Overarching Remedial Action Plan for The Barangaroo Project Site, Sydney

for Barangaroo Delivery Authority

1 June 2010

0114385RP01 Final

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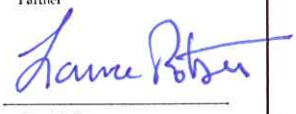
Signed:	
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Barangaroo Delivery Authority

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ABBREVIATIONS

ACM	Asbestos Containing Materials
AGL	The Australian Gas Light Company
AHD	Australian Height Datum
AMG	Australian Map Grid
ANZECC	Australia and New Zealand Environmental Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AS	Australian Standard
BDA	Barangaroo Delivery Authority
BTEX	Benzene, Toluene, Ethyl-benzene and Xylenes
CBD	Central Business District
CLM	Contaminated Land Management
COPC	Contaminants of Potential Concern
CUTEP	Clean Up To The Extent Practicable
DNR	Department of Natural Resources
DP	Deposited Plan
DQOs	Data Quality Objectives
E	East
EIL	Ecological Investigation Level
ERM	Environmental Resources Management Australia Pty Ltd
ESA	Environmental Site Assessment
ESD	Ecologically Sustainable Development
ha	hectare
HHERA	Human Health and Environmental Risk Assessment
HIL	Health-Based Investigation Levels
HSP	Health and Safety Plan
ISCO	In-Situ Chemical Oxidation
JSA	Job Safety Analysis
kg	kilogram
km	kilometre
L	litre
LOR	Limit of Reporting

LRTV	Low Reliability Trigger Value
m	metre
m bgl	metres Below Ground Level
mg	milligram
MGA	Map Grid of Australia
NEPC	National Environment Protection Council
NEPM	National Environment Protection (Assessment of Site Contamination) Measure
NHMRC	National Health and Medical Research Council
NSW DEC	New South Wales Department of Environment and Conservation (now NSW DECCW)
NSW DECC	New South Wales Department of Environment and Climate Change (now NSW DECCW)
NSW DECCW	New South Wales Department of Environment, Climate Change and Water (formerly NSW DECC / NSW DEC)
NSW EPA	New South Wales Environment Protection Authority
OCP	Organochlorine Pesticides
OPP	Organophosphorus Pesticides
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PPE	Personal Protective Equipment
PSH	Phase Separated Hydrocarbons
RAP	Remedial Action Plan
RBCL	Risk Based Clean Up Levels
RWP	Remedial Works Plan
S	South
SHTC	Sydney Harbour Trust Commissioners
SIL	Soil Investigation Level
SPC	Sydney Ports Corporation
SPMS	Sydney Ports Marine Services
SWMS	Safe Work Method Statement
TBT	Tributyl Tin
TPH	Total Petroleum Hydrocarbons
µg	microgram

EXECUTIVE SUMMARY

Environmental Resources Management Australia Pty Ltd (ERM) was engaged by the Barangaroo Delivery Authority (BDA) to prepare an Overarching Remedial Action Plan (Overarching RAP) for Barangaroo and an adjoining portion of Hickson Road (the Site). This Overarching RAP also takes into consideration roadways which are generally contiguous with the boundary of the Site and form part of the Barangaroo Project Site.

Barangaroo is a 22 hectare parcel of land located at Berths 3 - 8 Hickson Rd, Sydney, approximately 0.5 kilometres west of the Sydney Central Business District. The portion of Hickson Road addressed in the Overarching RAP is that part of Hickson Road that formerly contained the gasworks, as discussed below.

The part of the Site that comprised the footprint of the former gasworks has been declared a Remediation Site under the Contaminated Land Management (CLM) Act, 1997 (Declaration No. 21122), by the NSW Department of Environment, Climate Change and Water (DECCW) (the Remediation Site).

Barangaroo is the focus of a Concept Plan approved on 9 February 2007 by the Minister for Planning under Part 3A of the Environmental Planning and Assessment Act 1979 and State Significant Site Proposal which has been developed by the NSW Government. The Concept Plan incorporates guidelines for the type, mix, scale, location and height of proposed land uses.

The zoning of Barangaroo is defined in Schedule 3 of the SEPP (Major Development) 2005. Schedule 3, Part 12, S7 of the SEPP states that the land within the Barangaroo site is zoned as Zone B4 Mixed Use and Zone RE1 Public Recreation.

A number of Environmental Site Assessments (ESAs) have been completed at the Site, including two completed by ERM on behalf of the Sydney Harbour Foreshore Authority. An ESA of the Hickson Road portion of the Site was also completed by Coffey Environments Pty Ltd (Coffey) in 2008. The preliminary ESA identified that the Site was subject to potentially contaminating activities in the past, including the use of part of the Site as a gasworks, use of uncharacterised fill in reclaimed areas of the Site, petroleum storage, chemical and waste storage, vehicle/equipment washing and maintenance and the presence of structures containing asbestos containing materials (ACM).

The ESAs completed by ERM recommended that to mitigate risks posed by contaminated soil and groundwater to human and environmental receptors and render the Site suitable for the intended future mix of land uses, remedial measures would be required.

This Overarching RAP was commissioned by BDA to satisfy the requirements of the NSW Department of Environment, Climate Change and Water (DECCW). The objective of this Overarching RAP is to identify remedial options in order to address the Significant Contamination of the Remediation Site and once that has been addressed, to render the Remediation Site suitable for the proposed redevelopment; and to render the Development Area suitable for the proposed redevelopment. This Overarching RAP requires that specific RAPs be developed for the Remediation Site and each individual portion of the Site, when the nature of the development is known, and with specific Remediation Work Plans, which will detail the remedial measures.

This Overarching RAP presents a summary of the contamination issues identified by the previous ESAs and presents principles for remediation and a number of remedial options for each of four designated areas of the Site. The areas were divided into two main categories, being: (a) The Remediation Site and (b) the Development Area which is further designated as separate areas based on future land uses.

The remediation and management of Contamination at the Site is thus to be divided into two categories; (a) remediation required to address Significant Contamination within the Remediation Site; and (b) remediation and / or management of Contamination to accommodate development requirements for designated areas.

A Voluntary Management Proposal (VMP) has been prepared by the Barangaroo Delivery Authority for the Remediation Site which sets out a process of additional assessment, remediation technology trials and a more detailed remediation action planning process specific to the Remediation Site. The selection of a preferred remedial strategy for the Remediation Site will therefore be the subject of this VMP process and thus has not been determined as part of this Overarching RAP. It is however considered likely that removal and / or excavation and / or destruction and / or stabilisation of the source of Significant Contamination to groundwater and the Significant Contamination that provides an unacceptable risk to workers involved in intrusive works (particularly the materials most heavily impacted by tar and associated chemical substances) will form a key component of the preferred remedial strategy for this portion of the Site.

For all other areas of the Site, removal of "hotspots" of contaminated materials exceeding risk-based clean-up levels is proposed and, for contaminated materials that meet risk-based clean-up levels, on-site management involving capping of impacted materials. This Overarching RAP envisages that materials meeting risk-based clean-up levels may be used to establish the naturalistic headland at the northern part of Barangaroo, to be known as Headland Park or as fill materials in other parts of the Site following endorsement by the Site Auditor.

1 INTRODUCTION

1.1 DEFINITIONS

For the purposes of this RAP, the following definitions apply:

- "Remediation Site" - means those areas of the Site which are the subject of the declaration of significantly contaminated land by the Department of Environment Climate Change and Water, under the Contaminated Land Management Act 1997 (declaration Number 21122; Area Number 3221) dated 6 May 2009. This includes Areas 1 and 3 as described in Table 5.1.

- "Development Area" - means those areas of the Site that are not within the Remediation Site.

- "Remediation" – means removing, destroying, reducing or mitigating the Contamination that is giving rise or has potential to give rise to unacceptable risk to human health or the environment if one or more exposure pathways were completed.

- "Contamination" – means the presence in, on or under the land of a substance at a concentration above the concentration at which the substance is normally present in, on or under (respectively) land in the same locality, being a presence that presents a risk of harm to human health or any other aspect of the environment.

- "Significant Contamination" means Contamination which is significant enough to warrant regulation under the Contaminated Land Management Act 1997.

- "Site" refers to Lots 1, 3, 4, 5 and 6 of Deposited Plan (DP) 876514, along with parts of Hickson Road adjacent to:

  - 30 – 34 Hickson Road being Lot 11 DP1065410;

  - 36 Hickson Road being Lot 5 DP873158 and Lot 12 DP1065410; and

  - 38 Hickson Road being SP72797, Millers Point

- "Barangaroo" refers to Lots 1, 3, 4, 5 and 6 of Deposited Plan (DP) 876514, located at Berths 3-8, Hickson Road, Millers Point.

- "Barangaroo Project Site" refers to Barangaroo and the adjoining portions of Sussex Street, Hickson Road and Towns Place as shown in *Figure 1* of *Annex A*.

1.2 BACKGROUND

Barangaroo is a 22 hectare (ha) parcel of land located at Berths 3 - 8 Hickson Rd, Millers Point, approximately 0.5 kilometres west of the Sydney Central Business District (CBD). The location of the Site is presented in *Figure 1* of *Annex* A.

A number of Environmental Site Assessments (ESAs) have been completed at the Site, including two completed by ERM on behalf of the Foreshore Authority (refer to *Section 2.6*). Detailed ESAs identified the presence of Contamination of fill materials, natural soil and groundwater within the footprint of the former gasworks and minor Contamination of fill materials elsewhere on the Site. The ESAs recommended that in order to render the Site suitable for the intended future mix of land uses and minimise potential impacts to surrounding sites and sensitive receptors such as Darling Harbour, remedial measures would be required.

In March 2010, NSW DECCW requested BDA to prepare an Overarching RAP for the Site. ERM was commissioned by BDA to prepare an Overarching RAP. This Overarching RAP is based on a draft RAP prepared by ERM in early 2008. In addition to the Development Area, the Overarching RAP was also required to canvas remedial measures required to address the requirements of the declaration by NSW DECCW in relation to the Remediation Site. Consequently, the Overarching RAP also includes the adjoining portion of Hickson Rd, opposite numbers 30 – 34, 36 and 38 Hickson Rd, Millers Point. The Overarching RAP also takes into consideration roadways which are generally contiguous with the boundary of the Site including portions of Sussex Street, Hickson Road and Towns Place as shown in *Figure 1* of *Annex A* and form part of the Barangaroo Project Site.

The purpose of this Overarching RAP is to identify strategies and remedial options to address the Significant Contamination of the Remediation Site and once that has been addressed, to render the Remediation Site suitable for the proposed redevelopment; and to render the Development Area suitable for the proposed redevelopment. The remediation of the Remediation Site will be undertaken in accordance with a regulatory VMP process. The Proposed Phase 1 VMP (refer to *Annex B*) sets out a process of additional assessment, remediation technology trials and a detailed remediation action planning process. The selection of a preferred remedial strategy for the Remediation Site will therefore be subject to a VMP process and thus has not been determined as part of this Overarching RAP. It is however likely that removal of the source of Significant Contamination (particularly the materials most heavily impacted by tar and associated chemical substances) will form a key component of the preferred remedial strategy for this portion of the Site.

This Overarching RAP requires that specific RAPs be developed for each portion of the Site, when the nature of the development is known, and with specific Remediation Work Plans (RWP), which will detail the remedial measures:

- to address the Significant Contamination of the Remediation Site, and once that has been addressed, to render the Remediation Site suitable for the proposed redevelopment; and
- to render the Development Area suitable for the proposed development and address the specific requirements of the development proposed in the areas comprising the Development Area.

1.3 DECLARATION OF REMEDIATION SITE

A portion of the Site (identified on *Figure 2* of *Annex A* and in *Annex C*) has been declared a Remediation Site under the *Contaminated Land Management* (CLM) Act, 1997 (Declaration No. 21122), by NSW DECCW (the Remediation Site).

The Remediation Site to which the Declaration relates is part of the former Millers Point gasworks and is described as:

- Part Lot 5 and Part Lot 3 in Deposited Plan (DP) 876514, Hickson Rd, Millers Point
- The part of Hickson Road adjacent to:
  - 30 – 34 Hickson Road being Lot 11 DP1065410;
  - 36 Hickson Road being Lot 5 DP873158 and Lot 12 DP1065410; and
  - 38 Hickson Road being SP72797, Millers Point

Annex C contains a copy of the declaration.

1.4 NATURE OF THE PROPOSED REDEVELOPMENT

The Site is the focus of a Concept Plan approved on 9 February 2007 by the Minister for Planning under Part 3A of the *Environmental Planning and Assessment Act 1979* (Concept Plan) and State Significant Site Proposal which was developed by the NSW Government. The Concept Plan incorporates guidelines for the type, mix, scale, location and height of proposed land uses.

The approved Concept Plan essentially divides the Site into two areas (refer to *Figures 2 and 3* of *Annex A*):

- Eastern portion - intended for mixed use commercial/residential; and
- Western and northern portion – intended for public parkland.

The zoning of Barangaroo is defined in Schedule 3 of the SEPP (Major Development) 2005. Schedule 3, Part 12, S7 of the SEPP states that the land within the Barangaroo Site is zoned as Zone B4 Mixed Use and Zone RE1 Public Recreation. A zoning plan for Barangaroo is included as *Figure 3* of *Annex A*.

It is noted that following approval of the Concept Plan and appointment of Lend Lease as the preferred proponent to develop "Stage 1" of Barangaroo, applications have been submitted to the NSW Department of Planning (DoP) to modify certain elements of the approved Concept Plan and these applications have since been determined. At the time of this Overarching RAP, a number of additional project applications for the proposed redevelopment had also been submitted to the NSW DoP and were yet to be determined, these included:

- Barangaroo (formerly East Darling Harbour): MP06_0162 MOD 4 (Hotel development, additional GFA and Height)
- Barangaroo (formerly East Darling Harbour): MP10_0025 - Barangaroo - C4 Commercial Building
- Barangaroo (formerly East Darling Harbour): MP10_0024 - Barangaroo - C1 Commercial building
- Barangaroo (formerly East Darling Harbour): MP10_0022 -Barangaroo - Bulk excavation and basement car parking - Blocks 1-3
- Barangaroo (formerly East Darling Harbour): MP10_0023 -Barangaroo - Demolition and site establishment works - Blocks 1-3
- Barangaroo (formerly East Darling Harbour): MP10_0026 - Barangaroo - Remediation and land forming works

It is also understood from information provided by BDA that preparation for the submission of a further two project applications in relation to the open space portion of the Site is underway. These applications will relate to :

- Headland Park Early Works – receipt of fill from Stage 1 South, sandstone excavation and services.
- Headland Park Main Works – overall design for Headland Park.

1.5 OBJECTIVE

The primary objective of the Overarching RAP is to present a summary of the Contamination issues identified by the previous ESAs and to present principles for remediation / management and a number of options for each of four designated areas of the Site – the designated areas being based on the Remediation Site declared by NSW DECCW and future land uses.

The secondary objective of this Overarching RAP is to provide an outline for a coordinated approach to the remediation and management of the Site as a whole rather than simply as an aggregation of discrete development stages or blocks. In this respect, this Overarching RAP envisages that materials meeting risk-based clean-up levels derived in the Headland Park HHERA may be used to establish the naturalistic headland at the northern part of Barangaroo, to be known as Headland Park, or beneficially reused in other areas of the Site under the governance of the HHERA relevant to those areas following endorsement by the Site Auditor.

The Overarching RAP has been developed in general accordance with relevant guidance documents, including:

- NSW EPA (1997) *Guidelines for Consultants Reporting on Contaminated Site;* and
- NSW DEC (2006) *Guidelines for the NSW Site Auditor Scheme (2nd Edition)*.

1.6 SCOPE OF WORKS

This Overarching RAP is required to identify a preferred approach to remediate the Site, which may incorporate a variety of remedial techniques and will (if carried out in an appropriate and well coordinated manner) address the Significant Contamination of the Remediation Site, and once that has been addressed, to render the Remediation Site suitable for the proposed redevelopment; and render the Development Area suitable for the future intended land uses, which include commercial, high density residential, open space and public thoroughfare (Hickson Road).

This Overarching RAP requires that specific RAPs will be prepared for the various portions of the Site with specific Remediation Work Plans, which will document the specific remedial measures to be implemented:

- to address the Significant Contamination of the Remediation Site, and once that has been addressed, to render the Remediation Site suitable for the proposed redevelopment; and
- to render the Development Area suitable for the proposed redevelopment.

This Overarching RAP is therefore not intended to meet all of the reporting requirements for a RAP as outlined in NSW EPA (1997) *Guidelines for Consultants Reporting on Contaminated Sites*.

This Overarching RAP has been prepared to include the following;

- Overarching remediation goals for the Site;
- an estimation of the remediation required to address the Significant Contamination on the Remediation Site;
- an overview of environmental management measures required to address the Significant Contamination on the Remediation Site and once that has been addressed, to render the Remediation Site suitable for the proposed redevelopment; and to render the Development Area suitable for its proposed future land uses;
- an evaluation of relevant remedial options for the Site along with rationale/s for selection of recommended remedial options (where appropriate);
- identification of contingency measures should the recommended remedial strategy be unsuccessful or be limited in its application, through the identification of options; and
- general requirements for managing environmental compliance and occupational health and safety requirements during the course of remedial works.

2 SITE DESCRIPTION

2.1 SITE IDENTIFICATION

- The Site refers to Lots 1, 3, 4, 5 and 6 of Deposited Plan (DP) 876514, located at Berths 3-8, Hickson Road, along with the part of Hickson Road adjacent to:
  - 30 – 34 Hickson Road being Lot 11 DP1065410;
  - 36 Hickson Road being Lot 5 DP873158 and Lot 12 DP1065410; and
  - 38 Hickson Road being SP72797, Millers Point.

The Barangaroo part of the Site has a total area of approximately 22 ha and the Hickson Road part of the Site has an area of approximately 0.6 ha (*Figure 1* of *Annex A)*. A Site layout plan is presented as *Figure 2* of *Annex A*.

The elevation of the Site is approximately 2 - 3 m Australian Height Datum (AHD) and the Map Grid of Australia 1994 (MGA 94) coordinates for the approximate centre of the Site are:

- Easting– 333643 m E; and
- Northing - 6251851 m S.

The main vehicular access to the Site is via Hickson Road to the east, the portion of Hickson Road subject to this Overarching RAP is currently part of a public thoroughfare. This Overarching RAP also takes into consideration roadways which are generally contiguous with the boundary of the Site and form part of the Barangaroo Project Site.

It is noted that one small portion of the Site is excluded from this Overarching RAP, being Moore's Wharf (in the far north eastern section of the Site, refer to *Figure 2* of *Annex A*).

2.2 SURROUNDING LAND USES

The following surrounding land uses (as of June 2008) were noted:

- **North**: Immediately to the north is Sydney Harbour;

- **East:** Immediately to the east of the majority of the Site is Hickson Road, to the east of the portion of Hickson Road subject to the declaration lie the properties known as 30 – 34, 36 and 38 Hickson Road. A childcare facility is located adjacent to the eastern Site boundary on the ground floor of "The Bond" (30-34 Hickson Road). Beyond Hickson Rd. along the remainder of the eastern boundary of the Site lies the Sydney CBD comprising commercial high rise buildings to the south east and some residential properties to the east and north east.

- **South**: Immediately south of the overseas passenger terminal portion of the Site is the commercial King Street Wharf area, comprising retail shops, restaurants and residential apartments; and

- **West**: Immediately to the west is Darling Harbour.

The former gasworks structures are known to be present beneath part of Barangaroo and beneath the adjoining part of Hickson Road and beyond to the east. Within the footprint of the former gasworks, impacted fill materials and natural soil and rock and have resulted in Contamination of groundwater on the south eastern portion of the Site.

2.3 CURRENT SITE ZONING AND USAGE

The zoning of the Site is defined in Schedule 3 of the SEPP (Major Development) 2005. Schedule 3, Part 12, S7 states that the land within the Barangaroo site is zoned as Zone B4 Mixed Use and Zone RE1 Public Recreation as shown in *Figure 3* of *Annex A*. The portion of Hickson Road which forms part of the Remediation Site is currently zoned for use as a public thoroughfare.

The south-western portion of the Site includes Wharf 8, an operational cruise ship passenger terminal and function centre, operated by Sydney Ports Corporation (SPC). Wharf 8 consists of a large warehouse style building containing an arrivals hall, customs area and cargo bay, surrounded by car parking, gardens and the SPC office building in the south eastern corner.

Up until late 2007, the remainder of Barangaroo was occupied by Patrick Stevedoring with this portion being dominated by four large warehouse buildings (transit sheds), as shown in *Figure 2* of *Annex A,* which were demolished in early 2008. This portion of the Site was generally covered with concrete or asphaltic concrete hardstanding. The hardstanding surfaces were observed to be generally in a reasonable condition, with no evidence of significant degraded areas. At the completion of the ERM 2008 ESA, the workers amenities building remained on the eastern boundary of the Site along with the three gatehouses and the Sewage Pumping Station at the north of the Site, which is identified in the NSW State Heritage list.

2.4 SITE HISTORY

The historical use of the Site has been reviewed in detail, including historical title deed searches, review of historical aerial photographs and a review of previous environmental investigations. A summary of the historical use of the Site is provided in *Section 2.4.1*, however ERM understands that some gaps remain regarding historical activities conducted on the Site relating to the operation, decommissioning and demolition of the former gasworks and which may be the focus of future investigations. It is noted however, that these data gaps in the understanding of the Site history are unlikely to significantly impact upon the remedial strategy put forward in this Overarching RAP given the detailed soil and groundwater investigations conducted in the area.

2.4.1 *Chronology of Site Activities*

The historical activities and environmental investigations carried out at the Site are summarised as follows:

- *1839 to 1921*: A gasworks operated by The Australian Gas Light Company (AGL) was located on part of the Site and extended across what is now Hickson Road. The approximate location of the former gasworks infrastructure is shown in *Figure 2* of *Annex A*. The remainder of the Site was owned by merchants, compositors, manufacturers and various shipping companies and it is considered likely that the Site was also used for ship berthing and associated activities. Ownership was largely transferred to Sydney Harbour Trust Commissioners (SHTC) in approximately 1912, however it is understood that the gasworks site was leased to AGL until September 1921. The Hickson Rd portion of the Site was owned by a tin smelter and engineer during 1875. Other owners include ship builders, licensed victualler, shipowners and merchants.

- *1922 to 1925*: The gas holders and purifier beds associated with the AGL gasworks were demolished to ground level and the gas holding tanks were backfilled. The fill in the gas holder pits has been reported to contain odours, and tarry material from 2 m bgl depth (URS, 2001). The Site was used for workshops and stores, with many warehouse buildings constructed on the former gasworks area.

- *1925 to 1936*: The majority of the Site continued to be owned by the SHTC and was used for ship berthing and associated activities. According to the title search records, the Hickson Road portion of the Site has been used since 1925 as a road under the control and management of the City of Sydney Council.

- *1936 to 1998*: Part of the Site was owned by the Maritime Services Board of NSW and subject to various commercial leases. The majority of the remainder of the Site initially consisted of finger wharves, which were removed over time with a significant portion of land reclaimed from the harbour with unclassified fill between 1951 and 1972. In 1996 a vehicle maintenance area including wash bay, waste oil store and above ground diesel fuel tanks was identified.

- 1996-2007: A number of environmental investigations were conducted on the Site by Noel Arnold & Associates, Coffey Partners International, URS and ERM. These investigations are summarised in *Section 2.5*.

- *1998*: Marine Ministerial Holding Corporation was the proprietor of Lots 1 and 6 in Deposited Plan 876514. SPC was proprietor of Lots 2, 3, 4 and 5.

- *2007 - 2008*: The majority of the Site was vacated by Patrick Stevedores Operations. Four large warehouses were demolished and the Site cleared and levelled in preparation for future redevelopment. Additional site investigation works were completed by ERM in early 2008.

2.5 SITE CONTAMINATION HISTORY

Sources of Contaminants of Potential Concern (COPC) on the Site are outlined in detail in previous investigation reports by ERM (2007a and 2008), Coffey Environments Pty Ltd (Coffey) (2008) and URS (2001).

In summary, the Site was subject to potentially contaminating activities in the past, including the use of part of the Site as a gasworks, use of uncharacterised fill in reclaimed areas of the Site, below- and above-ground diesel storage/distribution, chemical and waste storage, above-ground petroleum storage, vehicle/equipment washing and maintenance and the presence of structures containing asbestos containing materials (ACM).

2.6 PREVIOUS INVESTIGATIONS

Nine ESA reports relating to the Site and the harbour sediments adjacent to the Site were reviewed in developing the remedial options for this Overarching RAP. A list of the reports reviewed, as well as a brief summary of the salient features of each, is provided in *Table 2.1.* In addition, it is understood that other investigations have been completed recently by others on parts of the former gasworks, to the east of the Site boundary.

Table 2.1 Previous Investigations

Date of Publication	Consultant	Report Title and Key Issues Identified.
January, 1986	ARUP Geotechnics	Upgrading Wharf 7/8 Darling Harbour, Geotechnical Site Investigation. This investigation details soil/rock design parameters for analyses, results of geotechnical analysis, advice on foundation system options and recommendations on the most suitable type of foundation for proposed development on Wharf 7/8. No contamination testing was undertaken as part of this assessment.
June, 1996	Noel Arnold & Associates Pty Ltd.	Initial Environmental Assessment, Sydney Ports Corporation, Darling Harbour, Berths 3-8 Hickson Road, Darling Harbour. This report details the findings of an ESA completed to provide an initial assessment of Contamination, to identify breaches of environmental law and to recommend any remedial work to ensure compliance with relevant environmental law or to allow the use of the Site without material risks to health and safety. The ESA found that known and potential Contamination at the Site did not present a material risk to health and safety associated with Patrick's Stevedores occupancy of the Site providing subsurface materials were not actively disturbed by excavation or similar works. The areas of known impacts were located within the former gasworks area. The areas with elevated levels of COPCs identified included: • Filled areas of the Site; and

Table 2.1 Previous Investigations (continued)

Date of Publication	Consultant	Report Title and Key Issues Identified.
		• Areas around the mechanical workshop, waste oil storage, above ground fuel tanks and vehicle wash areas. The ESA also highlighted issues of possible non-compliance with license requirements and general legal obligations in relation to storage and handling of fuels and waste oils, operation of vehicle wash bays, and the management of stormwater.
March, 1998	Coffey Partners International Pty Ltd.	Wharf 8 Darling Harbour Environmental Soil Quality Assessment This ESA involved limited soil sampling across Wharf 8, which was undertaken to assess COPCs in soil and to identify possible waste disposal options for excavated soil associated with a proposed Wharf Development. Conclusions of the assessment are as follows: • Wharf 8 soil contains low level PAH contamination. However the concentration does not pose an unacceptable level of risk to health. • Fill removed from Site for waste disposal is likely to be classified as industrial waste or hazardous waste.
July, 2001	URS Australia Pty Ltd.	Contamination Review for Darling Harbour- Berths 3-8. This document is a review of 11 reports produced by various consultants between May 1993 to July 2001 on the Darling Harbour-Berths 3-8 area. The review is a summary of the contamination identified on Site in these reports. Key contamination issues identified in the review are as follows: • COPCs in soil related to the use of fill on Site, particularly the areas associated with the former finger wharfs and former gasworks. • Soil contamination connected with dumping of wastes on Site, particularly from the former gasworks. • Soil contamination from current vehicle maintenance operations. • Groundwater contamination associated with on Site sources of COPCs in soil identified above. • COPCs in groundwater migrating on Site from up-gradient sources of COPCs.
August 2006	Jeffrey and Katauskas Pty Ltd	Geotechnical Investigation for Proposed Redevelopment of Wharves 3-8 at Hickson Road, Darling Harbour East, NSW (conducted concurrently with ERM (2007) as described below). This reported the findings of a geotechnical investigation designed to identify and document the geotechnical site conditions in preparation for development planning and included: • Borelogs; • Foundation analysis; and • Recommendations for design.

Table 2.1 Previous Investigations (continued)

Date of Publication	Consultant	Report Title and Key Issues Identified.
June 2007a	ERM Australia Pty Ltd	Environmental and Geotechnical Site Assessment, East Darling Harbour, Sydney, NSW Final Report – Revision 1 The objective of this ESA was to identify and document the environmental Site conditions in preparation for development planning. The works undertaken included; • Completion of a Stage One Site Investigation including a desk-top study of environmental and geotechnical issues and historical land uses; and • Completion of a Stage Two Site Investigation including drilling, sampling and analysis of soil and groundwater at over 150 locations across the Site. Two primary areas of elevated concentrations of COPCs in soil were identified in the vicinity of the former gasworks and in the north western portion of the Site. Groundwater depth ranged from 1.7 to 2.5 m bgl, possibly influenced by tidal fluctuations. Elevated concentrations of COPCs in groundwater were primarily in the vicinity of the former gasworks.
May 2008	Coffey Environments Pty Ltd	Preliminary Environmental Investigation at Hickson Road. This study focussed on the section of roadway between property numbers 30-38 Hickson Road. The primary objective of this study was to assess levels of contamination at the Site to establish the potential levels of risk the Site poses to road users and maintenance staff, adjoining properties and Sydney Harbour. Findings from this report can be summarised as follows: • High levels of soil and groundwater contamination were identified within former gasworks infrastructure such as the tar tank and 1870 gas holder. Sampling locations within the near vicinity of these structures also presented high levels of contamination. Contaminants including petroleum hydrocarbons (TPH), polycyclicaromatic hydrocarbons (PAHs) and benzene, toluene, ethylbenzene and xylenes (BTEX). • Bedrock has limited the migration of heavy hydrocarbon fractions from point sources such as the tar tank and the 1870 gas holder. • Soluble contaminants such as (volatile organic compounds (VOCs), BTEX and ammonia have the potential to impact surface and groundwater in surrounding areas as these migrate offsite in the dissolved phase. • The risks to human health posed by the observed impacts are considered by Coffey to be low given that there is no direct exposure to the public where roadways are sealed with asphalt and concrete. Coffey recommend that utility owners and operators should be made aware of Contamination issues at the Site so that appropriate risk management measures can be adopted. • The migration of dissolved phase contaminants with groundwater movement within fill material towards East Darling Harbour is considered by Coffey to be highly likely and to present a potential risk to the aquatic environment.

Date of Publication	Consultant	Report Title and Key Issues Identified.
June 2008a	ERM Australia Pty Ltd	Additional Investigation Works at Barangaroo, Hickson Road, Millers Point, NSW – Draft, Revision 1. The objective of this ESA was to address data gaps remaining after the previous Stage Two ESA. ERM advanced an additional 55 boreholes to an average depth of approximately 12 m bgl across the Site and installed 13 monitoring wells. Key finding of the study were; • a number of areas of concern were identified including the former gasworks and reclaimed areas between the former finger wharves; • Exceedences of assessment criteria for soil were observed across the Site for lead, Total Petroleum Hydrocarbons (TPH), Polycyclic Aromatic Hydrocarbons (PAH), Benzene, Toluene Ethylbenzene and Xylenes (BTEX) and sulfate. The highest identified concentrations of each of the identified COPC were located within the footprint of the former gasworks; • With minor exceptions, exceedences of the assessment criteria for groundwater for dissolved TPH, BTEX and PAH compounds were located within the gasworks footprint. Exceedences were observed in wells screened across fill material, natural clayey sand and sandstone; • Hydrogeological data indicated that the primary receptors for COPCs potentially migrating from the Site include Darling Harbour and areas to the east of the Site. The primary pathways for contaminant migration were likely to be bedding planes within the sandstone bedrock, the highly permeable fill aquifer and potentially anthropogenic pathways such as utility conduits; Phase separated hydrocarbons (PSH) were observed at a number of locations during drilling and accumulated in monitoring well MW204D, located within the gasworks footprint.

Table 2.1 Previous Investigations (continued)

Date of Publication	Consultant	Report Title and Key Issues Identified.
August 2008b	ERM Australia Pty Ltd	Preliminary Sediment Screening Works at East Darling Harbour, Adjacent to Barangaroo, NSW, Draft, Rev 03. ERM conducted preliminary sediment screening works at East Darling Harbour to assess if COPCs had potentially migrated from the former gasworks to sediments on the Harbour floor, adjacent to the Site. Sediment cores were collected from the Harbour floor along seven transects and discrete sediment samples were analysed for identified COPCs. A preliminary Tier 1 Screening exercise identified the following: 1. Concentrations of Polycyclic Aromatic Hydrocarbons (PAHs), Tributyl Tin (TBT) and metals exceeded the ANZECC/ARMCANZ (2000) ISQG-Low screening values across the majority of the area sampled. 2. Organochlorine Pesticides (OCPs) were detected at concentrations above screening values in one sample. 3. Elevated concentrations of TPH C10-C36 (>1000 mg/kg) were identified in five sediment samples collected from two sample locations, one located to the south and one to the north of the portion of the harbour adjacent to the former gasworks. 4. A potential source of elevated COPCs in sediment (with the exception of TBT) in the Harbour sediments may be contaminated soil and groundwater identified on Barangaroo. 5. Given the widespread impact to the quality of sediments expected in Darling Harbour, additional investigation of the quality of sediments in Darling Harbour is not considered to be warranted It is noted that NSW DECCW reviewed this assessment prior to issuing the declaration of Remediation Site and it is therefore not expected that remediation of the Harbour sediments would be required.

2.7 SENSITIVE ENVIRONMENTS

COPCs identified in fill materials and natural soil and groundwater on the Site have the potential to negatively impact the receiving waters and sediments of Darling Harbour. Preliminary sediment screening works in East Darling Harbour were conducted by ERM (2008b) *Preliminary Sediment Screening Works at East Darling Harbour, Adjacent to Barangaroo, NSW, Draft*. Concentrations of COPCs associated with Barangaroo were identified above ANZECC/ARMCANZ (2000) Tier 1 screening values in sediments adjacent to the Site. Preliminary results suggested that a potential source of elevated COPCs in the sediment may be contaminated soil and groundwater identified on Site. The draft report has been reviewed by the NSW DECCW and it is not expected that remediation of the Harbour sediments would be required given the wide spread impacts in sediments in Darling Harbour.

Other sensitive receptors in the vicinity of the Site include residential apartments and a childcare facility which are located adjacent to the eastern Site boundary.

2.8 TOPOGRAPHY AND HYDROLOGY

The topography of the Site is relatively flat, having been cut and filled for its previous use as a stevedoring facility. The Site abuts a cliff face on the eastern boundary in the northern portion of the Site.

The closest surface water body to the Site is Darling Harbour, located immediately adjacent to the west and north of the Site. Surface water from the Site is collected via a sub-surface drainage network, which generally flows toward Darling Harbour, as shown in *Figure 2* of *Annex A*.

2.9 GEOLOGY

According to the *1:100 000 Geological Survey of NSW (Sydney) Sheet 9130 (Ed 1)* 1983, the Site is generally underlain by man-made fill over Hawkesbury Sandstone, which is described as follows:

- man-made fill may consist of "*dredged estuarine sand and mud, demolition rubble, industrial and household waste*"; and
- Hawkesbury Sandstone is characterised as "*medium to coarse-grained quartz sandstone with very minor shale and laminite lenses*".

The general geological profile observed at the Site during the ERM 2008 investigation can be summarised as follows:

Table 2.2 Summary of Geological Profile

Unit	Description	Depth (mbgl)
Hardstanding	Asphaltic concrete or concrete, generally in good condition with no staining.	0 – 0.46
Road base fill	Very dark grey, dry, loose, medium grained sand to fine gravel, poorly sorted, sub angular, no odours or staining noted.	0 – 0.5
Fill	Silty, gravelly sand, olive brown, grey brown, light yellowish brown, dry to wet, fine to coarse sand, sandstone floaters. Fill material including building rubble, bricks, concrete. Black staining and a hydrocarbon odour noted in some boreholes particularly in and around the former gasworks area.	0 – 18.0
Marine Clay/Sand	Interbedded clayey sand and sandy clay, dark greyish brown, saturated, some shell fragments and organic matter. Sandy clay – soft, high plasticity. Clayey Sandy – loose to dense, fine to coarse sand, low to no plasticity.	3.0 – 18.4
Marine Clay/Sand	Interbedded clayey sand, sandy clay and sand, light yellowish brown, white, reddish brown or dark greyish brown, saturated. Sandy clay – stiff to hard, medium to high plasticity. Clayey Sandy and sand – loose to dense, fine to coarse sand, low to no plasticity.	4.9 – 32.75
Bedrock	Weathered sandstone, white, light yellowish brown, olive brown and reddish brown, wet, fine to coarse grained, some fracturing noted.	1.3 -32.75

Some areas along the western foreshore and building footprints were covered by concrete, with a thickness up to 0.5 m. A layer of fill was observed in all boreholes and ranged in thickness from 1.3 m on the east of the Site to 18 m on the west of the Site. As noted in ERM (2007a), boreholes drilled in the northern and eastern portion of the Site were generally devoid of a layer of natural soils, with fill immediately overlying bedrock. A generalised three dimensional geological model of the Site was developed based on the data obtained from the ERM ESAs and is presented in *Figure 6* of *Annex A*.

2.10 HYDROGEOLOGY

As outlined in ERM (2007a), information obtained from the Department of Natural Resources (DNR) in 2006 indicated that 32 registered groundwater bores were situated within a 4 km radius of the Site. Review of the groundwater abstraction bore information indicated that the bores were used for the following purposes: recreation (8), irrigation (3), and monitoring (22). None of the bores were registered for drinking water purposes. No registered groundwater bores were identified on or adjacent to the Site. Further details of the hydrogeological conditions observed on the Site are included in *Section 5.1.2.*

3 *DATA QUALITY OBJECTIVES*

Data Quality Objectives (DQOs) were developed to define the type and quality of data required to achieve the project objectives outlined in *Section 1*. The DQOs were selected with reference to relevant guidelines published by the New South Wales Environmental Protection Authority (NSW EPA), NSW Department of Environment and Conservation (DEC), NSW Department of Environment and Climate Change (DECC), Australian and New Zealand Environment Conservation Council (ANZECC) and National Environment Protection Council (NEPC), which define minimum data requirements and quality control procedures.

Specific guidelines referenced include:

- Australian Standard AS 4482.1 (1999), *Guide to Sampling and Investigation of Potentially Contaminated Soil (Part 1: Non-volatile and semi-volatile compounds)*;
- Australian Standard AS 4482.2 (1999), *Guide to Sampling and Investigation of Potentially Contaminated Soil (Part 2: Volatile Substances)*;
- Australia and New Zealand Environmental and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (ANZECC/ARMCANZ) (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality;*
- New South Wales Department of Urban Affairs and Planning (NSW DUAP) (1998) *Managing Land Contamination: Planning Guidelines, SEPP 55 Remediation of Land*;
- National Environment Protection Council (NEPC) (1999) *National Environment Protection (Assessment of Site Contamination) Measure 1999, Schedule B (2) – Guideline on Data Collection, Sample Design and Reporting* and *Schedule B (3) - Guidelines on Laboratory Analysis of Potentially Contaminated Soils*;
- New South Wales Environment Protection Authority (NSW EPA) (1994) *Guidelines for Assessing Service Stations*;
- NSW EPA (1995) *Sampling Design Guidelines*;
- NSW EPA (1997) *Guidelines for Consultants Reporting on Contaminated Sites*;
- NSW EPA (1999) *Guidelines on Significant Risk of Harm from Contaminated Land and the Duty to Report*;
- New South Wales Department of Environment and Conservation (NSW DEC) (2006) *Guidelines for the NSW Site Auditor Scheme - 2nd Edition*;
- NSW DEC (2007) *Guidelines for the Assessment and Management of Groundwater Contamination*;

- NSW EPA (2003) *Draft Guidelines for the Assessment of Former Gasworks Sites; and*

- NSW DECC (2008) *Waste Classification Guidelines.*

The DQO process used followed the seven-step approach identified in NSW DEC (2006), as described in the following sections.

3.1 STEP ONE – STATE THE PROBLEM

Previous investigations conducted at the Site (as identified in *Section 2.6*) have identified Contamination of soil and groundwater associated with historical activities undertaken at the Site associated with the former gasworks, historical land reclamation and other potentially contaminating activities. The primary aim of this project, as described in *Section 1.2*, is to identify remediation options in order to address Significant Contamination on the Remediation Site and once that has been addressed, to render the Remediation Site suitable for the proposed redevelopment; and to render the Development Area suitable for the proposed redevelopment.

3.2 STEP TWO – IDENTIFY THE DECISION

The decision to be made with respect to the Contamination at the Site relates to assessing the most appropriate remedial strategy to be adopted to address the Significant Contamination on the Remediation Site and once that has been addressed, to render the Remediation Site suitable for the proposed redevelopment; and to render the Development Area suitable for the proposed development.

3.3 STEP THREE – IDENTIFY INPUTS TO THE DECISION

The scope of work for this plan was based upon the following:

- Information provided directly to ERM by the Foreshore Authority and the BDA;

- a review of available historical information including previous reports prepared by various consultancies;

- a review of previous investigations conducted by others; and

- a review of data gathered during site investigation works completed by ERM in 2006 and 2008.

3.4 STEP FOUR - DEFINE THE BOUNDARIES OF THE STUDY

The extent of the area to which this RAP applies is as described in *Section 2.1* and shown on *Figures 1 and 2* of *Annex A*. This RAP applies to addressing the Significant Contamination of the Remediation Area and once that has been addressed, to rendering the Remediation Site suitable for the proposed redevelopment; and to rendering the Development Area suitable for the proposed redevelopment as described in *Section 1.2*.

3.5 STEP FIVE – DEVELOP A DECISION RULE

In view of the exceedences of adopted screening values identified in the ERM (2007 and 2008) ESA reports, a quantitative human health and environmental risk assessment (HHERA) should be prepared to develop risk-based clean-up levels (RBCLs) to guide remedial works based on the requirement to remove the source/s of groundwater Contamination and the intended use of each of the different areas of the Site. It is envisaged that the HHERA would be completed at an early stage to facilitate protection of the environment and once specific details of proposed future land uses are known (such as the location of any basements or sensitive commercial activities e.g. child day care centre) and that the RBCLs developed would be incorporated into the RWP specific to each part of the Site. It is envisaged that RBCLs would be developed to protect the quality of groundwater and that different sets of RBCLs would be developed for different areas of the Site, based on the intended future land use.

In the absence of site specific RBCLs, relevant Australian guideline values have been utilised within this Overarching RAP as described in *Section 4*.

3.6 STEP SIX – SPECIFY LIMITS ON DECISION ERRORS

Following completion of remediation activities, measured concentrations of identified COPCs in soil and groundwater across the Site must not pose a significant risk to human health, as assessed in the HHERA, which is to be completed in accordance with relevant NEPC (1999) guidance.

Laboratory QA/QC procedures and data incorporated in to the risk assessment are required to be assessed in accordance with the NEPM (1999), *Schedule B (3) - Guidelines on Laboratory Analysis of Potentially Contaminated Soils.*

3.7 STEP SEVEN – OPTIMISE THE DESIGN FOR OBTAINING DATA

A sampling, analysis and quality plan for the validation programs shall be developed based on NEPC (1999) *Schedule B (2)* and NSW EPA (1997) prior to the commencement of validation works. It is envisaged that this document would be incorporated in the specific RWPs and would culminate in Validation reports at the completion of remediation works. The aim of establishing the DQOs outlined above, prior to the project commencement, is to facilitate the collection of a suitably accurate, precise, comparable, representative and complete data set to validate the effectiveness of the remedial works.

4 ASSESSMENT CRITERIA FOR CHARACTERISATION

For the Site characterisation summarised in *Section 5*, relevant Australian guideline values have been used to evaluate the nature and extent of Contamination. For remediation/management purposes however (as described in *Section 3.5*) it is envisaged that a quantitative HHERA shall be completed for protection of groundwater quality and once specific details of future land uses and the nature of the development are fully known and that site-specific RBCLs (also known as Site Specific Target Criteria (SSTC)) will be developed and incorporated into the RWPs.

In the absence of site-specific RBCLs (or SSTC), relevant Australian guideline values have been utilised as assessment criteria within this RAP as described below.

4.1 SOIL

The soil assessment criteria adopted were based on the Soil Investigation Levels (SILs) outlined in the NEPC (1999), Schedule B(1) – *Health Investigation Levels* (Exposure Setting 'F' for commercial/industrial premises, 'D' for Residential with minimal opportunities for soil access and 'E' for Parks, recreational open space and playing fields). Sulfate concentrations were assessed against the NEPM (1999), Schedule B(1) – Ecological Investigation Level for the protection of built structures. It is noted that the SILs do not take into account the potential for contaminants in soils to act as a secondary source of impacts to groundwater and that this matter is required to be considered in the development of RBCLs in the future so that a key requirement of the Declaration is addressed.

Assessment criteria for petroleum hydrocarbons were assessed on sensitive land used guidelines provided within the NSW EPA (1994) *Guidelines for Service Station Sites*.

The Site assessment criteria for soil are presented in *Table 4.1* (below). It should be noted that although chemical substances for which assessment criteria have not been assigned were detected above the laboratory limit of detection, Tier 2 and Tier 3 HHERAs will be required to set clean-up levels for chemical substances that remain on the Site after completion of the remedial works.

Table 4.1 Soil Assessment Criteria

Analyte	Units	LOR	NSW EPA 1994 Health & Ecological	NEPM 1999 EIL	NEPM 1999 HIL D	NEPM 1999 HIL E	NEPM 1999 HIL F
Phenolic Compounds							
2,4,5-trichlorophenol	mg/kg	0.5					
2,4,6-trichlorophenol	mg/kg	0.5					
2,4-dichlorophenol	mg/kg	0.5					
2,4-dimethylphenol	mg/kg	0.5					
2,6-dichlorophenol	mg/kg	0.5					
2-chlorophenol	mg/kg	0.5					
2-methylphenol	mg/kg	0.5					
2-nitrophenol	mg/kg	0.5					
3-&4-methylphenol	mg/kg	1					
4-chloro-3-methylphenol	mg/kg	0.5					
Pentachlorophenol	mg/kg	2					
Phenol	mg/kg	0.5			34000	17000	42500
Inorganics							
Arsenic	mg/kg	5			400	200	500
Cadmium	mg/kg	1			80	40	100
Chromium	mg/kg	2					
Copper	mg/kg	5			4000	2000	5000
Cyanide Total	mg/kg	1			2000	1000	2500
Lead	mg/kg	5			1200	600	1500
Mercury	mg/kg	0.1			60	30	75
Nickel	mg/kg	2			2400	600	3000
Sulfate	mg/kg	100		2000			
Zinc	mg/kg	5			28000	14000	35000
BTEX Compounds							
Benzene	mg/kg	0.2	1				
Ethylbenzene	mg/kg	0.2	50				
m- & p-xylene	mg/kg	0.2					
o-xylene	mg/kg	0.2					
Toluene	mg/kg	0.2	130				
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	mg/kg	0.5					
Acenaphthylene	mg/kg	0.5					
Anthracene	mg/kg	0.5					
Benz(a)anthracene	mg/kg	0.5					
Benzo(a) pyrene	mg/kg	0.5			4	2	5
Benzo(b)fluoranthene	mg/kg	0.5					
Benzo(g,h,i)perylene	mg/kg	0.5					
Benzo(k)fluoranthene	mg/kg	0.5					
Chrysene	mg/kg	0.5					
Dibenz(a,h)anthracene	mg/kg	0.5					
Fluoranthene	mg/kg	0.5					
Fluorene	mg/kg	0.5					
Indeno(1,2,3-c,d)pyrene	mg/kg	0.5					
Naphthalene	mg/kg	0.5					
Phenanthrene	mg/kg	0.5					
Pyrene	mg/kg	0.5					
Polychlorinated Biphenyls							
PCBs (Sum of total)	mg/kg	0.1			40	20	50

Analyte	Units	LOR	NSW EPA 1994 Health & Ecological	NEPM 1999 EIL	NEPM 1999 HIL D	NEPM 1999 HIL E	NEPM 1999 HIL F
TPH Compounds							
TPH C 6 - C 9 Fraction	mg/kg	2	65				
TPH C10 - C14 Fraction	mg/kg	50					
TPH C15-C28 Fraction	mg/kg	100					
TPH C29-C36 Fraction	mg/kg	100					
TPH C10 - C36 (Sum of total)	mg/kg	250	1000				

Because no risk-based criteria are available in Australian guidance documents, groundwater constituents were assessed with reference to the guidelines outlined in the ANZECC/ARMCANZ (2000) and results were compared to the 95% level of protection for marine ecosystems. Mercury concentrations were compared to the 99% level of protection for marine ecosystems to account for potential bio-accumulation. These criteria are conservative in that they are for protection at the point of contact. The groundwater assessment criteria are detailed in *Table 4.2* (below). It is envisaged that risk-based clean-up levels for soils will be developed in the HHERA, that will be protective of groundwater quality.

Table 4.2 Groundwater Assessment Criteria

Analyte	Units	LOR	ANZECC 2000 Marine 99%	ANZECC 2000 Marine 95%	ANZECC Low Reliability Trigger Value (LRTV)
Phenolic Compounds					
2,4,5-Trichlorophenol	ug/L	1			4
2,4,6-trichlorophenol	ug/L	1			
2,4-dichlorophenol	ug/L	1			
2,4-Dimethylphenol	ug/L	1			2
2,6-Dichlorophenol	ug/L	1			31
2-chlorophenol	ug/L	1			
2-Methylphenol	ug/L	1			
2-Nitrophenol	ug/L	1			2
3 & 4-Methylphenol	ug/L	2			
4-Chloro-3-methylphenol	ug/L	1			
Pentachlorophenol	ug/L	2		22	
Phenol	ug/L	1		400	
Inorganics					
Ammonia	ug/L			910	
Arsenic (Filtered)	ug/L	1			
Cadmium (Filtered)	ug/L	0.1		5.5	
Chromium (Filtered)	ug/L	1		27.4	
Copper (Filtered)	ug/L	1		1.3	
Cyanide (Free)	ug/L	5			
Cyanide Total	ug/L	4		4	
Lead (Filtered)	ug/L	0.2		4.4	
Mercury (Filtered)	ug/L	0.1	0.1*	0.4	

Analyte	Units	LOR	ANZECC 2000 Marine 99%	ANZECC 2000 Marine 95%	ANZECC Low Reliability Trigger Value (LRTV)
Nickel (Filtered)	ug/L	1		70	
Sulfate	mg/L	1			
Zinc (Filtered)	ug/L	5		15	
BTEX Compounds					
Benzene	ug/L	1		700	
Ethylbenzene	ug/L	2			5
m- & p-xylene	ug/L	2			275
o-xylene	ug/L	2			350
Toluene	ug/L	2			180
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	ug/L	1			
Acenaphthylene	ug/L	1			
Anthracene	ug/L	1			0.4
Benz(a)anthracene	ug/L	1			
Benzo(a) pyrene	ug/L	0.5			0.2
Benzo(b)fluoranthene	ug/L	1			
Benzo(g,h,i)perylene	ug/L	1			
Benzo(k)fluoranthene	ug/L	1			
Chrysene	ug/L	1			
Dibenz(a,h)anthracene	ug/L	1			
Fluoranthene	ug/L	1			1.4
Fluorene	ug/L	1			
Indeno(1,2,3-c,d)pyrene	ug/L	1			
Naphthalene	ug/L	1		70	
Phenanthrene	ug/L	1			2
Pyrene	ug/L	1			
Polychlorinated Biphenyls					
PCBs (Sum of total)	ug/L	1			
TPH Compounds					
TPH C 6 - C 9 Fraction	ug/L	20			
TPH C10 - C14 Fraction	ug/L	50			
TPH C15 - C28 Fraction	ug/L	100			
TPH C29 - C36 Fraction	ug/L	50			
TPH C10 - C36 (Sum of total)	ug/L	200			

* 99% trigger value adopted to account for potential bioaccumulation / biomagnification in accordance with ANZECC/ARMCANZ (2000).

Given the proximity of the Site to Sydney Harbour, the most appropriate Tier 1 screening criteria for groundwater are considered to be the ANZECC/ARMCANZ (2000) 95% protection trigger value for marine waters. In the absence of a 95% trigger value for particular compounds, ANZECC/ARMCANZ(2000) Low Reliability Trigger Values (LRTVs) should be applied.

5 SITE CHARACTERISATION

5.1 NATURE OF IDENTIFIED CONTAMINATION

5.1.1 Soil

ERM (2008) reported analytical results from additional investigation works conducted on Site in early 2008 and previous results reported by ERM (2007a). Analytical results for 517 primary soil samples collected from over 200 boreholes (refer to *Figure 4* of *Annex A*) were presented. Samples were analysed by a commercial laboratory using methods registered by NATA for a suite of analytes, including:

- inorganics (arsenic, cadmium, total chromium, copper, lead, mercury, nickel, zinc, sulfate and cyanide),
- TPHs and BTEX,
- PAHs;
- OCPs and OPPs;
- PCBs; and
- phenolic compounds.

Coffey (2008) reported analytical results from investigation works conducted during early 2008 in the Hickson Road portion of the Site. Analytical results for 31 primary soil samples collected from 15 boreholes were presented. Samples were analysed by a NATA accredited laboratory for a suite of analytes, including:

- heavy metals;
- TPH and BTEX;
- PAHs;
- Phenolic compounds;
- Chlorinated hydrocarbons; and
- asbestos

To aid in the review and interpretation of the soil analytical results, the Site has been divided into four areas, based upon proposed future land use and whether the area fell within the boundary of the Remediation Site. Reported soil analytical results from areas proposed for future commercial and high-density residential land use were compared to the NEPM (1999) HIL 'D' and HIL 'F' criteria, whereas soil results from areas proposed for future open space land use were compared to the NEPM (1999) HIL 'E' criteria. Locations where concentrations of COPCs exceeding these criteria were identified are presented in *Figure 7* of *Annex A*.

It is noted specifically that the criteria adopted for soils were not protective of groundwater quality and that risk-based levels will be required to be developed in the HHERA so that the quality of groundwater is protected.

A description of the assessment areas is provided in *Table 5.1* below. Refer also to *Figure 2*, *Annex A*.

Table 5.1 Description of Separate Assessment Areas

Area	Description	Adopted Soil Assessment Criteria1
Area 1	Portion of the Site within the Remediation Site zoned for mixed use (commercial/residential).	NEPM (1999) HIL'D' & 'F'
Area 2	The portion of the Site outside the Remediation Site zoned for mixed use (commercial/residential).	NEPM (1999) HIL'D' & 'F'
Area 3	Portion of the Site within the Remediation Site within Hickson Road.	NEPM (1999) HIL 'E'
Area 4	The portion of the Site outside the Remediation Site zoned for open space land use	NEPM (1999) HIL 'E'

1. The NSW EPA (1994) criteria for TPH and NEPM (1999) Interim Urban Investigation Level for Sulfate are also applicable to all areas.

A summary of the maximum detected soil concentrations reported from the soil sampling conducted between May and August 2006 (ERM, 2007) and February and May 2008 (ERM, 2008) is provided in *Tables 5.2, 5.3* and *5.5 (below)*. It is noted that OCPs, OPPs, PCBs and most phenolic compounds were reported below the laboratory limit of reporting (LOR) in all samples analysed. A summary of the maximum detected soil concentrations reported in Coffey (2008) from samples collected in Area 3 is provided in *Table 5.4*.

Table 5.2 Maximum Soil Concentrations Area 1

Analyte	Location	Depth (m bgl)	Maximum Detected Concentration (mg/kg)
Arsenic	BH132	1.5-1.95	33
Cadmium	BH067	1.5-1.95	2
Chromium	BH058	1.5-1.95	89
Copper	BH074	1.5-1.95	1410
Lead	BH067	1.5-1.95	13 600
Mercury	BH115	0.8-1.0	5
Nickel	BH197	0.4	63
Zinc	BH067	1.5-1.95	4770
Sulfate	BH001	1.0	31 500
Cyanide Total	BH204D	1.5	575
TPH C_6 – C_9 Fraction	BH119	7.5-8.0	1140
TPH C_{10} - C_{14} Fraction	BH204D	1.5	54 200
TPH C_{15}-C_{28} Fraction	BH204D	1.5	72 400
TPH C_{29}-C_{36} Fraction	BH204D	1.5	20 600
TPH C_{10} - C_{36} Total	BH204D	1.5	147 200
Benzene	BH132	8.0-8.5	140
Toluene	BH132	8.0-8.5	232
Ethylbenzene	BH119	7.5-8.0	63
m- & p-xylene	BH132	8.0-8.5	225
o-xylene	BH132	8.0-8.5	120
Xylene Total	BH132	8.0-8.5	345
Acenaphthene	BH204D	1.5	222
Acenaphthylene	BH204D	1.5	605
Anthracene	BH204D	1.5	1200
Benz(a)anthracene	BH204D	1.5	823
Benzo(a) pyrene	BH204D	1.5	652
Benzo(b)fluoranthene	BH204D	1.5	587
Benzo(g,h,i)perylene	BH204D	1.5	305
Benzo(k)fluoranthene	BH204D	1.5	231
Chrysene	BH204D	1.5	631
Dibenz(a,h)anthracene	BH204D	1.5	71.4
Fluoranthene	BH204D	1.5	1550
Fluorene	BH204D	1.5	1190
Indeno(1,2,3-c,d)pyrene	BH204D	1.5	247
Naphthalene	BH204D	1.5	8410
Phenanthrene	BH204D	1.5	2700
Pyrene	BH204D	1.5	1510
PAHs (Sum of total)	BH204D	1.5	20 934
Phenol	BH204D	1.5	1720
Asbestos	BH203	1.5	Detected

Table 5.3 Maximum Soil Concentrations Area 2

Analyte	Location	Depth (m bgl)	Maximum Detected Concentration (mg/kg)
Arsenic	BH177	1.5	36
Cadmium	BH02	11-11.5	2
Chromium	BH195	5.45	65
Copper	BH177	1.5	1480
Lead	BH147	1.6-2.05	782
Mercury	BH177	1.5	8
Nickel	BH029	0.3-0.5	80
Zinc	BH195	9.9	1890
Sulfate	BH195	9.9	11 600
Cyanide Total	BH063	1.5-1.65	3
TPH C_6 – C_9 Fraction	BH117	15-15.5	244
TPH C_{10} - C_{14} Fraction	BH117	15-15.5	3090
TPH C_{15}-C_{28} Fraction	BH117	15-15.5	2180
TPH C_{29}-C_{36} Fraction	BH179	7.0	1180
TPH C_{10} - C_{36} Total	BH117	15-15.5	5580
Benzene	BH117	15-15.5	19
Toluene	BH117	15-15.5	65.9
Ethylbenzene	BH117	15-15.5	10.5
m- & p-xylene	BH117	15-15.5	54
o-xylene	BH117	15-15.5	29
Xylene Total	BH117	15-15.5	83.2
Acenaphthene	BH117	15-15.5	8.3
Acenaphthylene	BH117	15-15.5	63
Anthracene	BH117	15-15.5	25.6
Benz(a)anthracene	BH179	7.0	30
Benzo(a) pyrene	BH179	7.0	28.
Benzo(b)fluoranthene	BH179	7.0	33
Benzo(g,h,i)perylene	BH179	7.0	17
Benzo(k)fluoranthene	BH179	7.0	19
Chrysene	BH179	7.0	27
Dibenz(a,h)anthracene	BH179	7.0	4
Fluoranthene	BH179	7.0	54
Fluorene	BH117	15-15.5	36
Indeno(1,2,3-c,d)pyrene	BH179	7.0	14
Naphthalene	BH117	15-15.5	462
Phenanthrene	BH117	15-15.5	86
Pyrene	BH179	7.0	56
PAHs (Sum of total)	BH117	15-15.5	826.3
Phenol			<0.5

Table 5.4 Maximum Soil Concentrations Area 3

Analyte	Location	Depth (m bgl)	Maximum Detected Concentration (mg/kg)
Arsenic	MW7	4.5-4.6	8
	BH5	0.4-0.5	8
Cadmium	MW10	8.6-8.7	1
Chromium	MW10	8.6-8.7	171
Copper	BH2	3.4-3.5	308
Lead	BH5	0.4-0.5	1420
Mercury	MW7	4.5-4.6	3
Nickel	MW10	8.6-8.7	107
Zinc	MW10	8.6-8.7	614
Sulfate	-	-	Not tested
Cyanide Total	-	-	Not tested
TPH C_6 – C_9 Fraction	MW10	8.6-8.7	7590
TPH C_{10} - C_{14} Fraction	MW10	8.6-8.7	69 400
TPH C_{15}-C_{28} Fraction	MW10	8.6-8.7	93 200
TPH C_{29}-C_{36} Fraction	MW10	8.6-8.7	19 200
TPH C_{10} - C_{36} Total	MW10	8.6-8.7	181 800
Benzene	MW7	4.5-4.6	2080
Toluene	MW10	8.6-8.7	2650
Ethylbenzene	MW10	8.6-8.7	261
m- & p-xylene	MW10	8.6-8.7	1830
o-xylene	MW10	8.6-8.7	746
Xylene Total	MW10	8.6-8.7	2576
Acenaphthene	MW10	8.6-8.7	511
Acenaphthylene	MW7	5.0-5.1	4140
Anthracene	MW10	8.6-8.7	2150
Benz(a)anthracene	MW10	8.6-8.7	1470
Benzo(a) pyrene	MW7	5.0-5.1	677
Benzo(b&K)fluoranthene	MW7	5.0-5.1	1170
Benzo(g,h,i)perylene	MW7	5.0-5.1	88
Chrysene	MW10	8.6-8.7	771
Dibenz(a,h)anthracene	MW7	5.0-5.1	57
Fluoranthene	MW10	8.6-8.7	2440
Fluorene	MW10	8.6-8.7	2100
Indeno(1,2,3-c,d)pyrene	MW7	5.0-5.1	196
Naphthalene	MW10	8.6-8.7	13 200
Phenanthrene	MW10	8.6-8.7	5180
Pyrene	MW7	5.0-5.1	3110
PAHs (Sum of total)	MW10	8.6-8.7	41 270
Phenol	MW7	5.0-5.1	4170

Source: Coffey Environments (2008)

Table 5.5 Maximum Soil Concentrations Area 4

Analyte	Location	Depth (m bgl)	Maximum Detected Concentration (mg/kg)
Arsenic	BH126	1.5-1.95	77
Cadmium	BH150	9.5-10.0	2
Chromium	BH033	1.5-1.95	141
Copper	BH085	1.5-1.95	293
Lead	BH173	1.8	1320
Mercury	BH046	1.5-1.95	6
Nickel	BH053	0.3-0.5	164
Zinc	BH102	3-3.45	749
Sulfate	BH191	3.7	3710
Cyanide Total	BH063	1.5-1.95	3
TPH C_6 – C_9 Fraction	BH021	16-16.5	32
TPH C_{10} - C_{14} Fraction	BH021	16-16.5	510
TPH C_{15}-C_{28} Fraction	BH085	15.195	5050
TPH C_{29}-C_{36} Fraction	BH085	15.195	1770
TPH C_{10} - C_{36} Total	BH085	15.195	6950
Benzene	BH191	16.5	2.2
Toluene	BH191	16.5	5
Ethylbenzene	BH191	16.5	0.6
m- & p-xylene	BH191	16.5	6
o-xylene	BH191	16.5	2
Xylene Total	BH191	16.5	7.8
Acenaphthene	BH191	3.7	12.4
Acenaphthylene	BH085	1.5-1.95	15.8
Anthracene	BH191	16.5	46.9
Benz(a)anthracene	BH191	3.7	177
Benzo(a) pyrene	BH191	3.7	82.4
Benzo(b)fluoranthene	BH191	3.7	177
Benzo(g,h,i)perylene	BH191	3.7	39
Benzo(k)fluoranthene	BH191	3.7	46
Chrysene	BH191	3.7	144
Dibenz(a,h)anthracene	BH191	3.7	14
Fluoranthene	BH191	3.7	377
Fluorene	BH191, BH085	16.5, 1.5-1.95	18
Indeno(1,2,3-c,d)pyrene	BH191	3.7	41
Naphthalene	BH166	4.0	104
Phenanthrene	BH191	16.5	340
Pyrene	BH191	3.7	292
PAHs (Sum of total)	BH191	16.5	1813
Phenol			<0.5

5.1.2 Groundwater

Groundwater on the Site was assessed via a network of monitoring wells installed across the Site (as presented in *Figure 5* of *Annex A)*.

Hydrogeological data collected by ERM indicated that groundwater was strongly influenced by tidal fluctuations, especially in wells located near the Harbour and in monitoring wells MW209 and MW206, located inland (suggesting high hydraulic connection with the Harbour potentially due to conduits in the fill material).

At high tide, groundwater was observed to flow inland with a gradient of 0.003. At low tide groundwater flow was towards the harbour with a gradient of 0.006. Overall groundwater elevations were relatively flat and generally flowed toward the Harbour with an over all gradient of 0.0008. A noted exception to the general groundwater flow was observed at monitoring wells MW206 and MW209 where groundwater appeared to flow to the east rather than toward the Harbour.

A hydraulic conductivity of 211 m/day to 1894 m/day was estimated in fill material. Hydraulic conductivity was high in MW206 and MW209 with an estimated range of 4825 m/day to $1x10^6$ m/day, suggesting direct hydraulic conductivity with the Harbour. The Hydraulic conductivity in sandstone was estimated to be 0.01 to 6 m/day.

At high tide, groundwater velocities range between 3.2 and 28 m/day inland and at low tide groundwater flow velocities are likely to range between 6.3 m and 57 m/day toward Sydney Harbour. This suggests that much of the Site is likely to be subject to significant seawater flushing. Under average conditions there is likely to be a net groundwater flux toward Sydney Harbour, at a velocity of between 0 and 7.6 m/day.

Reported groundwater analysis results from samples collected at the Site indicated that the majority of criteria exceedences appear to be related to the impacted soil, fill and bedrock in the area of the former gasworks (refer to *Figure 8* of *Annex A*). Concentrations of COPCs in groundwater outside Areas 1 and 3 are generally consistent with what would be expected on an urban site of this nature as opposed to the highly elevated concentrations observed within Areas 1 and 3.

Table 5.6 Maximum Detected Groundwater Concentrations

Analyte	Location	Maximum Detected Concentration (ug/L)	Source
Inorganics			
Arsenic (Filtered)	MW10	24	Coffey 2008
Cadmium (Filtered)	MW08	10	ERM
Chromium (Filtered)	MW6	10	Coffey 2008
Copper (Filtered)	MW6	20	Coffey 2008
Lead (Filtered)	MW7	37	Coffey 2008
Mercury (Filtered)	MW7	1.1	Coffey 2008
Nickel (Filtered)	MW04	303	ERM
Zinc (Filtered)	MW10	373	Coffey 2008
Cyanide (Total)	MW198	18 600	ERM
Sulfate (Total)	MW212	6 540 000	ERM
TPH & BTEX Compounds			
TPH C_6 – C_9 Fraction	MW205	73600	ERM
TPH C_{10} - C_{14} Fraction	MW7	830 000	Coffey 2008
TPH C_{15}-C_{28} Fraction	MW10	152 000	Coffey 2008
TPH C_{29}-C_{36} Fraction	MW10	30 600	Coffey 2008
TPH C_{10} - C_{36} Total	MW7	907 870	Coffey 2008
Benzene	MW205	27 800	ERM
Toluene	MW7	6 440	Coffey 2008
Ethylbenzene	MW205	17 600	ERM
m- & p-xylene	MW205	3140	ERM
o-xylene	MW205	2000	ERM
Xylenes Total	MW205	5140	ERM
Polycyclic Aromatic Hydrocarbons			
Acenaphthene	MW10	369	Coffey 2008
Acenaphthylene	MW10	1140	Coffey 2008
Anthracene	MW10	1680	Coffey 2008
Benz(a)anthracene	MW10	1150	Coffey 2008
Benzo(a) pyrene	MW10	709	Coffey 2008
Benzo(b)fluoranthene	MW10	944	Coffey 2008
Benzo(g,h,i)perylene	MW10	260	Coffey 2008
Benzo(k)fluoranthene	MW204D	80.9	ERM
Chrysene	MW10	829	Coffey 2008
Dibenz(a,h)anthracene	MW10	80.4	Coffey 2008
Fluoranthene	MW10	2420	Coffey 2008
Fluorene	MW10	1670	Coffey 2008
Indeno(1,2,3-c,d)pyrene	MW10	258	Coffey 2008
Naphthalene	MW10	15 800	Coffey 2008
Phenanthrene	MW10	4390	Coffey 2008
Pyrene	MW10	2560	Coffey 2008
PAHs (Sum of total)	MW10	34 259.4	Coffey 2008

There appears to be significant potential for migration of mobile contaminants off Site into Sydney Harbour and possibly areas to the East of Hickson Road.

Preliminary sediment screening works in Sydney Harbour adjacent to the Site conducted by ERM (2008b) identified concentrations of COPCs in sediments above ANZECC/ARMCANZ (2000) Tier 1 screening values. Preliminary results suggested that a potential source of elevated COPCs in the sediment may be contaminated soil and groundwater identified on the Site. The draft report has been reviewed by the NSW DECCW and the Declaration did not refer to any significant contamination of the Harbour sediments.

5.2 EXTENT OF IDENTIFIED CONTAMINATION

An assessment of locations in which soil and groundwater exceed screening values is presented in full in ERM (2008a) and Coffey (2008) and these areas are also identified in *Figures 7* and *8* of *Annex A* and summarised below.

5.2.1 Soil and Bedrock Impacts

- Significant evidence of impact was identified within the fill, natural soil and bedrock on the Site, including staining, odours and, in the vicinity of the former gasworks structures, free-phase tar*;*

- The primary areas of identified impacts were within the footprint of the former gasworks and in a small volume of fill material in the north corner of the Site, surrounding and immediately beneath the location of former Warehouse 3. Localised hotspots were also identified within fill and natural soil within Wharf 8, adjacent to Hickson Road near the Gate 5 entry, west of the former gasworks infrastructure footprints and between former Warehouses 4 and 5. *Figure 7* of *Annex A* presents the approximate extent of identified exceedences of the soil assessment criteria.

- Asbestos was identified in one sample of 39 analysed by ERM and 4 analysed by Coffey from BH203 at 1.5 m bgl within the fill material.

- The maximum concentrations of COPCs were observed in Areas 1 and 3 which includes the former gasworks Remediation Site, in the area proposed for future commercial/residential land use and part of Hickson Road

- Evidence of potential vertical and lateral migration of hydrocarbons, was noted in the vicinity of the former gasworks. Evidence of free-phase tar was observed in fill, natural soils and sandstone at a number of locations in and around the former gasworks structures.

5.2.2 Groundwater

- Dissolved metals were identified at similar concentrations in all groundwater samples, and in many cases, concentrations exceeded the 95 % trigger values of marine waters for cadmium, copper, lead, nickel and zinc. It should be noted that the 95 % trigger values listed in ANZECC/ARMCANZ (2000) are considered to be a conservative guideline used for the protection of sensitive aquatic ecosystems. Given no groundwater abstraction was apparent on the Site, no significant risks to human health were identified from the concentrations of heavy metals.

- Leachable concentrations of cadmium, copper, lead, nickel and zinc in selected samples of fill materials from across the Site indicated that the fill materials could be potential sources of metal contamination in groundwater.

- All exceedences of the assessment criteria for BTEX and PAH compounds were identified within the footprint of the former gasworks, with the exception of those in MW179, located on the eastern boundary of the Site and a low concentration of pyrene was identified in MW20, located at Wharf 8.

- Concentrations of TPH above the laboratory limit of detection were observed in monitoring wells located within the footprint of the former gasworks, with the exception of minor detections in MW25, located on the north eastern corner of the Site, and in MW20 located at Wharf 8.

- Within the footprint of the former gasworks, significant exceedences of the assessment criteria for BTEX and PAH were observed in wells screened across each of fill material, natural clayey sand and sandstone.

- Free-phase tar was observed in groundwater in MW204D and in MW10, which are located close to the estimated former location of a gas holder and other gasworks structures. Free-phase tar was also observed in groundwater at MW7, situated close to the estimated former location of the tar tank. Significant tar was observed in the fill material during drilling suggesting the areas surrounding the estimated locations of both the gas holder and the tar tank may represent source zones for Contamination of fill materials, bedrock and groundwater.

The primary zones of groundwater impacts present on the Site are located in the area encompassed by MW21, MW08, MW198 and MW204S (ERM 2007, ERM 2008), as well as MW7 and MW10 (Coffey 2008), which are located within or adjacent to the footprint of the former gasworks, as presented in *Figure 8* of *Annex A*.

Based on the information obtained from the groundwater monitoring programs outlined above, the following key implications for contaminant migration at the Site are presented:

- The primary receptors for COPCs migrating from the Site include Sydney Harbour and areas to the east of the Site;
- The primary pathways for COPCs migration are likely to be within the sandstone bedrock, to the east, and via the highly permeable fill/service lines toward Darling Harbour;
- The high hydraulic conductivity values for the fill deposits likely result in significant and continual tidal flushing of the fill materials (especially near MW206) and may explain the presence of low concentrations of dissolved-phase COPCs in groundwater samples obtained from down-gradient wells screened within the fill aquifer system. Groundwater sampling conducted at times of low tide may serve to further quantify the migration of COPCs to Sydney Harbour when migration potential is at is greatest; and
- The rate of release of COPCs from source zones relative to the highly permeable fill aquifer may aid in dilution/attenuation of COPCs within the fill aquifer and also help to explain the low COPC concentrations reported within down-gradient wells screened within the fill materials.

5.3 POTENTIAL CHEMICAL DEGRADATION PRODUCTS

The environmental fate of the identified COPCs in groundwater is likely to be strongly influenced by degradation processes, both physicochemical and biological. Physicochemical processes include sorption, dilution, dispersion, volatilisation, hydrolysis and oxidation/reduction whilst biological degradation processes include uptake and/or metabolism by living organisms. The impact of biological degradation processes is generally more pronounced with respect to organic compounds than inorganics, as inorganics generally exhibit toxicity in the elemental form.

The more water-soluble hydrocarbons, such as BTEX compounds and low-molecular weight PAHs, are considered more susceptible to the effects of dilution and dispersion processes (Uchrin and Katz, 1991) along with volatilisation and biological degradation processes (Park *et al.*, 1990). Conversely, the more hydrophobic higher molecular weight PAHs have been found to be more resistant to biological degradation and more persistent in the environment due to a lower tendency to move through soil or groundwater (Enzminger and Ahlert, 1987).

PAHs are significant components of the higher molecular weight TPH constituents, which in the environment, generally bind strongly to soils and sediments and do not readily dissolve in water. This behaviour decreases as the molecular weight of the compound decreases. Oxidation and photolysis are important PAH degradation processes in the environment, however the extent to which these processes occur is limited in soil and groundwater. No evidence is available to indicate that hydrolysis or volatilisation are significant degradation pathways at the Site. Biodegradation by microorganisms is therefore considered to be the primary mechanism by which PAHs are broken down. This process occurs relatively slowly and due to their lipophilicity, PAHs may bio-accumulate in organisms unable to metabolise them. The main metabolites of PAHs due to biological degradation include aromatic ketones, quinones, hydroxylated and dihydroxylated compounds, all of which exhibit differing levels of toxicity and are not necessarily considered to be of lesser toxicity than the parent compound, however little published research is available on the many potential metabolites.

6 OVERARCHING REMEDIAL ACTION PLAN

6.1 REMEDIATION GOAL

The goal of the proposed remedial works is to address the Significant Contamination on the Remediation Site and once that has been addressed, to render the Remediation Site suitable for the proposed redevelopment; and to render the Development Area suitable for the proposed redevelopment.

To assist in achieving the remediation goal whilst adhering to the principles of ecologically sustainable development (ESD), it is essential that the historical and future use of the various portions of the Site are considered. Remedial options have, therefore, been assessed separately for each of the four areas of the Site (as described in *Table 5.1*) with the aim of achieving removal of sources of groundwater contamination and a common remediation goal for the Site using the most sustainable remedial option/s for each area.

The remediation and management of Contamination at the Site can be divided into three categories; (a) remediation required to address Significant Contamination within the Remediation Site, (b) remediation to accommodate development requirements for parts of the Site and (c) management of Contamination impacts which would give rise to unacceptable risk to human health if one or more exposure pathways were completed.

It is noted that whilst the physical remediation works within various portions of the Site may be undertaken by parties other than BDA (e.g. some remediation works within Stage 1 will be undertaken by Lend Lease), the ownership of the land will be retained by BDA. One of BDA's objectives in planning the remediation and development works is, therefore, that the Site should be considered as a whole rather than simply as discrete stages or separate development blocks.

6.2 REGULATORY AND PLANNING REQUIREMENTS

6.2.1 Planning Context

The redevelopment of Barangaroo was determined in March 2006 by the Minister for Planning to be a Major Project to which Part 3A of the *Environmental Planning and Assessment (EP & A) Act 1979* applies. As discussed previously in *Section 1.2*, a Concept Plan for the redevelopment of Barangaroo was subsequently developed by the NSW State Government and approved by the Minister for Planning in February 2007. The Concept Plan incorporates guidelines for the type, mix, scale, location and height of proposed land uses.

6.2.2 Requirements in Relation to the Concept Plan

With regard to Contamination issues, it is noted that the Director Generals Requirements for an Environmental Assessment in relation to the Concept Plan stated that *"Contamination and geotechnical issues associated with the EDH proposal should be identified and addressed in accordance with SEPP55 and other relevant legislation and guidance."* It is noted that under SEPP 55, remediation works on the Site would be classified as "Category 1 Remediation Works".

6.2.3 Requirements in Relation to Further Project Applications

Since the approval of the Concept Plan, a number of applications have been submitted to the NSW Department of Planning (DoP) to modify certain elements of the approved Concept Plan and these applications have since been determined. At the time of this Overarching RAP, a number of additional project applications for the proposed redevelopment had also been submitted to the NSW DoP and were yet to be determined (refer to Section 1.4) , however it is noted that the Director Generals Requirements for all of the current applications have been issued. The two applications with the greatest significance with regard to remediation works are:

- MP10_0026 - Remediation and land forming works - DECCW declared area
- MP10_0023 - Bulk excavation and basement car parking - Blocks 1-3

Copies of the specific Director Generals Requirements for these applications have been included in *Annex D*.

6.2.4 Requirements in Relation to the Remediation Site

As discussed previously the NSW DECCW issued a Declaration over the Remediation Site.

As noted in Section 4 of the Declaration, *"any person may submit a voluntary remediation proposal for the site to the EPA. If the proposal satisfies the requirements of s.26 of the Act, the EPA may agree not to issue a remediation order to the person or persons bringing the proposal."* Should the EPA not receive a satisfactory voluntary management proposal within a reasonable timeframe, the EPA may issue a management order in relation to the site..

6.2.5 *Other Requirements*

It is noted that, subject to the nature of the specific RAPs and RWPs prepared for the individual portions of the Site, additional licences and approvals may be required in relation to the works, for example, an Environmental Protection Licence would be required for the injection of reagents into the subsurface should an in-situ treatment method such as in -situ chemical oxidation (ISCO) be trialled or implemented on the Site. Ensuring that all of the relevant licences and approvals associated with the implementation of the individual RAPs and RWPs are in place shall be the responsibility of the party undertaking the remediation works in that portion of the Site.

6.3 *EXTENT OF REMEDIATION & MANAGEMENT REQUIRED*

As discussed in *Section 3*, a HHERA is required to be conducted to establish site-specific RBCLs based on the requirement to remove the source/s of groundwater Contamination and the intended use of each of the different areas of the Site. An assessment of reported concentrations of COPCs in soil, groundwater and potentially other environmental media (such as air and sediments) against these RBCLs will determine the final extent of remediation and/or management that is required in each area.

6.3.1 *Remediation Site*

Area 1

Area 1 is the portion of the Site within the Remediation Site which is zoned for mixed use (commercial/residential). As described in *Section 5,* the highest concentrations of all COPCs in both soil and groundwater across the Site were generally observed in Areas 1 and 3. The approximate lateral extent of impacts to soil and groundwater presented in *Figure 8* of *Annex A* also indicates that laterally, the majority of Area 1 contains concentrations of COPCs exceeding the screening values. Area 1 is known to have contained the majority of the former gasworks infrastructure, remnants of which still remain beneath the hardstanding currently covering the Site.

In consideration of the Declaration, remediation works will be required within Area 1 in order to address Significant Contamination.

The high concentrations of PAHs, heavy metals and TPH in fill materials within and around the former gasworks structures indicate that a significant proportion of the fill and some of the natural soil and bedrock in this area would be classified as either Hazardous Waste or as Restricted Solid Waste if they were to be excavated and disposed. Materials classified as Hazardous Waste would require stabilisation prior to being disposed to an off-site landfill.

Area 3

Area 3 is the portion of Hickson Road which forms part of the Remediation Site. As described in *Section 5,* the highest concentrations of all COPCs in both soil and groundwater across the Site were generally observed in Areas 1 and 3. The approximate lateral extent of impacts to soil and groundwater presented in *Figure 8* of *Annex A* also indicates that laterally, the parts of Area 3 containing sub-surface gasworks structures are characterised by concentrations of COPCs exceeding the screening values. Area 3 is known to have contained former gasworks infrastructure, remnants of which still remain beneath the hardstanding currently covering Hickson Road.

In consideration of the Declaration, remediation works will be required within Area 3 to address the Significant Contamination. In contrast to Area 1, remedial options which result in minimal excavation would be preferable in this area in order to minimise disruption to the use of Hickson Road, inconvenience and nuisance to occupiers of adjacent buildings and disturbance of the many underground services which run beneath Hickson Road.

Similar to Area 1, concentrations of PAHs, metals and TPH in soils within and around the former gasworks structures indicate that a significant proportion of the fill and some of the natural soil and bedrock in this area would be classified as either Hazardous or Restricted Solid Waste if they were to be excavated and disposed. Materials classified as Hazardous Waste would require stabilisation prior to being disposed to offsite landfill.

6.3.2 Development Area

Area 2

Area 2 is the portion of the Site outside the Remediation Site zoned for mixed use (commercial/residential). As this area is outside of the Remediation Site and the observed impacts to soil and groundwater have not been identified as being significant enough to warrant regulation, there is no immediate regulatory driver for the remediation or management of soil and groundwater in this area. Given that this portion of the Site is zoned for mixed use (commercial/residential) there is, however, likely to be a development-based driver for remediation or management of the identified impacts.

Parts of this area are likely to require excavation to allow for the construction of basements and for foundations for buildings to be constructed. Spoil generated from the excavation will therefore need to be either beneficially reused on-site (if possible) or classified in accordance with NSW DECC (2008) and disposed of off-site. Given the observed nature and extent of impacts to soil and groundwater in this area, it is considered likely that all materials not requiring excavation for development purposes could be managed in-situ.

Area 4

Area 4 is the portion of the Site outside the Remediation Site zoned for open space land use. As with Area 2, the observed impacts to soil and groundwater in Area 4 have not been identified by NSW DECCW as being significant enough to warrant regulation. There is, therefore, no regulatory driver necessitating immediate remediation or management of Contamination within this area. Given this area is to be developed as public recreation there is, however, likely to be a development driver for remediation or management of the observed impacts.

Should earthworks be required for landscaping or recontouring purposes within this area, spoil generated from these earthworks would therefore need to be either beneficially reused on-site (if possible) or classified in accordance with NSW DECC (2008) and disposed of off-site. Given the identified nature and extent of impacts to soil and groundwater in this area, it is considered likely that the majority of materials not requiring excavation for development purposes could be managed in-situ.

6.3.3 Location of the Former Gasworks

The former gasworks are known to extend from Barangaroo, eastwards beneath Hickson Road and into parts of the properties at 36 and 38 Hickson Road and it is understood that parts of the structures that formed part of the gasworks remain in place. The nature of the identified Contamination, the position of the former gasworks structures in relation to the boundary of Barangaroo and the relatively shallow depth to groundwater would make the effective remediation of Barangaroo (and particularly Area 1) in isolation from the adjoining section of Hickson Road extremely difficult.

In addition, undertaking the remediation works within Areas 1 and 3 separately may necessitate the construction of a barrier along the boundary of Barangaroo, which may involve either a sealed, sheet-pile wall, bentonite slurry wall or similar and associated groundwater containment (such as abstraction and treatment) to hydraulically isolate Barangaroo from Hickson Road and to minimise the opportunity for Contamination continuing to migrate during and after completion of the remediation works on the Site.

It is considered that the remediation of the gasworks structures beneath Hickson Road and on the Site could be completed much more efficiently, effectively and sustainably if they were to be completed simultaneously or concurrently.

6.4 HIERARCHY OF REMEDIAL OPTIONS

6.4.1 Soil and fill materials

The preferred hierarchy for remediation of soil and fill materials on contaminated sites, as set out in ANZECC/NHMRC (1992) and NSW DEC (2005) *Information for the assessment of former gasworks sites*, is outlined below:

1. *on-site treatment of the contamination so that it is destroyed or the associated risk is reduced to an acceptable level;*

2. *off-site treatment of excavated soil so that the contamination is either destroyed or the associated risk is reduced to an acceptable level, after which it is returned to the Site.*

3. *removal of contaminated material to an approved site or facility and replacement, where necessary, with validated clean fill; or*

4. *consolidation and isolation of the soil on-site by containment with a properly designed barrier.*

If remediation is likely to cause a greater adverse effect than leaving the Site undisturbed, remediation should not proceed.

In cases where it is not viable to remediate large quantities of soil with low levels of contamination, alternative strategies should be developed.

6.4.2 Groundwater

The NSW DEC (2007) guidelines do not provide as structured a hierarchy for the assessment of remedial options for groundwater contamination as is set out for soils and fill materials, however the same overarching principles apply. The guidelines state that:

Where contamination of groundwater is identified, the management objectives are to protect human and ecological health and to ultimately restore the groundwater to its natural background quality.

The following management responses must be considered:

- *control short-term threats arising from the contamination;*

- *restrict groundwater use;*

- *prevent or minimise further migration of contaminants from source materials to groundwater;*

- *prevent or minimise further migration of the contaminant plume; and*

- *clean up groundwater to protect human and ecological health, restore the capacity of the groundwater to support the relevant environmental values and, as far as practicable, return groundwater quality to its natural background quality.*

Clean-up objectives for contaminated groundwater should be established in the following preferential order:

1. *Clean-up so natural background water quality is restored.*

2. *Clean-up to protect the relevant environmental values of groundwater, and human and ecological health.*

3. *Clean-up to the extent practicable.*

6.5 OPTIONS ASSESSMENT – REMEDIATION SITE

The hierarchies for assessment of remedial options as set out in the relevant guidance documents (summarised above) and other relevant factors have been considered with regard to assessment of the various options available for remediation of the Remediation Site. It is noted that a VMP has been prepared by the BDA for the Remediation Site which sets out a process of additional assessment, remediation technology trials and a more detailed remediation action planning process specific to the Remediation Site. The selection of a preferred remedial strategy for the Remediation Site will therefore be the subject of this VMP process and thus has not been determined as part of this Overarching RAP. The following sections are therefore intended to simply provide a brief assessment of the available options and are not intended to pre-determine the outcomes of the VMP process.

6.5.1 Area 1

Do Nothing

This approach was eliminated for several reasons, including:

- This approach would be unacceptable to the NSW DECCW, given the Declaration. Inaction would likely result in a management order for the cleanup of the Remediation Site being issued by the NSW DECCW due primarily to the highly elevated levels of contaminants, particularly BTEX, PAHs and TPH identified in soil, fill materials and groundwater and the potential impact of contaminated groundwater on Darling Harbour and surrounding areas.; and

- The contaminants have already been identified and are known to be persistent in the environment with the potential to pose a long term hazard if left on-site.

On-site Treatment

On-site treatment of soil and groundwater could involve either in-situ or ex-situ treatment. Excavation of contaminated soil and fill materials and on-site ex-situ treatment may be a viable remedial option. Much of the excavated material could be beneficially re-used as fill in other parts of the Site following appropriate treatment and validation, thus reducing requirements for importation of fill materials to these areas. The volume of fill materials required for this operation may, however, be less than the total volume of material requiring remediation.

The establishment of a significant ex-situ soil treatment facility (such as a thermal desorption plant) on-site for the treatment of heavily impacted materials (containing tar), in such close proximity to the Central Business District and to sensitive uses in Hickson Road, would likely give rise to significant community and environmental health and aesthetic concerns.

The establishment of a treatment plant capable of treating less heavily impacted soil and fill (e.g. materials which would be classified as General Solid Waste according to NSW DECC (2008)) via ex-situ stabilisation/micro-encapsulation is considered less likely to cause community concerns as there would be significantly lower emissions to atmosphere and the material to be treated would generally contain lower levels of COPCs. The on-site ex-situ treatment of the lower to moderately impacted portion of the materials requiring remediation via stabilisation/microencapsulation or similar is therefore considered to be a potentially viable component of a remedial strategy, particularly given the requirements for fill materials in other parts of the Site.

In those portions of Area 1 where excavation for building basements is not required, in-situ treatment of soils may represent a viable alternative to excavation and ex-situ treatment. Excavation of these materials would be solely for remediation purposes and therefore additional consideration must be given to the need to excavate these materials, particularly as fill would also then be required to replace the materials disposed of.

It is noted that gasworks wastes, including free-phase coal tar, have been identified in the vicinity of the former gasworks structures. It is considered that the presence of free-phase coal tar may present technical challenges to the successful implementation of in-situ methods, particularly given the heterogeneous nature of the fill materials and the hydraulic connection between the groundwater on the Site and Darling Harbour.

The potential risks of causing adverse impacts to the surrounding environment using methods such as ISCO (if, for example, injected reagents or mobilised contaminants were transported via preferential pathways into Darling Harbour) would need to be considered in detail and appropriate monitoring and mitigation strategies developed as part of the detailed planning phase.

Implementation of in-situ methods, such as ISCO, would also require a detailed assessment, bench-scale testing and a pilot trial program prior to implementation, and an assessment of the results of these trials would need to be incorporated into either the detailed RAP(s) or RWP(s) for this area.

For in-situ methods to be employed on the Site, it is also considered that NSW DECCW would require the process to be licensed, even at the pilot trial stage, and for the pilot trial to have demonstrated that the contaminants have been destroyed without unacceptable impact to the environment.

On-site treatment of groundwater (from dewatering of excavations) will be required during excavation works and ongoing treatment may also be required following removal of identified primary and secondary sources of Contamination (to the extent practicable). In this respect, it is considered that ongoing treatment of groundwater would be required only if it is demonstrated that monitored natural attenuation has not been successful.

It is not possible to accurately assess in this Overarching RAP whether ongoing groundwater treatment would be required until the RBCLs have been established and source removal has been completed, however it is noted that given the highly modified nature of the surrounding environment, a clean up to the extent practicable (CUTEP) approach would most likely be adopted.

Excavation, Off-site Treatment and Reinstatement On-site

Excavating impacted materials, transporting them to an off-site facility for treatment and returning the treated material to the Site for reinstatement within Area 1 would not be practicable as the void space created by the excavation is likely to be occupied by basements of buildings. It is however possible that some treated material could be utilised as fill in other parts of the Site. As identified above, however, there is likely to be a surplus of fill materials on the Site, and thus some material would still require off-site disposal. The treatment of impacted materials off-site also comes at a far greater net environmental and economic cost than on-site ex-situ treatment, due primarily to the large number of vehicle movements and materials handling components of this method. This option would therefore only be a viable alternative to on-site ex-situ treatment and reinstatement if community or other concerns ruled out on-site treatment and if there was a net deficit of fill material on the Site.

In addition, the transport of odorous materials and some materials classified as Hazardous Waste in many hundreds of truck movements through streets of the Central Business District and surrounding suburbs to a distant landfill is considered to mitigate against this potential remedial method.

Removal of Contaminated Material to an Approved Site or Facility and Replacement, Where Necessary, with Validated Clean Fill

Removal of contaminated material would involve excavating all of the fill material and soil that exceed the RBCLs and, where possible, disposing of the material directly to an appropriately licensed landfill facility. The nature of some of the materials identified on the Site (particularly in the vicinity of the former gasworks structures, which would be classified as Hazardous Waste) would preclude the disposal of these materials directly to landfill. These materials would therefore require some form of treatment prior to disposal offsite. The primary advantage of this methodology is that it would greatly increase confidence that the source of impact is removed and minimises the need for ongoing management or maintenance.

This Overarching RAP does not contemplate that tar containing material will be accepted on Headland Park.

The transport of contaminated materials from the Site will require careful consideration, as the movement of a large number of trucks through the Central Business District may not be permitted. Movement of contaminated materials by barge to a point where the waste can be transferred to trucks is required to be considered, but resistance can be expected from persons living and/or working near the landing and reloading point.

It is considered that significant odours would be generated when excavating Contamination and that the odours would be difficult to confine to the Site. Consequently, consideration is required to be given to excavation being undertaken within negative-pressure, controlled-atmosphere enclosure as required. Other methods (such as odour suppressants) may also be appropriate.

On-site Management

On-site management of impacted materials involves creating a physical barrier around the impacted materials such that the risks to human health and the environment are minimised by effectively severing the pathways by which receptors could be exposed to contaminants. Given the extent and nature of the identified Contamination on the Site, the proximity to Sydney Harbour and the relatively shallow groundwater table, utilising this technique by itself would involve significant engineering complexity and long-term monitoring and would impose significant constraints on the future utility of the area and is also the least preferred option in the hierarchy described above.

6.5.2 Area 3

Do Nothing

This approach was eliminated for Area 3 for the same reasons as put forward for Area 1 as both areas are subject to the declaration.

On-site Treatment

In-situ treatment of soils within Area 3 would be difficult, as described in Section 6.5.1, however given the difficulties associated with excavation within Hickson Road (e.g. extensive major underground services and need for closure of a busy thoroughfare), this may present a viable alternative for this area. The additional distance of this area from Darling Harbour and the smaller quantities of high permeability fill present (in comparison to Area 1) also reduce the risks associated with implementation of in-situ treatment methods in this area. As discussed previously, detailed bench-scale and pilot trials and assessment of the potential risks associated with the release of any reagents used for in-situ treatment or mobilised contaminants beyond the defined boundaries of the Remediation Site would need to be undertaken and appropriate mitigation strategies for these risks would need to be developed in consultation with all relevant stakeholders.

As described in *Section 6.5.1,* the on-site ex-situ treatment of the lower to moderately impacted portion of the impacted fill material via stabilisation/microencapsulation or similar is also considered to be a potentially viable component of a remedial strategy.

If excavation works were conducted below the water table, on-site treatment of groundwater (from dewatering) may be required. It is considered likely that ongoing treatment of groundwater may also be required within Area 3. Ongoing monitoring of groundwater conditions is also likely to be required.

Excavation, Off-site Treatment and Reinstatement On-site

Excavating impacted materials, transporting them to an off-site facility for treatment and returning the treated material to the Site for reinstatement within Area 3 would be possible, however as described previously, this is less preferable to on-site treatment due to the additional financial and environmental cost of transport and materials handling. As described above the complications associated with excavation in a major service corridor and busy thoroughfare also reduce the suitability of this option for this portion of the Site.

Removal of Contaminated Material to an Approved Site or Facility and Replacement, Where Necessary, with Validated Clean Fill

Due to the significant volume of contaminated material identified at the Site, the application of this approach across Area 3, in addition to the impacted materials from elsewhere on-site, would be environmentally and economically costly. Given the difficulties associated with excavation in Hickson Road and the fact that the excavation of these materials would be solely for remediation purposes, additional consideration must be given to the need to excavate these materials, particularly as fill would also then be required to replace the materials disposed. This remedial approach may however form a necessary component of the wider remediation strategy for this area, particularly with regard to the most heavily impacted materials (e.g. heavily impacted materials and those containing / comprising tar) as discussed previously in *Section 6.5.1*.

Further, it is considered that significant odours would be generated when excavating Contamination and that the odours would be difficult to confine to the Site. Consequently, consideration is required to be given to excavation being undertaken within negative pressure, controlled-atmosphere enclosure.

On-site Management

The elevated concentrations of contaminants in Area 3 and the ongoing potential source of groundwater impact that the impacted materials would represent mean that on-site management of materials without any form of contaminant mass reduction is not considered a viable alternative for this Area and would not satisfy the requirements of the declaration.

6.6 OPTIONS ASSESSMENT – DEVELOPMENT AREA

6.6.1 Area 2

Do Nothing

This approach was eliminated for several reasons, including:

- Development works within Area 2 are likely to generate significant quantities of surplus spoil, which will need to be classified and managed in accordance with NSW DECC (2008);
- The impacted soil and groundwater may pose a potential risk to human health and the environment during redevelopment works and an unacceptable level of risk to human health and the environment could remain following redevelopment if not managed appropriately; and
- The contaminants have already been identified and are known to be persistent in the environment with the potential to pose a long-term hazard if left on-site without appropriate management.

On-site Treatment

In-situ treatment of soils on this part of the Site would not be practical as excavation of basements beneath the proposed commercial/residential buildings will likely be required and thus removal of soils (and potentially bedrock) from these areas is required.

Excavation of contaminated soil and fill materials and on-site ex-situ treatment may be possible. The excavated material would not be able to be reinstated in the same place, thus negating some of the benefits of on-site treatment and reuse. Some of this material could potentially be beneficially re-used as fill in other parts of the Site, following appropriate treatment and validation. The volume of fill required for this operation is, however, considered likely to be less than the total volume of material to be excavated.

As described in *Section 6.5.1*, the on-site ex-situ treatment of the lower to moderately impacted portion of the impacted soil and fill material via stabilisation/microencapsulation or similar is considered to be a potentially viable component of a remedial strategy.

On-site treatment of groundwater (from dewatering excavations) will be required during excavation works, it is however considered unlikely that ongoing treatment of groundwater would be required within Area 2 following removal of all identified primary and secondary sources of Contamination (to the extent practicable). Ongoing monitoring of groundwater quality is, however, likely to be required following completion of the remediation works until the quality is demonstrated to meet the remediation goals.

Excavation, Off-site Treatment and Reinstatement On-site

Excavating impacted materials, transporting them to an off-site facility for treatment and returning the treated material to the Site for reinstatement within Area 2 would not be practicable as the void space created by the excavation is likely to be occupied by basements of buildings. This option would therefore only be a viable alternative to on-site ex-situ treatment and reinstatement if on-site treatment was not possible and if there was a net deficit of fill material in other parts of the Site.

Removal of Contaminated Material to an Approved Site or Facility and Replacement, Where Necessary, with Validated Clean Fill

Due to the significant volume of contaminated material identified at the Site, the application of this approach across the whole of Area 2 would be environmentally and economically costly. Given that there may be a surplus of fill material created during the development, off-site disposal of at least some of the impacted materials may be necessary.

On-site Management

The likely need to excavate for the construction of basements makes this an impractical alternative for much of Area 2. Some on-site management of materials outside excavation areas within Area 2 may however be necessary and would be a viable alternative for this Area, given the generally lower levels of impact compared to Area 1.

6.6.2 Area 4

Do Nothing

This approach was eliminated for the following reasons:

- The impacted soil and groundwater may pose a potential risk to human health and the environment during redevelopment works and an unacceptable level of risk to human health and the environment could remain following redevelopment if not managed appropriately; and
- The contaminants have already been identified and are known to be persistent in the environment with the potential to pose a long term hazard if left on-site without appropriate management.

On-site Treatment

In-situ treatment of soils would be difficult, as described in *Section 6.5.1*, and would be complicated even further by the proximity of Area 4 to Sydney Harbour.

Excavation of contaminated soil and fill materials in Area 4 and ex-situ treatment would be possible, particularly for the impacted shallow fill materials identified in Area 4. As described in *Section 6.5.1,* the on-site ex-situ treatment of the lower to moderately impacted portion of the impacted fill material via stabilisation/microencapsulation or similar is considered to be a potentially viable component of a remedial strategy.

If excavation works were conducted below the water table, on-site treatment of groundwater (from dewatering) may be required. It is considered unlikely that ongoing treatment of groundwater would be required within Area 4 due to the relatively minor nature of groundwater impacts observed in this Area. Ongoing monitoring of groundwater conditions is however likely to be required.

Excavation, Off-site Treatment and Reinstatement On-site

Excavating impacted materials, transporting them to an off-site facility for treatment and returning the treated material to the Site for reinstatement within Area 4 would be possible, however as described previously, this is less preferable to on-site treatment due to the additional financial and environmental cost of transport and materials handling.

Removal of Contaminated Material to an Approved Site or Facility and Replacement, Where Necessary, with Validated Clean Fill

Due to the significant volume of contaminated material identified at the Site the application of this approach across Area 4 in addition to the impacted materials from elsewhere on-site would be environmentally and economically costly. Given that basement excavations are not planned for Area 4 (as they are for Areas 1 and 2) the excavation of these materials would be solely for remediation purposes and therefore additional consideration must be given to the need to excavate these materials, particularly as fill would also then be required to replace the materials disposed of. Some hotspots of heavily impacted materials which would be classified as Restricted Solid or Hazardous Waste do exist in Area 4. The fill materials associated with these hotspots may require treatment and disposal off-site if it is determined that they could not be effectively managed on-site in accordance with the requirements set out by the relevant HHERA.

On-site Management

Where there is no need to excavate in Area 4 and the concentrations of contaminants in Area 4 are significantly lower (particularly in groundwater) than in Area 1, on-site management of materials would be a viable alternative for this area.

6.7 RATIONALE FOR SELECTION OF PROPOSED OPTIONS

As noted previously, a VMP has been prepared by the BDA for the Remediation Site which sets out a process of additional assessment, remediation technology trials and a more detailed remediation action planning process specific to the Remediation Site. The selection of a preferred remedial strategy for the Remediation Site (i.e. Areas 1 and 3) will therefore be the subject of this VMP process and thus has not been determined as part of this Overarching RAP.

6.7.1 Area 2

The preferred option for Area 2 is excavation, ex-situ on-site treatment (if needed) and reuse of treated materials in other areas of the Site. Some off-site disposal of less heavily impacted materials (i.e. fill or soils which would otherwise be classified as General Solid Waste) may be required if there is an overall surplus of fill materials. This option was selected as it minimises costs (financial, environmental and social) associated with transport, materials handling and waste disposal whilst dealing with the proposed spoil from excavation of this area for basements and foundations. It is noted that in parts of Area 2 where excavation for basements or foundations is not required, other methodologies may be employed as appropriate. The adoption of this approach also addresses the previously stated objective of considering the remedial options from a site wide perspective rather than individual development stages in order to achieve the most sustainable outcome practical.

It is considered that significant odours would be generated when excavating Contamination and that the odours would be difficult to confine to the Site. Consequently, consideration is required to be given to excavation being undertaken within a negative pressure, controlled-atmosphere enclosure.

6.7.2 Area 4

The preferred remedial option for Area 4 is on-site management as it minimises the financial, environmental and social costs associated with the substantial excavation, materials handling, treatment and/or disposal which might otherwise be required to remediate this area. It is envisaged that on-site management would be implemented in Area 4, as described for Area 3 above. The adoption of this approach in Area 4 also addresses the previously stated objective of considering the remedial options from a site wide perspective rather than individual development stages in order to achieve the most sustainable outcome practical.

As noted in *Section 6.6.2,* some hotspots of heavily impacted materials that would be classified as Restricted Solid or Hazardous Waste exist in Area 4. These hotspots may require excavation, treatment and disposal off-site if it is determined that they could not be effectively managed on-site in accordance with the requirements set by the relevant HHERA.

6.8 SCOPE OF WORKS

It is envisaged that the remediation/management works will comprise, as a minimum, the following initial scope for all areas of the Site:

- Completion of a Quantitative HHERA to develop RBCLs for the protection of human health and the environment for each of the various areas of the Site. The HHERA should take into account proposed containment/control measures and the impact these will have on source/pathway/receptor relationships.

- Completion of any necessary pilot trials and additional assessment works to the satisfaction of the appointed Site Auditor to inform the detailed RAPs or RWPs as may be appropriate.

- Preparation of additional documentation which will include the following:

    1. Preparation of additional area specific RAPs as required for individual portions of the Site.

    2. Remediation Works Plan (RWP) that will set out in detail the remediation/management works to be conducted in each portion of the Site, provide detailed engineering design for any control/containment measures necessary (including a barrier between the Site and Hickson Road, if necessary) and present a detailed scope of works for the remediation contractor.

3. A Development/Remediation EMP to be applied during the course of the remedial works to facilitate the completion of the works in a manner which minimises negative impacts upon the environment.

4. An Occupational Health and Safety (OH&S) Plan to be applied during the course of the remedial works to assess potential health and safety risks and provide appropriate measures to mitigate these risks.

5. A Community Consultation Plan to notify all stakeholders including occupiers of neighbouring properties of the activities on site.

6. A long-term EMP may be applied over the long-term after completion of remediation/management works. This plan would set out control measures necessary to mitigate potential risks posed by impacted materials remaining in-situ and long-term monitoring requirements.

- Planning and approvals, including completion of the RWPs and a quantitative HHERA to develop RBCLs;

- Site establishment, including establishing appropriate security and environmental controls and monitoring;

- Demolition of remaining structures; and

- Appropriate off-site disposal/recycling of demolition materials in accordance with relevant legislative requirements.

The following sections discuss the scope of works for Areas 2 and 4 in further detail, whilst detailed scopes of work for Areas 1 and 3 will be detailed following completion of the VMP process.

6.8.1 Area 2

- Excavation to permit construction of basements (it is envisaged that sheet piling, or similar, will be required prior to excavation in most areas to maintain excavation stability and reduce groundwater ingress);

- In-situ treatment in areas where this is deemed appropriate;

- Appropriate management of potentially contaminated groundwater collecting within excavations;

- Stockpiling of excavated materials (either from within Area 2 or from other parts of the Site) and classification according to material type and contaminant concentrations;

- On-site treatment/stabilisation of materials which, following treatment/stabilisation, will be suitable, both geotechnically and chemically, for reinstatement in an appropriately engineered placement area (subject to endorsement by the Site Auditor), followed by confirmatory sampling to demonstrate the suitability of the materials;

- Classification and off-site disposal of surplus fill materials not requiring treatment/stabilisation (if necessitated by overall materials balance for site);

- Loading, transport and off-site treatment followed by confirmatory sampling and analysis of material assessed as too heavily impacted to be treated and reused on-site (Restricted Solid or Hazardous waste) followed by confirmatory sampling and off-site disposal at an appropriately licensed facility;

- Sampling and validation of the excavated surfaces, backfill materials (if required) and groundwater by a suitably qualified environmental consultant;

- Preparation of a Site Audit Report and Site Audit Statement by Site Auditor accredited by NSW DECCW certifying the suitability of the Area for the proposed purposes; and

- Ongoing monitoring of groundwater quality following completion of the remedial works until satisfactory remediation goals have been achieved to the satisfaction of the Site Auditor and NSW DECCW.

6.8.2 Area 4

- Removal of any hotspots of contaminated materials not deemed suitable for on-site management (it is envisaged that these will constitute relatively minor portions of Area 4);

- Stockpiling of excavated materials (either from within Area 4 or from other parts of the Site) and classification according to material type and contaminant concentrations;

- On-site treatment/stabilisation of materials which, following treatment/stabilisation, will be suitable, both geotechnically and chemically, for reinstatement in an appropriately engineered placement area (subject to endorsement by the Site Auditor), followed by confirmatory sampling to demonstrate the suitability of the materials;

- Installation of an appropriately engineered capping layer (including existing ground slabs if appropriate) across the area to minimise the opportunity for physical contact with the impacted materials and ingress of surface water;

- Installation of a collection, management and re-use system for stormwater runoff from the capping layer;

- In areas to be vegetated, placement of a layer of growing media (it is noted that when selecting plant species for use in landscaping of these areas, consideration must be given to the potential impact of root systems on the integrity of capping layers);

- Preparation of a Site Audit Report and Site Audit Statement by a Site Auditor accredited by NSW DECCW certifying the suitability of Area 4 for the proposed purposes, subject to implementation of the long term EMP; and
- Implementation of the long-term EMP, including monitoring and management of the integrity of the capping layer and monitoring of groundwater quality until not further required by NSW DECCW.

6.9 PROPOSED VALIDATION METHODOLOGY

A detailed description of the validation methodology to be employed following completion of remediation works is required to be included in the RWP. The DQOs outlined in Section 3, along with the requirements of NSW DEC (2007) and NEPC (1999), are required to form the basis of the validation methodology.

6.10 CONTINGENCY PLANS

The RWP and remediation /development EMP will be required to contain a Contingency Plan to address unexpected conditions that could feasibly occur at the Site, including:

- uncovering of unknown types of Contamination;
- increased volume of contaminated materials;
- a situation where on-site stabilisation/treatment of materials is not permissible due to sensitivity of surrounding receptors; and
- a situation where stabilisation methodology proves ineffective at reducing mobility of COPCs.

Typical procedures that may be used to address the contingencies are outlined in the following sections.

6.10.1 Unknown Types of Materials

The presence of unknown materials would be highlighted during works by the observation of any unusual physical or sensory characteristics of the soils, results of vapour monitoring or validation sampling.

In the event that any significant unknown type of material is identified, work in that area will be stopped, and an assessment of the nature and quantity of the material will be undertaken. This assessment would include proposed methods for managing and remediating the materials in accordance with the overall remediation goals of the project. If necessary, an addendum will be made to the RWP, which will require approval from the Auditor prior to re-commencement of work. All additional work would be documented and detailed in the final validation report.

6.10.2 Increased Volumes

Throughout the works, the quantity of materials encountered will be monitored. In the case of a significant increase in the estimated volume of waste soils from estimates included within the detailed RAP / RWP, a review of the remediation strategy will be undertaken by a qualified environmental engineer or scientist.

If the remediation strategy is revised, the revision is required to be endorsed by the Site Auditor. If the revision is made to either of Areas 1 and 3, the revision is required to be endorsed by the Site Auditor and by NSW DECCW.

6.10.3 On-Site Treatment/Stabilisation Not Possible

Should treatment/stabilisation of low to moderately impacted materials not be possible due to unacceptable emissions of vapours or odours, the remedial strategy for those areas where this methodology was to be implemented will need to be re-evaluated. Consideration should be given to off-site treatment/stabilisation of these materials and return of the treated materials to site for re-use.

If the remediation strategy is revised, the revision is required to be endorsed by the Site Auditor. If the revision is made to either of Areas 1 and 3, the revision is required to be endorsed by the Site Auditor and by NSW DECCW.

6.10.4 Treatment/Stabilisation Methodology Proves Ineffective

It is considered that if appropriate bench-scale and/or field-scale trials are completed prior to commencement of full-scale treatment, the likelihood of this methodology proving ineffective is considered to be low.

However, if the treatment/stabilisation methodology is shown to be ineffective, options which could be considered to address ineffective treatment include increasing the quantity of reagent used, trialling different re-agents and/or combinations of reagents. If not ultimately feasible, options for off-site disposal should be considered.

If the remediation strategy is revised, the revision is required to be endorsed by the Site Auditor. If the revision is made to either of Areas 1 and 3, the revision is required to be endorsed by the Site Auditor and by NSW DECCW.

7 *REMEDIATION/DEVELOPMENT ENVIRONMENTAL MANAGEMENT PLAN*

A summary of major environmental issues associated with the remediation works is provided in *Table 7.1*. These issues along with appropriate mitigation measures should be addressed in a detailed Remediation/Development Environmental Management Plan (EMP) to be prepared in conjunction with the RWP and be developed prior to mobilisation to the Site to commence the remedial works.

Table 7.1 Identified Environmental Issues

Aspect	Potential Issue/ Impact
Air Quality	Generation of dust from remediation activities;
	Mobilisation of asbestos or synthetic mineral fibres during removal of hazardous building materials or excavation of soils containing these.
	Odours and vapours generated from contaminated materials exposed during remediation..
	Particulate generation from plant and vehicle emissions.
Surface Water Quality and Sedimentation	Sediment laden surface runoff entering Sydney Harbour or the stormwater system.
	Contaminated soil or sediment entering Sydney Harbour or the stormwater system.
	A spill, release or disposal of a hazardous substance (e.g. ISCO reagent) causes pollution of the environment.
Waste	Inappropriate disposal of hazardous building materials, general demolition or other wastes generated by the works.
	Disposal of materials to landfill which could otherwise be reused or recycled.
	Cross contamination of clean materials or similar.
Heritage/ Archaeological Issues	There are a number of heritage structures present on the Site which could potentially be impacted by the works. A separate Heritage Impact Statement has been prepared by City Plan Heritage to address issues associated with these potential impacts.
Noise and Vibration	Generation of excessive noise or vibration may impact upon neighbouring residents/businesses or impact on heritage structures on the Site.
Traffic and Access	The remediation/management works will involve significant numbers of light and heavy vehicle movements. A separate traffic management plan may be requires to address issues associated with these potential impacts. Consideration should also be given to the potential transport of materials from the Site by barge.

8 *OCCUPATIONAL HEALTH AND SAFETY*

A detailed site Health & Safety Plan (HSP) is required to be developed prior to mobilisation to the Site to commence the remedial works. The HSP aims to protect the health and safety of all workers on the Site, as well as the general safety of occupiers of surrounding properties.

The HSP shall be in accordance with the *NSW OH&S Act (2000)*, *NSW WorkCover* and any additional and relevant governing regulations. Prior to commencing work, all Contractor personnel will complete a site induction and sign-off on the HSP to certify that they have read, understand and agree to abide by the contents of the HSP.

It is anticipated that all work will be performed using a minimum of Level D PPE, which includes but is not limited to steel-toed boots, protective eyewear with side shields, hearing protection, long trousers, long-sleeved shirt and hardhat. All the safety equipment shall meet all applicable Australian Standards (AS).

The Site has known contaminants that will require remediation. The Contractor may come into contact with the Contamination during the remedial works. As such, all COPCs identified in *Section 5* and those contaminants not identified at elevated concentrations, but known to be associated with former gasworks sites, will need to be considered when developing the HSP.

In addition, although bonded asbestos containing materials have been identified in only one location in fill appropriate abatement and control measures will be required to be implemented during excavation works. These mitigation measures are required to be detailed in the HSP.

At a minimum the HSP shall include:

- The Contractor must provide details of their health and safety program including an induction process for all personnel working on the Site and visitors to the Site, as well as incident management and reporting plans;
- Where applicable, detailed safe work method statements (SWMS) and Job Safety Analysis (JSA) shall be developed by appointed sub-contractors prior to the commencement of any work;
- Emergency phone numbers;
- A map showing the shortest route to nearby hospital/s or health centre/s;
- Daily safety meeting content and procedures;
- Definition of roles and responsibilities of personnel, including staff and other contractors;

- Hazard identification procedures and control measures;
- Material safety data sheets;
- Soil, water and material handling procedures;
- Personal protective equipment;
- Work zones, traffic routes and stockpile areas;
- Decontamination procedures;
- Contingency plans; and
- Incident management and reporting plans.

Project team members shall be trained on the contents of HSP prior to mobilisation to the Site. All employees will be required to sign-off on the HSP to certify that they have read, understand and agree to abide by the contents of the HSP. A copy of the sign-off sheet must be provided to the BDA. Copies of the HSP, SWMS, JSA and the sign-off sheets must be available on the Site.

9 *COMMUNITY CONSULTATION*

Because of the high environmental and social profile of the Site, a community consultation/communication plan shall be required to notify all stakeholders including occupiers of neighbouring properties of the activities on site. This plan will also facilitate the gathering of input from the stakeholders and communication of environmental compliance and rectification measures.

It is recommended that the community engagement and consultation process for the remedial works be commenced at the earliest possible opportunity.

10 LIMITATIONS

This Overarching RAP is based on the findings of previous site investigations undertaken by ERM and by other parties. ERM completed this Overarching RAP in a manner consistent with the normal level of care and expertise exercised by members of the environmental consulting profession. No warranties, express or implied, are otherwise made.

Subject to the Scope of Work, this Overarching RAP is strictly limited to remediating potentially adverse environmental conditions associated with the Site and does not include evaluation or remediation of the structural conditions of any buildings or other facilities on the Site.

The absence of any identified hazardous or toxic materials on any part of the Site should not be interpreted as a guarantee that such materials do not exist on the Site.

The remediation and validation strategy presented in this Overarching RAP is based upon site inspections and sampling conducted by ERM personnel and information from available reports by others outlining site conditions. All conclusions and recommendations regarding the Site are the professional opinions of the ERM personnel involved with the project, subject to the qualifications made above.

While normal assessments of data reliability have been made, ERM assumes no responsibility or liability for errors in any data obtained from regulatory agencies, statements from sources outside of ERM, or developments resulting from situations outside the scope of this project.

ERM is not engaged in environmental consulting and reporting for the purpose of advertising sales promoting, or endorsement of any client interests, including raising investment capital, recommending investment decisions, or other publicity purposes.

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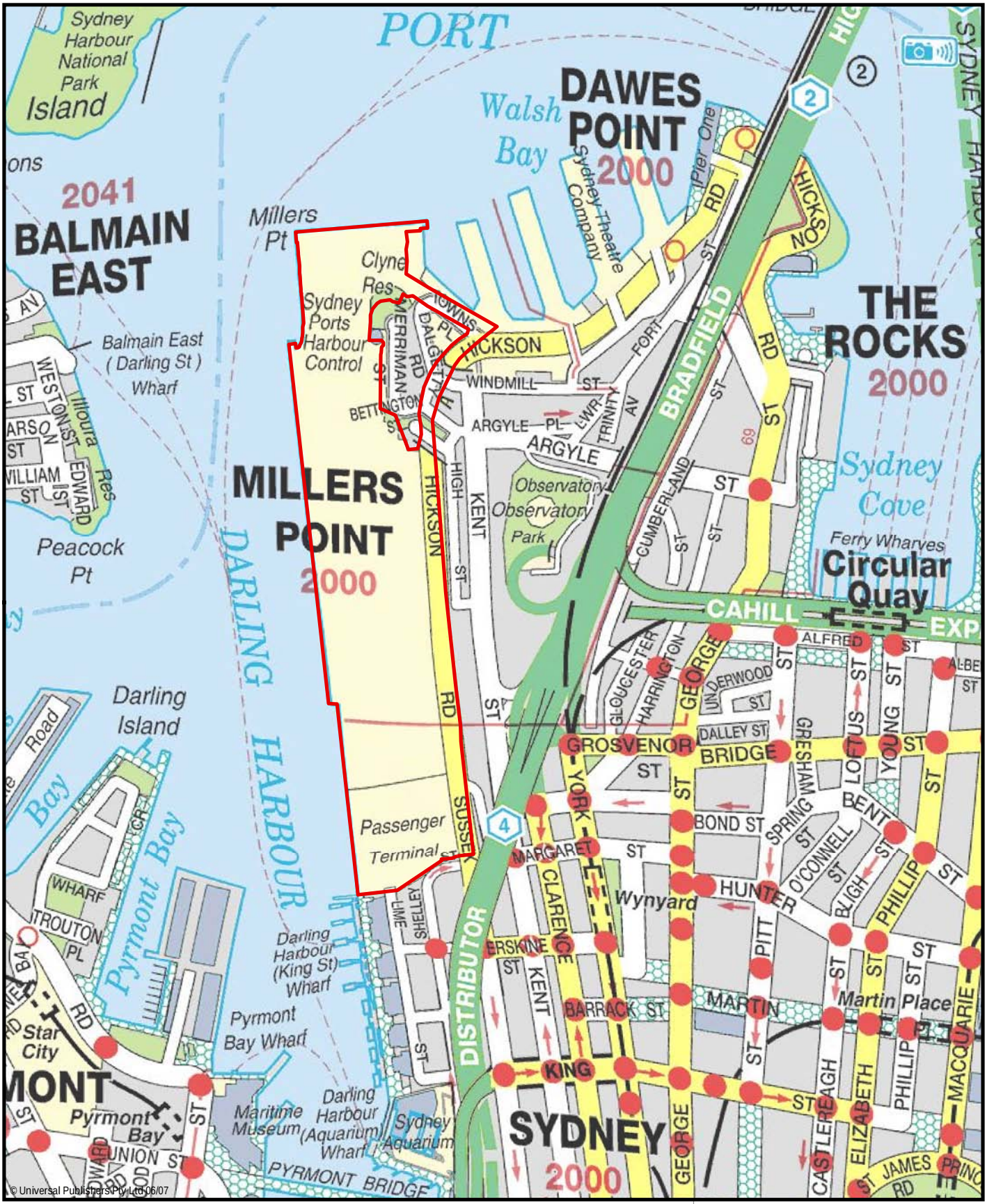
Annex A

Figures



Legend

Site Location

Figure 1

Site Location

Client:	Barangaroo Delivery Authority		
Project:	Barangaroo Overarching RAP		
Drawing No:	0114385s_RAP_GIS002_R0.mxd		
Date:	06/04/2010	Drawing size:	A4
Drawn by:	JF	Reviewed by:	PL
Projection:	GDA 1994 MGA Zone 56		
Scale:	Refer to Scale Bar		

N

0 100 200 300m

Maps and figures contained within this document may be based on third party data, may not be to scale and is intended for use as a guide only. ERM does not warrant the accuracy of any such maps or figures.

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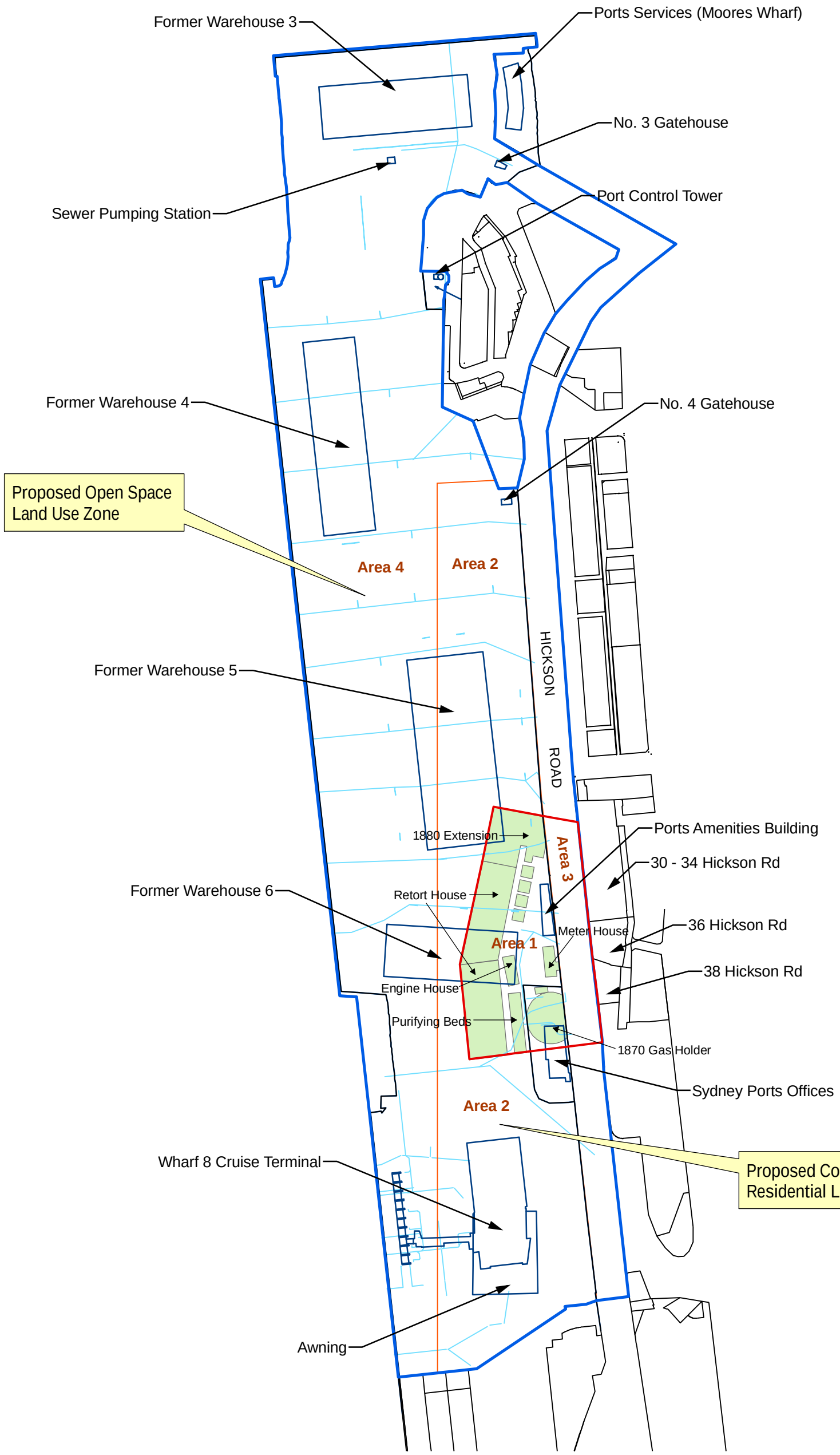
ERM



Legend

- Remediation Site
- Lot Boundaries
- Existing or Former Site Features
- Approximate Boundary of Landuse Zones
- Site Drainage
- Approximate Location of Former Gasworks Structures
- Barangaroo Project Site

Client:	Barangaroo Delivery Authority	
Project:	Barangaroo Overarching RAP	
Drawing No:	0114385s_RAP_GIS001_R0.mxd	
Date:	31/03/2010	Drawing size: A3
Drawn by:	JF	Reviewed by: PL
Projection:	GDA 1994 MGA Zone 56	
Scale:	Refer to Scale Bar	

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0 40 80 120m

Figure 2

Site Layout Plan

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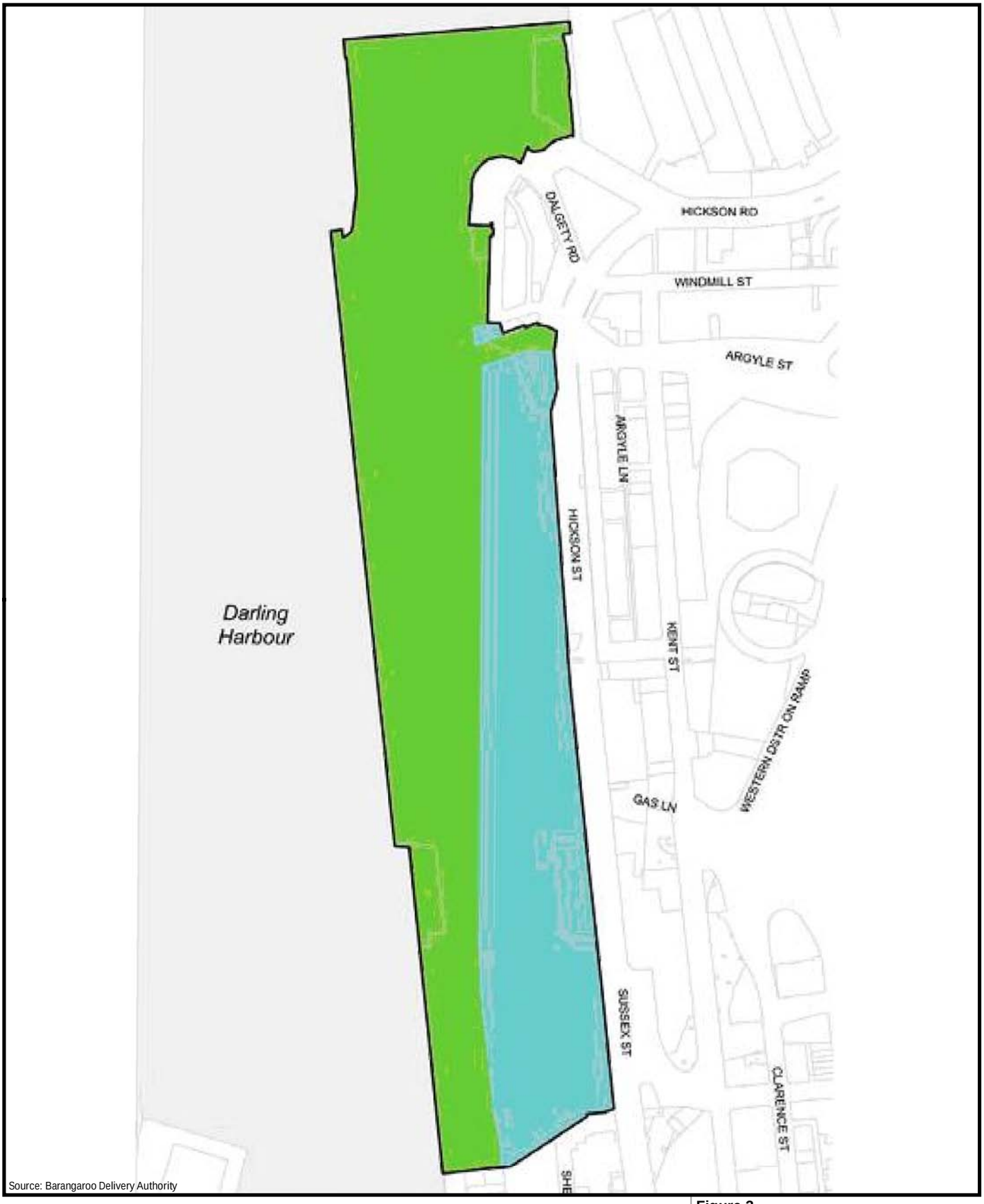

Source: Barangaroo Delivery Authority

Legend

Barangaroo
- Site Boundary
- Cadastral Parcels

Zone
- B4 Mixed Use
- RE1 Public Recreation
- Darling Harbour

Notes:
Environmental Planning and Assessment Act 1979 - State Environmental Planning Policy (Major Projects) Amendment No.18

Client:	Barangaroo Delivery Authority	
Project:	Barangaroo Overarching RAP	
Drawing No:	0114385s_RAP_GIS003_R0.mxd	
Date:	06/04/2010	Drawing size: A4
Drawn by:	JF	Reviewed by: PL
Projection:	GDA 1994 MGA Zone 56	
Scale:	Refer to Scale Bar	

N

0 50 100 150m

Figure 3

Barangaroo Zoning Map

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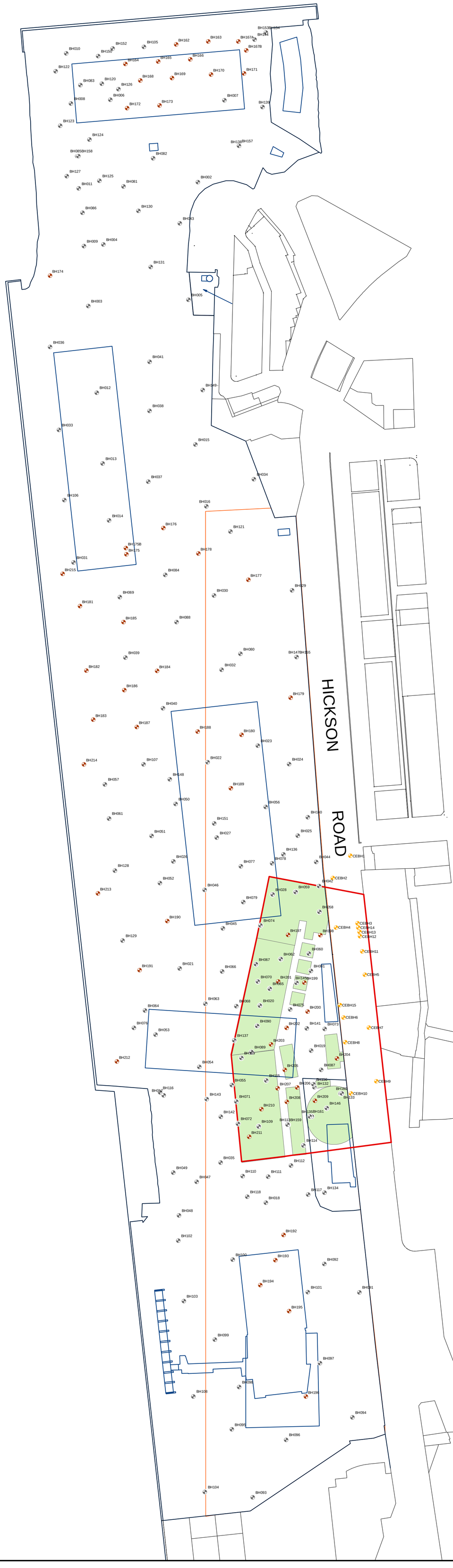

Legend

- Remediation Site
- Approximate Location of Former Gasworks Structures
- Additional ERM Soil Bores
- Existing ERM Soil Bores
- Coffey Soil Bores
- LotBoundaries
- Existing or Former Site Features
- Approximate Boundary of Landuse Zones

Figure 4
Soil Bore Locations

Client:	Barangaroo Delivery Authority	
Project:	Barangaroo Overarching RAP	
Drawing No:	0114385s_RAP_GIS004_R0.mxd	
Date:	15/04/2010	Drawing size: A1
Drawn by:	JF	Reviewed by: PL
Scale:	Refer to Scale Bar	

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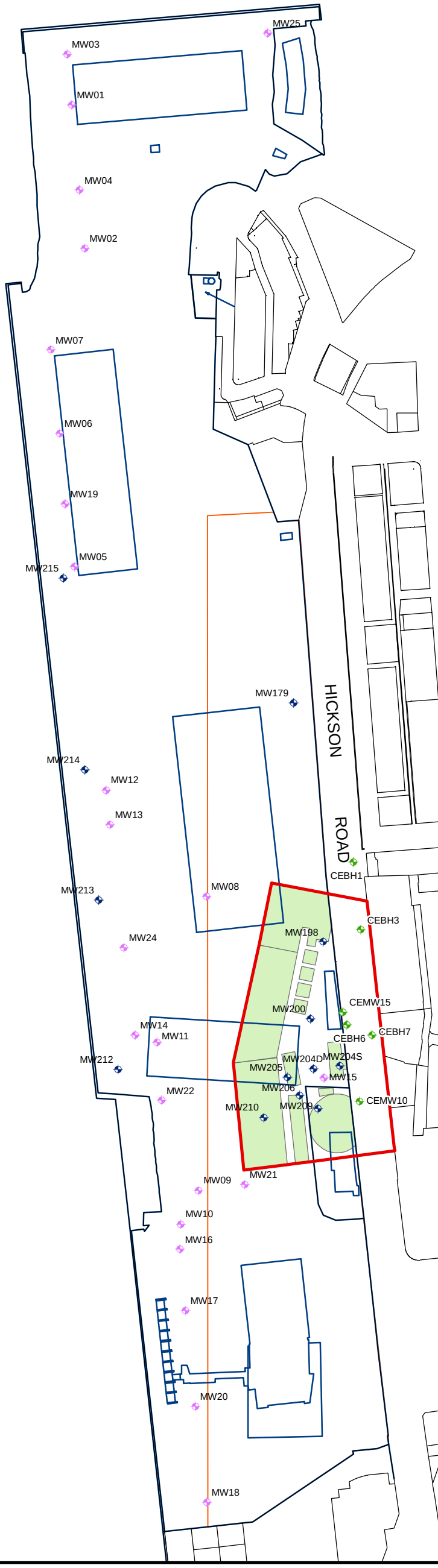

Legend

- Remediation Site
- Approximate Location of Former Gasworks Structures
- Existing ERM Monitoring Wells
- Additional ERM Monitoring Wells
- Coffey Monitoring Wells (Approximate Position)
- LotBoundaries
- Existing or Former Site Features
- Approximate Boundary of Landuse Zones

Client:	Barangaroo Delivery Authority	
Project:	Barangaroo Overarching RAP	
Drawing No:	A3 Portrait.mxt	
Date:	XX/XX/XXXX	Drawing size: A3
Drawn by:	XX	Reviewed by: PL
Projection:	Not Defined	
Scale:	Refer to Scale Bar	

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0 25 50 75 m

Figure 5

ERM & Coffey Monitoring Wells

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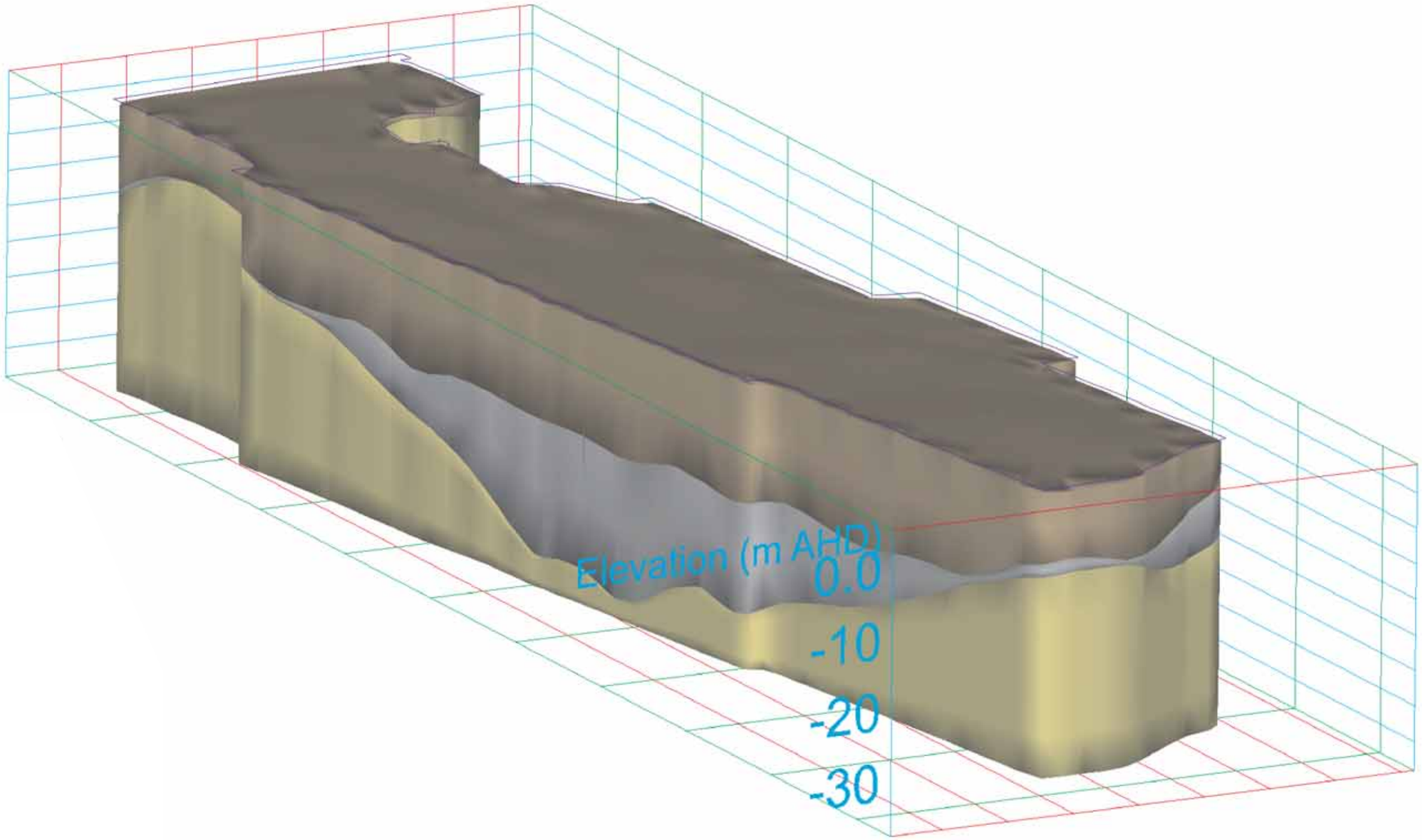

Legend

Geology

- Fill
- Sandy Clays
- Sandstone

Figure 6

Generalised 3D Geological Model

Client:	Barangaroo Delivery Authority		
Project:	Barangaroo Overarching RAP		
Drawing No:	0114685s_RAP_01_R0		
Date:	16/04/2010	Drawing size:	A3
Drawn by:	GC	Reviewed by:	PL
Scale:	As Shown		

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ERM

Legend

- Remediation Site
- Approximate Location of Former Gasworks Structures
- Approximate Extent of Soils Exceeding Comm/Residential Screening Values
- Approximate Extent of Soils Exceeding Open Space Screening Values
- Approximate Boundary of Landuse Zones
- Existing or Former Site Features
- Lot Boundaries
- Exceeds EPA 94 Criteria
- Exceeds HIL 'E'
- Exceeds HIL 'D' and / or 'F'
- Borehole Locations

Client:	Barangaroo Delivery Authority
Project:	Barangaroo Overarching RAP
Drawing No:	0114385s_RAP_GIS006_R0.mxd
Date:	15/04/2010 Drawing size: A3
Drawn by:	JF Reviewed by: PL
Projection:	GDA 1994 MGA Zone 56
Scale:	Refer to Scale Bar

N

0 25 50 75m

Figure 7

Approximate Extent of Soil Impacts Exceeding Screening Values

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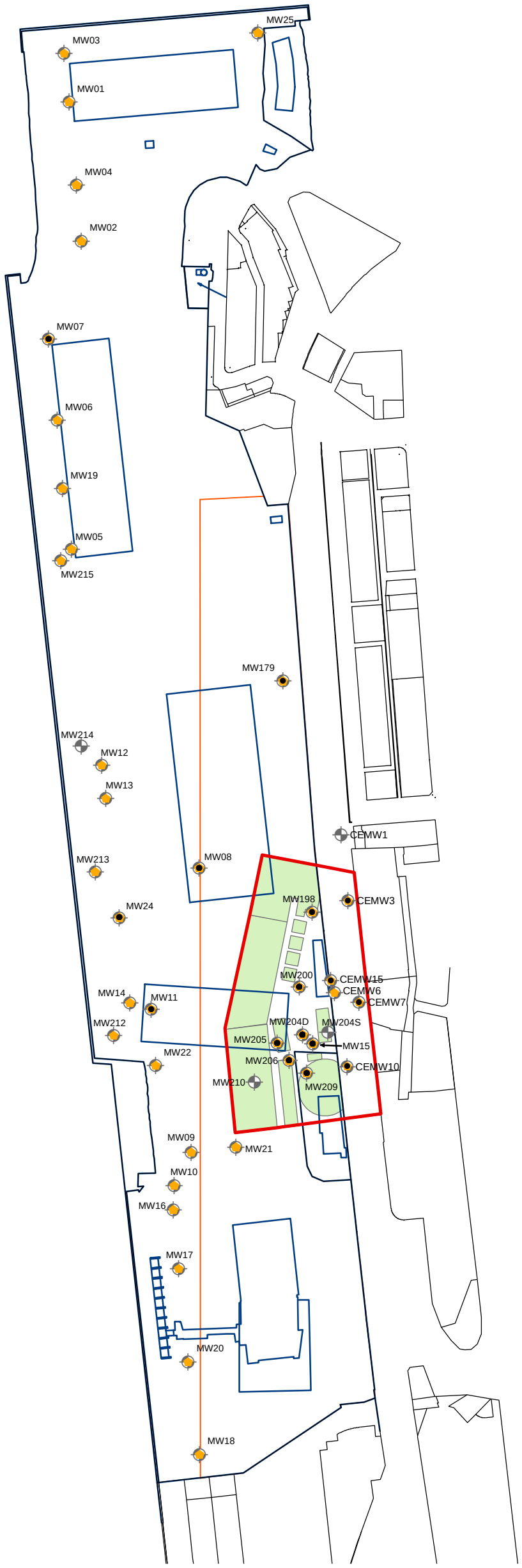

Legend

- Monitoring Well
- Detected Concentration Exceeds Adopted ANZECC Guideline Value
- Detected Concentration of Organic Contaminant Exceeds Adopted Guideline Value
- Remediation Site
- Approximate Location of Former Gasworks Structures
- Existing or Former Site Features
- Approximate Boundary of Landuse Zones

Client:	Barangaroo Delivery Authority	
Project:	Barangaroo Overarching RAP	
Drawing No:	0114385s_RAP_GIS007_R0.mxd	
Date:	15/04/2010	Drawing size: A3
Drawn by:	JF	Reviewed by: PL
Projection:	Unknown	
Scale:	Refer to Scale Bar	

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0 30 60 90m

Figure 8

Monitoring Wells With Detected Concentrations of Contaminants Exceeding the Adopted Guideline Values

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ERM

Annex B

Voluntary Management Proposal

VOLUNTARY MANAGEMENT PROPOSAL UNDER THE CONTAMINATED LAND MANAGEMENT ACT 1997

Part 1

Preliminary Details

1. Proponent's Details

(a) Name and contact details

Company name:	**Barangaroo Delivery Authority**
Contact:	**John Tabart**
Phone:	**9255 1703**
Fax:	**9271 5148**
Email:	**John.Tabart@barangaroo.nsw.gov.au**
Postal address:	**Level 3, Foreshore House, 66 Harrington Street, The Rocks, NSW**
Postcode:	**2000**

(b) Who the EPA should contact with technical enquiries about the proposal

Name:	**Sonja Shand**
Company:	**Barangaroo Delivery Authority**
Position title:	**Project Manager**
Type of business:	**Statutory authority created under the *Barangaroo Delivery Authority Act 2009* (NSW) to manage the city waterfront development at Barangaroo and to deliver world class benchmarks in urban design, public domain and sustainability.**
Phone (business):	**9255 1707**
Phone (after hours):	**0429 554 129**
Fax:	**9271 5148**
Email:	**Sonja.Shand@barangaroo.nsw.gov.au**

2. Site to which Proposal applies

The site to which the Proposal applies ("**Site**") is comprised of:

(a) Part Lot 5 and Part Lot 3 DP 876514, Hickson Road, Millers Point, NSW 2000;

(b) Part of Hickson Road adjacent to:

- 30-34 Hickson Road (Lot 11, DP1065410)
- 36 Hickson Road (Lot 5, DP873158) and
- 38 Hickson Road (SP72797) Millers Point.

3. The contamination

The EPA has declared that the Site is contaminated with gasworks waste and particularly waste tar as a result of the previous use of the site as a gasworks plant significant enough to warrant regulation under the *Contaminated Land Management Act* 1997 (NSW). The chemical composition of gasworks waste includes the following substances: (the "**Contaminants**"):

(a) polycyclic aromatic hydrocarbons (PAHs);
(b) benzene, toluene, ethylbenzene and xylenes (BTEX);
(c) total petroleum hydrocarbons (TPHs);
(d) ammonia;
(e) phenol and cyanide.

4. The management proposal

The management proposal (the "Proposal") comprises:

a) the information set out above;
b) the undertakings set out in Part 2 of this document;
c) the performance schedule set out in Part 3 of this document; and
d) the reports set out below:
    - Environmental Site Assessment East Darling Harbour, Sydney NSW, Site Investigation Report, Final Report Revision 1 (ERM, 21 June 2007);
    - Proposed Sampling, Analysis & Quality Plan for Additional Investigation Works at Barangaroo, Hickson Road, Sydney – draft Revision 2 (ERM, November 2007);
    - Additional Investigation Works at Barangaroo, Hickson Road, Millers Point (ERM, July 2008a);
    - Preliminary Sediment Screening Works at East Darling Harbour, Adjacent to Barangaroo, NSW (ERM, August 2008b);
    - Draft Stage 2 Remedial Action Plan for Barangaroo, Hickson Road, Sydney (ERM, September 2008); and
    - Proposal for Data Gap Investigation and Remediation Design Works, EPA Declaration Area 21122, Hickson Road (AECOM Australia Pty Ltd, 2010)

Part 2

Undertakings Included in Voluntary Management Proposal

THE PROPOSAL INCLUDES THE FOLLOWING UNDERTAKINGS:

General

1. All works or activities carried out in connection with the proposal, including sampling and preparation of associated reports ("the activities"), will be carried out in accordance with applicable provisions of *State Environmental Planning Policy 55 – Remediation of Land* and any requirements imposed under it in relation to the activities.
2. All matters listed as relevant to a remediation action plan by the EPA's *Guidelines for Consultants Reporting on Contaminated Sites* (1997) will be taken into account in the carrying out of the activities.
3. All the activities will be carried out consistently with guidelines made or approved under section 105 of the CLM Act.
   (See http://www.environment.nsw.gov.au/clm/guidelines.htm)
4. All the activities will be carried out in compliance with applicable NSW environmental legislation, and in particular:
   i) All the activities, including:
      (1) the processing, handling, movement and storage of materials and substances used to carry out the activities; and
      (2) the treatment, storage, processing, reprocessing, transport and disposal of waste generated by the activities

      will be carried out in a competent manner;
   ii) All plant and equipment installed at the site or used in connection with the activities:
      (1) will be maintained in a proper and efficient condition; and
      (2) will be operated in a proper and efficient manner.
5. All the activities at the site will be carried out in a manner that prevents or minimises the emission of dust, odour and noise from the site.
6. Waste generated or stored at the Site will be assessed and classified in accordance with DECC's *Waste Classification Guidelines Part 1: Classifying Waste*.

   (See http://www.environment.nsw.gov.au/waste/envguidlns/index.htm)
7. All waste transported from the Site that is required by the *Protection of the Environment (Waste) Regulation 2005* to be tracked must be tracked using DECC's on-line tracking system or an alternative tracking system approved in writing by DECC.

   (See http://www.environment.nsw.gov.au/waste/wastetracking.htm)

8. The proponent will, and acknowledges that the EPA may, make all documents and information relating to the proposal and activities carried out under the proposal available to the public free of charge.
9. The proponent consents to the EPA placing all documents relating to the proposal on its public website.
10. The proponent will:
    i) prior to the implementation of the proposal provide for the EPA's approval a strategy for communicating about that implementation, particularly the actual management works, with members of the public who are likely to have a real interest in or be affected by that implementation; and
    ii) implement the strategy as approved in writing by the EPA.

Monitoring, Record Keeping & Reporting

11. At least until the EPA has notified the proponent that the EPA no longer considers that the contamination is significant enough to warrant regulation under the *Contaminated Land Management Act 1997*, record and retain all monitoring data and information and provide this record to the EPA at any reasonable time if so requested by the EPA and as specifically provided under the proposal.
12. The EPA will be informed in writing within 7 days of the proponent becoming aware of information or data indicating a material change:
    a) in conditions at the site, or
    b) in its surrounding environment,

    which could adversely affect the prospects of successful management of the site or result in harm to the environment.
13. The EPA will be informed in writing within 7 days of the proponent becoming aware of any failure, either by the proponent or any other person, to comply with any term of the proposal.
14. The EPA will be informed in writing as soon as practicable of any notification by the proponent, its employees or its agents to an appropriate regulatory authority other than the EPA of any pollution incident at the site within the meaning of the *Protection of the Environment Operations Act 1997*.

    (See http://www.environment.nsw.gov.au/licensing/dutytonotify.htm)

Performance Schedule

15. The performance schedule which is in Part 3 of this document will be adhered to.

Part 3

PERFORMANCE SCHEDULE

1. Objectives of the Proposal

The Proposal envisages a two-staged Voluntary Management Proposal ("**VMP**") program as follows:

(a) Stage 1: VMP in which:

(1) investigative works would be undertaken with the objective of identifying, and obtaining the Site Auditor's and the EPA's approval of a preferred remedial strategy to address the groundwater contamination on the Site;
(2) presenting the detailed design of the remedial strategy in a Remedial Action Plan ("**RAP**") and a Remedial Work Plan ("**RWP**"); and
(3) obtaining the Site Auditor's endorsement of or confirmation that he has no objection to the RAP, and obtaining the EPA's approval of the RAP.

(b) Stage 2: VMP in which the remedial measures set out in the RAP would be implemented.

Stage 1

The main objectives of stage 1 will be achieved within the timeframes specified in this Proposal:

O1. Conduct a Data Gap Investigation for the Site in order to adequately characterise the nature and extent of the Site contamination.

O2. Prepare a Human Health and Ecological Risk Assessment ("**HHERA**") which would identify the Site specific soil and groundwater acceptance criteria for the Site and for the remediation works.

O3. Conduct remediation technology trials to determine applicability and selection of proposed remediation technologies for the Site.

O4. Prepare and submit a RAP (which outlines the agreed detailed design and specifications of the remedial measures and how these will be implemented, and is conditional upon a strategy to confirm the preferred remediation technologies (subject to completion of remediation technology trials)) to the Site Auditor and the EPA; obtain the Site Auditor's endorsement of the RAP or confirmation that he has no objection to the RAP; and obtain the EPA's approval of the RAP.

O5. Based on the RAP, prepare and submit a RWP (which sets out the technical specifications of the remediation works on the Site) to the Site Auditor and the EPA; obtain the Site Auditor's endorsement of the RWP or confirmation that he has no objection to the RWP; and obtain the EPA's approval of the RWP.

Stage 2

The objectives of stage 2 will be defined in a separate voluntary management proposal upon completion of stage 1 and will include the following:

O1. Implement the remedial measures set out in the RAP.

2. Principal features of stage 1

The principal features of stage 1 include, but are not limited to:

a. Capital works

P1. Drilling of additional wells to undertake future pilot trials and groundwater monitoring.

P2. Drilling and test pitting to obtain physical soil samples for material characterisation and future treatment trials.

P3. Remediation technology trials (i.e., bench scale and pilot trials) to assess and confirm applicability and selection of proposed remediation technologies for the Site.

b. Investigation

P4. Sampling and laboratory treatment trial to evaluate S-ISCO at the Site.

P5. Soil and groundwater sampling including sampling to characterise materials in-situ.

P6. Evaluation of groundwater and soil properties to determine the potential volume of groundwater present, flow direction and velocity.

P7. Assessment and testing for Potential Acid Sulfate Soils (**PASS**) on the Site.

P8. HHERA to establish site-specific clean-up and soil re-use criteria.

P9. Completion of a RAP and RWP.

The principal features of stage 2 will be set out in a separate proposal with the EPA.

3. Key milestones for investigation and other actions

All works set out in the Proposal must be completed by the deadlines specified below:

Works	***Deadline***
T1. Undertake data gap investigation.	Completed the data gap investigation and submitted a draft Data Gap Investigation Report by end of May 2010
T2. Conduct a HHERA (including submit draft and final HHERA reports).	Completed and submitted by end of June 2010
T3. Undertake remediation 1st stage technology treatment trials.	Completed by end of May 2010
T4. Prepare and submit a draft RAP (conditional on	Submitted by end of July 2010

remediation technology selection).

T5. Submit final RAP to the EPA (conditional on remediation technology selection).	Within 8 weeks of receipt of EPA comments on the draft RAP
T6. Obtain EPA approval on the remedial strategy.	Approval to be obtained within EPA timeframe.
T7. Undertake remediation 2nd stage technology treatment trials (i.e., S-ISCO pilot trial).	Completed by end of September 2010
T8. Prepare and submit a draft RWP.	Submitted by end of September 2010
T9. Submit a final RWP to the EPA.	Within 8 weeks of receipt of EPA comments on the draft RWP.

The deadlines for the remedial works will be set out in stage 2.

4. Reporting requirements and timeframe for submission of reports

The EPA must be provided with the following reports by the deadlines specified below:

Report	***Date submitted/to be submitted***
R1. Environmental Site Assessment East Darling Harbour, Sydney NSW, Site Investigation Report, Final Report Revision 1 (ERM, 21 June 2007)	16 August 2007
R2. Proposed Sampling, Analysis & Quality Plan for Additional Investigation Works at Barangaroo, Hickson Road, Sydney – draft Revision 2 (ERM, November 2007)	17 October 2007
R3. Additional Investigation Works at Barangaroo, Hickson Road, Millers Point (ERM, July 2008a)	6 August 2008 and 10 July 2008
R4. Preliminary Sediment Screening Works at East Darling Harbour, Adjacent to Barangaroo, NSW (ERM, August 2008b)	21 August 2008
R5. Draft Stage 2 Remedial Action Plan for Barangaroo, Hickson Road, Sydney (ERM, September 2008)	15 September 2008
R6. Final Proposal for Data Gap Investigation and Remediation Design Works, EPA Declaration Area 21122, Hickson Road (AECOM Australia Pty Ltd,	end of March 2010

2010)	
R7. Data Gap Investigation Report	end of May 2010
R8. Draft HHERA Report	end of May 2010
R9. Final HHERA Report	end of June 2010
R10. Draft RAP	end of July 2010
R11. Final RAP	Within 8 weeks of receipt of EPA comments on draft RAP
R12. Draft RWP	end of September 2010
R13. Final RWP	Within 8 weeks of receipt of EPA comments on draft RWP

The reports related to the remedial works to be contained in stage 2 and the deadlines for their submission to the EPA will be set out under a separate voluntary management proposal.

5. Conclusion of this Proposal

This Proposal will cease to be an approved proposal and the obligations and undertakings of the Proponent under this Proposal will be satisfied when the EPA issues a notice of satisfactory completion under section 17(7)(a) of the *Contaminated Land Management Act* 1997 (NSW).

Signature of proponent

This application for approval of this voluntary management proposal may only be signed by a person(s) with the legal authority to sign it. The various ways in which the application may be signed, and the people who may sign the application, are set out in the categories below.

Please tick (✓) the box next to the category that describes how this application is being signed.

If the proponent is:		**The application must be signed and certified by one of the following:**
an individual	☐	the individual.
a company	☐ ☐ ☐ ☐	the common seal being affixed in accordance with the *Corporations Act 2001, or* two directors, or a director and a company secretary, or if a proprietary company that has a sole director who is also the sole company secretary – by that director.
a public authority other than a council	☐ ☐	the chief executive officer of the public authority, or by a person delegated to sign on the public authority's behalf in accordance with its legislation (Please note: a copy of the relevant instrument of delegation must be attached to this application).
a local council	☐ ☐	the general manager in accordance with s.377 of the *Local Government Act 1993* ('LG Act'), or the seal of the council being affixed in a manner authorised under the LG Act.

I/We (the proponent):

- ***apply for approval of the voluntary management proposal set out in this Proposal and in any documents referred to in Part 1.4 of this Proposal***
- ***declare that the information in this Proposal form (including any attachment or document referred to in Part 1.4 of this proposal) is not false or misleading.***

Signature		Signature	
Name (printed)		Name (printed)	
Position		Position	
Date		Date	

Seal (if signing under seal):

Annex C

NSW EPA Declaration of Remediation Site

Environment Protection Authority

Declaration of Remediation Site

(Section 21 of the Contaminated Land Management Act 1997)

Declaration Number 21122; Area Number 3221

The Environment Protection Authority (EPA) declares the following land to be a remediation site under the Contaminated Land Management Act 1997 ("the Act"):

1. Land to which this declaration applies ("the site")

The site to which this declaration relates is part of the former Millers Point gasworks and is described as:

- Part Lot 5 and Part Lot 3 in Deposited Plan (DP) 876514, Hickson Rd, Millers Point
- The part of Hickson Road adjacent to:
    - 30 – 34 Hickson Road being Lot 11 DP1065410;
    - 36 Hickson Road being Lot 5 DP873158 and Lot 12 DP1065410; and
    - 38 Hickson Road being SP72797, Millers Point

in the City of Sydney local government area. The site coincides with the known foot print of the former gasworks facilities. A map of the site is available for inspection at the offices of the Department of the Environment and Climate Change, Level 14, 59-61 Goulburn Street, Sydney, NSW.

2. Nature of contamination affecting the site:

The EPA believes that the site is contaminated with gasworks waste and particularly waste tar as a result of the previous use of the site as a gasworks plant. The chemical composition of gasworks waste includes the following substances ("the contaminants"): polycyclic aromatic hydrocarbons (PAHs); benzene, toluene, ethylbenzene and xylenes (BTEX); total petroleum hydrocarbons (TPHs); ammonia; phenol and cyanide.

3. Nature of harm that the contaminants may cause:

The EPA has considered the matters in s.9 of the Act and for the following reasons has determined that the site is contaminated in such a way as to present a significant risk of harm to human health and the environment:

- Groundwater on the site has been found to be contaminated by TPHs, PAHs, BTEX, ammonia, phenol and cyanide at concentrations significantly exceeding the relevant trigger values for the protection of human health and aquatic ecosystems in the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC and ARMCANZ, 2000).
- These groundwater contaminants include human carcinogens and substances toxic to aquatic ecosystems.
- The contaminated groundwater is impacting on the surrounding areas including the basement of a residential building adjacent to the site, potentially exposing humans in that building to harmful vapours; however it is currently being effectively controlled.
- Contaminated groundwater is likely to be migrating from the site to Darling Harbour and could ultimately affect aquatic ecosystems.

4. Further action under the Act

The making of this declaration does not prevent the carrying out of a voluntary remediation of the site and any person may submit a voluntary remediation proposal for the site to the EPA. If the proposal satisfies the requirements of s.26 of the Act, the EPA may agree not to issue a remediation order to the person or persons bringing the proposal.

5. Submissions invited

The public may make written submissions to the EPA on:

- Whether the EPA should issue a remediation order in relation to the site; or
- Any other matter concerning the site.

Submissions should be made in writing to:

Manager Contaminated Sites
Department of Environment and Climate Change
PO Box A290
SYDNEY SOUTH NSW 1232

or faxed to 02 9995 5930

by no later than 3 June 2009

[Signed]

NIALL JOHNSTON
Manager Contaminated Sites
Department of Environment and Climate Change

Date: 6 May 2009

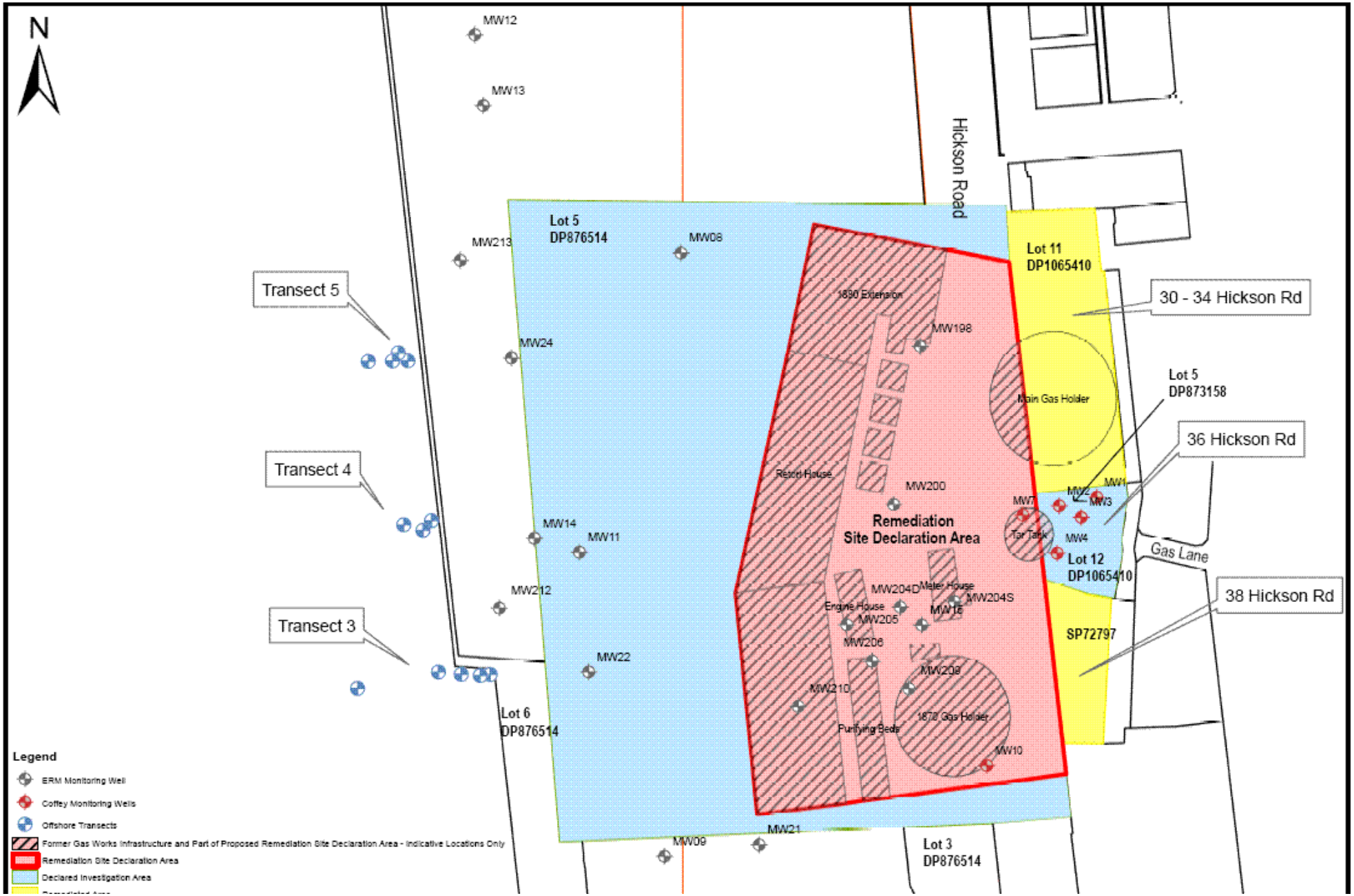
NOTE:
Remediation order may follow
If remediation of the site or part of the site is required, the EPA may issue a remediation order under s.23 of the Act.

Variation/Revocation
This declaration may be varied by a subsequent declaration. It remains in force until it is otherwise varied or revoked. A declaration may only be revoked when the EPA does not have reasonable grounds to believe that land is contaminated in such as way as to present a significant risk of harm (s.44 of the Act).

Information recorded by the EPA
Section 58 of the Contaminated Land Management Act 1997 requires the EPA to maintain a public record. A copy of this remediation declaration will be included in the public record.

Information recorded by councils
Section 59 of the Act requires the EPA to inform the relevant local council that this declaration has been made, as soon as practicable. The council is then required to note on its planning certificate issued pursuant to s.149 (2) of the Environmental Planning and Assessment Act that the land is currently within a remediation area. The EPA is required to notify council as soon as practicable when the declaration is no longer in force and the notation on the s.149 (2) certificate can be removed.

Relationship to other regulatory instrument
This declaration does not affect the provisions of any relevant environmental planning instruments which apply to the land or provisions of any other environmental protection legislation administered by the EPA.


N
MW12
MW13
MW213
MW08
MW24
MW14
MW11
MW212
MW22
MW09
MW21
Hickson Road
Lot 5
DP876514
Lot 11
DP1065410
30 - 34 Hickson Rd
1890 Extension
MW198
Main Gas Holder
Lot 5
DP873158
36 Hickson Rd
Retort House
MW200
Remediation
Site Declaration Area
MW7
MW2
MW1
MW3
Tar Tank
MW4
Gas Lane
Lot 12
DP1065410
Meter House
MW204D
MW204S
Engine House
MW205
MW16
MW206
38 Hickson Rd
SP72797
MW208
MW210
1878 Gas Holder
Purifying Beds
MW10
Lot 6
DP876514
Lot 3
DP876514
Transect 5
Transect 4
Transect 3
Legend
ERM Monitoring Well
Coffey Monitoring Wells
Offshore Transects
Former Gas Works Infrastructure and Part of Proposed Remediation Site Declaration Area - Indicative Locations Only
Remediation Site Declaration Area
Declared Investigation Area

Annex D

Director Generals Requirements

Director General's Requirements

Section 75F of the *Environmental Planning and Assessment Act 1979*

Application number	MP10_0026
Project	Remediation and land forming works
Location	Hickson Road, Barangaroo, Sydney
Proponent	Lend Lease Development Pty Ltd
Date issued	23 March 2010
Expiry date	If the environmental assessment is not exhibited within 2 years after this date, the applicant must consult further with the Director General in relation to the preparation of the environmental assessment.
Key issues	The Environmental Assessment (EA) must address the following key issues: **1. Relevant EPI's policies and guidelines** • Planning provisions applying to the site, including permissibility and the provisions of all plans and policies including: o State Environmental Planning Policy (Major Development) 2005; o State Environmental Planning Policy 55 - Remediation of Land; o Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005; o Sydney Harbour Foreshores and Waterways Area Development Control Plan 2005; o NSW State Plan, Sydney Metropolitan Strategy and the draft Sydney City Subregional Strategy; and o An outline of the nature and extent of any non-compliance with relevant environmental planning instruments, plans and guidelines and justification for any non-compliance. **2. Concept Plan** • The EA shall demonstrate compliance with the Concept Plan approval MP06_0162 (as amended) and justify any areas of non-compliance. **3. Remediation Action Plan** The Environmental Assessment must include a site wide Remediation Action Plan and a detailed Remediation Action Works Plan(s) for the relevant section(s) of the site. The Remediation Action Works Plan(s) must be prepared in accordance with the Guidelines for Consultants Reporting on Contaminated Sites (NSW EPA 1997), the relevant components of other guidelines made or approved under section 105 of the *Contaminated Land Management Act* 1997 and also include: • Characterisation of the nature and extent of contaminated material. • A description of the overall remediation strategy for the site, including the: o objectives of the remediation strategy; o proposed staging of the strategy; and o relationship between the various stages of the strategy. • Details of the proposed remediation process, including on-site and off-site treatment methodologies and the location, and transportation options, of any off-site treatment facility, and details of contingency processes. • Details of the proposed remediation management measures, including justification of the remediation criteria to be applied to all or respective parts of the site and proposed disposal or re-use of materials and management of wastewater, including agreements for disposal of trade wastes, including treated water from the contaminated areas. • Plans of any proposed containment cell(s) for contaminated material, including: o demonstration that the design and integrity of the cells would be consistent with best practice

standards;
  - demonstration that any material incompatibilities between the cell(s) and material to be stored in the cell(s) have been identified;
  - management procedures to address incompatibility issues must be provided; and
  - demonstration that the cell(s) would adequately contain the materials to be stored without impacting on the surrounding environment.
- Site validation plan.
- Details of compliance with the *Contaminated Land Management Act 1997* and remediation to address the current regulation on the site.
- Final landform following remediation and the suitability of fill material.
- On-going management and responsibility of the site following remediation.

The Remediation Action Works Plan(s) must clearly demonstrate that the site will be remediated to a standard commensurate with the final intended land use. The *plans* must be audited by an EPA accredited site auditor, and include a site audit statement detailing the findings of the audit.

Proposed remediation criteria must be developed consistently with *National Environment Protection (Assessment of Site Contamination) Measure 1999* (NEPM). Where contaminants are present on the site that are not listed under the NEPM, specific remediation criteria for those contaminants must be derived having regard to relevant NSW standards, national standards, then international standards and justification for the use of any criterion not currently endorsed by the NSW Department of Environment, Climate Change and Water.

4. Waste Management

- Provide details of the quantity and type of liquid and non-liquid waste generated, handled, processed or disposed of on-site. Waste must be classified according to the DECCW's Waste Classification Guidelines 2008.
- Provide details of the quantity, type and specifications for all output products proposed to be produced. The description should include the physical, chemical and biological characteristics (including contaminant concentrations) of those output products as well as relevant accredited standards against which the products would comply.
- Provide details of intended (or potential) end uses for output products and the relevant product standards used against which those products would be assessed.
- Provide details of the layout, the treatment process and the environmental controls of the proposal.
- Provide details of liquid waste and non-liquid waste management, including:
  - the transportation, assessment and handling of waste arriving at or generated at the site;
  - any stockpiling of wastes or recovered materials at the site;
  - any waste processing related to the proposal, including reuse, recycling, reprocessing or treatment both on- and off-site;
  - the method for disposing of all wastes or recovered materials;
  - the emissions arising from the handling, storage, processing and reprocessing of waste; and
  - the proposed controls for managing the environmental impacts of these activities.
- Provide details of spoil disposal (if applicable) with particular attention to:
  - the quantity of spoil material likely to be generated;
  - proposed strategies for the handling, stockpiling, reuse/recycling and disposal of spoil;
  - the need to maximise reuse of spoil material in the construction industry;
  - identification of the history of spoil material and whether there is any likelihood of contaminated material, and if so, measures for the management of any contaminated material; and
  - designation of transportation routes for transport of spoil.
- Provide details of procedures for the assessment, handling, storage, transport and disposal of all hazardous and dangerous materials used, stored, processed or disposed of, in addition to the requirements for liquid and non-liquid wastes.
- Provide details of the type and quantity of any chemical substances to be used or stored and describe

arrangements for their safe use and storage.

- In documenting or describing the composition of output products and/or wastes generated, reference should be made to DECCW's Waste Classification Guidelines 2008.

5. Soil and Water

- Assess impacts on water quality of Sydney Harbour and proposed management, mitigation and monitoring measures.
- Erosion and sediment controls during remediation.
- Details of water quality monitoring program for Sydney Harbour, with a focus on turbidity and key contaminants.
- Assess the impacts of the proposal on surface and groundwater hydrology and quality.
- Assess the potential impacts on marine vegetation and aquatic ecology, with the works to be designed so that the area and quality of riparian and aquatic habitat types is improved and any further impact on the aquatic environment is minimised.
- Management measures for any barging of contaminated material.
- Stormwater management during construction.
- Assess impacts on estuarine circulation, estuarine water quality and aquatic ecology of land formation works (including impacts on aquatic vegetation from direct smothering and any changes that may result from altered hydrological regimes of surrounding waters and bays). Any modification of estuarine foreshores (including the incorporation of measures to improve the habitat value of newly created waters (such as environmentally friendly seawalls) should consider *Environmentally Friendly Seawalls - A Guide to Improving the Environmental Value of Seawalls and Seawall-lined Foreshores in Estuaries* (DECC, 2009).
- Assess the potential impacts on aquatic habitat from altered hydrological regimes, contaminated sediments and potential acid sulphate soils from dredging activities whilst constructing the coves and connecting canal.
- The discharge of stormwater or other water should be assessed by comparison to the relevant water quality objectives and environmental values for Sydney Harbour estuarine waters, see: http://www.environment.nsw.gov.au/ieo/index.htm for NSW Water Quality Objectives; and refer to related Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000): http://www.mincos.gov.au/publications/australian_and_new_zealand_guidelines_for_fresh_and_marine_water_quality.

6. Health Impacts

- Assessment of the health implications of the project (including extraction of sediments, off-site transport and treatment as well as disposal of sediments), during and following remediation, including details of human exposure scenarios and demonstration that the project will not have unacceptable acute or chronic health effects.

7. Air, Noise and Odour Impacts

- Identify potential air quality, noise and odour impacts and appropriate mitigation measures.
- An assessment of odour from the excavation, transport and storage of contaminated sediments.
- Air quality impact assessment of the remediation works, including measures to collect and control air emissions.
- Details of an air quality monitoring program, including the identification of air quality criteria.
- In particular, the following must be addressed:

Air and Odour

The Environmental Assessment must include an Air Quality Impact Assessment that is prepared strictly in accordance with the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales 2005*, available at: http://www.environment.nsw.gov.au/resources/air/ammodelling05361.pdf.

The Air Quality Impact Assessment must also make appropriate reference to the *Assessment and*

Management of Odour from Stationary Sources in NSW: Technical Framework 2006 and *Assessment and Management of Odour from Stationary Sources in NSW: Technical Notes 2006*, available at: http://www.environment.nsw.gov.au/air/odour.htm.

The key air quality issues for the proposal will depend on the methods used to manage and remediate the contaminated material. Potential matters that must be covered in the Air Quality Impact Assessment include, where applicable:

- the identification of the pollutants of concern, including individual toxic air pollutants, dust and odours;
- the identification and assessment of all relevant fugitive and point source emissions;
- appropriate coverage of all aspects of the remediation, including the excavation, storage, transport and treatment of contaminated material; and
- proposed air quality management and monitoring procedures during remediation.

The Air Quality Impact Assessment must consider the requirements of the *Protection of the Environment Operations (Clean Air) Regulation 2002*.

Noise

The Environmental Assessment should include an assessment of noise and vibration impacts, prepared in consultation with DECCW. All feasible and reasonable noise impact mitigation measures should be implemented. The assessment should be prepared in accordance with the NSW government's Interim Construction Noise Guideline, Industrial Noise Policy and Application Notes, Environmental Criteria for Road Traffic Noise and Assessing Vibration: A Technical Guide, as appropriate, available at http://www.environment.nsw.gov.au/noise/.

8. Traffic Management and Accessibility Impacts

- Assess the likely impacts from the proposed works on surrounding areas (including the impact on nearby intersections and the need/associated funding for upgrading or road improvement works (if required)), major arterial and local road networks, local public transport (including proposed light rail on Hickson Road), pedestrians and cyclists in the vicinity of the site.
- Cumulative impacts associated with other construction activities on the Barangaroo site are to be considered.
- Details of anticipated truck movements to and from the site.
- Details of access arrangements for workers to/from the site, emergency vehicles and service vehicle movements.
- Details of any proposed transportation of waste materials via the Harbour and proposed locations for handling materials.
- Navigation and safety impacts on other water based traffic and ferry commuter services from any barging of contaminated materials, including navigation in and around Darling Island, King Street Wharf, Johnstons Bay and White Bay.
- Impacts on the temporary cruise ship terminal.

9. Environmental, Construction and Site Management Plan

The EA shall provide an Environmental and Construction Management Plan for the proposed works, and is to include:

- Community consultation, notification and complaints handling;
- Impacts of construction on adjoining development and proposed measures to mitigate construction impacts;
- Noise and vibration impacts on and off site;
- Air quality impacts on the neighbourhood;
- Odour impacts;
- Water quality management for the site; and
- Waste and chemical management.

	10. Climate Change and Sea Level Rise • An assessment of the risks associated with sea level rise on the proposal as set out in the *draft NSW Coastal Planning Guideline: Adapting to Sea Level Rise.* **11. Heritage** • An assessment of the likely impacts of the proposal on any heritage or archaeological items and proposed mitigation and conservation measures. **12. Visual** • Identify and assess the visual impacts of the project. **13. Staging** • Details regarding the staging of the proposed development. **14. Ecologically Sustainable Development (ESD)** • Identify how the development will incorporate ESD principles in the design and construction phases of the development. **15. Consultation** • Undertake an appropriate and justified level of consultation in accordance with the Department's Major Project Community Consultation Guidelines October 2007.
Deemed refusal period	60 days

Plans and Documents to accompany the Application

General	The Environmental Assessment (EA) must include: 1. An executive summary; 2. A thorough site analysis including site plans, areal photographs and a description of the existing and surrounding environment; 3. A thorough description of the proposed development: 4. An assessment of the key issues specified above and a table outlining how these key issues have been addressed; 5. An assessment of the potential impacts of the project and a draft Statement of Commitments, outlining environmental management, mitigation and monitoring measures to be implemented to minimise any potential impacts of the project; 6. The plans and documents outlined below; 7. A signed statement from the author of the Environmental Assessment certifying that the information contained in the report is neither false nor misleading; 8. A Quantity Surveyor's Certificate of Cost to verify the capital investment value of the project (in accordance with the definition contained in the Major Projects SEPP; and 9. A conclusion justifying the project, taking into consideration the environmental impacts of the proposal, the suitability of the site, and whether or not the project is in the public interest.
Plans and Documents	The following plans, architectural drawings, diagrams and relevant documentation shall be submitted (where relevant); 1. An **existing site survey plan** drawn at an appropriate scale illustrating; • the location of the land, boundary measurements, area (sq.m) and north point; • the existing levels of the land in relation to buildings and roads; • location and height of existing structures on the site; and • location and height of adjacent buildings and private open space. • all levels to be to Australian Height Datum. 2. A **Site Analysis Plan** must be provided which identifies existing natural elements of the site (including all hazards and constraints), existing vegetation, footpath crossing levels and alignments, existing pedestrian and vehicular access points and other facilities, slope and topography, utility services, boundaries, orientation, view corridors and all structures on neighbouring properties where relevant to the application (including windows, driveways, private open space etc), levels and building elements to be retained. 3. A **locality/context plan** drawn at an appropriate scale should be submitted indicating: • significant local features such as parks, community facilities and open space and heritage items; • the location and uses of existing buildings, shopping and employment areas; • traffic and road patterns, pedestrian routes and public transport nodes. 4. **Architectural drawings** at an appropriate scale illustrating: • the location of any existing building envelopes or structures on the land in relation to the boundaries of the land and any development on adjoining land; • detailed floor plans, sections and elevations of the proposed buildings; • elevation plans providing details of external building materials and colours proposed; • fenestrations, balconies and other features; • accessibility requirements of the Building Code of Australia and the Disability Discrimination Act; • the height (AHD) of the proposed development in relation to the land; • the level of the lowest floor, the level of any unbuilt area and the level of the ground;

	• any changes that will be made to the level of the land by excavation, filling or otherwise. 5. **Other plans (where relevant)**: • **Stormwater Concept Plan** - illustrating the concept for stormwater management; • **Erosion and Sediment Control Plan** – plan or drawing that shows the nature and location of all erosion and sedimentation control measures to be utilised on the site; • **Geotechnical Report** – prepared by a recognised professional which assesses the risk of Geotechnical failure on the site and identifies design solutions and works to be carried out to ensure the stability of the land and structures and safety of persons; • **Landscape plan** - illustrating treatment of open space areas on the site, screen planting along common boundaries and tree protection measures both on and off the site. • **Shadow diagrams** showing solar access to the site and adjacent properties at summer solstice (Dec 21), winter solstice (June 21) and the equinox (March 21 and September 21) at 9.00 am, 12.00 midday and 3.00 pm.
Documents to be submitted	• 1 copy of the EA, plans and documentation for the Test of Adequacy; • 12 hard copies of the EA (once the EA has been determined adequate); • 12 sets of architectural and landscape plans to scale, including one (1) set at A3 size (to scale); and • 1 copy of the Environmental Assessment and plans on CD-ROM (PDF format), not exceeding 5Mb in size.

Director General's Requirements

Section 75F of the *Environmental Planning and Assessment Act 1979*

Application number	MP10_0022 & MP10_0023
Project	(MP10_0022) Demolition and site establishment works, (MP10_0023) Bulk excavation and basement car parking
Location	Hickson Road, Barangaroo, Sydney
Proponent	Lend Lease Development Pty Ltd
Date issued	23 March 2010
Expiry date	If the environmental assessment is not exhibited within 2 years after this date, the applicant must consult further with the Director General in relation to the preparation of the environmental assessment.
Key issues	The Environmental Assessment (EA) must address the following key issues: **1. Relevant EPI's, policies and guidelines** • Planning provisions applying to the site, including permissibility and the provisions of all plans and policies including: o State Environmental Planning Policy (Major Development) 2005; o State Environmental Planning Policy 55 - Remediation of Land; o Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005; o Sydney Harbour Foreshores and Waterways Area Development Control Plan 2005; o NSW State Plan, Sydney Metropolitan Strategy and the draft Sydney City Subregional Strategy; and o An outline of the nature and extent of any non-compliance with relevant environmental planning instruments, plans and guidelines and justification for any non-compliance. **2. Concept Plan** • The EA shall demonstrate consistency with the terms of approval of Concept Plan MP06_0162 (as amended) and justify any areas of inconsistency. **3. Traffic Management and Accessibility Impacts** • Assess the likely impacts from the proposed works on surrounding areas (including the impact on nearby intersections and the need/associated funding for upgrading or road improvement works (if required)), major arterial and local road networks, local public transport (including proposed light rail on Hickson Road), pedestrians and cyclists in the vicinity of the site. • Assess the cumulative impacts associated with other construction activities on the Barangaroo site. • Details of anticipated truck movements to and from the site. • Details of access arrangements for workers to/from the site, emergency vehicles and service vehicle movements. • Details of any proposed transportation of waste materials via the Harbour and proposed locations for handling materials. • Navigation and safety impacts on other water based traffic and ferry commuter services from any barging of contaminated materials, including navigation in and around Darling Island, King Street Wharf, Johnstons Bay and White Bay. • Impacts on the temporary cruise ship terminal.

Further in relation to MP10_0023:

- Justification for basement car parking and its relationship and function with the Barangaroo site, future land uses and project proposals.
- Demonstrate the provision of on-site car parking for the proposal having regard to the Concept Plan approval (as amended), RTA guidelines and accessibility of the site to public transport.
- Details on the use and management of the car parking area.
- A Traffic Management and Accessibility Plan is to be prepared in accordance with the RTA's Guide to Traffic Generating Developments, considering traffic generation, access, loading dock(s), measures to promote public transport usage and pedestrian and bicycle linkages.

4. Visual Amenity (in relation to MP10_0023)

- Demonstrate that basement car parking and basement areas are contained beneath building blocks to provide public streets with a high quality landscaped public domain.
- Demonstrate how the entry and exit to basement car parking will not have a detrimental impact upon visual amenity and pedestrian safety.

5. Remediation Action Plan

The Environmental Assessment must include a site wide Remediation Action Plan and a detailed Remediation Action Works Plan(s) for the relevant section(s) of the site. The Remediation Action Works Plan(s) must be prepared in accordance with the Guidelines for Consultants Reporting on Contaminated Sites (NSW EPA 1997), the relevant components of other guidelines made or approved under section 105 of the Contaminated Land Management Act 1997 and also include:

- Characterisation of the nature and extent of contaminated material
- A description of the overall remediation strategy for the site, including the:
  - objectives of the remediation strategy;
  - proposed staging of the strategy; and
  - relationship between the various stages of the strategy.
- Details of the proposed remediation process, including on-site and off-site treatment methodologies and the location, and transportation options, of any off-site treatment facility, and details of contingency processes.
- Details of the proposed remediation management measures, including justification of the remediation criteria to be applied to all or respective parts of the site and proposed disposal or re-use of materials and management of wastewater, including agreements for disposal of trade wastes, including treated water from the contaminated areas.
- Plans of any proposed containment cell(s) for contaminated material, including:
  - demonstration that the design and integrity of the cells would be consistent with best practice standards;
  - demonstration that any material incompatibilities between the cell(s) and material to be stored in the cell(s) have been identified;
  - management procedures to address incompatibility issues must be provided; and
  - demonstration that the cell(s) would adequately contain the materials to be stored without impacting on the surrounding environment.
- Site validation plan.
- Details of compliance with the Contaminated Land Management Act 1997 and remediation to address the current regulation on the site.
- Final landform following remediation and the suitability of fill material.
- On-going management and responsibility of the site following remediation.

The Remediation Action Works Plan(s) must clearly demonstrate that the site will be remediated to a standard commensurate with the final intended land use. The plans must be audited by an EPA accredited site auditor, and include a site audit statement detailing the findings of the audit.

Proposed remediation criteria must be developed consistently with National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPM). Where contaminants are present on the site that are not listed under the NEPM, specific remediation criteria for those contaminants must be derived having regard to relevant NSW standards, national standards, then international standards and justification for the use of any criterion not currently endorsed by the NSW Department of Environment, Climate Change and Water.

6. Soil and Water

- Assess impacts on water quality of Sydney Harbour and proposed management, mitigation and monitoring measures.
- Erosion and sediment controls during remediation and excavation.
- Details of water quality monitoring program for Sydney Harbour, with a focus on turbidity and key contaminants.
- Assess the impacts of the proposal on surface and groundwater hydrology and quality.
- Assess the potential impacts on marine vegetation and aquatic ecology.
- Management measures for any barging of any excavated or contaminated material.
- Stormwater management and strategies during construction.
- Assess impacts on estuarine circulation, estuarine water quality and aquatic ecology of land formation works (including impacts on aquatic vegetation from direct smothering and any changes that may result from altered hydrological regimes of surrounding waters and bays). Any modification of estuarine foreshores (including the incorporation of measures to improve the habitat value of newly created waters (such as environmentally friendly seawalls) should consider *Environmentally Friendly Seawalls - A Guide to Improving the Environmental Value of Seawalls and Seawall-lined Foreshores in Estuaries* (DECC, 2009)).
- The discharge of stormwater or other water should be assessed by comparison to the relevant water quality objectives and environmental values for Sydney Harbour estuarine waters, see: http://www.environment.nsw.gov.au/ieo/index.htm for NSW Water Quality Objectives; and refer to related Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000): http://www.mincos.gov.au/publications/australian_and_new_zealand_guidelines_for_fresh_and_marine_water_quality.

7. Waste Management

- Provide details of the quantity and type of liquid and non-liquid waste generated, handled, processed or disposed of on-site. Waste must be classified according to the DECCW's Waste Classification Guidelines 2008.
- Provide details of the quantity, type and specifications for all output products proposed to be produced. The description should include the physical, chemical and biological characteristics (including contaminant concentrations) of those output products as well as relevant accredited standards against which the products would comply.
- Provide details of intended (or potential) end uses for output products and the relevant product standards used against which those products would be assessed.
- Provide details of the layout, the treatment process and the environmental controls of the proposal.
- Provide details of liquid waste and non-liquid waste management, including:
  - the transportation, assessment and handling of waste arriving at or generated at the site;
  - any stockpiling of wastes or recovered materials at the site;
  - any waste processing related to the proposal, including reuse, recycling, reprocessing or treatment both on- and off-site;
  - the method for disposing of all wastes or recovered materials;
  - the emissions arising from the handling, storage, processing and reprocessing of waste; and

- the proposed controls for managing the environmental impacts of these activities.

- Provide details of spoil disposal (if applicable) with particular attention to:
  - the quantity of spoil material likely to be generated;
  - proposed strategies for the handling, stockpiling, reuse/recycling and disposal of spoil;
  - the need to maximise reuse of spoil material in the construction industry;
  - identification of the history of spoil material and whether there is any likelihood of contaminated material, and if so, measures for the management of any contaminated material; and
  - designation of transportation routes for transport of spoil.
- Provide details of procedures for the assessment, handling, storage, transport and disposal of all hazardous and dangerous materials used, stored, processed or disposed of, in addition to the requirements for liquid and non-liquid wastes.
- Provide details of the type and quantity of any chemical substances to be used or stored and describe arrangements for their safe use and storage.
- In documenting or describing the composition of output products and/or wastes generated, reference should be made to DECCW's Waste Classification Guidelines 2008.

8. Air, Noise and Odour Impacts

- Identify potential air quality, noise and odour impacts and appropriate mitigation measures.
- An assessment of odour from the excavation, transport and storage of contaminated sediments.
- Details of an air quality monitoring program, including the identification of air quality criteria.
- In particular the following must be addressed:

Air and Odour

The Environmental Assessment must include an Air Quality Impact Assessment that is prepared strictly in accordance with the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales 2005*, available at: http://www.environment.nsw.gov.au/resources/air/ammodelling05361.pdf.

The Air Quality Impact Assessment must also make appropriate reference to the *Assessment and Management of Odour from Stationary Sources in NSW: Technical Framework 2006* and *Assessment and Management of Odour from Stationary Sources in NSW: Technical Notes 2006*, available at: http://www.environment.nsw.gov.au/air/odour.htm.

The key air quality issues for the proposal will depend on the methods used to manage and remediate the contaminated material. Potential matters that must be covered in the Air Quality Impact Assessment include, where applicable:

- the identification of the pollutants of concern, including individual toxic air pollutants, dust and odours;
- the identification and assessment of all relevant fugitive and point source emissions;
- appropriate coverage of all aspects of the remediation, including the excavation, storage, transport and treatment of contaminated material; and
- proposed air quality management and monitoring procedures during remediation.

The Air Quality Impact Assessment must consider the requirements of the *Protection of the Environment Operations (Clean Air) Regulation 2002*.

Noise

The Environmental Assessment should include an assessment of noise and vibration impacts, prepared in consultation with DECCW. All feasible and reasonable noise impact mitigation measures should be implemented. The assessment should be prepared in accordance with the NSW government's *Interim Construction Noise Guideline*, *Industrial Noise Policy* and Application

Notes, *Environmental Criteria for Road Traffic Noise* and *Assessing Vibration: A Technical Guide*, as appropriate, available at http://www.environment.nsw.gov.au/noise/.

9. Health Impacts

- Assessment of the health implications of the projects (including extraction of sediments, off-site transport and treatment as well as disposal of sediments), during and following remediation, including details of human exposure scenarios and demonstration that the projects will not have unacceptable acute or chronic health effects.

10. Climate Change and Sea Level Rise

- An assessment of the risks associated with sea level rise on the proposal as set out in the *draft NSW Coastal Planning Guideline: Adapting to Sea Level Rise*.

11. Heritage

- An assessment of the likely impacts of the proposal on heritage and archaeological items and proposed conservation and mitigation measures.

12. Environmental, Construction and Site Management Plan

The EA shall provide an Environmental and Construction Management Plan for the proposed works, and is to include:

- Community consultation, notification and complaints handling;
- Impacts of construction on adjoining development and proposed measures to mitigate construction impacts;
- Noise and vibration impacts on and off site;
- Air quality impacts on the neighbourhood;
- Odour impacts;
- Water quality management for the site; and
- Waste and chemical management.

13. Infrastructure and Services Provision

- Detail the existing infrastructure and services on site and outline what infrastructure and services will be decommissioned.
- Outline proposed infrastructure and services, including sustainability infrastructure and wastewater treatment facility and identify possible impacts.
- Detail measures to mitigate the impacts of the proposal on any remaining infrastructure items, including proposed relocation.

14. Temporary Structures

- Detail the proposed temporary structures on site, including sheds, compounds, hoardings and identify possible visual and amenity impacts.
- Detail measures to mitigate the impacts of the temporary structures on roads, streets and public domain areas.

15. Staging

Details regarding the staging of the proposed development.

16. Ecologically Sustainable Development (ESD)

Identify how the development will incorporate ESD principles in the design, construction and ongoing operation phases of the development.

17. Consultation

Undertake an appropriate and justified level of consultation in accordance with the Department's Major Project Community Consultation Guidelines October 2007.

Deemed refusal period	60 days

Plans and Documents to accompany the Application

General	The Environmental Assessment (EA) must include: 1. An executive summary; 2. A thorough site analysis including site plans, areal photographs and a description of the existing and surrounding environment; 3. A thorough description of the proposed development: 4. An assessment of the key issues specified above and a table outlining how these key issues have been addressed; 5. An assessment of the potential impacts of the project and a draft Statement of Commitments, outlining environmental management, mitigation and monitoring measures to be implemented to minimise any potential impacts of the project; 6. The plans and documents outlined below; 7. A signed statement from the author of the Environmental Assessment certifying that the information contained in the report is neither false nor misleading; 8. A Quantity Surveyor's Certificate of Cost to verify the capital investment value of the project (in accordance with the definition contained in the Major Projects SEPP; and 9. A conclusion justifying the project, taking into consideration the environmental impacts of the proposal, the suitability of the site, and whether or not the project is in the public interest.
Plans and Documents	The following plans, architectural drawings, diagrams and relevant documentation shall be submitted (where relevant); 1. An **existing site survey plan** drawn at an appropriate scale illustrating; • the location of the land, boundary measurements, area (s.q.m) and north point; • the existing levels of the land in relation to buildings and roads; • location and height of existing structures on the site; and • location and height of adjacent buildings and private open space. • all levels to be to Australian Height Datum. 2. A **Site Analysis Plan** must be provided which identifies existing natural elements of the site (including all hazards and constraints), existing vegetation, footpath crossing levels and alignments, existing pedestrian and vehicular access points and other facilities, slope and topography, utility services, boundaries, orientation, view corridors and all structures on neighbouring properties where relevant to the application (including windows, driveways, private open space etc). 3. A **locality/context plan** drawn at an appropriate scale should be submitted indicating: • significant local features such as parks, community facilities and open space and heritage items; • the location and uses of existing buildings, shopping and employment areas; • traffic and road patterns, pedestrian routes and public transport nodes. 4. **Architectural drawings** at an appropriate scale illustrating: • the location of any existing building envelopes or structures on the land in relation to the boundaries of the land and any development on adjoining land; • detailed floor plans, sections and elevations of the proposed buildings; • elevation plans providing details of external building materials and colours proposed; • fenestrations, balconies and other features; • accessibility requirements of the Building Code of Australia and the Disability Discrimination Act; • the height (AHD) of the proposed development in relation to the land; • the level of the lowest floor, the level of any unbuilt area and the level of the ground;

	• any changes that will be made to the level of the land by excavation, filling or otherwise. 5. **Other plans (where relevant)**: • **Stormwater Concept Plan** - illustrating the concept for stormwater management; • **Erosion and Sediment Control Plan** – plan or drawing that shows the nature and location of all erosion and sedimentation control measures to be utilised on the site; • **Geotechnical Report** – prepared by a recognised professional which assesses the risk of Geotechnical failure on the site and identifies design solutions and works to be carried out to ensure the stability of the land and structures and safety of persons; • **Landscape plan** - illustrating treatment of open space areas on the site, screen planting along common boundaries and tree protection measures both on and off the site.
Documents to be submitted	• 1 copy of the EA, plans and documentation for the Test of Adequacy; • 12 hard copies of the EA (once the EA has been determined adequate); • 12 sets of architectural and landscape plans to scale, including one (1) set at A3 size (to scale); and • 1 copy of the Environmental Assessment and plans on CD-ROM (PDF format), not exceeding 5Mb in size.