Lend Lease

Barangaroo Stage 1
Barangaroo Concept Plan Amendment (MP06_0162 MOD8)
Marine Ecology, Water Quality and Contaminated Sediment Impact Assessment

Prepared for Lend Lease (Millers Point) Pty Ltd

by Haskoning Australia Pty Ltd

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Issue 5 (Revised Final)

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1. INTRODUCTION

1.1 Project Background

The Barangaroo site is located on the north western edge of the Sydney Central Business District (CBD). It is bounded by:

- Sydney Harbour to the west and north;
- the historic precinct of Millers Point (for the northern half) or The Rocks and the Sydney Harbour Bridge approach to the east; and
- by a range of new developments dominated by large CBD commercial tenants to the south.

The Barangaroo site has been divided into three distinct redevelopment areas (from north to south) – the Headland Park, Barangaroo Central and Barangaroo South.

Lend Lease intends to develop the 7.5 hectare Stage 1 site of Barangaroo, located in the Barangaroo South area, to provide approximately 430,000 m^2 of mixed use gross floor area (GFA) and approximately 2.5 hectares of open space. The project will include a mix of commercial, retail, residential, cultural and civic facilities along with improved transport infrastructure.

The location of the Barangaroo site (as approved) is depicted in Figure 1, which also indicates the position of the Barangaroo South area (as per the Mod 8 Concept Plan Amendment).

1.2 Concept Plan and Amendments

On 9 February 2007, the Minister for Planning and Infrastructure approved a Concept Plan (MP06_0162) for the Barangaroo site, and on 12 October 2007 the land was rezoned to facilitate its redevelopment.

Several Concept Plan Amendments, or Modifications, have since been approved by the Minister pursuant to Section 75W of Part 3A of the *Environmental Planning and Assessment Act 1979*. The most recent proposed Concept Plan Amendment, Modification 8 (Mod 8), seeks to:

- relocate the landmark building (Block Y) extending into the harbour back onto the site in front of the existing Blocks 4A, B and C;
- revise the layout of Blocks 4A-C;
- amend the size and location of the Southern Cove and public domain;
- redistribute the GFA, public domain and land uses across development blocks 1-3, 4A-C, X and Y;
- increase the maximum GFA on the site to provide for additional GFA within the hotel building;
- increase the height of the buildings within modified 'Block 4' and the relocated Block Y;
- update the Urban Design Controls to reflect the modified concept design; and
- amend the conditions of the Concept Approval to reflect the modifications to development.

It is also proposed to amend Part 12 of Schedule 3 of *State Environmental Planning Policy (Major Development) 2005* to reconcile it with the modifications to the Concept Plan, including amending the location of the RE1 and B4 Mixed Use zones.

The Mod 8 Concept Plan Amendment relates to Barangaroo South only.

Figure 1: Location of Barangaroo site, with approximate location of Barangaroo South (as per Mod 8) shown shaded

The proposed application is the outcome of negotiations between Lend Lease and the NSW Government, including the Barangaroo Delivery Authority, to relocate the approved Landmark Hotel building (that was proposed to be on a pier in Sydney Harbour) to a location on land elsewhere on the site. It incorporates both the physical relocation of the hotel, along with a number of consequent and related changes that are required to maintain an appropriate built form and public domain outcome for the Barangaroo South site.

1.3 Site History

Over the previous two centuries the Barangaroo area has undergone significant transformation. During the 19th century the name Millers Point was given to the area, which was attributable to the windmills located on site (Barangaroo Delivery Authority, 2010). Following the introduction of gas lighting to Sydney, a large gasworks was constructed on the site (Figure 2). With the replacement of many sail driven vessels with steamships, a number of privately owned wharves were introduced to the site.

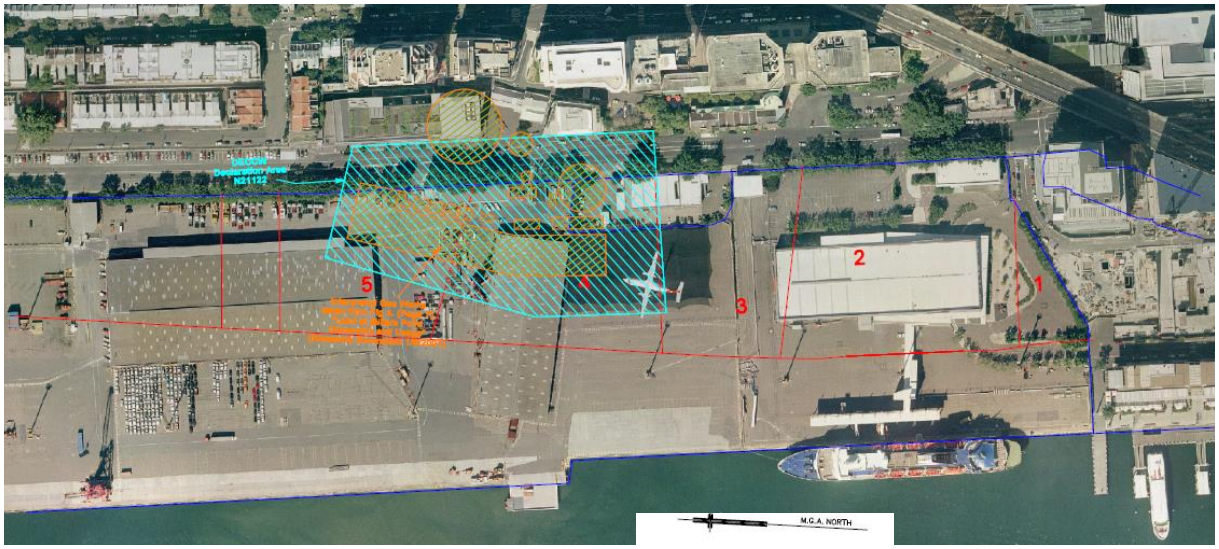


Figure 2: Location of the historical gasworks at Barangaroo (denoted by orange hatched areas)

When a bubonic plague struck in the early 20th century, the NSW Government seized control of the area. Hickson Road was cut into the point, dramatically changing the landscape. Long wharves and bond stores were built and lined the shore, and the headland was removed and a concrete apron built.

By the 21st century it became apparent that the modern cargo ships utilising the Barangaroo site required more space and access to freight rail, thus the site became unsuitable as a major port. As a result, Port Botany and Port Kembla were expanded to increase the export capacity of NSW. During this time, the Sydney CBD experienced increased demand for additional modern working spaces and recreational public spaces. As such, the NSW Government resolved to create a new western edge to the city and new foreshore parkland at east Darling Harbour. The name 'Barangaroo' was gazetted to the land in 2007, named after an indigenous woman who played a pivotal role in the early days of colonial Sydney (Barangaroo Delivery Authority, 2010). She was also the wife of Bennelong.

1.4 Physical Setting

The Barangaroo site is located within the Port Jackson estuary, which has a total catchment area of 347km^2 (NSW Maritime, 2004). The estuary is about 29.7km long, 5.3km wide, has an entrance width of 1.6km, perimeter of 237km and a water area of 50.5km^2 (NLWRA, 2001). The bathymetry of the estuary varies from 3m to 45m in depth. The estuaries of south-east Australia can be categorised as drowned river valleys and barrier estuaries (Roy, 1984). All estuaries in the Sydney metropolitan area are drowned river valleys (Roy et al., 2001).

The Port Jackson estuary is extensively modified (NLWRA, 2001). Approximately 90% of the catchment is industrialised, with developments including refineries, breweries, paint industries and construction, and the waterway is popular for recreational boating and water sports (Hatje et al., 2001). The Barangaroo site has a history of varying land use types over a period of some 200 years, some of which had the potential to contaminate portions of the site , in particular the former Australian Gas and Light Company gasworks. Other previous land uses that present potential historical sources of contamination include the use of the site to receive uncharacterised fill, below and above ground diesel storage / distribution, chemical and waste storage, above ground petroleum storage, vehicle and equipment washing and maintenance and operation of a ship berthing and stevedoring business.

The seafloor adjacent to the Barangaroo site can be generally described as per Table 1.

Table 1 Geology of the seafloor adjacent to the Barangaroo site (ERM, 2008a)

Lithological Unit	Description	Depth (m below harbour floor)
Silt	Dark brown / grey, saturated, loose, little shell fragments and organic matter. Sandstone rock.	0 to 0.2
Silty Sand / Sandy Silt	Dark brown / grey, becoming consolidated with depth, little shell fragments and organic matter.	0.5 to 1.2
Silty Clay	Dark brown / grey, some shell fragments and organic matter.	0.6 to 1.2

1.5 Purpose of this Report

The report herein has been prepared to provide an assessment of the potential marine ecology impacts associated with the proposed development with regard to the Mod 8 Concept Plan Amendment.

Marine ecology impacts were previously assessed for the Mod 4 Concept Plan Amendment, in WorleyParsons (2010). This previous report is referred to as the Mod 4 report herein, and the report herein is based on this previous report.

The Mod 4 report was prepared to address the following Director General Requirements (DGRs):

1. *Assess the potential impacts due to construction and operations on water quality, marine vegetation and aquatic ecology.*
2. *Assess potential impacts on aquatic habitats from changes to the quantity, quality and discharge of stormwater from the site.*
3. *Assess the geotechnical and contamination issues associated with the construction of the Landmark Building and associated pier / promenade.*

An updated assessment of marine ecology impacts has been undertaken herein for the Mod 8 Concept Plan Amendment. This assessment has updated the findings of the previous marine ecology assessment undertaken against the DGRs for the Mod 4 Concept Plan Amendment and addresses DGR No. 5 for the Mod 8 Concept Plan Amendment, issued 15 April 2014, being: "*5. Sydney Harbour - Detail the impacts on Sydney Harbour as a result of the changes to the foreshore promenade and pier, including its interaction with Barangaroo Central*".

Responses to the above DGRs are provided in summary in Section 2.

1.6 Scope of Work

Marine surveys were previously undertaken to support the Mod 4 Concept Plan Amendment. These surveys were undertaken in May 2010 along the foreshore of Barangaroo (impact site) and at two nearby reference locations, namely Berrys Bay (located to the north at Waverton) and Snails Bay (located to the north-west at Birchgrove). All sampling was undertaken in waters which were zoned "W1 Maritime Waters" under the *Sydney Regional Environment Plan (Sydney Harbour Catchment) 2005* (Harbour REP). The observations made during these surveys are relevant to the present (Mod 8) assessment and have therefore been replicated herein where appropriate.

In summary, the Marine Ecology Impact Assessment examines:

- **Construction Methodology** – Discussion of the proposed construction methodology for the Community Building (including associated pier and promenade), Globe Harbour (including current foreshore alignment amendments and cove creation) and new ferry terminals and the potential impact of construction methods on the marine environment.
- **Water Quality** – Assessing water quality at the site and examining this data with reference to the ANZECC / ARMCANZ[1] (2000) National Water Quality Guideline trigger values and the expected average water quality values for Australian estuaries (NSW Government, 1992). Assessing the potential impacts of the proposed development on water quality.
- **Aquatic Flora and Fauna** - Describing the aquatic flora and fauna at the site via a desktop review and previous field surveys (using divers and project specific underwater video transects). Creating habitat maps of aquatic vegetation in the vicinity of the site (where applicable) and assessing potential impacts of the proposed development.
- **Benthic Infauna** - Assessment of benthic infauna at the impact location (within the development footprint) and at two nearby reference sites to ascertain existing conditions and allow for assessment of future changes. Assessing the impact of proposed development.
- **Marine Sediments** - Review of the ERM (2007, 2008a, b) sediment reports regarding land-based and marine sediments at the site. Collection of marine sediments from the impact location and nearby reference locations for particle size analysis (PSA). Assessing potential impacts of the proposed development (i.e. through mobilisation of these sediments).

[1] Australian and New Zealand Environment and Conservation Council / Agriculture and Resource Management Council of Australia and New Zealand.

2. DIRECTOR GENERAL REQUIREMENTS AND LEGISLATION

2.1 NSW Planning Director General's Requirements (DGRs)

The Mod 8 proposal includes reducing the high-rise Landmark Building to a low level building constructed on top of a Public Pier (with a reduced footprint of about 30% of the Mod 4 footprint), to be known as the Community Building.

DGRs for the Mod 8 Concept Plan Amendment were issued 15 April 2014. The previous DGRs issued for Mod 4 Concept Plan Amendment were not included in the Mod 8 DGRs. The DGR of relevance to marine ecology for Mod 8 is No. 5, in which it is stated:

> *" 5. Sydney Harbour - Detail the impacts on Sydney Harbour as a result of the changes to the foreshore promenade and pier, including its interaction with Barangaroo Central."*

The report herein addresses this DGR and has been undertaken as an update of the earlier assessment against the DGRs for the Mod 4 Concept Plan Amendment. A summary of the outcomes of this assessment is provided below, structured against the previous Mod 4 DGRs.

1. Assess the potential impacts due to construction and operations on water quality, marine vegetation and aquatic ecology.

Water Quality

Construction activities associated with the Community Building, northern jetty and the Globe Harbour have the potential to impact on water quality in Darling Harbour. However, by employing industry standard and appropriate techniques, these impacts can be managed and minimised to acceptable levels.

Piling associated with construction of the Community Building, northern jetty and the proposed ferry terminals has the potential to generate localised short term increases in turbidity through suspension of sediments. If piling operations are not appropriately considered, designed and controlled, suspension of bottom sediments could result in the mobilisation of associated heavy metals and other contaminants into the water column. Once suspended, these contaminants have the potential to disperse into less polluted areas of the Harbour, potentially affecting fish, algae and invertebrates.

The Mod 8 Globe Harbour concept has the significant benefit that excavation landward of the existing revetment would not be required, as previously proposed for the Southern Cove. This reduces the risk of releasing contaminated land-based sediments and groundwater into the marine environment from the contaminated fill area landward of the revetment.

In consideration of appropriate design and construction methodologies associated with the Community Building, northern jetty and the Globe Harbour, it has been concluded that by employing the mitigation measures discussed in Section 7.3, any impacts of the proposed development on water quality within Darling Harbour are expected to be negligible, extremely localised and short-term in nature. Further details on water quality in Sydney Harbour and at the study site are provided in Section 4.3.1 and Section 6.1.

Marine Vegetation

No marine vegetation was recorded in the vicinity of the proposed development during field surveys undertaken in May 2010, nor was any marine vegetation mapped by DPI (2005) in the immediate area, as discussed in Sections 4.2.1 and 6.3.1. Due to the lack of aquatic vegetation at or in the vicinity of the Barangaroo South area, no impacts on these habitats are expected. The field surveys also showed that the wetland area which is mapped by DPI (2005) at Balmain East is in fact dominated by seawalls and other man-made structures. Although aquatic macroalgae occurs along the foot of these seawalls, no impact on these communities is expected if appropriate mitigation measures to prevent the spread of suspended sediments are employed as described in Section 7.3.

Aquatic Ecology

Benthic Infauna: The placement of piles and other structures into the seabed would displace soft sediment benthic habitat and any associated benthic fauna. The high availability of similar benthic habitat in Sydney Harbour suggests that benthic communities such as those recorded at Barangaroo would be widespread and thus, any localised impacts from the potential development on benthic invertebrate communities would be considered to be negligible.

Mobile Fauna: Mobile fauna such as fish and sharks may be impacted by the presence of barges and by noise generated during construction works. However, due to the current high levels of boating activity in Darling Harbour these effects are likely to be negligible. Mobile phytoplankton and bacteria may be affected by small-scale suspension of contaminated sediments (Nayar et al., 2004).

Velocities under and near the Public Pier would not be significantly altered, and therefore there is not likely to be any negative effect on fish species inhabiting Darling Harbour or enhanced mobilisation of existing bed sediments.

Sessile Organisms: Removal of the existing structures at Barangaroo would eliminate the existing artificial habitat for sessile invertebrates which currently exists at the site; however, new intertidal and subtidal habitats may be created. Recent research in Sydney Harbour has found that small infrequent disturbance of contaminated sediments does not significantly impact on sessile marine organisms such as ascidians and bryozoans, presumably as they have evolved to deal with frequent natural changes in water conditions within estuaries (e.g. salinity and turbidity) (Knott and Johnston, 2010). Therefore, it is unlikely that there would be any significant impact of the proposed development on sessile communities residing in the vicinity of the proposed works.

Threatened and Protected Species: The proposed Stage 1 development is not expected to have any impact on threatened or protected species of flora or fauna. Due to the high level of boating activity and lack of suitable habitat at Barangaroo, it is highly unlikely that any species of threatened fauna listed under the *Threatened Species Conservation Act 1995* (TSC Act) or *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), which have the potential to occur in the harbour, would utilise this area. Further, no aquatic vegetation protected under the *Fisheries Management Act 1994* (FM Act) is present in the vicinity of the proposed development.

To reduce the potential impacts of the proposed development on aquatic flora and fauna, the mitigation measures described in Section 7.3 should be employed. To increase habitat complexity and species diversity, and to reduce the likelihood of colonisation of novel habitats (e.g. Globe Harbour) by introduced marine species (Glasby et al., 2007), design and construction of seawalls in the Globe Harbour could be undertaken in accordance with DECC (2009), as described in Section 7.3.

For further detail on aquatic ecology at the site and mitigation measures to reduce the impacts on aquatic ecology, refer to Sections 4.2, 6.3 and 7.2.

In summary, if effectively mitigated using the industry standard methods and techniques described in Section 7.3, any potential impacts on water quality and aquatic ecology arising from the Community Building, northern jetty, new ferry terminals and the Globe Harbour would be negligible, temporary and localised.

2. Assess potential impacts on aquatic habitats from changes to the quantity, quality and discharge of stormwater from the site.

Throughout the development phase, all stormwater and wastewater onsite will be contained, collected, decontaminated / treated and discharged to either the sewage network (under trade waste agreement) or stormwater system. An onsite water treatment plant is currently being operated to ensure that stormwater entering the site is suitably treated prior to discharge to the harbour. In the case that treated water is discharged to the harbour, the increased freshwater input would cause localised decreases in salinity levels. However, due to the naturally high variability in salinity levels in estuarine environments such as Sydney harbour, this is unlikely to have a significant effect on the aquatic fauna or flora in the area. In the case where untreated water was to enter the Harbour, the mitigation measures adopted for water quality management (see Section 7.3) would ensure that any impacts would be localised and negligible.

In the longer term, upon completion of construction, principles of Water Sensitive Urban Design (WSUD) are proposed within the Barangaroo Stage 1 development to improve quality of any stormwater discharge to Darling Harbour. Stormwater is proposed to be collected for reuse within the development (as a source of irrigation etc) and therefore the quantity of stormwater discharge to Darling Harbour is expected to reduce from current levels.

3. Assess the geotechnical and contamination issues associated with the construction of the Landmark Building[2] and associated pier / promenade.

To mitigate against possible mobilisation of existing contaminated sediments, any activities not conducted in the dry and associated with construction of the Community Building, Public Pier and northern jetty (such as pile driving), should employ industry standard and appropriate techniques as described in Section 7.3. Prior to such activities, silt curtains should be installed.

The ambient water quality monitoring program currently being implemented for the Barangaroo South development should also continue (as planned) while these activities are undertaken to ensure that water quality conditions are maintained beyond the silt curtains and in the broader area. The requirements for this monitoring program are outlined in the Construction Water Quality Monitoring Plan (CWQMP), which forms an Appendix to the *Water & Stormwater Management Sub-Plan for Barangaroo Stage 1* (Lend Lease, 2011).

Piled foundations to the proposed Public Pier and northern jetty would be founded in suitable strength sandstone bedrock at appropriate depths below the existing harbour bed. On this basis, contamination issues associated with laying foundations are expected to be readily managed within acceptable limits.

[2] With regard to this DGR, the BIC, Public Pier and northern jetty have been considered in place of the Landmark Building herein.

2.2 Relevant Environmental Planning Instruments

2.2.1 State Environmental Planning Policy (Major Development) 2005

The Barangaroo site is identified as a State Significant Site under Schedule 3 of the *State Environmental Planning Policy [SEPP] (Major Development) 2005*. The Minister for Planning and Infrastructure is the current authority under Part 3A for the Concept Plan Amendment.

2.2.2 Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005

The *Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005* (Harbour REP) covers all the waterways and foreshores of the Port Jackson estuary (Sydney Harbour) and its entire catchment. The proposed Stage 1 development is located adjacent to, and extends into, waters which are zoned 'W1 Maritime Waters' under the Harbour REP. It is also within the City Foreshores Area of the Strategic Foreshore Sites Map of the Harbour REP. The Lend Lease Barangaroo Stage 1 Masterplan lies approximately 0.48 km south-east of an area designated as a Wetlands Protection Area under the Harbour REP (located at Balmain East).

2.2.3 Environmental Planning and Assessment Act 1979 (EP&A Act)

The EP&A Act sets out factors to be considered in preliminary assessments of whether there is likely to be a significant effect on threatened species arising from a development. An assessment of significance (7 part test) is used to determine whether a planned action would significantly affect threatened species, populations, ecological communities or their habitats. If so, a Species Impact Statement (SIS) may be required.

2.2.4 Fisheries Management Act 1994 (FM Act)

The FM Act and its Regulations are administered by the NSW Department of Primary Industries (DPI), and apply to habitat and aquatic flora and fauna which have the potential to be affected by a proposed development. The FM Act was amended in 1997 (*Fisheries Management Amendment Act 1997*) to include provisions to declare and list threatened species of fish and marine vegetation, endangered populations and ecological communities and key threatening processes. All aquatic vegetation (mangroves, seagrasses and seaweeds) are protected under the FM Act and when a proposal is likely to harm aquatic vegetation a permit to "Harm Marine Vegetation" must be obtained.

2.2.5 Threatened Species Conservation Act 1995 (TSC Act)

The TSC Act is administered by the NSW Office of Environment and Heritage (OEH). This Act applies to both threatened terrestrial and aquatic flora and fauna. In the aquatic environment seabirds, waders, aquatic reptiles, aquatic mammals and insects, endangered aquatic ecological communities and key threatening processes are addressed.

2.2.6 Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

The EPBC Act is administered by the Commonwealth Department of the Environment. Under the EPBC Act all actions which are likely to have a significant impact on matters of national environmental significance (NES) are subject to referral, assessment and approval. In the aquatic environment, the EPBC Act addresses threatened species, ecological communities and key threatening processes,

migratory species, cetaceans, marine species and Ramsar areas of national significance (Ramsar wetlands).

2.3 NSW Habitat Marine Habitat Survey Guidelines

In the *NSW Marine Habitat Survey Guidelines 2009* (**Appendix A**) it is stated that "when a structure or activity has the potential to impact on a marine habitat" a marine habitat survey must be undertaken and must include the following:

- scaled plans to showing the existence of any vegetation below the mean high water mark within a minimum 20 m of the proposal;
- details of the survey area and sampling method;
- photographs of the sampling area;
- description of the dominant habitats and species including their sensitivity to change and the incidence of threatened species;
- the nature of the intertidal and subtidal zone;
- direct and indirect impacts on the marine habitat during and after construction; and
- proposed monitoring of impacts after construction.

3. PROPOSED DEVELOPMENT AND CONSTRUCTION METHODOLOGY

3.1 Preamble

The proposed construction methodology for the Globe Harbour, Community Building (including Public Pier) and northern jetty is summarised below[3]. A description of these elements in comparison to the currently approved Mod 4 proposal is also provided. It should be noted that alternate methodologies may be developed and detailed at the Project Application phase, which would also include further details regarding management measures to minimise environmental impacts.

3.2 Globe Harbour

3.2.1 Proposed Development

For Mod 8, the area of the harbour is significantly reduced to around 25% of the area proposed for the Southern Cove under Mod 4 (Figure 3)[4]. The harbour is now proposed to extend only around 30 m landward of the existing deck (on the southern side).

In the centre of the harbour a stage is proposed to be supported by existing piles (subject to condition assessment). The stage may be a permanent structure or a demountable structure brought in from time to time as required (similar to other cinema and opera stage structures in the harbour).

Globe Harbour is designed to bring people towards the waterfront. However it is not designed to include any facilities to encourage the set-down/drop-off, mooring or general use of the water within the harbour, landward of the existing deck. This is the same as the use proposed in Mod 4. It is likely that existing piles in this area shall be retained to improve slope stability and some may be cut off well above bed level to provide ecological enhancement. This would further discourage vessel use in this area.

[3] Ferry terminals may also be constructed by the NSW Government in the future.
[4] Base image derived from Lend Lease Drawing No. AD0000011 Revision 02 (Site No. B10).

Figure 3: Mod 8 Concept Plan with approximate Mod 4 outline overlay shown in red (scale approximate)

3.2.2 Construction Methodology

The construction methods described in the Mod 4 report for the Southern Cove have been revised below. The amount of excavation required, and associated risks, are significantly reduced in the Mod 8 Concept Plan Amendment, and the construction methodology required has therefore been modified accordingly.

Within the footprint of the proposed Globe Harbour (Mod 8) the existing foreshore structure consists of a suspended deck on piles, with a rock revetment beneath (Figure 4). This means that excavation landward of the existing foreshore revetment is no longer required.

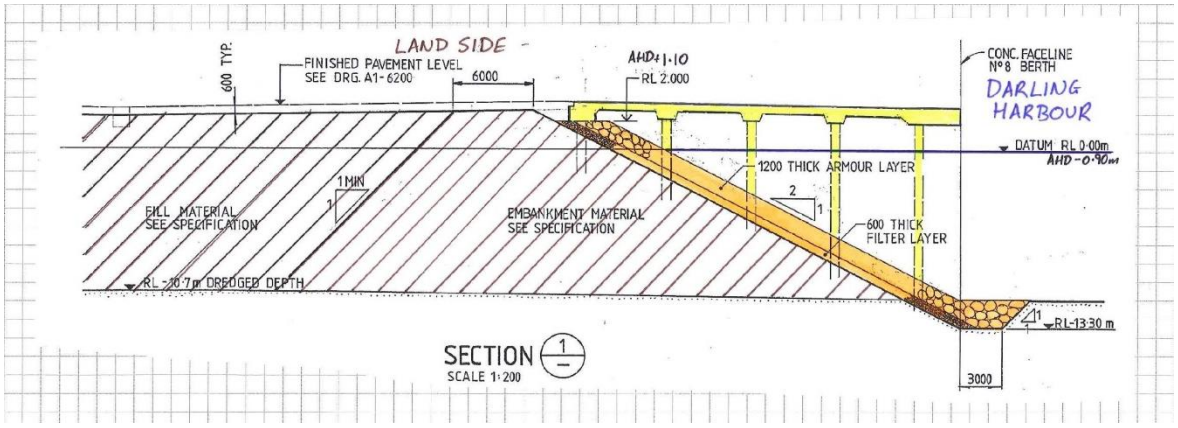


Figure 4: Cross Section through proposed Globe Harbour Location

The construction of the Mod 8 Globe Harbour would typically involve the following:

- installation of perimeter silt curtains around the extent of the works;
- removal of existing suspended concrete deck;
- existing piles cut off at bed level (some piles may be cut off above bed level and modified to incorporate ecological enhancement features);
- construction of foreshore treatment, such as steps, founded on existing piles (subject to condition assessment of existing piles);
- ecological enhancements to the revetment face above low water level (subject to further design considerations); and
- water quality monitoring during and after construction works.

A small circular stage is also proposed in the centre of Globe Harbour. This would be partly constructed on top of one of the existing piles (subject to condition assessment). The stage is likely to be fabricated off site and then barged to site to be fixed into position.

3.3 Public Pier and Community Building

3.3.1 Proposed Development

In the Mod 8 Concept Plan Amendment, the Public Pier and former (Mod 4) high-rise Landmark Building have been significantly reduced in scale. The pier has a reduced footprint, of about 30% of the Mod 4 footprint, and now extends around 35m less distance into the harbour. The high-rise

Landmark Building has been reduced to a low level building constructed on top of the pier (the Community Building), and a basement carpark is no longer proposed.

3.3.2 Construction Methodology

Construction of the Public Pier and Community Building would generally follow the same procedure outlined in the Mod 4 report with the exception of works associated with the submerged basement car park and connection through the existing caisson to the land side. The methodology required for the Mod 8 pier and building is summarised below:

- installation of perimeter silt curtains around the extent of the works;
- utilising barge mounted piling plant to install piles through to a sound stratum;
- installing deck above water, and building structure; and
- water quality monitoring during and after construction works.

3.4 Northern Jetty

3.4.1 Proposed Development

The Mod 8 concept plan includes the potential for a public water taxi jetty structure on the northern side of Globe Harbour. This piled jetty may extend approximately 50m into the harbour, which is less than the projection into the harbour by the public pier structure to the south.

3.4.2 Construction Methodology

Construction of the potential public jetty would follow standard industry practice and would typically include the following:

- installation of perimeter silt curtains around the extent of the works;
- utilising barge mounted piling plant to install piles through to a sound stratum;
- installing a deck above water, which could consist of a fixed or floating deck that could be constructed on site or fabricated off site and then barged to site and fixed;
- water quality monitoring during and after construction works.

4. BACKGROUND RESEARCH

4.1 Preamble

In this section, background information is provided on aquatic ecology, water quality and sediments in Sydney Harbour and in the vicinity of the proposed Barangaroo Stage 1 development site. In Section 7, an assessment of the potential impacts of the proposed Stage 1 development on water quality and aquatic ecology is provided, taking into account both the information in this section, and data gathered in the marine field surveys (Section 5).

4.2 Aquatic Flora and Fauna

4.2.1 Aquatic Flora

Seagrass

Seagrasses are specialised marine flowering plants which occur in sheltered and shallow marine and estuarine waters, growing in soft sediments such as mud or sand (DPI, 2007). Seagrasses are extremely important to the ecology of estuarine environments. They provide important habitat for juvenile fishes and mobile invertebrates, reduce erosion and improve water quality by stabilising sediments, and are significant components in the cycling of nutrients (Larkum et al., 1989; Bell and Pollard, 1989; DPI, 2007).

Extensive mapping of the aquatic vegetation in Sydney Harbour has been undertaken by DPI Fisheries (West *et al.*, 1985; DPI, 2005). All data was mapped at a scale of 1:1500 derived from aerial photographs with a positional accuracy of approximately 6 m. The latest estuarine vegetation maps (DPI, 2005) indicate that seagrass is absent from the vicinity of the study site (Figure 5). The water depth (~ 13 m) and associated low light penetration would likely restrict the growth of seagrasses in the footprint of the proposed Lend Lease development that extends into the Harbour.

Mangroves

The latest estuarine vegetation maps (DPI, 2005) indicate the absence of any mangroves in the vicinity of the study site (Figure 5). Also, no mangroves were observed at or near the Barangaroo South area during the site visit undertaken in May 2010 for the Mod 4 investigations.

Saltmarsh

The latest estuarine vegetation maps (DPI, 2005) indicate the absence of any saltmarsh in the vicinity of the study site (Figure 5). Also, no saltmarsh was observed at or near the Barangaroo South area during the site visit undertaken in May 2010 for the Mod 4 investigations.

Figure 5: Aquatic vegetation in the vicinity of the study site, extract from DPI (2005) aquatic vegetation maps

Wetland Areas

The *Sydney Harbour Regional Environmental Plan (Sydney Harbour Catchment) 2005 Wetlands Protection Area Map* indicates that the proposed Barangaroo Stage 1 development site is located opposite a Wetlands Protection Area at Balmain East (DIPNR, 2005) (Figure 6). Wetlands are described by DPI (2005) as depressions that are inundated permanently or temporarily with water that

is usually shallow, slow moving, or stationary. Wetlands include a wide range of habitats and in coastal areas and include:

- estuarine lakes and lagoons;
- mangrove and saltmarsh swamps;
- dune swamps and lagoons;
- upland lakes, lagoons and swamps;
- coastal floodplain forest; and
- coastal floodplain swamps and lagoons (DPI, 2005).

However, the wetland area mapped at Balmain East was found to be dominated by seawalls and pontoons, rather than wetland vegetation (Figure 7).

Impacts:

No seagrass or other aquatic vegetation was observed in the footprint of the proposed development during the site inspections undertaken in May 2010 for the Mod 4 investigations, by divers or on the underwater video. In addition, no aquatic vegetation has been mapped in the area by DPI (2005). Further, the wetland area mapped at Balmain East was found to be dominated by seawalls and pontoons, rather than wetland vegetation. Due to the lack of aquatic vegetation in the vicinity of the proposed Lend Lease development, no impacts on these sensitive habitats are expected.

Figure 6: Wetlands Protection Areas (green shading) in vicinity of Barangaroo from Harbour REP 2005

Figure 7: Aerial view of Balmain East area defined as a Wetlands Protection Area

4.2.2 Aquatic Fauna

Numerous marine fauna have the potential to occur in the vicinity of the Barangaroo South area. Intertidal and subtidal hard substrate habitats (including artificial structures) in Sydney Harbour support diverse assemblages of sessile organisms including colonial and solitary ascidians, bryozoans, sponges, polychaete worms, bivalves and barnacles (Bulleri *et al.*, 2005). Hard substrate habitat is currently available on the existing wharf / jetty structure and the caisson wall at Barangaroo, and also on extensive seawalls which occur to the west of the site. Small rocky subtidal areas are also found to the west near Balmain.

Soft sediment benthic marine habitats also support a diverse array of organisms including polychaete worms, molluscs (gastropods and bivalves), ascidians and crustaceans. These benthic macroinvertebrates are important to the ecology of estuarine environments and play a role in nutrient cycling and providing food for marine vertebrates such as fish (Snelgrove, 1998). Soft sediment habitat is available throughout Darling Harbour.

In addition to the above, motile marine fauna such as fish and sharks (e.g. bull sharks) and marine mammals (e.g. fairy penguins) are known to occur in the area. Fish species commonly occurring in Sydney Harbour include yellowfin bream (*Acanthopagrus australis*), tarwhine (*Rhabdosargus sarba*), snapper (*Chrysophrys auratus*), mullet (Family: Mugilidae), dusky flathead (*Platycephalus fuscus*), sand whiting (*Sillago ciliate*), leatherjackets (Family: Monocanthidae), luderick (*Girella tricuspidata*) and large tooth flounder (*Pseudorhombus arsius*) (Cardno Ecology Lab, 2009).

Impacts:

No significant impacts on marine fauna are expected. With the use of appropriate mitigation measures (see Section 7.3) any impacts would be highly localised and short-term.

Although removal of the existing caisson wall and wharf / jetty structure will eliminate the existing artificial habitat for sessile invertebrates, the Public Pier, northern jetty and associated structures will increase the surface area of habitat available for sessile marine fauna. In addition, ecological enhancements are being considered in the foreshore design of Globe Harbour, and therefore there could be a more positive outcome for sessile invertebrates. Any localised impacts on benthic

infauna from activities such as piling would be considered to be negligible considering the widespread availability of similar benthic habitat in Sydney Harbour. Since any disturbance of sediments would be mitigated, short-term and highly localised, the potential disturbance of sediments at the site is unlikely to have any significant impacts on sessile or mobile marine organisms in the vicinity.

Mobile fauna, such as fish and sharks, may be impacted by the presence of barges and by noise generated during construction works. However, due to the current high levels of boating activity in Darling Harbour these effects are likely to be negligible. Furthermore, these mobile species can remove themselves from the affected area. No significant changes in water velocity around the proposed structures are expected, so no significant impact on the movement of fish and other mobile species would be expected.

4.2.3 Introduced Species / Marine Pests

Marine pests are non-native plants or animals, which have been introduced from overseas or other regions of Australia, through vectors such as shipping, aquaculture and aquarium trades, which have a significant impact on our marine industries and environment (DPI, 2005). Marine pests can have severe ecological impacts. They may compete with native species for habitat or food resources, or may prey directly on them (DPI, 2005). Pest species can also cause considerable economic damage. For example, infestations of marine pests can impact on marine industries such as aquaculture, commercial and recreational fishing and boating, tourism and even international and domestic shipping. In addition, some marine pests, such as toxic dinoflagellates, can threaten public health (DPI, 2005).

There are three schedules of introduced marine species in Australia (Hewitt and Martin, 1996; 2001):

- Schedule 1. Australian Ballast Water Management Advisory Committee (ABWMAC) target introduced pest species.
- Schedule 2. Marine pests that pose a threat to Australia.
- Schedule 3. Known or likely exotic marine species in Australian waters.

The following marine pest species are known to occur in the Port Jackson estuary:

- Aquarium Caulerpa (*Caulerpa taxifolia*)
- Pacific Oyster (*Crassostrea gigas*)
- Dinoflagellates
    - *Alexandrium catenella* - Inactive Cysts
    - *Alexandrium tamarense* - Inactive Cysts
    - *Gymnodinium catenatum* - Inactive Cysts

The most recent estuarine vegetation maps (DPI, 2005) indicate that the study area is free of the invasive algae *Caulerpa taxifolia*. However, the dominant fauna observed on the pylon structures, at the northern end of the site were oysters, possibly the Pacific Oyster, *Crassostrea gigas*.

Impacts:

No introduced marine flora was observed at the site during the site inspections undertaken in May 2010 for the Mod 4 investigations. As such, it is considered that the proposed works do not have the potential to cause spread of species such as *Caulerpa taxifolia*. Removal of the existing

caisson wall and wharf / jetty structures will reduce the available habitat for the introduced species *Crassostrea gigas*.

4.2.4 Threatened and Protected Species

Searches of the National Parks and Wildlife Service (NPWS) Atlas of NSW Wildlife (for species listed under the *Threatened Species Conservation Act 1995* (TSC Act), the DEWHA Protected Matters Search Tool for species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), and Schedules of the *Fisheries Management Act 1994* (FM Act) were undertaken to determine any species, populations and matters of national / international significance occurring in the vicinity of the site.

Threatened Species Conservation Act 1995

A search of the NPWS Atlas of NSW Wildlife (12 April 2010) for marine species listed under the TSC Act as potentially occurring in the Sydney Harbour (unincorporated) Local Government Area (LGA) returned the following results (see **Appendix B1** for detailed search results)[5]:

- Little Penguin (*Eudyptula minor*) – Endangered Population (E2)
- Southern Right Whale (*Eubalaena australis*) – Vulnerable (V)
- Humpback Whale (*Megaptera novaeangliae*) - V
- New Zealand Fur-seal (*Arctocephalus forsteri*) - V
- Australian Fur-seal (*Arctocephalus pusillus doriferus*) - V
- Green Turtle (*Chelonia mydas*) – V

In Table 2 a summary is provided of the habitat required by each of these species and their likelihood of occurrence at the study site.

Table 2 Threatened marine species listed under the TSC Act with the potential to occur at the study site

Species	Status	Habitat	Potential to Occur
Little Penguin (fairy penguin) *Eudyptula minor*	Listed Marine Species (EPBC Act) Endangered Population (TSC Act) – Little Penguin in the Manly Point Area.	The nest site is typically a rocky burrow or shelter, although nests under dense vegetation are common where there is competition for burrows.	**Unlikely** – although the little Penguin may travel through this area, no foraging or nesting habitat exists and the high degree of boating traffic means its occurrence is unlikely. No areas listed as Little Penguin Critical Habitat under the Harbour REP 2005 occur in the area. No sightings with 10km of Barangaroo.

[5] Note that it is no longer possible to search in this Atlas with a restriction of the Sydney Harbour (unincorporated) LGA. However, based on a search dated 24 October 2013 over a 10km by 10km region surrounding Barangaroo, it was evident that no additional marine species would be included beyond those listed herein from the 2010 search. Note also that the Little Penguin, Humpback Whale and Green Turtle were not listed in the 2013 search. An additional 10km by 10km region search was also completed on 12 March 2015 as reproduced in **Appendix B2**.

Species	Status	Habitat	Potential to Occur
Southern Right Whale *Eubalaena australis*	Endangered (EPBC Act) Vulnerable (TSC Act)	Inhabits temperate and subpolar marine waters of the Southern Hemisphere. Feed in the open ocean in summer and move inshore in winter for calving and mating. Often seen in very shallow water, including estuaries and bays.	**Unlikely** – essentially an oceanic species.
Humpback Whale *Megaptera novaeangliae*	Vulnerable (EPBC Act) Vulnerable (TSC Act)	Oceanic and coastal waters worldwide.	**Unlikely** – essentially an oceanic species. No sightings with 10km of Barangaroo.
New Zealand Fur-seal *Arctocephalus forsteri*	Marine (EPBC) Vulnerable (TSC)	Marine waters of Australia and New Zealand. Prefers rocky parts of islands with jumbled terrain and boulders.	**Unlikely**– essentially a marine species which inhabits rocky areas and rocky shores/habitats
Australian Fur-seal *Arctocephalus pusillus doriferus*	Marine (EPBC Act) Vulnerable (TSC Act)	Marine waters of Australia. Prefers rocky parts of islands with flat, open terrain.	**Unlikely**– essentially a marine species which inhabits rocky areas and rocky shores/habitats
Green Turtle *Chelonia mydas*	Vulnerable / Migratory (EPBC Act) Vulnerable (TSC Act)	Ocean-dwelling species that is widely distributed in tropical and sub-tropical seas. Usually found in tropical waters but also occur in coastal waters of NSW, where it is generally seen on the north or central coast, with occasional records from the south coast. Scattered nesting records along the NSW coast. Forage in shallow benthic habitats such as tropical tidal and sub-tidal coral and rocky reef habitat or inshore seagrass beds.	**Unlikely** – although the specifies may occur within the general area the high level of boating and absence of any foraging habitat at Barangaroo means its occurrence is unlikely. No sightings with 10km of Barangaroo.

Environment Protection and Biodiversity Conservation Act 1999

An EPBC Act Protected Matters Report was generated on 12 March 2015 for an area of 1 km around the Barangaroo South development site (see **Appendix C** for detailed search results). In summary, the *Matters of National Environmental Significance* and *Other Matters* listed under the EPBC Act for this area included:

- two (1) National Heritage Places (Sydney Harbour Bridge and Colonial Sydney in Macquarie Street);
- no Wetlands of International Importance;
- no Commonwealth Marine Areas;
- 1 Threatened Ecological Community (Coastal Upland Swamps in the Sydney Basin Bioregion);
- 46 Threatened Species;
- 53 Migratory Species;
- 8 Commonwealth Lands;
- 279 Places on the RNE;
- 56 Listed Marine Species;
- 1 Whales and other Cetaceans;

- no Critical Habitats; and
- no Commonwealth Reserves.

The Barangaroo site currently lacks appropriate habitat for most of the threatened or migratory species identified in the EPBC Act Protected Matters Report. The only two species listed under the EPBC Act with the potential to occur in this area and possibly impacted by the proposed development include the Loggerhead Turtle (*Caretta caretta*) and Green Turtle (*C. mydas*), see Table 3. However, occurrence of these species is unlikely due to the high level of boating movements in the area and lack of nesting habitat. In summary, it is considered that the development proposed under the modified Concept Plan would not impact upon any Matters of National Environmental Significance listed under the EPBC Act.

Table 3 Threatened species listed under the EPBC Act with the potential to occur at the study site

Species	Status	Habitat	Potential to Occur
Loggerhead Turtle *Caretta caretta*	Endangered / Migratory (EPBC Act)	Occur in the waters of coral and rocky reefs, seagrass beds and muddy bays throughout eastern, northern and western Australia. Nest on open, sandy beaches. Use a wide variety of tidal and sub-tidal habitat as feeding areas e.g. rocky and coral reefs, muddy bays, sandflats, estuaries and seagrass meadows.	**Unlikely** – species or species habitat likely to occur within Sydney Harbour but high boating movements in the area would reduce the likelihood of occurrence.
Green Turtle *Chelonia mydas*	Vulnerable / Migratory (EPBC Act) Vulnerable (TSC Act)	Ocean-dwelling species that is widely distributed in tropical and sub-tropical seas. Usually found in tropical waters but also occur in coastal waters of NSW, where it is generally seen on the north or central coast, with occasional records from the south coast. Scattered nesting records along the NSW coast. Forage in shallow benthic habitats such as tropical tidal and sub-tidal coral and rocky reef habitat or inshore seagrass beds.	**Unlikely** – species or species habitat likely to occur within Sydney Harbour but high boating movements in the area would reduce the likelihood of occurrence. . No sightings with 10km of Barangaroo.

Fisheries Management Act 1994

With the exception of aquatic vegetation, no threatened species under *Schedule 4 - Endangered species, populations and ecological communities, Schedule 4A – Critically endangered species and ecological communities,* or *Schedule 5 – Vulnerable species and ecological communities* of the FM Act (as listed in **Appendix D**) are expected to occur in the Barangaroo South area. Further, it is considered that the proposed works do not constitute a Key Threatening Process under *Schedule 6* of the FM Act.

Impacts:

No impact on any species of threatened fauna listed under the TSC Act, EPBC Act or FM Act is expected. The existing Barangaroo site does not contain any appropriate nesting or foraging habitat for any of the potential threatened species listed in Table 2 or Table 3, and due to the high

level of maritime development and boating activity in this area their presence is highly unlikely. In addition, each of the species listed in Table 2 and Table 3 has the ability to remove themselves from the area if conditions were unfavourable. Water velocities in the area are unlikely to significantly change as a result of the proposed development, thus no significant negative effect on the movement of fish species in Darling Harbour would be expected.

4.3 Water Quality and Sediments

4.3.1 Sydney Harbour Water Quality

ANZECC / ARMCANZ (2000) National Water Quality Guidelines for slightly disturbed estuarine ecosystems in south eastern Australia, and expected average water quality values for Australian estuaries (NSW Government, 1992) provide the following water quality guideline values for the Port Jackson estuary:

- Salinity: 35 parts per thousand (ppt)
- Turbidity: 0.5 – 10 nephelometric turbidity units (NTU)
- pH: 7.0 – 8.5
- Dissolved Oxygen (DO): 80 – 110% saturation; and
- Conductivity: 54, 000µS/cm (microsiemens per centimetre)

Hatje *et al.* (2001) collected data on the spatial and temporal variation in water quality parameters in the Port Jackson estuary. Mean salinity in the estuary ranged from around 18 ppt in the upper reaches to 35 ppt at the estuary mouth. The estuary was found to be generally well mixed and almost entirely saline under low flow conditions. Mean water temperatures in the estuary varied from 15.9±0.2 ºC in winter to 26.5±1.4 ºC in summer. Dissolved oxygen (DO) increased with increasing salinity and was found to be saturated at the surface. Low DO values (approximately 3 mg/L) were observed during spring in upper waters of the Parramatta River. pH increases were observed during summer. Suspended particulate matter concentrations (turbidity) tended to decrease seaward. High turbidity was associated with resuspension of bottom sediments, flood events, tidal resuspension and season (Hatje *et al.* 2001).

Impacts:

Localised short term water quality impacts from the proposed development are expected, however these can be mitigated effectively with the use of appropriate measures as described in Section 7.3.

4.3.2 Sydney Harbour Sediments

Port Jackson has a long history of contamination from both urban and industrial waste and is considered the most contaminated waterway on the eastern seaboard of Australia. This long history of contamination has resulted in extensive areas of polluted sediments (Birch, 1996; Birch and Taylor, 1999; Birch and Taylor, 2002; Hatje *et al.*, 2001). Stormwater discharges via canals are the main point source of contaminants to the estuary (Barry *et al.*, 2001), while the embayments of the harbour act as traps for these contaminants (Birch and Taylor, 1999). Industrial and urban pollution can severely affect the diversity and abundance of biodiversity in estuarine environments (Stark, 1998; Johnston and Roberts, 2009).

Heavy metals are amongst the most common contaminants in estuarine environments (Birch and Taylor, 1999). Surficial sediments over extensive areas of the Port Jackson estuary are contaminated by a range of metallic and organic contaminants (Hatje *et al.*, 2001; McCready *et al.*, 2006). Until the release of the ANZECC / ARMCANZ Interim Sediment Quality Guidelines in 2000 (Table 4), sediment quality guidelines for Australia were based on those from North America. Levels of heavy metals such as cadmium (Cd), copper (Cu), cobalt (Co), nickel (Ni), lead (Pb) and zinc (Zn) in marine sediments of the Port Jackson estuary can be exceptionally high, especially in the upper and central harbour and tributaries, with four of the six metals exceeding the North American Effects Range Low (ERL) Guidelines (the level at which some adverse biological response may be expected) (Birch, 1996; Birch and Taylor, 2002). In the central area of Sydney Harbour (approximate location of the Barangaroo site), Cu occurs at concentrations of 300 to 400 µg/g (30 to 40 times above background levels), Zn at concentrations of 600 to 1000 µg/g (13 to 21 times above background), Ni at concentrations of 42 to 50 µg/g (2 times above background levels), and Pb at 500 to 700 µg/g (15 to 21 times above background levels) (Birch, 1996). In addition to urban and industrial discharges, the extensive shipping in the estuary is thought to account for high sediment metal loadings (Birch, 1996). In high concentrations heavy metals can be toxic to marine organisms (ANZECC / ARMCANZ, 2000).

High levels of other contaminants such as polycyclic aromatic hydrocarbons (PAHs) (McCready *et al.*, 2000), chlorinated hydrocarbons (Hunt *et al.*, 2008) and organochlorides (Birch and Taylor, 2000; Matthai and Birch, 2000) are also known to occur in surficial sediments in Sydney Harbour.

Table 4 ANZECC/ARMCANZ (2000) Interim Sediment Quality Guidelines

Contaminant	ISQG-Low (Trigger value)	ISQG-High
METALS (mg/kg dry weight)		
Antimony	2	25
Cadmium	1.5	10
Chromium	80	370
Copper	65	270
Lead	50	220
Mercury	0.15	1
Nickel	21	52
Silver	1	3.7
Zinc	200	410
METALLOIDS (mg/kg dry weight)		
Arsenic	20	70
ORGANOMETALLICS (µg Sn/kg dry weight)		
Tributyltin	5	70
ORGANICS (µg/kg dry weight)		
Total PAHs	4,000	45,000

4.3.3 ERM Sediment Report Reviews

Since the Barangaroo site has been subjected to a wide range of potentially contaminating activities, it has been the focus of a number of environmental investigations. A summary of the key findings of the three most recent reports detailing contamination of land-based and marine sediments at Barangaroo (ERM, 2007; ERM, 2008a; ERM, 2008b) is provided below. As sediment quality guidelines do not exist for many of the contaminants tested for by ERM (e.g. Total Petroleum Hydrocarbons (TPH), Benzene, Toluene, Ethylbenzene and Xylenes (BTEX) compounds and sulfate) comparisons to the ANZECC (2000) Guidelines were not made. Instead, ERM adopted soil investigation levels and reported any exceedances in their assessments.

***Environmental Site Assessment, East Darling Harbour, Sydney, NSW* (ERM, 2007)**

ERM (2007) undertook a site assessment at East Darling Harbour to identify and document existing geotechnical and environmental site conditions (regarding land-based sediments) in preparation for development planning. The following results were reported:

Geology: A layer of silty / gravelly sand was encountered in all boreholes drilled at the Barangaroo site, varying in thickness from 0.5 to 21 m. In the central and southern portions of the site the fill layer was underlain by natural marine sediments generally comprising sandy clays.

Soils: Soils in the vicinity of the former gasworks and in the north and western portion of the site adjacent to Warehouse 3 were sampled for a comprehensive suite of contaminants commonly associated with former gasworks and industrial sites. The primary contaminants of concern exceeding the adopted soil investigation levels identified were as follows:

- Lead - concentrations up to 13,600 mg/kg;
- Copper - concentrations up to 1,410 mg/kg;
- PAHs - concentrations up to 13,660 mg/kg;
- TPH in the C_6 - C_9 fraction up to 1,140 mg/kg, and in the C_{10} – C_{36} fraction up to 24,440 mg/kg;
- BTEX - concentrations up to 140 mg/kg (benzene), 232 mg/kg (toluene), 63 mg/kg (ethylene) and 345 mg/kg (xylene);
- Sulfate - detected at concentrations of up to 31,500 mg/kg above the applicable criteria for protection of built structures in a number of samples in the vicinity of the former gasworks; and
- a number of samples had reported metal concentrations at levels above the NEPM (1999) Interim Urban Ecological Investigation Levels (EILs).

Groundwater**:** Groundwater at the Barangaroo site flows towards Sydney Harbour. Groundwater levels in groundwater wells indicates that there is a strong tidal influence, particularly in wells closest to the Harbour. Dewatering activities on the eastern side of Hickson Road may also be influencing groundwater flow direction. Analysis of groundwater samples showed that the majority of impacts seem to be related to the observed soil impact in the area of the former gasworks. The key contaminants of concern identified in groundwater were:

- PAHs - concentrations up to 23,350µg/L;
- TPH in the C_6 - C_9 fraction up to 31,500µg/L and in the C_{10} – C_{36} fraction up to 66,360µg/L;
- BTEX - concentrations up to 14,400µg/L (benzene), 5,740µg/L (toluene), 3,020µg/L (ethylene) and 6,700µg/L (xylene);
- Metals - cadmium at concentrations up to 34µg/L, copper up to 6µg/L, lead up to 555µg/L and zinc up to 764µg/L; and
- free cyanide - concentrations up to 11µg/L.

***Additional Investigation Works at Barangaroo, Hickson Road, Millers Point, NSW* (ERM, 2008a)**

In 2008, additional land-based investigation works were undertaken by ERM (2008a) at the Barangaroo site. This investigation returned the following results:

Areas of concern: The former gasworks and the reclaimed areas between the former finger wharfs were identified as areas of concern.

Soils: Exceedance of the assessment criteria for contaminants of potential concern (COPC) in soils were found in some samples collected across the Barangaroo site for lead, TPH, PAHs, BTEX and sulfate. Highest COPC concentrations were found in the footprint of the former gasworks.

Groundwater: Exceedance of assessment criteria for groundwater for dissolved TPH, BTEX and PAH compounds were found in groundwater samples located within the footprint of former gasworks. Exceedance of assessment criteria for groundwater was observed in wells screened across fill material, natural clayey sand and sandstone.

Hydrology / Receptors: Groundwater across the site was found to be heavily influenced by tidal fluctuations. High tide groundwater velocities were estimated at between 3.2 and 28m/day inland while low tide velocities ranged between 6.3 and 57m/day towards the harbour. A net groundwater flux into the Harbour at a velocity of between 0 and 7.6m/day was considered to be is likely under average conditions. As much of the site is likely to be subject to significant seawater flushing, Darling Harbour is a potential receptor for COPC migrating from the site. Primary migration pathways were identified as the bedding planes within sandstone bedrock, the highly permeable fill aquifer and anthropogenic pathways (e.g. utility conduits).

Free phase product: Free phase tar was observed in fill, natural soils and sandstone in and around the former gasworks. It was also found at depth (about 18m to 19m below ground level) approximately 40m from the site boundary with the harbour, indicating potential migration towards Darling Harbour.

***Preliminary Sediment Screening Works at East Darling Harbour, Adjacent to Barangaroo* (ERM, 2008b)**

ERM (2008b) undertook screening of marine sediments adjacent to the Barangaroo site to assess whether COPC may have migrated into sediments on the Harbour floor. Transects were taken adjacent to Barangaroo South (Transects 1 and 2), to the west of the former gasworks (Transects 3 to 5), in waters slightly north of the former gasworks (Transect 6) and adjacent to Barangaroo North (Transect 7). A summary of findings is provided below. It was concluded that a potential source of elevated COPC in marine sediments adjacent to the Barangaroo site may be the contaminated soil and groundwater which was earlier identified at the Barangaroo site (ERM 2007; ERM, 2008a).

Geology: The general sediment profile at the site consisted of silt to 0.2m below the harbour floor (bhf), underlain by silty sand to approximately 0.5m bhf, becoming silty clay with depth (max depth tested was 1.2m bhf). Shell fragments were observed between 0.5 and 1.0m bhf and many sediment core samples showed evidence of roots and decaying plant material. Some anthropogenic debris was also observed including rocks, chains, bricks, steel and old fencing.

Metals: Concentrations of metals exceeded the adopted screening values across the majority of the area sampled. Concentrations of all metals analysed were detected above the level of reporting (LOR) in one or more sediment samples analysed. The majority of samples across the site showed exceedance in screening values for copper, lead, mercury and zinc (Table 5). The majority of exceedances for arsenic and chromium were identified in sediments from Transect 4 which lie directly north of the site boundary.

Table 5 Summary of heavy metals analysis (ERM, 2008b)

Metal	Mean Concentration (mg/kg)	Maximum Concentration (mg/kg)	Number of Samples Exceeding Screening Values in the 85 Samples Analysed.
Arsenic	16	46	24
Chromium	34	134	1
Copper	83	626	63
Lead	123	236	80
Mercury	1.1	2.05	82
Zinc	259	603	72

Volatile TPH C_6 - C_9: Concentrations of volatile TPH in the C_6 - C_9 fraction were below the LOR in all samples analysed.

Semi - Volatile TPH C_{10} - C_{36}: Mean concentrations of TPH C_{10} - C_{36} were higher in sediment from Transects 2 to 6 than in Transects 1 and 7. Elevated concentrations of TPH C_{10} - C_{36} (> 1000mg/kg) were identified in five sediment samples collected from locations BGOT6D and BGOT2A. Maximum concentrations of TPH C_{10} - C_{36} were identified in sediment collected from Transect 6 (Table 6).

Table 6 Summary of TPH C_{10} - C_{36} Results (mg/kg) (ERM 2008b)

Parameter	Transects 1 and 7	Transects 2 to 6
Mean detected concentration	137	502
Maximum detected concentration	288	4484
Minimum detected concentration	29	25
Mean concentration (normalised)	174	340
Maximum concentration (normalised)	439	3476
Minimum concentration (normalised)	34	12

BTEX: Concentrations of BTEX compounds were below the LOR in all samples analysed.

PAHs: Concentrations of PAHs exceeded the screening values across the majority of the area sampled. Mean PAH concentrations were higher in Transects 2 to 6 than Transects 1 to 7 (Table 7). The maximum concentrations of PAHs were identified in Transect 6. The mean total PAH concentration in sediments collected from above 0.3m bhf (37mg/kg) was greater than those collected from below 0.3m bhf (29mg/kg). Concentrations generally decreased with distance from Transect 6 to the north and south.

Table 7 Summary of Total PAH results, normalised to 1% organic carbon (mg/kg) (ERM, 2008b)

Parameter	Transects 1 and 7	Transects 2 to 6
Mean concentration (normalised)	8.2	33.4
Maximum concentration (normalised)	16	503.5
Minimum concentration (normalised)	2.4	0.2

Phenols: Concentrations of phenols (normalised to 1% organic carbon) were below the LOR in all samples except for one.

Organochlorine Pesticides (OCPs): Concentrations of OCPs (normalised to 1% organic carbon) were below the LOR in all samples except for one.

Tributyltin (TBT): TBT concentrations were above the LOR in all except one of the samples analysed, and exceeded the screening value in 77 of the 85 samples analysed. No spatial trends in TBT were evident. TBT is not a contaminant normally associated with former gasworks sites. The likely source of TBT was considered to be associated with anti-fouling agents used on ships hulls rather than the former gasworks.

Total Organic Carbon (TOC): The mean concentration of TOC in sediments was 1.6%, likely resultant from high concentrations of silt and mud.

Sediment Grain Size: Particle size analysis was undertaken on 6 samples. Mean particle size was 44% of particles less than 0.063mm (silt and clay), 52% between 2 and 0.06mm (sand) and 4% greater than 2mm (gravel).

Water Quality Parameters: Water quality was measured at the surface (0.3m) and 5 m below the surface, with the following results recorded:

- temperature ranged from 16.5°C to 17.2°C with a mean of 16.8°C;
- pH ranged from 5.5 to 8.1 and was higher in surface waters with a mean pH of 7.3 at 0.3 m and 6.1 at 5 m;
- conductivity ranged from 51.0mS/cm to 58.9mS/cm with an average of 54.9mS/cm; and
- dissolved oxygen ranged from 8.7 ppm to 9.8 ppm with an average of 9.1 ppm.

Impacts:

The resuspension of contaminated seafloor sediments or release of contaminated land-based sediments or groundwater into the Harbour has the potential to impact on water quality and marine ecology. However, due to its history as a working harbour, contaminated sediments are common in Sydney Harbour. Moreover, the Mod 8 Globe Harbour concept has the significant benefit that excavation landward of the existing revetment would not be required, which reduces the risk of releasing contaminated land-based sediments and groundwater into the marine environment from the contaminated fill area landward of the revetment. By minimising suspension and spread of marine sediments during the construction phase, and preventing land based sediments from entering the harbor, the potential impact of contaminants associated with these sediments would be mitigated. The construction methods proposed in Section 2 and mitigative measures described in Section 7.3 would reduce the potential effects of these sediments to an acceptable level and ensure that any impacts were short-term and localised.

5. SURVEY METHODS

5.1 Field Conditions

Field surveys were undertaken on 5 and 6 May 2010 as part of the investigations required for the Mod 4 Concept Plan Amendment, for the purpose of providing site-specific and up to date information about the marine flora and fauna, water quality and marine sediments within the footprint of the Barangaroo South area. The observations made during these surveys are relevant to the present (Mod 8) assessment and have therefore been replicated below.

On 5 May 2010, weather conditions were unsettled and stormy. Winds were from the NNW at 15 to 21 knots in the morning and from the west at 13 to 17 knots in the afternoon. The sea state was choppy with 0.5m to 1 m swells. There were heavy rain periods throughout the day. Water temperatures ranged from 20.5 to 20.8°C at the surface and 20.6 to 21°C at mid depth (~ 6 m deep).

On 6 May 2010, the conditions were fine and sunny. Winds were from the west at 11 to 15 knots in the morning, shifting to the WSW at 10 to 14 knots in the afternoon. The sea state was moderately choppy. Water temperatures ranged from 18.8 to 21.2°C at the surface and 18.6 to 21°C at mid depth.

Predicted tides at Fort Denison on 5 and 6 May 2010 are provided in Table 8.

Table 8 Predicted tidal data during field surveys

5 May 2010			6 May 2010		
Tide	**Height (m)**	**Time (24hr)**	**Tide**	**Height (m)**	**Time (24hr)**
High	1.54	0037	**High**	1.47	0131
Low	0.60	0741	**Low**	0.62	0833
High	1.19	1341	**High**	1.22	1442
Low	0.81	1901	**Low**	0.82	2010

5.2 Data Collection

Marine surveys were conducted using:

- commercially qualified divers who undertook visual assessment of the seafloor, underwater photography and sediment coring; and
- remotely operated video transect techniques.

All underwater images were captured using a Canon Powershot G11 with a Cannon waterproof casing. Video transects were undertaken using a Delta Vision Industrial Pro Package with a 45m long cable, DVD player and LCD Monitor. All spatial data for sampling sites and video transects was collected using a Garmin GPS 60CSx.

5.3 Survey Locations

Three locations were sampled. These included one impact location (Barangaroo, adjacent to the Stage 1 development area) and two reference locations (Berrys Bay and Snails Bay). Reference locations were chosen in nearby bays taking into account their similar depth, substrate and proximity

to other similar foreshore structures. At each location, four sites were sampled using systematic grid based sampling (Figure 8). Due to high winds and anchoring limitations, two sites (SB3 and SB4) in Snail Bay were moved slightly further south of the pre-selected sample locations. Whilst depths were shallower at these locations, substrate types were the same between the impact location and this reference location. The locations and maximum depths recorded at each of the sampling sites are listed in Table 9.

Table 9 Location of sampling sites

Location	Site ID	Latitude	Longitude	Depth (m)
Barangaroo (BG) (impact)	BG1	-33.8656	151.201	13
	BG2	-33.8647	151.201	14
	BG3	-33.8635	151.201	14
	BG4	-33.8627	151.200	13
Berrys Bay (BB) (reference)	BB1	-33.8454	151.197	9.1
	BB2	-33.8446	151.197	10.1
	BB3	-33.8461	151.198	10.0
	BB4	-33.8465	151.199	13.4
Snails Bay (SB) (reference)	SB1	-33.8498	151.188	11.1
	SB2	-33.8502	151.189	11.8
	SB3	-33.849	151.183	4.8
	SB4	-33.8504	151.186	6.8

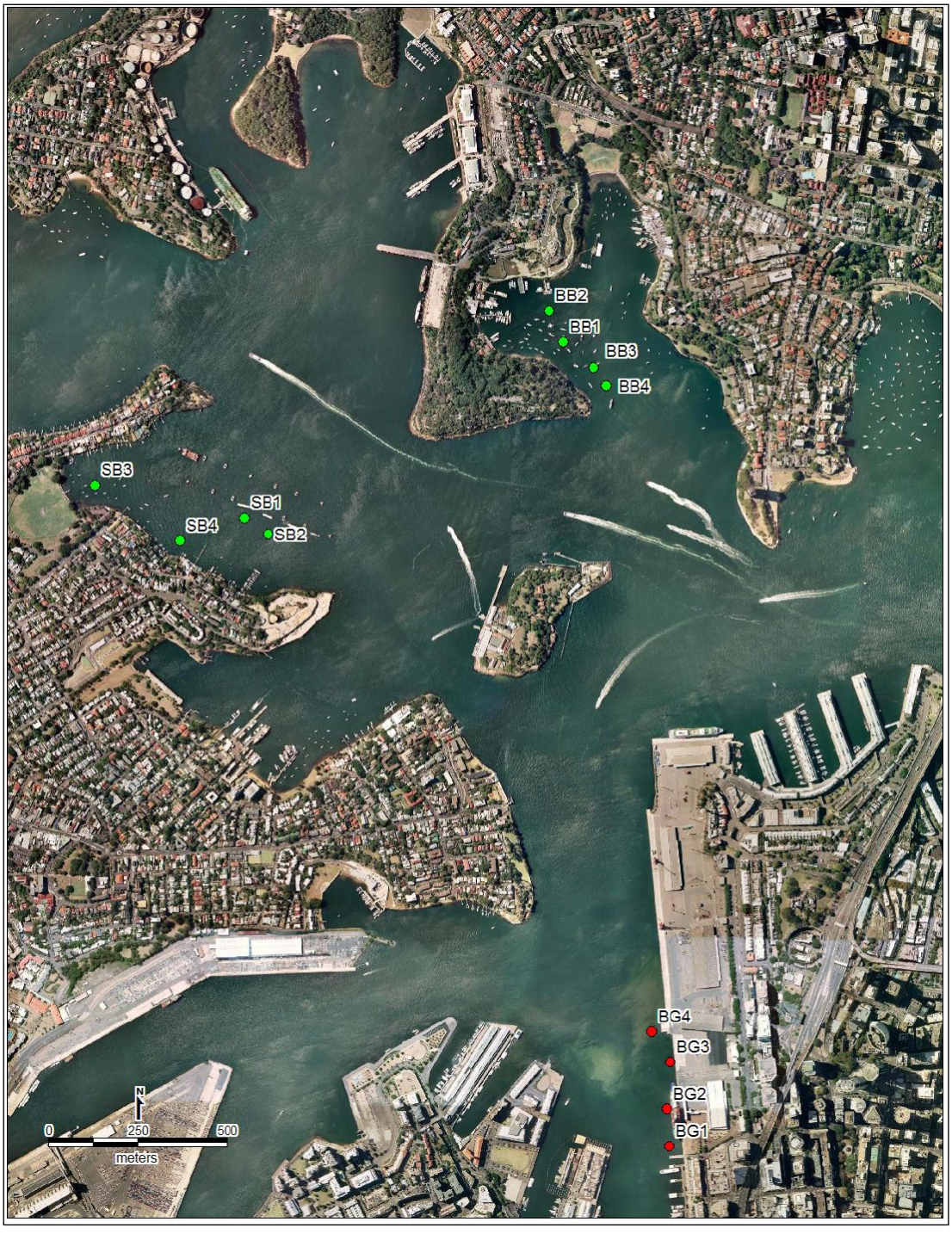


Figure 8: Location of sampling sites (red are impact sites and green are reference sites)

5.4 Water Quality

Water quality profiling was undertaken to provide background water quality data. Data was collected at the surface and at mid-depth (~ 6 m deep) at each sampling site using a TPS 90FL multi-parameter water quality meter. The water quality parameters measured included temperature (°C), salinity (ppt),

dissolved oxygen (DO), turbidity (NTU), pH and conductivity (µS/cm). For each location the mean, standard deviation and standard error of each of the water quality values for surface and mid-depth were calculated. Mean and standard error values are provided herein. The water quality parameter values obtained at each site were compared to the trigger values for slightly disturbed estuarine ecosystems in south east Australia as specified in ANZECC / ARMCANZ (2000), and the expected water quality values for Australian estuaries (NSW Government, 1992).

5.5 Sediment Sampling

Sediment sampling was undertaken to provide an overview of the particle size distribution of sediments at each of the sampling sites. Sediment samples were collected by diver coring at each sampling site (12 samples in total), using a 50mm polycarbonate core to a depth of 20cm. Particle size analyses were carried out by ALS Environmental (Warabrook) using the hydrometer method.

Analysis of heavy metals and other COPC in marine sediments adjacent to Barangaroo was undertaken by ERM (ERM, 2008b). The results of these analyses are summarised in Section 4.3.3.

5.6 Seabed Inspection and Mapping

Detailed inspection of the seafloor was undertaken within the footprint of the proposed Lend Lease development and at two reference locations (Figure 8). A total of four spot dives (sites) were undertaken by commercially qualified scientific divers at each location, to ascertain the seabed conditions and to determine the presence and extent of any sub-aquatic vegetation. Maximum depths at each site were recorded by divers using dive computers.

Underwater photography was used to record images of the seafloor. All underwater photos were captured using a Canon Powershot G11 with a Canon waterproof casing. In addition to underwater photography, four towed video transects were performed at the impact location, to provide a broader overview of the site and to confirm the presence or absence and extent of any sub-aquatic vegetation. Video transects were undertaken using a towed video system (Delta Vision Industrial Pro Package with 45m long cable, DVD player and LCD Monitor), deployed from the surface. The location of each video transect is shown in Figure 9.

The general location and length of each of the towed video transects was as follows:

- Transect 1: 113m, located adjacent to at the southern end of the development footprint;
- Transect 2: 77m, located adjacent to the southern end of the development footprint;
- Transect 3: 57m, located adjacent to the northern end of the development footprint at the approximate location of the proposed Public Pier; and
- Transect 4: 103 m, located in the central section of the development footprint.

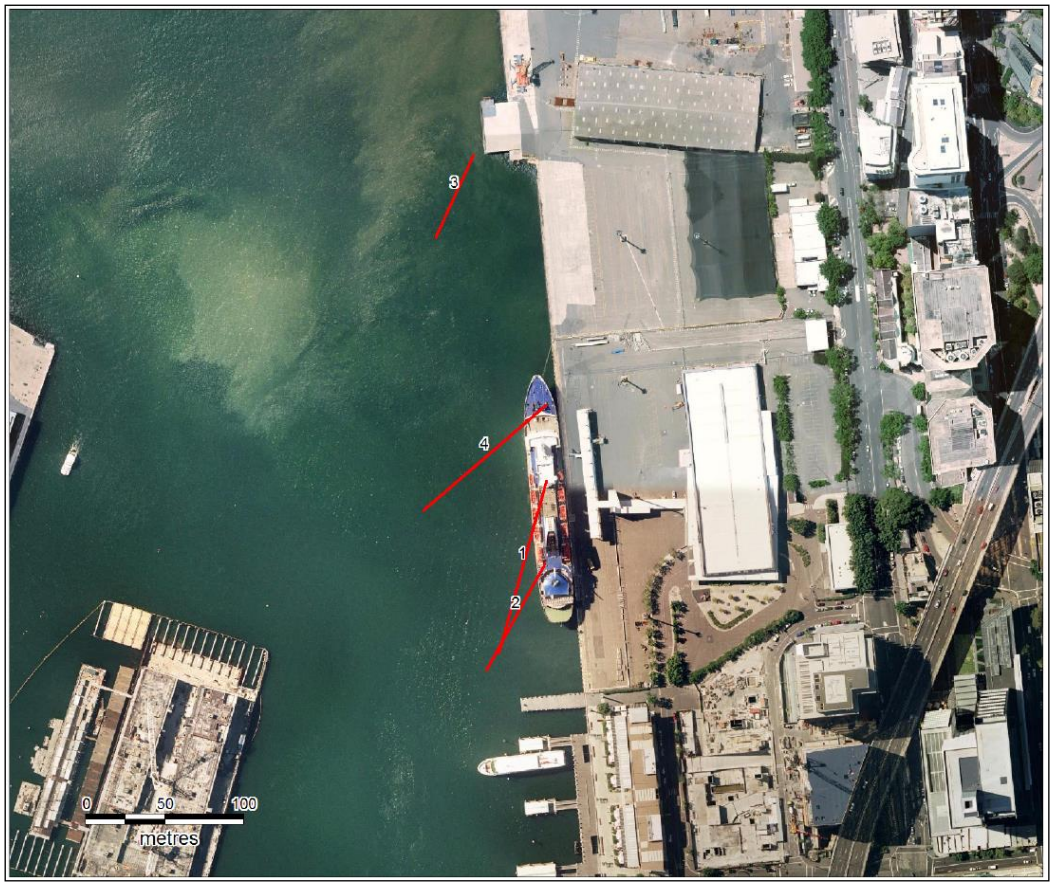


Figure 9: Locations of underwater video transects

5.7 Benthic Infauna Sampling

Benthic infauna samples were collected at each site from the impact location and the two reference locations (Figure 8). At each site divers collected three replicate benthic samples, at a distance of approximately 1m apart, using a 100mm diameter polycarbonate core to a depth of 25cm. The core was inserted into the seabed to its maximum depth, capped and then removed. Once removed, a bottom cap was inserted and the cores were returned to the surface. At the surface, samples were sieved through a 1mm mesh sieve and the retained material was placed in a plastic sample bag and preserved using formalin (4% formalin in final solution).

In the laboratory, samples were stained with Rose Bengal and sorted into taxonomic groups (to the lowest taxonomic level practicable). Data was analysed using Statistica Version 5. Tests for homogeneity of variance were undertaken using a means versus standard deviation test. Data was found to be normally distributed. Two-way ANOVA was used to examine differences in species diversity and abundance, between locations and between sites within locations. Regression analysis was undertaken to investigate correlations between grain size and species diversity and abundance.

6. EXISTING CONDITIONS

6.1 Water Quality

Water quality parameters were measured at the surface (~ 0.3 m below surface) and mid-depth at each site. The mean (± standard error) water quality values for each location are given in Table 10. Water quality values at all locations were generally within the expected values for estuaries in south eastern Australia, with slightly lower than expected conductivity values being the only exception. These lower conductivity values would have been due to freshwater (rainfall-runoff) inputs into the estuary.

Barangaroo

Water quality measurements indicated that physico-chemical conditions in Darling Harbour, in the vicinity of Barangaroo, were typical of a sub-tropical estuary in south eastern Australia. The average measured surface and mid-depth pH of 8.2 was within the general acceptable pH range (7 - 8.5) for subtropical eastern Australian estuaries (ANZECC / ARMCANZ, 2000). Average conductivity vales of 53,500µS/cm (surface) and 53,100µS/cm (mid-depth) were slightly below the ANZECC / ARMCANZ (2000) value of 54,000µS/cm. Turbidity in surface waters (average of 1.6NTU) was slightly higher than in mid-depths (average of 1.2 NTU) however, both values were within the general acceptable range (0.5 to 10 NTU) for subtropical eastern Australian estuaries (ANZECC/ARMCANZ, 2000). Dissolved oxygen concentrations of 8.2mg/L (surface) and 8.1mg/L (mid-depth), equating to percentage saturation values of approximately 88% and 86% respectively, were also within the acceptable range of 80 to 100% saturation. Mean surface water temperature at Barangaroo was 19°C and the mid-depth temperature was 19.2°C. This was somewhat higher than the Sydney Harbour average for May (winter) of 15.9°C ± 0.2°C (Hatje *et al.*, 2001), likely attributed to uncharacteristically warmer air temperatures.

Berrys Bay

Water quality measurements indicated that physico-chemical conditions at the Berrys Bay reference location were also typical of a sub-tropical south eastern Australian estuary. Average surface and mid-depth pH values of 8.2 were within the general acceptable pH range (ANZECC / ARMCANZ, 2000). As was the case at Barangaroo, average conductivity vales of 53,400µS/cm (surface) and 53,200 µS/cm (mid-depth) were slightly below the ANZECC / ARMCANZ (2000) value. Turbidity in surface waters and at mid-depth averaged 1.1 NTU, and was within the general acceptable range for subtropical eastern Australian estuaries (ANZECC / ARMCANZ, 2000). Dissolved oxygen concentrations of 7.9mg/L (surface and mid-depth), equating to % saturation values of about 86%, were slightly below the Barangaroo values, but also within the acceptable range. Mean surface water temperature at Berrys Bay was 20.8°C and mid-depth temperature was 20.7°C. These values are higher than the Harbour winter average (Hatje *et al.*, 2001).

Snails Bay

Water quality measurements indicate that physico-chemical conditions at Snails Bay were typical of a sub-tropical estuary in south eastern Australia. The average surface and mid-depth pH of 8.1 was within the general acceptable pH range for subtropical eastern Australian estuaries (ANZECC / ARMCANZ, 2000). Average conductivity values of 53,100µS/cm (surface) and 53,000µS/cm (mid-depth) were slightly below the ANZECC / ARMCANZ (2000) value and lower than at the other two locations. Turbidity in surface waters at Snails Bay (average of 1.6 NTU) was slightly lower than

turbidity in mid-depths (average of 2.1 NTU) and turbidity values were higher than at the other two locations. However, both values were within the general acceptable range for subtropical eastern Australian estuaries (ANZECC / ARMCANZ, 2000). Dissolved oxygen concentrations of 8.2mg/L (surface) and 7.8mg/L (mid-depth), equating to % saturation values of approximately 88% and 84% respectively, were also within the acceptable range. Mean surface water temperature was 19.4°C and mid-depth temperature was 19.3°C, higher than the Harbour winter average (Hatje *et al.*, 2001).

Table 10 Average water quality values (with standard errors in brackets) for surface and mid-depth at each survey location

Location	Depth	pH	Conductivity (µS/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L) / % saturation	Temperature (°C)
Barangaroo	Surface	8.2 (0.026)	53,500 (0.335)	1.6 (0.28)	8.2 (0.038) / 88%	19.0 (0.14)
	Mid-depth	8.2 (0.016)	53,100 (0.103)	1.2 (0.041)	8.1 (0.063) / 86%	19.2 (0.042)
Berrys Bay	Surface	8.2 (0.010)	53,400 (0.096)	1.1 (0.18)	7.9 (0.10) / 85%	20.8 (0.14)
	Mid-depth	8.2 (0.008)	53,200 (0.092)	1.1 (0.10)	7.9 (0.096) / 87%	20.7 (0.11)
Snails Bay	Surface	8.1 (0.014)	53,100 (0.165)	1.6 (0.12)	8.2 (0.075) / 88%	19.4 (0.25)
	Mid-depth	8.1 (0.015)	53,000 (0.075)	2.1 (0.33)	7.8 (0.019) / 84%	19.3 (0.25)
ANZECC / ARMCANZ (2000), NSW Government (1992)		7 to 8.5	54,000	0.5 to 10	80 to 100%	-
Hajte *et al.* (2001)		Increases in summer	-	Decreases seaward	More saturated at the water surface	15.9±0.2°C (winter) to 26.5±1.4°C (summer)

Impacts:

Localised short term water quality impacts from the proposed development are expected, however these can be mitigated effectively with the use of appropriate measures as described in Section 7.3.

6.2 Sediment Particle Size Analysis

Sediment samples collected at each site were analysed for particle size distribution by ALS Environmental using the hydrometer method based on a minimum size of 75µm. No testing of heavy metals or other contaminants was undertaken on the sediments collected as this has previously been investigated by ERM (2008b) as discussed in Section 4.3.3.

Overall, sediments at all locations sampled comprised high proportions of clay, silt and sand, with little or no gravel or cobble recorded (most sites had readings of < 1% for gravels and cobbles), see Figure 10 and **Appendix E**. Silt was the most common constituent of the sediments at all locations. While silt was most abundant at Berrys Bay, the proportions of silt did not differ considerably between the three locations. Barangaroo had significantly more clay than the two reference locations and Snails Bay had the highest percentage of sands. Sediments at Berrys Bay had the highest percentage of gravel, of about 2%. Sediment classification results for each site at each location based on particle size are shown in Table 11 to Table 13.

Sediment from individual sites showed considerable variation in composition. Most notable at Barangaroo was the high proportion of clay in the sediment collected from Site 1 (southern end of the sampling area). The findings of the sediment particle size analysis were consistent with the locations sampled being in the Central Mud Basin Geomorphic Zone of the Port Jackson estuary (Roy, 1984; Mesley, 2003).

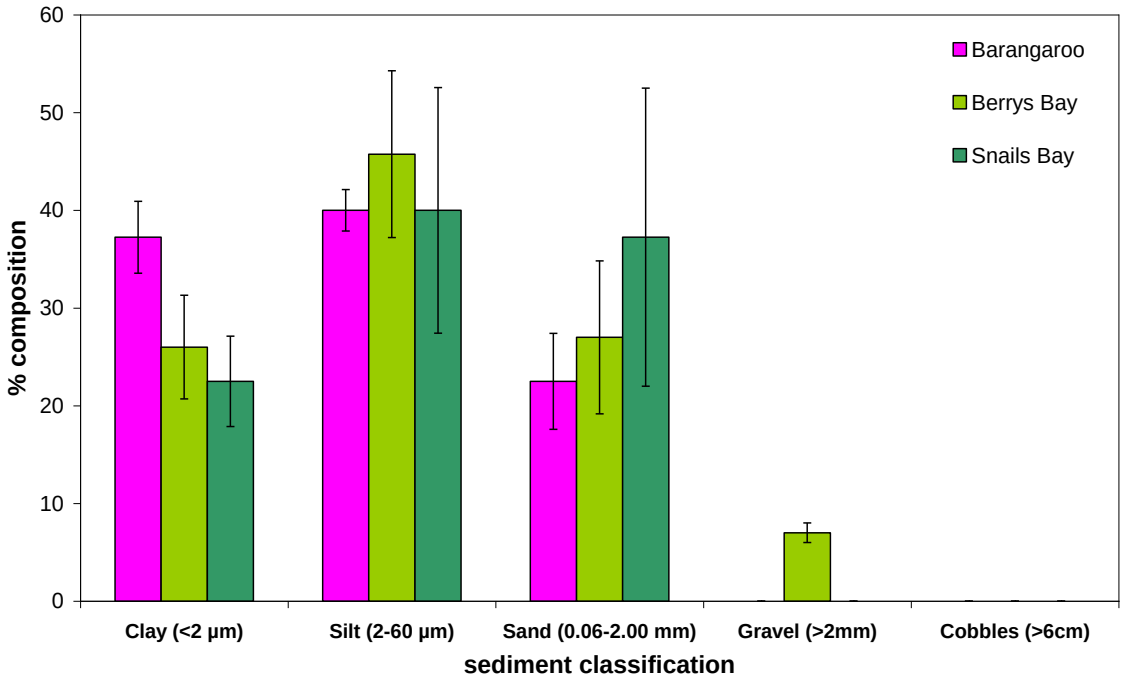


Figure 10: Classification of sediments at each location (bars represent standard error)

Table 11 Classification of sediments at Barangaroo based on particle size analysis

Sediment Classification	Site				Mean (± SE)
	BG1	BG2	BG3	BG4	
Clay (< 2µm)	48	36	32	33	37.3 (3.7)
Silt (2 - 60µm)	41	41	34	44	40.0 (2.1)
Sand (0.06 to 2mm)	10	23	34	23	22.5 (4.9)
Gravel (> 2 mm)	1	< 1	< 1	< 1	< 1
Cobbles (> 6cm)	< 1	< 1	< 1	< 1	< 1

Table 12 Classification of sediments at Berrys Bay based on particle size analysis

Sediment Classification	Site				Mean (± SE)
	BB1	BB2	BB3	BB4	
Clay (< 2µm)	29	22	39	14	26.0 (5.3)
Silt (2 - 60µm)	28	69	42	44	45.8 (8.5)
Sand (0.06 to 2mm)	38	9	19	42	27.0 (7.8)
Gravel (> 2mm)	5	< 1	< 1	< 1	1.8 (1.0)
Cobbles (> 6cm)	< 1	< 1	< 1	< 1	< 1

Table 13 Classification of sediments at Snails Bay based on particle size analysis

Sediment Classification	Site				Mean (± SE)
	SB1	SB2	SB3	SB4	
Clay (< 2µm)	21	30	10	29	22.5 (4.6)
Silt (2 - 60µm)	63	60	14	23	40.0 (12.6)
Sand (0.06 to 2mm)	16	10	76	47	37.3 (15.3)
Gravel (> 2mm)	< 1	< 1	< 1	1	< 1
Cobbles (> 6cm)	< 1	< 1	< 1	< 1	< 1

6.3 Aquatic Ecology

6.3.1 Benthic Habitat / Marine Flora

Impact Location - Barangaroo

The benthic habitat in Darling Harbour, adjacent to Barangaroo, consisted of clayey, silty, sandy sediments. Considerable bioturbation was evident across the entire site, presumably from burrowing organisms, such as polychaete worms and invertebrate crustaceans (see Figure 11 and Figure 12). The substrate towards the southern end of the development contained a high proportion of clay and was relatively undisturbed. Much of the substrate here had a 'honeycomb' type appearance. The middle and northern sections of the site contained a higher percentage of silt than the southern area. The underwater terrain was relatively flat across the site, with little evidence of features showing movement such as sand ripples. Video transects provided evidence of areas of dense shell rubble, possible organic materials (e.g. dark woody looking objects), occasional sponges and discarded anthropogenic objects on the seabed (Figure 12). No aquatic vegetation was observed by divers, or was reported on the underwater video transects.

Seagrass / Mangroves / Saltmarsh

No seagrass was observed during spot dives, or on the video transects undertaken at the study site. The water depth (~ 13 m) and associated low light penetration would presumably restrict the growth of seagrasses in the footprint of the proposed Lend Lease development. No mangroves or areas of saltmarsh were observed at, or near, the proposed development during the site visit. The site currently lacks appropriate substrate and habitat for such vegetation to occur.

Wetland Areas

During the site visit a sandstone seawall was found to extend for several hundred meters along the foreshore, where a Wetlands Protection Area is currently mapped at Balmain East. A number of private jetties also extended into the harbour there. Macroalgae was evident growing on subtidal rocks below the footing of the seawall. McLoughlin (2000) undertook a study examining the current extent of wetland vegetation along the Parramatta River, and suggested that some of the assumptions regarding the former extent of mangroves (which were based upon a variety of historical data sources), on which recent studies and foreshore plans were based, were inappropriate.

Introduced Marine Flora

No introduced marine algae *Caulerpa taxifolia* was observed during the spot dives or on video transects undertaken at the study site. It is possible that the oysters observed growing on the pylons at the north of the site were the Pacific Oyster, *Crassostrea gigas.*

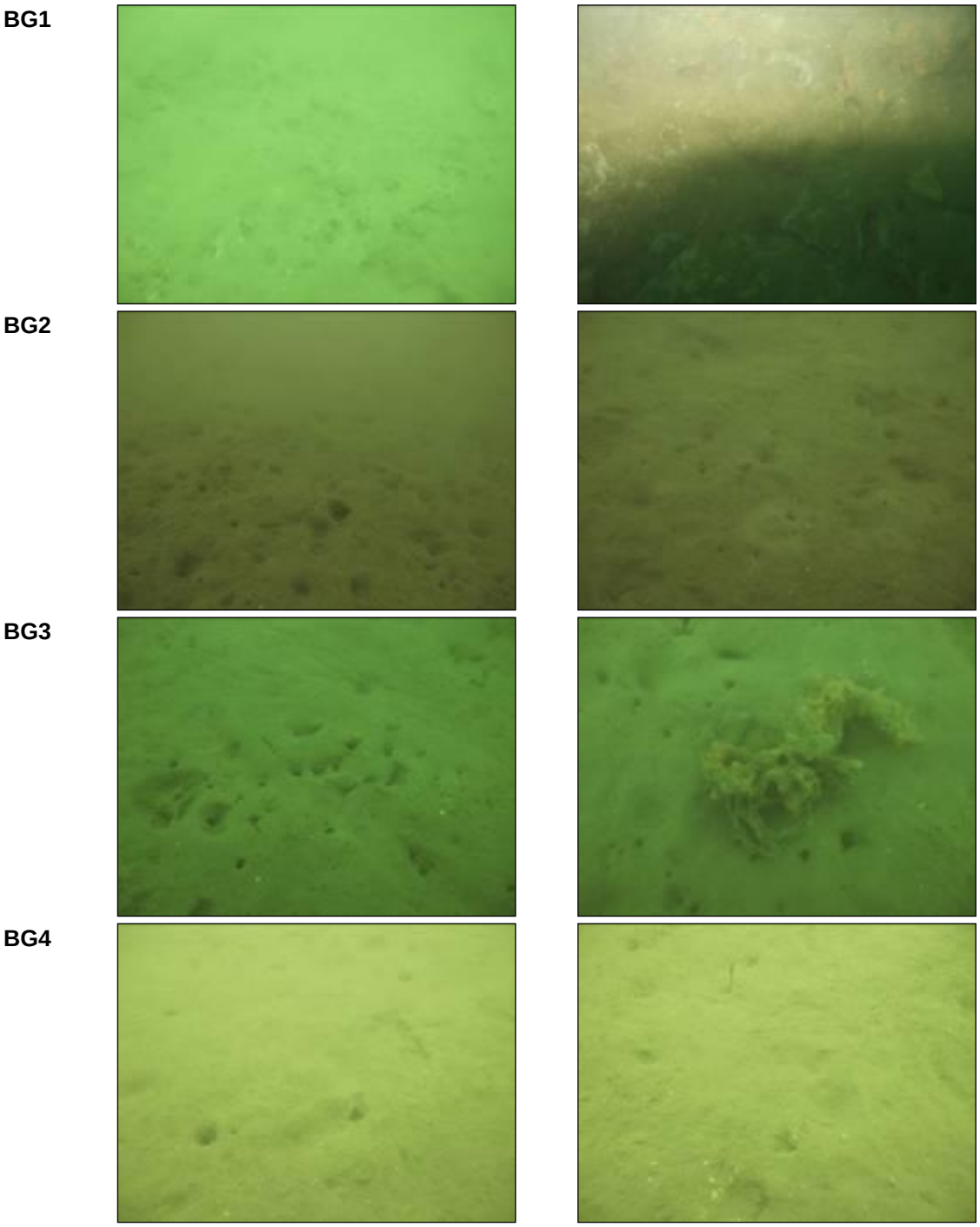
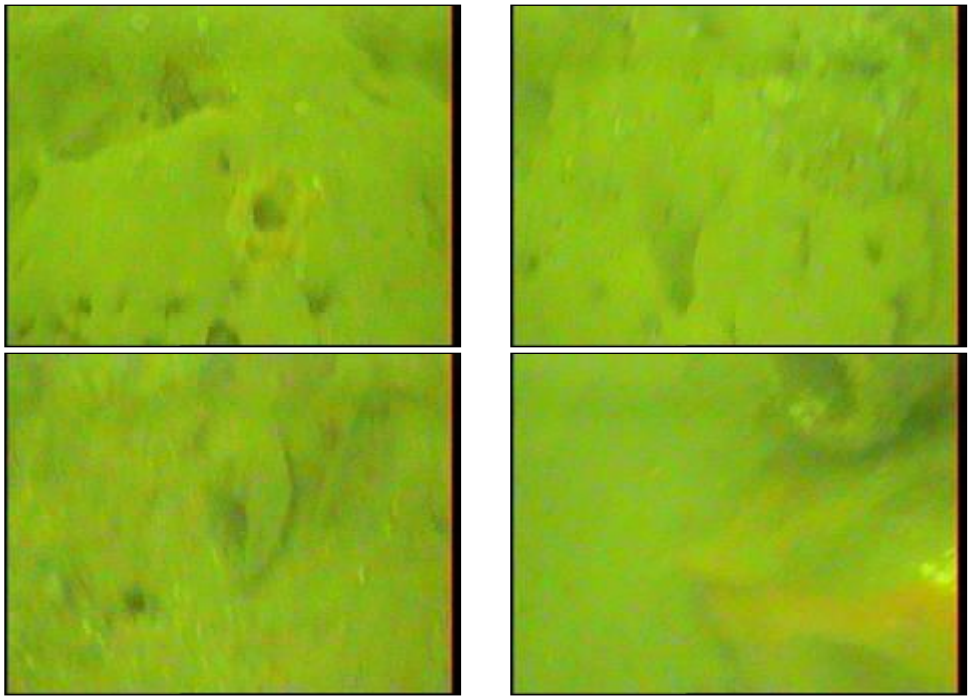
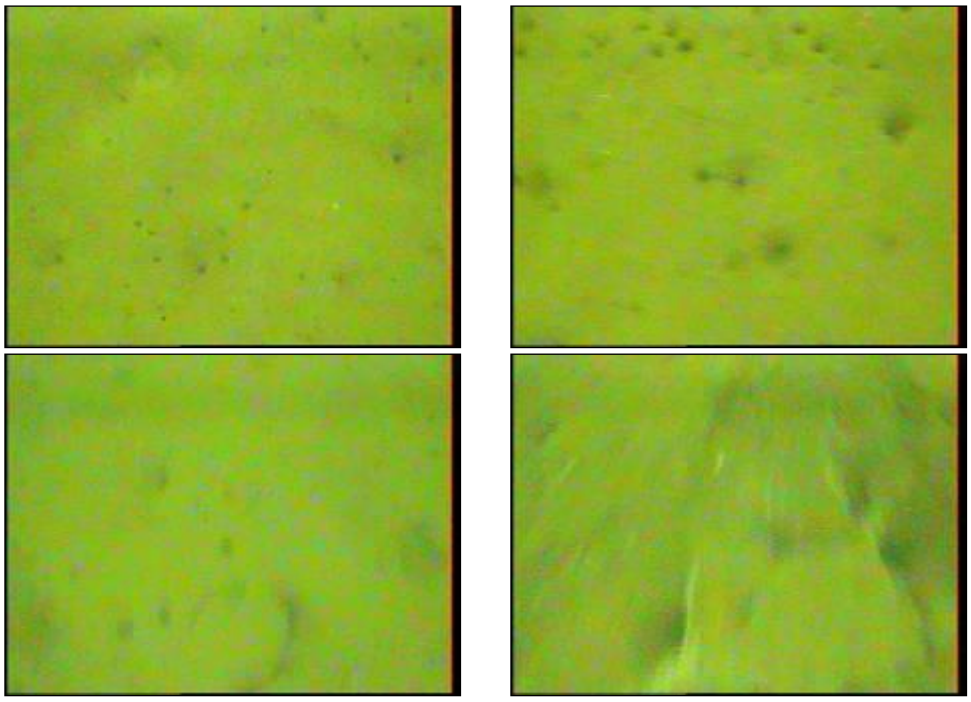


Figure 11: Benthic habitat at Barangaroo captured by diver photography

Transect 1



Transect 2



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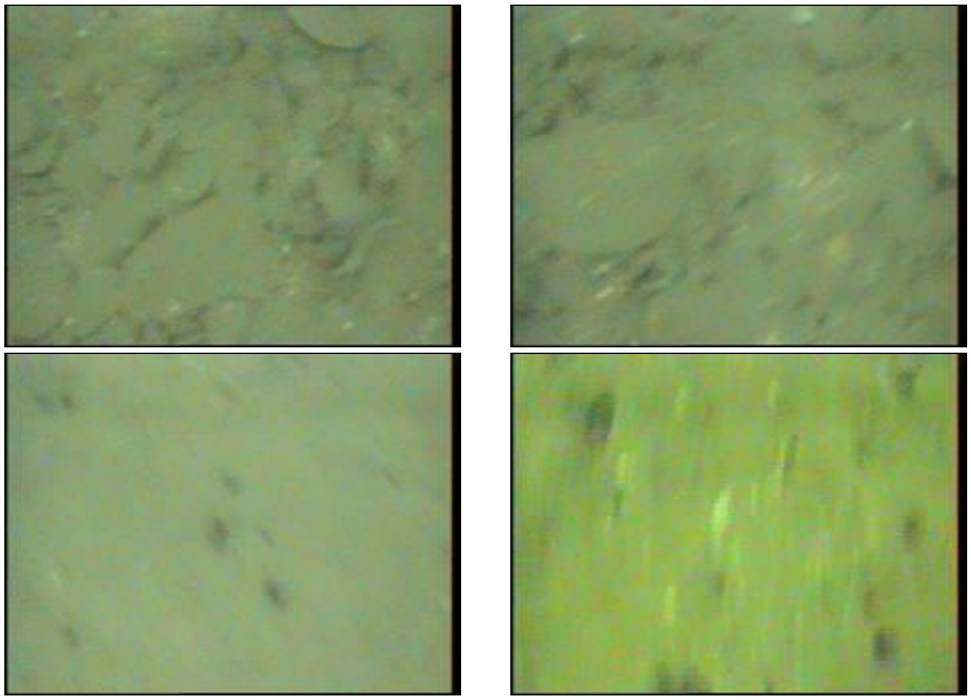

Transect 4

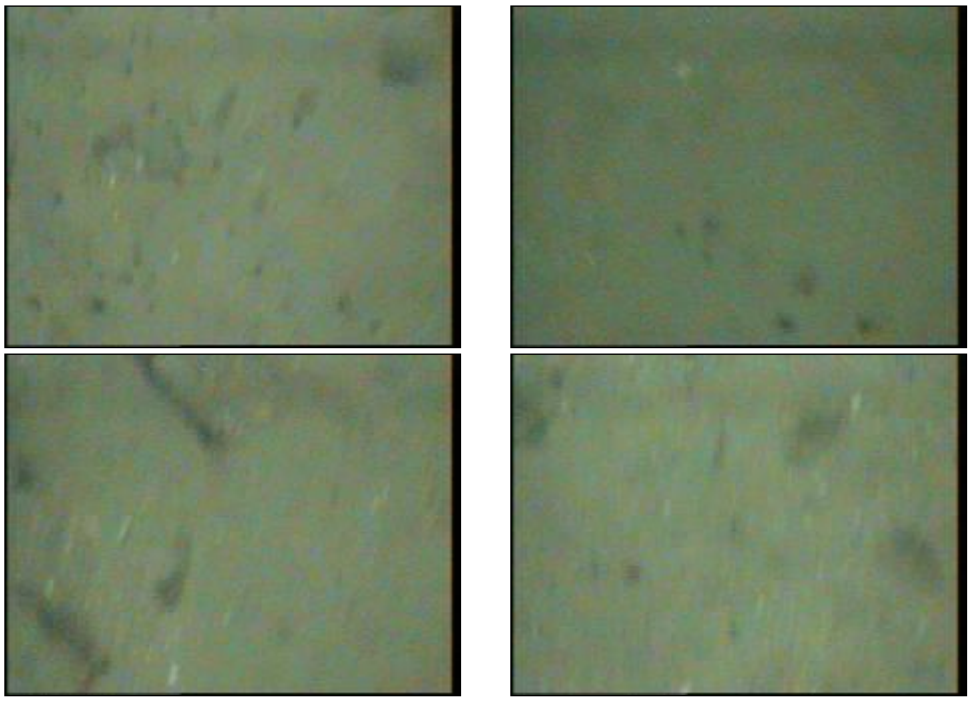

Figure 12: Benthic habitat at Barangaroo captured on video transects

Impacts:

Due to the lack of aquatic vegetation in the vicinity of the Barangaroo South area, no impacts on these sensitive habitats are expected.

Reference Location 1 - Berrys Bay

The benthic habitat at Berrys Bay consisted of silty sediments, with coral rubble and patchy subtidal reef evident at Sites 1, 2 and 4 (Figure 13). At these sites, sponges and colonial ascidians were present. Bioturbation of the sediments was observed at all sites within Berrys Bay, but no aquatic vegetation was observed during any of the spot dives that were undertaken.

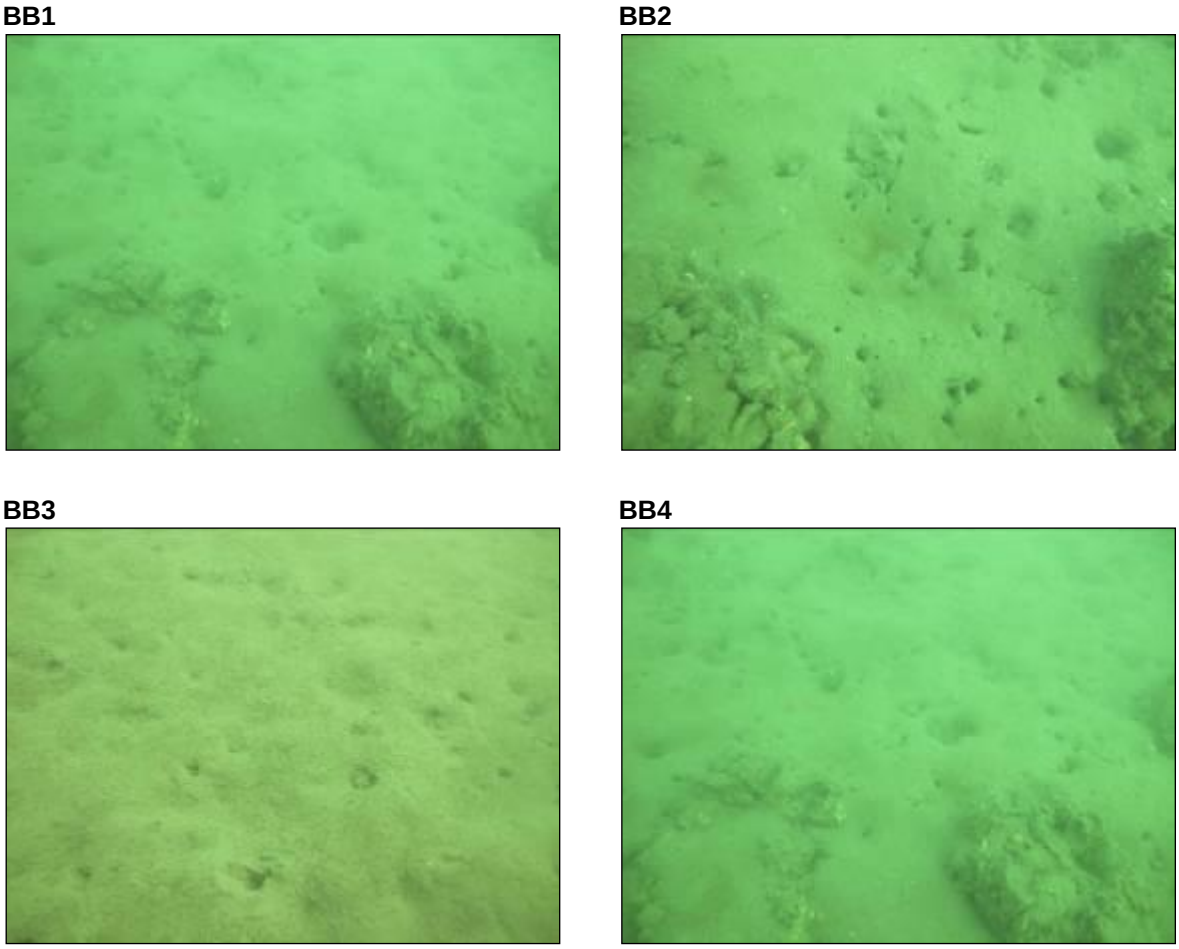

Figure 13: Benthic habitat at Berrys Bay captured by diver photography

Reference Location 2 - Snails Bay

The benthic habitat at Snails Bay comprised soft silty sand. Bioturbation was apparent at all sites, with evidence of burrowing invertebrate crustaceans and polychaete worms. A small clump of the large brown macroalgae, *Ecklonia radiata*, was observed at Site 4, close to the shoreline. Aquatic fauna including a Numb Ray (*Hypnos monopterygium*) and a number of unidentified fish species were also observed in Snails Bay. Photographs of the benthic habitat at Snails Bay are provided in Figure 14.

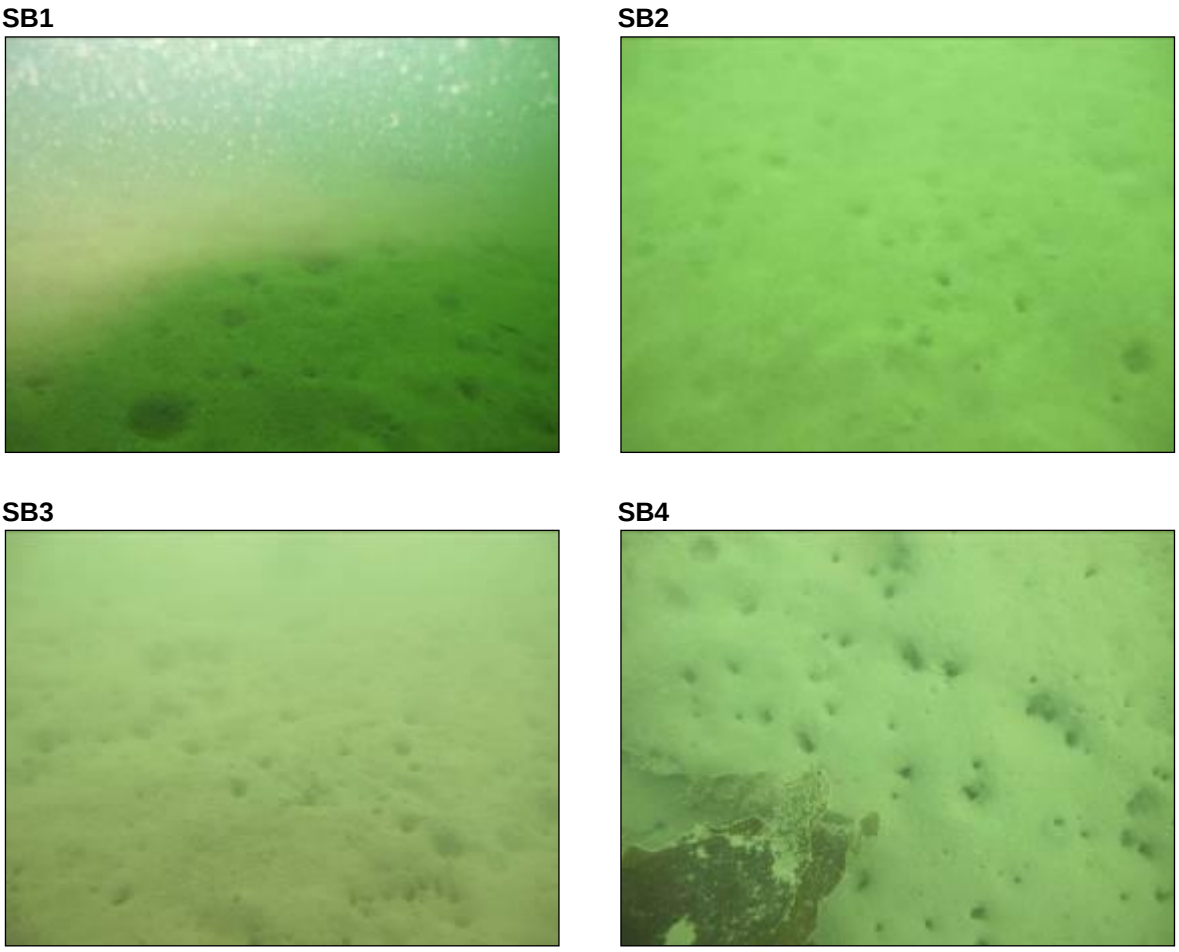

Figure 14: Benthic habitat at Snails Bay captured by diver photography

6.3.2 Marine Fauna (Benthic Infauna)

A diverse range of benthic marine organisms were identified in sediments from Barangaroo, Berrys Bay and Snails Bay including polychaete worms, amphipods (e.g. yabbies and shrimps), crustaceans (e.g. crabs, shrimps, isopods), ascidians (sea squirts), cnidarians (polyps found), brittle stars, bivalves (e.g. clams) and gastropods (marine slugs), see **Appendix F** for raw data.

Species Diversity

There were no significant differences in species diversity between locations ($p > 0.05$), or between sites (Two-way ANOVA, $df = 2$, $F = 1.4$, $p > 0.05$). There was a difference in species diversity between sites within locations ($df = 6$, $F = 7.9$, $p = 0.00$). Infauna diversity was not homogeneous across the locations, likely attributed to differences in substrate type, whereby, the southern end of Barangaroo was dominated by clayey silts and the centre and southern ends by silt. The regression analysis indicated that as sediment size increased, species diversity decreased (multiple $R = - 0.67$). Refer to Table 14 and Table 15.

Table 14 ANOVA - Species Diversity - Summary of all Effects

	df effect	MS effect	df error	MS error	F	p-value
Location	2	3.08333	24	2.194444	1.405063	0.264819
Site	3	5.03704	24	2.194444	2.295359	0.103383
Sites within locations	6	17.34259	24	2.194444	7.902954	0.000090

Table 15 Regression Analysis - Species Diversity

	BETA	SE of BETA	B	SE of B	T(10)	p-value
Intercept			9.245494	1.683759	5.49099	0.000265
PSA	-0.665240	0.236105	- 0.064948	0.023051	- 2.81756	0.018237

Regression Summary for Dependent Variable: SPECDIV
R= 0.66523978 R^2 = 0.44254397 Adjusted R^2 = 0.38679837
F(1,10) = 7.9386 p < 0.01824 Std. Error of estimate: 1.5261

Species Abundance

There were no significant differences in abundance between locations (*df* = 2, *F* = 1.3, *p* > 0.05). There was a difference in abundance between sites (df = 3, F = 4.1, p = 0.018) and between sites within locations (*df* = 6, *F* = 8.5, *p* = 0.00). Like species diversity, abundance was also variable across locations, also likely attributable to substrate types. The regression analysis indicated that as sediment size increased, species abundance decreased (multiple *R* = - 0.82). Refer to Table 16 and Table 17.

Table 16 ANOVA - Species Abundance - Summary of all Effects

	df effect	MS effect	df error	MS error	F	p-value
Location	2	24.1944	24	18.58333	1.301943	0.290532
Site	3	76.1481	24	18.58333	4.097658	0.017558
Sites within locations	6	157.1204	24	18.58333	8.454907	0.000054

Table 17 Regression Analysis – Species Abundance

	BETA	SE of BETA	B	SE of B	T(10)	p-value
Intercept			27.49646	4.025570	6.83045	0.000046
PSA	- 0.820080	0.180961	- 0.24975	0.055111	- 4.53180	0.001088

Regression Summary for Dependent Variable: ABUND
R = 0.82007957 R^2 = 0.67253050 Adjusted R^2 = 0.63978355
F(1,10) = 20.537 p < 0.00109 Std. Error of estimate: 3.6486

Impacts:

Any localised impacts on benthic infauna from activities such as piling would be considered to be negligible considering the widespread availability of similar benthic habitat in Sydney Harbour.

7. BARANGAROO DEVELOPMENT RISK (IMPACT) ASSESSMENT

7.1 Description of Proposed Works

The methods which are most likely to be used in the construction of the Globe Harbour, Community Building and Public Pier, northern jetty and ferry terminals were outlined in Section 3. The impact assessment outlined below is based on the general impacts of the proposed construction methods.

7.2 Potential Impacts of Construction

The proposed construction methods for the Globe Harbour, Community Building and Public Pier, northern jetty and ferry terminals could potentially generate a number of short term environmental impacts, which could affect the marine environment. Where appropriate, mitigation measures are discussed in Section 7.3. Potential impacts include:

Waste: Removal of the existing caisson walls and wharf / jetty structure may generate waste which has the potential to impact on the health of the marine environment in Darling Harbour if appropriate mitigation and waste disposal measures are not undertaken. Any wastewater discharges from the site have the potential to affect water quality in Darling Harbour.

Noise: Noise impacts on marine and terrestrial biota are expected over the duration of the works (e.g. from engines, generators, and construction equipment). However, mobile marine and terrestrial fauna have the ability to relocate to other areas during construction and no significant impacts are expected.

Marine Construction Equipment: The use of boats and barges during piling works for the Public Pier, northern jetty and ferry terminals would result in disturbance to benthic habitat through activities such as anchoring. Minimisation of anchoring impacts can be achieved by undertaking as much of the construction work as possible on land, and to reduce the time required for barges to be anchored. Anchoring would not occur in any sensitive environments such as seagrass beds as these do not occur in the vicinity of the proposed development. These vessels also have the potential to cause pollution through fuel and oil leaks. Potential impacts of fuel and oil leaks can be mitigated by making available spillage equipment so that any accidental spills or leaks can be absorbed immediately. Booms or silt curtains would also mitigate against spread of accidental leakages.

Water Quality: Proposed construction works have the potential to impact on water quality in Darling Harbour as follows:

- Piling associated with construction of the Public Pier, northern jetty and ferry terminals has the potential to generate localised short term increases in turbidity through resuspension of sediments.
- Resuspension of bottom sediments may cause the remobilisation of any associated heavy metals and other contaminants into the water column. If appropriate mitigation measures are not taken these contaminants have the potential to disperse into less polluted areas of the Harbour, potentially affecting fish, algae and invertebrates.

Stormwater: Variability in stormwater discharges from the site would alter freshwater input into Darling Harbour, varying salinity levels. However, since estuarine environments such as Sydney Harbour are naturally variable in salinity due to freshwater inputs (mean salinity in the estuary ranges from around 18 ppt in the upper reaches to 35 ppt at the estuary mouth) this would not likely have a significant effect on the aquatic fauna or flora in the area.

Benthic Infauna: Placement of piles and other structures into the seabed would displace soft sediment benthic habitat, crushing any associated benthic fauna. However, the high availability of similar benthic habitat in Sydney Harbour would suggest that benthic communities such as those recorded at Barangaroo would be widespread and thus any localised impacts from activities such as piling would be considered to be negligible at a broader scale. Contaminated sediments can have a significant impact on the diversity and abundance of marine organisms, reducing richness and evenness of communities (Clements, 2004; Millward *et al.*, 2004; Johnston and Roberts, 2009). However, considering the history of contamination of sediments in the harbour it would be expected that these benthic organisms have adapted to cope with such inputs.

Mobile fauna: Mobile fauna, such as fish and sharks, may be impacted by the presence of barges and by noise generated during construction works. However, due to the current high levels of boating activity in Darling Harbour these effects are likely to be negligible.

Mobile phytoplankton and bacteria can be affected by small-scale resuspension of contaminated sediments (Nayar *et al.* 2004).

Water velocities under and near the Public Pier and northern jetty would not be significantly altered, and therefore there is not likely to be any negative effect on fish species inhabiting Darling Harbour or enhanced mobilisation of existing bed sediments.

Sessile Organisms: Although removal of the existing caisson wall and wharf / jetty structure would eliminate the artificial habitat for sessile invertebrates which currently exists at the site, the Public Pier, northern jetty and associated structures would increase the surface area of habitat available for sessile marine fauna. In addition, ecological enhancements are being considered in the foreshore design of Globe Harbour, therefore there could be a more positive outcome for sessile invertebrates. It is expected that both intertidal and subtidal habitats would be increased, given materials used for construction are not deleterious to marine life (e.g. no anti-fouled surfaces or treated wood).

Although sessile organisms do not have the ability to move away from undesirable conditions, recent research in Sydney Harbour has found that small in-frequent disturbance of contaminated sediments does not significantly impact on sessile marine organisms such as ascidians and bryozoans, presumably as they have evolved to deal with frequent natural changes in water conditions within estuaries such as salinity and turbidity (Knott and Johnston, 2010). Since any disturbance of sediments would be mitigated, short-term and highly localised, the potential disturbance of sediments at the site is unlikely to have any significant impacts on sessile marine organisms in the vicinity.

Aquatic Vegetation: Physical disturbance and increased sedimentation can seriously degrade seagrass beds through direct removal, smothering and / or reduced light intensity (Poiner and Peterken, 1995; Smith and Pollard, 1999). Suspension of sediments can also smother the photosynthetic surfaces of algae (Knott and Johnston, 2010). In addition, new structures such as the Public Pier, northern jetty and ferry terminals have the potential to impact on light availability to the seabed. However, no seagrass or other aquatic vegetation was observed in the footprint of the proposed development during the site inspections undertaken in May 2010 for the Mod 4 investigations, by divers or on the underwater video. In addition, no aquatic vegetation has been mapped in the area by DPI (2005). Further, the wetland area mapped at Balmain East was found to be dominated by seawalls and pontoons, rather than wetland vegetation. Due to the lack of aquatic vegetation in the vicinity of the Barangaroo South area, no impact on this sensitive habitat is expected.

Threatened and Protected Species: The proposed Lend Lease development is not expected to have a significant impact on any threatened or protected species of flora or fauna. No aquatic vegetation protected under the FM Act is present in the vicinity of the proposed development. The only species of aquatic fauna which have the potential to occur in the area include the Little Penguin, Loggerhead Turtle and Green Turtle. However, appropriate habitat for these species does not exist at the site, and due to high level of maritime development and boating activity in this area their presence is unlikely. In addition, each of these species has the ability to remove themselves from the area if conditions are unfavourable.

Introduced Species: The dominant fauna observed on the pylon structures, at the northern end of the site were oysters. These may have been the introduced pest species Pacific Oyster (*C. gigas*). Removal of these structures would reduce the available habitat for this species.

Key Threatening Processes: Construction of the Public Pier and Globe Harbour should not be considered as key threatening processes under Schedule 6 of the FM Act in terms of "installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams": This is because water velocities under and near these areas would not be significantly altered as a result of the development.

7.3 Mitigation Measures

To minimise the impacts associated with the construction of Globe Harbour, Community Building and Public Pier, northern jetty and ferry terminals it is recommended that the following mitigation measures be implemented:

Solid Waste: To minimise solid waste impacts the following should be undertaken:

- removal of all construction waste from the site;
- preventing any waste from entering the Harbour;
- managing all waste in accordance with the EPA's Environmental Guidelines – Assessment, Classification and Management of Liquid and Non-Liquid Wastes;
- preparing and implementing a detailed Construction Environment Management Plan (CEMP) for the proposed development in which waste is addressed; and
- ensuring that all waste associated with barges and boats is contained and disposed of appropriately.

Stormwater / Wastewater: Any water generated from dewatering activities should be monitored to ensure that water quality conditions (i.e. site specific trigger limits) are suitable for returning wastewaters back into the Harbour (where applicable). The requirements for this monitoring program are outlined in Lend Lease (2011). Should water quality not be suitable (i.e. exceeds adopted water quality trigger limits), then these waters should be treated, or disposed of offsite e.g. to trade waste discharges or liquid waste facilities, in accordance with OEH requirements. Wastewater and additional stormwater discharges to the Sydney Harbour should be avoided where possible. All wastewater on site should be contained during construction and treated appropriately. Wastewater or stormwater should be assessed prior to discharge by comparison to the relevant water quality objectives and environmental values for Sydney Harbour estuarine waters.

Noise: Noise should be managed in accordance with the *NSW DECC Noise Control Guidelines – Construction Site Noise* (DECC, 2008). Silencers should be used on engines and machinery where possible to minimise noise impacts on marine and terrestrial biota.

Water Quality: To minimise water quality impacts the following should be undertaken:

- any construction activities associated with the seawalls, caissons, and existing embankment should limit the creation of turbid plumes into the marine environment, adjacent to the Barangaroo foreshore by utilising appropriately designed and positioned silt curtains, installed prior to the commencement of operations;
- ongoing implementation of the *Water & Stormwater Management Sub-Plan for Barangaroo Stage 1* (Lend Lease, 2011) in which erosion and sediment management are addressed;
- water quality monitoring should be undertaken (in accordance with protocols set out in the CWQMP (Lend Lease, 2011) surrounding the development, to ensure that water quality conditions are maintained beyond the silt curtains and in the broader area;
- having site spillage equipment available at the site to absorb any spills that may enter the water; and
- following construction of the Globe Harbour, the silt curtain should remain in place until turbidity levels within the Globe Harbour return to background conditions, reflective of levels outside of the silt curtain and at the nominated reference locations (see CWQMP).

Habitat Loss

It is noted that the Globe Harbour is proposed as a civic / urbane place for the gathering of people and a focal point of the public domain associated with the high density mixed use precinct of Barangaroo Stage 1. Structures that facilitate and encourage people to interact and engage with the water in the Globe Harbour area in an intimate manner may not be conducive to diverse habitat creation. However, it is noted that the proposed Northern Cove and the adjacent Headland Park at the north of the site pose a much greater opportunity for marine habitat creation at Barangaroo. The proposed Northern Cove has a greater depth, width, area and planned variety of foreshore types, while the proposed Headland Park has a greater foreshore area and length together with shoreline construction diversity.

To increase habitat complexity and species diversity, and to reduce the likelihood of colonisation of novel habitats created by introduced marine species (Glasby *et al.*, 2007) construction of any seawalls should be undertaken according to *Environmentally Friendly Seawalls* (DECC, 2009) as follows:

- incorporation of estuarine and riparian vegetation (this can only be undertaken where a seawall does not directly front deep waters) where appropriate (i.e. Headland Park and Northern Cove), for example:
    - step seawalls with mangrove / saltmarsh benches;
    - native riparian buffer landward of seawall.
- maximise habitat diversity and complexity where appropriate, (i.e. Headland Park and Northern Cove), for example:
    - use various sized / shaped boulders;
    - add cavities and pools that retain water at low tide;
    - do not cement between blocks to create crevices;
    - incorporate rubble toes for vertical seawalls;
    - utilise natural building materials;
    - utilise irregularly shaped and / or weathered blocks;

  - incorporate protruding / indented blocks; and
  - include concrete panels with indentations and exposed aggregate.
- Use low-sloping seawalls where appropriate, (i.e. Headland Park and North Cove), for example:
  - gentle slopes,
  - changes of slope, e.g. benches and steps.

8. CONCLUSIONS

The report herein has been prepared to provide an assessment of the potential marine ecology impacts associated with the proposed development with regard to the Mod 8 Concept Plan Amendment.

Marine field surveys were undertaken adjacent to the Barangaroo site and at two reference sites within Sydney Harbour (Berrys Bay and Snails Bay) in May 2010 to support the Mod 4 Concept Plan Amendment. This provided a description of the existing environment and allowed an assessment of the potential impacts of the Mod 4 development elements. The observations made during these surveys are relevant to the present (Mod 8) assessment and have therefore been utilised herein.

The DGRs addressed herein and a brief summary of the relevant findings are provided below. It is considered that the information contained within this report including background information, description of existing conditions, description of proposed works and mitigative measures satisfies all of the DGRs.

1. Assess the potential impacts due to construction and operations on water quality, marine vegetation and aquatic ecology.

Water Quality: Piling associated with construction of the Public Pier, northern jetty and ferry terminals has the potential to generate localised short term increases in turbidity through resuspension of sediments. Resuspension of bottom sediments has the potential to cause remobilisation of associated heavy metals and other contaminants into the water column. Once resuspended, these contaminants have the potential to affect fish, algae and invertebrates.

In comparison to the previously proposed Southern Cove (Mod 4), the Globe Harbour (Mod 8) concept has the significant benefit that excavation landward of the existing revetment would not be required. This reduces the risk of releasing contaminated land-based sediments and groundwater into the marine environment from the contaminated fill area landward of the revetment.

The construction methodologies associated with the Public Pier, northern jetty and Globe Harbour have been considered and it is concluded that by employing industry standards and mitigation measures, any impacts of the proposed development on water quality within Darling Harbour are expected to be negligible, localised and short-term in nature.

Marine Vegetation: No marine vegetation was recorded in the vicinity of the proposed development during field surveys, nor is any marine vegetation mapped by NSW DPI (2005) in the immediate area. Due to the lack of aquatic vegetation at or in the vicinity of Barangaroo, no impacts on these habitats are expected.

Aquatic Ecology: The placement of piles and other structures into the seabed would displace soft sediment benthic habitat and any associated benthic infauna. However, the abundance of similar benthic habitat in Sydney Harbour suggests that benthic communities such as those recorded at Barangaroo would be widespread and thus, any localised impacts from the potential development on benthic invertebrate communities of Sydney Harbour would be considered to be negligible.

Mobile fauna such as fish and sharks may be impacted in the short term by the presence of barges and by noise generated during construction works. However, due to the current high levels of boating activity in Darling Harbour these effects are likely to be negligible.

Removal of the existing structures at Barangaroo would eliminate existing artificial habitat for sessile invertebrates. However, new intertidal and subtidal habitats would be created at Barangaroo South. In addition, ecological enhancements are being considered in the foreshore design of Globe Harbour, therefore there could be a more positive outcome for sessile invertebrates. It should also be noted that small infrequent disturbance of contaminated sediments does not significantly impact on sessile marine organisms such as ascidians and bryozoans. Therefore, it is unlikely that there would be any significant impact on sessile communities residing in the vicinity of the proposed works.

The proposed Stage 1 development would not have any significant impact on any threatened or protected species of flora and fauna. Due to the high level of boating activity and lack of suitable feeding and nesting habitats at Barangaroo, it is highly unlikely that any species of threatened fauna listed under the TSC Act or EPBC Act , which have the potential to occur in Sydney Harbour, would utilise this area. Further, no aquatic vegetation protected under the FM Act is present in the vicinity of the proposed development.

In summary, if effectively mitigated using the industry standard methods and techniques described herein, any potential impacts on water quality and aquatic ecology arising from the proposed Mod 8 works would be negligible, temporary and localised.

2. ***Assess potential impacts on aquatic habitats from changes to the quantity, quality and discharge of stormwater from the site.***

It is expected that during development construction works, all stormwater and wastewater onsite would be contained, collected, decontaminated / treated and discharged to either the sewage network (under trade waste agreement) or stormwater system. The water quality monitoring program that is currently being implemented would continue throughout the construction period to ensure that water quality conditions (i.e. site-specific trigger limits) are satisfactory prior to discharge to sewer or into the harbour via stormwater. In the case that treated water is discharged to the harbor, the increased freshwater input would cause localised decreases in salinity levels. However, due to the naturally high variability in salinity levels in estuarine environments such as Sydney Harbour, this is unlikely to have a significant effect on the aquatic fauna or flora in the area. In the case where untreated water was to enter the Harbour, the mitigation measures put in place for water quality management would mean that any impacts would be localised and negligible.

In the longer term, upon completion of construction, principles of Water Sensitive Urban Design (WSUD) are proposed to improve the quality of any stormwater discharge to Darling Harbour. Stormwater is proposed to be collected for reuse within the development (e.g. as a source of irrigation) and therefore the quantity of stormwater discharged to Darling Harbour is expected to reduce from current levels.

3. ***Assess the geotechnical and contamination issues associated with the construction of the Landmark Building and associated pier / promenade.***

To mitigate against possible mobilisation of existing contaminated sediments, any activities not conducted in the dry, such as pile driving, should employ industry standard and appropriate techniques as described herein. Prior to such activities, silt curtains should be installed around the work area and water quality monitoring should be undertaken surrounding the development, to ensure that water quality conditions are maintained beyond the silt curtains and in the broader area. Piled foundations for the proposed Public Pier, northern jetty and ferry terminal would be founded at

appropriate depths below the existing harbour bed. On this basis, contamination issues associated with laying of the foundations are expected to be readily managed within acceptable levels.

In summary, it is concluded that through thoughtful design, detailing and construction methodology, and by employing the appropriate industry standard mitigate measures described herein, the proposed development would be unlikely to have any significant impacts on the marine environment (including water quality impacts and impacts on flora and fauna), with any impacts being short-term in nature and highly localised.

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Appendix A:
NSW Marine Habitat Assessment Guidelines

NSW MARITIME

Marine Habitat Survey

Why is it required?

- NSW Maritime owns the bed of Sydney Harbour and its tributaries, and is responsible for the conservation of and protection of the marine environment.
- There has been a significant loss of habitat, and NSW Maritime requires information to assess impacts in the marine environment.

When do applicants need to provide a marine habitat survey?

- When applying for Land Owner's Consent or development under Part 5 of the Environmental Planning and Assessment Act 1979.
- Where a structure or activity has the potential to impact on marine habitat.

What information is required?

- scaled plans showing the existence of any vegetation below mean high water mark (mangroves, seagrass varieties etc) within a minimum of 20m of the proposal
- details of the survey area and sampling method
- photographs of the sampling area
- description of dominant habitats and species, including their sensitivity to change and the incidence of threatened species
- the nature of the inter-tidal and sub-tidal zone (sand, rock etc)
- direct and indirect impacts on marine habitat of the proposal both during and after construction
- proposed mitigation measures both during and after construction
- proposed monitoring of impacts after construction

Who conducts the habitat surveys?

- Suitably qualified marine ecologists.
- You can refer to the Yellow Pages under Environmental Consultants or Natural Resource Consultants.

Appendix B1:
Threatened Species Conservation Act 1995
2010 Search

NSW National Parks & Wildlife Service
atlas of nsw wildlife

Search Results

Your selection: Fauna, threatened species, LGA - SYDNEY HARBOUR (UNINCORPORATED) returned a total of 54 records of 24 species.
Report generated on 12/04/2010 - 16:50 (Data valid to 11/04/2010)

view map | search again | clear selection

Choose up to 3 species to map.
** Exotic (non-native) species*

Aves	Map	Scientific Name	Common Name	Legal Status	Count	Info
Accipitridae						
	☐	Pandion haliaetus	Osprey	V	2	
Anseranatidae						
	☐	Anseranas semipalmata	Magpie Goose	V	1	
Ardeidae						
	☐	Ixobrychus flavicollis	Black Bittern	V	1	
Burhinidae						
	☐	Burhinus grallarius	Bush Stone-curlew	E1	1	
Charadriidae						
	☐	Charadrius mongolus	Lesser Sand-plover	V	1	
Diomedeidae						
	☐	Diomedea exulans	Wandering Albatross	E1	1	
	☐	Thalassarche melanophris	Black-browed Albatross	V	1	
Haematopodidae						
	☐	Haematopus fuliginosus	Sooty Oystercatcher	V	2	
	☐	Haematopus longirostris	Pied Oystercatcher	E1	1	
Laridae						
	☐	Sterna albifrons	Little Tern	E1	1	
	☐	Sterna fuscata	Sooty Tern	V	2	
Procellariidae						
	☐	Puffinus carneipes	Flesh-footed Shearwater	V	1	
Psittacidae						
	☐	Lathamus discolor	Swift Parrot	E1	1	
Spheniscidae						
	☐	Eudyptula minor	Little Penguin in the Manly Point Area (being the area on and near the shoreline from Cannae Point generally northward to the point near the intersection of Stuart Street and Oyama Cove Avenue, and extending 100 metres offshore from that shoreline)	E2	5	
Strigidae						
	☐	Ninox strenua	Powerful Owl	V	2	

Mammalia	Map	Scientific Name	Common Name	Legal Status	Count	Info
Balaenidae						

☐ Eubalaena australis	Southern Right Whale	V	3	
Balaenopteridae				
☐ Megaptera novaeangliae	Humpback Whale	V	1	
Otariidae				
☐ Arctocephalus forsteri	New Zealand Fur-seal	V	2	
☐ Arctocephalus pusillus doriferus	Australian Fur-seal	V	8	
Peramelidae				
☐ Perameles nasuta	Long-nosed Bandicoot, North Head	E2	2	
Pteropodidae				
☐ Pteropus poliocephalus	Grey-headed Flying-fox	V	9	
Vespertilionidae				
☐ Miniopterus australis	Little Bentwing-bat	V	1	
☐ Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	V	3	

Reptilia Map	Scientific Name	Common Name	Legal Status	Count	Info
Cheloniidae					
☐	Chelonia mydas	Green Turtle	V	2	

** Exotic (non-native) species*

Choose up to 3 species to map.

Appendix B2:
Threatened Species Conservation Act 1995
2015 Search

Data from the BioNet Atlas of NSW Wildlife website, which holds records from a number of custodians. The data are only indicative and cannot be considered a comprehensive inventory, and may contain errors and omissions. Species listed under the Sensitive Species Data Policy may have their locations denatured (^ rounded to 0.1°; ^^ rounded to 0.01°). Copyright the State of NSW through the Office of Environment and Heritage. Search criteria : Public Report of all Valid Records of Threatened (listed on TSC Act 1995) Animals in selected area [North: -33.8 West: 151.14 East: 151.24 South: -33.9] returned a total of 526 records of 35 species.
Report generated on 12/03/2015 3:57 PM

Kingdom	Class	Family	Species Code	Scientific Name	Exotic	Common Name	NSW status	Comm. status	Records	Info
Animalia	Amphibia	Myobatrachidae	3116	*Pseudophryne australis*		Red-crowned Toadlet	V,P		6	
Animalia	Amphibia	Hylidae	3166	*Litoria aurea*		Green and Golden Bell Frog	E1,P	V	3	
Animalia	Aves	Anseranatidae	0199	*Anseranas semipalmata*		Magpie Goose	V,P		9	
Animalia	Aves	Columbidae	0023	*Ptilinopus superbus*		Superb Fruit-Dove	V,P		7	
Animalia	Aves	Diomedeidae	0086	*Diomedea exulans*		Wandering Albatross	E1,P	E,J	1	
Animalia	Aves	Ardeidae	0197	*Botaurus poiciloptilus*		Australasian Bittern	E1,P	E	1	
Animalia	Aves	Ardeidae	0196	*Ixobrychus flavicollis*		Black Bittern	V,P		2	
Animalia	Aves	Accipitridae	0223	*^Erythrotriorchis radiatus*		Red Goshawk	E4A,P,2	V	1	
Animalia	Aves	Accipitridae	0225	*Hieraaetus morphnoides*		Little Eagle	V,P		1	

Animalia	Aves	Burhinidae	0174	*Burhinus grallarius*	Bush Stone-curlew	E1,P		4
Animalia	Aves	Haematopodidae	0130	*Haematopus longirostris*	Pied Oystercatcher	E1,P		1
Animalia	Aves	Scolopacidae	0161	*Calidris ferruginea*	Curlew Sandpiper	E1,P	C,J,K	8
Animalia	Aves	Laridae	0117	*Sternula albifrons*	Little Tern	E1,P	C,J,K	2
Animalia	Aves	Cacatuidae	0265	*^Calyptorhynchus lathami*	Glossy Black-Cockatoo	V,P,2		2
Animalia	Aves	Psittacidae	0260	*Glossopsitta pusilla*	Little Lorikeet	V,P		2
Animalia	Aves	Psittacidae	0309	*^^Lathamus discolor*	Swift Parrot	E1,P,3	E	3
Animalia	Aves	Strigidae	0246	*^^Ninox connivens*	Barking Owl	V,P,3		2
Animalia	Aves	Strigidae	0248	*^^Ninox strenua*	Powerful Owl	V,P,3		143
Animalia	Aves	Tytonidae	9924	*^^Tyto tenebricosa*	Sooty Owl	V,P,3		1
Animalia	Aves	Meliphagidae	0603	*Anthochaera phrygia*	Regent Honeyeater	E4A,P	E	2
Animalia	Aves	Meliphagidae	0448	*Epthianura albifrons*	White-fronted Chat	V,P		1
Animalia	Aves	Meliphagidae	0448	*Epthianura albifrons*	White-fronted Chat population in the Sydney Metropolitan Catchment Management Area	E2,V,P		1

Animalia	Aves	Estrildidae	0652	*Stagonopleura guttata*	Diamond Firetail	V,P		1
Animalia	Mammalia	Dasyuridae	1008	*Dasyurus maculatus*	Spotted-tailed Quoll	V,P	E	1
Animalia	Mammalia	Dasyuridae	1009	*Dasyurus viverrinus*	Eastern Quoll	E1,P		1
Animalia	Mammalia	Peramelidae	1097	*Perameles nasuta*	Long-nosed Bandicoot population in inner western Sydney	E2,P		14
Animalia	Mammalia	Burramyidae	1150	*Cercartetus nanus*	Eastern Pygmy-possum	V,P		2
Animalia	Mammalia	Pteropodidae	1280	*Pteropus poliocephalus*	Grey-headed Flying-fox	V,P	V	229
Animalia	Mammalia	Molossidae	1329	*Mormopterus norfolkensis*	Eastern Freetail-bat	V,P		10
Animalia	Mammalia	Vespertilionidae	1346	*Miniopterus australis*	Little Bentwing-bat	V,P		1
Animalia	Mammalia	Vespertilionidae	1834	*Miniopterus schreibersii oceanensis*	Eastern Bentwing-bat	V,P		56
Animalia	Mammalia	Vespertilionidae	1357	*Myotis macropus*	Southern Myotis	V,P		1
Animalia	Mammalia	Otariidae	1543	*Arctocephalus forsteri*	New Zealand Fur-seal	V,P		2
Animalia	Mammalia	Otariidae	1882	*Arctocephalus pusillus doriferus*	Australian Fur-seal	V,P		4
Animalia	Mammalia	Balaenidae	1561	*Eubalaena australis*	Southern Right Whale	E1,P	E	1

Appendix C:
EPBC Act Protected Matters Report

Australian Government

Department of the Environment

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 12/03/15 16:33:24

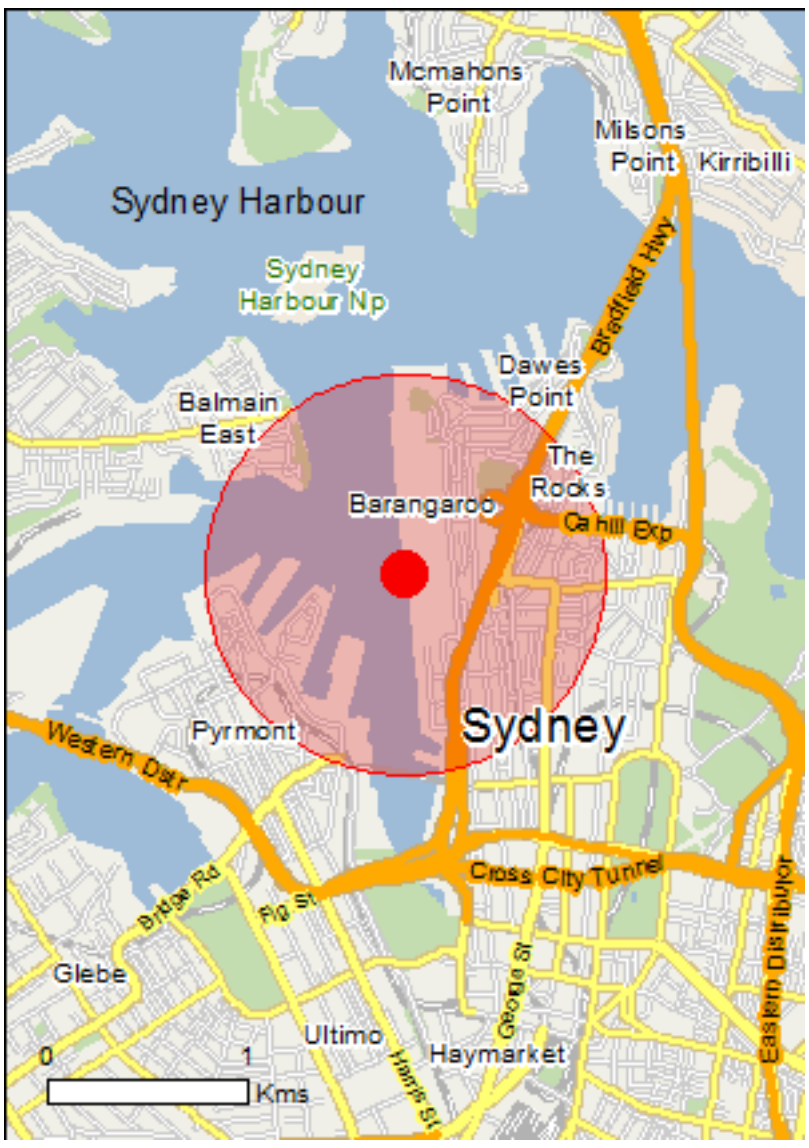
Summary

Details

- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

Caveat

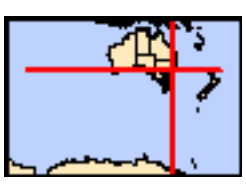
Acknowledgements



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates

Buffer: 1.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	1
National Heritage Places:	2
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Listed Threatened Ecological Communities:	1
Listed Threatened Species:	46
Listed Migratory Species:	53

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate.

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	8
Commonwealth Heritage Places:	2
Listed Marine Species:	56
Whales and Other Cetaceans:	1
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

Place on the RNE:	279
State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	50
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

World Heritage Properties [Resource Information]

Name	State	Status
Sydney Opera House - Buffer Zone	NSW	Declared property

National Heritage Properties [Resource Information]

Name	State	Status
Historic		
Sydney Harbour Bridge	NSW	Listed place
Colonial Sydney	NSW	Nominated place

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Coastal Upland Swamps in the Sydney Basin Bioregion	Endangered	Community may occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Anthochaera phrygia Regent Honeyeater [82338]	Endangered	Species or species habitat likely to occur within area
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat known to occur within area
Dasyornis brachypterus Eastern Bristlebird [533]	Endangered	Species or species habitat likely to occur within area
Diomedea epomophora epomophora Southern Royal Albatross [25996]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea epomophora sanfordi Northern Royal Albatross [82331]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans antipodensis Antipodean Albatross [82269]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area

Name	Status	Type of Presence
Diomedea exulans exulans		
Tristan Albatross [82337]	Endangered	Species or species habitat may occur within area
Diomedea exulans gibsoni		
Gibson's Albatross [82271]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans (sensu lato)		
Wandering Albatross [1073]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Lathamus discolor		
Swift Parrot [744]	Endangered	Species or species habitat may occur within area
Macronectes giganteus		
Southern Giant-Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli		
Northern Giant-Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Rostratula australis		
Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Sternula nereis nereis		
Australian Fairy Tern [82950]	Vulnerable	Breeding likely to occur within area
Thalassarche bulleri		
Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta cauta		
Shy Albatross, Tasmanian Shy Albatross [82345]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche cauta salvini		
Salvin's Albatross [82343]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche cauta steadi		
White-capped Albatross [82344]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche eremita		
Chatham Albatross [64457]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche melanophris		
Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris impavida		
Campbell Albatross [82449]	Vulnerable	Species or species habitat may occur within area
Fish		
Epinephelus daemelii		
Black Rockcod, Black Cod, Saddled Rockcod [68449]	Vulnerable	Species or species habitat likely to occur within area
Frogs		
Heleioporus australiacus		
Giant Burrowing Frog [1973]	Vulnerable	Species or species habitat likely to occur within area
Litoria aurea		
Green and Golden Bell Frog [1870]	Vulnerable	Species or species habitat may occur within area

Name	Status	Type of Presence
Mammals		
Chalinolobus dwyeri Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat likely to occur within area
Dasyurus maculatus maculatus (SE mainland population) Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population) [75184]	Endangered	Species or species habitat likely to occur within area
Isoodon obesulus obesulus Southern Brown Bandicoot (Eastern) [68050]	Endangered	Species or species habitat likely to occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT) Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat may occur within area
Pseudomys novaehollandiae New Holland Mouse, Pookila [96]	Vulnerable	Species or species habitat likely to occur within area
Pteropus poliocephalus Grey-headed Flying-fox [186]	Vulnerable	Species or species habitat likely to occur within area
Plants		
Acacia terminalis subsp. terminalis MS Sunshine Wattle [64829]	Endangered	Species or species habitat likely to occur within area
Caladenia tessellata Thick-lipped Spider-orchid, Daddy Long-legs [2119]	Vulnerable	Species or species habitat likely to occur within area
Cryptostylis hunteriana Leafless Tongue-orchid [19533]	Vulnerable	Species or species habitat likely to occur within area
Genoplesium baueri Yellow Gnat-orchid [7528]	Endangered	Species or species habitat likely to occur within area
Pimelea curviflora var. curviflora [4182]	Vulnerable	Species or species habitat may occur within area
Streblus pendulinus Siah's Backbone, Sia's Backbone, Isaac Wood [21618]	Endangered	Species or species habitat likely to occur within area
Syzygium paniculatum Magenta Lilly Pilly, Magenta Cherry, Pocket-less Brush Cherry, Scrub Cherry, Creek Lilly Pilly, Brush Cherry [20307]	Vulnerable	Species or species habitat likely to occur within area
Thesium australe Austral Toadflax, Toadflax [15202]	Vulnerable	Species or species habitat may occur within area
Reptiles		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species

Name	Status	Type of Presence
		habitat known to occur within area
[Hoplocephalus bungaroides](#) Broad-headed Snake [1182]	Vulnerable	Species or species habitat likely to occur within area
[Natator depressus](#) Flatback Turtle [59257]	Vulnerable	Species or species habitat known to occur within area
Sharks		
[Carcharias taurus (east coast population)](#) Grey Nurse Shark (east coast population) [68751]	Critically Endangered	Species or species habitat likely to occur within area
[Carcharodon carcharias](#) Great White Shark [64470]	Vulnerable	Species or species habitat likely to occur within area

Listed Migratory Species	[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.	

Name	Threatened	Type of Presence
Migratory Marine Birds		
[Apus pacificus](#) Fork-tailed Swift [678]		Species or species habitat likely to occur within area
[Diomedea antipodensis](#) Antipodean Albatross [64458]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
[Diomedea dabbenena](#) Tristan Albatross [66471]	Endangered*	Species or species habitat may occur within area
[Diomedea epomophora (sensu stricto)](#) Southern Royal Albatross [1072]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
[Diomedea exulans (sensu lato)](#) Wandering Albatross [1073]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
[Diomedea gibsoni](#) Gibson's Albatross [64466]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
[Diomedea sanfordi](#) Northern Royal Albatross [64456]	Endangered*	Foraging, feeding or related behaviour likely to occur within area
[Macronectes giganteus](#) Southern Giant-Petrel [1060]	Endangered	Species or species habitat may occur within area
[Macronectes halli](#) Northern Giant-Petrel [1061]	Vulnerable	Species or species habitat may occur within area
[Sterna albifrons](#) Little Tern [813]		Species or species habitat may occur within area
[Thalassarche bulleri](#) Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Species or species habitat may occur within area
[Thalassarche cauta (sensu stricto)](#) Shy Albatross, Tasmanian Shy Albatross [64697]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area

Name	Threatened	Type of Presence
Thalassarche eremita		
Chatham Albatross [64457]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida		
Campbell Albatross [64459]	Vulnerable*	Species or species habitat may occur within area
Thalassarche melanophris		
Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini		
Salvin's Albatross [64463]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Thalassarche steadi		
White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Migratory Marine Species		
Carcharodon carcharias		
Great White Shark [64470]	Vulnerable	Species or species habitat likely to occur within area
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata		
Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Lamna nasus		
Porbeagle, Mackerel Shark [83288]		Species or species habitat likely to occur within area
Manta birostris		
Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat may occur within area
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Species or species habitat known to occur within area
Sousa chinensis		
Indo-Pacific Humpback Dolphin [50]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Haliaeetus leucogaster		
White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Hirundapus caudacutus		
White-throated Needletail [682]		Species or species habitat known to occur within area
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis		
Black-faced Monarch [609]		Species or species habitat known to occur

Name	Threatened	Type of Presence
		within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat may occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Ardea alba Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat likely to occur within area
Arenaria interpres Ruddy Turnstone [872]		Species or species habitat known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]		Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Species or species habitat known to occur within area
Calidris tenuirostris Great Knot [862]		Species or species habitat known to occur within area
Charadrius bicinctus Double-banded Plover [895]		Species or species habitat known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]		Species or species habitat known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]		Species or species habitat known to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat known to occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]		Species or species habitat known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Species or species habitat known to occur

Name	Threatened	Type of Presence
		within area
Numenius madagascariensis Eastern Curlew [847]		Species or species habitat known to occur within area
Numenius phaeopus Whimbrel [849]		Species or species habitat known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Species or species habitat known to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land -
Commonwealth Land - Australian & Overseas Telecommunications Corporation
Commonwealth Land - Australian National University
Commonwealth Land - Australian Postal Commission
Commonwealth Land - Australian Postal Corporation
Commonwealth Land - Australian Telecommunications Commission
Defence - DSTO PYRMONT - (SEE SITE 1177)
Defence - MILLER'S POINT TRAINING DEPOT

Commonwealth Heritage Places [Resource Information]

Name	State	Status
Historic		
General Post Office	NSW	Listed place
Pyrmont Post Office	NSW	Listed place

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat likely to occur within area
Arenaria interpres Ruddy Turnstone [872]		Species or species habitat known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Calidris canutus Red Knot, Knot [855]		Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]		Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Species or species habitat known to occur within area
Calidris tenuirostris Great Knot [862]		Species or species habitat known to occur within area
Charadrius bicinctus Double-banded Plover [895]		Species or species habitat known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]		Species or species habitat known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]		Species or species habitat known to occur within area
Charadrius ruficapillus Red-capped Plover [881]		Species or species habitat known to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Diomedea dabbenena Tristan Albatross [66471]	Endangered*	Species or species habitat may occur within area
Diomedea epomophora (sensu stricto) Southern Royal Albatross [1072]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans (sensu lato) Wandering Albatross [1073]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea gibsoni Gibson's Albatross [64466]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered*	Foraging, feeding or related behaviour likely to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat known to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Himantopus himantopus Black-winged Stilt [870]		Species or species habitat known to occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat known to occur within area
Lathamus discolor Swift Parrot [744]	Endangered	Species or species habitat may occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant-Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat may occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew [847]		Species or species habitat known to occur within area
Numenius phaeopus Whimbrel [849]		Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area
Philomachus pugnax Ruff (Reeve) [850]		Species or species habitat known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Species or species habitat known to occur within area
Recurvirostra novaehollandiae Red-necked Avocet [871]		Species or species habitat known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Rostratula benghalensis (sensu lato)		
Painted Snipe [889]	Endangered*	Species or species habitat may occur within area
Sterna albifrons		
Little Tern [813]		Species or species habitat may occur within area
Thalassarche bulleri		
Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta (sensu stricto)		
Shy Albatross, Tasmanian Shy Albatross [64697]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Thalassarche eremita		
Chatham Albatross [64457]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida		
Campbell Albatross [64459]	Vulnerable*	Species or species habitat may occur within area
Thalassarche melanophris		
Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini		
Salvin's Albatross [64463]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Thalassarche steadi		
White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Tringa stagnatilis		
Marsh Sandpiper, Little Greenshank [833]		Species or species habitat known to occur within area
Reptiles		
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata		
Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Species or species habitat known to occur within area

Whales and other Cetaceans		[Resource Information]
Name	Status	Type of Presence
Mammals		
Sousa chinensis		
Indo-Pacific Humpback Dolphin [50]		Species or species habitat likely to occur within area

Extra Information

Places on the RNE [Resource Information]

Note that not all Indigenous sites may be listed.

Name	State	Status
Historic		
AWA Building (former)	NSW	Indicative Place
BBC Hardware	NSW	Indicative Place
Century House	NSW	Indicative Place
Darrell Lea Shop (Facade)	NSW	Indicative Place
IBM Centre (former)	NSW	Indicative Place
John Sands Building (former)	NSW	Indicative Place
Kindersley House	NSW	Indicative Place
Pyrmont Point	NSW	Indicative Place
Sydney Harbour Landscape Area	NSW	Indicative Place
Waterside Workers Federation Building	NSW	Indicative Place
Ways Terrace Group	NSW	Indicative Place
ANZ Bank	NSW	Registered
ANZ Bank (former)	NSW	Registered
ASN Hotel (former)	NSW	Registered
Accountants House	NSW	Registered
Agar Steps & Adjacent Trees	NSW	Registered
Agar Steps Houses	NSW	Registered
Alfreds Terrace	NSW	Registered
American Express Tower (former)	NSW	Registered
Angel Hotel (former)	NSW	Registered
Argyle Cut and Argyle Street Space	NSW	Registered
Argyle House	NSW	Registered
Argyle Place Park	NSW	Registered
Argyle Place Precinct	NSW	Registered
Argyle Precinct	NSW	Registered
Argyle Stores	NSW	Registered
Argyle Sub-Station	NSW	Registered
Argyle Terrace	NSW	Registered
Australian Hotel	NSW	Registered
Australian Joint Stock Bank (former)	NSW	Registered
Bakery (former)	NSW	Registered
Bakery House and Loft (former)	NSW	Registered
Barrack House	NSW	Registered
Beneficial House	NSW	Registered
Bettington and Merriman Streets Group	NSW	Registered
Brooklyn Hotel	NSW	Registered
Broughton House	NSW	Registered
Buildings	NSW	Registered
Burns Philp Building (former)	NSW	Registered
CBC Bank Facade (former)	NSW	Registered
Cadmans Cottage Space	NSW	Registered
Cahill Expressway Space	NSW	Registered
Cambridge Street Precinct	NSW	Registered
Carlson Terrace	NSW	Registered
Chamber of Commerce Building (former)	NSW	Registered

Name	State	Status
Charles Parsons and Company Building (former)	NSW	Registered
Cleland Bond Store	NSW	Registered
Clyde Bank	NSW	Registered
Colonial Mutual Building Facade	NSW	Registered
Commercial Building (former)	NSW	Registered
Commercial Buildings	NSW	Registered
Commercial Stores (former)	NSW	Registered
Commercial Terrace	NSW	Registered
Commonwealth Bank	NSW	Registered
Commonwealth Bank	NSW	Registered
Commonwealth Trading Bank Building	NSW	Registered
Corn Exchange and Fruit Market (former)	NSW	Registered
Corner Shop	NSW	Registered
Cottage	NSW	Registered
Cottage	NSW	Registered
Cumberland Street Group	NSW	Registered
Customs House Hotel	NSW	Registered
Dalgety Terrace	NSW	Registered
Dalgetys Bond Store (former)	NSW	Registered
Delphin House	NSW	Registered
Drill Hall (former)	NSW	Registered
Dundee Arms (former)	NSW	Registered
ES&A Bank (former)	NSW	Registered
Edwardian Buildings Group	NSW	Registered
Edwardian Commercial Group	NSW	Registered
Erskine Street Watch House Group	NSW	Registered
Five Storey Building	NSW	Registered
Fort Street School (former) (western addition)	NSW	Registered
Four Dwellings and former Shop	NSW	Registered
General Post Office	NSW	Registered
Gents Lavatory and Stone Walls	NSW	Registered
George Patterson House	NSW	Registered
George Street / Kendall Lane Precinct	NSW	Registered
George Street Business Precinct	NSW	Registered
Georgian Cottage	NSW	Registered
Georgian Warehouse (former)	NSW	Registered
Gloucester Street North Precinct	NSW	Registered
Gloucester Street North, Gloucester Walk and Escarpment Space	NSW	Registered
Glover Cottages	NSW	Registered
Grace Building	NSW	Registered
Grafton Bond Store (former)	NSW	Registered
Hardware House (former)	NSW	Registered
Harrington Argyle Precinct	NSW	Registered
Harrington Place Space	NSW	Registered
Hawken and Vance Produce Exchange (former)	NSW	Registered
Hero of Waterloo Hotel	NSW	Registered
Hexam Terrace	NSW	Registered
Hitching Posts (two)	NSW	Registered
Holy Trinity Anglican Church Hall	NSW	Registered
Hotel York (former)	NSW	Registered
House	NSW	Registered
House	NSW	Registered
House	NSW	Registered
House	NSW	Registered
House	NSW	Registered
Houses	NSW	Registered
Houses	NSW	Registered
Housing Board Building	NSW	Registered
Hudson House Facade (former)	NSW	Registered
Hunter River Steamship Company Office (former)	NSW	Registered
Italianate House	NSW	Registered
Italianate Terrace	NSW	Registered
Italianate Terrace	NSW	Registered
J A D Gibson and Company (facade)	NSW	Registered
Jobbins Terrace	NSW	Registered

Name	State	Status
Kent Street Terrace Group East Side	NSW	Registered
Kent Street Terrace Group West Side	NSW	Registered
Kent Street Warehouse Group	NSW	Registered
Kyle House	NSW	Registered
LEP House Facade	NSW	Registered
Lands Department Building	NSW	Registered
Letraset House	NSW	Registered
Lilyvale	NSW	Registered
Lisgar House	NSW	Registered
Longs Lane Precinct	NSW	Registered
Lord Nelson Hotel	NSW	Registered
Lower Fort Street West Side Group	NSW	Registered
Lower Fort Street East Side Group	NSW	Registered
MMI Building	NSW	Registered
Macknade House (former)	NSW	Registered
Macquarie House	NSW	Registered
Macquarie Place Buildings Group	NSW	Registered
Macquarie Place Park & Structures	NSW	Registered
Maritime Services Board Building (former)	NSW	Registered
Martin Place GPO Precinct	NSW	Registered
Martin Place Urban Conservation Area	NSW	Registered
Merriman Street Precinct	NSW	Registered
Millers Point Post Office	NSW	Registered
NSW Department of Labour & Industry Building (former)	NSW	Registered
NSW Government Railway Administrative Building	NSW	Registered
NSW Sports Club Five Storey Building	NSW	Registered
NSW Sports Club Four Storey Building	NSW	Registered
National Bank (former)	NSW	Registered
National Trust Centre	NSW	Registered
New York Hotel	NSW	Registered
Observatory Park	NSW	Registered
Old Training Block, Fort Street School (former)	NSW	Registered
Orient Hotel	NSW	Registered
Osborne House	NSW	Registered
Pair of Neo Classic Town Houses	NSW	Registered
Pair of Stone Houses	NSW	Registered
Pair of Stone Houses	NSW	Registered
Palisade Hotel	NSW	Registered
Palisade Hotel and adjoining Terraces	NSW	Registered
Pangas House	NSW	Registered
Parker Galleries	NSW	Registered
Paterson, Reid and Bruce Ltd Building	NSW	Registered
Perpetual Trustee Company Building	NSW	Registered
Pinnacle House	NSW	Registered
Police Station (former)	NSW	Registered
Premises	NSW	Registered
Pyrmont Bridge	NSW	Registered
Pyrmont Bridge Hotel	NSW	Registered
Pyrmont Bridge Road Hotel	NSW	Registered
Pyrmont Conservation Area	NSW	Registered
Pyrmont Point Carriageway Dividing Fence	NSW	Registered
Pyrmont Point Escarpment Face	NSW	Registered
Pyrmont Point Escarpment Palisade Fence and Stone Gateposts	NSW	Registered
Pyrmont Point Railway Cutting & Tunnel	NSW	Registered
Pyrmont Power Station Building A	NSW	Registered
Pyrmont Square Group	NSW	Registered
Queensland Insurance Building	NSW	Registered
Red Cross House	NSW	Registered
Regency Townhouses	NSW	Registered
Residence and Shop	NSW	Registered
Retail Traders Association of NSW Building (former)	NSW	Registered
Reynolds Cottage and Shop	NSW	Registered
Richmond Villa	NSW	Registered
Robert Reid and Company Warehouse	NSW	Registered
Royal Australian Naval House	NSW	Registered

Name	State	Status
Royal Edward Victualling Yard Group	NSW	Registered
Royal Exchange Assurance Building (former)	NSW	Registered
Royal George Hotel (former)	NSW	Registered
Schute, Bell, Badgery & Lumby Store	NSW	Registered
Seaforth House	NSW	Registered
Semi detached Houses	NSW	Registered
Shelbourne Hotel	NSW	Registered
Ship Inn Hotel (former)	NSW	Registered
Shipping Agents Office (former)	NSW	Registered
Shipwrights Arms Hotel (former)	NSW	Registered
Shops Residences and Offices	NSW	Registered
Shops and Hotel Group	NSW	Registered
Shops and Offices	NSW	Registered
Sirius House	NSW	Registered
Skinners Family Hotel (former)	NSW	Registered
Smith Copeland Warehouse (former)	NSW	Registered
Societe Generale House	NSW	Registered
Sport House including Original Interiors	NSW	Registered
St Bedes Church, School & Presbytery	NSW	Registered
St Brigids Catholic Church & School	NSW	Registered
St John House	NSW	Registered
St Patricks Catholic Church	NSW	Registered
St Patricks Convent	NSW	Registered
St Patricks Convent Chapel	NSW	Registered
St Patricks Hall and School	NSW	Registered
St Philips Anglican Church	NSW	Registered
Stafford Terrace (part)	NSW	Registered
Statue of Dunmore Lang	NSW	Registered
Stone Cottage and Adjacent Stone Wall	NSW	Registered
Strand Arcade and street facade	NSW	Registered
Susannah Place Terrace	NSW	Registered
Sussex Street Group	NSW	Registered
Sydney Arcade (former)	NSW	Registered
Sydney Observatory	NSW	Registered
T S Mort Statue	NSW	Registered
Tank Stream Tunnel	NSW	Registered
Telford Trust Building	NSW	Registered
Terrace	NSW	Registered
Terrace	NSW	Registered
Terrace	NSW	Registered
Terrace	NSW	Registered
Terrace	NSW	Registered
Terrace	NSW	Registered
Terrace Facade	NSW	Registered
Terrace House	NSW	Registered
Terrace Houses	NSW	Registered
Terrace Houses	NSW	Registered
Terrace Houses	NSW	Registered
Terrace Houses	NSW	Registered
Terrace Houses	NSW	Registered
Terrace Houses	NSW	Registered
Terrace Houses	NSW	Registered
Terrace Houses (former)	NSW	Registered
Terrace and Commercial Building	NSW	Registered
Terrace and Townhouses	NSW	Registered
Terrace of Three Shops	NSW	Registered
Terraced Houses	NSW	Registered
Terraces	NSW	Registered
Terraces	NSW	Registered
Terraces	NSW	Registered
Terraces	NSW	Registered
Terraces Facade	NSW	Registered
Terraces Facade	NSW	Registered
Terraces and Retaining Wall	NSW	Registered
Terraces and Townhouses	NSW	Registered
The Bushells Building	NSW	Registered

Name	State	Status
The Garrison Church	NSW	Registered
The Rocks Conservation Area	NSW	Registered
Three Victorian Residences	NSW	Registered
Townhouse	NSW	Registered
Townhouses	NSW	Registered
Towns Store	NSW	Registered
Tucker and Company Warehouse	NSW	Registered
Undercliff Cottage (former)	NSW	Registered
Union Bank (former)	NSW	Registered
Unwins Coach House	NSW	Registered
Unwins Store	NSW	Registered
Victorian Shops	NSW	Registered
View Terrace Facade	NSW	Registered
Wales House	NSW	Registered
Walsh Bay Wharves	NSW	Registered
Warehouse	NSW	Registered
Warehouse (former)	NSW	Registered
Warehouse (former)	NSW	Registered
Warehouse (former)	NSW	Registered
Warehouse (former)	NSW	Registered
Warehouse Facade	NSW	Registered
Warehouse Group	NSW	Registered
Warehouses	NSW	Registered
Warehouses (former)	NSW	Registered
Warehouses (former)	NSW	Registered
Warehouses (former)	NSW	Registered
Watch House (former)	NSW	Registered
Ways Terrace	NSW	Registered
Westpac Bank	NSW	Registered
Westpac Bank Archives (former)	NSW	Registered
Wharf 19, 20 & 21	NSW	Registered
Windermere Chambers	NSW	Registered
Windmill Street North Side Group	NSW	Registered
Windmill Street Southside Group	NSW	Registered
Winery Warehouse	NSW	Registered
Winsbury Terrace	NSW	Registered
York Street Group	NSW	Registered
Young Princess Hotel (former)	NSW	Registered

Invasive Species

[Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Alauda arvensis Skylark [656]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Carduelis chloris European Greenfinch [404]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Lonchura punctulata Nutmeg Mannikin [399]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Pycnonotus jocosus Red-whiskered Bulbul [631]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Turdus merula Common Blackbird, Eurasian Blackbird [596]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat likely to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Lepus capensis Brown Hare [127]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Alternanthera philoxeroides Alligator Weed [11620]		Species or species habitat likely to occur within area
Anredera cordifolia Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Asparagus aethiopicus Asparagus Fern, Ground Asparagus, Basket Fern, Sprengi's Fern, Bushy Asparagus, Emerald Asparagus [62425]		Species or species habitat likely to occur within area
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Asparagus plumosus Climbing Asparagus-fern [48993]		Species or species habitat likely to occur within area
Asparagus scandens Asparagus Fern, Climbing Asparagus Fern [23255]		Species or species habitat likely to occur within area
Cabomba caroliniana Cabomba, Fanwort, Carolina Watershield, Fish Grass, Washington Grass, Watershield, Carolina Fanwort, Common Cabomba [5171]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. monilifera Boneseed [16905]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera subsp. rotundata Bitou Bush [16332]		Species or species habitat likely to occur within area
Cytisus scoparius Broom, English Broom, Scotch Broom, Common Broom, Scottish Broom, Spanish Broom [5934]		Species or species habitat likely to occur within area
Dolichandra unguis-cati Cat's Claw Vine, Yellow Trumpet Vine, Cat's Claw Creeper, Funnel Creeper [85119]		Species or species habitat likely to occur within area
Eichhornia crassipes Water Hyacinth, Water Orchid, Nile Lily [13466]		Species or species habitat likely to occur within area
Genista linifolia Flax-leaved Broom, Mediterranean Broom, Flax Broom [2800]		Species or species habitat likely to occur within area
Genista monspessulana Montpellier Broom, Cape Broom, Canary Broom, Common Broom, French Broom, Soft Broom [20126]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana Broom [67538]		Species or species habitat may occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red		Species or species habitat likely to occur

Name	Status	Type of Presence
Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		within area
Lycium ferocissimum African Boxthorn, Boxthorn [19235]		Species or species habitat likely to occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
Pinus radiata Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Protasparagus densiflorus Asparagus Fern, Plume Asparagus [5015]		Species or species habitat likely to occur within area
Protasparagus plumosus Climbing Asparagus-fern, Ferny Asparagus [11747]		Species or species habitat likely to occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Sagittaria platyphylla Delta Arrowhead, Arrowhead, Slender Arrowhead [68483]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Senecio madagascariensis Fireweed, Madagascar Ragwort, Madagascar Groundsel [2624]		Species or species habitat likely to occur within area

Coordinates

-33.86313 151.20077

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Department of Environment, Climate Change and Water, New South Wales
-Department of Sustainability and Environment, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment and Natural Resources, South Australia
-Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts
-Environmental and Resource Management, Queensland
-Department of Environment and Conservation, Western Australia
-Department of the Environment, Climate Change, Energy and Water
-Birds Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-SA Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Atherton and Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
-State Forests of NSW
-Geoscience Australia
-CSIRO
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Appendix D:
FM Act Listed Species

Schedule 4 Endangered species, populations and ecological communities

(Section 220C)

Part 1 Endangered species

Fish

Archaeophya adamsi Fraser, 1959	Adam's emerald dragonfly
Austrocordulia leonardi	Sydney Hawk dragonfly
**Maccullochella ikei* Rowland	eastern freshwater cod
**Maccullochella macquariensis* (Cuvier)	trout cod
Macquaria australasica (Cuvier, 1830)	Macquarie perch
Mogurnda adspersa (Castelnau, 1878)	purple spotted gudgeon
Nannoperca australis Günther, 1861	southern pygmy perch
**Nannoperca oxleyana* Whitley	Oxleyan pygmy perch
Notopala sublineata (Conrad, 1850)	river snail
Sphyrna lewini (Griffith & Smith, 1834)	scalloped hammerhead shark
Thunnus maccoyii	southern bluefin tuna

Marine vegetation

Part 2 Endangered populations

Fish

Ambassis agassizii Steindachner, 1866, olive perchlet, western New South Wales population

Craterocephalus amniculus (Crowley and Ivanstoff, 1990), Darling River Hardyhead, Hunter River population

Gadopsis marmoratus, river blackfish, Snowy River population

Tandanus tandanus (Mitchell, 1838), eel tailed catfish, Murray-Darling Basin population

Marine vegetation

Posidonia australis Hook.*f.* (1858), seagrass, Port Hacking, Botany Bay, Sydney Harbour, Pittwater, Brisbane Waters and Lake Macquarie populations

Part 3 Endangered ecological communities

Aquatic ecological community in the natural drainage system of the lower Murray River catchment (as described in the recommendation of the Fisheries Scientific Committee to list the ecological community)

Aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River (described in the recommendation of the Fisheries Scientific Committee to list that aquatic ecological community, as the area covered by that recommendation)

Aquatic ecological community in the natural drainage system of the lowland catchment of the Lachlan River (described in the recommendation of the Fisheries Scientific Committee to list that aquatic ecological community, as the area covered by that recommendation)

Aquatic ecological community in the catchment of the Snowy River in NSW (as described in the final determination of the Fisheries Scientific Committee to list that aquatic ecological community)

Part 4 Species presumed extinct

Fish

Hadrachaeta aspeta Hutchings, 1977	marine worm
Pristis zijsron Bleeker, 1851	green sawfish
Metaprotella haswelliana Mayer, 1882	Haswells caprellid

Marine vegetation

Vanvoorstia bennettiana (Harvey) Papenfuss (1956)	Bennetts seaweed

Schedule 4A Critically endangered species and ecological communities

(Section 220C)

Part 1 Critically endangered species

Fish

**Carcharias taurus* Rafinesque, 1810	grey nurse shark
Craterocephalus fluviatilis (McCulloch, 1913)	Murray hardyhead
Euastacus dharawalus (Morgan, 1997)	Fitzroy Falls spiny crayfish
Galaxias rostratus	flathead galaxias
Smeagol hilaris Tillier & Ponder, 1992	marine slug

Marine vegetation

Nereia lophocladia J. Agardh (1897)	marine brown alga

Part 2 Critically endangered ecological communities

Schedule 5 Vulnerable species and ecological communities

(Section 220C)

Part 1 Vulnerable species

Fish

Austropetalia tonyana (Theischinger, 1995)	Alpine Redspot Dragonfly
Bidyanus bidyanus (Mitchell, 1838)	silver perch
Branchinella buchananensis Geddes, 1981	Buchanans fairy shrimp
**Carcharodon carcharias* (Linnaeus, 1758)	great white shark
Epinephelus daemelii (Günther, 1876)	black cod
Euastacus armatus (von Martens 1866)	Murray crayfish
Microrchestia bousfieldi Lowry & Peart, 2010	Bousfields marsh-hopper
Sphyrna mokarran Ruppell, 1837	great hammerhead shark

Marine vegetation

Part 2 Vulnerable ecological communities

Schedule 6 Key threatening processes

(Section 220C)

Degradation of native riparian vegetation along New South Wales water courses

Hook and line fishing in areas important for the survival of threatened fish species

Human-caused climate change

Installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams

Introduction of fish to waters within a river catchment outside their natural range

Introduction of non-indigenous fish and marine vegetation to the coastal waters of New South Wales

Removal of large woody debris from New South Wales rivers and streams

The current shark meshing program in New South Wales waters

Appendix E:
Sediment Data

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EN1001091**	Page	: 1 of 5
Client	: **WORLEY PARSONS - INFRASTRUCTURE MWE**	Laboratory	: Environmental Division Newcastle
Contact	: MS KATIE NEWTON	Contact	: Peter Keyte
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Telephone	: +61 02 4907 5324	Telephone	: +61-2-4968 9433
Facsimile	: ----	Facsimile	: +61-2-4968 0349
Project	: 301015-01696 05	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 11-MAY-2010
Sampler	: K. NEWTON	Issue Date	: 20-MAY-2010
Site	: ----		
		No. of samples received	: 13
Quote number	: EN/034/10	No. of samples analysed	: 13

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Dianne Blane	Laboratory Supervisor	Newcastle

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for processing purposes. If the sampling time is displayed as 0:00 the information was not provided by client.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID	BG1 - PSA	BG2 - PSA	BG3 - PSA	BG4 - PSA	SB1 - PSA
				Client sampling date / time	04-MAY-2010 15:00	04-MAY-2010 15:00	04-MAY-2010 15:00	04-MAY-2010 15:00	04-MAY-2010 15:00
					EN1001091-001	EN1001091-002	EN1001091-003	EN1001091-004	EN1001091-005
EA150: Particle Sizing									
+75µm	----	1	%		**9**	**21**	**32**	**21**	**5**
+150µm	----	1	%		**7**	**17**	**26**	**16**	**2**
+300µm	----	1	%		**4**	**8**	**13**	**7**	<1
+425µm	----	1	%		**3**	**4**	**5**	**4**	<1
+600µm	----	1	%		**1**	**2**	**2**	**2**	<1
+1180µm	----	1	%		<1	**1**	<1	**1**	<1
+2.36mm	----	1	%		<1	<1	<1	<1	<1
+4.75mm	----	1	%		<1	<1	<1	<1	<1
+9.5mm	----	1	%		<1	<1	<1	<1	<1
+19.0mm	----	1	%		<1	<1	<1	<1	<1
+37.5mm	----	1	%		<1	<1	<1	<1	<1
+75.0mm	----	1	%		<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size									
Clay (<2 µm)	----	1	%		**48**	**36**	**32**	**33**	**21**
Silt (2-60 µm)	----	1	%		**41**	**41**	**34**	**44**	**63**
Sand (0.06-2.00 mm)	----	1	%		**10**	**23**	**34**	**23**	**16**
Gravel (>2mm)	----	1	%		**1**	<1	<1	<1	<1
Cobbles (>6cm)	----	1	%		<1	<1	<1	<1	<1

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID: SB2 - PSA Client sampling date / time: 04-MAY-2010 15:00 EN1001091-006	SB3 - PSA 04-MAY-2010 15:00 EN1001091-007	SB4 - PSA 04-MAY-2010 15:00 EN1001091-008	BB1 - PSA 04-MAY-2010 15:00 EN1001091-009	BB2 - PSA 04-MAY-2010 15:00 EN1001091-010
EA150: Particle Sizing								
+75µm	----	1	%	**4**	**74**	**46**	**38**	**4**
+150µm	----	1	%	**2**	**70**	**40**	**28**	**2**
+300µm	----	1	%	**1**	**43**	**20**	**20**	**2**
+425µm	----	1	%	<1	**22**	**7**	**16**	**1**
+600µm	----	1	%	<1	**6**	**2**	**12**	<1
+1180µm	----	1	%	<1	<1	<1	**8**	<1
+2.36mm	----	1	%	<1	<1	<1	**5**	<1
+4.75mm	----	1	%	<1	<1	<1	**2**	<1
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	**30**	**10**	**29**	**29**	**22**
Silt (2-60 µm)	----	1	%	**60**	**14**	**23**	**28**	**69**
Sand (0.06-2.00 mm)	----	1	%	**10**	**76**	**47**	**38**	**9**
Gravel (>2mm)	----	1	%	<1	<1	**1**	**5**	<1
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID: BB3 - PSA	BB4 - PSA	QA - BG2	----	----
				Client sampling date / time: 04-MAY-2010 15:00	04-MAY-2010 15:00	04-MAY-2010 15:00	----	----
				EN1001091-011	EN1001091-012	EN1001091-013	----	----
EA150: Particle Sizing								
+75µm	----	1	%	**19**	**41**	**21**	----	----
+150µm	----	1	%	**12**	**35**	**16**	----	----
+300µm	----	1	%	**5**	**18**	**9**	----	----
+425µm	----	1	%	**2**	**6**	**6**	----	----
+600µm	----	1	%	**1**	**2**	**4**	----	----
+1180µm	----	1	%	<1	<1	**3**	----	----
+2.36mm	----	1	%	<1	<1	**3**	----	----
+4.75mm	----	1	%	<1	<1	**2**	----	----
+9.5mm	----	1	%	<1	<1	<1	----	----
+19.0mm	----	1	%	<1	<1	<1	----	----
+37.5mm	----	1	%	<1	<1	<1	----	----
+75.0mm	----	1	%	<1	<1	<1	----	----
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	**39**	**14**	**40**	----	----
Silt (2-60 µm)	----	1	%	**42**	**44**	**35**	----	----
Sand (0.06-2.00 mm)	----	1	%	**19**	**42**	**22**	----	----
Gravel (>2mm)	----	1	%	<1	<1	**3**	----	----
Cobbles (>6cm)	----	1	%	<1	<1	<1	----	----

Environmental Division

QUALITY CONTROL REPORT

Work Order	: **EN1001091**	Page	: 1 of 5
Client	: **WORLEY PARSONS - INFRASTRUCTURE MWE**	Laboratory	: Environmental Division Newcastle
Contact	: MS KATIE NEWTON	Contact	: Peter Keyte
Address	:	Address	: 5 Rosegum Road Warabrook NSW Australia 2304
E-mail	: knewton@worleyparsons.com	E-mail	: peter.keyte@als.com.au
Telephone	: +61 02 4907 5324	Telephone	: +61-2-4968 9433
Facsimile	: ----	Facsimile	: +61-2-4968 0349
Project	: 301015-01696 05	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 11-MAY-2010
Sampler	: K. NEWTON	Issue Date	: 20-MAY-2010
Order number	: ----		
		No. of samples received	: 13
Quote number	: EN/034/10	No. of samples analysed	: 13

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Dianne Blane	Laboratory Supervisor	Newcastle

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

		----						No Limit

- **No Laboratory Duplicate (DUP) Results are required to be reported.**

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

- **No Method Blank (MB) or Laboratory Control Spike (SCS) Results are required to be reported.**

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

- **No Matrix Spike (MS) Results are required to be reported.**

Environmental Division

INTERPRETIVE QUALITY CONTROL REPORT

Work Order	: **EN1001091**	Page	: 1 of 5
Client	: WORLEY PARSONS - INFRASTRUCTURE MWE	Laboratory	: Environmental Division Newcastle
Contact	: MS KATIE NEWTON	Contact	: Peter Keyte
Address	:	Address	: 5 Rosegum Road Warabrook NSW Australia 2304
E-mail	: knewton@worleyparsons.com	E-mail	: peter.keyte@als.com.au
Telephone	: +61 02 4907 5324	Telephone	: +61-2-4968 9433
Facsimile	: ----	Facsimile	: +61-2-4968 0349
Project	: 301015-01696 05	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 11-MAY-2010
Sampler	: K. NEWTON	Issue Date	: 20-MAY-2010
Order number	: ----		
		No. of samples received	: 13
Quote number	: EN/034/10	No. of samples analysed	: 13

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Interpretive Quality Control Report contains the following information:

- Analysis Holding Time Compliance
- Quality Control Parameter Frequency Compliance
- Brief Method Summaries
- Summary of Outliers

Analysis Holding Time Compliance

The following report summarises extraction / preparation and analysis times and compares with recommended holding times. Dates reported represent first date of extraction or analysis and precludes subsequent dilutions and reruns. Information is also provided re the sample container (preservative) from which the analysis aliquot was taken. Elapsed period to analysis represents number of days from sampling where no extraction / digestion is involved or period from extraction / digestion where this is present. For composite samples, sampling date is assumed to be that of the oldest sample contributing to the composite. Sample date for laboratory produced leachates is assumed as the completion date of the leaching process. Outliers for holding time are based on USEPA SW 846, APHA, AS and NEPM (1999). A listing of breaches is provided in the Summary of Outliers.

Holding times for leachate methods (excluding elutriates) vary according to the analytes being determined on the resulting solution. For non -volatile analytes, the holding time compliance assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These soil holding times are: Organics (14 days); Mercury (28 days) & other metals (180 days). A recorded breach therefore does not guarantee a breach for all non-volatile parameters.

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA150: Particle Sizing							
Snap Lock Bag							
BG1 - PSA, BG2 - PSA, BG3 - PSA, BG4 - PSA, SB1 - PSA, SB2 - PSA, SB3 - PSA, SB4 - PSA, BB1 - PSA, BB2 - PSA, BB3 - PSA, BB4 - PSA, QA - BG2	**04-MAY-2010**	**---**	---	----	**19-MAY-2010**	31-OCT-2010	✓
EA150: Soil Classification based on Particle Size							
Snap Lock Bag							
BG1 - PSA, BG2 - PSA, BG3 - PSA, BG4 - PSA, SB1 - PSA, SB2 - PSA, SB3 - PSA, SB4 - PSA, BB1 - PSA, BB2 - PSA, BB3 - PSA, BB4 - PSA, QA - BG2	**04-MAY-2010**	**---**	---	----	**19-MAY-2010**	31-OCT-2010	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(where) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix:

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Particle Size Analysis (Sieving)	EA150	SOIL	Particle Size Analysis by Sieving according to AS1289.3.6.1 - 1995
Particle Size Analysis by Hydrometer	EA150H	SOIL	Particle Size Analysis by Hydrometer according to AS1289.3.6.3 - 2003

Summary of Outliers

Outliers : Quality Control Samples

The following report highlights outliers flagged in the Quality Control (QC) Report. Surrogate recovery limits are static and based on USEPA SW 846 or ALS-QWI/EN/38 (in the absence of specific USEPA limits). This report displays QC Outliers (breaches) only.

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

- **For all matrices, no Method Blank value outliers occur.**
- **For all matrices, no Duplicate outliers occur.**
- **For all matrices, no Laboratory Control outliers occur.**
- **For all matrices, no Matrix Spike outliers occur.**

Regular Sample Surrogates

- **For all regular sample matrices, no surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

This report displays Holding Time breaches only. Only the respective Extraction / Preparation and/or Analysis component is/are displayed.

- **No Analysis Holding Time Outliers exist.**

Outliers : Frequency of Quality Control Samples

The following report highlights breaches in the Frequency of Quality Control Samples.

- **No Quality Control Sample Frequency Outliers exist.**

Appendix F:
Marine Infauna Data

Phylum	Subphylum	Class	Subclass	Order
Annelida	undifferentiated	Polychaeta	Palpata	Aciculata
Annelida	undifferentiated	Polychaeta	Palpata	Aciculata
Annelida	undifferentiated	Polychaeta	Palpata	Aciculata
Annelida	undifferentiated	Polychaeta	Palpata	Aciculata
Annelida	undifferentiated	Polychaeta	Palpata	Aciculata
Annelida	undifferentiated	Polychaeta	Palpata	Aciculata
Annelida	undifferentiated	Polychaeta	Palpata	Aciculata
Annelida	undifferentiated	Polychaeta	Palpata	Aciculata
Annelida	undifferentiated	Polychaeta	Palpata	Aciculata
Annelida	undifferentiated	Polychaeta	Palpata	Canapalpata
Annelida	undifferentiated	Polychaeta	Palpata	Canapalpata
Annelida	undifferentiated	Polychaeta	Palpata	Canapalpata
Annelida	undifferentiated	Polychaeta	Palpata	Canapalpata
Annelida	undifferentiated	Polychaeta	Palpata	Canapalpata
Annelida	undifferentiated	Polychaeta	Palpata	Canapalpata
Annelida	undifferentiated	Polychaeta	Palpata	Polychaeta
Annelida	undifferentiated	Polychaeta	Palpata	Polychaeta
Annelida	undifferentiated	Polychaeta	Palpata	Polychaeta
Annelida	undifferentiated	Polychaeta	Scolecida	Scolecida
Annelida	undifferentiated	Polychaeta	Scolecida	Scolecida
Annelida	undifferentiated	Polychaeta	Scolecida	Scolecida
Annelida	undifferentiated	Polychaeta	Scolecida	Scolecida
Arthropoda	Chelicerata	Pycnogonida	Pantopoda	undifferentiated
Arthropoda	Crustacea	Copepoda	undifferentiated	undifferentiated
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Amphipoda
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Amphipoda
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Amphipoda
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Decapoda
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Decapoda
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Decapoda
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Decapoda
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Decapoda
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Decapoda
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Decapoda
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Isopoda
Arthropoda	Crustacea	Malocostraca	Eumalocostraca	Mysida
Arthropoda	Crustacea	Malocostraca	undifferentiated	Tanaidacea
Arthropoda	Crustacea	Ostracoda	undifferentiated	undifferentiated
Arthropoda	Crustacea	undifferentiated	undifferentiated	undifferentiated
Arthropoda	Hexapoda	Insecta	Ptilota	Diptera
Bryazoa	undifferentiated	Gymnolaemata	undetermined	Cheilostomata
Bryazoa	undifferentiated	Gymnolaemata	undetermined	Cheilostomata
Chordata	Tunicata	Ascidiacea	undifferentiated	undifferentiated
Cnidaria	undifferentiated	Anthozoa	undifferentiated	undifferentiated
Echinodermata	Asterozoa	Stelleroidea	Ophiuroidea	Ophiurida
Mollusca	Diasoma	Bivalvia	Heterodonta	Veneroida
Mollusca	Diasoma	Bivalvia	Heterodonta	Veneroida
Mollusca	Diasoma	Bivalvia	Heterodonta	Veneroida
Mollusca	Diasoma	Bivalvia	Heterodonta	Veneroida
Mollusca	Diasoma	Bivalvia	Heterodonta	Veneroida
Mollusca	Diasoma	Bivalvia	Heterodonta	Veneroida
Mollusca	undifferentiated	Gastropoda	Heterobranchia	Cephalaspidea
Nematoda	undifferentiated	undifferentiated	undifferentiated	undifferentiated
Nemertia	Nemertia	Enopla	undifferentiated	Hoplonemertea
Sipuncula	undifferentiated	Sipunculidea	undifferentiated	undifferentiated
Platyhelminthes	undifferentiated	Trematoda	Digenia	undifferentiated

Suborder	Family	Common Name	BB1-1	BB1-2
Eunicida	Cirratulidae	Spagetti worms	2	3
Eunicida	Eunicidae	Eunicid worms	1	
Eunicida	Lumbrineridae	Lumbrinerid worms	1	
Phyllodocida	Glyceridae	Bloodworms		
Phyllodocida	Nephtyidae	Nephtyid worms		
Phyllodocida	Nereididae	Nereidid worms	1	
Phyllodocida	Phylodocidae	Paddle worms	1	
Phyllodocida	Pilargidae	Pilargid worms		
Phyllodocida	Syllidae	Syllid worms		1
Sabellida	Oweniidae	Oweniid worms		
Sabellida	Sabellidae	Feather-duster worms		
Spionida	Sigalionidae	Sigalionid worms		
Spionida	Spionidae	Spionid worms	1	
Terebellida	Terebellidae	Terebellid worms		
Terebellida	Trichobranchidae	Trichobranchid worms		
Phyllodocida	Hesionidae	Hesionid worms		
Phyllodocida	Lacydoniidae	Lacydoniid worms		
Spionida	Chaetopteridae	Chaetopterid worms	2	
Scolecida	Capitellidae	Capitellid worms		3
Scolecida	Maldanidae	Bamboo Worms		
Scolecida	Opheliidae	Opheliid worms		
Scolecida	Orbiniidae	Rag worms		
undifferentiated	Pantopoda sp.a	Sea spiders		
undifferentiated	Copepoda spp	Copepods		
so: Gammaridea	Caprellidae	Caprellid amphipods		
so: Gammaridea	Corophiidae	Corophid amphipods		
so: Gammaridea	Gammaridea spp	Gammarid amphipods		1
Callianassoidea	Callianassidae	Yabbys		
so: Pleocyemata	Alpheidae	Snapping shrimp		
so: Pleocyemata	Grapsidae	Grapsid crabs		1
so: Pleocyemata	Porcellanidae	Porcellin crabs		
so: Pleocyemata	Xanthidae	Mud crabs		
undifferentiated	Brachyura sp.a	Brachyuran crabs		
undifferentiated	Caridean sp.a	Caridean shrimps		
so: Anthuridea	Anthuridae	Isopods		
undifferentiated	Mysidae	Opossum shrimps		
undifferentiated	Apseudidae	Tanaids		
undifferentiated	Ostracoda sp. a	Seed shrimps	1	
undifferentiated	Invertebrate sp.	unidentified invertebrate		
Nematocera	Chironomidae	Non-biting midges		
undifferentiated	Cheilostomata spp	Lace animals (encrusting)		
undifferentiated	Cheilostomata spp	Lace animals (branching)		
undifferentiated	Ascidiacea sp.a	Seasquirts		1
undifferentiated	Cnidarian sp.a	Cnidarian polyp		
undifferentiated	Ophurida spp.	Brittle stars		
Tellinoidea	Mactridae	Trough clams		
Tellinoidea	Psammobiidae (Gari le	Sunset shells		
Tellinoidea	Psammobiidae frailis	Tellinoid clams		
undifferentiated	Veneridae	Venus clams		
undifferentiated	Bivalvia sp.a	Marine clams		
Veneroida	Veneroida sp.	Venerid clam		
sf: Philioidea	Philinidae	Marine slugs		1
undifferentiated	Nematod spp	Nematodes		
undifferentiated	Hoplonemertea spp.	Ribbon worms		1
undifferentiated	Sipuncula sp.a	Peanut worms		
undifferentiated	Digenia sp.	Parasitic flatworms		
	Total Abundance		**10**	**12**
	Richness		**8**	**8**

BB1-3	BB2-1	BB2-2	BBS-3	BB3-1	BB3-2	BB3-3
1						
1						
1					4	
2						
1	1	3	2	5		1
3						
			1			
6				2		
6		1		1		
	2	3	1	2		1
2					2	
					1	
			1			
					1	
2						
25	**3**	**7**	**5**	**10**	**8**	**2**
10	**2**	**3**	**4**	**4**	**4**	**2**

BB4-1	BB4-2	BB4-3	BG1-1	BG1-2	BG1-3	BG2-1
				1		
1						
2		1				
					1	
1						1
	1	1				
1	3	2				
				1		5
1	1	2				
1						6
1					1	2
			1			
			1			
			1		3	
				1		
			1			
				2		
8	5	6	4	5	5	14
7	3	4	4	4	3	4

BG2-2	BG2-3	BG3-1	BG3-2	BG3-3	BG4-1	BG4-2
			1			
	2				1	
	1					
	1				1	
						1
1		1	1	1		1
1	2		2			
					1	
	1	2		2	2	1
10	7	3	6	6	1	3
					1	
		1				
1	1	5	4	3		
			1			
			1			
					1	
1	3	1	2	1		
14	**18**	**13**	**18**	**13**	**8**	**6**
5	**8**	**6**	**8**	**5**	**7**	**4**

BG4-3	SB1-1	SB1-2	SB1-3	SB2-1	SB2-2	No sample
				1		
1	5	4	4	1	1	
		1				
	3	2			1	
			1			
1						
2	8	7	5	2	2	0
2	2	3	2	2	2	0

SB3-1	SB3-2	SB3-3	SB4-1	SB4-2	SB4-3	Total
	1				1	10
						1
						4
		1				1
						3
						6
						1
				1		6
		1				5
						3
						3
			2	1		38
3		1	1			14
						12
						1
			7	3	1	33
11	4	5	8	3	2	88
						20
		1				2
				1		3
						2
9	11	7	8	2	1	60
						2
						1
						1
						1
						1
	1					1
						2
						1
					1	1
						1
				1		3
	1					1
1	4	1		1		18
					1	1
						2
24	22	17	26	13	7	354
4	6	7	5	8	6	39