FINAL

Barangaroo
Lend Lease (Millers Point) Pty Limited
2 June 2010

AECOM

Remedial Action Plan

Barangaroo - Other Remediation Works (South) Area

Remedial Action Plan

Barangaroo - Other Remediation Works (South) Area

Prepared for

Lend Lease (Millers Point) Pty Limited

Prepared by

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2 June 2010

S4150030

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Quality Information

Document	Remedial Action Plan	
Ref	S4150030_ORWS_RAP_RPT_2June2010.docx	
Date	2 June 2010	
Prepared by	Andrew Rolfe	Author Signature
Reviewed by	Michael Jones	Technical Peer Reviewer Signature

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Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
1	9 April 2010	Draft report to LL	Michael Jones	
2	19 April 2010	Draft revised to address LL comments dated 13 April 2010	Michael Jones	
3	20 May 2010	Draft revised to address auditor comments dated 19 April, 27 April and 11 May 2010	Michael Jones	
4	2 June 2010	Draft revised to address BDA comments dated 25 and 28 May 2010	Michael Jones	

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Glossary of Terms and Acronyms

Term	Description
AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ASSMAC	New South Wales Acid Sulfate Soils Management Advisory Committee
As	Arsenic
Ba	Barium
BaP/ B(a)P	Benzo-α-pyrene
BDA	Barangaroo Development Authority
BH	Borehole location
BTEX	Benzene, Toluene, Ethyl benzene and Xylene
CBD	Central Business District
Cd	Cadmium
CIM	Confirmed Impacted Material
CLM	Contaminated Land Management
Co	Cobalt
CoC	Chain of Custody
CO_2	Carbon Dioxide
Cr	Chromium
CoPC	Chemicals of Potential Concern
Cr 6+/ Cr VI	Hexavalent Chromium
Cu	Copper
CUTEP	Clean Up to the Extent Practicable
DEC	Department of Environment and Conservation NSW (superseded)
DECC	Department of Environment and Climate Change NSW (superseded)
DECCW	Department of Environment, Climate Change and Water NSW
DGI	Data Gap Investigation
DoP	NSW Department of Planning
DP	Deposited Plan
DQO	Data Quality Objectives
DSI	Detailed Site Investigation
ECS	Emission Control Systems
EMP	Environment Management Plan
ESCO	Ex-Situ Chemical Oxidation

Term	Description
EPA	Environmental Protection Authority
ESA	Environmental Site Assessment
GMP	Groundwater Management Plan
Hg	Mercury
HHERA	Human Health and Ecological Risk Assessment
HERA	Health and Ecological Risk Assessment
m bgs	Metres below ground surface
Mn	Manganese
MW	Monitoring Well Location
MSDS	Material Safety Data Sheets
LL	Lend Lease (Millers Point) Pty Limited
LOR	Limit of Reporting
NATA	National Association of Testing Authorities
NEPC	National Environment Protection Council
NEPM	(National Environmental Protection (Assessment of Site Contamination) Measure
Ni	Nickel
NHMRC	National Health and Medical Research Council
NSW	New South Wales
OHS/OH&S	Occupational Health and Safety
OHSP	Occupational Health and Safety Plan
OPT	Overseas Passenger Terminal
ORWN	Other Remediation Works (North) Area
PAH	Polycyclic Aromatic Hydrocarbons
PASS	Potential Acid Sulfate Soils
PDA	Project Delivery Agreement
PID	Photoionisation Detector
PIM	Potential Impacted Material
Pb	Lead
POEO	Protection of the Environment Operations Act 1997 (NSW)
PPE	Personal Protective Enclosure
PSI	Preliminary Site Assessment
QA/QC	Quality Assurance/Quality Control
RAP	Remedial Action Plan
RBCL	Risk Based Clean Up Levels
RE	Remediation Enclosure
RL	Relative Level

Term	Description
RWP	Remediation Work Plan
SHFA	Sydney Harbour Foreshore Authority
SIL	Soil Investigation Level
S-ESCO	Surfactant Enhanced Ex-Situ Chemical Oxidation
SPA	Sydney Ports Authority
SPOCAS	Suspension Peroxide Oxidation Combined Acidity & Sulfate
SSTC	Site Specific Target Criteria
SWL	Standing Water Level
SVM	Site Validation Manager
SVOC	Semi Volatile Organic Compound
TBT	Tributyltin
TOC	Top of Casing
TPH	Total Petroleum Hydrocarbons
VMP	Voluntary Management Proposal
VOC	Volatile Organic Compound
VP	Validation Plan
VPD	Validation Project Director
UCL	Upper Confidence Level
USCS	Unified Soil Classification System
US EPA	United States Environment Protection Agency
VENM	Virgin Excavated Natural Material
Zn	Zinc

Units of Measurement			
℃	degrees Celsius	mg	milligrams
cm	centimetre	mS	milli-Siemens
ha	hectare	mV	millivolts
kg	kilogram	ppm	parts per million
km	kilometre	µg	microgram
m	metres	%	percent

Executive Summary

AECOM Australia Pty Limited (AECOM) was commissioned by Lend Lease (Millers Point) Pty Ltd (LL) to develop a Remedial Action Plan (RAP) for Blocks 1, 2 and 3 (including associated Public Domain areas) within the Barangaroo Stage 1 Development, Millers Point, NSW. The specific area covered by this RAP, hereafter referred to as "the Site", has also been referred to as the "Other Remediation Works (South) Area". In consideration of the objectives of this RAP and the areas that will be subject to the proposed development, the Site has been split into two areas comprising the proposed "Development Area (South)" and "Public Domain (South)".

The northern portion of the Barangaroo Stage 1 Development, comprising Blocks 4 and 5 and the Southern Cove (and also known as the Department of Environment, Climate Change and Water [DECCW] Declaration Area and Other Remediation Works [North] area) will be the subject of a separate series of RAPs.

Proposed Development and Land Use

Based on the current LL development plans, it is understood that the proposed land use across the Development Area (South) will comprise mixed commercial and high density residential (with minimal access to soil) with associated open space area. Key components of the proposed Development Area (South) include:

- A mix of commercial, retail and hotel land uses within the Public Domain;
- Basement car parking ranging typically between depths of Relative Level (RL) -20.0 m (here-in referred to as deep basement excavations) and RL -6.0 m (here-in referred to as shallow basement excavations) utilising:
  - Diaphragm walls will generally be constructed around the southern, western and northern boundaries; and
  - A combination of secant pile and concrete basement walls will generally be constructed along the eastern boundary.
- Below ground retail within basements at the southern end of the Development Area (South); and
- The Public Domain (South) will be typically utilised for recreational open space (incorporating retail, commercial and hotel land uses). While some excavations will be required for basement car parking along the eastern portion of the Public Domain, the existing concrete hardstand surfaces are proposed to be generally retained within the Public Domain. Additionally, the existing caisson walls associated with the historic wharf structures will be retained along the western (Darling Harbour) side of the Public Domain.

It is possible that the final details and configuration of land uses within the Development Area (South) and Public Domain (South) will be revised by LL as part of the continued development design. However, the proposed land uses - that is a mixture of commercial and high density residential and public open space (incorporating retail, commercial and hotel land uses) overlying extensive basements - will remain generally consistent with that described within this RAP.

Objectives

The key objective of the remediation of the Site is to facilitate the future land-use proposed as part of the Barangaroo Stage 1 Development Works. Additional objectives of the remediation works are:

- To ensure the remediated site is protective of human health in the context of the intended future land use;
- To protect the environment (specifically groundwater and the adjacent Darling Harbour) by remediation of the Site to a standard that will minimise the risk of ongoing contamination;
- Comply with applicable legislative requirements including the appropriate requirements of the NSW Department of Planning (DoP) and DECCW; and
- To maximise the beneficial reuse of excavated material (treated where required) from the basement excavations within other areas within Barangaroo and minimise off-site disposal.

It is noted that material proposed for re-use on other areas of Barangaroo will need to satisfy site acceptance criteria established in specific RAPs prepared for those areas. This includes a future Headland Park RAP being prepared by BDA.

Scope

The scope of work associated with the preparation of the RAP included the following:

- Review available data from previous environmental investigations undertaken at the Site, including the recent Data Gap Investigation undertaken by AECOM (March 2010), to assess the extent of remediation works required across the Site;
- Undertake an assessment of the potential remediation approaches and technologies;
- Outline how the remediation works will be undertaken to meet the remediation objectives, taking into consideration the information review and technical assessment; and
- Develop procedures to demonstrate that the remediation works have been undertaken to satisfy the remediation objectives.

Remediation Extent

In the first instance, identified soil impacts have been assessed against the relevant generic soil assessment guidelines dependent on the proposed land use at the Site. This screening method was used to identify where potential impacted material (PIM) is present at the Site. Confirmation of whether or not the PIM identified by this screening assessment represents a risk to human health or the environment (i.e. is Confirmed Impacted Material [CIM]), the resultant extent of remediation works and the suitability (or otherwise) of excavated materials for beneficial reuse, will ultimately be determined by the Site Specific Target Criteria (SSTC) derived from the human health and ecological risk assessment (HHERA).

The HHERA will be completed as an outcome of the DGI being undertaken in relation to Block 4 (and the adjacent Public Domain), Block 5 and the Southern Cove (which is also known as the Other Remediation Works (North) Area and the DECCW Declaration Area). It is anticipated that the contamination issues identified in relation to Blocks 1 to 3 will be addressed as a subset of the contamination issues associated with the Other Remediation Works (North) Area.

The HHERA will determine different SSTC for different areas/land uses at the Site. A separate, specific RAP for the Headland Park will determine acceptance criteria for potential excavated/treated material re-use at the proposed Headland Park.

An Addendum to the HHERA will be prepared to demonstrate the applicability of the soil and groundwater SSTC derived for Blocks 4 and 5 to the Site. An Addendum to this RAP will also be prepared following completion of the HHERA. The addendum will confirm locations where CIM will require remediation at the Site to ensure that unacceptable risks to human health or the environment will not occur following the proposed redevelopment works.

Remediation Strategy

The preferred remediation strategy for the Site will involve excavation of CIM, as defined by the HHERA and treatment of these materials (as required) for potential beneficial reuse at Headland Park (based on comparison to Headland Park acceptance criteria) and/or other areas of Barangaroo. In considering the preferred remediation strategy, consideration was given to the fact that the proposed development will include bulk excavation works for basement construction within the Development Area (South).

Material not meeting Headland Park acceptance criteria or the acceptance criteria developed for beneficial reuse in other areas of Barangaroo will be disposed off-site to licensed landfill. The suitability of other materials to be excavated for beneficial reuse will be validated based on the DGI (AECOM 2010) and additional in-situ characterisation sampling and analysis, and visual and olfactory observations during the excavation works.

This RAP also details the requirements for:

- Validation works required to confirm that the remediation objectives have been achieved;
- Materials tracking requirements for the cradle to grave tracking of materials during remediation;
- Groundwater monitoring prior to, during and after the remediation works;
- Environmental management measures during the remediation works to mitigate potential impacts to the environment;
- Occupational health and safety measures to ensure the remediation works are conducted in a safe manner; and

- Contingency actions for the identification and management of unexpected issues or events that may occur during the remediation works.

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1.0 Introduction

AECOM Australia Pty Limited (AECOM) was commissioned by Lend Lease (Millers Point) Pty Ltd (LL) to develop a Remedial Action Plan (RAP) for Blocks 1, 2 and 3 (including associated Public Domain areas) within the Barangaroo Stage 1 Development, Millers Point, NSW. The specific area covered by this RAP, hereafter referred to as "the Site", has been designated as the "Other Remediation Works (South) Area" (refer to **Figure F1** and **Figure F2**). In consideration of the objectives of this RAP and the areas that will be subject to the proposed development, the Site has been split into two areas comprising the proposed "Development Area (South)" and "Public Domain (South)".

The northern portion of the Barangaroo Stage 1 Development, comprising Blocks 4 and 5 and the Southern Cove (and also known as the Department of Environment, Climate Change and Water [DECCW] Declaration Area and Other Remediation Works [North] area) will be the subject to a separate series of RAPs (refer to **Figure F2**).

This RAP has generally been prepared to meet the general requirements of:

- NSW Environment Protection Authority (EPA), 1997. Contaminated Sites: Guidelines for Consultants Reporting on Contaminated Sites;
- Department of Environment and Conservation (DEC), 2006a. Guidelines for the NSW Site Auditor Scheme (2nd edition);
- Contaminated Land Management Amendment Act, (CLM), 2008;
- National Environment Protection Council, National Environment Protection (Assessment of Site Contamination) Measure (NEPC), 1999a;
- the DECCW letter titled 'Request for Provision of Details for Key Issues and Assessment Requirements, Barangaroo, East Darling Harbour, Sydney & Barangaroo Concept Development Plan Modification' (15 March 2010); and
- the Department of Planning (DoP) Director General's Requirements (DGRs, 23 March 2010).

1.1 Proposed Development and Land Use

Based on the current LL development plans, it is understood that the proposed land use across the Development Area (South) will comprise mixed commercial and high density residential (with minimal access to soil) with associated open space area. Key components of the proposed Development Area (South) include:

- A mix of commercial, retail and hotel land uses within the Public Domain;
- Basement car parking ranging typically between depths of Relative Level (RL) -20.0 m (here-in referred to as deep basement excavations) and RL -6.0 m (here-in referred to as shallow basement excavations, refer to **Figure F3**) utilising:
  - Diaphragm walls will generally be constructed around the southern, western and northern boundaries; and
  - A combination of secant pile and timber planking walls will generally be constructed along the eastern boundary.
- Below ground retail within basements at the southern end of the Development Area (South);
- The Public Domain (South) will be typically utilised for recreational open space (incorporating retail, commercial and hotel land uses). While some excavations will be required for basement car parking along the eastern portion of the Public Domain, the existing concrete hardstand surfaces are proposed to be generally retained within the Public Domain. Additionally, the existing caisson walls associated with the historic wharf structures will be retained along the western (Darling Harbour) side of the Public Domain; and
- The diaphragm walls to be constructed around the southern, western and northern boundaries of the Development Area (South) will extend from the ground surface to bedrock. Timber planking walls will be constructed along the northern end of the eastern boundary where the depth to bedrock is least. The timber planking will ultimately be replaced by a reinforced concrete retaining wall as part of the basement construction. Secant pile walls will be constructed along the southern end of the eastern boundary and will extend from the ground surface to bedrock. Where basement excavations extend into bedrock, exposed bedrock surfaces will be lined with shotcrete. It is anticipated that perimeter walls and shotcrete bedrock

lining, together with mechanical ventilation and other controls, which are standard practice for basement design, will effectively isolate the basement from surrounding ground conditions.

It is possible that the final details and configuration of land uses within the Development Area (South) and Public Domain (South) will be revised by LL as part of the continued development design. However, the proposed land uses - that is a mixture of commercial and high density residential and public open space (incorporating retail, commercial and hotel land uses) overlying extensive basements - will remain generally consistent with that described within this RAP.

1.2 Objectives

The key objective of the remediation of the Site is to facilitate the future land-use proposed as part of the Barangaroo Stage 1 Development Works. Additional objectives of the remediation works are:

- To ensure the remediated site is protective of human health in the context of the intended future land use;
- To protect the environment (specifically groundwater and the adjacent Darling Harbour) by remediation of the Site to a standard that will minimise the risk of ongoing contamination;
- Comply with applicable legislative requirements including the appropriate requirements of the NSW Department of Planning (DoP) and DECCW; and
- To maximise the beneficial reuse of excavated material (treated where required) from the basement excavations within other areas within Barangaroo and minimise off-site disposal.

It is noted that material proposed for re-use on other areas of Barangaroo will need to satisfy site acceptance criteria established in specific RAPs prepared for those areas. This is understood to include a future Headland Park RAP being prepared by the BDA.

1.3 Scope

The scope of work associated with the preparation of the RAP included the following:

- Establishment of Data Quality Objectives (DQOs) for the development of this RAP;
- Review available data from previous environmental investigations undertaken at the Site, including the recent Data Gap Investigation undertaken by AECOM (March 2010), to assess the extent of remediation works required across the Site;
- Undertake an assessment of the potential remediation approaches and technologies;
- Outline how the remediation works will be undertaken to meet the remediation objectives, taking into consideration the information review and technical assessment; and
- Develop procedures to demonstrate that the remediation works have been undertaken to satisfy the remediation objectives.

1.4 Remediation Documentation

Supporting Management Plans and Work Procedures that will be prepared prior to commencement of the remediation works include:

- Remedial Work Plan (also to be prepared by AECOM);
- Occupational Health and Safety Plan (OH&S);
- Community Consultation Plan;
- Environmental Management Plan;
- Project Management;
- Quality Management; and
- Emergency Response and Contingency Plan.

2.0 Assessment and Approval Process

2.1 Planning Approvals

The planning regime to guide the future redevelopment of the overall Barangaroo site is established by the:

- Planning provisions of Schedule 3 Part 12 of the State Environmental Planning Policy (Major Development), 2005; and
- Barangaroo Concept Plan, as approved on 9 February 2007 and modified on 25 September 2007 and 16 February 2009.

A number of project applications under Part 3A of the Environmental Planning and Assessment Act, 1979 are proposed to be submitted to support the staged development of the Barangaroo Stage 1 by Lend Lease. The Minister for Planning is the consent authority in this regard.

These planning applications will be supported by this RAP which demonstrates that the land is, or can be made, suitable for the proposed use. Implementation of remediation works as part of the Barangaroo Stage 1 Development will be staged (over several years) as the development works progress and undertaken in discrete stages through the life of the development. This RAP addresses the remediation and validation of the area referred to as Remediation Works (South) only (refer to **Figure F2**). Site Audit Statements will similarly be staged to progressively validate the Site for the proposed future land use(s).

It is understood that a "site-side" conceptual RAP is being prepared by ERM for BDA, to be an overarching conceptual document for the whole of Barangaroo. It is understood the site-wide RAP will allow for the provision of separate, detailed RAPs for site portions, of which this Other Remediation Works (South) RAP is one.

It is noted that material proposed for re-use on other areas of Barangaroo will need to satisfy site acceptance criteria established in specific RAPs prepared for those areas. AECOM understands that Headland Park Acceptance Criteria are being developed by the BDA.

2.2 Legislation Relevant to Remediation Works

The DECCW administers a number of Acts and legislative instruments relevant to the remediation works. These include:

- Contaminated Land Management Act (CLM Act, 1997);
- Contaminated Land Management Amendment Act, (CLM, 2008);
- The Protection of the Environment Operations (POEO) Act (1997), in particular, licensing obligations under that Act; and
- State Environmental Planning Policy (SEPP) 55 – Remediation of Land.

2.2.1 CLM Act (1997)

The CLM Act is the primary Act under which contaminated land is regulated by the DECCW. Relevant legislation relating to the CLM Act includes the *Contaminated Land Management Regulation* (2008), which commenced on 1 September 2008 and the *Contaminated Land Management Amendment Act*, (2008) which received assent on 10 December 2008. AECOM notes that the majority of the Amendment Act has not commenced and therefore the following discussion relates to the current in force status.

This section addresses the following aspects of the Act:

- Determination and suitability of a contaminated site for a proposed use including the generation of remediation criteria;
- Existing orders and regulatory instruments applicable to the site; and
- Voluntary remediation proposals and agreements.

The Guidelines for the NSW Site Auditor's Scheme (The Auditor Guidelines) (DEC, 2006a) were prepared by the Department of Environment and Conservation (DEC, now known as the DECCW) under the CLM Act (1997). The Auditor Guidelines (DEC, 2006a) describe a decision process for assessing urban redevelopment sites that should be followed by contaminated land consultants. The Guidelines prescribe soil investigation levels (SILs),

which are the concentrations of particular contaminants above which further investigation and evaluation (such as through completion of a quantitative risk assessment) are required.

The substances for which SILs have been prescribed do not include all of the Contaminants of Potential Concern (CoPC) identified at the Site. The Guidelines make the following provision for such circumstances:

> *"…where SILs are not available for particular contaminants, or assessment of contaminants against SILs at a particular site is inconclusive… The auditor must check whether the risk assessment is in accordance with the NEPM [National Environmental Protection (Assessment of Site Contamination) Measures] and any relevant guidelines made or approved by DEC. The auditor must also check that any human health risk assessment satisfies all the requirements in the checklist in Appendix VII. The auditor must check that all site-specific risk assessments are scientifically valid and that the site-specific criteria recommended by the consultant are appropriate to protect public health and the environment."*

Adoption of the SILs is generally considered inappropriate for remediation works as this may result in unnecessary increased remediation effort and cost. As such, where site investigations indicate that the SILs are exceeded, it is considered appropriate to adopt a health-based risk assessment approach in determining suitable criteria for the identified CoPC. With respect to the Site and in accordance with the ERM RAP (2008c), it is considered that a Tier 2 and Tier 3 Human Risk assessment and a qualitative ecological risk assessment may be required in the event that the SILs are exceeded to set site-specific clean up criteria for the proposed future use of the Site, which will be for a combination of residential, commercial and public open space uses. The proposed risk assessment process, by which the site-specific criteria will be derived, is summarised in **Section 5.3**.

The CLM Act also sets out requirements for site audits. The Act requires a site audit to be undertaken under certain circumstances, such as if the landuse is proposed to be changed, as is the case with the Site.

2.2.2 CLM Amendment Act (2008)

The majority of the provisions in the amending CLM Act (1997) commenced on 1 July 2009. The purpose of the amendments was to allow contaminated sites to be cleaned up more efficiently while reinforcing the 'polluter pays' principle. The key amendments to the Act included:

- introducing new powers to enable DECCW to require certain persons to carry out a preliminary investigation of site contamination;
- amalgamation of the investigation and remediation stages into a single 'management' stage that can cover investigation, remediation or both;
- removing the concept of 'significant risk of harm';
- enabling DECCW to declare land to be 'significantly contaminated land' if it has reason to believe that land is contaminated and the contamination is significant enough to warrant regulation;
- enabling management orders to be issued to any one or more persons who are responsible for the contamination of land;
- enabling DECCW to issue a management order or to withdraw its approval of a voluntary management proposal that has not delivered a satisfactory outcome in managing contamination;
- provision of a more objective basis for the duty to notify DECCW of contaminated land based on criteria to be listed in new guidelines; and
- requiring land owners and persons carrying out certain activities to notify DECCW of contamination when it becomes aware of that contamination.

2.2.3 Protection of the Environment Operations Act (1997)

Section 48 of the POEO Act requires a person to obtain a licence from the DECCW before carrying out any of the premises-based activities described in Schedule 1 of that Act.

Schedule 1 includes the following activity:

> *"Contaminated soil treatment works for on-site or off-site treatment (including, in either case, incineration or storage of contaminated soil but excluding excavation for treatment at another site) that:*
>
> *(1) handle more than 1,000 cubic metres per year of contaminated soil not originating from the site on which the works are located; or*

(2) handle contaminated soil originating exclusively from the site on which the works are located; and

(a) incinerate more than 1,000 cubic metres per year of contaminated soil, or

(b) treat otherwise than by incineration and store more than 30,000 cubic metres of contaminated soil, or

(c) disturb more than an aggregate area of 3 hectares of contaminated soil."

The remediation works for the Site will involve management of contaminated soil originating from the Site only and is not likely to involve the treatment of more than 30,000 m^3 of contaminated soil. Accordingly, the soil remediation works for the Site are not likely to require a licence under the POEO Act. This will be confirmed following preparation of the proposed RAP Addendum which will define the extent of remediation based on the outcomes of the HHERA.

2.2.4 State Environmental Planning Policy 55

State Environmental Planning Policy (SEPP) 55 – Remediation of Land specifies when remediation work will require Development Consent (i.e. Category 1 remediation work).

Clause 9 of SEPP 55 defines Category 1 remediation works as:

- Designated development; or
- Being carried out or to be carried out on land declared to be critical habitat; or
- Likely to have significant effect on a critical habitat or a threatened species, population or ecological community; or
- Development for which another State environmental policy or regional environmental plan requires development consent; or
- Carried out or to be carried out in an area or zone to which any classifications to the following effect apply under an environmental planning instrument.
    a) coastal protection
    b) conservation or heritage conservation
    c) habitat area, habitat protection area, habitat or wildlife corridor
    d) environment protection
    e) escarpment, escarpment protection or escarpment preservation
    f) floodway
    g) littoral rainforest
    h) nature reserve
    i) scenic area or scenic protection
    j) wetland.
- is “carried out or to be carried out on any land in a manner that does not comply with a policy made under the contaminated land planning guidelines by the council for any local government area in which the land is situated”.

All other remediation work may be carried out without development consent and is known as Category 2 remediation work.

The remedial works at the Site are classified as Category 1 remediation based on the requirements of SEPP (2005) which specifically addresses development (including remediation) of Barangaroo.

Notwithstanding, the Director Generals Requirements (DGRs) for the Blocks 1 to 3 Bulk Excavation and basement Car Parking Development Application require that planning consent be obtained for the proposed remediation works.

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3.0 Site Identification and History

3.1 Site Identification

The following table provides Site identification details.

Table 1: Site Identification Details

Item	Description
Site Owner	Barangaroo Delivery Authority (BDA)
Client	Lend Lease (Millers Point) Pty Limited (LL)
Site Address	Wharf 8, Hickson Road (Sussex Street), Barangaroo, NSW 2000
Legal Description (Lot and DP)	Southern portions of Lot 3, Lot 6 and Lot 5 in Deposited Plan (DP) 876514
County and Parish	County of Cumberland, Parish of Saint Phillip
Local Government Authority	City of Sydney
Current Zoning	Part zone B4 Mixed Use and part zone RE1 Public Recreation
Current Land Use	Commercial (Passenger Terminal and Venue Centre)
Proposed Land Use	Blocks 1 to 3: Commercial and High Density Residential (minimal access to soil) with basement car parking and associated Public Open Space Public Domain: Parks and Recreational Open Space with some retail / commercial land use
Approximate Site Area**	Block 1: 1645 m^2 Block 2: 15 640 m^2 Block 3: 7 655 m^2 Public Domain: 17 760 m^2
Approximate Average Elevation	2 - 3 m Australian Height Datum (AHD)
Site Location	**Figure F1**
Site Layout	**Figure F2**

Notes:

** Derived from CAD plans provided by LL

AHD – Australian Height Datum

3.2 Development and Bulk Excavation Areas

3.2.1 Proposed Land Uses – Development Area (South)

The indicative LL basement excavation plan (to be finalised) is summarised in **Figure F3** and the proposed land uses are shown in **Figure F4**. The proposed development incorporates a combination of high density residential (with minimal access to soils) and commercial development with associated public open space (planter boxes, paved areas and parkland).

The various structures to be constructed as part of the development will be generally founded on basement carparks which will extend to various depths across the entire footprint of Blocks 1 to 3. Additionally, basement retail may be included in some Site areas. Construction of the proposed basements will necessitate removal of a significant portion of the fill material, some natural soil and some bedrock from the Site. As a consequence, any contamination contained within the materials excavated for construction of the basements will also be removed and will require management as part of the remediation works.

3.2.2 Proposed Land Uses – Public Domain (South)

The proposed development for the Public Domain (South) incorporates public open space as well as some mixed commercial, retail and hotel landuse. While some excavations will be required for basement car parking along the eastern portion of the Public Domain, the existing concrete hardstand surfaces will be retained within the Public Domain to the extent practical. Additionally, the existing caisson walls associated with the historic wharf structures will be retained along the western (Darling Harbour) side of the Public Domain.

3.2.3 Basement Excavations

Based on the current basement design it is understood that the following bulk excavation works will be required:

- Deep basement excavations – typically to be excavated across the eastern portion of the Development Area (South) (directly adjacent to Hickson Road) to a typical depth of RL -20.0 m AHD. The entire basement footprint for this area will likely extend into the underlying bedrock which is inferred to range between approximately RL -0.0 m to -11.0 m AHD across the eastern part of Blocks 2 and 3; and
- Shallow basement excavations – typically to be excavated across the western portion of the Development Area (South) and partly beneath the eastern edge of the Public Domain to a typical depth of RL -6.0 m AHD. It is likely that no bedrock will be excavated during the bulk excavation works in western portion of the Development Area (South).

As noted previously, it is possible that the final details and configuration of land uses within the Site will be revised by LL as part of the continued development design.

3.2.4 Beneficial Reuse

It is proposed that excavation spoil which is surplus to the requirements of the Development within Blocks 1 to 3 will be reused elsewhere within the Barangaroo Development, specifically within:

- the Public Domain (which is proposed to be raised); and
- the proposed Headland Park (subject to compliance with the Site Acceptance Criteria to be defined in the Headland Park RAP).

3.2.5 Development Design Finalisation

It is possible that the final details and configuration of land uses within the Development Area (South) and Public Domain (South) will be revised by LL as part of the continued development design. However, the proposed land uses - that is a mixture of commercial and high density residential and public open space (incorporating retail, commercial and hotel land uses) overlying extensive basements - will remain generally consistent with that described within this RAP.

3.3 Site History

The history of the Millers Point area in which the Site is located, has been detailed in the publication *Land at Millers Pont Ownership and Usage* (Broomham, 2007). It is understood that the study was commissioned by the former Gasworks owners (Jemena) and focuses on that portion of the Barangaroo Stage 1 Development area. The historic layout of the gasworks infrastructure (previously located off-site to the north) is detailed in **Figure F2**. AECOM considers the information associated with the former gasworks is relevant to understanding the development history of the broader Stage 1 Development area and potential for Site contamination.

The following summarises historic information presented in Broomham (2007) and ERM (2007, 2008). Those historic activities which relate directly to the Site and/or other parts of Barangaroo are specifically noted.

- **1788-1839**: During early colonial times the shoreline was extended and a wharf and a cottage were constructed near the southern boundary of the original subdivision.
- **1839:** The part of land was occupied by the Australian Gas Light Company (AGL)] in 1839. The gasworks were extended in 1869 to include a retort house and gasholder 100 feet in diameter. The gasworks were located at the Eastern boundary of Barangaroo and extended across Hickson Road (north of the Site). The remainder of Barangaroo was used for shipping and manufacturing activities.
- **1882**: AGL acquired an additional land on the north side of the gasworks (north of the Site) and constructed an additional retort house, demolished the first two gas holders and replaced them with a larger 152 foot

diameter gas holder. A tramway system and hydraulic lift was also constructed to transport coke to a depot in Kent Street.

- **1897**: The waterfront was extended by a further 40 feet into Darling Harbour.
- **1899**: A building that housed a carburetted water gas plant was constructed (north of the Site).
- **1908**: Wharf frontages to the north of the gasworks were dredged to make way for the rat-proof sea wall.
- **1912**: The Sydney Harbour Trust Commissioners (SHTC) resumed part of the site and leased it to AGL until 1921.
- **1918**: Production at the gasworks was terminated (previously located north of the Site).
- **1921**: SHTC gained possession of the gasworks site (previously located north of the Site).
- **Mid 1920s**: The following activities occurred off-site, north of the Site, in the mid 1920s:
  - Portions of the gasworks (gasholder and purifier beds) were demolished. The previous gasholder was backfilled with reportedly impacted material. The Site was used for workshop and storage facilities.
  - Hickson Road was constructed through the former gasworks site. At those locations where no rock foundation was identified, a 4-inch thick foundation of blue metal followed by an 8 inch thick foundation of concrete was present. A 6-inch thick foundation of concrete was placed in those locations where a rock foundation was identified;
  - New jetties and cross-wharf sections of new berths required the complete dismantling of the AGL wharf and excavation into a significant part of the former gasworks;
  - The former gasworks site was covered with workshops, including blacksmiths, plumbers, carpenters and a motor garage at the northern end; and
  - There was a SHT depot located on the western side of Hickson Road.
- **Late 1930s**: MSB painted creosote on the wharf piles (located across Barangaroo Stage 1, including the Site) to protect them against insects. Part of the Site was transferred to MSB after the SHTC was dissolved in 1936;
- **1951**: Five finger wharfs with approximately a dozen east-west oriented narrow warehouse buildings were present on the western edge of Barangaroo Stage 1, including the Site.
- **1952**: MSB constructed a two storey brick workshop on the southern extremity of the Site.
- **1960s**: The wharfs were reconstructed across the Barangaroo Stage 1, including the Site. This included the construction of parallel berths with large cargo-moving areas, demolition and removal of some old wharf structures and formation of new sea walls by sinking caissons filled with concrete.
- **1968**: By 1968 the area behind (east of) the sea wall was in-filled (with unclassified fill) and the area was now a continuous wharf. These works occurred across the Barangaroo Stage 1, including the Site.
- **1970s and 1980s**: The wharves across the Barangaroo Stage 1 site, including the Site, remained utilised for port activities. The 1972 aerial photograph indicated the finger wharfs had been filled in and the Site comprised a sealed area with two large warehouses, on the northern and western boundary. A smaller workshop building in the southeast corner of the Site.
- **1988**: Southern Cove filled between the Site and Block 4. Ownership of Lot 6 in DP 876514 transferred to the Marine Ministerial Holding Corporation (MMHC).
- **1995**: The longshore wharves at the Barangaroo Stage 1 site, including the Site were leased to Patrick Stevedores No 2 until 2006. The Sydney Ports Corporation (SPC) was also established in 1995.
- **1998**: part of the Site was transferred from MSB to SPC.
- **1999:** The SHFA was formed under the Sydney Harbour Foreshore Authority Act 1998 to consolidate the work and functions of City West Development Corporation, Darling Harbour Authority and Sydney Cove Authority. Lots 3 and 5 of DP 876514 were transferred to SHFA in 2007. Wharf 8 Overseas Passenger Terminal constructed within the Site. The 2004 aerial photograph showed that the two large warehouses had been demolished to make way for the Passenger Terminal building.

- **2007**: Declaration of Investigation Area (located to the north of the Other Remediation Works [South] Area) by NSW EPA.
- **2008**: The wharf to the north of the Site vacated and warehouses demolished in preparation for development.
- **2009**: Declaration of Remediation Site (located to the north of the Other Remediation Works [South] Area).
- **2010**: part of the Site remains in use as an Overseas Passenger Terminal for visiting cruise ships.

3.3.1 Filling History

Based on a review of historic aerial photographs and maps of Barangaroo, the history of filling may be summarised as follows.

- **1836 to 1888**: there appeared to be some limited filling around Millers Point towards Darling and Sydney Harbours (north of the Site);
- **1888 to 1897**: filling occurred into Darling Harbour in the area in the vicinity of the Gas Works site and there were several finger wharves constructed at the southern end of Barangaroo (within the footprint of the Site);
- **1897 to 1951**: further filling around Millers Point (to the west and north) and four finger wharfs were constructed in the central portion of Barangaroo (between Millers Point and the gas works site) (north of the Site);
- **1951 to 1968**: the southern-most portion of Barangaroo (the current Overseas Passenger Terminal Area) was filled in to the current eastern extent of the Darling Harbour shoreline (within the Site);
- **1968 to 1986**: the area between the Southern Cove and Millers Point was filled in after the finger wharves were demolished (north of the Site);
- **1986 to 1988**: the Southern Cove was filled in (at the northern edge of the Site); and
- **1988 to present**: no more significant filling occurred.

It should be noted that, notwithstanding the filling history that can be inferred from site history, it is difficult to identify, based on observations from the DGI and previous investigations, distinct differences in fill type relative to the historical filling sequence at the Site. Further, it appears that the majority of the Site, with the possible exception of the north east corner toward the former gasworks, was filled in a single campaign between 1951 and 1968.

3.3.2 Gasworks Features (located Off-Site to the North)

The former AGL (now Jemena) gasworks occupied an area of land immediately to the north of the Site, corresponding with the eastern limit of Blocks 4 and 5, and extending to the area now occupied by Hickson Road. It is noted that no historic gasworks infrastructure has been identified beneath the Site, although historic gasworks infrastructure was present close to the north east corner of the Site (refer to **Figure F2**).

URS (2001) estimated the footprint of the former gasworks to encompass approximately 5,420 m^2 and comprised the following structures:

- Retort House;
- Meter House;
- Gasholders; and
- Purifier Beds

Previous investigations have identified existing gasworks features that extend across Hickson Road, including part of the annulus of the former gasholder, a smaller secondary gasholder and a tar well (Coffey, 2008).

3.4 Previous Investigations

A number of previous investigations have been completed and plans prepared for the Site. It is noted that these investigations also included parts of the Barangaroo Stage 1 Development not included in the Site that is considered by this RAP. The reports considered relevant to this RAP include the following:

- NA&A 1996. Initial Environmental Assessment, Sydney Ports Corporation, Darling Harbour Berths 3-8 Hickson Road, Darling Harbour. June.

- Jeffery and Katauskas (J&K). 2006. Geotechnical Report development of Wharves 3-8 at East Darling Harbour. August.
- ERM. 2007. Environmental Site Assessment, East Darling Harbour, Sydney, NSW, Final Report. 21 June.
- Coffey Environments. 2008. Preliminary Environmental Investigation, 30-38 Hickson Road, Millers Point, NSW 2000. 12 May.
- ERM. 2008a. Additional Investigation Works at Barangaroo, Hickson Road, Millers Point, NSW. July.
- ERM. 2008b. Preliminary Sediment Screening Works at East Darling Harbour, Adjacent to Barangaroo, NSW, Draft, Rev 03. August.
- ERM. 2008c. Draft Stage 2 Remedial Action Plan for Barangaroo, Hickson Road, Sydney. September.
- ARUP. 2008. Barangaroo Development, East Darling Harbour Geotechnical Desk Top Study. 28 October.
- AECOM Australia Pty Ltd, 2010. Data Gap Investigation (DGI), Other Remediation Works (South) Area, Barangaroo. May.

These reports are summarised in **Sections 3.4.1** to **3.4.10** below.

Sample locations from the previous investigations are presented in **Figure F5**.

In addition to the above investigations, the following additional documentation was reviewed and considered during the preparation of this RAP:

- LL supplied CD, 2010. BDA Supplied Historical Work As Executed Drawings for the Former Wharf Structures at Berths 3 to 8, Barangaroo. CD dated 21 January.
- LL supplied CD, 2010. Geotechnical Information - Barangaroo Area (including CBD Metro Geotechnical and Environmental Investigations, completed by Coffey). CD dated 21 January.
- LL Scheme CAD files provided to AECOM in December 2009.

3.4.1 NA&A (1996)

Noel Arnold and Associates (NA&A) were commissioned by the Sydney Ports Corporation to undertake an Initial Environmental Assessment at Berths 3-8 Hickson Road, Darling Harbour, NSW.

The report details results of an initial contamination assessment and provides options for remedial management of the area investigated. Known and potential contamination was not determined to be a risk to the ongoing use by the then occupant providing subsurface materials were not disturbed. Impact was identified in the area of the former AGL Gasworks located to the north of the Site.

3.4.2 Coffey (1998)

Coffey was engaged by Sydney Ports Corporation to undertake an Environmental Soil Quality Assessment of Wharf 8, Darling Harbour.

The investigation was a limited site assessment including soil sampling at Wharf 8 to identify contamination and provide options for disposal of excavated soil associated with proposed development. The ESA reported limited PAH contamination and identified material required for off-site disposal that would likely require industrial or hazardous waste classification.

3.4.3 URS (2001)

URS was commissioned by SHFA to conduct a Contamination Review for Darling Harbour – Berths 3/8, which comprised a review of the contamination issues collated from 11 reports produced between 1993 to 2001. The review identified soil and groundwater contamination associated with the former gasworks, including off-site migration, and soil contamination associated with current vehicle maintenance operations.

3.4.4 J&K (2006)

Jeffery and Katauskas Pty Ltd (J&K) undertook a Geotechnical Investigation for the East Darling Harbour property (Barangaroo). The investigation was undertaken concurrently with the ERM (2007) Environmental Site Assessment (ESA) which is summarised in Section **3.4.5** below.

Key geotechnical findings from the J&K investigation were:

- Fill was sandy and increased in clay content with depth and refusal occurred within fill at several locations across the Site;
- The fill contained large pieces of rubble and was poorly compacted;
- The alluvial sediments consisted predominantly of sandy clays which extended to sandstone bedrock; and
- Sandstone bedrock was generally shallower at the eastern portions of the Site and deepest over the western portion towards Darling Harbour.

3.4.5 ERM (2007)

ERM was commissioned by SHFA to undertake an ESA which consisted of a Stage 1 Preliminary Site Investigation (PSI) and Stage 2 Detailed Site Investigation (DSI) for the East Darling Harbour property (Barangaroo). The investigation was undertaken concurrently with the J&K (2006) investigation (summarised in **Section 3.4.4** above). The following provides information related to the Site.

The PSI component of the investigation reported that the Site was historically used for port/wharf activities and workshops. The AGL gasworks site was also located to the north of the Site (off-site) and reclamation activities had historically occurred at the Site for the construction of the wharfs.

Based on the historical information ERM concurred with URS (2001) investigation that the contaminants of potential concern (COPC) for the Site were TPH, BTEX, Heavy Metals, PAHs, PCBs, Cyanide, Sulfates, OCPs and OPPS.

The ESA made the following conclusions:

- Impacts to soil and groundwater were identified predominantly within the area of the former gasworks infrastructure and the reclaimed northwest portion of the Site, with the primary contaminants of concern confirmed as lead, TPH/BTEX and PAH;
- No Non aqueous phase liquids (NAPLs) were observed during the investigation, however concentrations of organic contaminants such as TPH indicated that NAPL was likely present in the vicinity of the former gasworks area located immediately north of the Site;
- The groundwater regime within the site was likely strongly influenced by tidal fluctuation; and
- There appeared to be potential for both migration of contamination onto the site from the east and migration of contamination from the site into adjacent properties and into Darling Harbour.

The ESA included the following key recommendations:

- The extent of the risks to human health and the environment should be assessed through further investigations and a site specific quantitative risk assessment; and
- Additional delineation investigations and assessment of vapour flux from impacted areas and further assessment of hydrogeological conditions should be undertaken before developing a RAP.

A summary of soil and groundwater results from the ESA is included in **Table 2** in **Section 3.4.7** along with the additional soil data from the 2008 ERM additional investigation.

3.4.6 Coffey (2008)

Coffey Environments Pty Ltd (Coffey) was commissioned by the Council of the City of Sydney to undertake a Preliminary Environmental Investigation (PEI) at the segment of Hickson Road (between numbers 30 to 38), Millers Point, NSW, which is located immediately northeast of the Site.

Soil samples were analysed for Heavy Metals, TPH, BTEX, PAH, phenols, chlorinated hydrocarbons and asbestos. Groundwater samples were analysed for Heavy Metals, TPH, BTEX, PAH, phenols, chlorinated hydrocarbons and ammonia.

The general ground conditions encountered during the intrusive investigation comprised asphalt overlaying concrete and fill ranging in depth between 3.1 and 9.4 m bgs. The fill generally consisted of gravelly sand and sandy gravels with minimal anthropogenic inclusions. The fill was generally underlain by sandstone, with the exception of residual clayey sand and sand soils at two locations (BH3 and BH2).

Tar was encountered in two boreholes which were located in the southern portion of the investigation area.

Concentrations of heavy metals, phenols and chlorinated hydrocarbons were either less than the laboratory limit of reporting (LOR) or the adopted assessment criteria in all samples analysed. Asbestos fibres were not detected in any sample analysed.

3.4.7 ERM (2008a)

ERM was commissioned by SHFA to undertake additional soil and groundwater investigation works at Barangaroo. The objectives of the works were to fill in data gaps in soil and groundwater data to enable a RAP to be developed for the Site.

A summary of the results from within the Site are provided in **Table 2** below, which also includes the ERM (2007) ESA results.

Table 2: Summary of soil analytical results from ERM 2007 and 2008 investigations and ERM (2007) groundwater results

Analyte	No. Soil Results	Soil Results	Groundwater Results
Heavy Metals	73	Concentrations of metals in samples were all less than NSW (DEC) SIL_4 Criteria (refer to **Section 6.2.1**) with the following concentration ranges: Lead (<5 -1320mg/kg) Arsenic (<5 – 16 mg/kg) Cadmium (<1– 2 mg/kg) Total Chromium (<2 – 81 mg/kg) Copper (<5 – 228 mg/kg) Mercury (<0.1 – 5.9 mg/kg) Nickel (<2 – 22 mg/kg) Zinc (<5 - 1890 mg/kg)	Arsenic – all results <LOR Cadmium – all results less than LOR with exception of MW09 (1.3 ug/L) Chromium - all results less than LOR with exception of MW20 (2 ug/L) Copper – all results less than LOR with exception of MW17 (2 ug/L) Mercury – all results less than LOR Nickel – results ranged between <10 to 24 ug/L Zinc – Concentrations ranged between 0.015 (MW10) and 0.128 (MW09)
TPH C_6-C_9	53	All concentrations were <LOR with exception of 3 results BH117_10-10.5 (10mg/kg) BH117_15-15.5 (244 mg/kg) BH110_23.3-23.8 (46 mg/kg)	All concentrations < LOR with exception of: MW21 – 60 ug/L
TPH C_{10}-C_{36}	53	All concentrations were <LOR with exception of 13 results which ranged between 150 mg/kg to 5580 mg/kg. Results greater than EPA (1994) Criteria were from BH100_3-3.45 (1005 mg/kg), BH117_15-15.5 (5580 mg/kg) and BH195_10.5 (2215 mg/kg).	All concentrations < LOR with exception of: MW09 – 985 ug/L MW20 – 2870 ug/L MW21 – 385 ug/L

Analyte	No. Soil Results	Soil Results	Groundwater Results
BTEX	53	Benzene: All <LOR with exception of 2 results BH110_23.3-23.8 (7.8 mg/kg) and BH117_15-15.5 (19.4 mg/kg) which exceed the NSW EPA (1994) Criteria. Ethylbenzene, Toluene and Total Xylene were detected in 3 samples at concentrations less than the NSW (EPA) 1994 Criteria.	All concentrations < LOR with exception of: MW21 – Benzene (3 ug/L), Toluene (8 ug/L), Ethylbenzene (2 ug/L) and Total Xylene (21 ug/L)
PAHs	38	Concentrations of Total PAHs ranged between 4.35 mg/kg and 826.3 mg/kg. One sample exceeded the NSW (DEC) SIL_4 Criteria (BH117_15-15.5 – 826.3 mg/kg). Benzo(a)pyrene ranged between <0.5 and11.4 mg/kg. Three samples exceeded the NSW (DEC) SIL_4 Criteria (BH100 3.0_3.45, BH117_15-15.5 and BH195_10.5).	All concentrations < LOR with exception of: MW21- Total PAH (25.1 ug/L) and B(a)P (0.7 ug/L) MW18 - Total PAH (8.65 ug/L) and Naphthalene (0.7 ug/L)
Phenols	18	Concentrations of Phenols were < LOR in all samples.	-
PCBs	8	Concentrations of PCBs were < LOR in all samples.	All results less than LOR
OCPs/OPPs	1	Concentrations were all < LOR.	All results less than LOR in MW20

The ERM Additional Investigation made the following recommendations:

- A quantitative human health and ecological risk assessment (HHERA) should be undertaken once further details of future redevelopment are known;
- Results of the investigation should be assessed with reference to previous investigations undertaken for Barangaroo;
- Routine groundwater monitoring should be considered to assess temporal variations in CoPC;
- Considering asbestos was identified in only one sample, it was unlikely that asbestos contamination was wide spread, however it was recommended that further work is required to determine the extent and nature of asbestos in fill; and
- A RAP should be developed and following completion of a RAP, a Remedial Work Plan (RWP) should be developed.

3.4.8 ERM (2008b)

ERM was commissioned by SHFA to undertake Preliminary Sediment Screening Works at East Darling Harbour, adjacent to Barangaroo. The preliminary sediment screening works were conducted in East Darling Harbour to identify potential offsite migration of contamination from the Site to sediments in Darling Harbour.

Sediment cores were collected from the Harbour adjacent to Barangaroo along 7 transects, two of which were adjacent to the Site (Transects 1 and 2). Screening identified PAH, tributyl tin (TBT) and metals exceeding ANZECC/ARMCANZ (2000) interim sediment quality guidelines (low). Elevated concentrations of TPH C_{10}-C_{36} were also reported. The report concluded that remediation of sediments in Darling Harbour would not be required.

3.4.9 ERM (2008c)

ERM was commissioned by SHFA to complete a conceptual RAP for Barangaroo. The conceptual RAP envisaged the following scope of works for the site remediation and management of various areas of the Site.

- Completion of a Quantitative HERA to develop Risk Based Cleanup Levels (RBCLs) for each area of the site;
- Preparation of a Remedial Works Plan (RWP), Remediation EMP, OH&S Plan, Community Consultation Plan, a Long Term EMP;
- Planning and approvals;
- Site establishment for remediation; and
- Demolition of and appropriate disposal of remaining structures.

The Site was divided into four areas (Area 1 to Area 4) for the purposes of the RAP. The Site (Blocks 1 to 3) is located within Area 2. The following remedial works were envisaged within Area 2:

- Excavation to permit construction of basements;
- Abstraction and treatment of contaminated groundwater collected within excavations;
- On-site treatment/stabilisation of excavated materials followed by reinstatement in an appropriately engineered placement area;
- Classification and off-site disposal of surplus fill materials;
- Offsite treatment for materials assessed as too heavily impacted to be treated on-site;
- Sampling and validation of excavated surfaces, backfilled materials and sampling of groundwater;
- Preparation of a Site Audit report; and
- Ongoing groundwater monitoring following completion of remedial works.

3.4.10 AECOM (2010)

The following scope of work was undertaken to achieve the DGI (AECOM 2010) objectives:

- A total of 35 boreholes were advanced across the Site at the locations shown on **Figure F5**. Soil samples were collected from each borehole location;
- An additional four boreholes were advanced across the Site for the installation of four soil vapour wells at the locations shown on **Figure F5**.
- Seven of the boreholes were converted to groundwater monitoring wells at the locations shown on **Figure F5**; and
- Preparation of a DGI report, discussing the methodologies, the investigation results and conclusions regarding the requirements for management and/or remediation of the Site during the re-development works.

The results of the DGI are briefly summarised below:

- Fill was encountered at the site overlying natural sands, gravelly sands, clays and weathered sandstone bedrock. The fill was generally shallower (up to 3 m bgs) in the eastern portion of the Site (near Hickson Road) and trended deeper (up to 19.2 m bgs) towards Darling Harbour;
- Soil impacts appeared to be associated with the historical presence of the former gasworks located immediately north of the Site and the fill materials used for land reclamation activities;
- Soil vapour results indicated some gasworks-derived impacts in locations closest to the former gasworks area, and low concentrations of CoPC (below soil vapour and ambient air guidelines) in some locations;
- Groundwater was present beneath the Site within fill materials at approximately 2.0 m bgs and was subject to tidal fluctuation. Tidal influence extended as far east (inland) as Hickson Road; and
- Groundwater impacts associated with the former gasworks infrastructure were limited to the north-eastern corner of the Site. Groundwater contamination associated with the remaining gasworks infrastructure located to the north of the Site did not appear to be migrating into the Harbour.

The DGI made the following conclusions with respect to the risks associated with contamination identified by the DGI and previous historical investigations.

- ***Future Land Use for Residential/Commercial Purposes within the Development Area (South)***: Whilst the current asphalt and concrete ground surface was considered adequate to limit exposure by Site users to underlying contamination, future earthworks/remediation/development at the Site may complete the exposure pathway.
- ***Future Land Use for Passive Recreation at the Public Domain (South):*** The area designated as Public Domain (South) is currently covered with concrete and/or asphalt with no complete exposure pathway to underlying soil or groundwater. Given the limited extent of contamination identified within the Public Domain, AECOM considered this area of the Site presents a low risk to human health in its current condition.
- ***Environment:*** The DGI identified potential risks to the down gradient environmental receptor (Darling Harbour). Based on the proposed development plan (i.e. excavation of basements), up gradient contaminant sources will be removed and therefore reduce the potential risk in the future.

The DGI provided the following recommendations:

- A RAP should be prepared to address hotspot remediation and management of potentially impacted materials that may be encountered during the excavation of the Site for future development;
- Additional assessment of the materials should be undertaken in accordance with the RAP in the event that materials encountered during the excavation and remediation works are different to those found during the DGI and/or previous investigations; and
- An Acid Sulfate Soil Management Plan may be required for the management of PASS during future excavation works in natural materials.

4.0 Site Condition and Surrounding Environment

4.1 Current Land Use

The Site covers an irregularly shaped area of approximately 4.27 ha (based on existing LL supplied Site plans). The location of the Site is presented on **Figure F1** and the Site layout is illustrated in **Figure F2**.

The Site currently consists of:

- the Wharf 8 Overseas Passenger Terminal (OPT), car parking and landscaped areas;
- brick office building and electrical substation located in the southeast;
- Sydney Ports Authority (SPA) workshop in the northeast; and
- Hard standing across the remainder of the Site.

The OPT consists of a main building in the central portion of the Site (containing a warehouse, offices and main passenger terminal area) and a cruise ship loading dock on Darling Harbour. The OPT is also used to host events such as conventions, exhibitions and public entertainment when the facility is not in use as a cruise ship passenger terminal.

There is a disused brick office building and electrical substation located in the southeast corner of the Site and a security Gate House on the eastern boundary entry (Hickson Road) of the Site.

The north east corner of the Site includes the southern half of the former SPA workshop building and carpark. The SPA workshop building is currently being used by the Barangaroo Delivery Authority (BDA) as a public display for the proposed Barangaroo development.

The entire Site is covered by hardstand including concrete and bitumen, with the exception of strips of landscaped gardens along the eastern and southern Site boundaries and along the main driveway through the Wharf 8 Terminal.

4.2 Surrounding Land Use

The Site is surrounded by the following land use:

- North: Barangaroo Stage 1 Development Blocks 4 and 5 and the Southern Cove (open space/concrete hardstand);
- South: Shelley Street followed by high-rise office buildings and King Street Wharf;
- East :Hickson Road followed by commercial and high density residential buildings; and
- West: Darling Harbour.

4.3 Topography and Drainage

The topography of the Site is relatively flat having been the subject of significant cut and fill reclamation works for its previous use as a stevedoring facility. The closest surface water body to the Site is Darling Harbour, located immediately west and north of the Site. The entire Site is covered in hardstand (concrete and bitumen), with the exception of several narrow garden beds along the southern and eastern boundary and along the main driveway through the Site.

The majority of stormwater runoff from the site is captured by a network of sub-surface stormwater drains which spread across the Site and drain into Darling Harbour (refer to **Figure F2**).

4.4 Geology

Reference to the *1:100, 000 Geological Survey of NSW (Sydney) Sheet 9130 (Ed 1), 1983* indicates that the stratigraphy of the Site comprises man-made fill material, marine clays and Hawkesbury Sandstone.

As described by **Section 3.3**, historical information indicates that the former 1880s shoreline ran approximately along the western edge of Hickson Road (i.e. along the eastern edge of the proposed Stage 1 Development). The area to the west of Hickson Road is understood to have been progressively reclaimed. Aerial photographs

from the 1950s indicate that the area between Hickson Road and the current shoreline was occupied by a number of finger wharves, extending from Hickson Road. It is understood that the space between the historical finger wharfs and seawalls were infilled in several stages between the 1960's and 1980's with various types of material. The former Southern Cove is understood to have been filled in 1988.

ERM (2007) identified and summarised the following subsurface conditions across the broader Barangaroo site:

- Hardstand (0 to 0.46 m bgs): consisting of concrete, asphalt and bitumen, generally in good condition with minimal staining;
- Road Base Fill (0 to 0.5 m bgs);
- Fill (0 to 18 m bgs): Fill materials consisting of sandstone, building rubble, bricks and concrete, silty gravelly sand. Black staining and odours (particularly around the former gasworks);
- Marine Clay/Sand (3.0 to18.4 m bgs): Interbedded Clayey Sand and Sandy Clay, dark greyish brown, saturated, some shell fragments and organic matter, Sandy Clay (soft, high plasticity), Clayey Sand and Sand (lose to dense, low plasticity, fine to coarse sand, low to non plasticity);
- Marine Clay/Sand (4.9 to 32.75 m bgs): Interbedded Clayey Sand, Sandy Clay and Sand, pale yellowish brown, white, reddish brown or dark greyish brown. Sandy Clay-stiff to hard, medium to high plasticity. Clayey Sand and Sand – loose to dense, fine to coarse sand, low or no plasticity; and
- Bedrock (1.3 to 32.75 m bgs): Weathered Sandstone, white, light yellowish, brown, olive brown and reddish brown, white, wet, fine to coarse grained, some fracturing noted.

It is noted that the above summary does not relate specifically to the Site but also incorporates the wider Barangaroo precinct to the north of the Site.

The DGI (AECOM 2010) summarised the fill materials, natural soils and bedrock beneath the Site to comprised the following:

- The fill materials were observed to be highly heterogeneous with ash, timber, steel and other extraneous materials present. Some slightly gaseous, tarry, hydrocarbon and organic odours were noted with occasional black staining;
- Natural soils comprised silty sands, gravelly sands, clays, weathered sandstone and sand with components of clay. Gradual boundaries noted between the strength and extent of weathering reflects changes in the energy regime during deposition; and
- The bedrock encountered was sandstone in every instance except for AECOM borehole BH13 where shale was encountered at 12.7 m bgs. The depth to bedrock encountered during the investigation was variable across the Site, with sandstone depths ranging from 3.0 m bgs (BH11) to 19.2 m bgs (BH28). Bedrock was generally shallower in the eastern portion of the Site closest to Hickson Road and deeper in the western portion of the Site. The thickness of fill material generally increased from east to west across the Site (refer to the cross sections in the DGI for further detail).

4.5 Hydrogeology

A search of the NSW Department of Natural Resources (DNR) groundwater bore data base was reported in ERM (2007) and indicated that there were 32 registered groundwater bores within a 4 km radius of the Site. Groundwater bore information indicated that the bores were registered for either recreation, irrigation or monitoring purposes.

The DGI (AECOM 2010) reported the following findings:

- Groundwater was encountered within both the fill and natural soil and sediments at the Site. Groundwater levels were relatively shallow (between 1.6 to 2.6 m bgs) which was expected given the Site's location adjacent Darling Harbour.
- The groundwater level gauging produced variable results, with no distinct flow direction ascertained. The variable results are considered a result of tidal fluctuations and the presence of subsurface structures (including the caisson wall along the Site boundary) which are likely to affect groundwater flow directions.
- The cation/anion chemistry of groundwater at the Site is dominated by chloride and sodium, with the proportion of sodium and chloride ions tending towards seawater composition. The presence of sodium and chloride dominated groundwater is expected due to the Site's location adjacent to Darling Harbour and the saline groundwater encountered at the Site.

- Biodegradation of hydrocarbons (natural attenuation) most commonly occurs by means of aerobic, nitrate-reducing, Fe (III)-reducing, sulphate-reducing, and methanogenic respiration. The geochemistry results for MW08 indicate that natural attenuation processes are actively occurring. MW08 was also the only well to report TPH concentrations above the laboratory Limit of Reporting (LOR).

  The results of MW08 reported increased alkalinity and TOC concentrations and significantly reduced sulphate and calcium concentrations when compared to the other reported groundwater results. Increased alkalinity often occurs in areas if microbial activity. Increases in alkalinity result from the dissolution of clays by the production of carbon dioxide from the metabolism of microorganisms. Alkalinity is important in the maintenance of pH as it buffers the groundwater system against acids generated during aerobic and anaerobic biodegradation.

  Reduced concentrations of sulphate in MW08, when compared to the all other groundwater samples collected at the Site, indicate that sulphate reduction is likely to be occurring.

- Standing water levels within MW19 and MW26 were monitored over a three day period to assess the extent and amplitude of tidal influence across the Site. The data collected from the two wells reported water level fluctuations of 0.727 m in MW19 and 0.809 m in MW26. The data shows the Site is tidally influenced, with the influence extending inland beyond MW19.
- Water level data collected from MW61, located in Hickson Road (north of Blocks 1 to 3), reported a maximum water fluctuation of 0.07 m, indicating that tidal influence extends as far as Hickson Road, although at a much reduced amplitude. This is supported by the presence of highly saline water within wells located in Hickson Road and along the eastern boundary of the Site.

4.6 Potentially Sensitive Receptors

The nearest receptor for groundwater and surface water coming from the Site is Darling Harbour, which form part of the larger Sydney Harbour and are classified in ANZECC (2000) as a ‘highly disturbed system’.

The Site is situated in a mixed commercial and residential area. No other environmentally sensitive receptors have been identified.

Potential human exposure to CoPC in impacted soil/fill materials and/or groundwater may occur via the following potential exposure pathways:

- Direct dermal contact with impacted materials;
- Incidental ingestion of impacted materials;
- Inhalation of volatile potential contaminants of concern; and
- Inhalation of potential contaminants of concern sorbed to air-borne particulates.

The following potential human receptors have been identified:

- Workers engaged in future remediation / redevelopment of the Site;
- Workers on the Site entering confined spaces or exposed to subsurface materials during maintenance work;
- The general public;
- Child care facilities, commercial tenants and passenger terminal users;
- Future residents inhabiting the Site;
- Off-site workers conducting construction, road or other sub-surface works in the vicinity of the Site; and
- Residents in neighbouring properties.

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5.0 Remediation Goals

5.1 Soil Remediation Goals

Soil remediation goals will ultimately be defined by the following:

- Reference to generic soil assessment guidelines, where appropriate; and
- A Human Health and Ecological Risk Assessment (HHERA) to define soil concentrations that are able to remain in-situ without remediation/management and the treatment standard for soil to be beneficially reused elsewhere in the development.

In specific circumstances, consideration will also be given to the principles of Clean Up To the Extent Practicable (CUTEP). For example, CUTEP may be considered as a contingency measure where the depth or location of material relative to other structures makes active remediation impractical.

5.1.1 Generic Soil Assessment Guidelines

The current generic assessment guidelines used in NSW to evaluate soil analytical results are based on the following:

- NSW EPA, 1997. Contaminated Sites: Guidelines for Consultants Reporting on Contaminated Sites;
- DEC, 2006a. Guidelines for the NSW Site Auditor Scheme (2nd edition);
- The CLM Act, 2008; and
- NEPC, National Environment Protection (Assessment of Site Contamination) Measure, 1999a.

The current investigation criteria used in NSW to evaluate soil analytical results for metals, cyanide, PAHs, OCPs, OPPs, phenol and PCBs are provided in NSW DEC (2006) guidelines which are based on guidance provided in NEPC (1999). These guidelines present a range of Health-Based Soil Investigation Levels (SILs) and Provisional Phytotoxicity-based Investigation Levels (PILs) for soils, which are considered to be appropriate for a range of land uses on urban sites in NSW, as follows:

- SIL_1 Residential with gardens and accessible soil;
- SIL_2 Residential with minimal access to soil (including high-rise apartments/flats);
- SIL_3 Parks, recreational open space, playing fields (including secondary schools); and
- SIL_4 Commercial or industrial.

It is noted that the PILs assume application to sandy loams with a pH 6 to 8 and the soils on the Site are generally characterised as fill clays and clayey sands to sandy clays. The application of the PILs has significant limitations as phytotoxicity depends on soil and species parameters in ways that are not fully understood. It is also understood that the Public Domain area will be generally constructed over the existing slab and within the footprint of the existing caisson walls and, consequently, vegetation exposure to the underlying soil in proposed landscaped areas is extremely unlikely. Therefore PILs will not be considered further.

Adoption of the above general soil assessment criteria is generally considered inappropriate for remediation works as this may result in unnecessarily increased remediation effort and cost. That is the generic criteria are investigation criteria and may be lower than is actually required to adequately remediate the Site to be protective of human health and the environment. Establishing appropriate, site-specific clean up criteria allows sustainable, targeted allocation of resources to a remediation solution.

5.1.2 Soil Remediation Goal Implementation

The approach considered appropriate for soil remediation goals for the Site is to adopt a combination of:

- Generic soil assessment guidelines (as appropriate); and
- Site-specific Target Criteria (SSTC) based on a site-specific HHERA as discussed in **Section 5.3**. The SSTC will supersede the generic soil assessment criteria detailed in **Table 3**.

In the first instance, identified soil impacts have been assessed against the relevant generic soil assessment guidelines dependent on the proposed land use at the Site. It is anticipated that this screening method is likely to identify where potential impacted material (PIM) is present at the Site. Confirmation of whether or not the PIM

identified by this screening assessment represents a risk to human health or the environment (i.e. is Confirmed Impacted Material [CIM]), the resultant extent of remediation works and the suitability (or otherwise) of excavated materials for beneficial reuse, will ultimately be determined by the SSTCs derived from the human health and ecological risk assessment (HHERA, refer to **Section 5.3** for further detail).

The generic soil assessment guidelines adopted for this screening assessment are dependent on the location of the material being screened. In particular:

- Within the Development Area (South):
  - Materials that are below the depth of the proposed basement excavations will be assessed against the most conservative of the residential and commercial criteria;
  - Materials that will be excavated as part of the proposed basement excavations will be assessed against the recreational, open space criteria (noting that they will be beneficially reused within Headland Park or the Public Domain); and
- Within the Public Domain (South) – all materials will be assessed against the recreational, open space criteria. While some parts of the Public Domain will include some mixed commercial and retail landuse, the more stringent recreational, open space criteria have been adopted for this area to add a level of conservatism to the screening process.

Contaminant concentrations that are considered representative of PIM will be further assessed against the SSTC's developed as an outcome of the HHERA to confirm the requirement, or otherwise, for remediation.

This approach to screening the analytical data is in accordance with the National Environment Protection (Assessment of Site Contamination) Measure (NEPC, 1999a). The assessment of PIM is provided in **Section 7.2**.

Table 3: Generic Soil Assessment Criteria

Analyte	Units	Adopted residential criteria[1]	Adopted open space criteria[2]	Adopted commercial criteria[3]
Arsenic (total)	mg/kg	400	200	500
Beryllium	mg/kg	80	40	100
Cadmium	mg/kg	80	40	100
Chromium (III)	%	48	24	60
Chromium (VI)	mg/kg	400	200	500
Cobalt	mg/kg	400	200	500
Copper	mg/kg	4000	2000	5000
Lead	mg/kg	1200	600	1500
Manganese	mg/kg	6000	3000	7500
Mercury (inorganic)	mg/kg	60	30	75
Nickel	mg/kg	2400	600	3000
Zinc	mg/kg	28000	14000	35000
Polycyclic aromatic hydrocarbons (PAHs)	mg/kg	80	40	100
Benzo(a)pyrene	mg/kg	4	2	5
Phenol	mg/kg	34000	17000	42500
>C35 Aliphatics	mg/kg	224000	112000	280000
Boron	mg/kg	12000	6000	15000
Cyanides (Complexed)	mg/kg	2000	1000	2500

Analyte	Units	Adopted residential criteria[1]	Adopted open space criteria[2]	Adopted commercial criteria[3]
Cyanides (free)	mg/kg	1000	500	1250
TPH (C6-C9)	mg/kg	65[4]	65[4]	65[4]
TPH (C10-C36)	mg/kg	1000[4]	1000[4]	1000[4]
Benzene	mg/kg	1[4]	1[4]	1[4]
Toluene	mg/kg	130[4]	130[4]	130[4]
Ethyl benzene	mg/kg	50[4]	50[4]	50[4]
Total Xylenes	mg/kg	25[4]	25[4]	25[4]

NOTES: [1] Based on SIL2

[2] Based on SIL3

[3] Based on SIL4

[4] Based on NSW EPA (1994)

5.2 Groundwater Remediation Goals

Groundwater remediation goals will ultimately be defined by:

- Reference to generic groundwater assessment guidelines, where appropriate;
- On-site water quality targets that will not represent a risk to site users/maintenance workers etc. as defined by a HHERA; and
- Off-site (at site boundary) water quality that will not represent an unacceptable risk to the environment in Darling Harbour as defined by a HHERA.

The proposed remediation approach will be to undertake removal of the primary sources of groundwater contamination such that the groundwater quality improves and is not considered a significant risk of harm. The effectiveness of the remediation will be assessed by evaluation of groundwater quality against groundwater remediation goals defined by a HHERA.

As for soil remediation goals, consideration will also be given to the principles of CUTEP in specific circumstances. For example, CUTEP may be considered as a contingency measure where the removal/treatment of CIM (which represents a source of groundwater contamination) is not practical.

5.2.1 Generic Groundwater Assessment Guidelines

The ANZECC/ARMCANZ, Australian and New Zealand Guidelines for Fresh and Marine Water Quality, 2000 (ANZECC 2000) have been used for assessing groundwater quality at the Site. ANZECC (2000) provides "Trigger Values" for chemicals within water, which represent the best current estimates of the concentrations of chemicals that should have no significant adverse effects on the aquatic ecosystem. The ANZECC (2000) guidelines indicate that an exceedence of a Trigger Value does not necessarily imply that there is an inherent risk, but that further assessment and monitoring may be required prior to implementing appropriate management actions. It is noted that according to ANZECC (2000), low reliability Trigger Values are Interim Levels only because "*low reliability guideline trigger values were derived, in the absence of a data set of sufficient quantity, using larger assessment factors to account for greater uncertainty*", and "*low reliability values should not be used as default guidelines*". ANZECC (2000) stipulates that the identification of the receiving environment or the likely beneficial use of the water is essential for selection of the most applicable criteria.

Darling Harbour, located on the western boundary of the Site, can be further considered under the ANZECC (2000) guidelines as a "*highly disturbed system*" and, as such, for the majority of the COPC the Trigger Values for protection of 95% of marine water species have been adopted and 99% protection for the bio-accumulative CoPC. There are currently insufficient data to derive high reliability Trigger Values for various CoPC. Given the limitations associated with the use of low reliability Trigger Values, these criteria have not been adopted for this RAP.

There are no current NSW DECCW endorsed high reliability assessment criteria for TPH in groundwater, although an arbitrary aesthetic criterion of 10 000 µg/L (10 mg/L) is provided in NSW EPA (1994). The ANZECC (2000) guidelines provide an interim low reliability value for crude oil of 7 µg/L (0.007 mg/L), which is known to contain hundreds of hydrocarbon species, many of which are not present in refined petroleum hydrocarbon fuels. In addition, this criterion is not considered to be appropriate as current commercial laboratory techniques cannot quantify TPH to this concentration and it has been derived on a worst case pollution scenario such as a constant discharge to the environment at a rate that exceeds the losses from evaporation or dispersion (Tsvetnenko, 1998). In the absence of high reliability TPH trigger value, AECOM has adopted the laboratory limits of reporting (LOR) as the 'default' screening criteria for TPH.

Table 4: Generic Groundwater Assessment Criteria

Analyte	Units	ANZECC (2000) Marine Ecosystems (95 %) Trigger Values
Metals		
Mercury (Filtered)	mg/L	0.0001*
Cadmium (Filtered)	µg/L	5.5
Chromium (III+VI) (Filtered)	µg/L	4.4
Copper (Filtered)	µg/L	1.3
Lead (Filtered)	µg/L	4.4
Nickel (Filtered)	µg/L	70
Zinc (Filtered)	mg/L	0.015
Organics		
Naphthalene	µg/L	70
Pentachlorophenol	µg/L	22
Phenol	µg/L	400
Other		
Cyanide Total	mg/L	0.004
Benzene		
Benzene	µg/L	700
* ANZECC (2000) Marine Water (99%) trigger value		

5.2.2 Groundwater Remediation Goal Implementation

The approach considered appropriate for groundwater remediation goals for the Site is to adopt, as appropriate, a combination of:

- Generic Groundwater Assessment Guidelines; and
- Site Specific Target Criteria (SSTC) based on a site-specific HHERA as discussed in **Section 6.3**. The SSTC will supersede the Generic Groundwater Assessment Criteria detailed in **Table 4**.

In the first instance, and as a screening tool for assessment of the significance of the identified groundwater contamination, the available analytical data has been assessed against the ANZECC trigger values.

Contaminant concentrations will be further assessed against the SSTC's developed as an outcome of the HHERA to confirm achievement of the remediation goals.

5.3 Human Health and Ecological Risk Assessment

A HHERA will be completed that will develop SSTC for the identification and remediation of CIM, in the context of the proposed development. That is, the SSTC will define:

- Soil concentrations that will not represent an unacceptable risk to human health or the environment if:
  - left in-situ at the Site ('in-situ SSTC'); or
  - incorporated elsewhere into the development (for example within the proposed Headland Park or Public Domain ('re-use SSTC'); and
- Groundwater concentrations that will not represent an unacceptable risk to human health or the environment (i.e. Darling Harbour).

5.3.1 HHERA Methodology

The HHERA will be completed as an outcome of the DGI being undertaken in relation to Block 4 (and the adjacent Public Domain), Block 5 and the Southern Cove (which is also known as the Other Remediation Works (North) Area and the DECCW Declaration Area). It is anticipated that the contamination issues identified in relation to Blocks 1 to 3 will be addressed as a subset of the contamination issues associated with the Other Remediation Works (North) Area.

The HHERA will determine different SSTC for different areas/land uses at the Site, and the proposed Headland Park and Public Domain.

As described by **Section 3.2**, it is anticipated that construction of proposed basements will necessitate removal of a large volume of fill material, soil and some bedrock. Therefore, the HHERA will be primarily applicable to defining material that is able to remain in place at the Site where residual impacts may remain outside of excavated basements (i.e. below the basements and within the Public Domain).

Importantly, the HHERA will also be applicable to defining the standard that must be achieved for excavated soils that are to be beneficially reused within the development. As such, the HHERA will define the inputs for assessing:

- the quality of material that is proposed to be re-used on other areas of Barangaroo based on the various exposure scenarios detailed in the HHERA. It is understood that specific re-use criteria for Headland Park will be as specified in a separate Headland Park RAP; and
- whether any treatment is required to achieve that standard.

The methodology adopted during the preparation of the HHERA is provided as **Appendix A**.

5.3.2 HHERA Implementation

Implementation of the HHERA, in the form of a Remediation Decision Making Process Flow Chart, is described on **Figure F10**. The flow chart details the various stages of assessment required for determining the fate and remediation requirements (if any) of PIM. The outcome of the remediation decision making flow will be documented in the RWP.

- **Scenario 1** – assessment of PIM against the 'in-situ SSTC' established by the HHERA confirms the material to be CIM:
  - if CIM will be excavated as part of the basement excavations:
    - assessment against the 're-use SSTC' established by the HHERA to determine whether it is suitable for beneficial reuse (with or without treatment)?
    - Validation to demonstrate the materials suitability for beneficial reuse (with or without treatment).
  - if CIM is located below or outside the proposed basement excavations:
    - if over excavation is practicable, manage the material as if it would have been excavated as part of the basement excavations;
    - if over excavation is not practicable, consider: refinement of the contaminant specific HHERA to confirm whether the CIM represents an acceptable risk to the environment and can therefore be left in-situ with ongoing groundwater monitoring; or, in-situ remediation technologies?

- **Scenario 2** – assessment of PIM against the 'in-situ SSTC' established by the HHERA confirms that the material is **not** CIM (i.e. is unimpacted material):
  - if material will be excavated as part of the basement excavations:
    - assessment against the 're-use SSTC' established by the HHERA to determine whether it is suitable for beneficial reuse (with or without treatment)?;
    - Validation to demonstrate the materials suitability for beneficial reuse (with or without treatment).
  - If material is located below or outside the proposed basement excavations no further action is required.

5.3.3 HHERA Suitability

A series of detailed HHERAs have been prepared for the Project Delivery Agreement (PDA) and Other Remediation Works (North) Area (ORWN), respectively, which are located directly north of the Site (refer to **Figure F2**). The objectives of the HHERA are to: (a) determine soil concentrations that will not represent an unacceptable risk to human health or the environment if left in-situ at the Site or beneficially reused elsewhere in the Development; and, (b) define groundwater concentrations that will not represent an unacceptable risk to human health or the environment. The general development plans, intertidal characteristics, contamination source, type and location for the Site are similar to those areas located directly to the north of the Site (that is the PDA and ORWN areas). It is therefore considered appropriate to compare SSTC derived for the areas directly to the north, to reported contaminant concentrations on the Site. An Addendum to the HHERA will be prepared to demonstrate the applicability of the soil and groundwater SSTC derived for Blocks 4 and 5 to the Site.

An Addendum to this RAP will also be prepared following completion of the HHERA. The addendum will confirm locations where CIM will require remediation at the Site to ensure that unacceptable risks to human health or the environment will not occur following the proposed redevelopment works. The outcomes of the RAP Addendum (specifically the areas of CIM which warrant remediation) will also be documented in the RWP.

6.0 Contamination Status

A detailed assessment of the contamination status and a summary of the contaminant exceedences within the Development Area (South) and the Public Domain (South) areas are provided in Section 10.2 of the DGI (AECOM 2010) and is summarised in the following sections. The contaminant concentrations in soil which exceed the Site Criteria (refer to **Section 5.1.1**) are presented in **Figure F6** to **Figure F8**.

6.1 Development Area (South)

A tabulated summary of all analytical data obtained from the Development Area (South) (that is Block 1 to 3) is provided in **Table 5**. Only analytes which have reported concentrations above the adopted residential and commercial criteria have been summarised.

Table 5: Development Area (South) Site Investigation Criteria Exceedence Summary (Soil)

Chemical	Number (count)		Concentration Range (mg/kg)		Number of Adopted Criteria Exceedences			Exceedence Location
	Results	Detects	Min	Max	NSW EPA (1994)	Residential	Commercial	
Metals								
Lead	166	148	<5	2050	-	2	2	AECOM BH11 - 2.6-2.7 AECOM BH15 – 2.0-2.2
TPH, BTEX, PAH and Phenols								
TPH C_6-C_9	96	10	<2	244	4	-	-	AECOM BH04-20.0-20.2 AECOM BH04-21.0-21.2 AECOM BH08-13.0-13.1 ERM BH117_15-15.5
TPH C_{10}-C_{36}	96	29	<50	13500	13	-	-	AECOM BH07-7.4-7.5 AECOM BH11-1.6-1.8 AECOM BH11-2.6-2.7 AECOM BH11-3.2-3.3 AECOM BH12-3.3-3.2 AECOM BH13-7.2-7.4 AECOM BH20-11.0-11.2 AECOM BH26-11.4-11.6 AECOM BH28-11.5-11.7 AECOM BH32-11.5-11.7 AECOM BH32-14.5-14.7 ERM BH117_15.0-15.5 ERM BH195-10.5
Benzene	99	9	<0.2	19.4	8	-	-	AECOM BH04-20.0-2.02 AECOM BH04-21.0-21.2 AECOM BH04-22.0-22.2 AECOM BH08-13.0-13.1 AECOM BH08-14.0-14.1 AECOM BH37_20.4-20.5 ERM BH110_23.3-23.8 ERM BH117_15.0-15.5
Total Xylene	99	10	<0.4	29.1	3	-	-	AECOM BH04-21.0-21.2 AECOM BH08-13.0-13.1 ERM BH117_15.0-15.5

Chemical	Number (count)		Concentration Range (mg/kg)		Number of Adopted Criteria Exceedences			Exceedence Location
	Results	Detects	Min	Max	NSW EPA (1994)	Residential	Commercial	
Total PAH	90	40	<LOR	1536	-	6	6	AECOM BH04-21.0-21.2 AECOM BH07-7.4-7.5 AECOM BH12-3.3-3.2 AECOM BH20-1.0-1.2 AECOM BH37_22.2 ERM BH117_15.0-15.5
B(a)P	90	38	<0.5	22.8	-	10	7	AECOM BH07-7.4-7.5 AECOM BH12-3.3-3.2 AECOM BH19-6.9-7.0 AECOM BH20-1.0-1.2 AECOM BH26-11.4-11.6 AECOM BH32-14.5-14.7 AECOM BH37_22.2 ERM BH100_3.0-3.45 ERM BH117_15.0-15.5 ERM BH195_10.5
Inorganics								
Sulfate	31	29	<100	2620	-	1	1	ERM BH194_1.85

Based on the findings of the DGI (AECOM 2010), the nature and distribution of CoPC at the Site can be summarised as follows:

- Concentrations of CoPC including lead, TPH (C_6-C_9 and C_{10}-C_{36}), benzene, xylenes, PAHs (including B(a)P) and sulfate variably exceeded the adopted Site Criteria. The reported results were broadly consistent with the findings of previous investigations with respect to the identified CoPC;
- Reported benzene and total xylene exceedences were all located in proximity to and down gradient from the former gasworks located immediately north of the Site;
- Reported B(a)P and total PAH exceedences were variably detected in shallow fill and at depth in natural materials. The distribution of exceedences indicates that the detected PAHs are associated with both contamination from the former gasworks and the presence of fill materials. Elevated PAH concentrations in fill were typically associated with the presence of black ash materials;
- Specific point-sources of lead have not been identified, and the elevated concentrations are considered likely to be associated with either fill materials or possibly workshop activities associated with the former vehicle maintenance facility;
- The reported exceedences appear to be associated with the historical presence of gasworks to the north of the Site and the presence of fill materials used for land reclamation activities. Contamination identified at the Site was generally concentrated within Block 3 of the Development Area in proximity to the former gasworks infrastructure;
- Benzene and total xylene exceedences were detected at depth and generally within natural soils. The lateral and vertical distribution of the exceedences indicates that this contamination may have been present prior to historical filling activities taking place and is likely to be associated with the presence of the former gasworks. This was consistent with the findings of the previous ERM investigations;
- Contamination was identified at the bedrock interface in several locations. AECOM did not undertake rock coring as part of this investigation, however previous investigations (ERM 2007) and J&K (2006) have identified subsurface gasworks related contamination within bedrock to the north of the Site;

- TPH (C10-C36) and PAH exceedences in soil are generally evenly distributed across the Site, lead exceedences are concentrated in the northern and eastern portions of the Site closest to the former gasworks infrastructure and Hickson Road;
- TPH (C10-C36) and lead exceedences in soil are more likely to be present in fill while PAH exceedences were reported in both fill and natural soils;
- BTEX compounds and TPH (C6-C9) exceedences were reported to be more likely present in natural materials at depth; and
- The DGI (2010) and previous investigations did not identify the presence of tar containing materials in the Development Area (South).

An assessment of the significance of the above soil results in relation to whether the material is likely to be PIM and whether remediation is likely to be warranted is provided in **Section 7.2** below.

6.2 Public Domain (South)

A tabulated summary of all soil analytical data obtained from the Public Domain (South) is provided in **Table 6**. Only analytes which have reported concentrations above the adopted Site Criteria (SIL_3 for recreational open space) have been summarised below.

Table 6: Public Domain Site Investigation Criteria Exceedence Summary (Soil)

Chemical	Number (count)		Concentration Range (mg/kg)		Number of Adopted Criteria Exceedences		Exceedence Location
	Results	Detects	Min	Max	NSW EPA (1994)	SIL_3	
Metals							
Lead	48	44	<5	1320	-	2	ERM BH102_3.0-3.45 ERM BH103_1.5-1.95
TPH, BTEX, PAH and Phenols							
TPH C_{10}-C_{36}	23	7	<50	7340	1	-	AECOM_BH23-4.7-4.9
B(a)P	19	7	<0.5	17.2	-	2	AECOM_BH23-4.7-4.9 AECOM-BH30-1.0-1.2
Total PAH	19	11	<LOR	281.2	-	2	AECOM_BH23-4.7-4.9 AECOM-BH30-1.0-1.2

The results of the soil analysis conducted within the Public Domain (South) and the field observations indicated that the fill material is highly heterogeneous in nature and contained some ash, decayed wood, with occasional black staining and slight petroleum hydrocarbon and hydrogen sulfide odours.

The DGI (2010) and previous investigations did not identify the presence of tar containing materials in the Public Domain (South).

6.3 Additional Soil Analysis Results

The following summary describes the findings of the DGI (AECOM 2010) with respect to the Site's soil leachability, the potential for acid sulphate soils and asbestos in soils.

- Deionised water leachability tests were undertaken on selected soil samples to evaluate leaching potential under neutral pH water conditions. Concentrations of metals including As, Ba, Cr, Co, Cu, Pb, Mn, Ni, Zn and PAHs including Fluorene, Napthalene, Phenanthrene and Pyrene were reported to be leaching at

concentrations above the laboratory LOR. Based on the samples analysed (including samples from the Public Domain [South]), the soil and fill material at the Site were considered to have a generally low to moderate leaching potential under deionised water leach conditions. It was also noted that metals concentrations in fill materials across the Site were generally relatively low. Consequently, significant impacts to the Site's groundwater from the mobilisation of contaminants in the fill material is not considered to be likely;

- A total of five samples were analysed for Suspension Peroxide Oxidation Combined Acidity & Sulfate (SPOCAS) to evaluate potential or actual acid sulfate soils to be present. The reported results indicate that Actual Acid Sulfate (AAS) soils were not present in the samples analysed, however there is a low potential for acid sulfate soils (PASS) to be present. Based on Table 4.4 of the ASSMAC Assessment Guidelines, the reported Sulfur trail (% Sulfur oxidisable) and Acid trail (mol H^+/tonne) exceeds the Action criteria (0.03% and 18 mol H^+/tonne respectively) if more than 1,000 tonnes of soils are to be disturbed triggering the need for an Acid Sulfate Soils management plan; and
- A total of four samples (collected from locations where buried fill and rubble were identified) were analysed for asbestos. No asbestos was detected in the samples analysed. No visual evidence of bonded fibre cement or possible asbestos fibres was observed by AECOM during the DGI investigation or during previous investigations on the Site by ERM. Consequently, asbestos containing materials are not considered to be widespread within fill materials at the Site.

6.4 Groundwater Sample Analysis

The following summary describes the findings of the DGI (AECOM 2010) with respect to groundwater quality as well as an assessment of natural attenuation parameters in groundwater across the Site. A tabulated summary is provided in **Table 7** below. Those contaminant concentrations in groundwater which exceed the Site Criteria are presented in **Figure F9**.

Table 7: Site wide Site Investigation Criteria Exceedence Summary (Groundwater)

Chemical	Number (count)		Concentration Range (ug/L)		Number of Adopted Criteria Exceedences
	Results	Detects	Min	Max	ANZECC (2000) Marine 95% (99% Hg)
Lead	14	7	<0.2	12	1
Cadmium	14	8	0.16	108	4
Copper	14	4	<0.5	79	4
Nickel	14	14	3	94.7	4
Zinc	14	13	<5	188	8
TPH C6-C9	14	1	<20	13 200	-
TPH C10-C36	14	1	<50	9380	-
Benzene	14	1	<1	4410	1
Toluene	14	1	<5	1600	1
Ethylbenzene	14	1	<2	683	1
Xylene (total)	14	1	<4	2290	1
Total PAH	14	7	0.825	4848.9	-
B(a)P	14	4	<0.05	7.7	-
Sulphate	14	14	472	3190	-
Phenol	7	0	<1	<1	-

Chemical	Number (count)		Concentration Range (ug/L)		Number of Adopted Criteria Exceedences
	Results	Detects	Min	Max	ANZECC (2000) Marine 95% (99% Hg)
Pentachlorophenol	7	0	<2	<2	-
Naphthalene	14	2	<0.1	4440	1
Cyanide (Free)	14	0	<0.004	<0.004	-
Cyanide Total	4	0	<0.004	<0.004	-
Weak Acid Dissociable Cyanide	10	0	<0.004	<0.004	-
Total Organic Carbon	14	10	<1	16	-
Ammonia as N	14	3	<100	5320	-
Ferrous Iron	14	11	<0.05	56	-
Methane	14	13	<0.01	1.37	-
Anions Total	14	14	428	667	-
Cations Total	14	14	389	664	-
Calcium (Filtered)	14	14	173	706	-
Magnesium (Filtered)	14	14	631	1410	-
Potassium (Filtered)	14	14	167	429	-
Sodium (Filtered)	14	14	6840	11800	-
Nitrate (as N)	14	12	<0.01	2.76	-
Nitrite (as N)	14	4	<0.01	0.05	-
Chloride	14	14	13900	21300	-
Sulphate	14	14	472	3190	-
Alkalinity (total) as CaCO3	14	14	137	933	-
pH (units)	14	14	5.49	7.41	-

NOTE: '-' no criteria available.

Laboratory analysis of groundwater samples collected from across the Site indicated the groundwater impacts associated with the former gasworks were limited to the north-eastern corner of the Site, with only MW08 reporting detectable concentrations of TPH, PAHs and BTEX. Concentrations of TPH, PAH and BTEX were not reported above the laboratory LOR in wells located down-gradient of MW08.

Heavy metals concentrations were reported above the assessment criteria in several groundwater samples analysed and exceedences were widespread across the Site. The reported concentrations were consistent with previous investigations and are likely to be related to the fill materials used to backfill the Site. The slightly acidic groundwater in some areas may be contributing to the mobilisation of heavy metals from within the fill materials.

The assessment of natural attenuation parameters indicate that biodegradation processes are actively occurring at the Site, particularly in the north-eastern portion of the Development Area. These processes appeared most pronounced in MW08 where there is evidence of sulphate reduction, increased alkalinity and higher TOC concentrations when compared to other wells across the Site.

In considering the above groundwater results in relation to an assessment of risk at the Site, the DGI (AECOM 2010) concluded that:

- Based on the reported groundwater laboratory results and the proximity of the Site to the adjacent Darling Harbour, it was considered that the presence of elevated concentrations of contaminants associated with the presence of the former gasworks and buried fill materials may pose a risk to off-site environments if migrating from the Site;
- The available data indicated that groundwater contamination is present at the Site, and has been variably identified in 8 of the 14 monitoring wells sampled. The reported exceedences currently indicate there is potential risk to the down gradient environmental receptor (Darling Harbour); and
- Based on the proposed development plan (i.e. excavation of basements) up gradient contaminant sources will be removed and therefore reduce the potential risk in the future.

As discussed in **Section 6.3**, based on the results of the deionised water leachability tests undertaken on soil samples across the Site as part of the DGI (AECOM 2010), soil and fill materials at the Site are considered to have a generally low to moderate leaching potential under deionised water leach conditions. Metals concentrations in the Site's fill materials were also noted to be generally relatively low. Consequently, significant impacts to the Site's groundwater from the mobilisation of contaminants in the fill material is not considered to be likely.

7.0 Remediation Extent

The preferred remediation strategy is to remediate soil contamination which has been demonstrated to represent a source of groundwater contamination and risk to human health or the environment. Within this context, it is anticipated that active groundwater remediation will not be required and groundwater contamination will be addressed by source removal. This approach is supported by the findings of the DGI (AECOM 2010) and the recommendations of the ERM RAP (ERM, 2008c). The effectiveness of this approach will be assessed by comparing groundwater CoC concentrations against the SSTC's developed by the HHERA (as discussed in **Section 5.2.2**).

Notwithstanding that active groundwater remediation is not anticipated to be necessary, appropriate management of water generated as part of the earthworks program and soil remediation works will be required.

The extent of soil remediation required to accomplish the goal of source removal at the Site will be predominantly defined by:

- The basement designs (refer to **Section 3.2**); and
- The distribution of confirmed impacted material (CIM) determined as an outcome of:
  - A screening assessment of soil concentrations in relation to generic soil assessment guidelines – to determine potentially impacted material (PIM) (refer to **Section 5.2.1**); and
  - The SSTC developed by the HHERA for the proposed land use – to determine CIM (refer to **Section 5.3**).

As discussed in **Section 5.3.2** and summarised by the flow chart presented in **Figure F10**, the final extent of remediation works will be subject to implementation of the HHERA. The outcomes of this assessment will be documented in the RWP.

7.1 Development/Remediation Assumptions

The following provides a summary of the key assumptions made in assessing the remediation requirements for the Site:

- The final extent of remediation will be dependent on the findings of the HHERA (refer to **Section 5.3.2**);
- Basement excavations in the Site will require excavation of fill and potentially some natural soils as described by **Section 3.2**. The final basement design will be subject to finalisation and potential change;
- Visual and olfactory observations of soil quality can be used as a guide for the characterisation of soil contamination. This approach is consistent with AECOM experience during remediation of other former gasworks sites and will be validated through additional characterisation samples to be conducted prior to the commencement of excavation (refer to **Section 16.2.1**);
- Material that is surplus to the development requirements at the Site, including material generated by the remedial works which is determined to be suitable, based on a HHERA (either with or without treatment), will be beneficially reused in the development of Headland Park and/or other areas of Barangaroo;
- The development includes construction of groundwater control walls, where required, to help facilitate excavations and control groundwater movement (refer to **Section 3.2**); and
- Dewatering and treatment of water, where required, will be undertaken as part of the bulk excavation works for the development basements.

It is also noted that the remediation strategy will need to be cognisant of and take into account the high profile of the development, its proximity to the CBD and the additional scrutiny which the project is therefore likely to receive (refer to **Section 19.0** for details on the proposed approach to Community Engagement).

7.2 Remediation and Development Areas

AECOM has identified that the likely remediation extent required such that the Site is rendered suitable for the proposed land use and does not present an unacceptable risk, will be driven by the remediation of CIM. Within this context, it is noted that the proposed development will include bulk excavation works for basement construction within the Development Area (South) and part of the Public Domain (South). These bulk excavations:

- Will include removal of material in addition to the CIM, but depending on the finished levels of the basement excavations; and
- May not include removal of all the CIM (i.e. where the material is present below the base of or outside the footprint of the proposed excavation and is not determined to present a risk).

Areas of PIM that, subject to confirmation based on the SSTC to be developed as an outcome of the HHERA, may require removal, treatment and/or management have been estimated by AECOM based on a screening assessment of the consolidated data set for the Site (as presented in the DGI, AECOM 2010) and in consideration of the proposed development excavations required to deliver the Lend Lease masterplan. The PIM areas presented in this RAP are based on the preliminary screening assessment of the available analytical data (refer to **Section 7.2.1** to **7.2.4** below and **Table T1**). The final remediation extent will be determined as an outcome of the HHERA (as discussed in **Section 5.3.2**) and described in the RWP.

The proposed extent of remediation, determined based on the screening assessment of PIM and consideration of risk to human health and the environment, for the Development Area (South) and Public Domain (South) within the Site is summarised in the following sections.

7.2.1 Block 1

No PIM has been identified within Block 1. Furthermore, no significant groundwater contamination has been identified within this area. Consequently, specific remediation works are not considered to be required in this part of the Site.

7.2.2 Block 2

Potential Impacted Material

Based on an assessment of the findings of the DGI (AECOM 2010) (refer **Section 6.1**), AECOM has identified eight hotspots of PIM present within Block 2 (refer to **Table T1 and Figure F11**). **Table T1** details the depth of the soil sample which exceeds the residential criteria, its relationship to the proposed basement excavations, and therefore whether the material is proposed to be removed during the bulk excavation works. The depth of the various hotspots of PIM and their location away from the former gasworks infrastructure, suggests that they are associated with the presence of localised contaminated fill materials. The hotspots are characterised as follows.

- **BH13** – heavy end TPH (C_{10}–C_{36}) was reported in buried fill from RL -4.17 to -4.69 m AHD. Deep basement excavations are currently proposed in this area, therefore impacted material identified at this hotspot would likely be **removed** as part of the bulk excavation works;
- **BH19** – PAH impact (consisting of B(a)P) was reported in buried fill from RL -4.17 to -4.69 m AHD. Deep basement excavations are currently proposed in this area, therefore impacted material identified at this hotspot would likely be **removed** as part of the bulk excavation works;
- **BH20** – heavy end TPH (C_{10}–C_{36}) and PAH impact (including B(a)P) was reported within the fill at depths of RL -1.76 and -8.24 m AHD. Shallow basement excavations are currently proposed in this area, therefore the impacted material associated with this hotspot would likely be only **partially** removed as part of the bulk excavation works;
- **BH26** – heavy end TPH (C_{10}–C_{36}) and PAH impact (consisting of B(a)P)was reported in fill material from RL -8.71 to -10.41 m AHD. Shallow basement excavations are currently proposed in this area, therefore the impacted material associated with this hotspot would likely **not** be removed as part of the bulk excavation works;
- **BH28** - heavy end TPH (C_{10}–C_{36}) and PAH impact (including B(a)P) was reported within the fill at a depths ranging from RL -9.35 to -10.85 m AHD). Shallow basement excavations are currently proposed in this area,

therefore the impacted material associated with this hotspot will likely **not** be removed as part of the bulk excavation works;

- **BH32** – heavy end TPH (C_{10}–C_{36}) and PAH impact (consisting of B(a)P) was reported within the fill at a depth ranging from RL -8.68 to -10.18 m AHD and at -11.68 m AHD). Shallow basement excavations are currently proposed in this area, therefore the impacted material associated with this hotspot will likely be only **partially** removed as part of the bulk excavation works;
- **BH100 (on the boundary with Block 3)** - heavy end TPH (C_{10}–C_{36}) and PAH impact (comprising of B(a)P) was reported within the fill at a depth of RL -0.37 m AHD. The lower extent of impacted fill at this hotspot is not known/could not be accurately determined. Shallow basement excavations are currently proposed in this area, therefore the impacted material associated with this hotspot will likely be either **partially** or **wholly** removed as part of the bulk excavation works; and
- **BH195** – heavy end TPH (C_{10}–C_{36}) and PAH impact (consisting of B(a)P) was reported in subsurface material from approximately RL -7.68 m AHD depth. Shallow basement excavations are currently proposed in this area, therefore the impacted material identified at this hotspot is **not** likely to be removed as part of the bulk excavation works.

Recommended Remediation Extent

Notwithstanding the comparison of the identified contaminant concentrations against the generic soil assessment guidelines, the hotspots of PIM indentified within Block 2 are generally considered to present only a minimal unacceptable risk to human health or the environment for the following reasons.

- The depth of PIM is generally such that it is below groundwater and will not be removed as part of the proposed basement excavations. Consequently, due to the construction of groundwater cut off walls (refer to **Section 3.2**) and concrete slabs required for the car park basements, there will be no complete exposure pathway between the environment and site occupants and the PIM (fill material);
- Many of the exceedances of the generic soil assessment guidelines are marginal and are not considered representative of a significant risk to human health;
- The generic soil assessment guidelines adopted were conservatively based on the most sensitive potential landuse - namely residential (with minimal access to soil) generic soil assessment guidelines. The nature of the development – specifically the presence of significant basements – means that the conditions on which these generic soil assessment guidelines are based are unlikely to eventuate as part of the development;
- Groundwater monitoring undertaken during the DGI (AECOM 2010) reported benzene, TPH and PAH (the main CoPC reported in the Block 2 hotspots) concentrations generally below the laboratory limit of reporting at the 6 down-hydraulic gradient monitoring wells sampled within the Public Domain (South);
- Deionised water leachability analysis undertaken on soil samples across the Site (AECOM 2010), indicate that soil and fill materials at the Site generally have a low to moderate leaching potential under deionised water leach conditions. Consequently, significant impact to the Site's groundwater from the mobilisation of contaminants in the fill material is not considered to be likely; and
- Heavy metal concentrations in the Site's fill materials are generally relatively low. Further, a large proportion of the contaminant mass (of heavy metals) currently present in the fill materials in the saturated zone, will be removed as a consequence of the proposed bulk excavation works. Consequently, an improvement to the Site's groundwater quality would be expected.

Based on the above information, remediation of the hotspots of PIM identified within Block 2 is not expected to be warranted. The only exception to this is the PIM associated with BH20. The shallow and deep identified impacts identified in association with BH20 are considered likely representative of CIM and therefore likely to require remediation.

The requirement to remediate, or otherwise, hotspots of PIM will be subject to confirmation of whether the subject material is CIM, based on the SSTC to be developed as an outcome of the HHERA. This assessment will be documented in the RWP.

Notwithstanding the preliminary remediation extent identified above, materials excavated as part of the basement construction will still be validated against the 're-use SSTC' established by the HHERA for the purpose of demonstrating its suitability for beneficial reuse within the Headland Park and/or other areas within Barangaroo.

7.2.3 Block 3

Potential Impacted Material

Based on an assessment of the findings of the DGI (AECOM 2010) (refer **Section 5.1**), AECOM has identified two separate zones of PIM present within Block 3 (refer to **Table T1 and Figure F11**). The zones of PIM are characterised as follows.

- **Zone 1 (northeast portion of Block 3)** - generally heavy end TPH (C_{10}-C_{36}) and PAH impacts with some BTEX impacts were reported within the shallower fill material and in natural soils overlying bedrock at depths ranging between RL -0.18 and -12.65 m AHD. The variability of the depths of the contamination suggests that it is associated with both contamination from the former gasworks and the presence of contaminated fill materials; and
- **Zone 2 (northwest portion of Block 3)** - generally benzene and some lighter fraction TPH (C_6-C_9) and PAH impact were reported at depth and generally within natural soils and the underlying weathered bedrock. The lateral and vertical distribution of the contamination indicates that this contamination may have been present prior to historical filling activities and is likely to be associated with the presence of the former gasworks. The impacts range in depth between RL -17.84 and -20.99 m AHD.

Recommended Remediation Extent

Deep basement excavations, extending well into the underlying bedrock, are currently proposed in Zone 1 (northeast portion of Block 3), therefore it is expected that the PIM associated with Zone 1 will be removed as part of the proposed bulk excavation works.

Conversely, shallow basement excavations are currently proposed in Zone 2 (northwest portion of Block 3), therefore it is expected that the PIM associated with Zone 2 will not be removed as part of the proposed bulk excavation works. The requirement to remediate, or otherwise, the Zone 2 PIM will be subject to confirmation of whether the subject material is CIM, based on the SSTC to be developed as an outcome of the HHERA. This assessment will be documented in the RWP.

7.2.4 Public Domain (South)

Potential Impacted Material

Based on an assessment of the findings of the DGI (AECOM 2010) (refer to **Figure F11**), AECOM has identified a series of hotspots of PIM within the Public Domain (South). The variability of the depths of hotspots of PIM and their location away from the former gasworks infrastructure, suggests that they are associated with the presence of contaminated fill materials. These hotspots are characterised below.

- Lead impact – was reported at two locations (BH102 and BH103) within shallow fill materials from an RL between -0.47 and 1.05 m AHD;
- PAH impact – was reported at two locations (BH30 and BH23) within relatively shallow fill materials from an RL between 1.42 and -2.30 m AHD; and
- Heavy end TPH (C_{10}-C_{36}) impact – was reported at one location one location (BH23) from within fill materials at RL of -2.30 m AHD.

Recommended Extent of Remediation

Notwithstanding the comparison of the identified contaminant concentrations against the generic soil assessment guidelines, the hotspots of PIM identified within the Public Domain (South) are considered to present only a minimal unacceptable risk to human health or the environment for the following reasons.

- The depth of PIM is generally such that it is below groundwater and will not be removed as part of the proposed limited basement excavations within the Public Domain. Further, retention of the existing concrete/asphalt hardstand and development of the Public Domain by filling above the existing hardstand will result in there being no complete exposure pathway between site occupants and the PIM (fill material);
- Many of the exceedances of the generic soil assessment guidelines are marginal and are not considered representative of a significant risk to human health;
- The generic soil assessment guidelines adopted were conservatively based on the most sensitive potential landuse - namely open space generic soil assessment guidelines. The nature of the development –

specifically retention of existing concrete slabs and caisson walls – means that the conditions on which these generic soil assessment guidelines are based are unlikely to eventuate as part of the development;

- Groundwater monitoring undertaken during the DGI (AECOM 2010) indicates that benzene, TPH and PAHs (the main CoPC reported in the Block 2 hotspots) concentrations were generally below the laboratory limit of reporting at the 6 down-hydraulic gradient monitoring wells sampled within the Public Domain (South);
- Deionised water leachability analysis undertaken on soil samples across the Site (AECOM 2010), indicate that soil and fill materials at the Site generally have low to moderate leaching potential under deionised water leach conditions. Consequently, significant impact to the Site's groundwater from the mobilisation of contaminants in the fill material is not considered to be likely;
- Heavy metal concentrations in the Site's fill materials are generally relatively low. Further, a large proportion of the contaminant mass (of heavy metals) currently present in the fill materials in the saturated zone, will be removed as a consequence of the proposed bulk excavation works. Consequently, an improvement to the Site's groundwater quality would be expected; and
- The existing caisson walls associated with the historic wharf structures along the western boundary of the area will be retained as part of the development. Groundwater monitoring in the Public Domain indicates that these structures are reducing the flux between the Site and the Harbour.

Based on the above information, remediation of the hotspots of PIM identified within the Public Domain is not expected to be warranted.

The requirement to remediate, or otherwise, hotspots of PIM will be subject to confirmation of whether the subject material is CIM, based on the SSTC to be developed as an outcome of the HHERA. This assessment will be documented in the RWP.

Notwithstanding the preliminary remediation extent identified above, materials excavated as part of the basement construction will still be validated against the 're-use SSTC' established by the HHERA for the purpose of demonstrating its suitability for beneficial reuse within the Headland Park and/or other areas within Barangaroo.

7.3 Assessment of Confirmed Impacted Material

As detailed in **Section 5.3.2** and **Figure F10**, confirmation of whether the PIM incorporated within the preliminary remediation extents described above is CIM, and therefore will require remediation, will be determined based on comparison against the SSTC developed as part of the HHERA.

The outcome of this comparison and the final remediation extent – including the lateral and vertical extent of CIM - will be documented in the RWP.

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8.0 Remedial Technology Assessment

A wide range of technology options were considered for remediation of the identified PIM in accordance with the nominated remediation goals and objectives. This section describes the Remedial Technology Assessment process which was applied by AECOM and Lend Lease towards selection of the preferred remediation alternative(s) described by this section. In undertaking this evaluation, AECOM and Lend Lease were cognisant of the fact that the most cost-effective and sustainable remediation approach may be a combination of one or more individual remedial technologies.

As described above the remediation goals and extent are focussed on removal, to the extent practicable, and management of materials which represent a source of groundwater contamination (CIM) or risk to human health or the environment. Therefore, the remedial technology assessment was focussed primarily on soil remediation technologies.

The remedial technology assessment process involved the following phases:

- **Identification of Remedial Technology Options** – a review of the primary information sources to identify potential treatment technologies for the Site;
- **Screening of Remedial Technology Options** –an initial comparison of all identified technologies to assess their suitability for implementation at the Site; and
- **Assessment of Remedial Technology Options** – a more detailed review of the highest rating technologies from the screening stage, against the key remediation objectives.

The remedial technology assessment has also drawn on previous direct experience that Lend Lease and members of the AECOM project team has had at The Bond and other remediation projects.

8.1 Identification of Remedial Technology Options

A review of primary information sources identified more than twenty remedial technology options that were potentially applicable to the remediation of the identified contaminated soils at the Site. The remediation technology options identified are presented in **Table T2** and summarised following.

8.1.1 In-situ remedial technologies

- In-situ Stabilisation or Solidification
- In-situ Chemical Oxidation
- Thermal Conductive Heating
- Monitored Natural Attenuation
- Soil Vapour Extraction
- In-situ Enhanced Bioremediation
- In-situ Containment
- Phytoremediation
- Electrical Resistive Heating
- In-situ Vitrification
- In-situ Steam Stripping
- Surfactant and/or co-solvent injection
- Permeable reactive barrier

8.1.2 Ex-situ remedial technologies

- Ex-situ Stabilisation or Solidification
- Ex-situ Thermal Desorption
- Co-burning

- Asphalt batching
- Ex-situ Bioremediation (biopiles, bioreactor, landfarming);
- Ex-situ chemical oxidation.
- Soil Washing
- Supercritical Water Oxidation
- Electrokinetics

8.2 Screening of Remediation Technologies

Based on AECOM's current understanding of the soil and groundwater contamination at the Site, the identified remedial technologies were screened in consideration of the following key parameters. A weighting factor, as summarised below, was assigned to each of the key parameters following a review process with Lend Lease and AECOM. A score ranging from 1 (low) to 5 (high) was then assigned to each of the key parameters for each of the identified remedial technologies (note that in the case of the financial category, a higher ranking relates to a lower cost alternative). The total score for each remedial technology was then calculated by summing the product of the weighting factor and score for each key parameter.

8.2.1 Feasibility of the Remediation Technology

- Sustainability (35%) - refer to Section **8.2.2** for details.
- Technical constraints (30%) – including:
  - Applicability of the technology to the identified contamination (specifically type, location, quantity and concentration);
  - Ability of the technology to achieve the required remediation goals; and
  - Acceptance of technology by local and international remediation practitioners and regulators (including anticipated regulatory acceptance);
- Financial (15%) – relative cost of implementing the technology at the Site including capital costs associated with equipment purchase and commissioning and continuing costs associated with operation, maintenance and water treatment/disposal;
- Logistical (10%) – additional factors that may limit the ability to implement the technology within the particular constraints of the Site, the associated development, and the surrounding land uses; and
- Timing (10%) – timeframe required to complete feasibility assessments, pilot trials and design of remediation system, and duration required until achievement of the remediation goals.

8.2.2 Sustainability of the Remediation Technology

- Resource Use (6%) – specifically energy and water;
- Waste Generation (6%) – production of by-products requiring further treatment or management for appropriate disposal;
- Material Reusability (6%) – potential for reuse or recycling;
- Carbon dioxide (CO_2) Generation (6%) – resulting from emissions during the remedial works;
- Community Impact (6%) – including likelihood of community acceptance of proposed strategy, community impact during the remedial works, and continuing impact from legacies remaining upon conclusion of the remediation; and
- Ongoing Management and Risk (5%) – continuing short term and long term maintenance and monitoring obligations and the risk of additional remedial works being required into the future.

8.2.3 Screening Outcomes

The results of the screening assessment are presented in the **Table T2**.

As an outcome of the screening assessment, many of the remedial technologies were discounted from further detailed consideration. Technologies were typically eliminated from further consideration on the basis that they:

- Are not suitable for the identified contaminants of concern;
- Are impractical in the context of addressing the identified contamination; or
- Have a very high cost in comparison with other technologies.

Those technologies which were considered to be potentially suitable, based on the nature of the identified soil contamination and the screening assessment, were evaluated in more detail against each of the remediation objectives. Based on the initial screening process, seven remediation technologies were selected for further detailed consideration as follows.

1. Excavation and Ex-Situ Thermal Desorption (on-site): Desorption and/or destruction of organic contaminants in excavated soil by heating, usually by a direct heating thermal unit.
2. Excavation and Ex-Situ Thermal Desorption (off-site): Desorption and/or destruction of organic contaminants in excavated soil by heating, usually by direct heating thermal unit. Requires transport of materials to an off-site thermal desorption facility.
3. Excavation and Ex-Situ Stabilisation (on-site): Encapsulation of contaminant by ex-situ blending with chemical binders to immobilise contaminants of concern. Stabilised material could be disposed off-site or re used on-site.
4. Physical Containment: Containment or capping of contaminated soil to prevent or significantly reduce contaminant migration and to prevent human and environmental exposure.

8.3 Assessment of Remedial Technology Options

The four remedial technologies selected based on the screening assessment were each subjected to a more detailed assessment against the key remediation objectives for the Site, namely:

- Ability to reduce potential risks to human health or the environment; and
- Ability to facilitate the proposed future land use.

8.3.1 Excavation and Ex-Situ Thermal Desorption (on-site)

This process heats excavated waste materials to high temperatures that will volatilise water and organic contaminants. Thermal desorption employs mechanical tumbling and heating to drive the organics from the soil into the gas phase. Temperatures and residence times are designed to volatilise selected contaminants, but not oxidize them. Waste gases are further oxidised in a secondary combuster and other wastes are treated or sent to a licensed facility for destruction.

Factors that may limit the applicability and effectiveness of a thermal desorption system include particle size requirements for handling, presence of fine grained clay and silty soils, high organic content, high metals content, high moisture content, presence of tarry soils/sediments and presence of abrasive material.

Significant materials handling including separation, dewatering, and drying would be required prior to thermal desorption of contaminated material. A pilot or demonstration project would likely be required to demonstrate the efficacy of the approach. Residual waste streams would also require further treatment which would increase treatment costs. Finally, it is considered highly unlikely that an on-site thermal desorption facility located on-site and adjacent to the Sydney CBD would receive regulatory or community endorsement. Thermal desorption is highly energy intensive and, depending on the treatment methods adopted to manage waste by products, will result in significant CO_2 emissions.

8.3.2 Excavation and Ex-Situ Thermal Desorption (offsite)

Section 8.3.1 provides a description of the thermal desorption process which is applicable to thermal desorption implemented both on-site and off-site.

The key difference between on-site and off-site thermal desorption is the likelihood of regulatory and community endorsement. It is considered more likely that regulatory approval of a thermal desorption facility would be received if established off-site. However, additional logistical limitations associated with the transport of large quantities of contaminated soil either through CBD streets or via Sydney Harbour would likely significantly inhibit the validity of this alternative.

8.3.3 Excavation and Ex-situ Stabilisation or Solidification

Ex-situ Solidification or Stabilisation reduces the mobility of contaminants through both physical and chemical means. Stabilisation or Solidification does not destroy the contaminants but alters the conditions of the material such that risks are significantly reduced. The main changes are reduced permeability of the treated mass and decreased mobility of the contaminants. The geotechnical properties are also improved.

Chemical additives (i.e., Portland Cement, lime, organic polymers, silicates, flyash, slag, kiln dust) are added to the contaminated matrix to limit the waste's solubility and mobility, and lower its toxicity. This technology can be applied ex-situ, by excavating and mixing the materials with the solidifying/stabilising agent and then placing the solidified material in an appropriate location. Soil is excavated, screened to remove materials too large to be effectively treated and its moisture content amended to suit treatment. The chemical additives are blended into the soil typically using a pugmill.

Stabilisation or Solidification can treat a broad range of contaminants including petroleum hydrocarbons, PAHs and metals. In-situ and ex-situ Stabilisation or Solidification processes have been used extensively in North America and Australia to address high levels of contaminants at former manufactured gas plants. Of specific relevance is the previous remediation of the adjacent Bond development in Hickson Road by Lend Lease in 2002, which successfully utilised ex-situ stabilisation / solidification to treat gas works waste, including tar, from the same gas works as is present within Blocks 4, 5 and Hickson Road. For the Bond remediation, approximately 13,000 tonnes of contaminated material were excavated and treated, including 1000 tonnes removed from the 9m deep gasholder annulus trench.

Bench scale trials, and pilot scale demonstration trials would be required as a precursor to design and finalisation of formulations for ex-situ solidification and stabilisation. Further, if disposal of the treated material to landfill is required, an immobilisation approval from the DECCW would also be required.

Depending on the quality of the treated material, capping and containment of the stabilised or solidified material can be undertaken to facilitate future land use.

Future monitoring may be required should the stabilised or solidified material be placed on-site or on Headland Park, to assess ongoing groundwater conditions.

Ex-situ remediation approaches, including stabilisation or solidification, are consistent with the proposed development regime for the Site which requires excavation of basements founded at or deep within bedrock in Blocks 1 through 3.

8.3.4 Physical Containment

Physical containment involves the construction and placement of barriers that sever the pathway between the contaminant source and the receptor. Containment barriers may be placed around its perimeter, as a cover, or in all of these areas, as dictated by site-specific conditions. Containment barriers can be constructed of clean materials, impermeable clay layers, and/or geomembranes.

Subsurface barriers, such as sheetpiles and bentonite clay walls, can also be used to contain groundwater, NAPLs and vapours. Monitoring systems are required to detect contaminant leaching and to ensure the continued integrity of the barrier systems.

Although physical containment does not remove or destroy the contamination, containment technologies can effectively manage exposure risks, can be implemented in a timely manner, and are generally economical. Physical containment technologies have been selected for use at other former manufactured gas works sites within Australia and around the world.

Physical Containment would contain, but not destroy, the identified contamination. Notwithstanding, it is considered unlikely that physical containment alone would be considered acceptable by regulators nor would containment satisfactorily address the DECCW declaration of investigation/remediation area.

Physical containment is consistent with the proposed development of the Headland Park which, it is understood, will require significant volumes of fill material for it to be regraded to match the original headland topography.

9.0 Preferred Remediation Options

Based on the available information, as described above, AECOM has identified that the preferred remediation strategy for rendering the Site suitable for the proposed land use should be focussed on the remediation of material identified as Confirmed Impacted Material (CIM). Within this context, AECOM has identified the preliminary estimated extent of remediation through a screening level assessment of the DGI (AECOM 2010) results against generic soil assessment guidelines (to determine PIM) together with an assessment of the risk the PIM represents to human health and the environment. The remediation extent presented in this RAP is subject to confirmation following implementation of the HHERA (refer to **Section 5.3.2** and **Figure F10**). The final, confirmed remediation extent will be documented in a RAP addendum, which will be prepared following completion of the HHERA, and reiterated in the RWP.

In recommending the preferred remediation options, consideration has been given to the fact that the proposed development will include bulk excavation works for basement construction within the Development Area (South).

The recommended preferred remediation options for the Development Blocks and Public Domain within the Site is summarised in the following sections.

9.1 Development Area (South)

9.1.1 Block 1

No PIM has been identified in Block 1 and remediation is not considered warranted.

Therefore, the preferred management strategy for this area is excavation as required by the proposed development; screening; and, transfer of material to the Headland Park and/or other areas of Barangaroo for beneficial reuse. It is expected, based on the available information, that the excavated material will be suitable for placement in Headland Park or the Stage 2 Public Domain without any further treatment. However this will require confirmation by validation sampling during the excavation program.

9.1.1.1 Strategy Summary

The management strategy in Block 1 is summarised following.

- Excavation of basements as required for the development including visual and olfactory observations during excavation, and sample analysis of excavated material to confirm its suitability for beneficial reuse (refer to **Section 5.3.2** and **Figure F10**);
- Physical separation of recyclable and oversize material, including timber, rock, concrete, steel and brick, from contaminated material;
- Stockpiling of material for processing and beneficial reuse (where appropriate); and
- Off-site disposal of contamination if unsuitable or unavailable for reuse.

9.1.1.2 Reasons for Strategy Selection

Feasibility

- The basement design requires excavation across part of the northern section of Block 1.
- It is anticipated that material removed as part of the basement excavation works will be suitable for beneficial reuse in Headland Park or Stage 2 Public Domain without any requirement for treatment.

Sustainability

The nominated management strategy is considered to be a sustainable solution within Block 1 because:

- It will utilise equipment and infrastructure also required for remediation of other parts of the Barangaroo Stage 1 Development (outside the scope of this RAP), therefore minimising duplication and maximising utilisation of the required equipment;
- It maximises the opportunity for recycling and reuse of material through segregation of oversize materials, timber and steel, etc; and

- The reuse of material in Headland Park and/or other areas of Barangaroo will minimise waste disposal off-site and minimise requirements for the import of fill to the Headland Park Development, therefore minimising:
  - CO_2 emissions through reduced transport requirements; and
  - Community impacts by reducing vehicle movements.

9.1.2 Block 2

A series of hot spots of PIM have been identified within Block 2 (refer to **Section 7.2** and **Figure F11**). As detailed in **Section 7.2.2**, based on the location of the hot spots, the proposed basement configuration and associated groundwater monitoring results, remediation of the PIM hot spots is not expected to be warranted (with the exception of the PIM associated with BH20). Notwithstanding, the extent of remediation will be confirmed based on the SSTC developed as an outcome of the HHERA and documented in the RAP Addendum and RWP.

Therefore, the preferred remediation strategy for this area is: confirming whether the PIM is CIM through assessment of the DGI (AECOM 2010) and additional in-situ characterisation / validation results against the SSTCs developed by the HHERA; excavation as required by the proposed development; screening; and, transfer of material to the Headland Park and/or other areas of Barangaroo for beneficial reuse.

Depending on the SSTC's developed by the HHERA, some of the CIM from Block 2 may require treatment by ex-situ stabilisation on-site prior to transfer to the Headland Park (refer to **Section 9.3**).

9.1.2.1 Strategy Summary

The strategy for the preferred remedial actions in Block 2 is summarised following:

- Assessment of the PIM identified by the screening assessment of the DGI (AECOM 2010) and additional in-situ characterisation / validation results (refer to **Section 7.2**) against the SSTC's developed by the HHERA. These SSTCs will determine which PIM can:
  - Remain in-situ, where its excavation is not otherwise required as part of the development;
  - Be beneficially reused within the Headland Park and/or other areas of Barangaroo; and
  - Be beneficially reused within Headland Park once treated through ex-situ stabilisation.
- The final extent of any required remediation works will be documented in the RAP Addendum and RWP (refer to **Section 5.3.2**);
- Excavation of basements required for the development; including, as required, parallel selective excavation of CIM identified per the process detailed in **Section 5.3.2** and **Figure F10**;
- Selective over-excavation, in addition to the requirements of the development basement excavations, of CIM identified by assessment of the DGI (AECOM 2010) and additional in-situ characterisation / validation results against the HHERA SSTC's (if required);
- Physical separation of recyclable and oversize material, including timber, rock, concrete, steel and brick, from contaminated material;
- Treatment of the CIM by ex-situ stabilisation or solidification (if required);
- Stockpiling of material (where required), including material treated by ex-situ stabilisation, for beneficial reuse within the Headland Park and/or Public Domain;
- Off-site disposal of contamination if unsuitable or unavailable for reuse; and
- Groundwater monitoring and assessment of groundwater CoC concentrations against the SSTC in accordance with a Groundwater Monitoring Plan (GMP) (refer to **Section 16.3.2**).

9.1.2.2 Reasons for Strategy Selection

Feasibility

- The basement design requires excavations founded at various depths generally ranging from within fill material on the western side Block 2 to within bedrock on the eastern side of Block 2. Therefore, a significant proportion of the hot spot CIM will be removed as part of the basement excavation making ex-situ remediation technologies applicable;
- The basement excavations to be constructed as part of the development will incorporate groundwater controls including diaphragm walls and secant pile walls on the eastern and western boundaries of Block 2;
- It is anticipated that material removed as part of the basement excavation works will be suitable for beneficial reuse in Headland Park and/or other areas of Barangaroo with only a limited requirement for ex-situ stabilisation works; and
- Ex-situ stabilisation or solidification is considered the most practical, cost effective, and established remediation technology based on the type of contaminants identified in the DGI (AECOM 2010).

Sustainability

The nominated remediation strategy is considered a sustainable solution to remediation of contamination within Block 2 because:

- It will utilise equipment and infrastructure also required for the development and remediation of other parts of the Barangaroo Stage 1 Development, therefore minimising duplication and maximising utilisation of the required equipment;
- It maximises the opportunity for recycling and reuse of material through segregation of oversize materials, timber and steel, etc; and
- The reuse of material in Headland Park and/or other areas of Barangaroo will minimise waste disposal to landfill and minimise requirements for the import of fill to the Headland Park Development, therefore minimising:
  - CO_2 emissions through reduced transport requirements; and
  - Community impacts by reducing vehicle movements.

9.1.3 Block 3

Two zones of PIM have been identified within Block 3 (refer to **Section 7.2** and **Figure F11**). Therefore, the preferred remediation strategy for this area is: confirming whether the PIM associated with the two zones is CIM through assessment of the DGI (AECOM 2010) and additional in-situ characterisation / validation results against the SSTC's developed by the HHERA; excavation as required by the proposed development; screening; and, transfer of material to the Headland Park and/or other areas of Barangaroo for beneficial reuse.

Depending on the SSTC's developed by the HHERA, some of the CIM from Block 3 may require treatment by ex-situ stabilisation on-site prior to transfer to the Headland Park (refer to **Section 9.3**)

9.1.3.1 Strategy Summary

The strategy for the preferred remedial actions in Block 3 is summarised following:

- Assessment of the PIM identified by the screening assessment of the DGI (AECOM 2010) and additional in-situ characterisation / validation results (refer to **Section 7.2.3**) against the SSTC's developed by the HHERA. These SSTCs will determine which PIM can:
  - Remain in-situ, where its excavation is not otherwise required as part of the development;
  - Be beneficially reused within the Headland Park and/or other areas of Barangaroo; and
  - Be beneficially reused within Headland Park once treated through ex-situ stabilisation.
- The final extent of any required remediation works will be documented in the RAP Addendum and RWP (refer to **Section 5.3.2**).

- Excavation of basements required for the development; including, as required, parallel selective excavation of CIM identified per the process detailed in **Section 5.3.2** and **Figure F10**;
- Selective over-excavation, in addition to the requirements of the development basement excavations, of CIM identified by assessment of the DGI (AECOM 2010) and additional in-situ characterisation / validation results against the HHERA SSTC's (as required);
- Physical separation of recyclable and oversize material, including timber, rock, concrete, steel and brick, from contaminated material;
- Treatment of the CIM by ex-situ stabilisation or solidification (as required);
- Stockpiling of material (where required), including material treated by ex-situ stabilisation, for beneficial reuse within the Headland Park and/or Public Domain;
- Off-site disposal of contamination if unsuitable or unavailable for reuse; and
- Groundwater monitoring and assessment of groundwater CoC concentrations against the SSTC in accordance with a GMP (refer to **Section 16.3.2**).

9.1.3.2 Reasons for Strategy Selection

Feasibility

- The basement design requires excavations founded at various depths ranging from within fill material on the western side of Block 3 to within bedrock on the eastern side of Block 3. Therefore, a significant percentage of the CIM will be removed as part of the basement excavation making ex-situ remediation technologies applicable. In particular, it is expected that all of Zone 1 (refer to **Section 7.2.3**) will be removed as part of the basement excavations;
- The basement excavations to be constructed as part of the development will incorporate groundwater controls including diaphragm walls on the western boundaries of Block 3;
- It is anticipated that material removed as part of the basement excavation works will be suitable for beneficial reuse in Headland Park and/or other areas of Barangaroo with only a limited requirement for ex-situ stabilisation works; and
- Ex-situ stabilisation or solidification is considered the most practical, cost effective, and established remediation technology based on the type of contaminants identified in the DGI (AECOM 2010).

Sustainability

The nominated remediation strategy is considered a sustainable solution to remediation of contamination within Block 3 because:

- It will utilise equipment and infrastructure also required for remediation of other parts of the Barangaroo Stage 1 Development, therefore minimising duplication and maximising utilisation of the required equipment;
- It maximises the opportunity for recycling and reuse of material through segregation of oversize materials, timber and steel, etc; and
- The reuse of material in Headland Park and/or other areas of Barangaroo will minimise waste disposal to landfill and minimise requirements for the import of fill to the Headland Park Development, therefore minimising:
  - CO_2 emissions through reduced transport requirements; and
  - Community impacts by reducing vehicle movements.

9.2 Public Domain (South)

A series of hot spots of PIM have been identified within the Public Domain (refer to **Section 7.2** and **Figure F11**). As determined in **Section 7.2.4**, based on the location of the hotspots, the concentrations relative to the generic soil assessment guidelines and associated groundwater monitoring results, remediation of the PIM hotspots is not expected to be warranted. Notwithstanding, the extent of remediation will be confirmed based on the SSTC developed as an outcome of the HHERA and documented in the RAP Addendum and RWP.

Therefore, the preferred remediation strategy for this area is: confirming whether the PIM is CIM through assessment of the DGI (AECOM 2010) and additional in-situ characterisation / validation results against the SSTCs developed by the HHERA; excavation as required by the proposed development; screening; transfer of material to the Headland Park and/or other areas of Barangaroo for beneficial reuse; and, retention of all remaining material in-situ.

It is expected, based on the available information, that the excavated material will be suitable for placement in Headland Park or the Stage 2 Public Domain without any further treatment. This will be confirmed by in-situ characterisation / validation sampling prior to commencement of the the excavation program.

9.2.1 Strategy Summary

The strategy for the preferred remedial actions at the Public Domain is summarised following:

- Assessment of the PIM identified by the screening assessment of the DGI (AECOM 2010) and additional in-situ characterisation / validation results (refer to **Section 7.2**) against the SSTC's developed by the HHERA. These SSTCs will determine which PIM can:
  - Remain in-situ, where its excavation is not otherwise required as part of the development;
  - Be beneficially reused within the Headland Park and/or other areas of Barangaroo; and
  - Be beneficially reused within Headland Park once treated through ex-situ stabilisation.
- The final extent of any required remediation works will be documented in the RWP (refer to **Section 5.3.2**);
- Excavation of basements as required for the development; including, as required, parallel selective excavation of CIM identified per the process detailed in **Section 5.3.2** and **Figure F10**);
- Selective over-excavation, in addition to the requirements of the development basement excavations, of CIM identified by assessment of the DGI (AECOM 2010) and additional in-situ characterisation / validation results against the HHERA SSTC's (if required);
- Physical separation of recyclable and oversize material, including timber, rock, concrete, steel and brick, from contaminated material;
- Stockpiling of material for beneficial reuse (where required);
- Off-site disposal of contamination if unsuitable or unavailable for reuse; and
- Groundwater monitoring and assessment of groundwater CoC concentrations against the SSTC in accordance with a GMP (refer to **Section 16.3.2**).

9.2.2 Reasons for Strategy Selection

Feasibility

- The basement design requires excavation founded within fill material. Therefore, a percentage of the hot spot CIM will be removed as part of the basement excavation making ex-situ remediation technologies applicable;
- It is anticipated that material removed as part of the basement excavation works will be suitable for beneficial reuse in Headland Park and/or other areas of Barangaroo with only a limited requirement for ex-situ stabilisation works;
- Ex-situ stabilisation or solidification is considered the most practical, cost effective, and established remediation technology for management of the excavated material based on the type of contaminants identified in the DGI (AECOM 2010);

- The Public Domain is to be developed for open space, mixed commercial/retail and hotel use. Excavation of the public space is not necessarily required to facilitate this end land use;
- Retention of the existing concrete and asphalt hardstand and caisson structures, will effectively manage potential exposure pathways for future site users and the environment to the underlying material;
- Retention of material in-situ is considered the most practical and cost effective remediation technology for materials not otherwise requiring excavation as part of the development based on the type of contaminants anticipated and the risk they represent to human health and the environment; and
- Retention of material in-situ has been successfully implemented on a number of previously remediated foreshore sites around Sydney Harbour and is expected to be readily accepted by regulators and other stakeholders.

Sustainability

The nominated remediation strategy is considered a sustainable solution to remediation of contamination within the Public Domain because:

- Excavation and ex-situ stabilisation will:
  - Utilise equipment and infrastructure also required for the development and remediation of other parts of the Barangaroo Stage 1 Development, therefore minimising duplication and maximising utilisation of the required equipment;
  - It maximises the opportunity for recycling and reuse of material through segregation of oversize materials, timber and steel, etc.; and
  - The reuse of material in Headland Park and/or other areas of Barangaroo will minimise waste disposal to landfill and minimise requirements for the import of fill to the Headland Park Development, therefore minimising: CO_2 emissions through reduced transport requirements; and, community impacts by reducing vehicle movements.

- Retention of material in-situ in conjunction with excavation as required by the development works will:
  - minimise earthworks, materials handling, separation, dewatering and drying requirements, therefore minimising emissions from diesel operated equipment and machinery and the overall carbon footprint for the development;
  - minimise fugitive emissions and odours from handling of contaminated material, therefore minimising the risk of adverse stakeholder concerns. It will minimise the quantities of material that requires off-site disposal to landfill; and
  - appropriately manage the risks that the limited contamination within the public domain represents (specifically human health exposure) without unnecessary and resource intensive remediation works.

9.3 Beneficial Reuse in Headland Park and Public Domains

To achieve a sustainable solution for Barangaroo, a key component of the remediation strategy for the Site is to maximise the reuse of materials excavated as part of remediation and basement construction. To achieve this, the following is noted:

1. The Headland Park at Barangaroo requires significant volumes of fill to be provided to create the new, elevated topography;
2. The footprint of the proposed Headland Park may be quarried as a source of sandstone rock that will subsequently be featured within the Stage 1 Development which will provide increased capacity for containment of materials generated by the Stage 1 Development; and
3. The Stage 1 Development will result in a significant volume of excavated fill that is considered suitable for beneficial reuse at the future Headland Park.

The entire Barangaroo development can thus realise significant gains overall by applying a strategy of transferring suitable material removed from the Stage 1 Development to the Headland Park. This will avoid the need to import fill for the Headland Park and avoid disposing significant volumes of suitable fill from the Stage 1 Development to an off-site landfill.

Accordingly, the recommended preferred remediation strategies involve transfer of the majority of excavated and treated material from the Site to the Headland Park for reuse. Material will be validated and treated where necessary, to ensure suitability for use at the Headland Park. This will result in significant environmental benefits and cost savings.

This strategy is based on a nominated area being available at Headland Park for storage of material for reuse to minimise stockpiling requirements.

9.3.1 Strategy Summary

The strategy for the management of materials at Headland Park is summarised as following:

- The BDA is preparing a RAP which will present acceptance criteria for material that can be placed within the Headland Park without imposing restrictions on the intended land-use (which is anticipated to be public open space/parkland);
- Maximise reuse of suitable, contaminated material within the development:
  - CIM generated by the basement excavations and over-excavation (if required) from Blocks 1 to 3, that is, material that meets the ‘Reuse SSTCs’, will be reused in the Headland Park (where required).
  - CIM generated by the basement excavations and over-excavation (if required) within Blocks 1 to 3 which does not meet the ‘Reuse SSTCs’ will be treated through stabilisation or solidification to make it suitable for reuse in the Headland Park.
- Given the range of material types to be reused in the Headland Park (ranging from treated CIM to Virgin Excavated Natural Material), the Headland Park RAP and associated risk assessment will necessarily be based on a series of assumptions regarding where the different material types will be placed within the Headland Park; and
- The BDA will not accept tar containing material or treated tar containing material in the Headland Park. Treated tar containing material refers to tar containing material that has been treated by a methodology that does not result in the reduction of PAH concentrations.

9.3.2 Reasons for Strategy Selection

Feasibility

- The Headland Park RAP and associated risk assessment will use an established process to calculate contaminant concentration thresholds which do not represent an unacceptable risk to human health or the environment if placed in Headland Park.
- The placement of treated material within Headland Park, in accordance with the findings of the Headland Park RAP, is technically sound and will not impact on land use at Headland Park. Reuse of suitable treated material is consistent with the current Modification to a Major Projects Application by SHFA for the Headland Park (MP 06-0162), which contemplates containment of any existing Headland Park contamination on-site.
- The beneficial reuse of treated material has been successfully implemented as part of remediation projects at a number of former industrial sites within Sydney (including the Allied Feeds and Lednez sites at Rhodes, with which AECOM personnel have had direct involvement as NSW Site Auditors).
- If required, controls can be imposed on the placement of materials reused in Headland Park to address aesthetic, odour or perception concerns associated with the reuse of treated material and which are not dealt with quantitatively by the Headland Park risk assessment. Controls considered might include:
  - Provision of a clean layer above any treated material;
  - Placement of treated material at a particular depth below ground surface;
  - Placement of treated material at a particular orientation relative to below ground structures constructed within Headland Park (for example the proposed car park); and/or,
  - Placement of treated material in a particular position relative to the harbour.

Sustainability

The beneficial reuse of excavated materials in Headland Park is considered a sustainable solution due to the following considerations:

- It will significantly reduce the quantities of materials that require off-site disposal;
- A significant quantity of material is required for the proposed development of Headland Park which would otherwise need to be imported to the Barangaroo Development;
- It will minimise earthworks and materials handling requirements, therefore minimising emissions from diesel operated equipment and machinery; and
- It will minimise the carbon footprint of the overall Barangaroo re-development.

It should also be noted that off-site disposal of material (including excavation spoil which is essentially “clean”) may be problematic because under the DECCW Waste Management Guidelines the material will be classified as a waste. The only facilities licensed to receive wastes are typically landfills, which are limited in terms of the annual quantity of materials they can receive. Further, landfills represent a valuable and limited community resource. Minimising the quantity of material deposited in landfills, through the beneficial reuse of material in Headland Park therefore provides a key differentiator in terms of sustainability and intergenerational equity.

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10.0 Remediation Works Overview

10.1 General Works Program Overview

The following sections do not include consideration of planning requirements which are described in **Section 2.0**. It is anticipated that planning activities will be commenced in parallel with the Site Data Gap Investigation program and preparation of this RAP. The planning process will necessarily be concluded prior to execution of the full scale remediation works.

As described by Section 3.2, the proposed development plans are is still to be finalised and so may be subject to adjustment and change. Consequently, this may affect the nature of the proposed remediation works described herein and how these works are staged across the Site. Notwithstanding, the proposed land uses (that is a mixture of commercial and high density residential and public open space overlying extensive basements) will remain generally consistent with that described this RAP.

10.2 Project Schedule

The proposed remedial works at the Site will be scheduled under the following tasks:

- Approvals process, including concept, project and development approval;
- Preparation of a RAP addendum documenting:
  - The final remediation extent based on the 'in-situ SSTCs' developed by the HHERA (being completed as an outcome of the Blocks 4, 5 and Southern Cove DGI).
- In-situ characterisation / validation of fill materials to be excavated will be undertaken prior to the commencement of excavation and based on the final Stage 1 development plans. Additional samples will be located to address data gaps remaining following the DGI (AECOM, 2010). Field observations of odour and visual appearance will be correlated with analytical data to facilitate visual confirmation of materials characterisation as they are excavated;
- Preparation of a RWP:
  - Reiterating the extent of remediation established based on the HHERA; and
  - Documenting the outcomes of the stabilisation treatability trials (being completed as a precursor to the Blocks 4, 5 and Southern Cove RAP) and the resultant treatment strategy;
- Site Establishment and construction of treatment plant;
- Excavation and treatment (as required);
- Tracking of all excavated materials in accordance with the Materials Tracking Procedure (refer to **Section 12.7.2**);Validation (progressive and concurrent with remediation excavation and treatment) to demonstrate compliance with the requirements of this RAP and the Headland Park RAP (in the case of materials to be beneficially reused in Headland Park);
- Reporting;
- Decommissioning and demobilisation; and
- Groundwater monitoring and assessment of groundwater CoC concentrations against the SSTC in accordance with the GMP to be prepared for the Site (refer to **Section 16.3.2**).

10.3 Remediation Works

Summary detail of the proposed remediation works to be completed is provided following:

- In-situ characterisation sampling of fill materials to be excavated will be undertaken prior to the commencement of excavation to supplement the DGI results (refer to **Section 16.2.1**) and facilitate the identification of CIM hotspots (by comparison to the HHERA 'in-situ SSTCs') and determine the materials suitability (by comparison to the HHERA 'reuse SSTCs' and criteria established by the BDA for Headland Park, as applicable):

  - For beneficial reuse within the Public Domain without treatment;
  - For beneficial reuse within the Headland Park and/or other areas of Barangaroo without treatment; or
  - For beneficial reuse within the Headland Park following treatment.
- If the presence of CIM is confirmed based on the process detailed in **Section 5.3.2** and **Figure F10** and described above:
  - Selective excavation of CIM in parallel with the broader excavations required for the development basement excavations;
  - Selective over-excavation of CIM in addition to the excavation requirements of the development basements (if required); and
  - Confirmation of the presence of CIM based on visual and olfactory observations during excavation.
- Physical separation of recyclable and oversize material, including timber, rock, concrete, steel and brick from contaminated material;
- Ex-situ stabilisation or solidification of CIM as required to facilitate beneficial reuse in the Headland Park or the Public Domains. Based on the available information, the contamination in Blocks 2 and 3 and the Public Domain are primarily related to TPH (C_{10}-C_{36}) and PAH impacts with some BTEX impacts. Selection of appropriate additives and additive rates will be the subject of the stabilisation treatability trials being completed as a precursor to the Blocks 4, 5 and Southern Cove RAP;
- Tracking of all excavated materials in accordance with the Materials Tracking Procedure (refer to **Section 12.7.2**);
- Transfer of material, including material characterised as being suitable for containment within the Headland Park both with and without treatment, for subsequent placement within Headland Park;
- Where required, material determined as unsuitable for re-use on Headland Park or other areas of Barangaroo (for example tar containing material or treated tar containing material) will be disposed off-site to a landfill licensed to accept the waste;
- Validation (progressive and concurrent with remediation excavation and treatment) to demonstrate compliance with the requirements of this RAP and the Headland Park RAP (in the case of materials to be beneficially reused in Headland Park); and
- Groundwater monitoring and assessment of groundwater CoC concentrations against the SSTC (refer to **Section 16.3.2**).

11.0 Site Establishment

11.1 Work to be Completed Prior to Site Establishment

Prior to site establishment, all plans, programs, licences, certificates and other documents necessary for the commencement of work will be completed. These documents will include, but not be limited to the following:

- Management Plans and Work Procedures for the remedial program for:
  - Remedial Work Plan (to be prepared by AECOM);
  - Occupational Health and Safety (OH&S);
  - Environmental Management;
  - Project Management;
  - Quality Management; and
  - Emergency Response and Contingency.
- Detailed work program and logic diagram;
- All necessary licences and approvals from regulatory authorities;
- Submission of all WorkCover Authority notifications;
- Additional in-situ characterisation of fill materials to be excavated (refer to **Section 16.2.1**);
- Commissioning and Mobilisation of Plant; and
- Utilities and Recourses.

11.2 Site Preparation

Works to be undertaken prior to remediation works include:

- Establishment of site offices;
- Demolition of existing structures and removal of concrete pavements.
- Installation of groundwater control walls, where required;
- Establishment of exclusion zones; and
- Establishment of the Remediation Enclosure (RE) (if required, refer to **Section 13.1**) and Ex-situ Treatment Facility.

11.3 Site Facilities and Procedures

Site facilities required for the remediation works will be established in compliance with the relevant regulations. These facilities will be connected to appropriate utilities as required. All connections and reticulations will be carried out by licensed and qualified personnel in accordance with statutory requirements and standards.

The following facilities will be established for the Remediation Works at the Site:

- Ex-situ treatment facility;
- Remediation Enclosure (RE) for the management of CIM excavations at the Site; and
- Emissions Control Systems (ECS) for the RE and ex-situ treatment facilities.

It is intended that the ex-situ treatment facility will be established in a central location; likely situated on Block 5 or the associated Public Domain. Material excavated from the Site requiring treatment will be transferred to this facility.

Other activities for the set-up of site offices adjacent to the RE, fencing, decontamination stations, environmental control measures and other associated facilities include:

- Wheel wash zones at the entrance and exit points to the RE;
- Stores, work sheds, lunchrooms and changing areas for the use of subcontractors and consultants;
- Temporary site sheds, first aid and emergency facilities, bathroom facilities and decontamination units, and
- Any additional site facilities to facilitate work in other areas of the Site, or in areas requiring additional safety measures.

11.3.1 Exclusion Zone

Exclusion Zones are areas of the Site that will be outlined in the occupational health and safety plan (OHSP) that either require additional protective measures or may require the adoption of additional OH&S requirements and work practices. Exclusion Zones may also include other areas affected by emissions from the works being undertaken at any point in time. All Exclusion Zones will incorporate a buffer area along the boundary of the zone.

The boundaries of the Exclusion Zones will be defined by fencing and safety signs erected at regular intervals around each exclusion zone warning of the boundary of the exclusion zone, the nature of the hazard associated with it and access restrictions that apply for entry into the zone. Access of personnel into and out of the Exclusion Zones, will be controlled at a Decontamination Station, and will depend on the personnel classification. The location and extent of Exclusion Zones will be detailed in the OHSP and outlined in the Site-Specific Safety Induction.

The Ex-situ treatment facility and RE will be nominated as an Exclusion Zone at the Site.

11.4 Site Access and Security

11.4.1 General

Only authorised personnel and equipment will be allowed into the exclusion zones and other areas associated with the remediation works. Access will be strictly controlled throughout the course of the remediation works using the following procedures.

11.4.2 Site Haul Roads & Parking Areas

Existing concreted areas will be utilised as haul roads to the extent practicable. Traffic movements on-site will be directed around areas that are the subject of remediation works.

11.4.3 Site Access

The primary access route to the Site will be either via Hickson Road or Lime Street gate located on the southern site boundary (to be confirmed as part of the application process and determined as part of the site staging). The entry point will control access to and around the Site during the remediation works.

All site personnel entering and leaving the Remediation works will be required to pass through the clean/dirty zone and the decontamination station.

11.4.4 OHS Signage

Signage will be installed at the site entrance detailing the location of the site offices, Remediation works, decontamination units, first aid facilities and parking. Traffic restrictions will be installed to limit access further into the Site to the north and ensure the safety of site visitors.

Signage at the main gate will include after hours contact details.

As detailed in **Section 11.3.1**, additional signage will be erected along Exclusion Zone boundaries to restrict access to these areas to authorised personnel only.

11.4.5 Fencing

Security fencing will be established around the remediation works areas. Additional fencing will be erected where necessary to secure portions of the Site.

11.4.6 Control of Site Entry and Exit

Entry to any designated remediation works areas will be controlled through the use of a sign-on/sign-off log system at the main gate. Only authorised personnel will be allowed into the remediation works area.

Personnel will gain access to the remediation works area only after they have:

- Attended and completed a site safety induction briefing (applicable to all site workers and visitors);
- Are wearing all applicable PPE as detailed in the OHSP; and
- Been inducted into the OHSP.

All construction vehicles and delivery vehicles will enter the Site through the nominated main gate.

In the event of an emergency on-site and the need for emergency services personnel to access the site works, the site access process may be expedited. In these situations, which require the need to minimise delays in accessing injured site personnel, prior arrangement will be made for special site access procedures. However, given the nature of the remediation works, all PPE and decontamination protocols will remain in effect at all times.

An Emergency Response Plan will be developed prior to site establishment detailing the specific procedures relating to site emergencies.

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12.0 General Remediation Excavation and Materials Management

12.1 Background

This section addresses works associated with the excavation of CIM in Block 2, Block 3 and the Public Domain as determined by:

- comparison of additional in-situ characterisation / validation investigation (as discussed in **Section 7.1**) and the DGI results to the SSTCs developed by the HHERA (as detailed in **Section 6.3**);
- comparison of the additional in-situ characterisation sampling of fill materials (as discussed in **Section 16.2.1**) with the SSTCs developed by the HHERA (as detailed in **Section 6.3**); and
- visual and olfactory observations during excavation.

Any CIM that requires treatment will be transferred to the central treatment facility and treated in accordance with the processes outlined in **Section 13**.

The following general remediation excavation and material management activities are described as part of the following sections:

- Site establishment and disestablishment;
- Control and minimisation of emissions from the excavation area;
- Control and treatment of water from the remedial excavations;
- Excavation of the CIM; and
- Loading of excavated materials for transport.

12.2 Pre Treatment of Materials

Prior to excavation of materials, some preparation and pre-treatment of material may be necessary as summarised in **Section 12.7.3**.

12.3 Excavation Planning

The materials to be excavated comprise heterogeneous fill materials, soil, bedrock, as well other potentially gas works related waste (for example ash). Therefore, prior to commencement of excavations, detailed excavation plans will be prepared outlining the anticipated classification of materials based on the additional in-situ characterisation sampling of fill materials (refer to **Section 16.2.1**) and the results of the preceding DGI. Correlations between field observations (both visual and olfactory) and analytical data will also be used to guide the visual characterisation of fill materials during excavation.

All remediation excavation works will be undertaken in accordance with the following procedures, in sequence:

- Prior to commencement of excavations on each work shift, all necessary environmental, OH&S measures and related equipment will be established and all worker PPE and respiratory controls will be checked to ensure they are in full working order in accordance with the OH&S Management Plans;
- All excavation plant operators, haulage operators and supervisors will be made familiar with the excavation strategy, and all workers will be made aware of their responsibilities prior to the commencement of each shift;
- Stockpile areas will be prepared with adequate capacity to receive the contaminated materials after excavation prior to the commencement of excavation;
- Exclusion zones will be set up around the active remediation works areas and as required;
- All truck haulage roads will be made suitable for transportation and haulage of the excavated materials;
- All haulage trucks will be covered prior to exiting the exclusion zone/excavation area and will be decontaminated at the end of each shift of haulage operations in accordance with the environmental

management plan (EMP). All haulage trucks will be fitted with liquid seals which will be inspected daily to ensure their integrity; and

- All personnel, vehicles and equipment leaving the excavation enclosure will be properly decontaminated in accordance with the EMP.

12.4 Excavation Operations

Where PIM are identified to be present, excavation operations will commence by the removal of unimpacted overburden material. The overlying unimpacted material will be classified based on the preceding in-situ characterisation sampling (refer to **Section 16.2.1** for details of in-situ material classification / validation) and DGI to determine whether it meets the suitability criteria for reuse material and transfer to the Headland Park.

Excavations will be regularly inspected by a suitably experienced environmental engineer or scientist to confirm that the visual and olfactory characteristics of the excavated materials are consistent with expectations. Odorous materials will be managed as per the requirements of **Section 13** and **17.3**. These regular inspections will also serve to identify additional hotspots of CIM that may not otherwise have been identified by the preceding DGI and in-situ characterisation sampling programs.

Any CIM will be removed and kept separate from uncontaminated materials. Depending on the level of contamination in excavated material (relative to the SSTCs developed by the HHERA), excavated CIM will be either transferred to the treatment facility for treatment, or transferred direct to Headland Park.

In the event that material is unsuitable for beneficial reuse it will be designated for off-site recycling or disposal in accordance with **Section 12.7** and **Section 12.8**.

12.5 Dewatering of Excavations

De-watering during the remediation, excavation & construction works will be undertaken. Management of water and groundwater within excavations will be undertaken in accordance with the procedures outlined in **Section 14.0.**

12.6 Excavation Support

As part of the bulk earthworks for the excavation of the basements required by the proposed masterplan, permanent secant through slurry trench wall and diaphragm walls will be installed around the proposed excavation area.

In particular:

- A permanent secant through slurry trench wall is proposed along the southern and eastern (Hickson Road) boundaries of the Site where rock depth is understood to be relatively shallow. This wall will be approximately 500 mm to 800 mm wide (depending on design load requirements) and will be keyed into the underlying rock. The walls will be designed to be generally impervious to liquids, with controlled infiltration and provision for collecting/extracting any minimal seepage; and
- A diaphragm wall is proposed for the western (along Darling Harbour) and northern boundaries of the Site. The wall will be constructed of concrete and steel reinforcement bars, and water bar details between the diaphragm wall sections. The wall will be approximately 600 mm to 1,000 mm wide (depending on design load requirements) and will be keyed into the underlying bedrock. As per the secant slurry wall, the diaphragm wall will be designed to be generally impervious to liquids, with controlled infiltration and provision for collecting/extracting any minimal seepage.

Final wall structure details and the basement layout will be finalised during the detailed design phase of the project so may be subject to adjustment and change.

12.7 Materials Handling

12.7.1 Background

This section outlines the procedures for materials handling following excavation, specific procedures relating to materials tracking and the required environmental controls.

12.7.2 Materials Tracking

All materials handled during the remediation works will be tracked in order to allow verification of the correct movement and handling. The system will track materials from cradle-to-grave, and will provide detailed information on the location and quantity of all material movements both on and off-site, so that the material being handled can be identified and accounted for. The tracking system shall include accurate tracking of stockpiles throughout the entire material handling stage and will included confirmation of stockpile locations via registered survey. This is to reduce the risk of cross-contamination between stockpiles.

As part of this process, accurate records shall be kept to ensure that backfilling of excavations (where required) and beneficial reuse of material only occurs following the successful validation of the subject materials. Plans will be made with respect to the extent of each excavation. A register of all analytical results for stockpiles and excavations will be maintained throughout the validation works.

Standard forms shall be prepared as part of the Materials Tracking Procedure, the details of which will be developed collaboratively between LL and the BDA and included in the RWP. The forms and their function shall include, but not be limited to:

- **Off-site Transport/Disposal Form** - Providing a record of materials removed from the Site and including the material type, quantity, origin, shipping destination and an approval by the nominated environmental consultant that the material meets the disposal requirements;
- **Imported Fill Form** - Providing a record of materials imported to the Site including the date, material type, quantity, point of origin, intended use and the suitability of the material for use as backfill at the Site;
- **Material Excavation Form** - Providing a record of excavated materials for each excavation on the Site including the date, material type, excavated quantity, origin and intended destination;
- **Material Treatment Form** – Providing a record of material treatment including the date, material type, treatment regime, stockpile of origin and destination stockpile;
- **Material Stockpiling Form** - Provides a record of all materials placed in stockpiles. The form will include the date, material type, stockpiled quantity, origin and intended end use; and
- **Material Placement Form** - This form provides a record of all materials backfilled on the Site and includes the date, material type, quantity backfilled and origin.

Each form shall be completed on a weekly basis and collated into a cumulative log for each process on a weekly basis.

12.7.3 Material Preparation

Excavated materials may require preparation prior to transport to stockpiles and the on-site ex-situ treatment facility.

Material preparation may include, but not be limited to:

- Mixing of saturated material in-situ to make the material spadeable prior to excavation. This may be achieved by either mixing with other soils or by addition of fly ash, lime or cement;
- Drainage and drying of saturated excavated materials. This will require installation of appropriate measures to control run off; and
- Screening of material to separate oversize and/or materials suitable for recycling (e.g. steel, concrete footings/historic sea walls, brick and rock fill, timber piles, construction and demolition waste). Physical separation will be achieved by a combination of:

- Manual separation using excavators fitted with grabs or skeleton buckets; and
- Power screens.

Odorous materials will be managed as per the requirements of **Section 13** and **17.3**.

12.7.4 Crushing/Shredding of Materials

The crushing of oversize excavated materials may be necessary to ensure that the excavated materials can either be reused on-site or can be treated in the ex-situ treatment facility.

12.7.5 On-site Transportation of Materials

Materials at the Site will be excavated, handled, moved, treated and stockpiled in a manner designed to minimise exposure to the environment. The following materials handling requirements will be developed for trucks transporting materials within the Site:

- Trucks carrying excavated materials will be covered and decontaminated in the wheel wash facility within the excavation area before exiting the area;
- Trucks will proceed directly to the on-site ex-situ treatment facility or soil stockpile area, as appropriate, along the predetermined haul roads;
- Trucks carrying contaminated materials will not be permitted to drive over areas of the Site which have previously been excavated, validated or reinstated;
- Trucks carrying contaminated materials will remain covered until authorised to unload within the on-site ex-situ treatment facility. The trucks will be decontaminated at the on-site ex-situ treatment facility and the truck body covered before exiting the area;
- Empty trucks will return directly to the excavation are along predetermined haul roads; and
- The validated excavation will be effectively isolated from contaminated areas of the Site by the use of physical means such as the placement of clean material bunds, temporary fences and by use of signage.

12.7.6 Off-site Transportation of Materials

The following materials handling requirements will be developed for trucks transporting materials off the Site:

- Trucks carrying excavated materials will be covered and decontaminated in the wheel wash facility before exiting the excavation area and exiting the Site;
- Trucks carrying contaminated materials will be covered prior to exiting the Site and will remain covered until authorised to unload at the destination;
- Trucks will be fitted with seals to ensure that the movement of potentially saturated materials is undertaken appropriately. The integrity of the seals will be inspected and tested prior to commencement of each day's haulage works; and
- Trucks will exit the Site through predetermined exit points and will follow a predetermined transport route to the destination (landfill or other).

12.7.7 Stockpiling of Materials

Stockpile Locations

Treated and validated soil materials will be stockpiled within a designated stockpile area. The stockpiled soil will then be transported directly from the stockpile area to the designated Headland Park stockpile area and/or other areas of Barangaroo for placement and compaction as backfill (as appropriate). The location of stockpiles will be confirmed via GPS as part of the Materials Tracking System.

Where possible, in-situ testing of material may be undertaken prior to excavation, to pre-classify materials and minimise interim stockpiling requirements.

It is assumed that an area within the Headland Park will be available for any acceptable material supplied from Stage 1 for future use by BDA on Headland Park and/or other areas of Barangaroo.

Stockpile Area Preparation

During site establishment, stockpile areas will be prepared using the following methods:

- Noting that the majority of the Barangaroo Stage 1 Development site is covered by an existing hardstand surface, works will be undertaken initially to clear the area of rubbish, rubble, structures and vegetation;
- Diversion drains and bunds will be constructed around the perimeter of the stockpile areas. Additional sediment and erosion control measures including silt fencing and hay bales will be installed where necessary;
- Signs will be erected at the entrance to the stockpile area and at locations around the stockpile specifying individual stockpile numbers and the type of materials stored; and
- Buffer zones will be established around each stockpile area to enable access to the stockpiles and minimise impacts of the stockpile area on the surrounding facilities.

Stockpile Construction and Maintenance

The drainage, sediment and erosion control measures installed within stockpiling areas at the commencement of the project will be maintained, repaired and replaced where necessary for the duration of the stockpiling activities. Where necessary, all long term soil stockpiles on-site will be covered or stabilised with spray grass seeding or other suitable measures to reduce dust generation and erosion.

All stockpiles will be maintained in a tidy and safe condition with stable batter slopes.

12.7.8 Classification of Treated Materials

Following treatment of materials on-site, the materials will be assessed for their suitability for beneficial reuse in accordance with the SSTCs established by the HHERA.

Where materials are deemed not suitable for on-site reuse the material will be classified for off-site disposal.

12.7.9 Classification for On-site Reuse

Stockpiled and treated material will be assessed for its suitability for beneficial reuse by collection of representative samples and chemical analysis for the CoC for associated with the site.

Where possible, in-situ testing of material may be undertaken prior to excavation, to pre-classify materials directly for on-site reuse and minimise stockpiling requirements.

The analytical results will be assessed against the SSTCs which will be derived from the HHERA for the beneficial reuse of materials within the Headland Park and/or other areas of Barangaroo.

12.7.10 Waste Classification For Off-site Disposal

Materials deemed not suitable for reuse as part of the Barangaroo Development will be assessed for off-site disposal in accordance with the DECC NSW Waste Classification Guidelines Part 1: Classifying Waste, April 2008 (DECC, 2008) or Part 4 of those guidelines in the case of potential acid sulphate soils (PASS) and acid sulphate soils (ASS).

Where possible, in-situ testing of material may be undertaken prior to excavation, to pre-classify materials directly for off-site disposal and minimise stockpiling requirements.

12.8 Material Fate

12.8.1 Recycling

LL will aim to maximise recycling of all excavated materials. Where possible, materials won from the screening of excavated materials will be assessed for their recycling suitability as follows:

- Steel materials will be transported to appropriate off-site steel recyclers;
- Concrete, brick and rock may be crushed to create fill for use in other areas of the development (as required) and for construction of haul roads or recycled off-site; and
- Timber will be recycled off-site, where possible.

12.8.2 Beneficial Reuse of Materials On-site

Materials deemed suitable for beneficial reuse will be either stockpiled for future use or used for reinstatement in remediated areas, such as under roads as appropriate.

12.8.3 Stockpiling

Materials to be used for future reinstatement (e.g. within Headland Park and/or other areas of Barangaroo) will be stockpiled and managed separately. AECOM understands that an area within the Headland Park will be available for any stockpiled material supplied from Stage 1 Development for future use by BDA on Headland Park and/or other areas of Barangaroo to minimise stockpiling requirements.

12.8.4 Reinstatement

Where material is used for reinstatement purposes, the material will be placed in accordance with specific geotechnical requirements which will be dependent on the area of reinstatement (e.g. parks, roads, under buildings). The geotechnical requirements will be determined as part of the Technical Specifications for the Development.

12.8.5 General Solid Waste

If off-site disposal is required, materials classified as General Solid Waste in accordance with the Waste Classification Guidelines (DECC, 2008) will be transported off-site and disposed of at a landfill licensed to accept Solid Unrestricted Waste.

12.8.6 Restricted Solid Waste

If off-site disposal is required, materials classified as Restricted Solid Waste in accordance with the Waste Classification Guidelines (DECC, 2008) will be transported off-site and disposed of at a landfill licensed to accept Solid Restricted Waste.

13.0 Remediation

In addition to the general excavation and materials management outlined in **Section 12**, any works related to the remediation of CIM at the Site will be subject to particular controls due to the nature of the contamination.

This section outlines the proposed additional controls that will be implemented to manage materials that require treatment at the Site as well as outlining the proposed methodology.

13.1 Remediation Enclosure and Emissions Control System

Part of the proposed odour management system for works will include a remediation enclosure (RE) and emissions control system (ECS) to be used, where practical, during excavation of particularly odorous areas or areas where it is anticipated that fugitive emissions will be significant (i.e. during excavation of significant zones of gasworks waste at the Site). It is anticipated that a RE would not be required for the excavation of hotspot areas within Block 2 and the Public Domain.

Given the potentially odorous nature of the materials to be excavated at the Site, significant 'source' material excavation works (for example those required in relation to Zone 1 in Block 3 – refer to **Section 7.2.3**) will be undertaken within a RE, where practical. The purpose of the RE will be to mitigate, to the extent practical, uncontrolled emissions during excavation and truck loading processes and to ensure these emissions are vented to atmosphere through an ECS.

It is noted that a RE may not be practical in all excavation areas, particularly in areas where CIM has been identified in a series of discontinuous hotspots. In the event that a RE is not considered practical, additional, alternative rigorous odour control measures will be implemented as described by **Section 13.2**.

Operation of the RE and associated ECS will be in accordance with operation and maintenance management systems developed on completion of the final design of the system. An overview of the controls to be designed into the system is provided below.

- The RE will be a temporary structure that can be erected over relevant parts of the CIM excavation area. The final design of the RE will be developed prior to the start of the remediation works. The structure is likely to include a negative pressure working enclosure with an air-lock doorway and an air extraction system for the control of odours and diesel exhaust.
- Where practical, excavations for remediation of identified CIM will be undertaken within the RE. Excavated material will be placed into stockpiles within the RE by use of tracked excavator and a rubber tyred loader. The structure will be equipped with personnel entrances and a truck entrance. The truck entrance will comprise an automated door to minimise any impact on negative air pressure whilst the truck exits and enters the RE. The negative air pressure will be maintained for the duration of the excavation works.
- The ECS will consist of a ductwork system, induced draft fan, particulate control device, activated carbon adsorption system and stack. The ECS would be designed with sufficient capacity to provide a safe working environment within the RE. The ductwork system will consist of a central header that will be suspended along the centreline of the RE. There will be hoods located along the length of the header.
- The air exhausted from the RE will first pass through a particulate control device (bag-house or pleated paper filter system) to remove fugitive dust. The particulate control system will include a system to remove particulates from the filter media. Dust removed will be collected in enclosed drums or hoppers.
- After the exhaust gas exits the particulate filter, it will pass through an activated carbon adsorption system. The activated carbon system will be equipped with a number of monitoring ports. A monitoring protocol will be developed for the various ports along the activated carbon adsorption system. This protocol will form the basis for deciding when activated carbon beds need to be replaced. Air would be exhausted to the atmosphere via a stack.

13.2 Excavation Operations

To the extent practical, excavation of CIM will be conducted within a RE. As above, the plant operating within the RE is likely to comprise a tracked excavator and a loader for excavation, interim stockpiling and truck loading purposes.

Excavation operations will commence by the removal of the unimpacted overburden material. The unimpacted overburden material will be classified based on the preceding in-situ characterisation sampling and DGI to determine whether it meets the SSTCs for beneficial reuse established by the HHERA.

It is anticipated that, to the extent practical, materials will be excavated as follows:

- Non-odorous materials will be excavated outside the RE and managed using appropriate environmental control measures;
- Slightly odorous materials classified for potential beneficial reuse will also be excavated outside the RE and managed using appropriate environmental control measures including appropriately covering at the end of each day's earthworks; and
- Odorous materials, particularly those classified as requiring onsite treatment prior to beneficial reuse, will be excavated and managed within the RE before transfer to the onsite treatment facility by truck.

As above, it is noted that a RE may not be practical in all excavation areas where odorous materials are encountered. For example, in areas where CIM has been identified in a series of discontinuous hotspots. In the event that a RE is not practical, additional and/or alternative rigorous odour control measures will be implemented over and above the environment control measures provided during excavation of non-odorous and slightly odorous materials. Additional measures may include: minimisation of exposed excavation surfaces, limiting excavation to favourable weather conditions; and the use of odour suppressants and covers.

13.3 Treatment Operations – Ex-situ Stabilisation

13.3.1 Background

As detailed in **Section 9.0**, ex-situ stabilisation is the preferred remedial technology for CIM which requires treatment prior to beneficial reuse within Headland Park and/or other areas of Barangaroo.

This section describes the methodologies to be employed for preparing and treating the nominated materials using ex-situ stabilisation. The suitability of ex-situ stabilisation is being assessed via treatability trials currently being prepared as part of the Blocks 4 to 5 RAP and may be applicable for treatment of materials from the Site.

13.3.2 Pre-Treatment of Materials

The pre-treatment of CIM, if required, will be undertaken in two stages. Initially, the excavated material may be blended at the excavation face to make the material 'spadeable' (as detailed in **Section 12.7.3**). CIM requiring treatment prior to beneficial reuse will be transported to the Ex-situ Treatment Facility, where further screening and testing of this material will take place.

The CIM will be stockpiled in the ex-situ treatment facility using a front end loader before undergoing secondary screening through a powerscreen to achieve a grade of 40 mm minus. This is the minimum size requirement for material to feed into a pug mill. All screened overburden material will be set aside into type for potential crushing/recycling. The powerscreening of the contaminated material will achieve a relatively homogenous feed material prior to being loaded into the feed hopper of the pug mill and minimise the quantity of material which requires treatment.

13.3.3 Ex-situ Treatment Facility and Emission Control System (ECS)

The ex-situ treatment facility will be enclosed within a Remediation Enclosure (RE). The purpose of the RE is to control emissions during remediation treatment activities and ensure these emissions are vented to atmosphere through an ECS. Operation of the RE and associated ECS will be in accordance with operation and maintenance management systems developed on completion of the final design of the system. An overview of the controls to be designed into the system is provided below.

- The RE will be a clear span shed constructed of a steel frame with metal sheeting (or equivalent). The building will be sized to contain the powerscreen and pugmill and have sufficient room for truck access, machinery and stockpiles. It will include doors, lights, electrical, adjustable louvers and other ancillary facilities that are required for safe and efficient operation.
- The building will contain approximately a 2-3 day working inventory of feed soil plus a sufficient buffer for soil curing and other pre-treatment activities. This inventory volume is designed to provide adequate storage capacity to feed the treatment plant during periods when unforeseen conditions interfere with normal excavation activities.
- ECS will consist of a ductwork system, induced draft fan, particulate control device, activated carbon adsorption system and stack. The ECS would be designed with sufficient capacity to provide a safe working environment within the RE. The ductwork system will consist of a central header that will be suspended along the centreline of the RE. There will be hoods located along the length of the header.
- The final design of the RE will be developed prior to the start of the remediation works. The structure is likely to include a negative pressure working enclosure with an air-lock doorway and an air extraction system for the control of odours and diesel exhaust.
- The air exhausted from the RE will first pass through a particulate control device (bag-house or pleated paper filter system) to remove fugitive dust. The particulate control system will include a system to remove particulates from the filter media. Dust removed will be collected in enclosed drums or hoppers.
- After the exhaust gas exits the particulate filter, it will pass through an activated carbon adsorption system. The activated carbon system will be equipped with a number of monitoring ports. A monitoring protocol will be developed for the various ports along the activated carbon adsorption system. This protocol will form the basis for deciding when activated carbon beds need to be replaced. Air would be exhausted to the atmosphere via a stack.
- The ECS for the RE will operate in the same way as the system for the RE, as described in **Section 13.2**.

13.3.4 Pug Mill Treatment Plant

Ex-situ stabilisation of contaminated soils during the full scale remediation phase is intended to be accomplished by using a pugmill fed by a loader/excavator. The nature and quantity of agents used for stabilisation will be the subject of a stabilisation trial. The pugmill mixing chamber and computer controlled weight cells will allow the complete mixing of the additives with the soil matrix. A pugmill has been selected in recognition that the DECCW prefers aggressive mixing techniques (such as a pugmill) because they provide for complete mixing of the materials.

These analysis results will be used to demonstrate that the treated material is suitable for either:

- Placement/containment in Headland Park; *or*
- Disposal to an appropriately licensed off-site landfill (in accordance with DECCW)

Pug mill plants typically have a rated capacity of 600-1,000 tons per hour. This rate will vary depending on the physical properties of the soil, amount and type of additive, and the desired production rate.

The type of treatment plant will be based on the final design by the treatment contractor. Below is a description of the potential major components that may comprise a plant system.

Self-erecting Silo

The silo is filled pneumatically from bulk tankers. Additives such as cement, fly ash, lime and bentonite are blown into the silo. The silo is equipped with a dust control system.

Material feed hopper

This hopper is fed with the soil(s) to be processed. It may be divided so as to accommodate two types of soil or aggregate. The hopper and may be fed one of three ways. First, a front-end loader can feed the hopper directly by building a ramp perpendicular to the hopper. Second, material may be conveyed into the hopper. Third, a screen can process directly into the hopper.

Twin shaft paddle pugmill

The pugmill is designed to achieve a violent mixing action throughout its length resulting in a well mixed homogeneous product. This type of mixing, with no slump or low moisture products, is more effective than a drum type mixer that merely folds the product.

Hydrostatic cleated belt additive feeder

The additive is fed to the pugmill at the beginning of the mixing operation by means of the computer controlled cleated belt. Accuracies of better than plus/minus 2% of the design proportioning of the additive are achieved.

Water tank

The water requirement is determined by the mix design and the native water in the material to be mixed. Water is fed from an outside source into the plant's onboard water tanks. This water is fed at the design rate into the mixing chamber by two hydraulic pumps which are computer controlled.

Discharge belt

The mixed product is discharged from the pugmill on this conveyor belt. The finished product is continuously and cumulatively weighted on a Ramsey belt scale.

Gob Hopper

The gob hopper is utilized to interrupt the continuous flow of mixed material allowing trucks to enter and exit the loading area. If trucks are used to transport the mixed material away from the plant, the direction of travel of the trucks should be with the driver's side closest to the plant so that he/she may see the plant operator. The gob hopper maybe left open continuously so that a conveyor may be used to remove the finished product from the mixing plant.

Particulate Additive

Fine particulate additives such as cement, fly ash, lime and bentonite are pneumatically transferred from bulk tankers and stored in the self erecting silo. If more than one type of additive is required, an optional self erecting auxiliary silo may be set up next to the plant. The silos are equipped with negative pressure dust control systems, which filter and evacuate the pressurized air entering the silo. This process maintains constant silo pressure so as not to affect the consistency of the feeder.

Mixing Chamber

All ingredients enter simultaneously at the beginning of the mixing chamber allowing them maximum mixing time. The mixing chamber houses an interlaced twin shaft variable speed paddle pugmill designed to achieve a violent mixing action throughout its length resulting in a well-mixed homogeneous product. This type of mixing, with no slump or low moisture products, is greatly more effective and efficient than a drum type mixer that merely folds the product.

Control System

The Programmable Logic Controller and colour active matrix Operator Interface is directed by control software. Designed for harsh industrial environments, this versatile and reliable system has extensive self-diagnostics and is completely modular, making diagnosing and repairing problems as easy as plugging in a new module.

The software provides fully automated plant control and monitoring of all plant systems including engine, flow meters, sensors and switches. Displays indicate all flow rates, set points, feeder speeds, totals and status of all feeds and processes. All critical mechanical systems are monitored to alleviate damage and prevent down time. Inventory of fine particulate and admixture are computed and tracked.

13.3.5 Treated Soil

The RE will have a base capacity to stockpile between 2-3 days of treated soils from the pug mill. Treated materials stored in this area will undergo validation testing and classification to determine whether the treatment process has been effective. Materials that have not been treated to an acceptable level will be retreated.

Stockpiles would be then moved outside of the RE to a main stockpile area. This location (to be identified) will preferably be adjacent to the Headland Park where the majority of the treatment materials are proposed to be placed. Where required, stockpiles will be covered with suitable material or wetted to control dust.

13.4 Alternative Treatment Option – Surfactant Enhanced Ex-situ Chemical Oxidation

As an alternative treatment option (if required), surfactant enhanced ex-situ chemical oxidation (S-ESCO) will be considered for the treatment of excavated CIM. The technology is currently being assessed as part of the treatability trials for Blocks 4, 5 and the Southern Cove and, based on the findings of those trials, may be assessed as an alternative treatment strategy. The final treatment option will be detailed in the RWP.

Chemical oxidation converts hazardous contaminants to non-hazardous or less toxic compounds that are more stable, less mobile, and/or inert. The oxidizing agents most commonly used are ozone, hydrogen peroxide/Fenton's Reagent (including modified Fenton's Reagent), permanganates, hypochlorites, chlorine, sodium persulphate, and chlorine dioxide. Chemical oxidation has been used on a number of sites to address chlorinated solvents, petroleum hydrocarbons and "by-product like material" (tar) associated with former manufactured gas works plants.

The oxidation process is non-selective and the oxidant is consumed by other organics and inorganics in soil and not necessarily the target contaminant. Excess chemical is therefore required to overcome the inherent soil demand. The success of chemical oxidation is dependent on the permeability of the soil matrix, the ability of the oxidant to be delivered to the identified contamination, the organic content of the soil, and the solubility of the contaminants. These constraints are less apparent in ex-situ applications of chemical oxidation when the excavated soil is mixed and the oxidant (and surfactant as catalyst) are added in a pugmill.

Surfactant enhanced ESCO is an innovative technology which has successfully been implemented at former gas works sites. The process works by dissolving the tar material using a surfactant and then oxidising the resulting tar and surfactant mixture. The key design considerations are: which surfactants and oxidants work best in combination; whether they should be added simultaneously or in sequence; and, what conditions, such as might be provided by the addition of a catalyst, will enhance the reaction. Increasing the heat of reaction also assists in mobilising the contaminants.

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14.0 Management of Water

14.1 Surface Water Management Methods

14.1.1 Surface Water Management from Undisturbed Areas

Surface water management is critical to successful remediation of the Site and reduction of cross contamination issues and to prevent impact to the harbour. Successful management of site water is also essential for materials handling and management.

Surface water flows and stormwater will be managed by segregating clean water from impacted water and preventing the inflow of surface water to excavation areas using surface bunds, silt fences and drainage diversions. The preferred hierarchy for management of water on-site is as follows:

- Minimise volume of contaminated water during the works wherever possible by directing surface water away from excavations, depressions, pits and stockpiles by the construction of drainage works such as bunds and diversion drains. These measures will minimise the flow of clean water into other areas of the Site that contain contaminated materials;
- Recycling water where possible by using on-site as dust suppression for other site operations including wheel washing and truck washing To ensure that the use of recycled water does not impact on surrounding areas, the following data will be obtained prior to undertaking these activities:
  - Chemical data which demonstrates that the water to be recycled complies with the reuse criteria, including consideration of potential for odour generation;
  - Definition of the area where the water is to be discharged;
  - Details of environmental protection measures installed to ensure that the use of recycled water will have no adverse environmental impact; and
  - Appropriate tracking of recycled water reused at the Site.
- Discharge to stormwater or sewer, with or without treatment, as per regulatory guidelines and in accordance with a POEO license and Trade Waste License to be obtained for the project.

14.1.2 Surface Water Management from Disturbed Areas

Clean water will be generated from surface water collected from remediated and undisturbed areas of the Site. Undisturbed surface water runoff will continue to follow existing drainage patterns, unless diversion from active site areas is warranted. Surface water drainage will also be arranged so that surface water run-off from disturbed or contaminated areas does not enter remediated or undisturbed areas.

Clean water will be retained on-site and used to the maximum extent possible for dust suppression. Excess clean water will be discharged to stormwater or sewer in accordance with the discharge conditions for the site. Formal discharge criteria for surface waters will be negotiated with Council and the DECCW as part of the remediation works and likely included as a condition of the POEO license and Trade Waste License for the project. It is anticipated that the discharge criteria will be based on the contaminant concentrations, sediment and turbidity levels of existing surface water runoff from the site.

To assist in the collection of surface waters from undisturbed areas of the site, a sediment basin may be constructed in a suitable location to be determined during site establishment. The location of the basin will be selected to provide for the whole remediation works.

14.2 Groundwater Water Management Methods

Groundwater encountered during excavation (for basements and/or as part of remedial works) will require management. Control walls will be installed to minimise groundwater infiltration into excavations as part of the development, where required. Dewatering and control of groundwater seepages will also be required.

Groundwater collected from the excavations will be transferred to the on-site water treatment plant (where required), prior to discharge to stormwater with appropriate approvals. If required, limited contaminated water may be disposed off-site with use of truck tankers.

14.3 Wastewater Treatment System

A wastewater treatment system will be established for the remediation works and is likely to consist of at least the following process units:

- Pumps and a buffer storage for transferring flows to the plant;
- Dissolved Air Flotation unit for the removal of fats, oils, greases and hydrocarbons which might also include a coagulant and surfactant dosing to assist with solids removal;
- A chemical dosing step to adjust the pH and promote chelation and precipitation of heavy metal complexes;
- Reaction & mixing vessels to facilitate the metals removal process providing flow buffering and adequate reaction times;
- Activated carbon filtration, as required to polish specific residual or trace contaminants from the groundwater and ensure compliance with specific trade waste requirements;
- Sludge handling and/or sludge thickening equipment (or at least a tank, sludge separator) to minimise the residuals that require disposal off-site; and
- Effluent balancing storage (in holding tank) prior to pumping to the transfer sump.

Duty / standby pumps (variable speed drives) control the pumped outflow to the Sydney Water sewerage system or stormwater if appropriate testing is conducted and approvals obtained.

14.4 Groundwater Management

14.4.1 During Remediation

Groundwater monitoring will be undertaken on a quarterly basis during the remediation works to build a robust data set for groundwater quality at the Site and to demonstrate that the continuing remediation works are not having a detrimental impact on the environment.

14.4.2 Post Remediation

Following completion of the soil remediation and validation works (which are focussed on making the Site suitable for the proposed landuse), a groundwater monitoring program will be implemented at the Site to assess whether CoC concentrations in groundwater are consistent the SSTCs established by the HHERA.

Within this context, the objective of the post remediation groundwater monitoring program will be to:

- measure the effectiveness of the remediation works that have been undertaken (specifically source removal and groundwater quality improvement) in terms of protection of the environment; and
- make provision for any necessary management measures (contingency measures) that may be required to respond to the monitoring results. The contingency measures will be detailed in the Post-Remediation Groundwater Monitoring Plan.

To this end, the post remediation groundwater monitoring program will:

- consist of quarterly groundwater monitoring undertaken at groundwater monitoring wells located on the down-hydraulic gradient Site boundary for a period of two years following completion of the remediation works;
- monitor CoC concentrations in groundwater in relation to previously identified results;
- monitor CoC concentrations in groundwater in relation to the SSTCs established by the HHERA; and
- provide for additional risk assessment or contingency planning in the event that the CoCs in groundwater are not consistent with the SSTCs.

Specific details of the post remediation groundwater monitoring program (including the groundwater monitoring network) will be set out in a Post-Remediation Groundwater Monitoring Plan that will be developed prior to completion of the Remediation Work and in consultation with the Auditor.

15.0 Imported Materials

Due to the extent of excavations required for the proposed basements as part of the development, it is expected the requirement for importation of material will be limited. However, material may be required to be imported for use on the Site for uses such as for landscaping for public open space areas.

Materials imported to the Site will be required to meet the environmental and geotechnical requirements specified for the particular end use.

Material imported for use as backfill or capping material at Headland Park will be required to be:

- Virgin Excavated Natural Material (VENM) in accordance with the NSW DECCW Waste Classification Guidelines, Part 1: Classifying Waste (DECC NSW 2008); or
- Excavated Natural Material (ENM) with the Protection of the Environment Operations (Waste Regulation 2005 – General Exemption under part 6, Clause 51 and 51A, July 2008.

The requirements for imported material will be confirmed following completion of the HHERA which will confirm the extent of remediation required, and thus determine if imported material will be required to cap/backfill excavations.

The final RWP for the remediation works will outline the following:

- Requirements for assessing suitability of material for use on the Site;
- Sampling and analytical requirements; and
- Geotechnical requirements.

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16.0 Validation Strategy

This section outlines the proposed validation strategy and protocols required to demonstrate that the remedial action has met the remediation objectives. The proposed validation strategy may be altered/refined depending on the findings of the HHERA.

16.1 Validation Principles

All soil materials to be retained on-site or reused at Headland Park and/or other areas of Barangaroo must comply with the SSTCs (as discussed in **Section 6.3**).

The HHERA will include advice on the method for implementation of the SSTC, including:

- A statistical approach to remedial validation with respect to large excavations;
- The SSTC approach to isolated pockets of contamination; and
- Approaches to exceptions to the SSTC such as in the case of residual tar impacted rock fractures.

The sampling and analysis program proposed to demonstrate compliance with the SSTC described by the HHERA is described below.

It is anticipated that the HHERA will prescribe that validation data will assessed in accordance with the *National Environment Protection* (Assessment *of Site Contamination) Measure*, *National Environment Protection Council, 1999*. This will involve demonstrating that:

- the 95% Upper Confidence Limit (UCL) of the mean concentration is less than the adopted SSTC for all CoPCs;
- each individual sample concentration does not exceed the adopted SSTC by more than 2.5 times; and
- the standard deviation of the sample set, is not more than 50% of the adopted SSTC.

The above criteria will be applied separately to the excavation walls where there is insufficient analytical data for the fill materials in that area. This may apply to the fill materials located within the Site but outside the footprint of the eventual basement excavations and where residual fill materials will remain (i.e. beneath the Public Domain, refer to **Figure F3**). This will also apply if different strata (i.e. fill materials, natural soils and bedrock) are observed to be present in the retained material. Consequently, the analytical data obtained from the validation of residual material retained below the excavation base and behind excavation walls will be assessed separately as per the requirements of the *National Environment Protection* (Assessment *of Site Contamination) Measure*, *National Environment Protection Council, 1999*.

16.2 Soil Validation

Validation of soil will be undertaken at various stages prior to and during the Remediation Works to assess the soil against the SSTC which will be derived from the HHERA (refer to **Section 6.3**).

Materials that will require validation sampling will be as follows:

- In-situ characterisation / validation of fill materials in parts of the Site to be excavated as part of the development and where there insufficient data currently available from the DGI;
- Validation of excavation base and walls (i.e. material that will remain in-situ at the completion of the bulk excavation works);
- Validation of materials to remain in-situ outside the proposed excavation footprints;
- Validation of excavated materials for reuse onsite (i.e. the Public Domain); and
- Validation of treated materials for reuse at Headland Park and/or other areas of Barangaroo.

The Site Auditor will be invited to undertake regular site inspections during the excavation works.

16.2.1 In-situ Characterisation / Validation of Fill Materials

Fill materials to be excavated will be characterised / validated in-situ prior to excavation based on a combination of:

- Analytical results from the DGI (AECOM 2010) and where there is insufficient data available from the DGI; and
- Additional samples collected from test pit and soil bores.

In-situ characterisation / validation samples will be collected at a frequency of one sample per 20 m grid intervals across the footprint of the proposed excavation. Samples will be collected at 1.0 m depth intervals over the full depth of the proposed fill excavation. Where appropriate existing data from the DGI and historic investigations will be utilised in lieu of additional in-situ characterisation / validation samples.

In-situ characterisation / validation samples will be collected from either soil bores or test pits (depending on the depth of the excavation and the timing of the validation program relative to removal of the existing hardstand surface).

Visual and olfactory observations of fill materials will be recorded during the in-situ characterisation / validation program with a view to establishing a correlation between field observations and analytical data. Subject to demonstration of an appropriate correlation, it is anticipated that the in-situ characterisation / validation of fill material in later phases of the Remediation Works will be affected using a combination of: field observations (visual and olfactory); and sample collection at a reduced frequency. This approach is consistent with AECOM experience during remediation of other former gasworks sites.

Any modification to the sample frequency will be made in consultation with the Auditor.

It is noted that the sampling frequency for acceptance of validated materials into Headland Park will be agreed following consultation with LL, BDA and the Site Auditor.

16.2.2 Validation of Excavation Base

Following completion of excavation works, any residual soil remaining on-site in the excavation base will be validated / characterised by a combination of visual observations and representative sampling with analytical testing, depending on the exposed material in the final basement excavation (e.g. bedrock, natural soil, fill, etc).

Excavation base samples (discrete) will be collected and analysed at a frequency of one sample per 20 m grid intervals across the footprint of the excavation.

- Where the excavation is founded in rock, the excavation base will be validated by visual observation and photographic documentation;
- Where the excavation is founded in natural residual soils, the excavation base will be validated by collection of discrete soil samples to a depth of 100 mm at each location;
- Where the excavation is founded in fill, the excavation base will be validated by collection of:
  - A discrete soil sample to a depth of 100mm at each location; and
  - Collection of soil samples at 1.5 m intervals until natural soil / bedrock is encountered.

Excavation base validation samples will be collected using a trowel (in the case of excavations founded in natural residual soils) or from soil bores (in the case of excavations founded in fill).

Validated areas will be clearly marked and identified to ensure that cross contamination of surface areas with CIM is mitigated.

16.2.3 Validation of Excavation Walls

Excavation walls in soil will typically be supported (and effectively retained) by perimeter cutoff walls (in particular a combination of secant pile walls, diaphragm walls and timber planking). As a consequence it will not be possible to directly sample materials remaining in excavation walls.

As a consequence, any residual soil remaining on-site behind the proposed cutoff walls will be validated / characterised by a combination of visual observations and representative sampling. In particular:

- Where the excavation wall is comprised of rock (which will be unsupported), the excavation wall will be validated by visual observation and photographic documentation; and
- Where the excavation wall is comprised of fill or natural soil (supported behind a cutoff wall):
  - The cutoff wall is located on the Site Boundary such that there is effectively no site material remaining behind it, the excavation wall will not be subject to any validation testing; and
  - The cutoff wall is located within the Site Boundary such that it is retaining site material behind it (that will not be excavated as part of a subsequent stage of the development program), the excavation wall and the material it retains will be validated in accordance with **Section 16.2.4**.

16.2.4 Validation of Materials to Remain In-situ

Based on the current proposed basement plans, and the proposed remediation extent described by the RAP, it is expected that fill materials will remain in-situ beneath part of the Public Domain. Areas in which fill materials are to remain in-situ following the remediation works will be validated based on a combination of:

- Analytical results from the DGI (AECOM 2010); and where there is insufficient data available from the DGI; and
- Additional samples collected from test pit and soil bores.

Samples to validate fill materials to remain in-situ will be collected at a frequency of one sample per 20 m grid intervals across the footprint of the material to remain. Samples will be collected at 1.5 m depth intervals over the full depth of the fill material, within a final sample collected within the top 0.5 m of natural residual material. Where appropriate existing data from the DGI and historic investigations will be utilised in lieu of additional in-situ characterisation / validation samples

16.2.5 Validation of Materials for Reuse Onsite

Materials to be excavated for potential reuse will be selectively excavated based on:

- the findings of the DGI and the in-situ characterisation / validation program (refer to **Section 16.2.1**); and
- field observations (visual and olfactory).

Wherever possible, this material will be taken directly to Headland Park or other re-use areas of Barangaroo.

If field observations during the bulk excavation works indicate that the excavated material is significantly different to that determined by the DGI and in-situ characterisation / validation program the material will be stockpiled and additional discrete validation samples collected and analysed from each stockpile at a sampling frequency of 1 sample per 400 m^3.

16.2.6 Validation of Treated Materials for at Headland Park and/or other areas of Barangaroo

Following the treatment works, samples will be taken of the soil at a sampling frequency of 1 per 400 m^3 of stockpiled material and submitted to a NATA accredited laboratory for analysis.

Samples will also be submitted for unconfined compressive strength (UCS) tests if a microencapsulation treatment method is used.

A less stringent sampling frequency will be adopted if the analytical results for the treated soil are confirmed to be statistically reliable.

16.2.7 Treatment Area and Stockpiling Areas

Activities within the RE, including the treatment and stockpiling works, will be undertaken on appropriately sealed hardstand areas, with diversion drains and bunding constructed around the perimeter of the area. Consequently, the soil beneath the hardstand is unlikely to be impacted by the stockpiling activities and subsequently, validation testing of these areas, once the hardstand is removed, is not proposed.

As a precautionary measure, before removal of hardstand is commenced, a careful inspection of these will be undertaken to identify the presence of contamination. If this inspection indicates the visual presence of any contamination relating to treatment operations, validation of the soil beneath the hardstand will be undertaken.

16.2.8 Validation Laboratory Analysis

Soil validation samples will be submitted for selected chemical analysis for the CoC identified for the Site including:

- Inorganics (heavy metals and cyanide);
- TPH;
- BTEX; and
- PAHs.

In addition, the 5% of samples with the highest total concentrations will also be selected for ASLP analysis. Once sufficient analytical data is obtained regarding the leachability of similar fill materials, this sampling frequency may be reduced in consultation with the auditor.

If field observations during the bulk excavation works indicate that asbestos containing materials are present within the Site's fill materials, soil validation soil samples will also be analysed for asbestos in appropriate areas.

16.2.9 Analytical Methods

Two laboratories will analyse original, duplicate and triplicate soil samples using NATA registered methods. Both laboratories must undertake the required analytical testing in accordance with the requirements of the *National Environment Protection (Assessment of Site Contamination) Measure (NEPC, 1999a)*. Details regarding the analytical methods to be used will be discussed with the Site Auditor and the appropriate analytical laboratory engaged to undertake the works.

16.3 Sampling Methodology

Fieldwork will be conducted in accordance with written standard operating procedures, copies of which will be maintained in a register on-site during the remedial works. This will ensure that representative samples of materials are collected and the sampling methodology remains consistent throughout the duration of the remedial works.

16.3.1 Sampling Methodology

Sample collection will be by:

- sampling trowel from excavation bases;
- grab samples directly from the centre of an excavator bucket from the centre of stockpiles for validation of stockpiled or treated material;
- split spoon sampler (or equivalent) for validation of material to remain in-situ, if required (refer to **Section 16.2.4**) and in-situ characterisation / validation of fill materials (refer to **Section 16.2.1**); and
- grab samples directly from the centre of an excavator bucket from test pits excavated as part of the in-situ characterisation / validation of fill materials (refer to **Section 16.2.1**)

All validation sample points will be surveyed.

Materials will be described in accordance with the Unified Soil Classification System (USCS), with soil type, descriptive properties (colour, particle size, moisture content, sorting), as well as discolouration, staining, odours and other indications (if any) being noted. The information will be recorded on field logs completed for each location.

On-site screening of samples for volatile organic compounds (VOCs) in the field will be undertaken using a portable photoionisation detector (PID). The PID will be calibrated at least once daily (at the start of each sampling day) with a known concentration of isobutylene.

Soil samples will be placed into laboratory supplied glass jars as soon as practicable after collection. The jar size will be sufficient to meet the laboratory requirements for the requested analysis. All sample containers will be filled completely using a method such that the loss of volatile components is minimised. All sample containers will be clearly labelled with information such as sample number, sample location, depth, date collected and sampler's identification. After filling, sample containers will then be transferred to a chilled esky for sample preservation

prior to and during shipment to the testing laboratory. The sample preservation requirements are listed in **Table 8** below.

Table 8: Soil Sample Preservation and Storage

Analyte	Preservation	Storage
Inorganics		
Metals (General)	Unpreserved, glass jar with Teflon lined lid.	Store at <4°C, analysis within 6 months.
Metals (Chromium VI by alkali digestion)	Unpreserved, glass jar with Teflon lined lid.	Store at <4°C, extract within 28 days, analyse within 7 days.
Metals (inorganic Mercury)	Unpreserved, glass jar with Teflon lined lid.	Store at <4°C, analysis within 28 days.
Cyanide	Unpreserved, glass jar with Teflon lined lid.	Store at <4°C, extraction within seven days, analyse within 14 days.
Organics		
TPH C_6-C_9	Unpreserved, glass jar with Teflon lined lid.	Store at <4°C, nil headspace, analysis within 14 days.
TPH C_{10}-C_{36}	Unpreserved, glass jar with Teflon lined lid.	Store at <4°C, extraction within 14 days, analysis within 40 days.
BTEX	Unpreserved, glass jar with Teflon lined lid.	Store at <4°C, nil headspace, analysis within 14 days.
PAHs	Unpreserved, glass jar with Teflon lined lid.	Store at <4°C, extraction within 14 days, analysis within 40 days

A sample register will be updated daily to manage and track the validation process.

16.3.2 Sampling Equipment Decontamination

Equipment decontamination will be undertaken as described below. The following equipment will be needed for the detergent wash and water rinse decontamination process:

- laboratory (phosphate-free) detergent or Decon 90;
- tap water and deionised water;
- buckets or tubs (sufficient for size of equipment to be cleaned); and
- stiff brushes for cleaning.

Equipment that cannot be thoroughly decontaminated using the detergent wash and water rinse should be steam cleaned, or if a steam cleaner is not available, not used for further sampling (and marked clearly "not decontaminated") or discarded. Equipment decontaminated using the high pressure steam cleaner will be further decontaminated as described above.

16.3.3 Quality Control samples

The following quality control (QC) samples will be collected as part of the field quality control procedures:

- Intra-Laboratory Duplicates – are identical to field samples, but both samples are sent anonymously to the primary laboratory. Blind duplicates provide an indication of the analytical precision of the main testing laboratory, but may also be affected by sampling techniques and inherent heterogeneity in the sample medium;
- Inter-Laboratory Duplicates – are identical to blind duplicates, but the duplicate sample is sent to the second (check) laboratory. Split duplicates provide an indication of the accuracy of the main testing laboratory;
- Equipment Blanks – are prepared in the field (at the sampling site) using empty bottles and the distilled water used during the final rinse of sampling equipment. After completion of the decontamination process

fresh distilled water is poured over the sampling equipment and collected. The distilled water is exposed to the air for approximately the same time the sample would be exposed. The collected water is then transferred to an appropriate sample bottle and the proper preservative added, if required. Equipment blanks are a check on equipment decontamination procedures;

- Trip Blanks/Spikes – are samples of soil or water prepared by the laboratory with either zero or known anolyte concentration. Trip blanks/spikes are a check on the sample contamination originating or lost from sample transport and handling, and shipping. One Trip Blank/Spike will be analysed per sample batch;
- Field Blanks – are similar to trip blanks except the water is transferred to sample containers on-site. Field blanks are a check on sample contamination originating from sample transport, handling, shipping, site conditions or sample containers. One Field Blank will be analysed per water sample batch; and
- Rinsate blanks - one rinsate blank sample (from an item of sampling equipment) will be collected per day of sampling by running distilled water over the selected item and decanting directly into the sample bottle. The rinsate will be taken from the final rinse of the equipment after decontamination.

Procedures for duplicate sampling will be identical to those used for routine sampling and duplicate samples will be despatched for analysis for the same parameters using the same methods as the routine sample. Duplicate soil samples will be collected from directly adjacent to original samples (i.e., from the adjacent area of the excavation base or wall). No homogenisation of samples will occur to reduce the loss of volatile compounds.

Duplicates and equipment blank samples will be collected as follows:

- Intra-Laboratory duplicate samples will be collected at a rate of approximately 1 in 10 soil samples and analysed for the full analyte suite. At least one blind duplicate sample will be included in each batch of samples;
- Inter-Laboratory duplicates samples will be collected at a rate of approximately 1 in 20 soil samples and analysed for the full analyte suite. At least one split duplicate sample will be included in each batch of samples; and
- One equipment blank of soil sampling equipment will be collected for every day of sampling and analysed for the full analyte suite. At least one equipment blank will be included in each batch of samples.

16.3.4 Laboratory QA/QC

The laboratories will undertake the analyses utilising their internal procedures and their test methods (for which they are NATA, or equivalent, registered) and in accordance with their quality assurance (QA) system which forms part of their registration.

Laboratory quality control procedures, which will be used during the project, will comprise the following:

- Laboratory Duplicate Samples – these are sub-samples taken from one sample submitted for analytical testing in a batch. A laboratory duplicate provides data on analytical precision. The rate of duplicate analysis will be according to the requirements of the laboratory's accreditation but will be at least one per batch;
- Matrix Spiked Samples – the purpose of the matrix spike is to monitor the performance of the analytical methods used, and to determine whether matrix interferences exist. A sample is spiked by adding an aliquot of known concentration of the target analyte(s) to the sample matrix prior to sample extraction and analysis. A spike documents the effect of the sample matrix on the extraction and analytical techniques. These will be analysed at a rate of approximately 5% of all analyses. At least one per batch will be reported;
- Laboratory Blank – this is usually an organic or aqueous solution that is as free of analyte as possible and contains all the reagents in the same volume as used in the processing of the samples. The reagent blank must be carried through the complete sample preparation procedure and contains the same reagent concentrations in the final solution as in the sample solution used for analysis. The reagent blank is used to correct for possible contamination resulting from the preparation or processing of the sample. Blanks will be analysed at a rate of once per process batch, and typically at a rate of 5% of all analyses;
- Laboratory Control Samples – these comprise either a standard reference material or a control matrix fortified with analytes representative of the analyte class. Recovery check portions should be fortified at concentrations that are easily quantified but within the range of concentrations expected for real samples. These will be analysed at a rate of one per process batch, and typically at a rate of 5% of analyses; and
- Surrogates – surrogate spikes are known additions to each sample, blank and matrix spike or reference sample analysis, of compounds which are similar to the analytes of interest in terms of:

- extraction;
- recovery through clean-up procedures; and
- response to chromatography or other determination;

but which:

- are not expected to be found in real samples;
- will not interfere with quantification of any analyte of interest; and
- may be separately and independently quantified by virtue of, for example, chromatographic separation or production of ions of different mass in a GC/MS analyser.

Surrogate spikes are added to the analysis before extraction. The purpose of surrogates is to provide a means of checking, for every analysis, that no gross errors have occurred at any stage of the procedure leading to significant analyte losses. Other internal laboratory quality control procedures, as required for NATA, or equivalent, registration, will also be performed.

Results of the QC analyses for both laboratories will be reported with each batch.

16.4 Validation Reporting

Following completion of the remediation and validation works, validation reports will be prepared. Depending on the final staging and development requirements, it is anticipated that separate validation reports will be required for each of the different development blocks and the Public Domain within the Remediation Works (South) Area.

It is assumed that reporting will be undertaken for the separate portions as follows:

- Block 1;
- Block 2;
- Block 3; and
- Public Domain.

The reporting requirements for the different areas will be confirmed with the various stakeholders including but not limited to the LL, NSW EPA Accredited Site Auditor, NSW DECCW and the BDA.

- The validation reports will be prepared in accordance with the requirements of the NSW DECCW and will include the following information:
- An overview of the remediation works carried out for the Block;
- A summary of the site history and basis for the remediation approach for the area;
- Surveyed figures outlining the extent of the remediation works;
- The location of validation and characterisation samples;
- Descriptions of sampled materials (including visual and olfactory observations);
- Summary tables for soil and groundwater analytical results;
- NATA registered laboratory analytical certificates;
- Summary of the tracking and fate of materials including materials excavated for on-site treatment, reuse of site or off-site disposal;
- Landfill weighbridge dockets (if required);
- An assessment of risk demonstrating that the ‘Significant Risk of Harm’ issues at the site have been addressed;
- Conclusions as to the suitability of the land for its proposed use; and
- Recommendations (if required) for further works.

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17.0 Environment Management Plan – During Remediation

17.1 General

This section of the RAP describes the minimum standards to be adopted to protect the environment during the remediation works. The Remediation Contractor will develop and implement a suitable Environmental Management System in compliance with legislative and regulatory requirements. A site-specific Environmental Management Plan (EMP) will be developed prior to commencement of the works. The EMP will detail the appropriate information and mitigation measures necessary to conduct the remediation works in a manner that will minimise the risk to the environment.

17.2 Water Management

The Environment Management Plan for the works will include procedures for the management of surface and groundwater during the works as outlined in **Section 13.0**.

17.3 Air Quality Management

An Air Quality Impact Assessment will be prepared in accordance with the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (DEC, 2005) to assess potential air and odour issues generated during the remediation works. This assessment will make reference to the following guidance documents:

- Assessment and Management of Odour from Stationary Sources in NSW: Technical Framework (DEC 2006); and
- Management of Odour from Stationary Sources in NSW: Technical Notes (DEC 2006).

17.3.1 Odours

Odour management is recognised as a critical aspect of site environmental management and will need to be given high priority in the planning of all excavation and stockpiling of contaminated soil at the Site. Odours are expected during the soil excavation, and consequently, management procedures will need to be developed within the EMP to address odour issues.

Primarily, odours at the Site will be associated with the excavation of hydrocarbon impacted materials. Odour generation at the Site will be influenced by weather conditions, the extent of open excavations stockpiles, and the quality of material exposed.

Appropriate odour management will address the following key issues:

- Sources of odours;
- Minimisation of odour/source;
- Odour management response procedures;
- Progressive contingency measures;
- Monitoring;
- Excavation in excavation enclosure, where practical;
- Stockpiling in excavation enclosure (odorous soils);
- Covering surfaces;
- Minimising exposed/excavation areas;
- Odours suppressants;
- Odour monitoring; and
- Undertake activities taking account of weather conditions.

A detailed odour management system will incorporate the use of various management options as deemed appropriate for particular areas. Such options will include: temporary enclosures, odour suppressants, misting systems, restricting exposed excavated surfaces and covering of exposed excavation surfaces.

17.3.2 Dust

Care should be taken to manage wind-blown dust at the Site during excavation and earthworks activities. Dust can be generated through a range of means and activities:

- Wind action:
  - Exposed soil surfaces will generate dust during winds;
- Agitation and movement:
  - Excavation, mixing and placement of soil will generate dust;
  - Transfer of soil in uncovered trucks may result in dust generation;
- Vehicle Movements:
  - Vehicles' wheels on exposed soil surfaces (such as unsealed roadways) will generate dust.

Appropriate management of dust is required to ensure that it is minimised and/or prevented. Dust management will include the following:

- Excavation in the excavation enclosure for the contaminated areas;
- Covering surfaces;
- Minimising exposed/excavation areas;
- Wetting down; and
- Dust monitoring.

17.4 Noise and Vibration Management

An assessment of noise and vibration impacts potentially generated during the remediation works will be prepared in consultation with the DECCW. The assessment will be prepared in accordance with the *Interim Construction Noise Guideline* DECC (2009)*, Industrial Noise Policy* (NSW EPA 2000) and *Application Notes, Environmental Criteria for Road Traffic Noise* (NSW EPA 1999) *and Assessing Vibration: A Technical Guide* (DEC 2006).

The potential for noise and vibration impacts from the remediation works will result from:

- Works associated with preparation of the Site;
- Movement of construction vehicles around the Site; and
- Operation of plant and activities on the Site.

17.5 Long Term Environmental Management Plan

It is anticipated that a Site Management Plan may be required to describe contingency management methods which may need to be applied by future users if they wish to re-develop their Premises beyond the area affected by the Remediation and Development Works undertaken at the Site.

The Site Management Plan will be prepared as an outcome of the Soil Validation Program and in consultation with the Auditor.

18.0 Occupational Health and Safety – During Remediation

18.1 General

This section of the RAP describes the minimum standards to be adopted to protect the health and safety of all persons involved in the remediation works. The Remediation Contractor will develop and implement a suitable Health and Safety Management System in compliance with legislative and regulatory requirements. A site-specific Occupational Health and Safety Plan (OHSP) will be developed prior to commencement of the works. The OHSP will detail the appropriate health and safety information necessary to conduct the remediation works in a safe manner.

18.2 Occupational Health & Safety Plan

The purpose of the site-specific OHSP is to present all relevant health and safety information for the works. The information presented in the OHSP will include:

- Assignment of responsibilities for management personnel and workers;
- An outline of the existing Site conditions;
- Details of all work to be conducted;
- An evaluation of hazards and risks;
- Details of the proposed measures to be implemented to manage the identified hazards and risks;
- Establishment of personnel protection standards and mandatory safe work procedures;
- Establishment of OHS monitoring protocols;
- Training requirements for emergency team members;
- Communication protocols and training procedures;
- Evacuation procedures, emergency contacts and emergency drills to be implemented; and
- Provision for contingencies and changes in work practices.

18.2.1 Responsibilities

The responsibilities and duties of the Remediation Contractor in relation to OHS will include:

- Ensuring all work undertaken is performed in accordance with relevant legislation and regulations, and directions issued by regulatory authorities;
- Developing and documenting safe working practices for all employees and subcontractors;
- Ensuring workers are adequately trained to undertake their work tasks using the adopted work practices;
- Ensuring that work is performed in strict adherence to the adopted work practices;
- Appointing a suitably qualified and experienced Site Safety Officer (SSO) to supervise and control safety matters;
- Supplying and maintaining first aid kits, first aid facilities and ensuring first aid attendants are present in accordance with statutory requirements;
- Ensuring that all workers are inducted prior to their commencement of work. This will include site-specific training in regard to the site conditions, works procedures, emergency and evacuation procedures, first aid procedures, decontamination procedures and other relevant matters detailed in the OHSP;
- Ensuring that copies of the OHSP are readily available;
- Establishment and maintenance of a record of all hazardous substances on the Site including provision of Material Safety Data Sheets (MSDSs);
- Ensuring that all personnel who work with contaminated materials undergo a medical examination prior to and at the completion of their work on-site;

- Reporting all site incidents and accidents to the WorkCover Authority;
- Ensuring that the SSO is on-site during all site works to monitor compliance with the OHSP;
- Ensuring that regular documented OHS inspections are conducted, including the use of a documented follow-up system to monitor improvements and measures introduced to rectify any observations made;
- Supplying and maintaining the required personal protective equipment (PPE);
- Ensuring all workers are trained in the use of the PPE and correctly use PPE; and
- Ensuring that all electrical equipment, plant and tools comply with appropriate statutory requirements and are maintained in a good, serviceable and safe condition.

18.2.2 OH&S Legislation, Regulations and Standards

The remediation works will be conducted in compliance with applicable OH&S legislation, regulations and standards. In addition, the remediation works will comply with relevant industry codes of practice, guidelines and other publications that have been developed by the WorkCover Authority. These may include:

- The Occupational Health and Safety Act 2000 and Regulation 2001;
- The Dangerous Good Act 1975 and General Regulation 1999;
- Guide for Riggers (November 1995);
- Electrical Practices for Construction Work (February 1992); and
- Exposure Standards for Atmospheric Contaminants in the Occupational Environment (May 1995).

A number of Australian Standards have been identified relating to OH&S issues for the works proposed at the Site. These standards include:

- AS 1319 -1994 Safety Signs for the Occupational Environment;
- AS 1336 -1997 Recommended Practices for Occupational Eye Protection;
- AS 1470 -1986 Health and Safety at Work - Principles and Practices;
- AS 1715 -1994 Selection, Use and Maintenance of Respiratory Protective Devices;
- AS 1716 -2003 Respiratory Protective Devices;
- AS 1801 -1997 Occupational Protective Helmets;
- AS 1885.1 -1990 Measurements of Occupational Health and Safety Performance - Describing and Reporting Occupational Injuries and Disease (known as the National Standard for Workplace Injury and Disease Recording);
- AS 2161 - 2000 Occupational Protective Gloves;
- AS 2210 - 2000 Occupational Protective Footwear;
- AS 2436 -1981 Guide to Noise Control on Construction, Maintenance and Demolition Sites;
- AS 2601 -2001 The Demolition of Structures;
- AS/NZS 2865-2001 Safe Working in a Confined Space;
- AS 2986 -1987 Workplace Atmospheres - Organic vapours - Sampling by Solid Adsorption Techniques;
- AS/NZS 3012 -1995 Electrical Installations – Construction and Demolition Sites;
- AS 3640 -1989 Workplace Atmospheres - Method for Sampling and Gravimetric Determination of Inspirable Dust; and
- AS/NZS 4576 -1995 Guidelines for Scaffolding.

18.3 Risk Assessment

A hazard analysis should be conducted prior to site establishment to identify the OHS hazards expected during the course of the remediation works. A Risk Management Plan will be developed to identify hazards associated with the proposed remediation works, evaluate the associated risks and determine the necessary measures to reduce or mitigate those risks. This section of the RAP outlines some of the hazards expected over the course of the project. Hazard identification and risk assessment will be conducted and documented on an ongoing basis as the project works proceed.

18.3.1 Chemical Hazards

Based on the information provided in previous investigations at the Site, the presence of metals, TPH and PAHs has been confirmed within the Sites soils. The hazard posed by these materials will be evaluated and the associated risks assessed in the Risk Management Plan.

18.3.2 Atmospheric Exposure Limits and Recognition Qualities

The exposure limits and recognition qualities of the chemicals likely to be encountered in the remediation works will be taken from the following guidelines (listed in order of precedence) and detailed in the OHSP:

- NOHSC, Exposure Standards for Atmospheric Contaminants in the Occupational Environment, 1995. The most up-to-date Australian exposure standards are located on the Safe Work Australia Hazardous Substances Information System (http://hsis.ascc.gov.au/SearchHS.aspx); and
- National Institute for Occupational Safety and Health (NIOSH) 2007, Pocket Guide to Chemical Hazards. Also refer to http://www.cdc.gov/niosh/npg/.

18.3.3 Additional Hazards and Risks

The OHSP will identify and describe a range of other hazards anticipated during the remediation works. These hazards will include:

- Heat stress;
- Explosive atmospheres in areas dealing with contaminated materials;
- Oxygen deficient atmospheres and confined spaces (as defined under AS/NZS 2865 - 2001 Safe Working in a Confined Space);
- Underground utilities;
- Underground pipelines, pits, and other obstructions;
- Above ground electrical and utility hazards;
- Traffic hazards;
- Instability of excavation batters and stockpiled material;
- Hazards associated with the construction and decontamination of the RE and ECS;
- Hazards associated with operation of the treatment works;
- Hazards associated with the airlock and decontamination operations in the RE; and
- Physical hazards such as trip hazards and mobile plant.

Specific minimum standards for these hazards will be outlined within the Risk Management Plan.

18.4 Work Zones

The Site will be divided into a number of work zones, as follows:

- Exclusion Zones – the RE (as detailed in **Section 11.3.1**);
- Decontamination Zones – decontamination stations located in the Remediation Area; and
- Support Zones – the site office and site facilities areas within the Remediation Area.

Movement of personnel and equipment between these zones will be minimised and restricted to specific access control points and decontamination stations to prevent cross contamination to clean areas.

18.4.1 Decontamination Stations

The decontamination stations will be the only entry and exit points to Exclusion Zones. The stations will be located to minimise the transportation of contaminants between the various areas of the Site, and to ensure that the Support Zone does not become contaminated or affected by other site hazards.

As discussed in Section 21.3.4, clean and dirty zones will be established at all decontamination stations. All workers will be required to pass through the Decontamination Stations when entering and exiting the Exclusion Zones.

These stations will also house the PPE stock rooms and change rooms, so that when entering the Exclusion Zones workers are able to apply the necessary PPE.

18.4.2 Support Zone

The Support Zone refers to the site office and other support facilities involved in administering the remediation works. Site personnel may wear normal work clothes within this zone, leaving any potentially contaminated clothing, equipment and materials in the decontamination station until decontaminated or appropriately disposed of.

In the event of an emergency, support zone personnel are responsible for alerting the correct authorities. All emergency telephone numbers, evacuation route maps, vehicle keys and site safety information would be held within the Support Zone

19.0 Community Engagement

Community engagement prior to and during remediation is an integral component of successfully delivering remediation works. LL has developed a comprehensive stakeholder/community engagement strategy and action plan that will be implemented for delivery of the remediation works in the Site.

The proposed strategy will include a process for communicating with the local community on the remediation works, discussing potential short term impacts and mitigation measures relating to the remediation.

The engagement strategy will be part of an overall strategy for delivery of the Stage 1 development. Further specific details will be included in the LL community engagement plan.

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20.0 Contingency Planning

20.1 Approach

The purpose of the contingency plan is to outline procedures for the identification and management of unexpected issues or events that may occur during the works. The contingency plan will detail the following information:

- The assignment of responsibilities to nominated key personnel;
- The assessment of hazards associated with such situations, and the potential off-site impacts;
- Contingency responses; and
- Procedures for reporting relevant issues to regulatory authorities.

The following unexpected events have been identified as having the potential to occur during the remediation works:

- Identification of greater amounts of CIM than presently anticipated;
- Identification of CIM at depths greater than presently anticipated (in particular below the depth of the proposed excavation works);
- Variation of contaminant characteristics or identification of unanticipated contaminants and materials;
- Failure of the preferred treatment approach to achieve the SSTCs;
- Insufficient storage capacity at Headland Park to stockpile all required materials; and
- Operational issues during the remediation works including but not limited to:
    - Flooding of the site;
    - Generation of unacceptable levels of dust during excavation and reinstatement works;
    - Release of unacceptable levels of fugitive emissions during the excavation works;
    - Generation of unacceptable odours from the excavation works;
    - Generation of unacceptable noise levels during site works;
    - Generation of unacceptable vibration levels during excavation and reinstatement works; and
    - Spills and leaks of hazardous materials.

These items are described in the following sections.

20.2 Increased Volumes of Contaminated Material

The remediation strategy is to undertake remediation works to the extent practicable such that the Site is suitable for its proposed land use. The areas of 'PIM' possibly requiring remediation have been estimated based on a preliminary screening assessment of the results of the DGI (AECOM, 2010). SSTCs generated as an outcome of the HHERA will be used to refine the areas of CIM and associated remediation volumes.

Excavated and reused materials will be managed on-site using the Materials Tracking System described in **Section 12.7.2**. The quantities of materials excavated will be regularly compared to the estimated quantities.

Increased volumes of foreign materials in the form of steel reinforcement, scrap steel and pipe work may have the potential to adversely impact on the project. Depending on the magnitude of the changes of anticipated volumes of excavated materials, and the extent of contamination, changes to the depth of excavation and to the final reinstatement levels may be made during the project. These changes may require revision of the HHERA.

20.3 Variation of Contaminant Depth

Should additional CIM be identified at greater depths than can be practicably excavated, the following approach will be adopted:

- Review the HHERA (including specific consideration of the subject material) to assess whether the subject material is CIM and represents an unacceptable risk;
- Consider in-situ remediation techniques;
- Consider the principles of CUTEP and whether the material can be practically removed in the light of: for example, its depth below both ground surface and the water table; and proximity to existing structures and the harbour; and
- Ongoing groundwater monitoring to assess potential impacts to the environment (as discussed in **Section 14.4**).

20.4 Failure of the preferred treatment approach

Should the preferred stabilisation treatment approach prove to be unsuccessful, other stabilisation methods will be assessed using different additives. The preferred treatment methodology for the Blocks 4 to 5 remediation works will also be considered based on the findings of remedial trials being conducted at those sites (if required).

20.5 Insufficient Storage Capacity at Headland Park

If all or part of the Headland Park is not available to receive material from Stage 1, the following options will be assessed:

- Explore alternative options for reuse of the material as part of the Barangaroo Stage 1 or Stage 2 developments;
- Maximise the reuse of suitable, non-contaminated material (eg. natural soil or rock) either within the development or for beneficial reuse off-site;
- Off-site disposal of materials classified as Virgin Excavated Natural Material (VENM) for beneficial reuse on other sites; and
- Off-site disposal to landfill of material classified as waste in accordance with NSW DECCW requirements.

20.6 Variation of Contaminant Characteristics

The range of contaminants analysed in the DGI and previous site investigations is considered to be appropriate for development of SSTCs. However, there is the potential for occurrence of as-yet unidentified contaminants, and for variation to the concentration or distribution of known contaminants.

Should any significant changes to the nature or types of contaminants be identified during the works a variation to the RAP and site-specific SSTCs may be required. Variations will be issued to the Site Auditor for review and approval.

It is noted that Lend Lease are familiar with potential site conditions having excavated and remediated the adjacent Bond site. Notwithstanding this, it is considered that any different materials encountered can be adequately addressed by AECOM and Lend Lease following assessment and refinement of any required remediation design.

20.7 Operational Contingencies

Flooding of the Site

The EMP for the remediation works will be developed to control the impact of site works in order to minimise and mitigate against any impacts to off-site waters (Darling Harbour). As outlined in **Section 13.0**, the implementation and maintenance of a variety of environmental control measures will be undertaken during the project to manage water encountered during the works. Measures such as the installation of drains to divert clean water from up gradient areas to on-site stormwater drains, recycling of water and off-site water treatment will be conducted to manage and control water.

In extreme situations such as flooding or heavy rainfall, the discharge of treated water may be permitted to the sewer system in accordance with the conditions of a Sydney Water licence. All water intended for discharge will be stored on-site and tested prior to discharge to confirm compliance.

Records of all discharges will be kept describing the estimated volume of water discharged, the time period over which the discharge occurred, and the water quality results of water samples collected prior to discharge.

These control measures will be monitored during significant rainfall events to confirm their integrity and suitability.

Control of Dust

Should unacceptable levels of dust be detected during the remediation works, an investigation will be conducted to determine the source of the dust, and evaluate the appropriate measures to be implemented.

These measures may include the following:

- Increased use of a water cart or water sprays to suppress dust in open areas;
- Installation of temporary sheeting to cover localised exposed areas and stockpiles;
- Installation of dust screens around the Remediation Area;
- Covering stockpiles of contaminated soil which will remain on the Site for more than 24 hours (where practical);
- Alteration of the works program to minimise the extent of disturbed open areas;
- Consolidation of material stockpiles;
- Use of chemical dust-suppressants provided the chemicals do not pose a contamination or OHS hazard;
- Use of alternative coverings such as hydromulch to stabilise the surface of open disturbed areas;
- Use of additional dust suppression features on items of dust generating plant and equipment;
- Securely covering all loads entering or exiting the Site; and
- Use of alternate work practices such as modified equipment to minimise dust generation.

Fugitive Emissions and Odours

Should unacceptable levels of fugitive emissions be detected at the Site boundaries or in the surrounding area during the project, an investigation will be conducted to determine the source of the emissions, and to evaluate the appropriate measures to be implemented.

These measures may include the following:

- Alteration in the works program to minimise in the extent of disturbed open areas;
- Prompt removal and treatment of heavily contaminated materials that have been exposed and are identified to have caused the emissions;
- Use of fine mist sprays around the Remediation Area;
- Conducting the work in more favourable weather conditions;
- Use of alternate work practices to minimise the period of impact of the emissions;
- Use of additional features to control emissions from plant and equipment;
- Use of alternate work practices such as using modified equipment;
- Relocation of offending plant and equipment to less sensitive on-site areas;
- Reducing the number of plant and equipment items on-site; and
- Use of a deodorant within water sprays at locations on-site and at Site boundaries provided the chemicals do not pose a contamination or OHS hazard.

Noise and Vibration

Should unacceptable noise and/or vibration levels be detected during the remediation works the following measures may be implemented:

- Modify the works program to minimise the impact of noisy or vibratory operations, including:
  - Modify the timing of the works to appropriate times of the day; and
  - Accelerate the works program to complete the works quickly and minimise the period of disturbance;
- Install additional noise suppression features on plant and equipment;
- Construct additional noise attenuation measures such as stockpile barriers, works area enclosures; and
- Use of different items of plant and equipment that generate less noise or vibration.

Spills and Leaks

A spill response plan will be developed and implemented as part of the Emergency Response Plan (ERP) detailing the procedures for responding to spills and leaks. The procedures outlined in the plan will be aimed at minimising the impact of any contaminant releases that may occur during the works.

The following actions will be taken in preparation for spills or leaks:

- Training of site personnel in appropriate spill response techniques;
- Allocation of spill response materials and equipment on-site (such as oil absorbent pads, booms and biodispersants);
- Containment of all storage tanks and drums inside bunded areas with a capacity of 110% of the largest container, or 25% of the total volume of all containers, whichever is greater.
- Initial assessment of the spill;
- Notification of the appropriate authorities if necessary;
- Following a spill or leak, an investigation to determine the root cause of the incident will be undertaken; and
- Corrective and preventative actions implemented to prevent future incidents.

Emergency Response Plan

An ERP will be prepared prior to the commencement of the site remediation works. The plan will outline the process for identifying possible emergency situations and detailing the procedures necessary to ensure the safety of both on-site and off-site personnel in the event of an emergency.

The plan should include the following general information:

- Assignment of responsibilities to nominated key personnel;
- Assessment of the potential on and off-site impacts of hazards;
- Emergency reporting procedures including on-site reporting and reporting to the appropriate authorities;
- Emergency response procedures including, but not limited to, the following:
  - On-site fires or explosions;
  - Chemical spills;
  - Rupture of buried services;
  - Hazardous gas releases and emissions;
  - Confined spaces situations;
  - Traffic accidents both involving the transportation of "Dangerous Goods";
  - First aid for injured personnel;
  - Evacuation of on-site personnel; and

- Managing unknown/uncertain situations.

- Incident investigation procedures to determine the root cause of the incident, and to identify the appropriate corrective and preventative actions to prevent future incidents.

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21.0 Key Personnel

The contractual framework of delivery of the remediation works has not yet been determined by LL. Potential contractual structures include:

- Turn key deliver of the remediation works by a remediation contractor; and
- Supervision of the remediation works by a superintendant and validation team engaged separately for the remediation contractor; and
- A variation on the above.

Notwithstanding the contractual framework initially adopted by LL, the key roles and responsibilities associated with the remediation works are as discussed following and will be detailed in the RWP. Depending on the contract structure the various roles and responsibilities may be discharged by one or more entities.

21.1 Project Director

The Project Director is responsible for ensuring that the remedial works undertaken on-site are in accordance with this RAP, the EMP, the OHSP and other relevant documentation (including the RWP), and that the objectives stated within the RAP are ultimately met. The Project Director will generally also be responsible for ensuring that the project occurs within the timeframe nominated and within the financial budget allocated, and is completed safely. The Project Director assumes ultimate responsibility for the project.

21.2 Project Manager

The Project Manager is responsible for daily operations and directs the site operations to ensure effective planning, verification, documentation and management of operational and environmental and safety issues in accordance with this RAP. This includes maintaining a liaison with regulatory authorities to ensure that all necessary work is undertaken to satisfy the DECCW and Site Auditor that the remediation achieves the objectives of this RAP.

The Project Manager is responsible for the implementation of all Project Plans including the RAP, EMP, OHSP Plan, Quality Plan, the RWP and other relevant contractual documents associated with the remediation works. This includes responsibility for:

- any design that may be required during the work;
- implementation and scheduling of the remedial works in accordance with the abovementioned documents; and
- ensuring compliance with relevant legislation and regulations.

The Project Manager is also responsible for ensuring that human health and the environment are protected at all times, including the provision of training and site inductions to all appropriate subcontractors and workers.

The Project Manager will be a primary community contact and the first point of contact for sub-contractor issues.

21.3 Validation Team

A suitably qualified consultant will undertake the supervision and validation of the remedial works under the direction of a Validation Project Director (VPD). The VPD is responsible for ensuring that all required validation systems are fully functional, and that staff are trained in the requirements of the Validation Plan (VP) as detailed in this RAP.

Daily validation management will be from an on-site project office. A site-based administrative system will be established to ensure that the project is fully documented. A daily fieldwork summary will be prepared and filed. All job-related incoming and outgoing communications will be logged in a register.

Decisions related to validation will be made in accordance with relevant guidelines endorsed by the DECCW and Site Auditor. Copies of relevant guidelines will be kept in the Site office. All fieldwork will be undertaken by qualified environmental engineer(s)/scientist(s) with experience working on contaminated sites.

A member of the Consultant's field team will be the Site Validation Manager (SVM) responsible for making all validation decisions and directing all routine site fieldwork. Prior to commencement of the project, the SVM will

prepare a project manual containing all required procedures and forms. The manual will be updated, in conformance with the VP, on an as needed basis. It is the responsibility of the SVM to ensure that the VP is followed.

Site meetings will be convened, as required, to discuss fieldwork procedures. At least one meeting per week will be held with the SVM and the Project Manager to plan work for the following week and to resolve outstanding issues.

Where, because of an unforseen circumstance, the SVM considers that a departure from the VP is required, this must be discussed with the VPD and Site Auditor before any other related action is taken. If the departure is approved it will be documented in site files. If urgent action is required, the VPD will be responsible for deciding the particular issue. The Site Auditor will be sent written confirmation as soon as practicable, but in any case within 5 working days of the reasons for making the changes to the VP procedures and feedback and endorsement of the changes will be requested in writing from the Contaminated Land Auditor.

21.4 Site Foreman

The Site Foreman implements day-to-day operations as directed by the Project Manager.

21.5 Safety/Quality Officer and Environment

The Safety / Quality Officer is responsible for implementation of the quality and safety management systems. This person assists the Project Manager with day-to-day tasks that arise, reports activities undertaken, directs the subcontractors, maintains accurate records of works such as safety checklists, and maintains a photographic record of works undertaken. This will include review and update of the OH&S Plan and EMP plus health and safety manuals, rules and procedures.

The Safety / Quality Officer ensures personnel and visitors to the site are inducted and has responsibility for emergency response and training in accordance with the Emergency Plan. The Safety / Quality Officer has the authority and independence to require reasonable steps to be taken to avoid or minimise unintended or adverse work safety impacts, and can direct relevant actions to be ceased should any adverse impact on worker safety be likely to occur.

The Safety / Quality Officer ensures all H&S monitoring devices are operating in accordance with the RAP, EMP, OHSP and RWP and also keeps the incident and accident register up to date with notification given to Work Cover NSW as necessary.

The Safety / Quality Officer will provide advice and recommendations, when appropriate, with regards to:

- legal requirements;
- changes in legislation;
- dealings with Work Cover New South Wales
- prevention of injury or damage;
- accident and injury investigations and reports;
- work methods, equipment, or materials which could reduce risk; and
- selection, suitability and application of safety equipment.

The Safety/Quality Officer will be responsible for holding regular ‘toolbox’ safety meetings with all site personnel and will ensure meeting minutes are appropriately documented.

21.5.1 Subcontractors

All work, irrespective of who it is completed by will be undertaken, as specified by the Project Manager, and per the requirements stated within this RAP and the EMP, OHSP, RWP and relevant management plans.

Subcontractors will be advised of required work procedures through induction, training, and meetings provided by the Contractor. Maintenance of subcontractor equipment will be the responsibility of the subcontractors.

The Subcontractor is responsible for ensuring that all works executed by the subcontractor complies with relevant Work Cover NSW as necessary.

22.0 References

AECOM Australia Pty Ltd, 2010. Data Gap Investigation (DGI), Other Remediation Works (South) Area, Barangaroo. May.

ANZECC, 1992. Australian Water Quality Guidelines for Fresh and Marine Waters. Australian and New Zealand Environment and Conservation Council.

ANZECC, 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Environment and Conservation Council and Agriculture and Resourced Management Council of Australia and New Zealand.

ANZECC/NHMRC, 1992. Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites. Australian and New Zealand Environment and Conservation Council and National Health and Medical Research Council.

Broomham, R. 2007. Land at Millers Point Ownership and History. June 2007

Coffey Environments. 2008. Preliminary Environmental Investigation, 30-38 Hickson Road, Millers Point, NSW 2000. 12 May.

DEC, 2005. Approved Methods for the Modelling and Assessment of Air Pollutants in NSW

DEC, 2006a. Guidelines for the NSW Site Auditor Scheme (2nd edition).

DEC, 2006b. Assessing Vibration: A Technical Guide

DEC, 2007. Guidelines for the Assessment and Management of Groundwater Contamination.

DECC, 2008. Waste Classification Guidelines.

DECC, 2009. Interim Construction Noise Guideline

DECCW, 15 March 2010. Request for Provision of Details for Key Issues and Assessment Requirements, Barangaroo, East Darling Harbour, Sydney & Barangaroo Concept Development Plan Modification.

ERM, 2007. Environmental Site Assessment, East Darling Harbour, Sydney, NSW, Final Report, 21 June 2007

ERM. 2007. Environmental Site Assessment, East Darling Harbour, Sydney, NSW, Final Report. 21 June.

ERM. 2008a. Additional Investigation Works at Barangaroo, Hickson Road, Millers Point, NSW. July 2008.

ERM. 2008b. Preliminary Sediment Screening Works at East Darling Harbour, Adjacent to Barangaroo, NSW, Draft, Rev 03. August.

ERM. 2008c. Draft Stage 2 Remedial Action Plan for Barangaroo, Hickson Road, Sydney. September 2008.

Herbert C, 1983. Sydney 1:100 000 Geological Sheet 9130, 1st edition. Geological Survey of New South Wales, Sydney.

Jeffery and Katauskas, 2006. Geotechnical Report development of Wharves 3-8 at East Darling Harbour. August 2006.

Lend Lease Development supplied CD, 2010. BDA Supplied Historical Work As Executed Drawings for the Former Wharf Structures at Berths 3 to 8, Barangaroo. CD dated 21 January.

Lend Lease Development supplied CD, 2010. Geotechnical Information - Barangaroo Area (including CBD Metro Geotechnical and Environmental Investigations, completed by Coffey). CD dated 21 January.

Lend Lease Development Scheme CAD files provided to AECOM in December 2008.

NEHF, 1998. Health-Based Soil Investigation Levels. National Environmental Health Forum Monographs. Soil Series No 2. National Environmental Health Forum.

NEPC,1999. National Environment Protection (Assessment of Site Contamination) Measure (NEPM). National Environment Protection Council.

NEPC, 1999a. Guideline on the Investigation Levels for Soil and Groundwater. Schedule B(1). National Environmental Protection Measure. National Environmental Protection Council.

NEPC, 1999b. Guideline on Data Collection, Sample Design and Reporting. Schedule B(2). National Environmental Protection Measure. National Environmental Protection Council.

NEPC 1999c. Guideline on Laboratory Analysis of Potentially Contaminated Soils. Schedule B(3). National Environmental Protection Measure. National Environmental Protection Council.

NEPC, 1999d. Guideline on Health Risk Assessment Methodology. Schedule B(4). National Environmental Protection Measure. National Environmental Protection Council.

NSW ASSMAC, 1998. Acid Sulfate Soils Assessment Guidelines. NSW Acid Sulfate Soil Management Advisory Committee

NSW EPA, 1994. Guidelines for Assessing Service Station Sites.

NSW EPA, 1995. Contaminated Sites: Sampling Design Guidelines.

NSW EPA, 1997. Contaminated Sites: Guidelines for Consultants Reporting on Contaminated Sites.

NSW EPA, 1999. Environmental Criteria for Road Traffic Noise

NSW EPA, 2000. Industrial Noise Policy and Application Notes

Tables

BLOCK 2 HOTSPOTS

			Location Code	AECOM_BH19	
			Sample Depth	6.9-7.0	
		BH Elevation (RL AHD)		2.53	Excavations proposed to RL -20.0
		Sample Elevation (RL AHD)		-4.37	
			Area	Block 2	
Analyte	**LOR**	**Adopted Residential Criteria**	**Adopted Commerical Criteria**	**Result**	
Benzo(a) pyrene	0.5	4	**5**	4.2	Will be excavated

			Location Code	AECOM_BH20	
			Sample Depth	1.0-1.2	
		BH Elevation (RL AHD)		2.76	No excavation proposed
		Sample Elevation (RL AHD)		1.76	
			Area	Block 2	
Analyte	**LOR**	**Adopted Residential Criteria**	**Adopted Commerical Criteria**	**Result**	
Benzo(a) pyrene	0.5	4	**5**	**18.1**	Excavations not proposed
PAHs (Sum of total)	0.5	80	**100**	**300.7**	Excavations not proposed

			Location Code	AECOM_BH20	
			Sample Depth	11.0-11.2	
		BH Elevation (RL AHD)		2.76	Excavations proposed to RL -6.0
		Sample Elevation (RL AHD)		-8.24	
			Area	Block 2	
Analyte	**LOR**	**Adopted Residential Criteria**	**Adopted Commerical Criteria**	**Result**	
TPH (C10-C36) Sum of Total	50	1000	**1000**	**4560**	Excavations not proposed

			Location Code	AECOM_BH26	
			Sample Depth	11.4-11.6	
		BH Elevation (RL AHD)		2.59	Excavations proposed to RL -6.0
		Sample Elevation (RL AHD)		-8.81	
			Area	Block 2	
Analyte	**LOR**	**Adopted Residential Criteria**	**Adopted Commerical Criteria**	**Result**	
TPH (C10-C36) Sum of Total	50	1000	**1000**	**1620**	Excavations not proposed
Benzo(a) pyrene	0.5	4	**5**	4.3	Excavations not proposed

			Location Code	AECOM_BH28	
			Sample Depth	11.5-11.7	
		BH Elevation (RL AHD)		2.15	Excavations proposed to RL -6.0
		Sample Elevation (RL AHD)		-9.35	
			Area	Block 2	
Analyte	**LOR**	**Adopted Residential Criteria**	**Adopted Commerical Criteria**	**Result**	
TPH (C10-C36) Sum of Total	50	1000	**1000**	**2990**	Excavations not proposed

			Location Code	AECOM_BH32	
			Sample Depth	11.5-11.7	
		BH Elevation (RL AHD)		2.82	Excavations proposed to RL -6.0
		Sample Elevation (RL AHD)		-8.68	
			Area	Block 2	
Analyte	**LOR**	**Adopted Residential Criteria**	**Adopted Commerical Criteria**	**Result**	
TPH (C10-C36) Sum of Total	50	1000	**1000**	**2190**	Excavations not proposed

			Location Code	AECOM_BH32	
			Sample Depth	14.5-14.7	
		BH Elevation (RL AHD)		2.82	Excavations proposed to
		Sample Elevation (RL AHD)		-11.68	RL -6.0
			Area	Block 2	
Analyte	**LOR**	**Adopted Residential Criteria**	**Adopted Commerical Criteria**	**Result**	
TPH (C10-C36) Sum of Total	50	1000	**1000**	**1660**	Excavations not proposed
Benzo(a) pyrene	0.5	4	**5**	4.8	Excavations not proposed

			Location Code	BH100	
			Sample Depth	3.0-3.45	
		BH Elevation (RL AHD)		2.63	Excavations proposed to
		Sample Elevation (RL AHD)		-0.37	RL -6.0
			Area	Block 3	
Analyte	**LOR**	**Adopted Residential Criteria**	**Adopted Commerical Criteria**	**Result**	
TPH (C10-C36) Sum of Total	50	1000	**1000**	**980**	Will be excavated
Benzo(a) pyrene	0.5	4	**5**	**6.2**	Will be excavated

			Location Code	BH195	
			Sample Depth	10.5	
		BH Elevation (RL AHD)		2.15	Excavations proposed to
		Sample Elevation (RL AHD)		-8.35	RL -6.0
			Area	Block 2	
Analyte	**LOR**	**Adopted Residential Criteria**	**Adopted Commerical Criteria**	**Result**	
Benzo(a) pyrene	0.5	4	**5**	**6**	Excavations not proposed
TPH (C10-C36) Sum of Total	50	1000	**1000**	**2215**	Excavations not proposed

ZONE 1 - BLOCK 3

			Location Code	AECOM_BH07	
			Sample Depth	7.4-7.5	
		BH Elevation (RL AHD)		2.42	Excavations proposed to
		Sample Elevation (RL AHD)		-4.98	RL -20.0
			Area	Block 3	
Analyte	**LOR**	**Adopted Residential Criteria**	**Adopted Commerical Criteria**	**Result**	
TPH (C10-C36) Sum of Total	50	1000	**1000**	**2620**	Will be excavated
Benzo(a) pyrene	0.5	4	**5**	**9.3**	Will be excavated
PAHs (Sum of total)	0.5	80	**100**	**251.3**	Will be excavated

			Location Code	AECOM_BH08	
			Sample Depth	13.0-13.1	
		BH Elevation (RL AHD)		2.22	Excavations proposed to
		Sample Elevation (RL AHD)		-10.78	RL -20.0
			Area	Block 3	
Analyte	**LOR**	**Adopted Residential Criteria**	**Adopted Commerical Criteria**	**Result**	
TPH (C6-C9)	2	65	**65**	**170**	Will be excavated
Benzene	0.2	1	**1**	**13.9**	Will be excavated
Xylene Total	-	25	**25**	**46.5**	Will be excavated

			Location Code	AECOM_BH08	
			Sample Depth	14.0-14.1	
		BH Elevation (RL AHD)		2.22	Excavations proposed to
		Sample Elevation (RL AHD)		-11.78	RL -20.0
			Area	Block 3	
Analyte	**LOR**	**Adopted Residential Criteria**	**Adopted Commerical Criteria**	**Result**	
Benzene	0.2	1	**1**	**1.4**	Will be excavated

				Location Code	AECOM_BH11
				Sample Depth	2.6-2.7
			BH Elevation (RL AHD)	2.42	Excavations proposed to
			Sample Elevation (RL AHD)	-0.18	RL -20.0
				Area	Block 3
Analyte	**LOR**	**Adopted Residential Criteria**	**Adopted Commerical Criteria**	**Result**	
Lead	2	1200	**1500**	**2050**	Will be excavated
TPH (C10-C36) Sum of Total	50	1000	**1000**	**13550**	Will be excavated

				Location Code	AECOM_BH11
				Sample Depth	3.2-3.3
			BH Elevation (RL AHD)	2.42	Excavations proposed to
			Sample Elevation (RL AHD)	-0.78	RL -20.0
				Area	Block 3
Analyte	**LOR**	**Adopted Residential Criteria**	**Adopted Commerical Criteria**	**Result**	
TPH (C10-C36) Sum of Total	50	1000	**1000**	**2070**	Will be excavated

				Location Code	AECOM_BH12
				Sample Depth	3.0-3.2
			BH Elevation (RL AHD)	2.66	Excavations proposed to
			Sample Elevation (RL AHD)	-0.34	RL -20.0
				Area	Block 3
Analyte	**LOR**	**Adopted Residential Criteria**	**Adopted Commerical Criteria**	**Result**	
TPH (C10-C36) Sum of Total	50	1000	**1000**	**1510**	Excavations not proposed
Benzo(a) pyrene	0.5	4	**5**	**16**	Excavations not proposed
PAHs (Sum of total)	0.5	80	**100**	**324.3**	Excavations not proposed

				Location Code	AECOM_BH13
				Sample Depth	7.2-7.4
			BH Elevation (RL AHD)	2.5	Excavations proposed to
			Sample Elevation (RL AHD)	-4.7	RL -6.0
				Area	Block 3
Analyte	**LOR**	**Adopted Residential Criteria**	**Adopted Commerical Criteria**	**Result**	
TPH (C10-C36) Sum of Total	50	1000	**1000**	**1430**	Will be excavated

				Location Code	AECOM_BH15
				Sample Depth	2.0-2.2
			BH Elevation (RL AHD)	2.71	Excavations proposed to
			Sample Elevation (RL AHD)	0.71	RL -20.0
				Area	Block 2
Analyte	**LOR**	**Adopted Residential Criteria**	**Adopted Commerical Criteria**	**Result**	
Lead	2	1200	**1500**	**1630**	Will be excavated

				Location Code	BH117
				Sample Depth	15.0-15.5
			BH Elevation (RL AHD)	2.35	Excavations proposed to
			Sample Elevation (RL AHD)	-12.65	RL -20.0
				Area	Block 3
Analyte	**LOR**	**Adopted Residential Criteria**	**Adopted Commerical Criteria**	**Result**	
TPH (C6-C9)	2	65	**65**	**244**	Excavations not proposed
TPH (C10-C36) Sum of Total	50	1000	**1000**	**5580**	Excavations not proposed
Benzene	0.2	1	**1**	**19.4**	Excavations not proposed
Xylene Total	-	25	**25**	**83.2**	Excavations not proposed
Benzo(a) pyrene	0.5	4	**5**	**11.4**	Excavations not proposed
PAHs (Sum of total)	0.5	80	**100**	**826.3**	Excavations not proposed

ZONE 2 - BLOCK 3

			Location Code	AECOM_BH04	
			Sample Depth	20.0-20.2	
		BH Elevation (RL AHD)		2.16	Excavations proposed to
		Sample Elevation (RL AHD)		-17.84	RL -6.0
			Area	Block 3	
Analyte	**LOR**	**Adopted Residential Criteria**	**Adopted Commerical Criteria**	**Result**	
TPH (C6-C9)	2	65	**65**	**79**	Excavations not proposed
Benzene	0.2	1	**1**	**5.6**	Excavations not proposed

			Location Code	AECOM_BH04	
			Sample Depth	21.0-21.2	
		BH Elevation (RL AHD)		2.16	Excavations proposed to
		Sample Elevation (RL AHD)		-18.84	RL -6.0
			Area	Block 3	
Analyte	**LOR**	**Adopted Residential Criteria**	**Adopted Commerical Criteria**	**Result**	
TPH (C6-C9)	2	65	**65**	**121**	Excavations not proposed
Benzene	0.2	1	**1**	**9.7**	Excavations not proposed
Xylene Total	-	25	**25**	**30.7**	Excavations not proposed
PAHs (Sum of total)	0.5	80	**100**	**151.25**	Excavations not proposed

			Location Code	AECOM_BH04	
			Sample Depth	22.0-22.1	
		BH Elevation (RL AHD)		2.16	Excavations proposed to
		Sample Elevation (RL AHD)		-19.84	RL -6.0
			Area	Block 3	
Analyte	**LOR**	**Adopted Residential Criteria**	**Adopted Commerical Criteria**	**Result**	
Benzene	0.2	1	**1**	**8**	Excavations not proposed

			Location Code	AECOM_BH37	
			Sample Depth	20.4-20.5	
		BH Elevation (RL AHD)		2.23	Excavations proposed to
		Sample Elevation (RL AHD)		-18.17	RL -6.0
			Area	Block 3	
Analyte	**LOR**	**Adopted Residential Criteria**	**Adopted Commerical Criteria**	**Result**	
Benzene	0.2	1	**1**	**3.1**	Excavations not proposed

			Location Code	AECOM_BH37	
			Sample Depth	22	
		BH Elevation (RL AHD)		2.23	Excavations proposed to
		Sample Elevation (RL AHD)		-19.77	RL -6.0
			Area	Block 3	
Analyte	**LOR**	**Adopted Residential Criteria**	**Adopted Commerical Criteria**	**Result**	
Benzo(a) pyrene	0.5	4	**5**	**22.8**	Excavations not proposed
PAHs (Sum of total)	0.5	80	**100**	**1536**	Excavations not proposed

			Location Code	BH110	
			Sample Depth	23.3-23.8	
		BH Elevation (RL AHD)		2.31	Excavations proposed to
		Sample Elevation (RL AHD)		-20.99	RL -6.0
			Area	Block 3	
Analyte	**LOR**	**Adopted Residential Criteria**	**Adopted Commerical Criteria**	**Result**	
Benzene	0.2	1	**1**	**7.8**	Excavations not proposed

PUBLIC DOMAIN

		Location Code	BH102	
		Sample Depth	3.00-3.45	
		BH Elevation (RL AHD)	2.53	Excavations not proposed
		Sample Elevation (RL AHD)	-0.47	
		Area	Public Domain Blocks 1-3	
Analyte	**LOR**	**Adopted Public Domain Criteria**	**Result**	
Lead	2	**600**	**878**	Excavations not proposed

		Location Code	BH103	
		Sample Depth	1.50-1.95	
		BH Elevation (RL AHD)	2.55	Excavations not proposed
		Sample Elevation (RL AHD)	1.05	
		Area	Public Domain Blocks 1-3	
Analyte	**LOR**	**Adopted Public Domain Criteria**	**Result**	
Lead	2	**600**	**1320**	Excavations not proposed

		Location Code	AECOM_BH23	
		Sample Depth	4.7-4.9	
		BH Elevation (RL AHD)	2.44	Excavations not proposed
		Sample Elevation (RL AHD)	-2.26	
		Area	Public Domain Blocks 1-3	
Analyte	**LOR**	**Adopted Public Domain Criteria**	**Result**	
TPH (C10 - C36) Sum of Total	50	**1000**	**7340**	Excavations not proposed
Benzo(a) pyrene	0.5	**2**	**17.2**	Excavations not proposed
PAHs (Sum of total)	-	**40**	**281.2**	Excavations not proposed

		Location Code	AECOM_BH30	
		Sample Depth	1.0-1.2	
		BH Elevation (RL AHD)	2.42	Excavations proposed to RL -6.0
		Sample Elevation (RL AHD)	1.42	
		Area	Public Domain Blocks 1-3	
Analyte	**LOR**	**Adopted Public Domain Criteria**	**Result**	
Benzo(a) pyrene	0.5	**2**	**8.7**	Will be excavated
PAHs (Sum of total)	-	**40**	**99.4**	Will be excavated

Note:

AECOM_BH01 = Denotes AECOM Borehole location
BH101 = Denotes ERM Borehole location
- = No data available
Result = Data exceeding adopted site assessment criteria only
LOR's, Adopted Criteria's and Results are expressed in mg/kg unless stated otherwise
Result Shaded - Result > Adopted Residential Criteria
Result Bold = Result > Adopted Commercial Criteria

Remediation Technology	Technology Description	Feasibility				Sustainability						Comments	Total Score
		Technical 30%	Financial 15%	Logistical 10%	Timing 10%	RU 6%	WG 6%	MR 6%	CO2 6%	CI 6%	OGM 5%		
Ex Situ Stabilisation or Solidification (on or off site)	Encapsulation of contaminant by ex situ blending with chemical binders to immobilise and solidify contaminants of concern.	5	4	5	5	4	5	5	3	3	3	Immobilises contaminants and neutralises soil. Has been used for treatment of source zone soils at a number of MGP sites in North America and Australia. Treated material could potentially be re-used on-site or require off-site disposal. Off-site disposal would likely require disposal to landfill - which depending on quantities may presnt difficulties with existing landfill licence conditions. Excavation of soil can create significant odour issues thereby requiring negative pressure shed and air emmissions control.	4.45
Surfactant-enhanced Ex Situ Chemical Oxidation (S-ESCO)	Strong oxidants such as hydrogen peroxide, permanganate or persulphate are applied to excavated materials (typically using a pugmill) to degrade a wide range of organic contaminants.	4	5	4	4	5	5	5	4	4	3	Efficacy dependent on soil oxidant demand and contaminant type. Use of pugmill improves effectiveness of technology. Has been applied at several former MGP sites in North America with good effectiveness. Surfactant enhancement can be used to overcome some difficulties assocaited with tar contamination from former MGP sites.	4.28
In Situ Stabilisation or Solidification (on site)	Encapsulation of contaminant by in situ blending with chemical binders to immobilise contaminants of concern.	4	4	4	4	4	5	5	3	4	3	Immobilises contaminants and neutralises soil. Has been used for treatment of source zone soils at a number of MGP sites in North America. Effective in situ mixing may be difficult in fine grained soils or where large obstructions are present as would be expected in areas of significant fill.	4.01
Ex situ Chemical Oxidation (on site)	Ex-situ traetment of excavation soils using strong oxidants, such as hydrogen perodixe, permanganate or prsulphate to degrade a wide range of organic contaminatns.	3	5	4	4	4	5	5	3	3	4	As for ISCO, efficacy is dependant on soil oxidant demand and contaminant type. Chemical dosing of the soil is accomplished in parallel with physical mixing using specially designed injection equipment. Relatively novel technology that has not been widely demonstrated, however ISCO is known to be effective on former MGP sites in North America. The ex-situ nature of the technology and the ability to physically amend the mateiral shou;d improve the treatment efficacy.	3.85
Excavation and Ex Situ Thermal Desorption (likely off site)	Desorption and/or destruction of organic contaminants in excavated soil by heating, usually by direct heating thermal unit.	4	3	4	4	2	5	5	1	1	4	Demonstrated PAH and organic contaminant reduction and has been widely used for the remediation of MGP residues at many sites in both North America and Australia. Based on understanding of SHFA requirements, treatment would need to be as an off site location - which would need to be appropiately licenced by the DECC. Logistically and timing likely to be preferable where volumes are large (>20,000 m^3) may be financially more viable. Air emissions control required. Excavation of soil can create significant odour issues thereby requiring negative pressure shed. Public perception of thermal treatment and regulatory licencing requirements would make establishment of a thermal treatment plant difficult and time consuming.	3.49
Thermal Conductive Heating (TCH)	Soil heating via in-well heaters or thermal blankets in the case of very shallow soil to vaporise/volatilise fluids and contaminants. Temperatures can be raised to above 450^{o}C to remove 4 and 5 ring PAHs and other recalcitrant compounds.	4	1	4	3	2	5	5	1	4	3	Works well under wide range of soil types including clay. Removes contaminants under existing structures. Has been used for in situ remediation at former MGP sites including staged heating for removal of volatile components only. Requires closely spaced wells (<5 m) and has high electrical consumption.	3.22
Physical Containment	Containment or capping of contaminated soil to prevent or significantly reduce contaminant migration and to prevent human and environmental exposure.	2	3	3	3	4	5	4	4	4	1	Does not remove contamination sources and would require long term management and deed restriction. Will not satisfy regulatory requirements.	2.96
Excavation & Co-burning	Combustion of MGP residues with coal in utility boilers and cement kilns.	4	3	1	2	1	3	4	1	1	4	Technology has been used for remediation of several MGP sites in North America. Significantly lower cost than on-site thermal treatment. Requires the removal and transport to a large coal fired boiler. Coordination with co-burners can be problematic. Daily throughput can be very low, making storage and staging of excavated materials difficult to manage leading to increased costs. Handling and transportation of coal tar, including associated odour could be a logistical problem. Technology has never been used in Australia and may not be acceptable to community and regulators.	2.75
Excavation & Cold or Hot-Mix Asphalt Batching	Encapsulation of contaminant by blending residues, wet aggregate and asphalt emulsion at ambient or high temperatures.	2	4	3	3	2	3	4	2	1	4	Viable treatment technology for coal tars. Immobilises PAHs and reuses materials. Not suitable for fine-grained materials (e.g., clays) and would require addition of high grade aggregate. Physical properties of final product not always appropriate for traffic reuse. May be suitable for zones where extensive tar is present.	2.72
In Situ Steam Stripping	Injection of steam into subsurface contaminants to volatilise and mobilise contaminants.	1	1	3	3	2	2	2	2	3	2	Technology works best in sandy permeable soils and generally not suitable for very shallow unsaturated zone soils. Temperature is limited to 100 ^{o}C and therefore suitable for removal of volatile component only. Very high initial capital cost.	1.81
Monitored Natural Attenuation (MNA)	Natural subsurface processes—such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials—are allowed to reduce contaminant concentrations to acceptable levels.											Not effective as first approach in source areas. Will not satisfy regulatory requirements. Retain for future option post-remediation	0.00
Soil Vapour Extraction System (SVE)	Soil vapour extraction (SVE) is an in situ unsaturated (vadose) zone soil remediation technology in which a vacuum is applied to the soil to induce the controlled flow of air and remove volatile and some semi volatile contaminants from the soil. The extracted vapour requires treatment to recover or destroy the contaminants.											Well established proven technology will remove volatile component and reduce risks to future users of site. Has additional benefit of removing contaminants from areas where excavation is not feasible (e.g. easements). However, will not remove the higher chain TPH fraction and may not be as effective in fine grained soils. Will also promote in situ biodegradation through increased oxygen in unsaturated zone. Technology may not be suitable for use over large source zone but may be used in conjunction with other technologies for targeted source removal.	0.00

Remediation Technology	Technology Description	Feasibility				Sustainability						Comments	Total Score
		Technical 30%	Financial 15%	Logistical 10%	Timing 10%	RU 6%	WG 6%	MR 6%	CO2 6%	CI 6%	OGM 5%		
In Situ Enhanced Bioremediation (ISEB)	Destruction of organic compounds in subsurface contaminated soil by microorganisms.											Timeframe for reduction of contaminants, in particular coal tar may be very long. Treatment uniformity uncertain because of subsurface variables. Verification of destruction is sometimes difficult. Not effective for higher molecular-weight hydrocarbons. Whilst technology has been highly successful for the treatment of hydrocarbons and lower molecular weight PAHs at many sites, it has not been demonstrated for treatment of MGP coal tar.	0.00
Ex Situ Bioremediation (Landfarming/Biopiles/Bioreactor)	Destruction of organic compounds in contaminated soil by microorganisms. Treatment occurs through soil amendment and stockpiling or enclosed reactor vessel.											Shorter treatment period that in situ bioremediation alternative. However, not effective for higher molecular weight hydrocarbons and will be significantly slower than alternative treatment technologies. May be suitable for impacted soil but unlikely to be feasible for residual coal tar. Requires a large amount of space and VOC and odour emissions likely to be a significant constraint in urban setting.	0.00
Phytoremediation	Phytoremediation is a process that uses plants to remove, transfer, stabilize, and destroy contaminants in soil and sediment. Contaminants may be either organic or inorganic.											Technology requires long timeframe for removal of contaminants which renders site unusable for other purposes. Has not been demonstrated for use at MGP sites.	0.00
Electrical Resistive Heating	Similar to TCH, however electrodes are used instead of heater wells. Temperature cannot exceed 100 ^{o}C since process requires transmission of heat via pore water											Technology is suitable for most soil types and in particular low permeability clays. Technology can not exceed temperatures of 100^{o}C and is suitable for removal of volatile compounds only. Technology requires moisture in the soil for conduction of heat between electrodes and may not be suitable for unsaturated zone soils. Requires closely spaced electrodes (<5 m) and has high electrical consumption.	0.00
Soil Washing	Physical/chemical process for scrubbing soils ex situ to remove contaminants.											High degree of certainty regarding treatment performance. Material handling possibly expensive. Effectiveness limited by complex waste mixtures and high humic content. Generally not suitable for fine grained soil.	0.00
In Situ Vitrification (ISV)	In situ vitrification (ISV) is another in situ S/S process which uses an electric current to melt soil or other earthen materials at extremely high temperatures (1,600 to 2,000 ℃) and thereby immobilise most inorganics and destroy organic pollutants by pyrolysis.											Method designed for sandy soils. Prohibitively expensive.	0.00
Surfactant and/or Co-solvent injection	Surfactant/Alcohol generally used in combination to lower interfacial tension, decrease density and increase solubility leading to removal of free phase and residual tar.											Requires detailed knowledge of DNAPL composition to determine correct flushing fluid composition. Not effective in removing tar from low permeability material. Not very effective treatment for sorbed or diffused contaminants. Requires significant above ground treatment infrastructure for the recovery/re-use of surfactant and treatment of contaminants. Technology has not be used for treatment of MGP residues.	0.00
Permeable Reactive Barrier (PRB)	A permeable reaction wall is installed across the flow path of a contaminant plume, allowing the water portion of the plume to passively move through the wall. The contaminants will either be degraded or retained in a concentrated form by the barrier material.											Technology not suitable for unsaturated zone soils.	0.00
Supercritical water oxidation	Supercritical Water Oxidation (SCWO) is a high-efficiency, thermal oxidation process capable of treating a wide variety of hazardous and non-hazardous wastes.											Technology is not suitable for treatment of soils. Typically used to treat small quantities of hazardous liquid waste/slurries in commercial reactors.	0.00
Electrokinetics	Electrokinetic remediation uses electrochemical and electrokinetic processes to desorb, and then remove, metals and polar organics											Not applicable for the contaminants of concern.	0.00

RU Resource Use
WG Waste Generation
MR Material Reusability
CO2 CO2 Generation
CI Community Impact
OGM Ongoing Management and Risk

Figures

PROJECT ID: S4150030 CREATED BY: TO LAST MODIFIED: TO 14 04 2010 AECOM www.aecom.com		**Site Location**
0 600m		**Lend Lease Development** *Remedial Action Plan* *Barangaroo Other Remediation Works (South) Area* Hickson Road, Millers Point NSW
		Figure **F1**

Map Document: G:\S4\S41500_S41599\S41500 Barangaroo\S4150030 Remedial Action Plan\S4150030 F1

A4 Size

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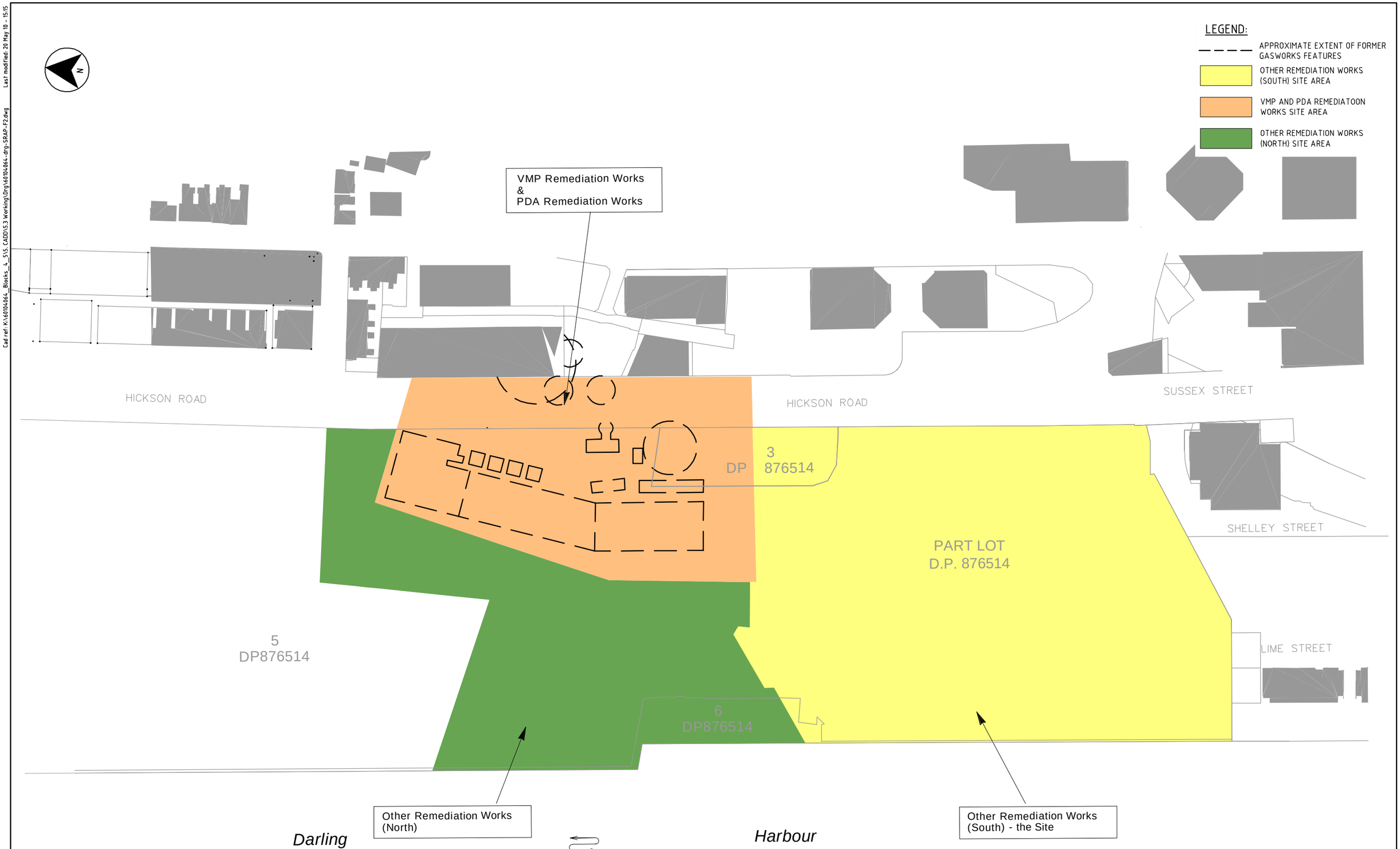

REVISIONS				
No.	BY	DATE	DESCRIPTION	APPD
01	MT	15.04.2010		DFM
01	SS	07.04.2010		DFM

SCALES:

THE SIGNING OF THIS TITLE BLOCK CONFIRMS THE DESIGN AND DRAFTING OF THIS PROJECT HAVE BEEN PREPARED AND CHECKED IN ACCORDANCE WITH THE AECOM QUALITY ASSURANCE SYSTEM TO ISO 9001-2000

DESIGNED	KP/DFM	CHECKED	KP/DFM
DRAWN	SS	CHECKED	JA
APPROVED	DFM	DATE	07.04.2010

DESIGNER:

AECOM

AECOM Australia Pty Ltd A.B.N. 20 093 846 925

OTHER REMEDIATION WORKS (SOUTH) AREA RAP

SITE LAYOUT AND SURROUNDING AREA
FIGURE F2

STATUS:	DRAWING NO:	REV:
DRAFT	60104064-DRG-SRAP-F2	01

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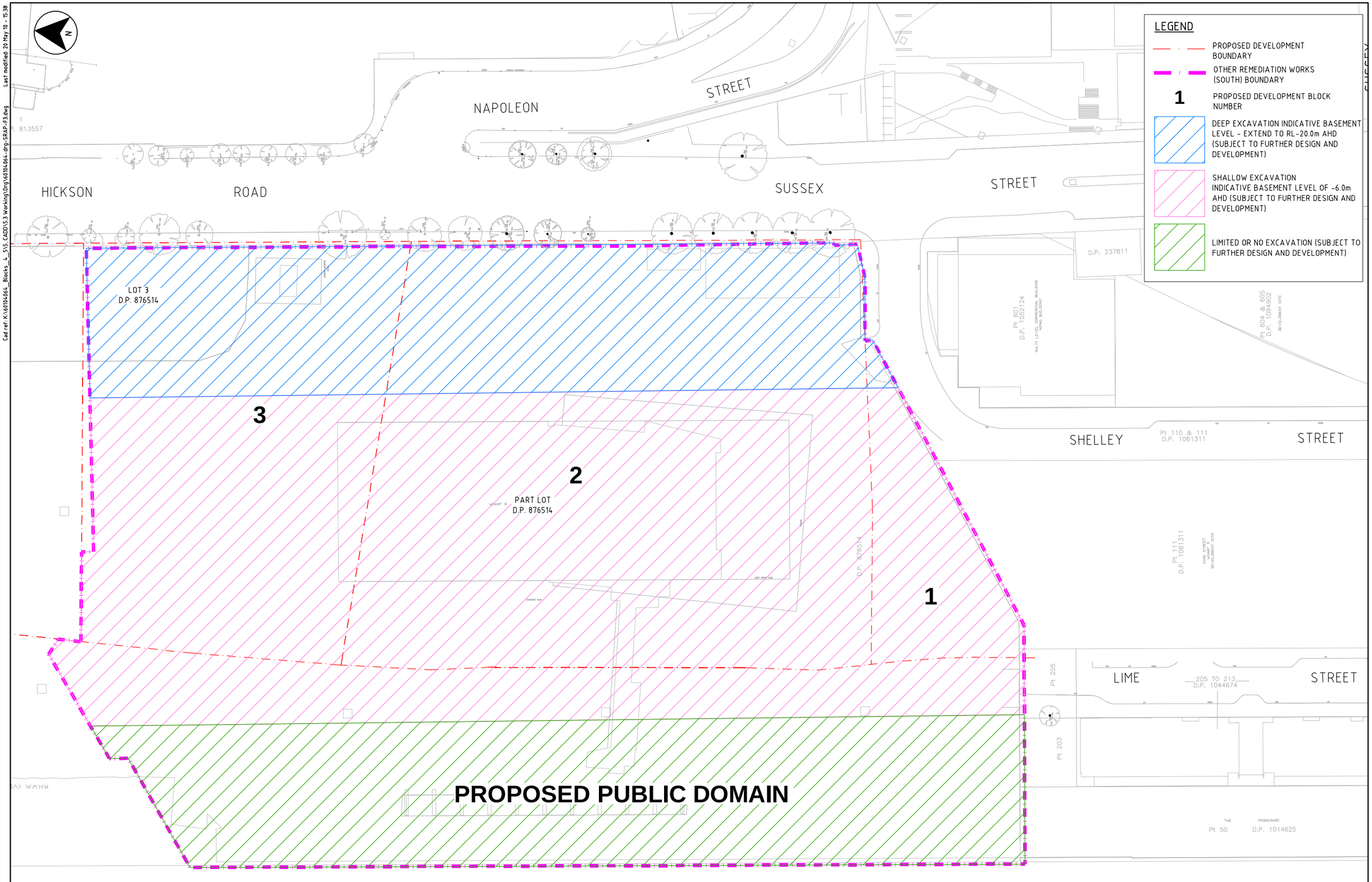


LEGEND

- PROPOSED DEVELOPMENT BOUNDARY
- OTHER REMEDIATION WORKS (SOUTH) BOUNDARY
- 1 — PROPOSED DEVELOPMENT BLOCK NUMBER
- DEEP EXCAVATION INDICATIVE BASEMENT LEVEL - EXTEND TO RL-20.0m AHD (SUBJECT TO FURTHER DESIGN AND DEVELOPMENT)
- SHALLOW EXCAVATION INDICATIVE BASEMENT LEVEL OF -6.0m AHD (SUBJECT TO FURTHER DESIGN AND DEVELOPMENT)
- LIMITED OR NO EXCAVATION (SUBJECT TO FURTHER DESIGN AND DEVELOPMENT)

REVISIONS

No.	BY	DATE	DESCRIPTION	APPD
01	MT	15.04.2010		DFM
01	SS	07.04.2010		DFM

SCALES:

THE SIGNING OF THIS TITLE BLOCK CONFIRMS THE DESIGN AND DRAFTING OF THIS PROJECT HAVE BEEN PREPARED AND CHECKED IN ACCORDANCE WITH THE AECOM QUALITY ASSURANCE SYSTEM TO ISO 9001-2000

DESIGNED	KP/DFM	CHECKED	KP/DFM
DRAWN	SS	CHECKED	JA
APPROVED	DFM	DATE	07.04.2010

DESIGNER:

AECOM

AECOM Australia Pty Ltd A.B.N. 20 093 846 925

OTHER REMEDIATION WORKS (SOUTH) AREA RAP

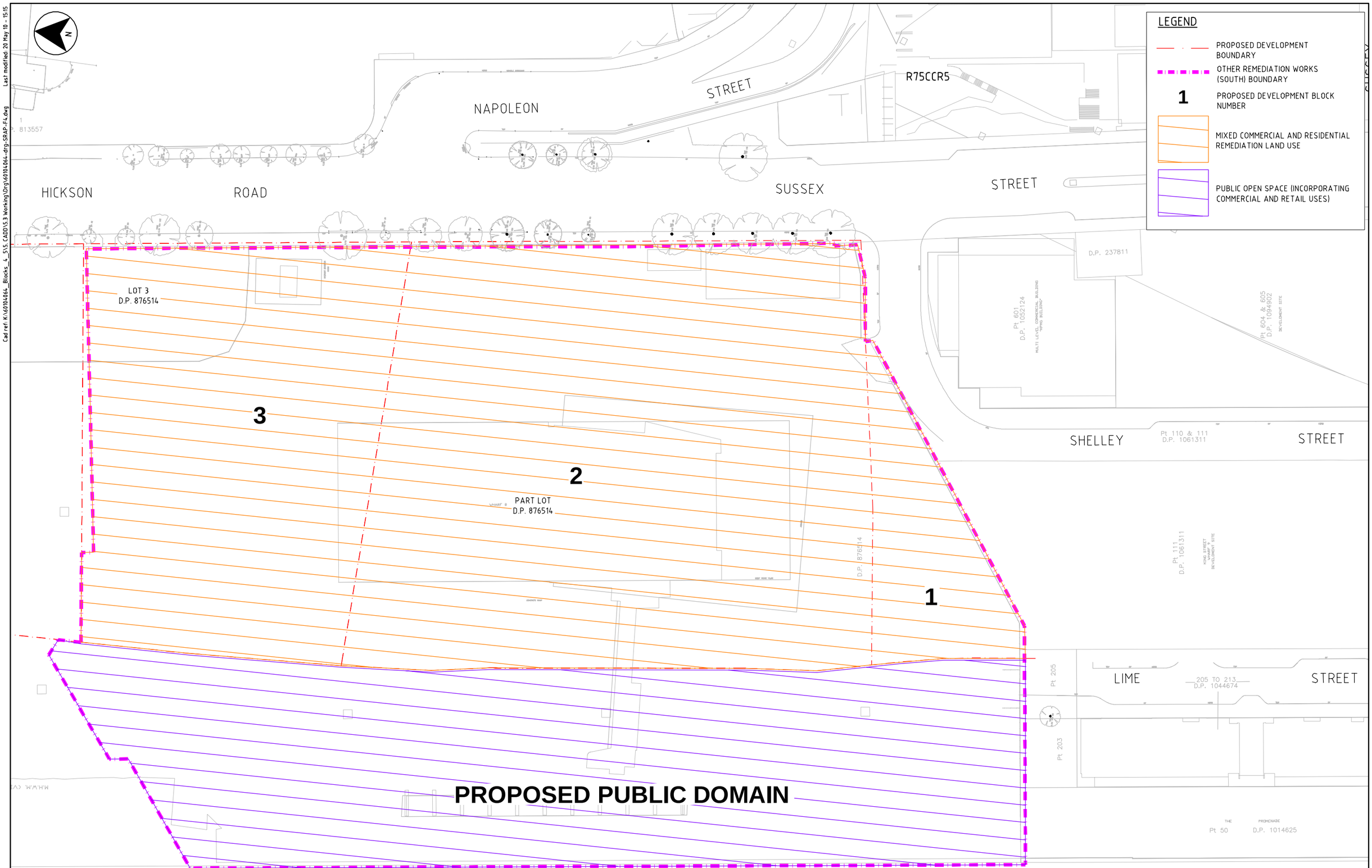
PROPOSED BASEMENT
EXCAVATION PLAN
FIGURE F3

STATUS: DRAFT

DRAWING NO: 60104064-DRG-SRAP-F3

REV: 01

Cad ref: K:\60104064_Blocks_4_SYS_CADD\S3 Working\Drg\60104064-drg-SRAP-F4.dwg Last modified: 20 May 10 - 15:15



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REVISIONS				
01	MT	15.04.2010		DFM
01	SS	07.04.2010		DFM
No.	BY	DATE	DESCRIPTION	APPD

SCALES:

5000 0 5000 10000 15000mm

1 : 500 FULL SIZE A1

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DESIGNED	KP/DFM	CHECKED	KP/DFM
DRAWN	SS	CHECKED	JA
APPROVED	DFM	DATE	07.04.2010

DESIGNER:

AECOM

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OTHER REMEDIATION WORKS (SOUTH) AREA RAP

PROPOSED LAND USE
FIGURE F4

STATUS:	DRAWING NO:	REV:
DRAFT	60104064-DRG-SRAP-F4	01

Last modified: 20 May 10 - 15:16

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N

STREET

NAPOLEON

HICKSON ROAD

SUSSEX STREET

SHELLEY STREET

LIME STREET

LOT 3
D.P. 876514

PART LOT
D.P. 876514

D.P. 876514

D.P. 237811

Pt 601
D.P. 1052124

Pt 604 & 605
D.P. 1094902

Pt 110 & 111
D.P. 1061311

Pt 111
D.P. 1061311

Pt 205

Pt 203

205 TO 213
D.P. 1044674

THE PROMENADE
Pt 50
D.P. 1014625

3

2

1

BH11 BH15 BH091 BH18 BH094 BH092 BH07 BH134 SV03 BH114 BH117/MW23 BH16 BH101 BH097 BH20 BH112 BH10 BH33 SV01 BH111 BH05 BH06 BH192 BH196 BH195 BH193 BH32 BH194 BH28 BH25 BH096 BH36 SV02 BH211 BH118 BH110/MW21 BH22 H41 SV04 BH04 BH37 BH035 BH100 BH29 BH098 BH093 BH03 BH14 BH31 BH095 BH24 BH099 BH30 BH038 BH01 BH049 BH048/MW10 BH102/MW16 BH02 BH103/MW17 BH27 BH108/MW20 BH23 BH104/MW18

PROPOSED PUBLIC DOMAIN

LEGEND

- ERM BORHOLE LOCATION
- ERM GROUNDWATER MONITORING WELL LOCATION
- AECOM BOREHOLE LOCATION
- AECOM GROUNDWATER MONITORING WELL LOCATION
- AECOM SOIL VAPOUR LOCATION

- OTHER REMEDIATION WORKS (SOUTH) BOUNDARY
- PROPOSED DEVELOPMENT BOUNDARY
- EXISTING CAISSION WALL STRUCTURE
- 3 PROPOSED DEVELOPMENT BLOCK NUMBER

REVISIONS				
01	MT	15.04.2010		DFM
01	SS	07.04.2010		DFM
No.	BY	DATE	DESCRIPTION	APPD

SCALES:

5000 0 5000 10000 15000mm

1 : 500 FULL SIZE A1

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DESIGNED	KP/DFM	CHECKED	KP/DFM
DRAWN	SS	CHECKED	JA
APPROVED	DFM	DATE	07.04.2010

DESIGNER:

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OTHER REMEDIATION WORKS (SOUTH) AREA RAP

SITE PLAN AND SAMPLING LOCATIONS
FIGURE F5

STATUS: DRAFT

DRAWING NO: 60104064-DRG-SRAP-F5

REV: 01

Cad ref: K:\60104064_Blocks_4_515.CADD\5.3 Working\Drg\60104064-drg-SRAP-F6.dwg Last modified: 20 May 10 - 15:16

Location Code	AECOM_BH15
Sample Depth	2.0-2.2
Sampled Date	8/02/2010
Area	Block 2

Analyte	LOR	Adopted Residential Criteria	Adopted Commerical Criteria	Result
Lead	2	1200	**1500**	**1630**

Location Code	BH195
Sample Depth	10.5
Sampled Date	9/04/2008
Area	Block 2

Analyte	LOR	Adopted Residential Criteria	Adopted Commerical Criteria	Result
Benzo(a) pyrene	0.5	4	**5**	**6**
TPH (C10-C36) Sum of Total	50	1000	**1000**	**2215**

Location Code	AECOM_BH32
Sample Depth	11.5-11.7
Sampled Date	12/02/2010
Area	Block 2

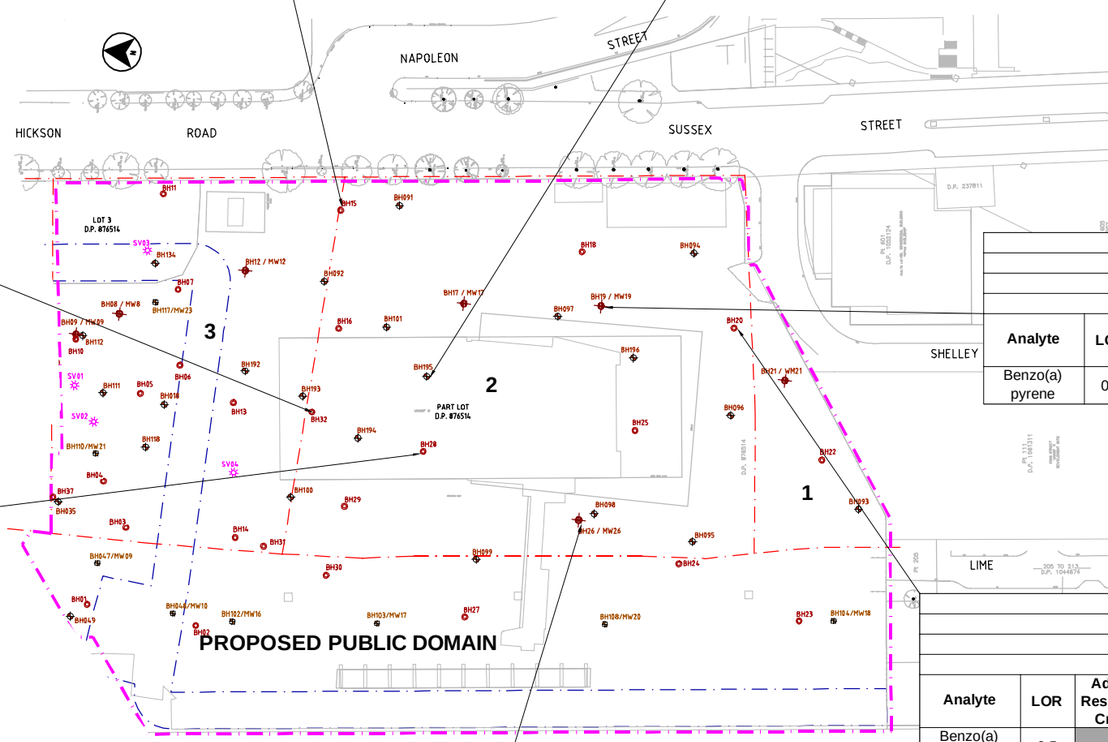
Analyte	LOR	Adopted Residential Criteria	Adopted Commerical Criteria	Result
TPH (C10-C36) Sum of Total	50	1000	**1000**	**2190**

Location Code	AECOM_BH32
Sample Depth	14.5-14.7
Sampled Date	12/02/2010
Area	Block 2

Analyte	LOR	Adopted Residential Criteria	Adopted Commerical Criteria	Result
TPH (C10-C36) Sum of Total	50	1000	**1000**	**1660**
Benzo(a) pyrene	0.5	4	**5**	4.8

Location Code	AECOM_BH28
Sample Depth	11.5-11.7
Sampled Date	15/02/2010
Area	Block 2

Analyte	LOR	Adopted Residential Criteria	Adopted Commerical Criteria	Result
TPH (C10-C36) Sum of Total	50	1000	**1000**	**2990**



Location Code	AECOM_BH19
Sample Depth	6.9-7.0
Sampled Date	9/02/2010
Area	Block 2

Analyte	LOR	Adopted Residential Criteria	Adopted Commerical Criteria	Result
Benzo(a) pyrene	0.5	4	**5**	4.2

Location Code	AECOM_BH26
Sample Depth	11.4-11.6
Sampled Date	11/02/2010
Area	Block 2

Analyte	LOR	Adopted Residential Criteria	Adopted Commerical Criteria	Result
TPH (C10-C36) Sum of Total	50	1000	**1000**	**1620**
Benzo(a) pyrene	0.5	4	**5**	4.3

Location Code	AECOM_BH20
Sample Depth	1.0-1.2
Sampled Date	11/02/2010
Area	Block 2

Analyte	LOR	Adopted Residential Criteria	Adopted Commerical Criteria	Result
Benzo(a) pyrene	0.5	4	**5**	**18.1**
PAHs (Sum of total)	0.5	80	**100**	**300.7**

Location Code	AECOM_BH20
Sample Depth	11.0-11.2
Sampled Date	11/02/2010
Area	Block 2

Analyte	LOR	Adopted Residential Criteria	Adopted Commerical Criteria	Result
TPH (C10-C36) Sum of Total	50	1000	**1000**	**4560**

LEGEND

- ERM BORHOLE LOCATION
- ERM GROUNDWATER MONITORING WELL LOCATION
- AECOM BOREHOLE LOCATION
- AECOM GROUNDWATER MONITORING WELL LOCATION
- AECOM SOIL VAPOUR LOCATION

AECOM_BH01 = Denotes AECOM Borehole location
BH101 = Denotes ERM Borehole location
- = No data available
Result = Data exceeding adopted site assessment criteria only
LOR's, Adopted Criteria's and Results are expressed in mg/kg unless stated otherwise
Result Shaded - Result > Adopted Residential Criteria
Result Bold = Result > Adopted Commercial Criteria

- OTHER REMEDIATION WORKS (SOUTH) BOUNDARY
- PROPOSED DEVELOPMENT BOUNDARY
- EXISTING CAISSION WALL STRUCTURE
- **2** PROPOSED DEVELOPMENT BLOCK NUMBER

SCALES:

THE SIGNING OF THIS TITLE BLOCK CONFIRMS THE DESIGN AND DRAFTING OF THIS PROJECT HAVE BEEN PREPARED AND CHECKED IN ACCORDANCE WITH THE AECOM QUALITY ASSURANCE SYSTEM TO ISO 9001-2000

DESIGNED	KP/DFM	CHECKED	KP/DFM
DRAWN	SS	CHECKED	JA
APPROVED	DFM	DATE	07.04.2010

REVISIONS

No.	BY	DATE	DESCRIPTION	APPD
01	MT	15.04.2010		DFM
01	SS	07.04.2010		DFM

DESIGNER:

AECOM

AECOM Australia Pty Ltd A.B.N. 20 093 846 925

OTHER REMEDIATION WORKS (SOUTH) AREA RAP

SOIL EXCEEDENCES - BLOCK 2 DEVELOPMENT AREA
FIGURE F6

STATUS: DRAFT

DRAWING NO: 60104064-DRG-SRAP-F6

REV: 01

Cad ref: K:\60104064_Blocks_4_515.CADD\5.3 Working\Drg\60104064-drg-SRAP-F7.dwg Last modified: 20 May 10 - 15:16

Location Code	BH110
Sample Depth	23.3-23.8
Sampled Date	27/06/2006
Area	Block 3

Analyte	LOR	Adopted Residential Criteria	Adopted Commerical Criteria	Result
Benzene	0.2	1	**1**	**7.8**

Location Code	AECOM_BH37
Sample Depth	20.4-20.5
Sampled Date	18/02/2010
Area	Block 3

Analyte	LOR	Adopted Residential Criteria	Adopted Commerical Criteria	Result
Benzene	0.2	1	**1**	**3.1**

Location Code	AECOM_BH37
Sample Depth	22
Sampled Date	18/02/2010
Area	Block 3

Analyte	LOR	Adopted Residential Criteria	Adopted Commerical Criteria	Result
Benzo(a) pyrene	0.5	4	**5**	**22.8**
PAHs (Sum of total)	0.5	80	**100**	**1536**

Location Code	AECOM_BH04
Sample Depth	20.0-20.2
Sampled Date	9/12/2009
Area	Block 3

Analyte	LOR	Adopted Residential Criteria	Adopted Commerical Criteria	Result
TPH (C6-C9)	2	65	**65**	**79**
Benzene	0.2	1	**1**	**5.6**

Location Code	AECOM_BH04
Sample Depth	21.0-21.2
Sampled Date	10/12/2009
Area	Block 3

Analyte	LOR	Adopted Residential Criteria	Adopted Commerical Criteria	Result
TPH (C6-C9)	2	65	**65**	**121**
Benzene	0.2	1	**1**	**9.7**
Xylene Total	-	25	**25**	**30.7**
PAHs (Sum of total)	0.5	80	**100**	**151.25**

Location Code	AECOM_BH04
Sample Depth	22.0-22.1
Sampled Date	10/12/2009
Area	Block 3

Analyte	LOR	Adopted Residential Criteria	Adopted Commerical Criteria	Result
Benzene	0.2	1	**1**	**8**

Location Code	AECOM_BH08
Sample Depth	13.0-13.1
Sampled Date	8/12/2009
Area	Block 3

Analyte	LOR	Adopted Residential Criteria	Adopted Commerical Criteria	Result
TPH (C6-C9)	2	65	**65**	**170**
Benzene	0.2	1	**1**	**13.9**
Xylene Total	-	25	**25**	**46.5**

Location Code	AECOM_BH08
Sample Depth	14.0-14.1
Sampled Date	8/12/2009
Area	Block 3

Analyte	LOR	Adopted Residential Criteria	Adopted Commerical Criteria	Result
Benzene	0.2	1	**1**	**1.4**

Location Code	AECOM_BH11
Sample Depth	2.6-2.7
Sampled Date	5/02/2010
Area	Block 3

Analyte	LOR	Adopted Residential Criteria	Adopted Commerical Criteria	Result
Lead	2	1200	**1500**	**2050**
TPH (C10-C36) Sum of Total	50	1000	**1000**	**13550**

Location Code	AECOM_BH11
Sample Depth	3.2-3.3
Sampled Date	5/02/2010
Area	Block 3

Analyte	LOR	Adopted Residential Criteria	Adopted Commerical Criteria	Result
TPH (C10-C36) Sum of Total	50	1000	**1000**	**2070**

Location Code	AECOM_BH07
Sample Depth	7.4-7.5
Sampled Date	8/12/2009
Area	Block 3

Analyte	LOR	Adopted Residential Criteria	Adopted Commerical Criteria	Result
TPH (C10-C36) Sum of Total	50	1000	**1000**	**2620**
Benzo(a) pyrene	0.5	4	**5**	**9.3**
PAHs (Sum of total)	0.5	80	**100**	**251.3**

Location Code	AECOM_BH12
Sample Depth	3.0-3.2
Sampled Date	10/02/2010
Area	Block 3

Analyte	LOR	Adopted Residential Criteria	Adopted Commerical Criteria	Result
TPH (C10-C36) Sum of Total	50	1000	**1000**	**1510**
Benzo(a) pyrene	0.5	4	**5**	**16**
PAHs (Sum of total)	0.5	80	**100**	**324.3**

Location Code	BH117
Sample Depth	15.0-15.5
Sampled Date	29/06/2006
Area	Block 3

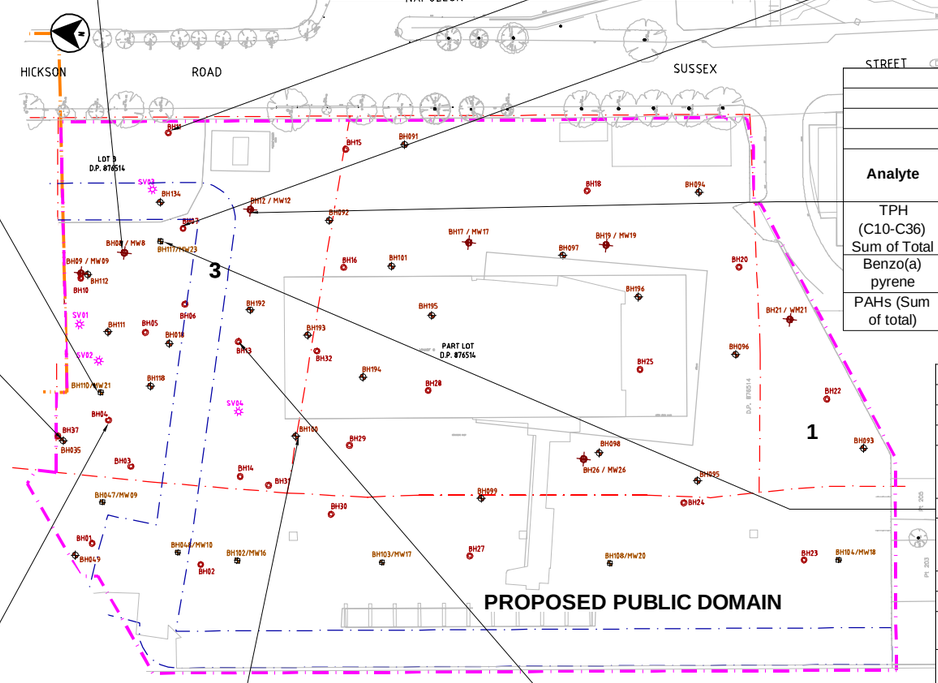
Analyte	LOR	Adopted Residential Criteria	Adopted Commerical Criteria	Result
TPH (C6-C9)	2	65	**65**	**244**
TPH (C10-C36) Sum of Total	50	1000	**1000**	**5580**
Benzene	0.2	1	**1**	**19.4**
Xylene Total	-	25	**25**	**83.2**
Benzo(a) pyrene	0.5	4	**5**	**11.4**
PAHs (Sum of total)	0.5	80	**100**	**826.3**

Location Code	BH100
Sample Depth	3.0-3.45
Sampled Date	15/06/2006
Area	Block 3

Analyte	LOR	Adopted Residential Criteria	Adopted Commerical Criteria	Result
TPH (C10-C36) Sum of Total	50	1000	**1000**	**980**
Benzo(a) pyrene	0.5	4	**5**	**6.2**

Location Code	AECOM_BH13
Sample Depth	7.2-7.4
Sampled Date	5/02/2010
Area	Block 3

Analyte	LOR	Adopted Residential Criteria	Adopted Commerical Criteria	Result
TPH (C10-C36) Sum of Total	50	1000	**1000**	**1430**



LEGEND

- ERM BORHOLE LOCATION
- ERM GROUNDWATER MONITORING WELL LOCATION
- AECOM BOREHOLE LOCATION
- AECOM GROUNDWATER MONITORING WELL LOCATION
- AECOM SOIL VAPOUR LOCATION

AECOM_BH01 = Denotes AECOM Borehole location
BH101 = Denotes ERM Borehole location
- = No data available
Result = Data exceeding adopted site assessment criteria only
LOR's, Adopted Criteria's and Results are expressed in mg/kg unless stated otherwise
Result Shaded - Result > Adopted Residential Criteria
Result Bold = Result > Adopted Commercial Criteria

- OTHER REMEDIATION WORKS (SOUTH) BOUNDARY
- PROPOSED DEVELOPMENT BOUNDARY
- EXISTING CAISSION WALL STRUCTURE
- 3 PROPOSED DEVELOPMENT BLOCK NUMBER

This drawing is confidential and shall only be used for the purposes of this project.

SCALES:

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No.	BY	DATE	DESCRIPTION	APPD
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DRAWN	SS	CHECKED	JA
APPROVED	DFM	DATE	07.04.2010

DESIGNER:

AECOM

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OTHER REMEDIATION WORKS (SOUTH) AREA RAP

SOIL EXCEEDENCES - BLOCK 3
DEVELOPMENT AREA
FIGURE F7

STATUS: DRAFT

DRAWING NO: 60104064-DRG-SRAP-F7

REV: 01

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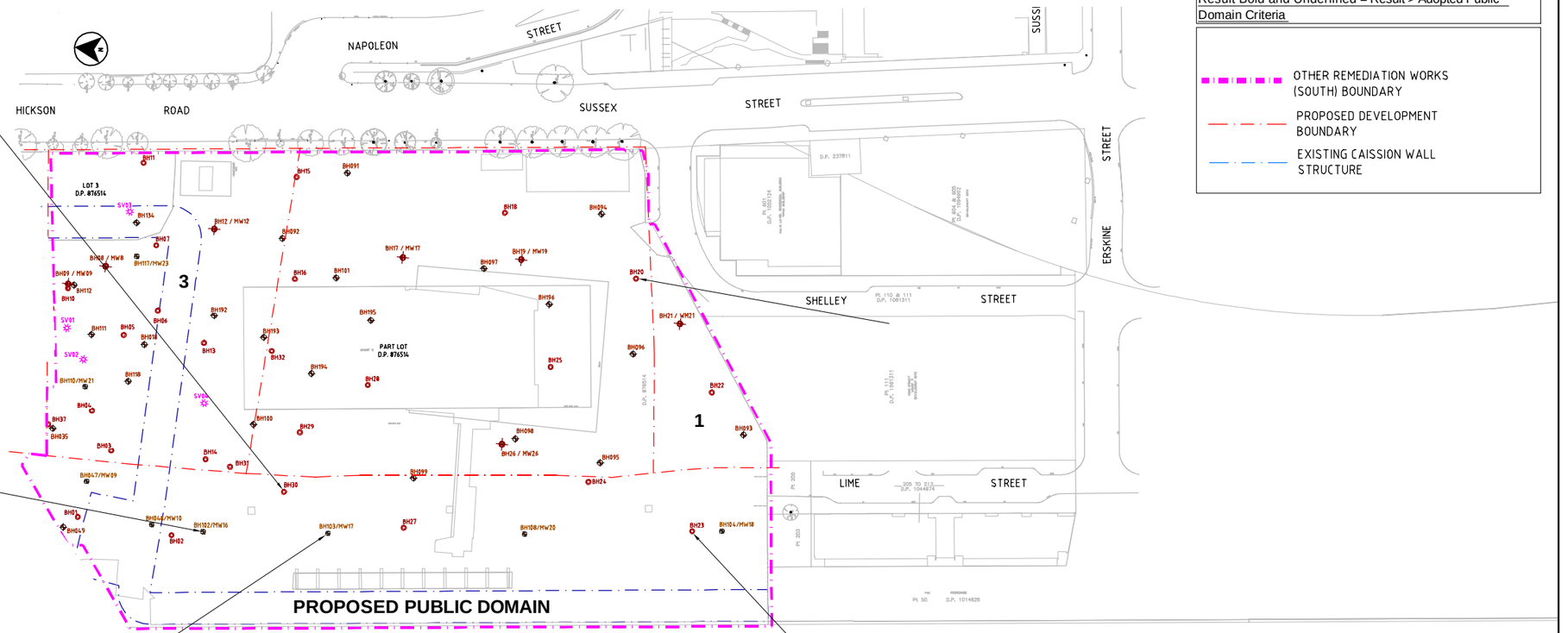
LEGEND

- ERM BORHOLE LOCATION
- ERM GROUNDWATER MONITORING WELL LOCATION
- AECOM BOREHOLE LOCATION
- AECOM GROUNDWATER MONITORING WELL LOCATION
- AECOM SOIL VAPOUR LOCATION

AECOM_BH01 = Denotes AECOM Borehole location
BH101 = Denotes ERM Borehole location
- = No data available
Result = Data exceeding adopted site assessment criteria only
LOR's, Adopted Criteria's and Results are expressed in mg/kg unless stated otherwise
Result Bold and Underlined = Result > Adopted Public Domain Criteria

- OTHER REMEDIATION WORKS (SOUTH) BOUNDARY
- PROPOSED DEVELOPMENT BOUNDARY
- EXISTING CAISSION WALL STRUCTURE



Location Code	AECOM_BH30
Sample Depth	1.0-1.2
Sampled Date	15/02/2010
Area	Public Domain

Analyte	LOR	Adopted Public Domain Criteria	Result
Benzo(a) pyrene	0.5	**2**	**8.7**
PAHs (Sum of total)	-	**40**	**99.4**

Location Code	BH102
Sample Depth	3.00-3.45
Sampled Date	16/06/2006
Area	Public Domain

Analyte	LOR	Adopted Public Domain Criteria	Result
Lead	2	**600**	**878**

Location Code	BH103
Sample Depth	1.50-1.95
Sampled Date	19/06/2006
Area	Public Domain

Analyte	LOR	Adopted Public Domain Criteria	Result
Lead	2	**600**	**1320**

Location Code	AECOM_BH23
Sample Depth	4.7-4.9
Sampled Date	2/05/2010
Area	Public Domain

Analyte	LOR	Adopted Public Domain Criteria	Result
TPH (C10 - C36) Sum of Total	50	**1000**	**7340**
Benzo(a) pyrene	0.5	**2**	**17.2**
PAHs (Sum of total)	-	**40**	**281.2**

REVISIONS

No.	BY	DATE	DESCRIPTION	APPD
01	MT	15.04.2010		DFM
01	SS	07.04.2010		DFM

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DESIGNED	KP/DFM	CHECKED	KP/DFM
DRAWN	SS	CHECKED	JA
APPROVED	DFM	DATE	07.04.2010

DESIGNER:

AECOM

AECOM Australia Pty Ltd A.B.N. 20 093 846 925

OTHER REMEDIATION WORKS (SOUTH) AREA RAP

SOIL EXCEEDENCES
PUBLIC DOMAIN AREA
FIGURE F8

STATUS:	DRAWING NO:	REV:
DRAFT	60104064-DRG-SRAP-F8	01

Location Code	AECOM_BH08
Monitoring Well ID	MW08
Sampled Date	27/02/2010
Area	Development Area (Block 3)

Analyte	Units	LOR	Adopted Groundwater Criteria	Result
Benzene	µg/L	1	700	4410
Cadmium (Filtered)	µg/L	0.05	5.5	47.8
Napthalene	µg/L	20	-	**13200**
TPH (C6-C9)	µg/L	50	-	**9380**
TPH (C10-C36) Sum of Total	µg/L	1	70	4440

Location Code	AECOM_BH17
Monitoring Well ID	MW17
Sampled Date	25/02/2010
Area	Development Area (Block 2)

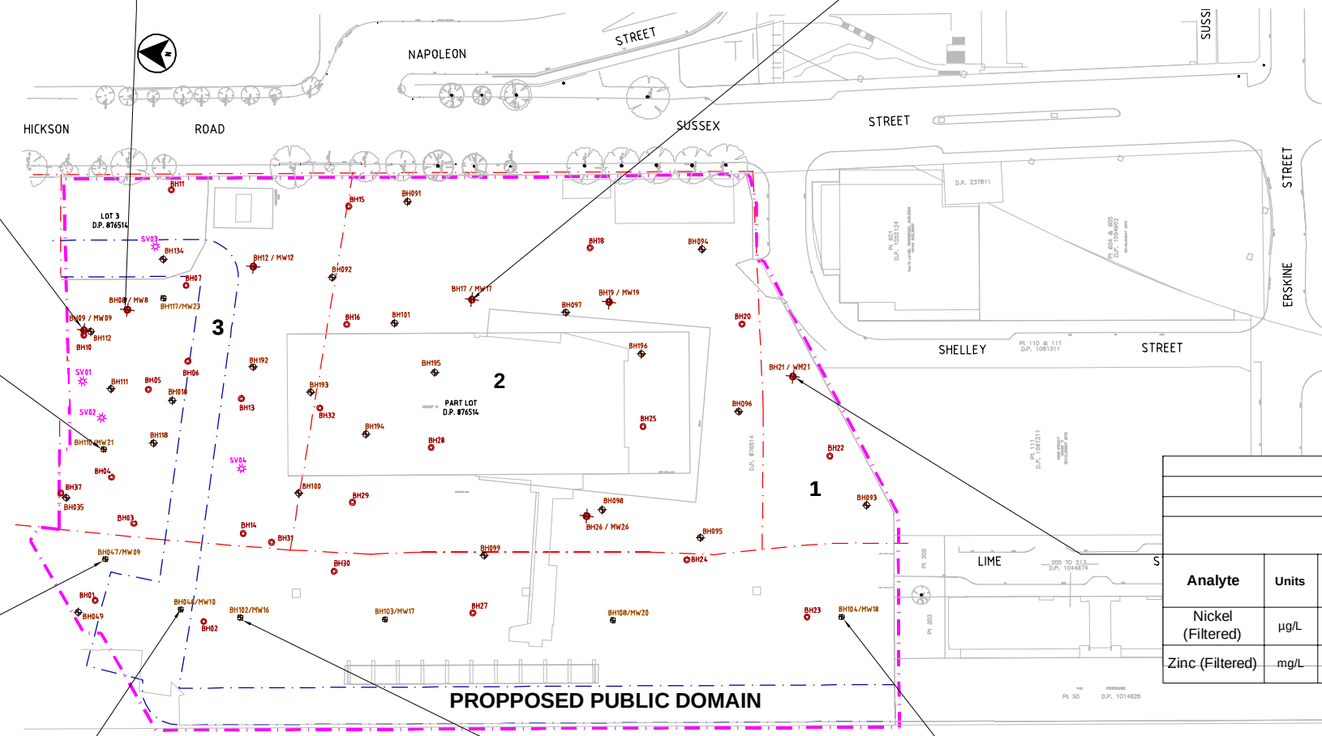
Analyte	Units	LOR	Adopted Groundwater Criteria	Result
Nickel (Filtered)	µg/L	0.5	70	87.1
Zinc (Filtered)	mg/L	0.001	0.015	0.018

Location Code	AECOM_BH09
Monitoring Well ID	MW09
Sampled Date	27/02/2010
Area	Development Area (Block 3)

Analyte	Units	LOR	Adopted Groundwater Criteria	Result
Zinc (Filtered)	mg/L	0.001	0.015	0.019

Location Code	BH110
Monitoring Well ID	MW21
Sampled Date	15/03/2010
Area	Development Area (Block 3)

Analyte	Units	LOR	Adopted Groundwater Criteria	Result
Zinc (Filtered)	mg/L	0.001	0.015	0.074



Location Code	BH047
Monitoring Well ID	MW09
Sample Date	15/03/2010
Area	Public Domain

Analyte	LOR	Units	Adopted Groundwater Criteria	Result
Cadmium (Filtered)	0.05	µg/L	5.5	108
Copper (Filtered)	0.5	µg/L	1.3	55
Nickel (Filtered)	0.5	µg/L	70	72.1
Zinc (Filtered)	0.001	mg/L	0.015	0.13

Location Code	BH048
Monitoring Well ID	MW10
Sampled Date	3/12/2010
Area	Public Domain

Analyte	LOR	Units	Adopted Groundwater Criteria	Result
Cadmium (Filtered)	0.05	µg/L	5.5	25.2
Copper (Filtered)	0.5	µg/L	1.3	7
Zinc (Filtered)	0.001	mg/L	0.015	0.036

Location Code	BH102
Monitoring Well ID	MW16
Sample Date	15/03/2010
Area	Public Domain

Analyte	LOR	Units	Adopted Groundwater Criteria	Result
Cadmium (Filtered)	0.05	µg/L	5.5	23.5
Copper (Filtered)	0.5	µg/L	1.3	14
Lead (Filtered)	0.1	µg/L	4.4	12
Zinc (Filtered)	0.001	mg/L	0.015	0.087

Location Code	BH104
Monitoring Well ID	MW18
Sampled Date	3/12/2010
Area	Public Domain

Analyte	LOR	Units	Adopted Groundwater Criteria	Result
Copper (Filtered)	0.5	µg/L	1.3	79
Nickel (Filtered)	0.5	µg/L	70	77
Zinc (Filtered)	0.001	mg/L	0.015	0.188

Location Code	AECOM_BH21
Monitoring Well ID	MW21
Sampled Date	25/02/2010
Area	Development Area (Block 1)

Analyte	Units	LOR	Adopted Groundwater Criteria	Result
Nickel (Filtered)	µg/L	0.5	70	94.7
Zinc (Filtered)	mg/L	0.001	0.015	0.059

LEGEND

- ERM BORHOLE LOCATION
- ERM GROUNDWATER MONITORING WELL LOCATION
- AECOM BOREHOLE LOCATION
- AECOM GROUNDWATER MONITORING WELL LOCATION
- AECOM SOIL VAPOUR LOCATION

AECOM_BH01 = Denotes AECOM Borehole location
BH101 = Denotes ERM Borehole location
mg/L - milligrams pre litre
µg/L - micrograms per litre
LOR - Laboratory Limit of Reporting
- = No data available
Result = Data exceeding adopted site assessment criteria only
Result Shaded = Result > Adopted Groundwater Criteria
Result Bold = Result > Adopted Groundwater Screening Criteria - LOR

- OTHER REMEDIATION WORKS (SOUTH) BOUNDARY
- PROPOSED DEVELOPMENT BOUNDARY
- EXISTING CAISSION WALL STRUCTURE
- 2 PROPOSED DEVELOPMENT BLOCK NUMBER

SCALES:

REVISIONS

No.	BY	DATE	DESCRIPTION	APPD
01	MT	15.04.2010		DFM
01	SS	07.04.2010		DFM

THE SIGNING OF THIS TITLE BLOCK CONFIRMS THE DESIGN AND DRAFTING OF THIS PROJECT HAVE BEEN PREPARED AND CHECKED IN ACCORDANCE WITH THE AECOM QUALITY ASSURANCE SYSTEM TO ISO 9001-2000

DESIGNED	KP/DFM	CHECKED	KP/DFM
DRAWN	SS	CHECKED	JA
APPROVED	DFM	DATE	07.04.2010

DESIGNER:

AECOM

AECOM Australia Pty Ltd A.B.N. 20 093 846 925

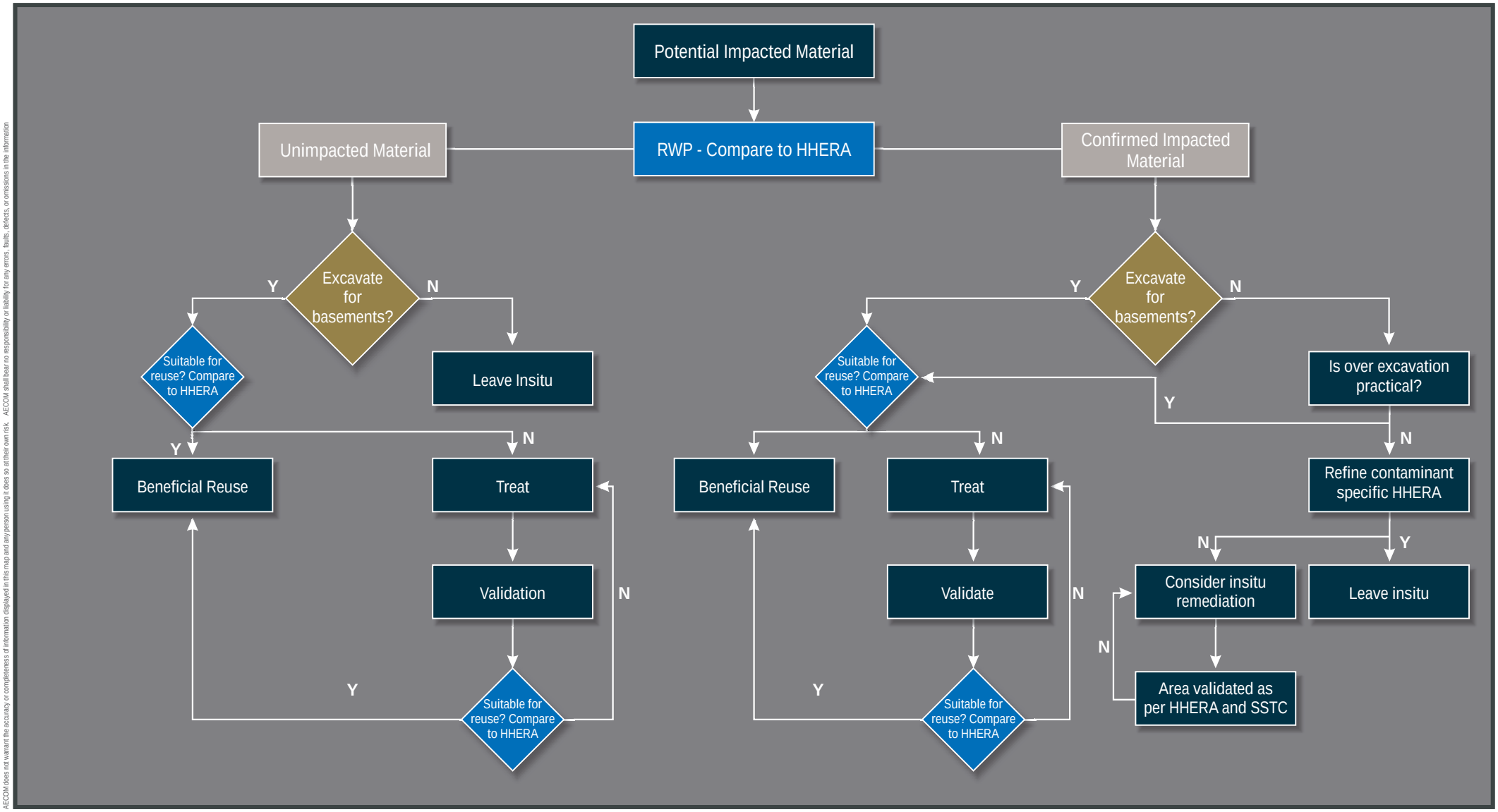
OTHER REMEDIATION WORKS (SOUTH) AREA RAP

GROUNDWATER EXCEEDENCES
FIGURE F9

STATUS: DRAFT

DRAWING NO: 60104064-DRG-SRAP-F9

REV: 01



PROJECT ID: S4150030
CREATED BY: TO
LAST MODIFIED: TO 16 04 2010
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Remediation Decision Making Process Flow Chart

Lend Lease Development
Remedial Action Plan
Barangaroo Other Remediation Works (South) Area
Hickson Road, Millers Point NSW

Figure F10

Map Document: G:\S4\S41500_S41599\S41500 Barangaroo\S4150030 Remedial Action Plan\S4150030 F9

A4 Size

Last modified: 20 May 10 - 15:15

Cad ref: K:\60104064_Blacks_4_515_CADD\5.3 Working\Drg\60104064-drg-SRAP-F11.dwg

HICKSON ROAD

NAPOLEON STREET

SUSSEX STREET

SHELLEY STREET

38 HICKSON ROAD

1 D.P. 813557

LOT 3 D.P. 876514

ZONE 1

ZONE 2

3

2

1

PART LOT D.P. 876514

LIME

205 TO 213 D.P. 1044674

Pt 205

Pt 203

Pt 111 D.P. 1061311

Pt 50

D.P. 876514

M.H.W.M. (VIDE D.P.876514)

BH9 BH10 BH43 BH160 BH133 BH11 BH15 BH091 BH18 BH094 BH42 BH44 BH146 BH132 BH156 BH209/MW209 BH135 SV06 SV03 BH134 BH12 / MW12 BH07 BH092 BH206/MW206 SV05 BH161 BH114 BH08 / MW8 BH117/MW23 BH09 / MW09 BH112 BH10 BH17 / MW17 BH19 / MW19 BH097 BH16 BH101 BH20 BH208 BH35 BH113 BH207 BH45/MW45 BH159 BH33 BH192 BH196 BH195 BH21 / WM21 SV01 BH111 BH05 BH06 BH018 BH210/MW210 BH34 BH109 BH36 BH13 BH193 BH32 BH096 BH211 SV02 BH25 BH194 BH28 BH071 BH072 BH110/MW21 BH118 BH22 BH055 BH41 SV04 BH04 BH142 BH37 BH035 BH100 BH29 BH098 BH093 BH143 BH40/MW40 BH03 BH14 BH31 BH26 / MW26 BH095 BH046 BH047/MW09 BH099 BH24 BH30 BH038 BH01 BH048/MW10 BH102/MW16 BH103/MW17 BH27 BH108/MW20 BH23 BH104/MW18 BH017 BH116/MW22 BH039 BH049 BH02

PROPOSED PUBLIC DOMAIN

LEGEND

- ERM BORHOLE LOCATION
- ERM GROUNDWATER MONITORING WELL LOCATION
- AECOM BOREHOLE LOCATION
- AECOM GROUNDWATER MONITORING WELL LOCATION
- AECOM SOIL VAPOUR LOCATION
- OTHER REMEDIATION WORKS (SOUTH) BOUNDARY
- PROPOSED DEVELOPMENT BOUNDARY
- EXISTING CAISSION WALL STRUCTURE
- 3 PROPOSED DEVELOPMENT BLOCK NUMBER
- POTENTIAL IMPACTED MATERIAL - EXPECTED TO REQUIRE REMEDIATION
- POTENTIAL IMPACTED MATERIAL - NOT EXPECTED TO REQUIRE REMEDIATION

REVISIONS

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APPROVED	DFM	DATE	07.04.2010

DESIGNER:

AECOM

AECOM Australia Pty Ltd A.B.N. 20 093 846 925

OTHER REMEDIATION WORKS (SOUTH) AREA RAP

ZONES OF POTENTIAL SOURCE MATERIAL AND HOTSPOTS FIGURE F11

STATUS: DRAFT

DRAWING NO: 60104064-DRG-SRAP-F11

REV: 01

Appendix A

HHERA Methodology

AECOM

Memorandum

To	Mark Burns, BLL	Page	1
CC	Warwick Bowyer, LLD		
Subject	Barangaroo HHERA Proposed Scope of Work and Methodology		
From	Garry Smith Michael Jones		
File/Ref No.	S41500_MEM018	Date	27 April 2010

Dear Mark,

As requested, this memo presents a summary of the scope of work and methodology proposed for completion of the Human Health and Ecological Risk Assessment (HHERA) in relation to the Barangaroo Stage 1 Development. It should be noted that the scope of work does not include consideration of the risk to construction workers or the public for which a separate scope of work and methodology will be prepared.

1.0 Human Health and Ecological Risk Assessment

The human health and ecological risk assessment (HHERA) will utilise data, available information and field observations from:

- Historical investigation results;
- The ongoing Blocks 1 to 3 DGI;
- The proposed DGI for Blocks 4 to 5 DGI and Hickson Road;
- Historical Work as Executed Plans detailing existing physical structures and geotechnical conditions; and
- Proposed new physical structures to be constructed as part of the Stage 1 Development, including basements, seawalls and pavements.

Analysis has been performed for heavy metals and organic compounds consistent with historic industrial Site use.

Based on the available reports, a number of potential contaminants in soil and groundwater are above Australian-recognised soil and groundwater screening guidelines in a number of Site locations, notably in the area of Blocks 4 to 5 (and adjacent areas of the Public Domain and Southern Cove), in Hickson Road and in a small section of Block 3. This includes, for example, several heavy metals, polycyclic aromatic hydrocarbons (PAH) and total petroleum hydrocarbons (TPH), present with gross tar and in fill materials. Gas holders and tar pit structures were located in the area of Blocks 4 and 5 and Hickson Road and some infrastructure is understood to remain below ground. Past investigations in Blocks 1, 2 and 3 indicate that concentrations of contaminants were broadly less than guideline values for commercial land use and free of non-aqueous phase liquids (NAPLs).

Based on the available historical investigation information, the HHERA will generate Site Specific Target Criteria (SSTC) principally to be used for development of:

- A Remedial Action Plan (RAP) for:
  - The Voluntary Management Plan (VMP) associated with the DECCW Declaration Area;
  - The Project Delivery Agreement (PDA) associated with of the DECCW Declaration Area; and
  - The Other remediation works required in Blocks 4 to 5 and the Southern Cove outside the DECCW Declaration Area.
- A Remediation Work Plan (RWP) for:
  - The VMP associated with the DECCW Declaration Area;
  - The PDA associated with the DECCW Declaration Area; and
  - The Other remediation works required in Blocks 4 to 5 and the Southern Cove.

Subject to the findings of the ongoing Blocks 1 to 3 DGI, the HHERA may also be applicable to Blocks 1 to 3 and therefore contribute to development of the RAP and RWP to be prepared in relation to Blocks 1 to 3.

1.1 HHERA Objectives

The objective of the HHERA is to conduct a human health and ecological risk assessment in accordance with relevant guidelines (including the current National Environment Protection Measure (NEPM), and Site Auditor requirements to develop SSTC for soil and groundwater for use in defining the remediation end-point for the Site.

1.1.1 Site Specific Target Criteria

SSTC will be developed as remedial criteria in consideration of:

- Removal of the DECCW Remediation Declaration which addresses contaminated groundwater, and the potential impact of the contaminated groundwater on surrounding areas including the basement of an adjacent property and potential groundwater migration to Darling Harbour) ; and
- The land uses proposed as part of the Stage 1 Development.

These criteria will be used to guide the remediation process and will specify a chemical concentration that is considered to represent an acceptable level of risk to the health of end-users of the Site or adjacent sites and the environment. Advice on the method for implementation of the SSTC will also be provided, including:

- A statistical approach to remedial validation with respect to large excavations;
- The SSTC approach to isolated pockets of contamination; and
- Approaches to exceptions to the SSTC such as in the case of tar impregnated rock fractures.

The HHERA is expected to be largely redundant in Blocks 1 and 2 and outside the Southern Cove in Block 3 and some of Block 4 and Block 5 because:

- The areas are outside the area affected by the DECCW Remediation Declaration; and
- The majority of material will be removed for beneficial reuse as part of the development.

The HHERA will define material that may remain in place, as appropriate, within:

- Parts of Block 1, 2 and 3 (including the adjacent Public Domain);
- Part of Block 4 (including the adjacent Public Domain);
- Block 5 (including the adjacent Public Domain);
- The Southern Cove; and
- Hickson Road.

The HHERA will also be applicable to defining the standard that must be achieved for excavated and/or remediated soils that are to be re-used on the site (e.g. derived from excavation of basements for Blocks 1 to 4), including in:

- Headland Park (noting the proposed car park development and void that will result from proposed rock quarrying for the Stage 1 Development);
- The Stage 1 Public Domain; and
- The Stage 2 Public Domain.

1.1.2 Protection of Workers and the Public

It should be noted that potential contamination based risks to short term construction workers involved directly and indirectly (i.e. working adjacent to areas being remediated) and the public during construction will be considered as part of a separate scope of work.

1.2 Scope of Work Overview

1.2.1 Approach

The HHERA will be undertaken in general accordance with the following nationally adopted guidelines, policy and guidance:

- National Environmental Protection Council (NEPC), 1999, National Environment Protection (Assessment of Land Contamination) Measure.
- Appendix VII of NSW Department of Environment and Conservation (DEC) Guidelines for the NSW Site Auditor Scheme (2nd Edition), April 2006.
- Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia & New Zealand (ARMCANZ), 2000. The Australian and New Zealand Guidelines for Fresh and Marine Water Quality.
- enHealth: Environmental Health Risk Assessment, Guidelines for Assessing Human Health Risks from Environmental Hazards (2002).
- Current Australian and other international toxicity and risk guidance including Australian Drinking Water Guidelines, WHO (2004) Guidelines for Drinking-Water Quality, United States Environment Protection Agency (2008) Regional Screening Levels (RSL) for Chemical Contaminants at Superfund Sites.

1.2.2 Summary

The specific Scope of Work proposed to achieve the HHERA objectives is summarised following.

- Review of additional data from the ongoing Other Remediation Works (South) DGI, Other Remediation Works (North) DGI and VMP and PDA Remediation Works DGIs.
- Confirmation and refinement of the conceptual site model (CSM) for the purpose of the HHERA, including:

- Review of existing laboratory analytical data relevant to the Site;
- Confirmation of the chemicals of potential concern (CoPC) present in soil and groundwater;
- Identification of potentially significant receptors. Based on the information currently available, the potentially significant receptors on and near the Site to be assessed in the HHERA will be the following:
    - Future employees working on the Site;+
    - Future residents living on the Site;
    - Future parkland users of the Site;
    - Off-Site neighbours (commercial and residential);
    - Groundwater quality;
    - Surface water quality; and
    - Ecological receptors (primarily Darling Harbour) located adjacent to the Site;
- Identification of potentially significant exposure pathways. The potential for direct contact pathways (ingestion, dermal contact and inhalation) to contribute to overall human health risk at the Site, and adjacent indicative ecosystem risks, will be considered after the review of the available data for the Site. The review of exposure pathways will also include consideration of the proposed remediation work methodologies.
- Description of site physical conditions (including site geology and hydrogeology, existing physical structures and proposed structures to be constructed as part of the development) to be used in assessment of contaminant fate and transport modelling.

- Vapour Fate Transport Modelling including:
    - Assessment of soil vapour concentrations (measured as part of the DGI) relative to published exposure limits;
    - Modelling to estimate chemical concentrations in indoor and outdoor air as a result of volatilisation from contaminated soil, groundwater or potential NAPL;
    - Conceptual modelling of contamination fate and transport including consideration of tidal flushing influences.
- Human Health Risk Assessment:
    - Review of toxicological data for relevant CoPC and identification of appropriate toxicity values to use in the HHERA.
    - Review of chemical and physical properties of each CoPC for risk assessment purposes. Consideration of contaminant fate and transport modelling has been included in this proposal.
    - Establishment of representative exposure point concentrations (EPCs) in soil and groundwater for evaluation of direct contact risks. Reasonable average or upper bound (95% upper confidence limit or maximum) concentrations will be derived for indicative Site areas requiring assessment relevant to land uses associated with the proposed development.
    - Establishment of relevant exposure parameters for identified receptors and exposure pathways;

- Estimation of chemical intake factors associated with exposure-adjusted soil, water and, where relevant, air concentrations (e.g. vapour intrusion) for each receptor and exposure pathway.

- Conduct an ecological risk assessment using modelled EPCs adjacent the Site based on reported on-site soil, groundwater concentrations (where applicable) for relevant off-site habitats and ecological receptors. This will include comparison of contaminant concentrations with relevant ANZECC ecological screening criteria. Specific species risk assessment will not be undertaken for these screening activities.
- Development of soil and groundwater SSTC and implementation strategy.
- Preparation of a report, which includes the above components.

1.3 Data Review

As a precursor to the proposed Data Gap Investigation, the quantity and quality of available data will be evaluated to confirm its adequacy for achieving the data quality objectives determined for the project.

1.4 Data Confirmation

Data confirmation is a specific requirement of the nationally adopted guidelines and policies according to which the HHERA will be completed.

Data confirmation will include compilation and analysis of the existing data set, and in particular confirmation that the key CoPC are adequately identified and described. AECOM will undertake an initial data review prior to commencement of the DGI. This approach will ensure that any data gaps identified in relation to the HHERA are addressed by the DGI. Therefore, it is expected that the Data Confirmation process will not identify any inadequacies with the data. The only exception to this may be localised circumstances in which conditions are discovered during preparation of the HHERA that were not anticipated or addressed by the DGI. This risk of this occurring is considered minimal.

As required by the relevant guidance documents, data confirmation will include consideration of:

- Sample collection using suitable methods to ensure that analytical data are representative of environmental conditions at time of collection;
- Use of suitable chain of custody protocols relating to the collection, preservation, transportation and storage of samples;
- Use of suitable NATA accredited laboratories and methodologies;
- Collection and analysis of appropriate quality control samples, and achievement of acceptable relative percent differences (RPDs) between duplicate and split samples; and
- Use of sufficiently low limits of reporting to enable detection of adverse health or ecological risks.
- The outcome of the data confirmation process will be to confirm the:
- Quality and quantity of available data and information and confirmation of its sources, analytical methodologies and documentation comply with respect to the human health and ecological risk assessment; and
- Manner in which minor data gaps (as identified by the preceding data review) will be addressed in the risk assessment for data gap screening purposes.

1.5 Refined Conceptual Site Model

The existing site conceptual site model (CSM) will be refined and developed based on the findings of the ongoing Other Remediation Works (South) DGI and Other Remediation Works (North) DGI. The refined CSM will describe:

- The nature and extent of known chemical and ecological data;
- Background chemical concentrations and ecological data;
- Site history;
- Site geology, hydrogeology and hydrology;
- Existing site infrastructure (including existing concrete slabs, seawalls and caisson walls);
- Proposed site infrastructure to be constructed as part of the Stage 1 Development;
- Proposed works procedures and methodologies (with respect to construction workers); and
- Remediation studies.

Previous reports have indicated that the highest soil and groundwater concentrations of CoPCs were located in the area of the former gasworks. The hydraulic conductivities in fill deposits are reportedly high and likely to result in significant and continued tidal flushing of the aquifer. This observation was used by ERM (July 2008) to explain the relatively low concentrations of dissolved phase COPCs in groundwater down hydraulic gradient of the source zone areas. Such flushing effects are expected to influence potential contaminant concentrations in proposed building footprint areas and for ecological RPCs of contaminants at groundwater discharge points in Darling Harbour adjacent the Site.

The description of groundwater flow and tidal flushing influences will be based on existing Site reports and on the outcomes of the proposed DGI. These results will also be used to refine the CSM by describing the influences of groundwater flow and tidal flushing on relevant Site and adjacent harbour exposure point concentrations. This study will include description of the:

- hydrogeological influences of the physical works proposed for the Site including excavation of subsurface materials;
- groundwater treatment by flushing, tidal influence and flushing effects;,
- effects of the proposed Southern Cove on flushing / tidal effects; and
- influences of existing and proposed structures (such as existing caisson walls and proposed diaphragm walls) on the water front and future building footprints on groundwater hydrogeology.

1.6 Vapour Transport Modelling

Modelling to estimate chemical concentrations in indoor and outdoor air as a result of volatilisation from contaminated soil, groundwater or potential NAPL will be undertaken.

Reference will also be made in the risk assessment to the DGI sub-soil vapour testing results.

Vapour modelling will follow procedures described in the following documents.

- ASTM International. Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites. E1739 – 95 (reapproved 2002).
- US Environmental Protection Agency (USEPA). Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils. Federal Register, 67 (230): 71169-71172 (2002); and the following companion documents and downloadable resources:

- User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings (2004).
- User's Guide for the NAPL-Screen and NAPL-ADV Models for Subsurface Vapor Intrusion into Buildings (2000).
- USEPA modelling spreadsheets

The ASTM and USEPA documents and resources are based on the fundamental theoretical developments of Johnson and Ettinger, upon which a number of Australian and New Zealand guidance documents for derivation of risk-based screening levels at petroleum hydrocarbon impacted sites are also based. These documents will also be used as reference sources for vapour transport modelling.

1.7 Human Health Risk Assessment

The broad methodology to be followed for the human health chemical risk assessment task is described in the NEPM (1999). In brief, the methodology and approach for conducting the human health risk assessment will include:

- Refinement of the CSM;
- Selection of chemicals of potential concern (CoPC) for each media through comparison to standard default screening levels considered protective of the most sensitive current or future populations at the Site;
- Representative exposure point concentrations (EPCs) for CoPC in environmental media (soil, groundwater, surface water and air) to which receptors may be exposed. Exposure point concentrations will be determined for a number of different areas within each site based on the observed distribution of contamination and on expected land use patterns;
- Review of the potential hazards and toxicity of each CoPC, including adoption of relevant quantitative dose-response criteria for quantification of potential health risks;
- Exposure assessment combining the pollutant linkages identified in the CSM with exposure assumptions taken from Australian risk assessment guidance in the first instance and US EPA/ASTM guidance where appropriate, and the observed contamination concentrations at the Site. This is achieved using mathematical algorithms published by recognised bodies which calculate contaminant intake;
- Risk characterisation, which combines the toxicity and exposure assessments to calculate estimated cumulative risk levels for comparison to acceptable levels such as a non-cancer hazard index (HI) of 1.0 and a cancer maximum allowable risk level (MARL) range of 1x10-4 to 10-6; and
- Uncertainty and sensitivity analyses, which consider the level of confidence in the assumptions used in the risk assessment process, and identify additional data or information which may enable more accurate estimates of risk associated with the Site.

1.8 Ecological Risk Assessment

The ecological risk assessment methodology will be based on relevant Australian and United States guidance documents. The framework provided in these documents consists of an iterative process for evaluating ecological risk. The risk assessment will consist of the following steps.

- ***Step 1: Initial Problem Formulation***. In this step existing data and site information will be collected to refine the Conceptual Site Model (CSM). The CSM includes an evaluation of relevant receptors, exposure media and pathways, type of contaminant, and transport pathways to define a set of Assessment Endpoints. The assessment endpoints define the key ecological processes and effects to be evaluated to determine if an ecological risk is potentially present. Measurement endpoints are defined to answer the risk questions posed in the Assessment Endpoints.

- ***Step 2: Screening Level Risk Assessment.*** In this step, site chemical data are compared to conservative available toxicity screening levels or toxicity reference values. Suitably conservative exposure assumptions are applied to ensure that false negatives are avoided. The outcome of this step is a determination of whether ecological risk can be excluded. In most cases this step allows elimination of some pathways and chemicals of concern.
- ***Step 3: Determination of Relevant Exposure Point Concentrations of COPC in the Receiving Environment***. The Site area is extensively covered with hard surface and devoid of significant habitat areas. Relevant exposure points for ecological receptors are therefore believed to be confined to harbour water and sediment at emergence points in Darling Harbour for Site groundwater. The highest soil concentrations of COPC and exceedences of groundwater assessment criteria are reported to be located in the former gasworks areas at further distance from Darling Harbour. Hydraulic conductivities in fill deposits are believed to cause significant and continued tidal flushing of the aquifer, resulting in reduced concentrations of dissolved phase CoPCs in groundwater samples down gradient of the source zone areas. The fate and transport study undertaken as part of this HHERA will estimate contaminant fluxes and appropriate ecological receptor point concentrations of contaminants at groundwater emergence points in Darling harbour adjacent the Site.
- ***Step 4: Screening of Estimated Exposure Point Concentrations against Relevant Guidance values for the protection of marine and freshwater aquatic systems***. Estimated exposure point concentrations at groundwater emergence points in Darling harbour adjacent the Site will be compared with relevant COPC trigger values for the protection of marine and freshwater aquatic systems presented in ANZECC\ARMCANZ, Australian and New Zealand Guidelines for Fresh and Marine Water Quality, 2000. This comparison will indicate whether identified ecosystem receptors adjacent the Site are potentially at risk from the flux of COPC potentially emerging from the Site using an adopted level of 95% ecological protection.
- ***Step 5: Refined Problem Formulation and Screening Risk Assessment***. A refinement of the screening level risk assessment may be undertaken in this step based on the results of Step 4. This refinement involves introduction, where relevant, of site-specific and local species-specific exposure data and less conservative toxicity data, refining the risk assessment using more realistic conditions and relevant ecological receptors, thereby identifying appropriate source zone soil or groundwater SSTC that reduce risks to the harbour and associated ecosystems.

1.9 Reporting

1.9.1 Remediation Criteria Calculations

The results of the human health and ecological risk assessments will be used to develop SSTC for soil and groundwater for use in the remediation works, including consideration of potential beneficial re-use of material within:

- the Barangaroo Stage 1 Development (specifically the Public Domains);
- the Barangaroo Stage 2 Development Public Domains; and
- Headland Park.

These calculations will interpret and specify soil and groundwater concentrations of COPC which are not considered to represent a risk in the long term to site users or the environment under the proposed land-use. Given that future land-use and configuration may vary across the Site, area specific SSTC may be developed in consideration of building footprints and basement configurations.

The criteria calculations will endeavour to identify SSTC:

- Above which in-situ contamination will require remediation and/or management in the various locations, conditions and land uses;
- Below which in-situ contamination is suitable for their intended land use;
- Suitable for demonstrating successful completion of the remedial works, and
- Which define material that can be re-used on the Site without unacceptable risks to human health or the environment in various applications

1.9.2 Reports

Three reports will be prepared as an outcome of the HHERA:

1. VMP Remediation Works HHERA;
2. PDA Remediation Works HHERA; and
3. Other Remediation Works (North) HHERA.

The results of the risk assessment undertaken for the Other Remediation Works (North) Area will be applied to specification of appropriate remediation criteria for the Other Remediation Works (South) Area broad land uses and for soil re-use on the wider Barangaroo site. Should unexpected and non-gasworks residue contaminants be identified in the Other Remediation Works (South) Area additional risk assessment, in addition to the current scope of work, may be required.

Yours faithfully,

AECOM Australia Pty Ltd

Garry Smith

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