maritime infrastructure	Low	Improbable	Minor	Improbable	Minor	Improbable	Minor
Potential shipwrecks	Low	Highly Improbable	Moderate	Highly Improbable	Moderate	Highly Improbable	Minor
Potential shipwrecks	Medium	Improbable	Moderate	Highly Improbable	Moderate	None	N/A
Potential discard	Low	Improbable	Minor	Improbable	Minor	Improbable	Minor

8.6.3 Area C

The proposed construction activities in Area C are limited to the installation of the temporary mooring facility, and as such only the direct impact category will be addressed.

It is improbable that the installation of the temporary mooring facility would impact a shipwreck or discards from a vessel. However, the consequences of impacting a shipwreck could be Moderate. It is less likely the remains of maritime infrastructure would be impacted, with the consequences of such impacts being Negligible to Minor.

Table 27: Assessment of potential impacts on potential maritime heritage sites in Area C

Site	Sensitivity	Anchoring Probability	Anchoring Level
Potential maritime infrastructure	Low	Highly Improbable	Minor
Potential shipwrecks	Low	Improbable	Moderate
Potential discard	Low	Improbable	Minor

8.6.4 Cumulative impacts

Cumulative impacts on the cultural heritage resource may be defined as impacts that result from incremental changes caused by past, present or reasonably foreseeable actions to which the project makes a contribution. Consideration of such impacts generally relies on a comprehensive understanding of the resource or baseline data against which to measure change. In the case of cultural heritage, an understanding of the entire inventory of items of cultural heritage significance within a particular locality, state or nation is not realistic. This is due in part to the framework for the heritage listing of items tending to be an *ad hoc* process, predominantly driven by development pressures and community concerns, rather than a systematic or strategic approach to recognising significant places in an area. Additionally, examining the cumulative impact of previous development is difficult as there is no comprehensive data on these impacts, and no readily accessible data on earlier baselines of the cultural heritage resource prior to other developments. Because of these limitations, the discussion in this current assessment is focused on the impacts of the project on the current known maritime heritage resource, particularly those resources where project impacts, unmitigated, are potentially Moderate.

This assessment also considers that sub-surface bed of the harbour impacts in NSW tend to be localised either in the form of piling or trenching for services. Dredging tends to take place in areas that have been

previously dredged and hence the cumulative impacts on maritime heritage are limited and localised. Development projects of this kind, involving extensive capital dredging, have become rare in recent decades in Sydney and across NSW. There are two comparable projects, both in the early 1990s: the excavation for the Sydney Harbour Tunnel and the Parramatta River Project to extend the ferry service to Parramatta. Both projects involved maritime archaeological input in the form of survey, excavation and monitoring (Atkinson 1988, Wolfe n.d). During the assessment phase these projects did not record any previously unidentified shipwrecks however through dredging the Parramatta River Project recovered a considerable amount of cultural material associated with historically significant sites along the Parramatta River (Bower & Staniforth 1992).

Even without mitigation, the level of potential impacts on the majority of maritime heritage identified in this assessment would be Negligible or Minor. The risk of such impacts has been further minimised in the mitigation measures presented in Chapter 9.

8.6.5 Summary of potential impacts

Item name	Listing	Impact type	Impact rating
Known heritage items			
Clive Park Tidal Pool	*Willoughby Local Environmental Plan 2012*	Direct impacts: No planned direct physical impact Potential direct impacts: There is potential, though highly improbable, for the site to be physically impacted from anchoring by project vessels. Indirect impacts: • The site will potentially be impacted by vibrations arising from the construction of the nearby cofferdam • The site would definitely be temporarily visually impacted by the presence of the nearby cofferdam.	The identified impacts arising out of proposed works would result at most in a partial reduction in maritime heritage values intrinsic to the site through physical loss of integrity. As such the resultant level of impact would be Minor. With respect to visual impacts the effects would be temporary. The potential level of impact can be further reduced or prevented by implementing Mitigation Measures A, C and E as described in Section 9.2.
'Harbour Foreshores' (Seaforth)	*Manly Local Environmental Plan 2013*	Direct impacts: No planned direct physical impact though there is potential, considered improbable, impact from the installation of the cofferdam. Potential direct impacts: There is potential, though improbable, that the site would be physically impacted from anchoring by project vessels. Indirect impacts: • The site will potentially be impacted by vibrations arising from the construction of the cofferdam • The site would definitely be temporarily visually impacted by the presence of the cofferdam.	The identified potential impacts arising out of proposed works for the most part would result at most in a partial reduction in maritime heritage values intrinsic to the site through physical loss of integrity. As such the resultant level of impact would be Minor. With respect to visual impacts the effects would be temporary. The potential level of impacts can be further reduced or prevented by implementing Mitigation Measure G as described in Section 9.2.
Clive Park Unidentified Shipwreck No 1	Unlisted	Direct impacts: No planned direct physical impact. Potential direct impacts: • It is highly probable that the site would be physically impacted from anchoring by project vessels • There is potential, though improbable, that the wreck would be impacted by propeller jet turbulence. Indirect impacts: It is highly probable that the site would be impacted by vibrations arising from the construction of the cofferdam.	The identified potential impacts arising out of proposed works could result in a substantial reduction in maritime heritage values intrinsic to the site through loss to site integrity. As such the resultant level of impact if left unmitigated would be Moderate. The potential level of impact can be reduced to Minor by implementing Mitigation Measures A, D and E as described in Section 9.2. The aim of these measures is to safeguard archaeological information from this site by detailed investigation prior to any construction taking place.

Item name	Listing	Impact type	Impact rating
Middle Harbour Unidentified Shipwreck No. 1	Unlisted	Direct impacts: No planned direct physical impact. Potential direct impacts: No anticipated potential direct physical impact. Indirect impacts: It is highly improbable that the site would be impacted by vibrations arising from the construction of the cofferdam.	The assessed level of impact to this site would be **Negligible** as it is expected that there would be no discernible alterations to existing natural and human processes already impacting on the site.
Concrete pipe (Target 16W-002)	Unlisted	Direct impacts: N/A Potential direct impacts: N/A Indirect impacts: N/A	Item assessed to be of Nil cultural heritage significance (see Section 7.3.1 and Table 15) and as such any impacts to this item would have a Negligible impact on its cultural heritage values.
Timber pile, outboard engine and steel pipe (Target 16W-004)	Unlisted	Direct impacts: N/A Potential direct impacts: N/A Indirect impacts: N/A	Items assessed to be of Nil cultural heritage significance (see Section 7.3.1 and Table 15) and as such any impacts to these items would have a Negligible impact on its cultural heritage values.
Mooring buoy (Target 16W-005)	Unlisted	Direct impacts: N/A Potential direct impacts: N/A Indirect impacts: N/A	Item assessed to be of Nil cultural heritage significance (see Section 7.3.1 and Table 15) and as such any impacts to this item would have a Negligible impact on its cultural heritage values.
Timber pile (Target 16W-008)	Unlisted	Direct impacts: N/A Potential direct impacts: N/A Indirect impacts: N/A	Item assessed to be of Nil cultural heritage significance (see Section 7.3.1 and Table 15) and as such any impacts to this item would have a Negligible impact on its cultural heritage values.
Glass beer bottles (Target 16W-010)	Unlisted	Direct impacts: N/A Potential direct impacts: N/A Indirect impacts: N/A	Items assessed to be of Nil cultural heritage significance (see Section 7.3.1 and Table 15) and as such any impacts to these items would have a Negligible impact on its cultural heritage values.
Pearl Bay Unidentified No. 1 Shipwreck (Target 18W-01)	Unlisted	Direct impacts: It is improbable that the site would be physically impacted from piling for the temporary wharf. Potential direct impacts: It is improbable that the site would be physically impacted from anchoring by project vessels Indirect impacts: There are no anticipated indirect impacts to this site.	The identified potential impacts arising out of proposed works could result in a substantial reduction in maritime heritage values intrinsic to the site through loss to site integrity. Though the likelihood of the identified potential impacts occurring can be considered improbable the level of such impacts could be **Moderate**. The potential level of impacts **could be reduced to Minor** by implementing Mitigation Measures A, C and D as described in Section 9.2. The twin aims of these measures is to take steps to avoid impact and obtain archaeological information from this site prior to any construction in the event that accidental impact occurs.
Wreck of recently sunk yacht	Unlisted	Direct impacts: N/A Potential direct impacts: N/A Indirect impacts: N/A	Item assessed to be of Nil cultural heritage significance (see Section 7.3.1 and Table 15) and as such any impacts to this item would have a Negligible impact on its cultural heritage values.
Seawall	Unlisted	Direct impacts: N/A Potential direct impacts: N/A Indirect impacts: N/A	Item assessed to be of Nil cultural heritage significance (see Section 7.3.1 and Table 15) and as such any impacts to this item would have a Negligible impact on its cultural heritage values.
Potential heritage items			

Item name	Listing	Impact type	Impact rating
'Barge'	Unlisted	Direct impacts: No planned direct physical impact Potential direct impacts: No anticipated potential direct physical impact Indirect impacts: It is highly improbable that the site would be impacted by vibrations arising from the construction of the cofferdam.	The assessed level of impact to this site would be **Negligible** as it is expected that there would be no discernible alterations to existing natural and human processes already impacting on the site.
Side Scan Sonar anomaly 16W-06	Unlisted	Direct impacts: This anomaly would be impacted by dredging Potential direct impacts: N/A Indirect impacts: N/A	This anomaly is expected to be of low heritage sensitivity and its full removal resulting in the complete loss of its intrinsic heritage values can be considered to be a **Minor** impact. The implementation of Mitigation Measures A and B as described in Section 9.2 would ensure that the potential impact **remains at Minor**.
Mag anomaly 1	Unlisted	Direct impacts: This anomaly would be impacted by dredging Potential direct impacts: N/A Indirect impacts: N/A	This anomaly is expected to be of low heritage sensitivity and its full removal resulting in the complete loss of its intrinsic heritage values can be considered to be a **Minor** impact. The implementation of Mitigation Measures A and B as described in Section 9.2 would ensure that the potential impact **remains at Minor**.
Mag anomaly 2	Unlisted	Direct impacts: This anomaly would be impacted by dredging Potential direct impacts: N/A Indirect impacts: N/A	This anomaly is expected to be of low heritage sensitivity and its full removal resulting in the complete loss of its intrinsic heritage values can be considered to be a **Minor** impact. The implementation of Mitigation Measures A and B as described in Section 9.2 would ensure that the potential impact **remains at Minor**.
Mag anomaly 3	Unlisted	Direct impacts: No planned direct physical impact. Potential direct impacts: • It is highly probable that the anomaly would be physically impacted from anchoring by project vessels • There is potential, though highly improbable, that the anomaly would be impacted by propeller jet turbulence Indirect impacts: It is highly probable that the anomaly would be impacted by vibrations arising from the construction of the cofferdam.	The identified potential impacts arising out of proposed works could result in a substantial reduction in maritime heritage values intrinsic to the anomaly, suspected to be associated with the Clive Park Unidentified Shipwreck No 1, through loss to site integrity. As such the resultant level of impact if left **unmitigated would be Moderate**. The potential level of impact **can be reduced to Minor** by implementing Mitigation Measures A, D and E as described in Section 9.2. The aim of these measures is to safeguard archaeological information from this site by detailed investigation prior to any construction taking place.
Side Scan Sonar anomaly 18W-002	Unlisted	Direct impacts: It is improbable that the anomaly would be physically impacted from piling for the wharf. Potential direct impacts: • It is improbable that the anomaly would be physically impacted from anchoring by project vessels • It is probable that the anomaly would be physically impacted from propeller jet turbulence created by project vessels Indirect impacts: There are no anticipated indirect impacts to this site.	The identified potential impacts arising out of proposed works could result for the most part in a partial reduction in maritime heritage values intrinsic to the site through physical loss of integrity. As such the resultant level of impact would be **Minor**. The potential level of impact can be further reduced or prevented by implementing Mitigation Measure A as described in Section 9.2.

Item name	Listing	Impact type	Impact rating
Side Scan Sonar anomaly 18W-003	Unlisted	Direct impacts: No planned direct physical impact Potential direct impacts: No anticipated potential direct physical impact Indirect impacts: No anticipated potential indirect impact	There are no anticipated impacts to this anomaly. The level of any unexpected impacts can be reduced or prevented by implementing Mitigation Measure A as described in Section 9.2.
Potential archaeological remains			
Potential archaeological sites in Middle Harbour between Northbridge and Seaforth (Area A)	Unlisted	Direct impacts: There is potential impact from dredging with lesser potential from installation of the cofferdams. Potential direct impacts: • It is improbable that potential archaeological remains would be physically impacted from anchoring by project vessels • It is probable that potential archaeological remains would be impacted by propeller jet turbulence Indirect impacts: It is probable that potential archaeological remains would be impacted by vibrations arising from the construction of the cofferdam.	The identified potential impacts arising out of proposed works the bulk of potential archaeological remains could result at most in a partial reduction in maritime heritage values intrinsic to the item/site through physical loss of integrity and as such would be considered a Minor impact. There is a much lesser likelihood for undiscovered shipwrecks to be affected however the unmitigated impact to such sites could be Moderate. The potential level of impact can be reduced to and/or retained at Minor by implementing Mitigation Measure A, B and F as described in Section 9.2.
Potential archaeological sites in Middle Harbour and Pearl Bay, west of The Spit (Area B)	Unlisted	Direct impacts: It is improbable that archaeological remains would be impacted by piling for the wharf. Potential direct impacts: • It is improbable that potential archaeological remains would be physically impacted from anchoring by project vessels • It is improbable that potential archaeological remains would be impacted by propeller jet turbulence Indirect impacts: No anticipated potential indirect impact	The identified potential impacts arising out of proposed works the bulk of potential archaeological remains could result at most in a partial reduction in maritime heritage values intrinsic to the item/site through physical loss of integrity and as such would be considered a Minor impact. There is a much lesser likelihood for undiscovered shipwrecks to be affected however the unmitigated impact to such sites could be Moderate. The potential level of impact can be reduced to and/or retained at Minor by implementing Mitigation Measure A and F as described in Section 9.2.
Potential archaeological sites in Middle Harbour between Northbridge and Beauty Point (Area C)	Unlisted	Direct impacts: No planned direct impact Potential direct impacts: It is improbable that potential archaeological remains would be physically impacted from anchoring by project vessels Indirect impacts: No anticipated potential indirect impact	The identified potential impacts arising out of proposed works the bulk of potential archaeological remains could result at most in a partial reduction in maritime heritage values intrinsic to the item/site through physical loss of integrity and as such would be considered a Minor impact. There is a much lesser likelihood for undiscovered shipwrecks to be affected however the unmitigated impact to such sites could be Moderate. The potential level of impact can be reduced to and/or retained at Minor by implementing Mitigation Measures A and B which are described in Section 9.2.

8.7 Comparative analysis

Condition 2e of the SEARs requires the provision of *a comparative analysis to inform the rarity and representative value of any heritage places proposed for demolition*. No known heritage places, sites or items are proposed to be demolished in the study area.

There is a reasonable probability that during the course of dredging and excavation within Area A, the remains of maritime infrastructure (such as collapsed piles and the occasional mooring, as well as items discarded from vessels) would be removed from their context. These classes or types of maritime heritage have been assessed to be of Low heritage sensitivity, due to in large part to their ubiquitous nature within

Sydney's underwater cultural landscape as well as the relatively unremarkable historical associations with the study area. These types of maritime heritage are neither rare nor representative of their type. As such, a comparative analysis for the potential loss of these maritime heritage remains is not required.

9 MANAGEMENT

9.1 Introduction

Appropriate forms of mitigation are presented in this chapter based on the consideration of a number of factors such as:

- Relevant heritage policies (refer Section 3.4)
- Best practice
- Consultant experience in forming and implementing mitigation measures in a marine environment.

The underlying principle in safeguarding the cultural heritage significance of maritime heritage is to avoid or minimise any impacts (immediate or long-term) on a site. This approach is refined depending on the level of cultural heritage significance of an item or site, the risk of impact and the scale of impact. The scale or consequence of impact relates to the degree of loss (immediate or gradual) of cultural heritage significance.

Generally, the selection of an appropriate mitigation measure for a site follows the principles set out below:

- For sites of High significance, if impacts are assessed to be Moderate or higher, the appropriate mitigation measure would be to avoid the site. This could require re-designing a project element
- For sites of Medium significance, where there is a reasonably high probability that the impacts would be Moderate, some form of archaeological recording may be a more appropriate form of mitigation, whether through survey or excavation. Such recording would reduce the impact by saving information about the site that would otherwise be lost.
- For sites or items of Low significance, or for which the probability of impact is Low, some form of sampling or monitoring protocol during construction would be an appropriate form of mitigation.

9.2 Proposed mitigation measures

Mitigation measure A – Prepare a Maritime Heritage Management Plan

A Maritime Heritage Management Plan that details the objectives and methodologies to conserve maritime heritage and mitigate impacts should be prepared by a qualified and experienced maritime archaeologist. The Maritime Heritage Management Plan should specify:

- Unexpected finds protocols relevant to each type of activity such as dredging or piling
- Artefact management procedures, including identification of approved submerged reburial locations
- Relevant work method requirements and maritime heritage inductions tailored for each type of work activity such as dredging or piling
- Restricted zones, archival, baseline and periodic monitoring protocols for Clive Park Tidal Pool, Clive Park Unidentified No. 1 wreck and Pearl Bay Unidentified No. 1 wreck before and during construction, including a final site inspection within three months of completion of works
- An archaeological research design to guide the investigation of Clive Park Unidentified No. 1 wreck.

This measure would ensure the impact on known and potential maritime heritage remains, such as maritime infrastructure, shipwrecks and discarded objects, would be Negligible to Minor.

Mitigation measure B – Maritime archaeologist involvement in pre-dredge bed of the harbour clearance of Middle Harbour

Any pre-dredge bed of the harbour clearance by divers in Middle Harbour must be carried out in the presence of a maritime archaeologist, who will identify any additional inspection or documentation that should be carried out during the clearance dive. This may include inspecting the locations of known or potential submerged maritime heritage sites and items, either recording *in situ* or recovery and/or relocation.

This measure would reduce the impact on potential maritime heritage remains, such as maritime infrastructure, shipwrecks and discarded objects, to Negligible or Minor.

Mitigation measure C – Establish restricted zones around sites

Establish restricted zones around the following sites:

- Clive Park Tidal Pool
- Pearl Bay Unidentified No. 1.

The dimensions of the restricted zones and how they are to be physically marked are to be specified in the Maritime Heritage Management Plan (see Mitigation Measure A).

This measure would reduce the potential impact on these sites to Negligible.

Mitigation measure D – Carry out archival recording and limited excavation of Clive Park Unidentified No. 1

To mitigate the likely loss of information resulting from a breakdown of site integrity, an archival record of the site should be carried out. The archival recording should have the following objectives or research questions:

- Identifying and recording the extent of the site
- Identifying the type and function of the vessel (which would mean determining its construction)
- Identifying what the vessel was carrying at the time of loss
- Re-assessing the cultural heritage significance of the site.

The archival recording of the wreck would require limited excavation of the site to recover and examine its contents. This excavation should be carried out in accordance with the research design (see Mitigation Measure A) and any artefacts recovered from the site should be buried, after analysis, in an approved location nearby.

This measure would reduce the potential impact on this site to Minor.

Mitigation measure E – Carry out archival recording of maritime heritage items

Prepare a detailed archival recording of the following maritime heritage items, consistent with relevant NSW Heritage Council approved standards and guidelines:

- Clive Park Tidal Pool
- Pearl Bay Unidentified No. 1.

The archival records should also capture any relevant information needed to serve as a baseline for monitoring during the project, as identified in the Maritime Heritage Management Plan (see Mitigation Measure A). The final archival record should be updated with any changes identified during monitoring or investigation prior to lodgement.

This measure would reduce the potential impact on these sites to Negligible.

Mitigation measure F – Complete and review the side scan sonar surveys for areas to be affected by project works

Prepare a side scan sonar survey for the following areas:

- Sections of the Middle Harbour disturbance footprint not already covered (Area A)
- Location of off shore construction support site at Spit West Reserve not already covered (Area B).

A qualified maritime archaeologist should assess the results of the side scan survey to identify any additional potential heritage items requiring investigation and assessment.

This measure would reduce the impact on potential maritime heritage remains, such as maritime infrastructure, shipwrecks and discarded objects, to Negligible or Minor.

Mitigation measure G – Prepare a structural survey of the 'Harbour Foreshore' at Seaforth

Prepare a structural survey for all maritime infrastructure within the Seaforth 'Harbour Foreshore' that may be subject to vibrational impact to determine minimum working distances and vibration limits to be observed to prevent cosmetic damage. Vibration monitoring should be carried out during works to ensure vibration levels do not exceed appropriate limits. Although the impact on the cultural heritage values of

these sites may be no more than Minor, the recommended actions in Technical working paper: Noise and vibration should be followed to ensure the impacts are reduced to Negligible (Technical working paper: Noise and vibration).

Mitigation measure H – Carry out requisite steps to minimise settlement impacts for 'Harbour Foreshore' at Seaforth

This site may undergo slight aesthetic damage as a result of settlement from mainline tunnelling and marine piling works. Although the impact on the cultural heritage values of these sites may be no more than Minor, the recommended measures in Technical working paper: Noise and vibration should be followed to minimise vibration and settlement impacts to acceptable levels. This measure would reduce the potential impact on these sites to Negligible.

Mitigation measure I – Dive inspections for proposed temporary mooring facility east of Clive Park in Middle Harbour

A dive team under the supervision of a maritime archaeologist should inspect the location of the proposed temporary mooring facility to assess the maritime heritage value of any cultural object present and either relocate the object or, if significant, relocate the proposed mooring.

This measure would reduce the impact on potential maritime heritage remains such as maritime infrastructure, shipwrecks and discarded objects to Negligible.

REFERENCES

Project Specific

Arup wsp (17 November 2017), Western Harbour Tunnel and Beaches Link, Beaches Link – Tunnels Immersed Tube Tunnel. Sheet No. TM-2061 RMS Reg. No. DS2016/002059

Cosmos Archaeology Pty Ltd (November 2017a), *Western Harbour Tunnel and Beaches Link – Maritime Archaeology Issues Paper.* Prepared for Roads and Maritime Services

Cosmos Archaeology Pty Ltd (November 2017b), *Western Harbour Tunnel and Beaches Link – Maritime Archaeological Desktop Study*. Prepared for Roads and Maritime Services

Cosmos Archaeology Pty Ltd (January 2018), *Western Harbour Tunnel and Beaches Link: Maritime Archaeological Dive Inspections December 2017* Prepared for Roads and Maritime Services

Cosmos Archaeology Pty Ltd (2020), *Beaches Link and Gore Hill Freeway Connection Project, Potential Submerged Aboriginal Sites Assessment*. Prepared for Transport for NSW

Douglas Partners & Golder Associates (August 2017), Non-Core Drill Hole – Geological Log. File: 16.0000302526.2138

Earth Technology Solution Pty Ltd (July 2017a, WHTBL *Marine Geophysical Survey July 2017, Sydney Harbour & Middle Harbour*. Report No ET471/1 prepared for Golder Associates Pty Ltd/Douglas Partners Pty Ltd on behalf of Roads & Maritime Services.

Earth Technology Solution Pty Ltd (July 2017b), *RMS Western Harbour Tunnel Beaches Link Seismic Refraction Survey July 2017*. Report No ET471.2 prepared for Golder Associates Pty Ltd/Douglas Partners Pty Ltd on behalf of Roads & Maritime Services.

Golder Associates & Douglas Partners (October 2017), Test Locations; Western Harbour Tunnel and Beaches Link; Middle Harbour. Drawing No. 2, Revision 1, drawn 19 October 2017. Prepared for Roads and Maritime Services.

Jacobs Group Pty Ltd (12 February 2018), Beaches Link Disturbance footprint – Revised Coffer Dam (12.02.2018). Western Harbour Tunnel and Beaches Link Environmental Assessment

Marine & Earth Sciences (November 2017), *Western Harbour Tunnel Beaches Link Seismic Refraction Survey*. Prepared for Golder Associates Pty Ltd.

Renzo Tonin (2020), *Beaches Link and Gore Hill Freeway Connection – Construction and Operational Noise and Vibration Impact Assessment.* Prepared for Transport for NSW**.**

Royal HaskoningDHV (2020), *Beaches Link – Hydrodynamic and Dredge Plume Modelling.* Prepared for Transport for NSW, Document No. M&APA1694-BL-R002D01

WSP ARUP (2020), Western Harbour Tunnel and Beaches Link – Memorandum – Tunnels – Settlement assessment. Prepared for Transport for NSW.

Primary sources

Anon (ca.1850), 'Ellery's Punt Reserve circa 1850', National Parks Association

Anon (ca. late 1880s), 'Wharf used for coal loading during the punt era at the Spit', Mosman Library, File 000/000681

Anon (1890), *Parish of Manly Cove, Sheet No. 11.* National Library of Australia, Map 232129654.

Anon (ca.1890s), 'The Spit, ca.1890s, looking north', Carroll Collection, Mosman Library, File No. CC0/CCO112

Anon (1909), 'The Bluff, Middle Harbour, 1909: Real estate poster', Northern Beaches Council, Manly Local Studies Image Library, file 009/009444

Anon (28 June 1927), 'Launch Burns: On Middle Harbour: Value Exceeds £1000', *Sydney Morning Herald*.

Anon (ca.1930s), 'The Spit After 1930', NSW Government Printing Office, NSW State Library, Image No. GPO 3-01334

Anon (1935), 'Reclamation work for the Spit bridge being carried out at Pearl Bay', NSW State Records, Digital ID 9856_a017_A017000193.jpg

Anon (1970), 'The Bluff, Seaforth, 1970', Northern Beaches Council, Manly Local Studies Image Library, file 009/009556

Anon (1994), 'Clive Park baths, Northbridge, looking north, 1994 (picture)', Willoughby City Council, file 6535\6535155

Chief Surveyor and Land Valuer (1910 with amendments to 1921), *Plan of The Spit, Middle Harbour, Municipality of Mosman, Parish of Willoughby, County of Cumberland*, NSW Maritime Authority, Field Book Vol. 27, Fol. 29

Chief Surveyor and Land Valuer (1924 with amendments to 1963), *Plan of The Spit, Middle Harbour, Municipality of Mosman, Parish of Willoughby County of Cumberland*, NSW Maritime Authority, Willby 232

Commonwealth of Australia/Crawford House Publishing (1995), Crawford's Mariners Atlas – Port Stephens to Jervis Bay (complete compendium of Royal Australian Navy Charts

Crown Plan (ca.1870s), 'Plan showing traverses for the delineation of the part of Flat-Rock Creek and of High Water Mark in Long and Sailors Bays', Roads and Maritime Services, plan CP14-440

Crown Plan (ca.1980s), 'P.J.580', Roads and Maritime Services plan PJ580

Crown Plan (ca.1980s), 'P.J.581', Roads and Maritime Services plan PJ581

Dare, N.R. (1929), *Plan of New Concrete Roadway at the Spit, Middle Harbour, Parish of Willoughby, County of Cumberland*, NSW Maritime Authority Archives, Field Book Vol. 79, Fol. 58, Sydney Harbour Trust

Foster, Arthur G. (ca.1930s), 'View of Spit Bridge', Collection of photographs of Sydney, National Library of Australia, Image No. nla.pic-vn3084709

Hurley, Frank (ca. late 1950s), 'The Spit, Sydney Harbour, New South Wales', Hurley Series No. SH48, National Library of Australia, Image No. nla.pic-an23817204

Hurley, Frank (ca. early 1960s), 'General view, Spit and Middle Harbour, Sydney', Frank Hurley negative collection, National Library of Australia, Image No. nla.pic-an23817315

Jensen, Rodney (1986), 'Northbridge Sailing Club and boatshed, 1986', Willoughby City Council, file 6535\6535365

Kerry and Co (ca.1900s), 'The Spit, Middle Harbour', Tyrell Photographic Collection, Inventory No. 3/34, Kerry Studio Number 156

Kerry and Co (ca.1910), 'The Spit, Middle Harbour', Powerhouse Museum Collection 85/1284-2064

King, Henry (ca.1880), 'The Spit, Middle Harbour, Sydney', Tyrell Photographic Collection, image 85/1285-149

King, Henry (ca.1880s-1890s), 'The Spit and ferry, Middle Harbour – Sydney area, NSW', NSW State Library, Image No. BCP 06030

Liddell, A. I. & A. Clarkson (1890) *Parish of Willoughby, County of Cumberland.* NSW Archives Office Map No. 295.

Mitchell, A.G. (ca.1940s), 'Clive Park Baths, Northbridge, ca.1940s (picture)', A.G. Mitchell Collection, Willoughby City Council, file 6540\6540973

NSW Department of Lands (1899), 'Map of the parish of Willoughby', Image 14019001

Phillips, W. (1962, 'Plan showing Hydrographic Survey: Powder Hulk Bay to The Spit: Middle Harbour', The Maritime Services Board of NSW

Richard Lamb & Associates (2016), 'Sailor Bay Boatshed', Photography RLA, available http://www.richardlamb.com.au

Rose Post Cards (ca.1900s), 'The Spit, Middle Harbour, Sydney, New South Wales', Eric Milton Nicholls Collection, National Library of Australia, Image File No. nla.pic-vn3603884-s347

S.W. Post Card Company (ca.1908), 'The Spit and Seaforth from Parriwi Head', Manly Municipal Library File 00/005413

SKM Sydney Suburbs Ausimage from RTA photography (1943), NSW Department of Lands and Spatial Information Exchange (SIX).

Women's Cricket Association tour of Australia (1934), 'Old Spit Bridge, Middle Harbour, Sydney, 1934', National Library of Australia, Image No. nla.pic-vn3261847

Secondary sources

Andrews, G. (2002), 'The Watermen of Port Jackson – Part 23: The Port Jackson Explosives Run', *Afloat*

Artefact Heritage Services (2016), *HarbourLink Project – Preliminary Heritage Constraints Assessment.* Report to WSP/Parsons Brinckerhoff

Ashton, Paul (2008), 'Manly', *Dictionary of Sydney*, available http://dictionaryofsydney.org/entry

Atkinson, K. (1988), 'The Sydney Harbour Tunnel maritime archaeology survey.' *The Bulletin of the Australian Institute for Maritime Archaeology*. Vol. 12 No. 2

Australian National Maritime Museum Australian Register of Historic Vessels. http://arhv.anmm.gov.au/en/collections

Bower, B. and Staniforth, M. (1992), *Report of the maritime archaeology survey of areas of the upper Parramatta River affected by dredging for the Rivercat ferry service.* Prepared for Strategic Projects Branch, Marine & Air Division, NSW Department of Transport

Bower, R. and Staniforth, M. (1993), *Report of the maritime archaeological survey of areas of the upper Parramatta River affected by dredging for the Rivercat Ferry service,* NSW Department of Transport, Sydney, NSW

Bower, R and Staniforth, M. (1994), 'Wet Mud: Processes and patterns of cultural material deposition in the Parramatta River' in *Muddy Waters: Proceedings of the first conference in the submerged and terrestrial archaeology of historic shipping on the River Murray*. State Heritage Branch, Adelaide.

Bureau of Meteorology, Australian Government (2018), 'Tide Predictions for Australia, South Pacific and Antarctica – Sydney (Fort Denison), NSW – February 2018', available http://www.bom.gov.au/australia/tides/#!/nsw-sydney-fort-denison accessed, 24 December 2017.

Butler, Mark (2016), 'Northbridge'. *Dictionary of Sydney*, available http://dictionaryofsydney.org/entry/northbridge

Chapman, Garry, Consulting Town Planner (2008), '0.00 Sailors Bay Boat Shed Clive Park, Northbridge – Sailors Bay Ward', Ward Inspection Committee, available http://www.willoughby.nsw.gov.au/IgnitionSuite/uploads/docs/Sailors%20Bay%20Boat%20Shed,%20Clive%20Park,%20Northbridge.pdf

Coroneos, C. (2004), 'Port Arthur's Maritime Legacy'. In A Harbour Large To Admit a Whole Fleet: The Maritime History and Archaeology of Port Arthur. *Port Arthur Occasional Papers* No. 1. Port Arthur Historic Site Management Authority.

Cosmos Archaeology Pty Ltd (September 2006a), *The Spit Bridge Over Middle Harbour Proposed Bridge Widening: Maritime & Historical Archaeological Impact Assessment,* Prepared for Roads and Traffic Authority.

Cosmos Archaeology Pty Ltd (November 2006b), *Houseboat #3 'Spec' at Pearl Bay, Mosman. Prepared for Michael Chapman, Maritime Consultant and Lawyer.*

Cosmos Archaeology Pty Ltd (May 2010), *D'Albora Marina, The Spit: Aboriginal, Historical and Maritime Archaeological Impact Assessment*, report for Ardent Leisure Pty Ltd.

Cosmos Archaeology Pty Ltd (2019), *Western Harbour Tunnel and Warringah Freeway Upgrade Project – Potential Submerged Aboriginal Sites Assessment.* Report prepared for NSW Roads and Maritime Services.

Godden Mackay (July 1991), *Sydney and Middle Harbours Heritage Study*, report for NSW Department of Planning

Godden Mackay Logan Pty Ltd (1996), *Mosman Heritage Study*, unpublished report prepared for Mosman Municipal Council, NSW

Graham Brooks and Associates, Taylor Brammer Landscape Architects & Mary Dallas Consulting Archaeologists (2001), *Bantry Bay Conservation Management Plan*, unpublished report for NSW National Parks and Wildlife Service

Hedge, L.H., Ahyong, S.T., Booth, D.J. *et al* (2014), *Sydney Harbour – A systematic review of the science 2014*. Sydney institute of Marine Science Technical Report

McAteer, B. (2006), *A History of Seaforth*. Printed by Headland Press, Brookvale

McCarthy, M. (2005), *Ship's Fastenings from sewn boat to steamship.* Published by Texas A&M University Press

MacRitchie, John (2008), 'Seaforth', *Dictionary of Sydney*, available http://dictionaryofsydney.org/entry/seaforth

Manly Council and Clontarf / Bantry Bay Estuary Management Working Group (2007), *Clontarf/Bantry Bay Data Compilation and Estuary Processes Study.* Clontarf/Bantry Bay Estuary Management Planning Process, NSW

NSW Wrecks Info (2010), 'Shipwreck Position Database', available http://www.nswwrecks.info/

PIANC (2014), *Dredging and Port Construction: Interactions with features of archaeological or heritage interest*. PIANC Guidance Document No. 124-2014. Published by the PIANC Secretariat General, Belgium.

Sapp, M. (2011), 'Welding Timeline 1900-1950', A History of Welding, available http://weldinghistory.org/whfolder/folder/wh1900.html

Sayenga, D. **(n.d.),** 'Modern History of Wire Rope', available http://atlantic-cable.com/Article/WireRope/Sayenga/wirerope4.htm

Souter, G. (2004), *Times & Tides: A Middle Harbour Memoir.* Simon & Schuster, Pymble, NSW.

Sturrock, R. (1982), *A Pictorial History of Mosman*, self-published, Mosman, NSW

Wolfe, A. (n.d) 'The Parramatta River Project: an introduction to the maritime and underwater archaeological significance of ten sites on the banks of the Parramatta River.' *The Bulletin of the Australian Institute for Maritime Archaeology*. Vol. 15 No. 1

Statutory references

Australian Government Department of the Environment and Energy (2016), 'View Shipwreck – Mureegar', Australian National Shipwrecks Database, shipwreck ID 1293, available https://dmzapp17p.ris.environment.gov.au/shipwreck/public/wreck/wreck.do?key=1293

Australian Government Department of the Environment and Energy (2016), 'View Shipwreck – Itata', Australian National Shipwrecks Database, shipwreck ID 918, available https://dmzapp17p.ris.environment.gov.au/shipwreck/public/wreck/wreck.do?key=918

Australian Government Department of the Environment and Energy (2018), 'View Shipwreck – Mystery', Australian National Shipwrecks Database, shipwreck ID 1302, available https://dmzapp17p.ris.environment.gov.au/shipwreck/public/wreck/wreck.do?key=1302

Australia ICOMOS (1999, *Charter for the conservation of places of cultural significance*

Department of Sustainability Environment Water Population and Communities (2013), *Actions on, or impacting upon, Commonwealth land, and actions by Commonwealth agencies: Significant Impact Guidelines 1.2, Canberra.*

Heritage Council of New South Wales (2001), *New South Wales Historical Themes: Table showing correlation of national, state and local themes, with annotations and examples,* Office of Environment and Heritage, available http://www.environment.nsw.gov.au/resources/heritagebranch/heritage/themes2006.pdf

NSW Heritage Office (2001), *Assessing Heritage Significance*

NSW Heritage Office and Department of Urban Affairs and Planning (1996), *History and Heritage: The Use of Historical Context and Themes in Heritage Assessment*, Office of Environment and Heritage, available http://www.environment.nsw.gov.au/resources/heritagebranch/heritage/hmhistoryheritage.pdf

NSW Office of Environment and Heritage, Department of Premier and Cabinet (2011), Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW.

NSW Office of Environment and Heritage (2013), 'Northbridge Sailing Club – Clive Park', Willoughby Local Environment Plan listing I182, available http://www.environment.nsw.gov.au/heritageapp/ViewHeritageItemDetails.aspx?id=2660032

NSW Office of Environment and Heritage (2013), 'Clive Park and Tidal Pool', Willoughby Local Environment Plan listing I179, available http://www.environment.nsw.gov.au/heritageapp/ViewHeritageItemDetails.aspx?id=2660027

NSW Office of Environment and Heritage*, Fame* http://www.environment.nsw.gov.au/maritimeheritageapp/ViewSiteDetail.aspx?siteid=1422

NSW Office of Environment and Heritage, Maritime Heritage http://www.environment.nsw.gov.au/MaritimeHeritage/index.htm

NSW Office of Environment and Heritage, Department of Premier and Cabinet (2011), *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW.*