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LEND LEASE

# Barangaroo Stage 1

## Barangaroo Concept Plan Amendment (MP06_0162 MOD4) - Marine Ecology, Water Quality and Contaminated Sediment Impact Assessment

301015-02234 24-MA-REP-0003

28 July 2010

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LEND LEASE
BARANGAROO STAGE 1
BARANGAROO CONCEPT PLAN AMENDMENT (MP06_0162 MOD4) - MARINE ECOLOGY, WATER QUALITY AND CONTAMINATED SEDIMENT IMPACT ASSESSMENT

## Disclaimer



**PROJECT 301015-02234 - BARANGAROO STAGE 1**

| REV | DESCRIPTION | ORIG | REVIEW | WORLEY-PARSONS APPROVAL | DATE | CLIENT APPROVAL | DATE |
|---|---|---|---|---|---|---|---|
| A | Issued for internal review | K Newton | A Cohen | | 28/5/10 | | |
| B | Issued for client review | K Newton | Lend Lease | | 1/6/10 | | |
| C | Issued for client review | K Newton | Lend Lease | | 2/6/10 | | |
| D | Final Report | K Newton | Lend Lease | | 4/6/10 | | |
| E | Amended Final Report | K Newton | P McCallum | | 28/7/10 | | |
| F | Amended Final Report | K Newton | P McCallum | as per K.Newton | 29/7/10 | | |

# EXECUTIVE SUMMARY

WorleyParsons was engaged by Lend Lease Millers Point to undertake a Marine Ecology, Water Quality and Contaminated Sediment Impact Assessment to accompany a Concept Plan Amendment (MP06_0162 MOD4) Application for proposed works at Barangaroo. Marine field surveys were undertaken to provide a description of the existing environment and allow assessment of the potential impacts of the proposed development. In summary, it was concluded that if effectively mitigated using industry standard methods and techniques, any potential impacts on water quality and aquatic ecology arising from construction of the Landmark Building or Southern Cove would be negligible, temporary and localised.

Construction related activities associated with the Landmark Building and the Southern Cove have the potential to impact on water quality in Darling Harbour. Potential water quality impacts associated with construction of the Landmark Building include localised short term increases in turbidity through resuspension of sediments and remobilisation of associated heavy metals and other contaminants into the water column. Additionally, excavation of the Southern Cove has the potential to cause the release of contaminated land-based sediments and groundwater into the marine environment. Suspended sediments and associated contaminants will be contained using appropriate industry standard and proven methods such as silt curtains to reduce potential impacts on water quality. It is expected that during development excavation and construction works, all stormwater and wastewater onsite will be contained, collected, decontaminated / treated and discharged to either the sewage network or stormwater system. Water generated from dewatering activities during bulk excavation will be monitored and treated 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. By employing appropriate proven industry standard construction techniques and mitigation measures, any impacts of the proposed development on water quality within Darling Harbour can be managed and minimised to acceptable levels and are expected to be extremely localised and short-term in nature.

Potential impacts on aquatic flora and fauna are expected but are considered to be negligible. No aquatic vegetation (i.e. seagrass beds, mangroves or saltmarsh habitat) protected under the *Fisheries Management Act* 1994 is present in the vicinity of the proposed development. As such, no impacts on these habitats are expected. The placement of piles and other structures into the seabed would displace small areas of soft sediment benthic habitat and associated benthic infauna. However, the abundance of similar benthic habitat in Sydney Harbour suggests that these benthic communities would be widespread and thus, any localised impacts on benthic invertebrate communities would be minor. While subtidal artificial habitat for sessile marine invertebrates such as ascidians and bryozoans will be impacted, new intertidal and subtidal habitats are to be created at the Barangaroo North, South and central precincts. 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 also likely to be insignificant. In addition, the proposed development would be highly unlikely to have any impact on

any threatened or protected species of 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 *Threatened Species Conservation Act* 1995 or *Environment Protection and Biodiversity Conservation Act* 1999, which have the potential to occur in Sydney Harbour, would utilise this area.

In summary, it is concluded that through thoughtful design, detailing and appropriate construction methodology, and by employing appropriate industry standard mitigative measures as described throughout this report, the proposed Lend Lease Barangaroo South development would be unlikely to have any significant or lasting impacts on the marine environment (including water quality impacts and impacts on flora and fauna), and any impacts would be short-term in nature and highly localised.

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# 1 INTRODUCTION

On the 20th December 2009, Lend Lease (Millers Point) Pty Limited (Lend Lease) was appointed as the preferred proponent to develop Stage 1 of Barangaroo, comprising Block 1 to 4 and associated public recreation area. WorleyParsons was engaged by Lend Lease to undertake a Marine Ecology Impact Assessment to accompany a Concept Plan Amendment (MP06_0162 MOD4) Application for proposed works at Barangaroo. This report has been prepared in support of the Concept Plan Amendment (Modification 4). It addresses the following Director General Requirements:

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.*

## 1.1 Location

Barangaroo is located at Millers Point, on the eastern shore of Darling Harbour. Darling Harbour is located on the southern shoreline of the Port Jackson estuary, along the western fringe of the Sydney CBD. The Barangaroo site is 22 hectares (ha) and covers 1.4 km of foreshore land (**Figure 1.1**).

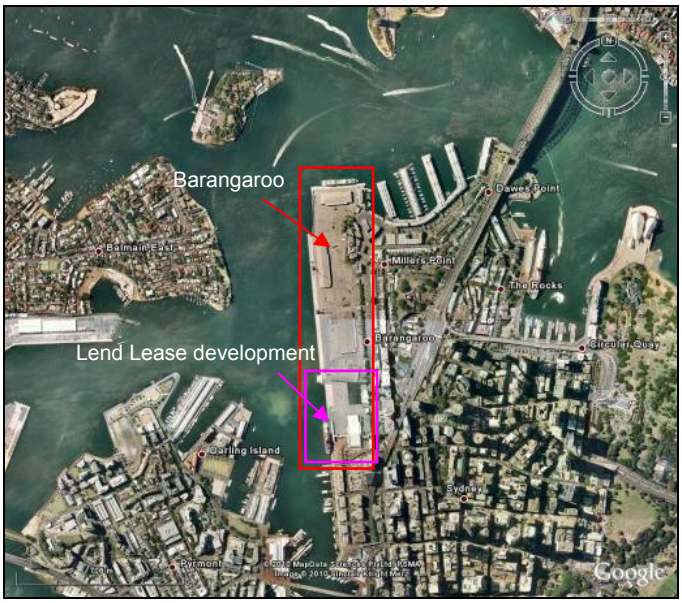


**Figure 1.1 Location (approximate) of Barangaroo and the proposed Lend Lease development.**

## 1.2 Proposed Development

Lend Lease has prepared an Indicative Design for an area of land at the southern end of Barangaroo. The Indicative Design is the subject of the Concept Plan Amendment (MP06_0162 MOD4) Application. The focal points of the proposed Lend Lease Concept Plan Amendment include a Landmark Building and associated pier (with a submerged basement structure underneath connected back to the landside through the existing caisson foreshore). The pier encroaches approximately 85 m into marine waters of east Darling Harbour (perpendicular to the existing shoreline). A second key focal element of the proposed Lend Lease development scheme is the creation of a new Southern Cove, generally within the footprint of the former Maritime Service Boards berths 6 and 7.

### 1.2.1 Planning History

**Approved Concept Plan February 2007**

On 9th February 2007 the Minister approved a Concept Plan for the site and on 12th October 2007 the land was rezoned to facilitate its redevelopment. The Approved Concept Plan allowed for:

- a mixed use development involving a maximum of 388,300 $m^2$ of gross floor area (GFA) contained within 8 blocks on a total site area of 22 hectares;
- approximately 11 hectares of new public open space / public domain, with a range of formal and informal open spaces serving separate recreational functions and including a 1.4 km public foreshore promenade;
- maximum building heights and maximum GFA for each development block within the mixed use zone; and
- public domain landscape concept, including parks, streets and pedestrian connections.

A condition of consent required two enlarged water intrusions into the Barangaroo site, one at the northern end and one at the southern end, and the creation of a natural northern headland.

**Modification Application (Modification 1)**

A modification application (Modification 1) was approved in September 2007. This application corrected a number of minor typographical errors.

**Approved Concept Plan February 2009 (Modification 2)**

On 25th February 2009 the Minister approved the Modification to the Concept Plan. The Approved Concept Plan, as modified, allowed for a mixed use development involving a maximum of 508,300 $m^2$ of gross floor area (GFA) contained within 8 blocks on a total site area of 22 hectares.

**Approved Concept Plan November 2009 (Modification 3)**

On 11th November 2009 the Minister approved the Modification to the Concept Plan to allow for a modified design for the Headland Park and Northern Cove. The Approved Concept Plan as modified allowed for a mixed use development involving a maximum of 489,500 $m^2$ of gross floor area (GFA) contained within 8 blocks on a total site area of 22 hectares.

**Concept Plan Amendment (Modification 4)**

The current modification application seeks the Minister's consent for:

- additional GFA within Barangaroo South, predominantly related to an increase in residential GFA;
- an increase in height within Barangaroo South;
- the establishment of the new pier and Landmark Building extending into the Harbour; and
- reconfiguration and activation of the public waterfront area through the introduction of users including retail and residential to the west.

## 1.3 Background / Site History

Over the last two centuries Barangaroo has undergone significant transformation. During the 19th century the name Miller's 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 1.2**). With the replacement of many sail driven vessels with steamships, a number of privately owned wharfs were introduced to the site. When the plague struck in the early 20th century, the New South Wales (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. These historical landuses suggest potential for land contamination.

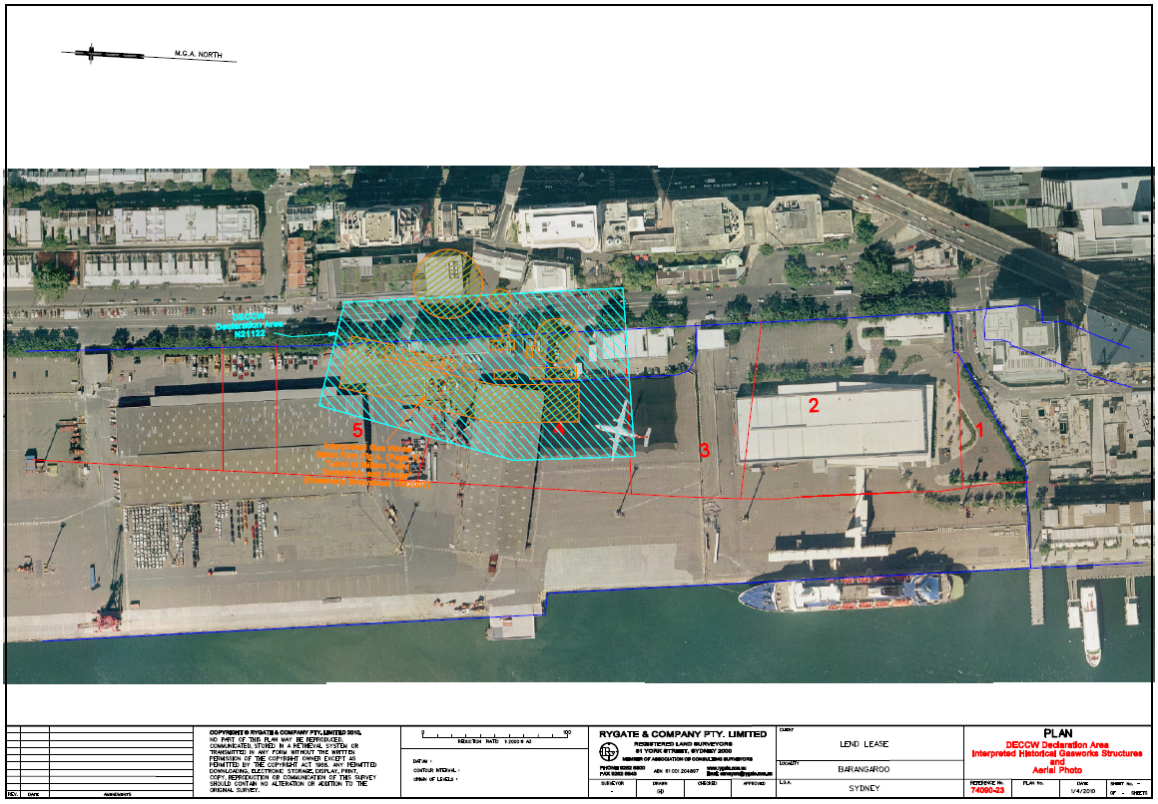


**Figure 1.2 Location of the historical gasworks at Barangaroo (denoted by orange area).**

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 saw a 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, after Barangaroo who was a powerful 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.

The Barangaroo site is proposed to be redeveloped to create a vibrant mixed use foreshore precinct which will incorporate commercial, residential, retail, tourism and recreational uses. Development within Barangaroo is proposed to occur principally within three distinct areas; The Headland Park, to the north of the site, Barangaroo Central and Northern Cove, and Barangaroo South being the portion of the site known as Stage 1 for which lend Lease is the preferred development proponent. The present study which is the subject of this report, addresses Stage 1. Approximately half the Barangaroo site will be dedicated to open space and public domain, and the redevelopment will complete the 14 km Sydney Foreshore Walk from the Anzac Bridge to Woolloomooloo (Barangaroo Delivery Authority 2010).

## 1.4 Existing Site

The Barangaroo site is currently largely vacant with the exception of the Wharf 8 cruise ship passenger terminal at the southern end of the site, which is currently being relocated to the north of Stage 1 for a temporary period of 2 years (refer **Figure 1.3**). Barangaroo and surrounding land at East Darling Harbour is owned by a variety public and private authorities and companies including Australand, Multiplex, Crown, Multiplex Funds Management Limited, NSW Land and Housing Corporation, GFC Trading Pty Ltd, Roads & Traffic Authority of NSW, Sydney Ports Corporation, Council, KSW Properties Pty Limited and the Barangaroo Delivery Authority.

**Figure 1.3 The current Barangaroo site.**

## 1.5 Physical Setting

Survey sites selected by WorleyParsons as part of this commission, for the purpose of the Concept Plan Amendment Marine Ecology Impact Assessment were located within the Port Jackson estuary. The Port Jackson estuary has a total catchment area of 347 $km^2$ (NSW Maritime 2004). It is 29.7 km long, 5.32 km wide, has an entrance width of 1.58 km, perimeter of 237.31 km and a water area of 50.47 $km^2$ (NLWRA 2001). The bathymetry varies from 3 to 45 m in depth. The estuaries of southeast 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 (developments include refineries, breweries, paint industries and construction, and the waterway is popular for recreational boating and water sports (Hatje *et al.* 2001). The site of Barangaroo has a history of varying landuse types over a period of some 200 years, some of which have the potential to have contaminated portions of the site. Principal of these former polluting land uses was the former Australian Gas and Light Company gasworks. Other potential landuses 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 follows: silt typically occurs from 0 - 0.2 m below the harbour floor, silty sand / sandy silt typically occurs from 0.5 – 1.2 m, and silty clay typically from 0.6 – 1.2 m (ERM 2008b) (**Table 1.1**).

**Table 1.1 Geology of the seafloor adjacent to the Barangaroo site (ERM 2008).**

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

## 1.6 Study Objectives

The objective of the current study was to undertake a Marine Ecology Impact Assessment to assist Lend Lease in responding to the NSW Planning Director General Requirements (DGR's) relating to the Barangaroo Concept Plan Amendment (MP06_0162 MOD4). Full responses to the DGRs listed below are provided in **Section 2**.

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.*

## 1.7 Scope of Works

To address these DGRs, WorleyParsons (on behalf of Lend Lease), undertook marine surveys in waters adjacent to Barangaroo (impact site) and at two nearby reference locations; Berrys Bay (located to the north at Waverton) and Snails Bay (located to the north-west at Birchgrove) on May 5th and 6th 2010. All sampling was undertaken in waters which are zoned W1 Maritime Waters under the Sydney Regional Environment Plan (Sydney Harbour Catchment) 2005 (Harbour REP). In summary, the Marine Ecology Impact Assessment examines:

- **Construction Methodology** – Discussion of the proposed construction methodology for the Landmark Building (including associated pier, submerged basements structure and connection through existing foreshore alignment) and Southern Cove (including current foreshore alignment amendments and cove creation) and the potential impact of construction methods on the marine environment.
- **Water Quality** – Assess water quality at the site and examine these data with reference to the ANZECC / ARMCANZ (2000) National Water Quality Guideline trigger values and the expected average water quality values for Australian estuaries (NSW Government 1992). Assess the potential impacts of the proposed development on water quality.
- **Aquatic Flora and Fauna** - Describe the aquatic flora and fauna at the site via a desktop review and field surveys (using divers and project specific underwater video transects). Create habitat maps of aquatic vegetation in the vicinity of the site (where applicable) and asses potential impacts of the proposed development.
- **Benthic Infauna** - Assessment of benthic infauna (marine organisms living within the bottom sediments) 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. Assess the impact of proposed development on benthic infauna.
- **Marine Sediments** - Review of the Environmental Resource Management Australia (ERM) (2007, 2008a, 2008b) 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). Assess potential impacts of the proposed development (i.e through mobilisation of these sediments).

# 2 DIRECTOR GENERAL REQUIREMENTS & LEGISLATION

## 2.1 NSW Planning Director General's Requirements (DGRs)

Responses to the relevant NSW Planning Director General Requirements (DGR's) relating to the Barangaroo Concept Plan Amendment (MP06_0162 MOD4) for the Lend Lease Barangaroo Stage 1 Master Plan are as follows:

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

**Water Quality:**

Construction related activities associated with both the Landmark Building and the Southern Cove 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 Landmark Building has the potential to generate localised short term increases in turbidity through resuspension of sediments. If piling operations are not appropriately considered, designed and controlled, resuspension of bottom sediments could cause remobilisation of associated heavy metals and other contaminants into the water column. Once resuspended, these contaminants have the potential to disperse into less polluted areas of the Harbour, potentially affecting fish, algae and invertebrates.

Excavation of the Southern Cove has the potential to cause the release of contaminated land-based sediments and groundwater into the marine environment, impacting on water quality and aquatic ecology if not appropriately considered, designed and controlled.

WorleyParsons have considered appropriate design and construction methodologies associated with the Landmark Building and Southern Cove and have concluded that by employing the mitigation measures discussed in **Section 7.2.1**, any impacts of the proposed development on water quality within Darling Harbour are expected to be negligible, extremely localised and short-term in nature. See **Sections 4.2.1**, **6.1** for further detail on water quality in Sydney Harbour and at the study site.

**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 as discussed in **Sections 4.1.1** and **6.3.1**. Due to the lack of aquatic vegetation at or in the vicinity of Stage 1, no impacts on these habitats are expected. Field surveys found that the wetland area which is mapped 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 are expected if

appropriate mitigation measures to prevent the spread of suspended sediments are employed as described in **Section 7.2.1**.

**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. If accidentally released, the settlement of contaminated land-based sediments on the seafloor, excavated during construction of the Southern Cove, could also impact on nearby benthic marine 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 of Sydney Harbour 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 resuspension of contaminated sediments (Nayar *et al.* 2004). Hydrodynamic numerical modelling undertaken by WorleyParsons (June 2010) has found that velocities under and near the proposed Landmark Building (and associated submerged basement structure) are unlikely to be significantly increased, and are not likely to have any negative effect on fish species inhabiting Darling Harbour or mobilisation of existing bed sediments.

Sessile Organisms: Removal of the existing structures at Barangaroo will 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 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 (e.g. salinity and turbidity) (Knott and Johnston 2010). Therefore, it is unlikely that there will 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 any 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 *TSC Act* 1995 or *EPBC Act* 1999, which have the potential to occur in the harbour, would utilise this area. Further, no aquatic vegetation protected under the *FM Act* 1994 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 7.2.1** should be employed. To increase habitat complexity and species diversity, and to reduce the likelihood of colonisation of novel habitats such as new seawalls by introduced marine species (Glasby *et al.* 2007), design and construction of any seawalls at Barangaroo (e.g. at the headland parkland or Northern Cove) should be undertaken according to the guidelines in *Environmentally Friendly Seawalls* (DECC 2009), as described in **Section 7.2.1**. For

further detail on aquatic ecology at the site and mitigation measures to reduce the impacts on aquatic ecology refer to **Sections 4.1**, **6.3**, and **7.2**.

In summary, if effectively mitigated using the industry standard methods and techniques described in **Section 7.2.1**, any potential impacts on water quality and aquatic ecology arising from the Landmark Building (including piled foundations, submerged basement and associated pier) or new Southern Cove, 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 excavation and construction works, 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. Water generated from dewatering activities during bulk excavation would be monitored and treated to ensure that water quality conditions (i.e. site specific trigger limits) were satisfactory prior to discharge to sewer or into the Harbour via stormwater. 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 put in place for water quality management as described in **Section 7.2.1** 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 within Stage 1 to improve quality of any storm water discharge to Darling harbour. Stormwater is proposed to be collected for reuse within the development (as a source of irrigation etc) and therefore quantity of stormwater discharge to Darling harbour is expected to reduce form current levels.

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

The proposed submerged basement structure below the Landmark Building and associated pier is proposed to be suspended above the current harbour bed level. Hydrodynamic numerical modelling undertaken by WorleyParsons (June 2010) has found that velocities under and near the proposed Landmark Building are unlikely to be significantly increased such that existing bed sediments would be mobilised.

To mitigate against possible mobilisation of existing contaminated sediments, any activities not conducted in the dry, associated with construction of the Landmark Building and submerged basement carpark (such as pile driving) should employ industry standard and appropriate techniques as described in **Section 7.2.1**. Prior to such activities, silt curtains should be installed. Water quality monitoring should be undertaken (in accordance with protocols set out in the **Water Quality Report** prepared by WorleyParsons (June 2010) for the Bulk Excavation and Basement Carparking

Application) surrounding the development, to ensure that water quality conditions are maintained beyond the silt curtains and in the broader area.

Piled foundations to the proposed Landmark Building would be founded in suitable strength sandstone bedrock 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.

## 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 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

The *Environmental Planning and Assessment Act* (*EP&A Act*) 1979 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 significant (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

The *Fisheries Management Act* (*FM Act*) 1994 and its Regulations are administered by the Department of Primary Industries (DPI). The *FM Act* and Regulations 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

The *Threatened Species Conservation Act* (*TSC Act*) 1995 is administered by the Department of Environment, Climate Change and Water (DECCW). This Act applies to both threatened terrestrial and aquatic flora and fauna. In the aquatic environment seabirds, waders, aquatic retiles, aquatic mammals and insects, endangered aquatic ecological communities and key threatening processes are addressed.

### 2.2.6 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act* (*EPBC Act*) 1999 is administered by the Commonwealth Department of Environment, Water, Heritage and the Arts (DEWHA). 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

The NSW Maritime *Marine Habitat Survey Guidelines 2009* (**Appendix 1**) State 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 PROPOPSED CONSTRUCTION METHODOLOGY

The proposed construction methodology for the Southern Cove and Landmark Building (including pier, submerged basement and landside basement connection) are summarised below. In the case of Southern Cove, two constructions options are discussed here for the purpose of the assessment; however, alternate methodologies may be developed and detailed at the Project Application Phase.

## 3.1.1 Southern Cove

Two feasible construction options for the creation of the Southern Cove are outlined below; in the "wet" or in the "dry". Other options including hybrids of "wet" and "dry" may also be possible and can be further discussed at the Project Application Stage.

### SOUTHERN COVE – WET OPTION

This option assumes that there is a low level of contamination for dissolved (water soluble) contaminants near the ground surface or that contaminants are of acceptably low concentrations or not readily mobilised in ground water or only present deep in the ground below the depth to be excavated. Pre-environmental testing and construction stage monitoring would need to be undertaken to confirm. This methodology is broadly described below:

1. Install a temporary silt curtain(s) (installation of two silt curtains; an inner curtain to contain the immediate work area and an outer curtain to confine the entire work area would be considered) and boom to enclose the western end of the area proposed to be excavated for the purpose of the creation of Southern Cove;
2. Install diaphragm walls to the north, east and south side of the cove for the adjacent building basements and to create foreshore / seawall face;
3. Initially retain the existing MSB revetment lined earth embankment which exists across the west mouth of former berths 6 and 7 quay and proposed entry to the Southern Cove;
4. Demolish existing waterfront apron concrete slabs and excavate "in the dry" from landside using conventional excavators down to the ground water level;
5. Undertake excavation "in the wet", from ground water level down to the planned excavation level. Water would remain in this excavation, with the excavators working outward and removing the fill from below the water surface. This is expected to leave a turbid body of water;
6. De-water and stockpile the excavated saturated spoil prior to use as fill for the Headland Park. The water removed from the spoil would need to be stored, tested and treated as necessary;

7. Potentially flocculate the turbid water in the excavated area, then treat the bed of the newly created cove with a geotextile and small rock armour. This would be dependant on the particle size, predicted future mobility and any residual contamination of the sediments;
8. Open the embankment which would exist across the western mouth of the Southern Cove to join the body of water within it (which has been treated as necessary) with the rest of Sydney Harbour;
9. Complete the excavation of the embankment before removing the temporary silt curtain(s) and boom; and
10. Appropriate monitoring of water quality will be undertaken during and after construction works.

### SOUTHERN COVE – DRY OPTION

This methodology is broadly described below:

1. Install a temporary silt curtain(s) (installation of two silt curtains; an inner curtain to contain the immediate work area and an outer curtain to confine the entire work area would be considered) and boom to enclose the western end of the proposed Southern Cove;
2. Install groundwater control walls to the north, eastern and southern sides of the cove for the adjacent building basements;
3. Construct water-tight connections with the diaphragm walls to the existing caissons at the northern and southern sides of the mouth of the cove;
4. Retain the existing embankment that occurs across the western mouth of the Southern Cove;
5. Investigate the expected water flows through this western embankment. Make a 'watertight' basin by using either the embankment alone with a dewatering system, or the embankment with a shallow cut-off wall (grout curtain, permeation grouting or sheet pile wall) and a dewatering system.
6. Commence and maintain the de-watering system with the extracted ground water treated as per requirements;
7. Excavate material from the Southern Cove "in the dry";
8. As this option involves excavation within an enclosed perimeter, dewatering outside the confines of the Southern Cove causing settlement along Sussex Street or Hickson Road should not be an issue, though monitoring during construction would confirm this;
9. Open the existing embankment across the western mouth of the Southern Cove to allow a controlled flow of water from Sydney Harbour into the new Southern Cove;

10. Complete the excavation of the embankment before removing the temporary silt curtain and boom; and
11. Appropriate monitoring of water quality will be undertaken during and after construction works.

### 3.1.2 Landmark Building

#### CONSTRUCTION OF LANDMARK BUILDING, PIER & BASEMENT CARPARK

Construction of the Landmark structure will typically involve:

1. Installing piles for the pier and building structure;
2. Constructing the submerged building basement and connection through existing caissons to the land side; and
3. Construction of the pier deck and Landmark Building.

Installation of piles would follow industry standard practice.

Construction of the submerged building basement would follow a similar approach to that demonstrated by the recent Walsh Bay 2/3 development which was partially poured in sections above the water and then jacked down into position. Watertight seals between the submerged basement units and the existing caisson walls would involve concrete pours undertaken in the water with divers. Similar construction methodology was adopted on the Sydney Harbour Tunnel.

Construction methodology for the pier deck and Landmark Building would follow industry standard practice.

A typical construction methodology would generally be as follows:

- Install perimeter silt curtains around the perimeter of the works;
- Utilise barge mounted piling plant to install piles through to sound stratum;
- Prepare and cast basement slab and walls within formwork supported off the piles above high water level;
- Strike formwork and jack basement slab and walls down into position into the water;
- Divers to fix formwork and pour concrete to seal between the piles and the basement slab pile sleeves;
- Divers to fix formwork and pour concrete to seal between the existing Berth 8 caisson units and the east wall of the basement box;
- Dewater basement box and connection to land between basement box and caisson units;

- Complete connection between caisson units and the land based basement areas; and
- Appropriate monitoring of water quality will be undertaken during and after construction works.

A future Project Application for the construction of the Southern Cove and Landmark Building will more thoroughly detail the preferred construction methodology and management measures to minimise environmental impacts.

# 4 BACKGROUND RESEARCH ON AQUATIC ECOLOGY, WATER QUALITY AND SEDIMENTS

This section provides background information on aquatic ecology, water quality and sediments in Sydney Harbour and in the vicinity of the proposed Barangaroo Stage 1 development site. **Section 7** provides as assessment of the potential impacts of the proposed Stage 1 development on water quality and aquatic ecology, taking into account both the information in this section, and data gathered in the marine field surveys (**Section 6**). A brief summary of impacts is provided here.

## 4.1 Aquatic Flora and Fauna

### 4.1.1 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 (NSW 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; NSW DPI 2007).

Extensive mapping of the aquatic vegetation in Sydney Harbour has been undertaken by the NSW Department of Primary Industries (DPI) (Fisheries) (West *et al.* 1985, NSW DPI 2005). All data were mapped at a scale of 1:1500 derived from aerial photographs with a positional accuracy of approximately 6 m. The latest estuarine vegetation maps (NSW DPI 2005) indicate that seagrass is absent from the vicinity of the study site (**Figure 4.1**). 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 (NSW DPI 2005) indicate the absence of any mangroves in the vicinity of the study site (refer **Figure 4.1**). No mangroves were observed at or near the proposed Lend Lease Barangaroo development during the site visit.

**Saltmarsh**

The latest estuarine vegetation maps (NSW DPI 2005) indicate the absence of any saltmarsh in the vicinity of the study site (refer **Figure 4.1**). No saltmarsh was observed at or near the proposed Lend Lease Barangaroo development during the site visit.


**Figure 4.1 Aquatic vegetation in the vicinity of the study site (extraction taken from NSW 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 (DIPNIR 2005) (refer **Figure 4.2**). Wetlands are described by NSW 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 (NSW DPI 2005).

**Figure 4.2 Wetlands Protection Area mapped at Balmain East (opposite Barangaroo) (Harbour REP 2005).**

*IMPACTS: No seagrass or other aquatic vegetation was observed in the footprint of the proposed development during the site inspections, by divers or on the underwater video. In addition, no aquatic vegetation has been mapped in the area by NSW 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 impact on these sensitive habitats are expected.*

### 4.1.2 Aquatic Fauna

Numerous marine fauna have the potential to occur in the vicinity of the proposed Lend Lease development. 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, mollusks (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 **Sections 7.2.1** and **7.3.1**) any impacts will 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 Landmark Building and associated structures will increase the surface area of habitat available for sessile marine fauna. 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 will 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; therefore this will not impact the movement of fish and other mobile species.*

### 4.1.3 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 (NSW 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 (NSW 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 (NSW 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 from Port Jackson:

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

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

*IMPACTS: No introduced marine flora was observed at the site so the proposed works do not have the potential to cause spread of species such as C. taxifolia. Removal of the existing caisson wall and wharf / jetty structures will reduce the available habitat for the introduced species C. gigas.*

### 4.1.4 Threatened and Protected Species

Searches of the National Parks and Wildlife Service (NPWS) Atlas of NSW Wildlife (for species listed under the *NSW Threatened Species Conservation Act* 1995), the DEWHA Protected Matters Search Tool (for species listed under the *Environment Protection and Biodiversity Act* 1999) and Schedules of the *NSW Fisheries Management Act* 1994 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* 1995 as potentially occurring in the Sydney Harbour (unincorporated) LGA returned the following results (see **Appendix 2** for detailed search results):

- 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; and
- Green Turtle (*Chelonia mydas*) – V.

**Table 4.1** provides a summary of the habitat required by each of these species and their likelihood of occurrence at the study site. Of the species listed, the only ones with any likelihood of occurring in the vicinity of the proposed development are the Little Penguin and Green Turtle. However, no areas listed as *Little Penguin Critical Habitat* under the Harbour REP 2005 occur in the area.

**Table 4.1 Threatened marine species listed under the *TSC Act* 1995 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)<br>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. |
| **Southern Right Whale** *Eubalaena australis* | Endangered (EPBC Act)<br>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)<br>Vulnerable (TSC Act) | Oceanic and coastal waters worldwide. | **Unlikely** – essentially an oceanic species. |
| **New Zealand Fur-seal** *Arctocephalus forsteri* | Marine (EPBC)<br>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 areas with rocky shores / habitats. |
| **Australian Fur-seal** *Arctocephalus pusillus doriferus* | Marine (EPBC Act)<br>Vulnerable (TSC Act) | Marine waters of Australia. Prefers rocky parts of islands with flat, open terrain. | **Unlikely** – essentially a marine species which inhabits areas with rocky shores / habitats. |
| **Green Turtle** *Chelonia mydas* | Vulnerable / Migratory (EPBC Act)<br>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 NSW coastal waters, where it is generally seen on the north or central coast, with occasional records from the south coast. Forage in shallow benthic habitats such as tropical tidal and sub-tidal coral and rocky reef habitat or inshore seagrass beds. | **Unlikley** – although the species may occur within the general area the high level of boating traffic and absence of any foraging habitat at Barangaroo means its occurrence is unlikely. |

***Environment Protection and Biodiversity Conservation Act* 1999**

An *EPBC Act* 1999 Protected Matters Report was generated on the 28 April 2010 for an area of 1 km around the Barangaroo proposed Stage 1 development site (see **Appendix 2** for detailed search results). In summary, the *Matters of National Environmental Significance* and *Other Matters* listed under the *EPBC Act* 1999 for this area included:

- National Heritage Places x 1 (Sydney Harbour Bridge);
- Wetlands of International Significance x 1 (Towra Point Nature Reserve – located within the same catchment area);
- No Commonwealth Marine Areas;
- No Threatened Ecological Communities;
- 15 Threatened Species (3 birds, 2 frogs, 4 mammals, 3 reptiles, 3 plants);
- 33 Migratory Species (7 terrestrial birds, 20 wetland birds, 4 marine birds, 2 marine reptiles);
- 3 Commonwealth Lands;
- 182 Places on the RNE;
- 36 Listed Marine Species (34 bird species, 2 reptiles);
- No Whales and Cetaceans;
- No Critical Habitats; and
- No Commonwealth Reserves.

The Barangaroo site currently lacks appropriate habitat for most of the threatened or migratory species referred to above. The only two species with the potential to occur in this area and be impacted by the proposed development, which are listed under the *EPBC Act 1999*, are the marine species the Loggerhead Turtle (*Caretta caretta*) and the Green Turtle (*C. mydas*) (**Table 4.2**), however, this is unlikely due to the high level of boating movements in the area and lack of nesting habitat here. In summary, it is considered that the development proposed under the modified Concept Plan will not impact upon any *Matters of National Environmental Significance* listed under the *EPBC Act*.

**Table 4.2 Threatened species listed under the *EPBC Act 1999* 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. | **Unlikley** – species or species habitat likely to occur within Sydney Harbour but high boating movements in area would reduce the likelihood of occurrence. |
| **Green Turtle** *Chelonia mydas* | Vulnerable / Migratory (EPBC Act)<br><br>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. | **Unlikley** – species or species habitat likely to occur within Sydney Harbour but high boating movements in area would reduce the likelihood of occurrence. |

### *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* 1994 (as listed in **Appendix 2**) are expected to occur in the proposed development location. Nor do we consider the proposed works to constitute a Key Threatening Process under *Schedule 6* of the Act.

*IMPACTS: No impact on any species of threatened fauna listed under the TSC Act 1995, EPBC Act 1999 or FM Act 1994 is expected. The existing Barangaroo site does not contain appropriate nesting or foraging habitat for any of the potential threatened species listed in **Tables 4.1** or **4.2,** 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 the tables above has the ability to remove themselves from the area if conditions are unfavorable. In terms of Key Threatening Processes, Hydrodynamic modelling undertaken by WorleyParsons (June 2010) has determined that the proposed Landmark Building (and associated submerged basement structure) are unlikely to significantly increase water velocities in the area and thus will have no negative effect on the movement of fish species in Darling Harbour.*

## 4.2 Water Quality and Sediments

### 4.2.1 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, 000 µS/cm (microsiemens per centimeter).

In 2001, 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) profiles in the estuary increased with increasing salinity and were 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 (SPM) concentrations (affecting turbidity readings) tended to decrease seaward. They were 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 7.2.1***

### 4.2.2 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 discharge via canals is the main point source of contaminants to the estuary (Barry *et al.* 2001) and 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 4.3**), 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 are 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 – 400 µg/g (30 – 40 times above background levels), Zn at concentrations of 600 – 1000 µg/g (13 – 21 times above background), Ni at concentrations of 42 – 50 µg/g (2 times above background levels), and Pb at 500 – 700 µg/g (15 – 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 of Sydney Harbour.

**Table 4.3 ANZECC/ARMCANZ 2000 Interim Sediment Quality Guidelines.**

| Contaminant | ISGQ-Low (Trigger value) | ISGQ-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 |

### 4.2.3 ERM Sediment Report Summary

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 ERM (2007, 2008a, 2008b) reports, detailing contamination of land-based and marine sediments at Barangaroo is provided below. As sediment quality guidelines do not exist for many of the contaminants tested for by ERM (e.g. Total Petroleum Hydrocarbons, BTEX Compounds and sulfate) comparisons to the ANZECC guidelines were not made. ERM adopted soil investigation levels and reported any exceedance of these 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 – 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;
- Polycyclic Aromatic Hydrocarbons (PAHs) - concentrations up to 13, 659.4 mg/kg;
- Total Petroleum Hydrocarbons (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;
- Benzene, Toluene, Ethylbenzene and Xylenes (BTEX) - concentrations up to 140 mg/kg, 232 mg/kg, 63 mg/kg and 345 mg/kg respectively;
- 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 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 show 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, 350.4 µg/L;
- TPH in the $C_6$ - $C_9$ fraction up to 31, 500 µg/L and in the $C_{10}$ – $C_{36}$ fraction up to 66, 360 µg/L;
- Benzene, Toluene, Ethylbenzene and Xylenes (BTEX) - concentrations up to 14, 400 µg/L, 5, 740 µg/L, 3, 020 µg/L and 6, 700 µg/L respectively;

- Metals - cadmium at concentrations up to 34.2 µg/L, copper up to 6 µg/L, lead up to 555 µg/L and zinc up to 764 µg/L; and
- Free cyanide - concentrations up to 11 µg/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 (COPCs) in soils were found in some samples collected from across the Barangaroo site for lead, Total Petroleum Hydrocarbons (TPH), Polycyclic Aromatic Hydrocarbons (PAH), Benzene, Toluene Ethylbenzene and Xylenes (BTEX), and sulfate. Highest COPCs 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 heavily influenced by tidal fluctuations. High tide groundwater velocities were estimated at between 3.2 and 28 m/day inland and low tide velocities range between 6.3 and 57 m/day towards the harbour. A net groundwater flux into the Harbour at a velocity of between 0 and 7.6 m/day 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 COPCs 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 (17.95 to 18.95 m below ground level) approximately 40 m from the site boundary with the Harbour, indicating potential migration towards Darling Harbour.

### PRELIMINARY SEDIMENT SCREENING WORKS AT EAST DARLING HARBOUR, ADJACENT TO BARANGAROO, NSW (ERM 2008B)

ERM (2008b) undertook screening of marine sediments adjacent to the Barangaroo site to assess whether COPCs may have migrated into sediments on the Harbour floor. Transects were taken adjacent to Barangaroo South (Transect 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. They concluded that a potential source of elevated COPCs 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, 2008a).

**Geology:** The general sediment profile at the site consisted of silt to 0.2 m below the Harbour floor (bhf), underlain by silty sand to approximately 0.5 m bhf, becoming silty clay with depth (max depth tested was 1.2 m bhf). Shell fragments were observed between 0.5 and 1.0 m 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 (refer **Table 4.4**). The majority of exceedance for arsenic and chromium was identified in sediments from Transect 4 which lies directly north of the site boundary.

**Table 4.4 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 $C_{10}$ - $C_{36}$ (> 1000 mg/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 4.5 Summary of TPH $C_{10}$ - $C_{36}$ Results (mg/kg) (ERM 2008b).**

| | 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. The maximum concentrations of PAHs were identified in Transect 6. The mean total PAH concentration in sediments collected from above 0.3 m bhf (37 mg/kg) was greater than those collected from below 0.3 bhf (29 mg/kg). Concentrations generally decreased with distance from Transect 6 to the north and south.

**Table 4.6 Summary of Total PAH Results, Normalised to 1% Organic Carbon (mg/kg) (ERM 2008b).**

| | 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.

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

**Tributyl Tin (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 1.59%, 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 0.063 mm (silt and clay), 52% between 2 and 0.06 mm (sand) and 4% greater than 2 mm (gravel).

**Water Quality Parameters:** Water quality was measured at the surface (0.3 m) and 5 m below the surface.

- Temperature ranged from 16.5°C to 17.2°C with a mean of 16.8°C.
- pH ranged from 5.52 to 8.1 and was slightly higher in surface waters with a mean pH of 7.3 at 0.3 m and 6.1 and 5 m.
- Conductivity ranged from 51.0 mS/cm to 58.9 mS/cm with an average of 54.91 mS/cm.
- Dissolved oxygen ranged from 8.71 ppm to 9.82 ppm with an average of 9.08 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. By minimising resuspension and spread of marine sediments during the construction phase, and preventing land based sediments from entering the harbour, 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 7.2.1*** *will reduce the potential effects of these sediments to an acceptable level and ensure that any impacts are short-term and localised.*

# 5 SURVEY METHODS

## 5.1 Field Conditions

Field surveys were undertaken on Wednesday 5th and Thursday 6th May 2010, 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 proposed Lend Lease Barangaroo Stage 1 development.

On Wednesday 5th May, the conditions were unsettled and stormy. Winds were NNW 15 to 21 knots in the morning and W 13 to 17 knots in the afternoon. Sea state was choppy with 0.5 - 1 m swells. There were heavy rain periods throughout the day. Water temperatures ranged from 20.5 - 20.8°C at the surface and 20.6 - 21°C mid water (~ 6 m deep). On Thursday 6th May, the conditions were fine and sunny. Winds were W 11 to 15 knots in the morning, shifting WSW 10 to 14 knots in the afternoon. The sea state was moderately choppy. Water temperatures ranged from 18.8 - 21.2°C at the surface and 18.6 - 21°C mid water. Tides at Fort Denison on the 5th and 6th May 2010 were as follows:

**Table 5.1 Tidal data for the 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 (1) commercially qualified divers who undertook visual assessment of the seafloor, underwater photography and sediment coring and (2) 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 150 ft 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 proposed Stage 1 development) 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 5.1**). 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 location and maximum depth recorded at each of the sampling sites is shown in **Table 5.2**.

**Table 5.2 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 |