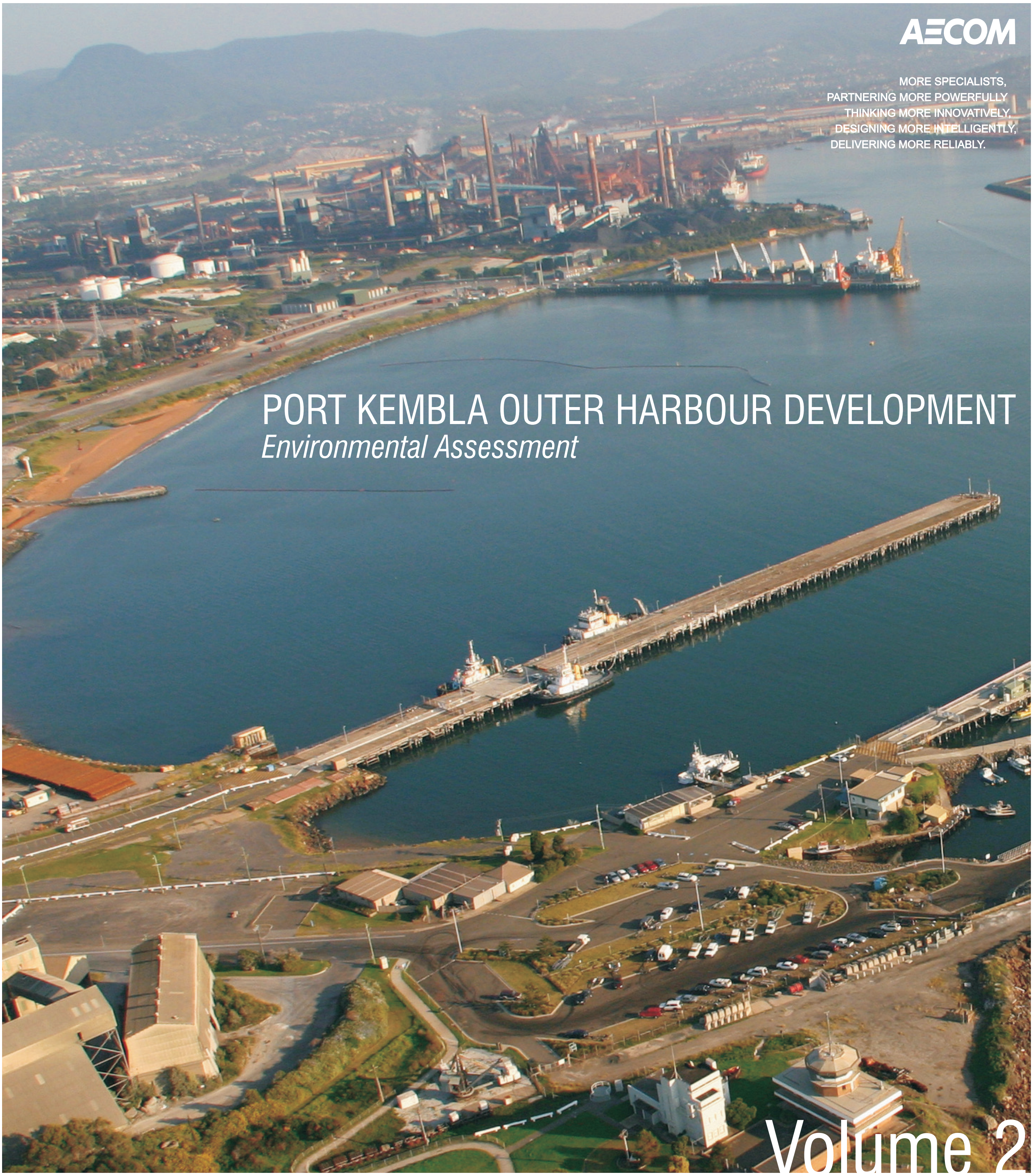


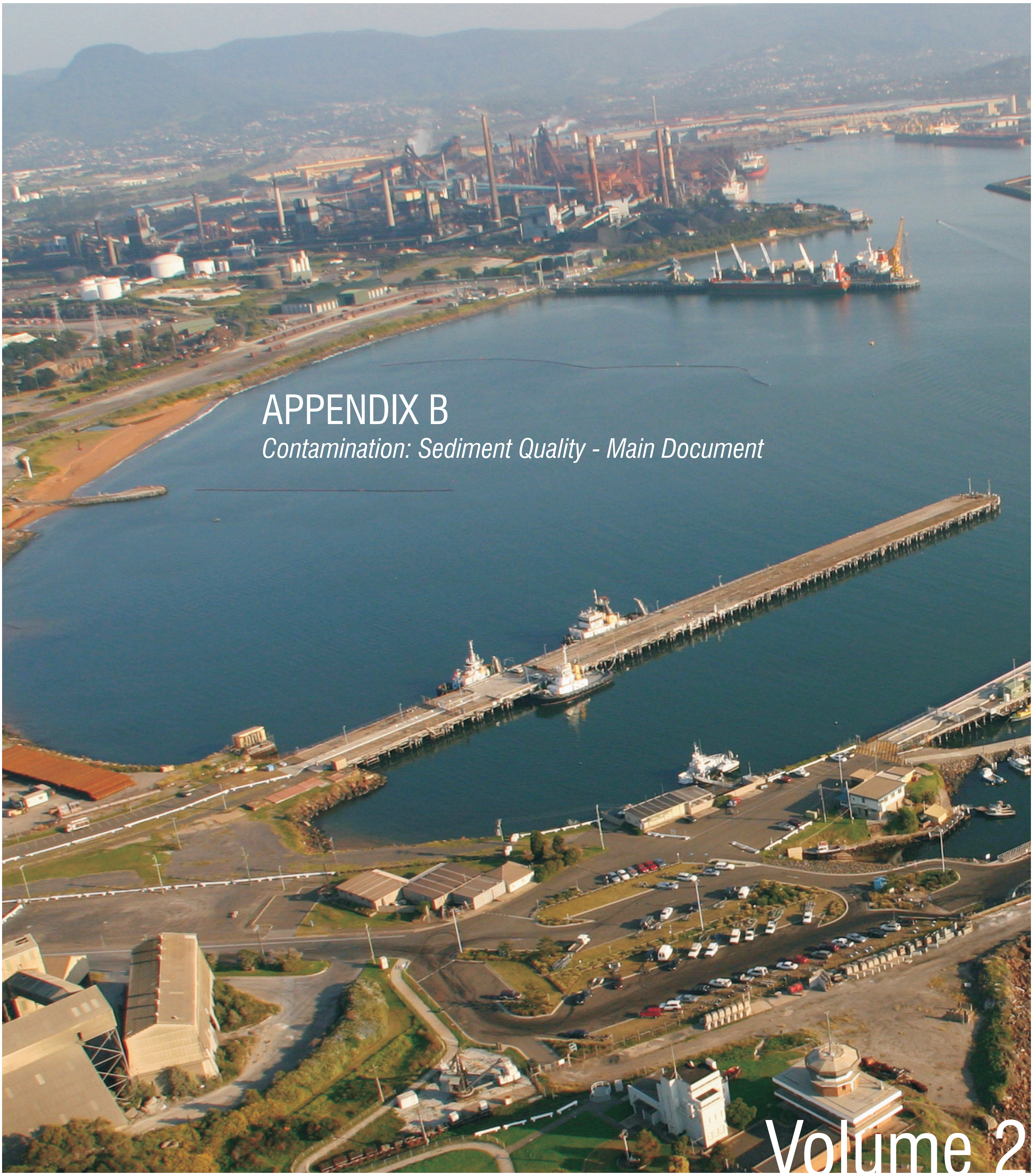
PORT KEMBLA OUTER HARBOUR DEVELOPMENT

Appendix B: Contamination: Sediment Quality - Main Document

Prepared for
Port Kembla Port Corporation

March 2010

PORT KEMBLA
PORT CORPORATION



APPENDIX B

Contamination: Sediment Quality - Main Document

Volume 2

F I N AL

Sediment Investigation

Port Kembla Outer Harbour Development

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Distribution

Sediment Investigation Report
Part of EA for PKPC Port Kembla Outer Harbour Port Kembla, NSW

4 March 2010

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Glossary of Terms

General Terms	
ANZECC/ARMCANZ	Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand
ASS	Acid sulphate soil
ASSMAC	New South Wales Acid Sulphate Management Advisory Committee
BTEX	Benzene, Toluene, Ethyl benzene and Xylene
CoPC	Contaminant of Potential Concern
COC	Chain of Custody
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
DGR	Director General Requirement
DQO	Data Quality Objective
DQI	Data Quality Indicator
DECC	NSW Department of Environment Conservation and Climate Change
DECCW	NSW Department of Environment Conservation, Climate Change and Water
EIL	Ecological Investigation Level
EMP	Environmental Management Plan
EPA	Environmental Protection Agency
HASP	Health and Safety Plan
ISQG	Interim Sediment Quality Guidelines
LOR	Limit of Reporting
NEHF	National Environmental Health Forum
NEPC	National Environment Protect Council
NEPM	National Environmental Protection Measure
NSW EPA	New South Wales Environment Protection Authority
OCC	Organochlorine Pesticide
OCP	Organophosphate Pesticide
OHLs	Outer Harbour Lands
OH&S	Occupational Health & Safety
PAH	Polycyclic Aromatic Hydrocarbons
PASS	potential acid sulphate soil
PIL	Phytotoxicity-based Investigation Level
PKOH	Port Kembla Outer Harbour
POEO	Protection of the Environment Operations Act
PSI	Preliminary Site Investigation
QA/QC	Quality Assurance/Quality Control

General Terms	
SAC	Site Assessment Criteria
SIL	Health-Based Soil Investigation Level
SPOCAS	Suspension Peroxide Oxidation Combined Acidity and Sulfate
SRA	State Rail Authority
SVOC	Semi-Volatile Organic Compound
TBT	Tributyltin
TCLP	Toxicity characteristics leaching procedure
TOC	Total Organic Carbon
TPH	Total petroleum hydrocarbons
UCL	Upper Confidence Limit
VOC	Volatile Organic Compound

Units			
km	kilometre	µg/kg	micrograms/kilogram
m	metre	µg/L	micrograms/litre
mg/kg	milligrams/kilogram	ppm	parts per million
mg/L	milligrams/litre	ºc	Degree Celsius
mV	milli volts	L	Litre
µS/cm	micro Siemens per centimetre	pH	Potential hydrogen

Executive Summary

AECOM Australia Pty Ltd (AECOM) was commissioned by Port Kembla Port Corporation (PKPC) to undertake a Sediment Investigation (SI) of the Port Kembla Outer Harbour (PKOH, hereafter referred to as 'the Site'). This SI, together with other specialist studies will inform the Environmental Assessment (EA) for the proposed PKOH development. As part of the proposed PKOH development, PKPC proposes to develop additional landside facilities to attract new trade as well as increasing the volume of existing Cargo through the Port. In order to develop the potential of the existing Port, PKPC proposes to create new port facilities through dredging, reclamation and the construction of new berths in the Outer Harbour.

The development of the Outer Harbour is intended to maximise the available land area and to provide a maximum number of berths suitable for container handling, bulk trades and general cargo. As such, the development must be staged appropriately to meet the needs of prospective customers, to cater for growing port needs and regional development, and to increase the potential to address the needs of new industry for 30 years into the future.

The Concept Plan for the proposed Outer Harbour development is to develop the Outer Harbour in discrete stages reflecting market demand. Once completed the development would comprise dredging, reclamation of the land, construction and operation of a multi-purpose terminal and associated berthing facilities, construction and operation of a container terminal and associated berthing facilities, landward pavement to extend to the rail siding west of the Outer Harbour and to Foreshore Road in the south, roads and rail infrastructure to service the port terminal facilities.

Port Kembla Port Corporation is seeking concurrent Concept Plan approval for the total development and Major Project approval for Stage 1 of the development.

Concept Plan

The Outer Harbour development is to be constructed in three discrete stages over the next 30 years with an anticipated completion date of 2037. Concept Plan approval is being sought for the total development. Construction of the Concept Plan would be staged to meet the needs of prospective customers, to cater for growing port needs and regional development, and to increase the potential to address the needs of new industry for 30 plus years into the future.

The Concept Plan provides a framework for the progressive completion of the Outer Harbour development and comprises creation of land dedicated to port activity. The reclaimed land would be divided into two main areas, one devoted to the import and export of dry bulk, break bulk and bulk liquid cargoes (multi-purpose terminals) and one devoted to container trade (container terminals).

Once the Concept Plan is completed, the reclamation footprint of the development would extend from the existing Port Kembla Gateway jetty in the north to Foreshore Road in the south, the boat harbour to the east and existing rail sidings to the west.

Physical features of the Concept Plan include the following:

- At least 42 hectares of hard stand, to accommodate new multi-purpose terminals and new container terminals
- Dredging would be completed over a series of dredging campaigns for:
  - Berth boxes and basins between multi-purpose terminals and container terminals;
  - Basins east of the container terminals; and
  - Container berth boxes and approach channels.
- 1770 metres total new berth length.
- A total of seven new berths, including:
  - Four container berths with a total length of 1,150 metres;
  - Two multi-purpose berths designed to handle dry bulk, break bulk and bulk liquid with a total berth length of 620m; and
  - A multi-purpose berth at the site of the existing No. 6 Jetty.
- Retention of the existing oil berth on the northern breakwater of the Outer Harbour.

- Berthing basins and approaches with up to -16.5 metres water depth below Port Kembla Harbour Datum for new berths.
- Road and rail infrastructure to support the expansion, including:
  - New road link from Christy Drive to the multi-purpose and container terminals;
  - Rail infrastructure upgrade in the South Yard;
  - A new road link connecting Darcy Road; and
  - An extension of existing sidings to connect to a rail siding on the container terminals.

Major Project

Major Project approval is being sought to construct and operate Stage 1 of the Concept Plan. Construction of the Major Project would be divided into three sub-stages, identified as Stage 1a, Stage 1b and Stage 1c. Construction elements of Stage 1 comprise demolition of No.3 and No.4 Jetties, and reclamation and dredging for the footprint of the total development, with the following exceptions:

- An area in the vicinity of the Port Kembla Gateway; and
- Expansion of the current swing basin area (ship turning circle).

At the completion of Stage 1 the central portion of the multi-purpose terminals (one berth) would be operational. Road and rail infrastructure to support the first multi-purpose berth would also be constructed, and would comprise:

- Upgrade of rail infrastructure in the South Yard.
- A new road link from Christy Drive to the central portion of the multi-purpose terminals.
- A temporary road link from Foreshore Road to facilitate construction of the container terminals.

The Major Project application sits within, and is part of, the overarching Concept Plan. Stage 1 is proposed to be constructed between 2010 and 2018. Major Project approval would allow PKPC to commence reclamation and dredging for the multi-purpose and container terminals and construct and commence operations for the first multi-purpose berth. Major Project Approval for Stages 2 and 3 of the Concept Plan would be subject to separate applications for Project approval made at a later date.

It should be noted that the areas investigated as part of this SI relate specifically to the Stage 1 Major Project works. As such, they did not assess the area north and south of the Gateway berth (currently leased until 2022) or south of the northern seawall. It is understood that dredging works will be required in these areas in the future as part of the Stage 3 works to accommodate manoeuvring of vessels in and out of the proposed outer harbour berths once the eastern container terminals are operational. Given the dynamic nature of sediments in the ocean environment, AECOM recommends that a sediment investigation be conducted in these areas at a later date.

Objectives

The objectives and scope of this sediment Investigation have been specifically designed to address specific contamination management requirements listed by the DGRs.

The overarching objective of this SI was to inform the EA required for the Concept Plan and Major Project under Part 3A of the *Environmental Planning and Assessment Act* (1979). Within this context and in accordance with the specific contamination management requirements specified by the DECCW in the DGRs and subsequent Adequacy Review comments, the key objectives of this SI were to:

- Characterise the lateral and vertical distribution of contaminated sediments in the area of proposed dredging operations;
- Assess harbour water quality at high and low tide;
- Collect data required to undertake a qualitative human health and ecological risk assessment of in-situ sediments and groundwater (reported separately);
- Inform construction and operational environmental management plans for the proposed development; and
- Inform an evaluation of the practicability and suitability of re-use of the dredged material within the proposed reclamation.

Scope of Work

The scope of work for the SI comprised:

- Review of previous investigation reports specific to the properties along the Site's foreshore and sediment quality within the Site;
- The collection and analysis of sediment samples from both the anoxic and oxidic sediment layers from within the proposed dredge footprints and existing underwater emplacement area;
- The collection and analysis of harbour water samples from the entrance to the Inner Harbour, centre of the Outer Harbour and entrance to the Outer Harbour;
- Preparation of a qualitative human health and ecological risk assessment of in-situ sediment and groundwater contamination to identify whether contaminated sediments and waters pose a significant risk of harm to human health and environmental receptors (reported separately in Appendix D of the EA);
- Preparation of illustrated maps which present the distribution of sediment contamination in accordance with the Handbook for Sediment Quality Assessment (Australia's Commonwealth Scientific and Industrial Research Organisation [CSIRO], 2000); and
- Preparation of a report that details a review of the results of this and previous investigations undertaken on sediments within the Site.

Previous Investigations

A review of previous investigation reports considering sediment quality within the Site included the Douglas Partners (2002) sediment sampling of the Harbour for proposed maintenance dredging. Of the 74 sampling locations assessed in this assessment, most were located across the Inner Harbour and only one was located within the Outer Harbour. The results of the sample (identified as 'Sample 3.2') collected from the Outer Harbour were as follows:

- Antimony, cadmium, cyanide, selenium, silver, TBT, vanadium, TPH, BTEX, OCPs, PCBs and Total phenolics concentrations were all reported at concentrations below the laboratory Limit of Reporting;
- A zinc concentration of 81 mg/kg and an iron concentration of 9,100 mg/kg was reported in the analysed sample; and
- Copper, lead, mercury, molybdenum and Total PAHs concentrations in 'Sample 3.2' were reported to exceed the ISQG-Low while none of these concentrations exceeded the ISQG-High.

Patterson Britton (2005a and b) undertook two sediment sampling programs focussed on the south west part of the Outer Harbour, to assess contaminant concentrations prior to the construction of an underwater emplacement area (containing sediments dredged from the Inner Harbour). The two stages of investigation found that the 95% Upper Confidence Limit (UCL) for all analytes was generally above the *ANZECC Interim Sediment Quality Guideline* (ISQG)-Low trigger values and that the 95% UCLs for copper lead, mercury, silver, zinc and naphthalene were all above the ANZECC ISQG-High trigger values.

Results

The analytical results obtained from the SI were generally consistent with the findings of previous investigations on the contamination of sediments within the Outer Harbour. The extent and nature of contamination identified within the sediments during the SI is summarised below:

- Heavy metals contamination (concentrations exceeding the ANZECC (2000) Interim Sediment Quality Guideline [ISQG] Low trigger values) was identified across the majority of the dredge footprint within the shallow sediments (approximately 0-0.3 m bgs);
- The highest concentrations of heavy metals (with concentrations greater than their respective ANZECC ISQG-High) were identified predominantly within the top 1.0 m of the emplacement area;
- Copper and lead concentrations (and to a lesser degree arsenic) exceeded the NEPC (1999) National Environment Protection (Assessment of Site Contamination) Measure Health-Based Soil Investigation Levels (SILs) for a commercial/industrial land use in localised areas at the southern end of the eastern dredge footprint and also in the vicinity of the Darcy Road Drain;
- PAH contamination was identified across the majority of the dredge footprint within the shallow sediments (approximately 0-0.3 m bgs). The highest PAHs concentrations (greater than their respective ANZECC ISQG-High) were identified within the emplacement area in the south west part of the Site;

- TBT contamination (exceeding the ANZECC ISQG-High) appeared to be confined to the southern end of the eastern dredge footprint adjacent to the eastern breakwater; and

The analytical results for SPOCAS analysis indicated that there is a potential for acid sulphate material between 0 and 3.3 m (oxidic and anoxic layers) at the Site.

These potential impacts will be readily managed during the dredging and reclamation activities simply by avoiding or minimising PASS coming into contact with oxygen. This will be achieved by continuously transporting wet sediments within the water column from the point of dredging for immediate disposal at the emplacement (reclamation) site.

The analytical results of the harbour water samples are summarised below:

- Heavy metals concentrations in the Harbour water samples were less than the adopted assessment criteria (ANZECC [2000] 95% Marine Water), with the exception of the following:
  - Cadmium - concentrations in two harbour water samples (10 400 µg/L and 65 400 µg/L respectively) (both collected at high tide) exceeded the adopted assessment criteria (5.5 µg/L). These very high cadmium concentrations are considered to be erroneous and require additional investigation/monitoring; and
  - Copper – concentrations in one harbour water sample (2 µg/L) (collected at high tide) exceeded the adopted assessment criteria (1.3 µg/L).

The analytical results of the elutriate tseting are summarised below:

- The elutriate results (not allowing for dilution effects as discussed below) indicated that there is a potential for copper, arsenic, vanadium and zinc to be released into the water column during dredging at concentrations which could exceed their respective ANZECC (2000) 95% Marine trigger values.
- Both arsenic and copper concentrations, the key CoPCs in relation to the elutriate results, were typically three to four times the ANZECC (2000) 95% marine trigger value. However, in consideration of a dilution ratio of 1:4, which would simulate the likely dilution and dispersion effects, it is considered that the elutriate results indicate that the dredging and reclamation works are unlikely to have a significant impact on the receiving environment.
- Dredging works would be undertaken within an area protected by silt curtains and using a dredging methodology aimed at minimising the dispersal of sediments within the water column. Dredged sediment would be placed within a bunded containment area at depth to form the base for the reclamation and covered with suitable materials to encapsulate the sediments. Silt curtains would also be used at the emplacement area to control turbidity in the water column.
- The risk to human health and the environment associated with the contaminated sediment (in particular the potential sediment contamination hotspots) would be evaluated by a further qualitative risk assessment. If the risk assessment concludes that the contamination hotspots present an unacceptable risk to the environment, a Remedial Action Plan would be prepared to appropriately manage the identified materials of concern. Remedial actions could include placing more contaminated materials at greater depths, encapsulation/stabilisation works or removal offsite.

Conclusions

The following conclusions can be drawn from the SI:

- Sediment within and around the dredge footprints predominantly composed of sandy silty clay, sandy clay and minor gravelly clay. Anthropogenic inclusions were observed within sediments and comprised predominantly coal, timber and aluminium fragments. Some hydrocarbon, tar-like, hydrogen sulphide and chemical odours were noted in the sediments in parts of the dredge footprints and emplacement area;
- Heavy metals contamination (concentrations exceeding their respective ISQG-high and -low trigger values) was identified across the majority of the dredge footprint within the shallow sediments (approximately 0-0.3 m bgs);
- The highest concentrations of heavy metals (with concentrations greater than their respective ISQG-High trigger values) were identified predominantly within the top 1.0 m of the emplacement area;
- Copper and lead concentrations (and to a lesser degree arsenic) exceeded the SIL_4 (NEPC, 1999) criteria in relatively localised areas at the southern end of the container berth dredge box and also in the vicinity of the Darcy Road Drain (multi-purpose berth dredge box). Consequently, the sediment is considered to be suitable for reclamation works related to proposed commercial/industrial development with no significant risk to human health;

- PAH contamination (concentrations exceeding their respective ISQG-high and -low trigger values) was identified across the majority of the dredge footprint within the shallow sediments (approximately 0-0.3 m bgs). The highest concentrations of PAHs (concentrations greater than their respective ISQG-High trigger values) were identified within the emplacement area;
- The extent of TBT contamination (concentrations greater than the ISQG-High trigger values) appeared to be confined to the southern end of the container berth dredge box, adjacent to the eastern breakwater;
- The analytical results for SPOCAS analysis indicated that there is a potential for acid sulphate material between 0 and 3.3 m (anoxic layer) at the Site;
- The concentrations of CoPC within the harbour water samples were less than the adopted ANZECC (2000) 95% Marine trigger values with the exception of:
  - Copper for which one sample reported a concentration (2 µg/L) that exceeded the trigger value of 1.3 µg/L; and
  - Cadmium for which two samples reported concentrations (10,400 µg/L and 65 400 µg/L) which exceeded the trigger value of 5.5 µg/L but are considered to be erroneous based on other harbour surface water, sediment and elutriate analytical results reported as part of this investigation and historic harbour water quality results from the Port Kembla Harbour water quality monitoring program.
- The elutriate results for the key CoPCs (arsenic and copper) indicated that there is a potential impact to the water column during dredging and reclamation works at concentrations which could exceed the respective ANZECC (2000) 95% Marine trigger values. The exceedances generally corresponded with sediment samples with total concentrations which also exceeded the ISQG-High trigger values (that is, hot spot materials). In consideration of the likely dilution effects of dredging and reclamation, it is considered that the results, which were typically three to four times the ANZECC (2000) 95% marine trigger value, indicate that the dredging and reclamation works would be unlikely to have a significant impact on the receiving environment. This will be confirmed as part of the further qualitative risk assessment which will assess whether or not hot spot materials are suitable for dredging and, consequently, require specific management via a Remedial Action Plan.
- AECOM concludes that the dredging and reclamation works are unlikely to have a significant impact on the receiving environment based on consideration of:
  - The typical elutriate results, using a conservative assessment of the likely dilution of CoPC during dredging and reclamation works.
  - Placement of dredged material at depth (where it will not be subject to a hydraulic gradient) within revetment structures and below other approved reclamation materials.
  - Proposed mitigation measures including preparation of DEMP, ASSMP, SWMP and implementation of a water quality and turbidity monitoring program.

Recommendations

Based on the above conclusions, AECOM recommends that:

- A Dredging Environmental Management Plan (DEMP) be prepared (as a precursor to the dredging works) once the detailed design for the dredging works is finalised and a further qualitative sediment risk assessment has been undertaken. This would be based on the measures recommended by this SI and ensure that the recommended mitigation measures incorporated into the DEMP are appropriate and specific to the proposed dredging works, therefore minimising potential impacts to the environment.
- The sediments would be dredged and emplaced in the reclamation area at essentially the same time, with this process occurring within the water column, which negates the need for land storage and wastewater management.
- A Soils and Water Management Plan be prepared to appropriately manage the accumulation of surface water from rainfall until the reclamation areas are finally paved. In the preparation of this plan, consideration would be given to potential surface water contamination issues during the construction phase, when the area is not capped, with contingency measures such as sediment basins being constructed. During the operational phase, contingency measures such as a first flush capture system would be also implemented;
- In considering the elutriate analysis results, the following mitigation measures would be detailed in the DEMP to minimise impact on the receiving environment of the Outer Harbour during the proposed dredging and placement works:

- Dredged sediments deposited as part of the proposed reclamation would be contained in an engineered containment structure which will be constructed of higher quality and less impacted material;
- The sediment would effectively be encapsulated and confined within the engineered structure;
- Dredged sediments would be placed at depth, likely below the depth of wave action at the base of the reclamation fill to maximise the opportunity for future consolidation and reduce the potential for further disturbance;
- It is unlikely that the quality of dredged sediments placed as part of the reclamation works would be required to meet the criteria for open water disposal as the Outer Harbour is a semi enclosed (breakwaters) and highly disturbed environment;
- Dredging and reclamation would be undertaken within the protection of parallel silt curtains encompassing both the dredging and reclamation areas;
- Dredging technologies would be selected in consideration of their ability to minimise the generation of turbidity;
- Real time turbidity monitoring would be employed in conjunction with observations by personnel undertaking the dredging and reclamation activities to assist in early identification of problems and proactive implementation of mitigation measures;
- Monthly flyovers would be conducted to assess the presence of potential sediment plumes and algal blooms from the dredging or placement areas; and
- Contingency measures that could be implemented immediately in the event visible turbidity and harbour water quality impacts are identified during routine monitoring.

• The mitigation measures described above are based on AECOM's project experience on similar projects and involving similar contaminants (including the Hunter River remediation project) in which the measures proposed following successfully minimised adverse affects to the receiving environment. Consequently, AECOM considers that modelling/field trials to assess the potential mobilisation and/or dispersion of contaminants would not be required. Due to the large mobilisation costs associated with such field trials, these works are also likely to be impracticable and cost prohibitive.
• A harbour water quality and turbidity monitoring plan should be developed to confirm that the discussed mitigation measures are successful in protecting the receiving aquatic ecosystem for the duration of the dredging works.
• An appropriate acid sulphate soil management plan will be required as a precursor to the dredging and reclamation works to ensure that these works either avoid exposing potential acid sulphate soils (PASS) to oxygen or provide for appropriate management of the PASS.
• The risk to human health and the environment associated with the contaminated sediment identified by the SI (in particular the identified sediment contamination hotspots) should be evaluated by a further qualitative risk assessment. If the risk assessment concludes that the contamination hotspots present an unacceptable risk to the environment, a Remedial Action Plan will be prepared to appropriately manage the identified materials of concern. Remedial actions could include placing more contaminated materials at greater depths, encapsulation/stabilisation works or removal offsite. To this end, reference should be made to the qualitative human health and ecological risk assessment that has been prepared by AECOM based on the outcomes of this SI and in response to the DGRs (refer to Appendix D of the EA).
• Based on the data obtained from this SI, AECOM anticipates that the sediments likely to be encountered by the proposed development can be managed appropriately using typical dredging technologies and standard mitigation measures as discussed above.
• A sediment investigation should be conducted in the area north and south of the Gateway Berth and south of the northern seawall (the swing basin) as dredging works will be required in these areas in the future as part of future applications for Stage 3 works. Assuming that the additional SI demonstrates that the sediment in these areas has similar characteristics to that considered by this SI, it is likely that the proposed dredging and emplaced mitigation measures outlined in this document can also be applied to the other areas in the future and will appropriately protect the environment.

1.0 Introduction

AECOM Australia Pty Ltd (AECOM) was commissioned by Port Kembla Port Corporation (PKPC) to undertake a Sediment Investigation (SI) of the Port Kembla Outer Harbour (PKOH, hereafter referred to as 'the Site'). This SI, together with other specialist studies will inform the Environmental Assessment (EA) for the proposed PKOH development. As part of the proposed PKOH development, PKPC proposes to develop additional landside facilities to attract new trade as well as increasing the volume of existing Cargo through the Port. Land within the Inner Harbour is almost fully occupied and growth in trade is constrained by lack of suitable port facilities. In order to develop the potential of the existing Port, PKPC proposes to create new port facilities through dredging, reclamation and the construction of new berths in the Outer Harbour.

The development of the Outer Harbour is intended to maximise the available land area and to provide a maximum number of berths suitable for container handling, bulk trades and general cargo. As such, the development must be staged appropriately to meet the needs of prospective customers, to cater for growing port needs and regional development, and to increase the potential to address the needs of new industry for 30 years into the future.

The Concept Plan for the proposed Outer Harbour development is to develop the Outer Harbour in discrete stages reflecting market demand. Once completed the development would comprise dredging, reclamation of the land, construction and operation of a multi-purpose terminal and associated berthing facilities, construction and operation of a container terminals and associated berthing facilities, landward pavement to extend to the rail siding west of the Outer Harbour and to Foreshore Road in the south, roads and rail infrastructure to service the port terminal facilities.

Concurrent approval for the Concept Plan and Major Project is being sought for the development of the Outer Harbour.

It should be noted that the areas investigated as part of this SI relate specifically to the Major Project works. As such, the area north and south of the Gateway berth (currently leased until 2022) or south of the northern breakwater have not been assessed (refer to **Figure F2**). It is understood that dredging works will be required in these areas in the future as part of future approvals. Given the dynamic nature of sediments in the ocean environment, AECOM recommends that a sediment investigation be conducted in these areas at a later date as part of the subsequent approval process.

1.1 Concept Plan

The Outer Harbour development is to be constructed in three discrete stages over the next 30 years with an anticipated completion date of 2037. Concept Plan approval is being sought for the total development. Construction of the Concept Plan would be staged to meet the needs of prospective customers, to cater for growing port needs and regional development, and to increase the potential to address the needs of new industry for 30 plus years into the future.

The Concept Plan provides a framework for the progressive completion of the Outer Harbour development and comprises creation of land dedicated to port activity. The reclaimed land would be divided into two main areas, one devoted to the import and export of dry bulk, break bulk and bulk liquid cargoes (multi-purpose terminals) and one devoted to container trade (container terminals).

Once the Concept Plan is completed, the reclamation footprint of the development would extend from the existing Port Kembla Gateway jetty in the north to Foreshore Road in the south, the boat harbour to the east and existing rail sidings to the west.

Physical features of the Concept Plan include the following:

- At least 42 hectares of hard stand, to accommodate new multi-purpose terminals and new container terminals
- Dredging would be completed over a series of dredging campaigns for:
    - Berth boxes and basins between multi-purpose terminals and container terminals;
    - Basins east of the container terminals; and
    - Container berth boxes and approach channels.
- 1770 metres total new berth length.
- A total of seven new berths, including:

  - Four container berths with a total length of 1,150 metres;
  - Two multi-purpose berths designed to handle dry bulk, break bulk and bulk liquid with a total berth length of 620m; and
  - A multi-purpose berth at the site of the existing No. 6 Jetty.
- Retention of the existing oil berth on the northern breakwater of the Outer Harbour.
- Berthing basins and approaches with up to -16.5 metres water depth below Port Kembla Harbour Datum for new berths.
- Road and rail infrastructure to support the expansion, including:
  - New road link from Christy Drive to the multi-purpose and container terminals;
  - Rail infrastructure upgrade in the South Yard;
  - A new road link connecting Darcy Road; and
  - An extension of existing sidings to connect to a rail siding on the container terminals.

PKPC is seeking Concept Plan approval for the total development of the Outer Harbour with the understanding that separate Major Project applications would be made for approval to construct and operate facilities on the site. PKPC would construct the reclamation, road and rail infrastructure and basic services for the site as a whole. Development of specific facilities may be undertaken by PKPC or third party operators who would lease part of the site from PKPC for a specific purpose. It is initially intended that the first stage of the multi-purpose terminals, including utilities and amenities, would be developed, operated and maintained by PKPC as a common user facility.

Stage 1 of the Concept Plan would be constructed between 2010 and 2018, Stage 2 between 2014 and 2025 and Stage 3 between 2026 and 2037.

1.2 Major Project

Major Project approval is being sought to construct and operate Stage 1 of the Concept Plan. Construction of the Major Project would be divided into three sub-stages, identified as Stage 1a, Stage 1b and Stage 1c. Construction elements of Stage 1 comprise demolition of No.3 and No.4 Jetties, and reclamation and dredging for the footprint of the total development, with the following exceptions:

- An area in the vicinity of the Port Kembla Gateway; and
- Expansion of the current swing basin area (ship turning circle).

At the completion of Stage 1 the central portion of the multi-purpose terminals would be operational. Road and rail infrastructure to support the first multi-purpose berth would also be constructed, and would comprise:

- Upgrade of rail infrastructure in the South Yard.
- A new road link from Christy Drive to the central portion of the multi-purpose terminals.
- A temporary road to facilitate construction of the container terminals.

The Major Project application sits within, and is part of, the overarching Concept Plan. Stage 1 is proposed to be constructed between 2010 and 2018. Major Project approval would allow PKPC to commence reclamation and dredging for the multi-purpose and container terminals and construct and commence operations for the first multi-purpose berth. Major Project approval for Stages 2 and 3 of the Concept Plan would be subject to separate applications for Project approval made at a later date.

The location of the proposed Outer Harbour development is illustrated on **Figure F1**. The proposed dredge footprint (the Site) is shown on **Figure F2**. Sampling locations are presented on **Figure F5.** The SI was extended beyond the dredge footprint to facilitate characterisation of materials in an underwater emplacement area constructed during earlier dredging from the Inner Harbour and that will be impacted by the proposed dredge footprint and reclamation area.

1.3 Reclamation and Dredging Volumes

The programmed staging of the reclamation works is indicative only and will be driven by market demand and availability of reclamation materials. Reclamation and dredging volumes have been estimated (refer to Section 6.3 of the EA) based on preliminary designs to provide indicative volumes to assist in programming and sourcing of requisite material (**Table 1)**.

Table 1: Stage 1 Dredging and Reclamation Volumes

Stage	Phase	Reclamation Area	Dredging Area		Balance of fill
		Volume of reclamation area (m^3)	Volume of rock to be dredged (m^3)	Volume of soft sediments to be dredged (m^3)	Balance of fill required to be sourced and transported from external locations (m^3)
1	1a	798,398 Areas 1 & 2	89,225 Area 3	293,150 Area 3	798,398 (blast furnace slag)
	1b	2,016,000 Area 5	0 Area 6	60,000 Area 6	1,573,625
	1c	1,813,651 Area 9	294,350 Area 8	480,525 Area 8	1,038,776
	Totals	**4,628,049**	**383,575**	**833,675**	**3,410,799**

Note. In addition to Area 6, Area 3 dredged material would also be incorporated into Phase 1b reclamation footprint.

1.4 Objectives

The overarching objective of this SI was to inform the EA required for the Concept Plan and Major Project Application under Part 3A of the *Environmental Planning and Assessment Act* (1979). Within this context and in accordance with the specific contamination management requirements specified by the DECCW in the DGRs and Adequacy Review comments, the key objectives of this SI were:

- Characterise the lateral and vertical distribution of contaminated sediments in the area of proposed dredging operations with respect to the Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand (ANZECC/ARMCANZ, 2000) *Interim Sediment Quality Guidelines (ISQGs)*;
- Assess harbour water quality at high and low tide;
- Collect data required to undertake a qualitative human health and ecological risk assessment of *in-situ* sediments and groundwater to identify whether the identified contaminated sediments and waters pose a significant risk of harm to human health and environmental receptors;
- Inform construction and operational environmental management plans and environmental management control design for the proposed PKOH development; and
- Inform an evaluation of the practicability and suitability of re-use of the dredged material within the reclamation.

1.5 Director Generals Requirements

The Minister of Planning approved the lodgment of the concept plan for the project on 7 January 2009. An EA for the Project is required under section 75F of the EP&A Act (1979). The DG provided “General Requirements” (dated 27 January 2009) that are to be considered as part of the project EA which include the following requirements that are specific to ‘Contamination’:

- Consideration of potential contaminated land, sediments and groundwater and their disturbance, future emplacement, re-use and identification for the need for remediation;
- Characterisation of the distribution of contamination (illustrated on maps) in accordance with the Handbook for Sediment Quality Assessment (CSIRO, 2000); and
- Where remediation is required, presentation of a Remedial Action Plan (RAP) in accordance with relevant DECCW (EPA) guidelines.

1.6 DECCW requirements

The DGRs include specific contamination management requirements (among others) in respect of the Project Application prepared by the DECCW (24 December 2008).

Representatives from AECOM (Mr. David Fitzgibbon and Miss Rebecca Organo) attended a meeting with the DECCW (Paul Wearne, Maria Bowen and Mark Warner) on 31 March 2009 with the purpose of clarifying DECCW's requirements for the preparation of the EA.

Table 2 presents a summary of the DECCW contamination management requirements that were discussed, the clarification that the DECCW provided with respect to their key requirements and the agreed outcome.

Table 2: Clarification of DECCW requirements

<table>
<tr><th>DECCW Rqmt.</th><th>Requirement</th><th>Clarification</th><th>Task</th></tr>
<tr><td>1</td><td>A human health and ecological risk assessment of in-situ sediments and groundwater to identify whether the identified contaminated sediments and waters pose a significant risk to human health and environmental receptors.</td><td>DECCW indicated that they are expecting a qualitative risk assessment to be undertaken as part of the EA. Should the qualitative risk assessment suggest that a further assessment is warranted, this could be undertaken prior to commencing dredging works but must be included in the statement of commitments.</td><td rowspan="3">PKPC to undertake a SI at the Site (by AECOM). The objective of the SI will be to collect sufficient data to fulfill DECCW requirements 1, 2 and 3.
The SI will incorporate a qualitative risk assessment (also by AECOM) based on the data from the SI.
PKPC to undertake a separate study (by UNSW) to assess sediment chemistry, toxicity and benthic community structure.</td></tr>
<tr><td>2</td><td>Characterisation of the lateral and vertical distribution of contaminated sediments in the area of proposed dredging operations with respect to the ISQGs. Surface effects should be assessed as well as considerations of the concentrations at depth (nb sampling methods should ensure that samples of the oxidic layers should be collected separately from anoxic sediments to enable assessment to enable an assessment of the bioavailability of contaminants).</td><td>DECCW indicated that this requirement must be undertaken as part of the Major Project.</td></tr>
<tr><td>3</td><td>Assessment of sediment chemistry, toxicity and benthic community structure and consideration of how this may be altered during dredging (may include an assessment of the toxicity of sediment pore water where appropriate).</td><td>DECCW indicated that this requirement must be undertaken as part of the Major Project .</td></tr>
</table>

DECCW Rqmt.	Requirement	Clarification	Task
4	Consideration of hydrogen sulphide odours in the anoxic sediments as well as an assessment of the possible interaction between the identified acid sulphate soils (ASS) and the proposed treatment materials.	ASS is a construction issue and should be addressed as part of the Construction Environmental Management Plan (CEMP).	PKPC will prepare a CEMP prior to commencement of works. This will be included in the statement of commitments.
5.	Assessment of the potential for mobilisation of sediments and increased turbidity as a result of proposed rock blasting, dredging and shipping operations.	AECOM indicated that this would require modeling and field trials. DECCW indicated that this could be addressed after EA approval and should be included in the statement of commitments.	PKPC will undertake the required studies following major project approval. This will be included in the statement of commitments.
6.	Phase 1 soil and groundwater investigation in the proposed land excavation area (adjacent to the berth facility) including delineation of heavy metals, TPH, PAH and asbestos.	Investigation along the proposed road alignment that services the berth facility which must be undertaken as part of the EA approval.	PKPC to undertake a limited investigation to characterize the material along the proposed road alignment (linking Christy Drive with the multi-purpose terminal) as part of the project approval.
7.	Delineation of contaminants in groundwater (including metals and PAH) and an assessment of harbour water quality at low and high tide.	DECCW indicated that this requirement must be undertaken as part of the EA approval.	PKPC to delineate contaminants in groundwater through review of previous reports as part of the land based investigation (refer requirement 6). An assessment of harbour water quality at high and low tide will be undertaken as part of the SI.
8.	Assessment of the fate of impacted/contaminated water generated from the proposed works (including liquid waste generated during de-watering of sediments).	PKPC and AECOM indicated that contaminated water is unlikely to be generated as part of the proposed works and de-watering of sediments is not proposed therefore an assessment of the fate of impacted water would not be required.	No action required.
9.	Evaluation of the practicability and suitability of the re-use of slag, coal wash, roadwork's waste, mine spoil and dredged material, including an assessment of the environmental and geotechnical characteristics of the material and the potential for contamination of waters (groundwater and surface water) from the placement of such fill material at the Site.	DECCW indicated that a table of limits for specific materials to be used or that have the potential to be used in the various aspects of the project will be required. A similar method was used for the Inner Harbour EA process.	PKPC to prepare a table of limits for specific materials to be used in the various aspects of the project as required by DECCW.

DECCW Rqmt.	Requirement	Clarification	Task
10.	Clarification on the DGR for the preparation of a RAP as part of the EA Approval.	DECCW indicated that it did not consider that a RAP would be required and that if a RAP is required then this could be done following approval of the EA.	PKPC will prepare a RAP (if required) following major project approval and will include this action within the statement of commitments.

Representatives from AECOM (Mr. David Fitzgibbon, Miss Deborah Bowden, Mr. Michael Jones and Mr. Christiaan Donnetti) attended a second meeting with the PKPC and DECCW (Greg Newman, Mark Bourne, Tony Roach, Muhammad Ullah, Paul Wearne, Anthony Pik) on the 17 June 2009. The purpose of the second meeting was to outline AECOM's proposed approach addressing the DECCW's contamination management requirements for the EA (as described by **Table** 2 above). The outcomes of the meeting are summarised in **Table 3.**

Table 3: Summary of outcomes from the meeting with the DECCW (17th June 2009)

DECCW Rqmt.	DECCW Comments on AECOM's proposed Scope	Action
1	The proposed sediment sampling location plan, even though systematic and grid based, should be locally biased to address potential contamination hotspots.	AECOM's systematic sampling grid has been developed to target areas of potential concern at the Site. Potential areas of concern selected for targeted investigation by AECOM included sediments around the outlets Salty Creek and the Darcy Road Drain. The existing underwater emplacement area known to contain sediments impacted with PAH and Metals was also targeted as part of the sampling program.
2	Prepare a SAQP for submission to DECCW that provides justification for the proposed sampling and analysis program and in particular selection of the nominated Contaminants of Potential Concern (CoPC).	AECOM has submitted an SAQP (AECOM, 2009) to DECCW.

1.7 Scope of Work

The scope of work for the SI comprised:

- Review of previous investigation reports specific to the properties along the Site's foreshore and sediment quality within the Site;
- The collection and analysis of sediment samples from both the anoxic and oxidic sediment layers from within the proposed dredge footprints and existing underwater emplacement area located in the south west part of the Site;
- The collection and analysis of harbour water samples from the entrance to the Inner Harbour, centre of the Outer Harbour and entrance to the Outer Harbour;
- Preparation of a qualitative human health and ecological risk assessment of in-situ sediment and groundwater contamination to identify whether contaminated sediments and waters pose a significant risk of harm to human health and environmental receptors (refer to Appendix D of the EA document);
- Preparation of illustrated maps which present the distribution of sediment contamination in accordance with the Handbook for Sediment Quality Assessment (CSIRO, 2000); and
- Preparation of a report that details a review of the results of this and previous investigations undertaken on sediments within the Site.

1.7.1 Reclamation Methodology

The initial dredging and reclamation works would involve the construction of underwater walls to contain the contaminated sediments on the sea floor within the reclamation areas. The walls would be constructed from rock, coal wash, slag and other suitable materials with these materials also used to overly and encapsulate the sediments. This approach is considered to appropriately manage the potential impacts of wave action as well as minimising development of any significant hydraulic gradient between the sediments and the Outer Harbour which could promote leaching of contaminants from the sediments. Rock wall revetments underlain by geotextile to provide sediment filtration would be constructed as temporary structures but also as final wharf edge structures where berthing activities are not undertaken (refer to **Figure F2**).

In areas where berthing activities are to be undertaken, permanent edge structures will be constructed. Given the relatively shallow depths of the hard bedrock and the related difficulty of piling into these materials, it is understood that the design of the edge structures is likely to comprise of mass gravity structures such as precast conterfort units, circular cell cofferdam units or caisson units.

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2.0 Site Identification and Surrounding Environment

2.1 Site Description and Current Use

Port Kembla Port (the Port) is located in the Wollongong Local Government Area and is approximately 80 km south of Sydney's CBD and 60 km from Sydney's south western suburbs. The Port is considered to be one of NSW's three main international trade ports.

The Site extends from the southern shoreline to the northern and eastern breakwaters and is defined as the bed of the PKOH. The Port Kemboa eastern breakwater lies att he eastern extent odf the PKOH and the land based area of the PKOH is bounded by Foreshore Road and Old Port Road to the south and west. The existing shipping channel and northern breakwater lie in the northern portion of the PKOH.

The Site is characterized by a mixture of both the built environment and natural features (refer to **Figures F1 and F2**), which include:

- Three jetties (identified as No. 3, No. 4 and No. 6 Jetties) and an inflammable liquids berth. No. 6 jetty is located in the south western area of the Site and extends from the foreshore in a north easterly direction into the Site and is approximately 200 m in length. This jetty is currently under a long term lease to Gateway and the wharf structure has undergone major strengthening works over the past 15 years. Jetties No. 3 and No. 4 are located in the south eastern corner of the Site. Jetty No. 3 was strengthened and modified in 2000 and currently serves as a tug berth for all tugs operating in the Harbour. Jetty No. 4 underwent major modifications in 1998 and currently serves as a non flammable bulk liquids jetty;
- A saltwater intake channel that supplies cooling water for BlueScope Steel operations located on the south eastern corner of the entrance to the Inner Harbour;
- A concrete lined storm water drain, identified as Darcy Road drain, located adjacent to lots currently occupied by Brick and Block and Sydney Water;
- Salty Creek, which extends from an area adjacent to the Port Kembla railway station and flows via a culvert under Old Port Road and discharges to the PKOH;
- A small recreational boat harbour and boat ramp located adjacent to the eastern breakwater;
- A number of commercial and industrial operations on and immediately adjacent to the Site's foreshore include PKPC, Port Kembla Gateway Pty Ltd, Brick and Block manufacturing structural masonry products, Morgan Cement, BlueScope Steel, Orica Chemnet, Port Kembla Copper and BHP Billiton;
- An existing rail network (including rail corridor and sidings) located between Darcy Road and Foreshore Road, Old Port Road and Five Islands Road, recently acquired by PKPC; and
- Port Kembla Heritage Park located on the southern headland adjacent to the Site, south of the eastern breakwater. Heritage Park has been developed to conserve military, cultural and historic heritage in the area.

2.2 Surrounding Land Use

The Site is surrounded by commercial/industrial properties to the south and south west of the Site. The closest residential and commercial properties to the south west of the Site are located along Wentworth Road, approximately 400 m from the Site's foreshore. Housing is also located to the south along Electrolytic Street, approximately 600 m south of Foreshore Road.

The Five Islands Nature Reserve, a cluster of Islands, which include Flinders Islet, Bass Islet, Martins Islet, Big Island and Rocky Island are located between 1.5 km and 2.0 km to the south east and east of the Port. The Islands provide habitat to breeding and feeding sea birds which include endangered species (the southern giant petrel and sooty tern).

Wollongong sewage treatment and recycling plant is located approximately 2 km north of the northern breakwater. The 1 km long discharge pipe for the plant extends in a south eastern direction towards the breakwaters. The Port Kembla storm sewage treatment plant is located on Red Point approximately 2 km south of the Site.

2.3 Sea Bed Conditions and Stratigraphy

Sediments within the Site are affected by both natural processes, such as tidal flushing and longshore drift and to a lesser extent mechanical mixing from deep draft vessels and tug boat movements.

The bed profile at the Site comprises a layer of marine estuarine sediments which comprise silty clays, sandy silts and silty sandy clays with fine to coarse gravels. Based on previous studies the Site is characterised by a grain size gradient with coarse sand and fine gravels present around the breakwatersand central area of the Site with fine grained silty, sandy clays present towards the entrance to the Inner Harbour.

The surficial sediments are underlain by stiff alluvial clays and shallow bedrock. Rock contours indicate a rock level of RL-17 m just below the PKOH turning basin which grades upwards towards the south west of the Site and varies between RL-7m to RL -15m under the shoreline. Other key features include a valley present beneath Jetty No. 3 and a ridge of high rock located in the western portion of the Site toward the Port Kembla Gateway Jetty (Jetty No. 6) and an area of high rock close to the shoreline near Jetty No. 3.

An underwater emplacement (disposal) area is also present in the western portion of the Site nearest the shoreline. Prior to construction of the underwater emplacement area the water depth in this area increased rapidly from the shoreline. The underwater emplacement area contains a variety of material types, generated from historical dredging campaigns in the Inner Harbour and is discussed further in this report.

2.4 Aquatic Ecology

The main habitats for aquatic flora and fauna at the Site are the soft, deposited bottom sediments, the extensive constructed rocky revetments and the water column.

2.4.1 Flora

Sediments

Neither mangroves nor sea grasses have been recorded in previous studies of the Site. Wave action and high turbidity do not provide a suitable habitat for their occurrence.

Low levels of cysts of the potentially toxic dinoflagellate *Alexandrium* have been found in all bottom sediments. When disturbed, these cysts can develop into algal blooms causing toxins to accumulate in shellfish and leading to Paralytic Shellfish Poisoning in humans.

Revetments

Many species of macroalgae (seaweed) have been found in PKOH on hard substrata. The existing revetment walls provide potential habitat for macroalgae at shallower depths where light penetration is adequate. Macroalgae provide habitat for invertebrates and fishes. No introduced macroalgae species have been found in PKOH.

Water Column

There is no evidence of a toxic bloom having occurred in harbour waters although concern has been expressed that this may occur if cysts present in bottom sediments are disturbed during times when ambient conditions are suitable for germination.

2.4.2 Fauna

Sediments

The lack of sea grass and mangrove habitat limits the assemblage of marine organisms to benthic invertebrates, such as worms and bivalves, in the soft sediments. These organisms provide food for fish and, despite contamination, these sediments would be regarded by NSW Fisheries as feeding habitat for fish.

Revetments

The rock revetments have been identified as potential habitat for juveniles of one threatened fish species, the black cod (*Epinephelus daemelii).* However, the species has not been observed within the Outer Harbour. The revetments support a range of attached and mobile (e.g. starfish) invertebrate species which provide food for other species. A variety of pest species also colonize hard substrata in the Harbour as a result of the discharge of ballast water. These include sponges, anemones, hydrozoans, bryozoans, polychaete worms, barnacles, crustaceans, ascidians and pest fish (goby) species.

Water Column

A large number of fish species have been recorded feeding in PKOH. None of the recorded fish are listed under the NSW *Fisheries Management Act*.

2.5 Acid Sulfate Soils

AECOM conducted a review of the Acid Sulfate Soil Risk Map (Edition 2) for Wollongong, published by the Department of Natural Resources (DNR 2002). The plan indicates that there is a 'High Probability' ASS within the 'Estuarine Bottom Sediments' of the Inner Harbour and that there is a potential for severe environmental risk if bottom sediments are disturbed by activities such as dredging. This conclusion can be reasonably extrapolated to PKOH which is categorised by the Map as Ocean and therefore not classified.

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3.0 Background

3.1 Summary of History

Port Kembla originated in the late 1800's as a result of the coal industry in the Illawarra region. The first Jetty was constructed on Five Islands Point in 1883 to service coal loading from the Mount Kembla Coal and Coke Company. In the 1920s the Hoskins Steelworks was developed which contributed significantly to the growth of the Port. By the 1960s six jetties had been constructed at the Site and coal export operations were transferred to the Inner Harbour.

Jetty's No.4 & No. 6 Jetty were originally constructed to service the needs of Electrolytic Refining and Smelting Co of Australia (ER&S) and Broken Hill Proprietary Company Limited (BHP) and the growing demand for larger vessels. During the 1970's further construction resulted in the addition of the Products Berths and deepening of the Inner Harbour.

The PKOH foreshore is considered to be the land between Jetty No. 3 and Jetty No. 6 which is bounded by Foreshore Road and Old Port Road. The land along the foreshore has been used for over 60 years for industrial uses which include a power station, a coke works, ship building yards, material stockpiling, electrical equipment storage, rubbish dumping and metals fabrication.

Historic land use at the PKOH and surrounds remains industrial with a mix of uses including acid recycling/dilution (Orica Chemnet), copper smelting (PK Copper), coke works, steel production and fabrication, steel coating, scrap metal processing, ship building yards, material stockpiling, rail infrastructure, electrical equipment storage and a power station. Current industrial operations on the foreshore include Brick and Block Masonry products manufacture, Morgan cement, Blue Scope Steel, and BHP Billiton. A history of heavy industry, land reclamation and filling has resulted in a legacy of contamination issues both on shore and off shore.

Contaminants leaching from the fill materials in addition to those migrating from up gradient sources have impacted groundwater beneath the PKOH. The PKOH is the receiving water body for historic stormwater discharge from the Darcy Road Drain, discharges from Salty Creek and run off from the industrial catchment of the Port Kembla Foreshore.

3.2 Previous Investigations

PKPC supplied AECOM with a document register and three compact disks that contained previous reports and/or data sets relating to a variety of properties at and associated with the PKOH. The reports addressed contamination related issues including: air quality, the properties and use and of slag in the construction industry, soil quality, groundwater quality and sediment quality.

The document register listed 75 separate reports; of which 32 were found to be on the CD's. Of the 32 reports on the CDs, 19 were completed after 2002 and therefore were subject to a detailed review. Reports prepared prior to 2002 are considered unsuitable for satisfying the DGRs because they were prepared prior to implementation of the current suite of guidelines and regulations which inform the assessment of contamination in NSW.

Review of the available previous investigation reports assisted AECOM in developing the proposed sampling and analysis plan and in particular the selection of the nominated CoPC for this SI.

A summary of the reports reviewed is provided below and each of the site investigation areas is illustrated in **Figure F5**:

3.3 Soil and Groundwater Quality

3.3.1 Preliminary Site Investigation, Old Port Road, Port Kembla, NSW (EGIS Consulting 2002a)

Egis Consulting was commissioned by the State Rail Authority (SRA) of NSW to undertake a Preliminary Site Investigation (PSI) of a property located on Old Port Road, Port Kembla NSW (refer to **Figure F2**). At the time that the report was written the property was owned by SRA. The PSI was undertaken to assess potential contamination of the property in preparation for its sale.

Objectives

The main objectives of the PSI were to:

- Document the site history;
- Assess potential on and off site sources of contamination;
- Assess the risk of these contaminant sources with respect to the contamination status of the property; and
- Conclude whether or not the property was suitable for continued commercial / industrial use without further assessment, or provide recommendations for further assessment (if required) to enable such conclusions.

Scope of Work

The scope of work undertaken by Egis comprised of the following:

- Review of site historical information including aerial photographs, SRA/RSA records, local council information;
- Review and assessment of any other historical contamination, environmental or geotechnical studies undertaken on the site or on nearby SRA sites;
- Review of topography, geology and hydrogeology;
- Preparation of site specific safety, sampling and analysis, and environmental management plans;
- Detailed inspection of site facilities and subsurface investigations, in accordance with relevant EPA Guidelines (including the Sampling Design Guidelines (EPA, 1995)) comprising. Soil samples were analysed for TPH, BTEX, heavy metals, PAHs, OCPs, PCBs and Asbestos.
- Preparation of a PSI report presenting the results of the investigations, results of the laboratory testing program, and an assessment of contamination at the site, with conclusions.

Site History Summary

- Prior to 1972, the property was owned by the Minister of Public Works and was reported to be vacant based on a review of historic aerial photographs and certificates of title;
- From 1972- 2002, the property is reported to have been developed as a car park, sealed at the surface; and
- The surrounding area is reported to have been used for heavy industrial activities which included up-gradient copper smelting operations (PK Copper), down gradient fertiliser manufacture (Incitec), and Steel manufacturing and coating activities (BHP Steel haven).

Results Summary

- Copper concentrations exceeded the residential Health Based Soil Investigation Levels (NEPC 1999) (1,500 mg/kg) in one sample; and
- No other parameters exceeded the adopted Site Assessment Criteria (SAC).

Conclusions and Recommendations

- The report concluded that the property was suitable for ongoing/commercial industrial use without further investigation, remediation or management; and
- The report recommended that due to the existing infrastructure on the site and the surrounding industrial land use, SRA release the property for continued commercial/industrial use.

3.3.2 Preliminary Site Investigation, Darcy Road, Port Kembla, NSW, (EGIS Consulting 2002b)

Egis Consulting was commissioned by the SRA to undertake a PSI of a property located on Darcy Road, Port Kembla, NSW (refer to **Figure F5**). At the time that the report was written the property was owned by SRA. The PSI was undertaken to assess potential contamination of the property in preparation for its sale.

Objectives

The main objectives of the PSI were to:

- Document the site history;
- Assess potential on and off site sources of contamination;
- Assess the risk of these contaminant sources with respect to the contamination status of the property; and
- Conclude whether or not the property was suitable for continued commercial / industrial use without further assessment, or provide recommendations for further assessment (if required) to enable such conclusions.

Scope of Work

The scope of work undertaken by Egis comprised of the following elements:

- Review of site historical information including aerial photographs, SRA/RSA records, local council information;
- Review and assessment of any other contamination, environmental or geotechnical studies undertaken on the site or on nearby SRA sites;
- Review of topography, geology and hydrogeology;
- Preparation of site specific safety, sampling and analysis, and environmental management plans;
- Detailed inspection of site facilities and subsurface investigations in accordance with the relevant EPA guidelines (including Sampling Design Guidelines). Soil samples were sampled and analysed from 16 locations for TPH, BTEX, heavy metals, PAHs, OCPs,PCBs and Asbestos. Three samples were also subject to TCLP testing for lead
- Preparation of a report presenting the results of the investigations, results of the laboratory testing program, an assessment of contamination at the property, and conclusions.

Site History summary

- The property was reported as being vacant prior to 1972 when it was owned by the Minister of Public Works; and
- Between 1972 and 2002 the property was developed as a car park, sealed at surface with bitumen.

Results Summary

- Lead concentrations above health-based site investigation levels SIL_4 (NEPC, 1999) criteria for industrial sites were reported at 4 sampling locations and ranged between 1,600 to 5,100 mg/kg. The SIL_4 for industrial land use is 1,500 mg/kg;
- An arsenic concentration (5,500 mg/kg) exceeding the SIL_4 (NEPC, 1999) criteria for industrial sites was reported at 1 location;
- High sulphate concentrations, exceeding NEPM Structural Guidelines, were reported at a single sampling location. Sulfate-like crystals were observed in the fill material in certain areas across the site and laboratory analysis of these samples reported concentrations of sulphate exceeding the criterion for the protection of structures
(2 000 mg/kg); and
- TCLP analysis indicated high leaching potential for lead across the property and lead was considered to have the potential to impact groundwater.

Conclusions and Recommendations

- Preliminary investigations at the property indicated that there were concentrations of lead that required remediation or management for continued commercial/industrial use or redevelopment;
- Lead in soils at the property were not considered to represent a significant risk of harm to human health based on the land use at the time of the investigation and the site being sealed at surface with bitumen;
- Future developments at the property would need to consider the potential affect that the sulphate in the soils may have upon built structures;
- Options for remediation recommended by the report included:
  - Remediate the identified areas of lead contamination and divest for commercial/industrial use; and
  - Remediate the identified lead hotspot (PK14), further investigate the remaining areas of lead contamination, and divest for commercial/industrial use.

3.3.3 Stage 1 Preliminary Site Investigation Lot 202 DP 1007128 Old Port Rd, Port Kembla (Alchemy Sciences Pty Ltd 2002) CLR01122

Alchemy Sciences Pty Limited (Alchemy) was engaged by SRA to conduct a Stage 1 PSI of a property located at Lot 202 DP 1007128, Old Port Road, Port Kembla (refer to **Figure F5**). The report stated that *"It is believed that the site is to be sold for industrial land use."*

Objectives

The objectives of the PSI were to review the history of the site, inspect the site, and determine land use options available to SRA according to NSW EPA guidelines.

Scope of Work

The scope of work included the following:

- Review of SRA site records, aerial photographs, land titles and EPA and WorkCover certificates relating to the property;
- Consultation with site stakeholders;
- Site inspection to observe any environmental contamination or potential environmental risks associated with the site (performed 13 February 2002);
- Assessment of management requirements for intended lease;
- Recommendation of further assessment and the requirement for Section 60 notification under the Contaminated Land Management Act (1997); and
- Preparation of a Stage 1 PSI report.

Site History Summary

- Acquired in 1900 by the Minister of Public Works, for the construction of the deepwater PKOH; and
- Land transferred to the Minister of Transport as a wagon repair depot in 1965.

Conclusions and Recommendations

- Based on the site history, it was considered that there was a moderate potential for contamination onsite. Significant industrial and SRA practices with the potential to cause contamination were identified as having been performed onsite; however it appeared that no substantial excavation, landfilling or demolition had occurred. Most site activities related to site access, transmission lines, administration and SRA related rail operations and infrastructure. No aboveground or underground storage tanks were identified; and
- The property was not considered suitable for sale or lease for commercial or industrial use (or any more sensitive land use) without further environmental investigation, if the proposed future land use was to involve disturbance of the property.

3.3.4 Environmental Site Assessment Vacant Land near Jetty No. 3 Foreshore Road, Port Kembla (IT Environmental Pty Ltd, 2002)

IT Environmental Pty Ltd was commissioned by PKPC to undertake an environmental assessment of a property located along Foreshore Road, near Jetty No. 3 at the Site (refer to **Figure F5**).

Objectives

The objectives of the ESA were to determine the baseline environmental condition of fill and soil on the property and determine whether an assessment of groundwater was required.

Scope of Work

The scope of work included the following:

- Excavation of 10 ten test pits to a maximum depth of 3.0 m;
- Collection of soil samples to a maximum depth of 3.0 m below ground surface (bgs);
- Screening of soil samples for volatile vapours;
- Laboratory analysis of selected surface and subsurface samples for heavy metals, TPH, BTEX, PAH, VOCs, SVOCs and TOC;
- Preparation of a Site Investigation report.

Site History Summary

Historic land uses were reported as including:

- Quarantine Zone (no dates given);
- Fertiliser and car storage (no dates given);
- Scrap metals operation (no dates given); and
- Timber yard.

Results Summary

- Lead concentrations exceeding the SIL_4 (NEPC, 1999) criteria was detected at two locations on the site and found to be leaching under neutral conditions with the potential to impact groundwater;
- An arsenic concentration exceeding the SIL_4 (NEPC, 1999) criteria was detected at one location on the site and found to be leaching under neutral conditions with the potential to impact groundwater;
- Copper and zinc concentrations detected below the SIL_4 (NEPC, 1999) criteria were also considered to have the potential to leach under neutral conditions and impact groundwater at the site;
- The site is generally underlain by layers of fill (silt, clay, sand, gravel, boulders and ash) to a depth of up to 3 m bgs;
- The nearest receptor was identified as the surface waters of the site.

Conclusions and Recommendations

- Lead and arsenic concentrations present in the surface layers of fill at the site present a potential risk to human health and require further delineation of hotspots and possible removal and replacement and/or capping to prevent leaching to groundwater if the site is to be redeveloped;
- A management plan – based on removal of hot spots - for the site would help minimise exposure to metals in surface soils; and
- Further investigation including installation of monitoring wells to determine potential impacts to groundwater was recommended.

3.3.5 Groundwater Monitoring Well Installation & Groundwater Monitoring Program, Proposed Hyrock Site, Eastern Corner, Old Port Road and Christy Drive Port Kembla New South Wales, (Absolute Environmental, 2004)

Hyrock commissioned Absolute Environmental to install four groundwater monitoring wells and undertake two groundwater monitoring events (GME's) at the proposed Hyrock site at the eastern corner, Old Port Road and Christy Drive (shown on **Figure F5**), prior to redevelopment. A summary of the report is provided below.

Objectives

The objective of the assessment was to assess current groundwater conditions in the area of the site reported to be down hydraulic gradient of an identified area of heavy metals and PCB impacted soil.

Scope of Works

The scope of work included the following:

- Install four groundwater monitoring wells at the site;
- Undertake two rounds of groundwater monitoring at the site; and
- Produce a GME report.

Site History Summary

The Site was a former public works depot before which it became part of the Port Kembla Power station site. Prior to this it belonged to the Maritime Service Board.

Results Summary

- The groundwater flow direction was from west to east, with a hydraulic gradient of approximately 1.5 m across the site in dry weather periods and 2.0m during wet weather periods;
- Arsenic concentrations above laboratory EQL were detected in all wells ranged between 2 -75 µg/l. Arsenic concentrations in groundwater for the Port Kembla area range between 100-200µg/l with a maximum peak of 500 µg/l. Background regional concentrations of arsenic vary between 1 and 50 µg/l;
- Zinc concentrations above laboratory EQL were detected in all wells and ranged between 39 -120 µg/l;
- Background concentrations of zinc in soils, as reported by NEPC, are between 10-300 mg/kg. Previous investigations undertaken by CMPS&F (1993) reported zinc concentrations in soil ranging between 26-4790 mg/kg; and

- OCPs and PCBs were not detected at concentrations greater than the Limit of Report (LOR) in groundwater samples.

Conclusions and recommendations

- The arsenic concentrations in the groundwater were thought to be due to background levels resulting from natural sedimentary soils in the Outer Harbour area;
- Arsenic had not been analysed in previous GME's at the Hyrock Site and it was recommended that it should be analysed in future monitoring rounds undertaken by PKPC;
- The zinc concentrations in groundwater were attributed to both background levels (natural soils), sediments and fill materials at the site; and
- It was recommended that based on the mixed origin of zinc groundwater impact and the distance to the Port Kembla Outer Harbour, zinc concentrations in groundwater did not warrant remediation. However, it was recommended that future groundwater monitoring undertaken by PKPC include the Hyrock Site and wells located along the foreshore between No. 3 and No. 6 Jetties, along Old Port Road, Christie Drive and Foreshore Road.

3.3.6 Lot 201, Old Port Road, Port Kembla, NSW (SKM 2004)

SKM was commissioned by the SRA to undertake a combined, preliminary and detailed site investigation at Lot 201, Old Port Road, Port Kembla, NSW (refer to **Figure F5**).

Objectives

The objectives of the assessments were to:

- Confirm and detail the site boundaries and title descriptions;
- Document the site history;
- Assesses potential on and off site sources of contamination;
- Report on the nature and extent of contamination in soil (and groundwater if relevant) at the site, and provide clear conclusions as to the land's suitability for its intended land use (and other land uses).

Scope of Works

The scope of work comprised the following elements:

- Review of site history for purposes of determining potentially contaminating activities and liability;
- Conduct appropriate field investigations, sampling and analyses, including installation of 39 boreholes and four groundwater monitoring wells;
- Analysis of selected soil samples for heavy metals, PAHs, TPHs, BTEX, OCC/OCPs and VOCs and SVOCs;
- Assess the risk/impact of contamination sources within the context of the property;
- Conclude whether or not the property is suitable for continued use for commercial and/or industrial purposes;
- Recommend future management measures or remediation necessary to facilitate continued use for commercial and/or industrial purposes; and
- Preparation of a Contaminated Site Investigation Report.

Site History

The site history assessment revealed that the property was utilised as a rail wagon maintenance centre since at least 1970. Between 1910 and 1965, the Commissioner for Public Works held title to the property for the purposes of deepwater harbour construction.

Results Summary

- All soil samples returned heavy metal concentrations below the SIL_4 (NEPC, 1999) criteria;
- Concentrations of heavy metals exceeding the EILs were reported for copper (14 of 45 samples), manganese (36 of 45 samples) and zinc (16 of 45 samples); and

- Concentrations exceeding the ANZECC (2000) Marine Ecosystem Criteria were reported for Cobalt, Copper, Nickel and Zinc in groundwater at the site.

Conclusions and Recommendations

- Soils beneath the maintenance centre were not able to be investigated due to the presence of deep basements;
- Site soils were all found to comply with the SIL_4 (NEPC, 1999) criteria;
- Some exceedances of the EILs were reported, however, these were not considered significant as the property is used for industrial purposes only;
- Groundwater flow through the property was considered to be low due to a relatively small catchment area and a low rate of infiltration given the high proportion of impermeable surfaces. Consequently, the surficial aquifer was considered to be discontinuous or patchy across the property;
- Exceedances of the ANZECC (2000) Marine Water Quality Criteria were reported for cobalt, copper, nickel and zinc. However, these results were not considered significant because the low flow of groundwater through the property implies there is minimal connectivity between the surficial aquifer and the Port Kembla Harbour;
- One exceedance of the ANZECC (2000) Water Quality Criteria for Freshwater Ecosystems was reported for manganese. However, due to the discontinuous nature of the perched aquifer and the low flux of groundwater through the property, there appeared to be a lack of connectivity between the aquifer and the nearest creek (~100m away). Furthermore, the creek system is located in an industrial setting and is highly disturbed;
- Elevated concentrations of manganese in the slag fill material appeared to contribute to the elevated concentrations in the surficial groundwater;
- The investigation did not consider the water quality of the regional aquifer, but given the impermeable nature of the clay layer and the low flow of groundwater through the surficial aquifer, it was considered unlikely that there would be significant connectivity between the shallow perched aquifer and the deeper regional aquifer; and
- The property was not considered to represent a significant risk of harm at the time of the investigation.

Based on the conclusions provided above the report made the following recommendations:

- Due to the identified elevated levels of manganese in the slag fill material and the level of uncertainty as to the relative toxicity of this substance, it was considered prudent to avoid uncovering significant areas of the slag fill to avoid creating exposure pathways to future site workers; and
- Elevated levels of manganese in the fill material appeared to be causing elevated concentrations in the surficial groundwater. Consequently, it was concluded that future users of the property should avoid land use scenarios whereby surface water infiltration and groundwater recharge rates are increased.

3.3.7 Phase II Environmental Site Assessment Port Kembla Port Corporation Inner and Outer Harbour Soil and Groundwater Assessment Port Kembla NSW (URS 2004)

URS was commissioned by PKPC to undertake a Soil and Groundwater Assessment of the foreshore land adjacent to the Inner and Outer Port Kembla Harbour. The investigation area is shown in **Figure F5**.

Objectives

The primary objective of the investigation was to assess the soil and groundwater quality conditions of the Port.

Scope of Work

The scope of work undertaken comprised the following elements:

- Drilling of 20 bore holes in the Inner and Outer Harbour;
- Installation of groundwater monitoring wells at all borehole locations;
- Soil and groundwater sampling;
- Laboratory analysis consisting of:

  - **Soils**: Metals, PAH, TPH, BTEX, OCP, OPP, PCB, VOCs
  - **Groundwater**: Metals and PAH's
- Reporting (including recommendations for future monitoring).

Site History

- The land between Jetty No. 3 and jetty No. 6 has been used for at least 60 years for a range of industrial uses including:
  - power station;
  - coke works;
  - ship building companies;
  - material stockpiling;
  - electrical equipment storage;
  - rubbish dumping;
  - metal fabrication, etc; and
  - Fertiliser production.

Results Summary

- Concentrations reported for all analytes were below the SIL_4 (NEPC, 1999) criteria; and
- The analytical results indicate that the groundwater beneath the investigation area had concentrations exceeding the ANZECC [2000] 95% level of species protection - Marine Water for copper, lead, nickel and zinc. The most elevated concentrations of these occur beneath the eastern portion of the site.

Conclusions

- The lithology consisted of a sequence of fill, comprising slag, gravel, rock fragments and sand and varying layers of silty clay and sands;
- Groundwater quality was highly saline and unlikely to be utilised for drinking water;
- No soil analytical results exceeded the nominated investigation criteria. However slightly elevated concentrations were recorded for chromium, copper, lead and zinc;
- Comparison of groundwater results with ANZECC (2000) guidelines indicated that copper, nickel, zinc and lead were detected above the relevant investigation criteria in groundwater beneath the site; and
- Leaching of metal contaminants into the groundwater appeared to be minimal, based on the elevated levels of chromium in the soil analytical results and the groundwater analytical results being below or near the LOR.

The following specific conclusions for the Outer Harbour site were reported:

- The area in the Outer Harbour bound by No 3 Jetty to the east and the Darcy Road Drain to the west, formerly known as Area A had the highest proportion of groundwater samples which exceeded the nominated investigation criteria;
- The assessment of historical data for the existing groundwater monitoring wells in the Outer Harbour area indicated that there appeared to have been a pulse of metal/metalloid contaminated groundwater, which appeared to have diluted and dispersed as it approached the harbour shoreline;
- Impacted groundwater is likely to be regional rather than localised to the site due to the industrialised nature of the region; and
- Impacted groundwater has the potential to migrate into and impact the Port Kembla Harbour.

Recommendations

The report recommended an initial groundwater monitoring round in six months time and followed by annual monitoring.

3.3.8 Port Kembla Port Corporation Outer Harbour Groundwater Monitoring Event, Port Kembla NSW (URS 2006)

URS was commissioned by PKPC to further assess groundwater conditions in the areas surrounding the PKOH (refer to **Figure F5**).

Objectives

The primary objectives of the investigation were to:

- Further assess groundwater conditions;
- Ensure that there were no immediate risks to human health and the environment; and
- Communicate to interested parties whether there were significant risks associated with the property and whether it was suitable for the relevant land use.

Scope of Work

The scope of work undertaken comprised the following elements:

- Groundwater gauging;
- Collection of groundwater samples from 19 monitoring wells;
- Laboratory analysis of groundwater and surface water samples for heavy metals and PAH's;
- Reporting of investigation results; and
- Recommendations for future monitoring.

Results Summary

- Groundwater elevations ranged between 0.158 and 0.804 m AHD;
- Groundwater seepage velocity was calculated to be approximately 29m/year;
- Groundwater is impacted with cadmium, copper, lead, nickel and zinc all of which exceed the ANZECC (2000) 95% level of species protection for marine waters;
- The highest concentrations of metals reported in groundwater were from the area around Jetty No. 3 and to the west of the Darcy Road Drain; and
- Up hydraulic monitoring wells on Foreshore Road also recorded concentrations of copper, nickel and zinc above the adopted assessment criteria.

Conclusions

- Up hydraulic gradient groundwater is a possible source of the metal contamination at the investigation area;
- Concentrations of dissolved metals in the eastern portion of the PKOH foreshore had remained relatively constant since the commencement of monitoring in 1996 with some zinc fluctuations;
- Concentration of cadmium above the adopted assessment criteria were detected above the adopted assessment criteria in a single monitoring well located in the central portion of the PKOH foreshore;
- Possible sources of contamination could include leaching from in situ soil / fill and migration from up gradient off site sources;
- Groundwater impacts in the Port Kembla region are a regional issue, rather than a local issue. Impacted shallow groundwater appears to be migrating towards the PKOH from up gradient and off site sources;
- Due to the proximity to the PKOH, the potential exists for impacted groundwater to migrate into the surface water body of the PKOH; and
- Groundwater monitoring results suggest that concentrations decrease adjacent to the shore line, most likely due to dispersion and dilution.

Recommendations

- Monitoring should continue to monitor trends in groundwater contamination;
- Nickel, PAHs and selenium should be included in the analytical suite for future monitoring rounds;
- Repair or replace up gradient monitoring wells and continue monitoring off site groundwater conditions;
- Install 2 additional wells in up hydraulic gradient locations;
- Should an increase in metal concentrations become apparent during future monitoring rounds, PKPC should consider steps to try and identify the source; and

- Surface water sampling should be considered to assess contaminant contribution to harbour water from up stream sources.

3.3.9 Report on Soil and Groundwater investigation, Outer Harbour Lands, Port Kembla (Douglas Partners 2009)

Douglas Partners was commissioned by PKPC to undertake a groundwater investigation in the Outer Harbour Lands (OHLs) of the Port Kembla Harbour (refer to **Figure F5**). The aim of the investigation was to collect updated information for environmental and occupational health and safety purposes during the proposed re-development and reclamation of the OHL.

Objectives

The primary objectives of the investigation were to:

- Provide up to date data for groundwater in the OHL;
- Maintain and enhance the existing OHL monitoring well networks to provide adequate coverage of areas of potential groundwater contamination;
- Assess the concentration of potential contaminants of concern in groundwater; and
- Assessment of soil contamination at new well locations.

Scope of Work

The scope of work for this investigation involved:

- Site and well inspection;
- Reinstallation of wells MW16 and OHMW28 using a trailer-mounted drill rig;
- Installation and development of two additional monitoring wells (MW31 and MW32);
- Collection of soil samples from new and reinstalled boreholes and laboratory analysis for heavy metals, TPH, BTEX, PAHs, OCP, OPP, PCB and asbestos;
- Measurement of groundwater levels to provide information on the flow regime;
- Purging of wells prior to sampling of 16 wells using low flow micro purge technique;
- Measurement of field parameters including electrical conductivity (EC), temperature, pH, dissolved oxygen (DO), and oxidation-reduction potential (redox);
- Laboratory analysis of groundwater samples for heavy metals, arsenic, TPH, BTEX and PAHs; and
- Compilation of an interpretive report detailing the findings of the investigation.

Results Summary

- Several exceedances of the Groundwater Investigation Levels (GILs) were reported for copper, zinc, arsenic III, arsenic V, cadmium, lead and nickel. AECOM notes that the adopted GIL's for metal and metalloid concentrations in groundwater were based on the Port Kembla Environmental Group Trigger values provided to Douglas Partners (DP) by PKPC. Notwithstanding, the report also makes an assessment of the potential risk of harm to the environment using the ANZECC (2000) 95% trigger values of protection for Marine Quality;
- Arsenic V concentrations (ranging between 7-154 µg/l) exceeded the GIL's for all samples submitted for laboratory analysis;
- Soils collected and analyzed during the installation of two new wells reported contaminant concentrations less than the commercial/industrial land use criteria with the exception of asbestos that was detected at one location between 0.5-1.0m bgs;
- The report provides a summary and comparison of current and previous groundwater results from up and down gradient wells which suggested:
    - Arsenic concentrations in MW15 (located close to Foreshore Rd) were consistently higher than at any other well, a trend that continued through monitoring in the OHL;
    - Cadmium, copper, nickel and zinc concentrations were generally higher in the up gradient wells;
    - Chromium and lead concentrations were generally consistent with down gradient wells;
    - TPH, BTEX and PAH concentrations were not considered to pose a risk to the receiving water of the site;

  - Arsenic III concentrations that exceeded the adopted site assessment criteria may bioaccumulate in some marine organisms. However, the report also states that its toxicity may be reduced by the presence of Iron III, chromium III and barium. Reference is also made to the fact that sulphides may also remove arsenic III;
  - Arsenic V concentrations that exceeded the adopted site assessment criteria may also bioaccumulate to some extent in some marine organisms. However, the report also states that its presence may also be reduced by clay; and
  - Cadmium, copper and lead concentrations marginally exceeding the guideline were not considered to be significant in terms of risk.

Conclusions

- Whilst the groundwater monitoring well network within the OHL was considered to be extensive, some of the wells had been destroyed or damaged or lost and could no longer be sampled. Many wells had been sampled for 2 or less rounds;
- Heavy metal concentrations are generally higher in up gradient wells than down gradient wells with the exception of chromium and lead;
- The exceedances of the GILs and other reference values, and comparison to Port Kembla water quality results, indicated that there may be a potential risk to the environment;
- Nickel concentrations, where detected, had generally increased from previous sampling events; and
- The number of sampling events varies between wells, and as such the limited data set restricts the interpretation of clear trends.

Recommendations

- Continued sampling of groundwater wells to monitor trends in groundwater contamination; and
- Additional monitoring from all wells should be undertaken to allow better characterisation of groundwater quality and variation over time.

3.4 Sediment Quality

Dredging campaigns in the 1990s involved the dredging of sediments for the creation of two new berths and maintenance of shipping channels within the Inner Harbour. The sediments dredged from the Inner Harbour were disposed and used for reclamation purposes.

3.4.1 MPB3 & EB4 Dredging and Disposal to the Outer Harbour Environmental Assessment (Patterson Britton 2005a)

The sediment quality of the material to be dredged and emplaced in the PKOH was assessed as part of investigations undertaken by Patterson Britton to determine the suitability of the material for sea disposal.

Scope of Work

Samples were retrieved using a combination of vibrocoring and sediment grabs.

Samples collected from the Inner Harbour generally comprised a contaminated, very soft, dark grey to black estuarine clay layer which varied between 0.5 and 4.0 m in thickness. This layer was underlain by stiff alluvial residual clays.

As part of the assessment, sediment samples were also collected from the PKOH to assess the potential impacts of emplacing the dredged material. Samples were recovered from 12 locations in the south western portion of the Site in the area proposed for disposal of the sediment dredged from the Inner Harbour.

Results Summary – Inner Harbour

Sample results from samples collected from the Inner Harbour were assessed against the ISQGs which indicated:

- Concentrations of contaminants in the estuarine clay layer appeared to increase with depth;
- Concentrations of cadmium chromium, copper, lead mercury, nickel and tributyltin (TBT) exceeded the ISQG-Low;
- Concentrations of zinc and some PAH compounds exceeded the ISQG-High;

- Analysis of the underlying stiff residual silty clay confirmed that it was uncontaminated (all analytes below the ISQG-Low) and therefore suitable for unconfined sea disposal (approximately 330,000 m^3 of uncontaminated material was later disposed of through sea dumping);
- Estuarine clays were determined to be unsuitable for sea disposal and instead were disposed (emplaced) into the underwater emplacement area within the PKOH (300,000 m^3 of material was deposited into the underwater reclamation (emplacement area) area located between Jetty No. 3 and Jetty No. 6); and
- The deposited (emplaced) material comprised the following:
  - Very soft dark grey to black contaminated silty estuarine clay;
  - Sandy fill;
  - Slag/gravel fill (including sandwiched clay layers);
  - Slag crust; and
  - Contaminated soft to firm estuarine clay.

Results Summary – Outer Harbour

Sample results from samples collected from the Outer Harbour were assessed against the ISQGs which indicated the following:

- Sediments comprised very soft dark grey to black silty clay;
- Concentrations of arsenic, cadmium, chromium, copper, lead, mercury, naphthalene, nickel, silver, TBT and total PAH exceeded the ISQG-Low;
- Comparison of the results indicated that for the majority of compounds tested, concentrations of contaminants in the Outer Harbour sediments were similar to or higher than the dredged material from the Inner Harbour; and
- Concentrations of arsenic, copper, lead, mercury, silver and TBT were reported to be higher than those of the dredged sediments from the Inner Harbour whilst concentrations of chromium, zinc and PAH were reported to be greater in the dredged sediments.

AECOM notes that the 12 samples collected from the Outer Harbour were located within the underwater emplacement area and did not provide sufficient coverage of the areas proposed for dredging as part of the current PKOH development.

3.4.2 Port Kembla Outer Harbour Reclamation Area Sediment Sampling and Testing (Patterson Britton 2005b)

The sediment investigation was undertaken on behalf of PKPC as Part of the EA for development of the Inner Harbour.

Objectives

The objective of the sediment investigation was to assess the potential impacts of disposal of dredging sediments from the Inner Harbour within the proposed PKOH reclamation area.

Scope of Work

The scope of work undertaken comprised the following elements:

- Sediment sampling at 8 locations using a grab sampler (surface sediments);
- Sediment sampling at 4 locations using vibro coring techniques to a maximum depth of 0.5 m; and
- Analysis of all samples for metals, TPH, BTEX, PAH, OCPs, PCBs, Orgno-tins and TOC.

Results Summary

- The results indicate that the 95% Upper Confidence Limit (UCL) for all analytes were generally above the ISQG-Low; and
- The 95% UCL's for copper, lead, mercury, silver, zinc and naphthalene were all above the ISQG-High.

Conclusions and Recommendations

The report made no conclusions or recommendations other than:

- There is a low probability that there would be toxic effects on benthic biota if contamination levels are below the ISQG-Low;
- There is a high probability that there will be toxic effects if contamination levels exceed the ISQG–High; and
- Contamination levels between the ISQG-Low and ISQG–High have an intermediate probability of effects.

3.4.3 Report on Sediment Sampling and Analysis, Port Kembla Port (Douglas Partners, 2002)

Objectives

Douglas Partners was commissioned by PKPC to undertake a sediment investigation of a proposed maintenance dredging area for the purpose of assessing offshore disposal options.

Scope of Work

- A dive team was utilised for the collection of sediment samples. Sediment samples were collected to a maximum depth of 1.0 m using a 50 mm diameter core-tube;
- Sediment samples were collected from 74 locations (mainly across the Inner Harbour) with only one sample collected from the Outer Harbour ('Site 3.2' at approximately 11 metres depth). This sample was located south east of Jetty No. 6;
- 35 samples were analysed for physical properties and chemical testing was conducted on 39 samples;
- Selected samples were analysed for acid volatile sulphides (AVS) and simultaneously extractable metals (SEM) to assess the bioavailability of the sediments; and
- Samples were analysed for a range of heavy metals, Total PAHs, TBT, TPH, OCPs and cyanide.

Results Summary

- Antimony, cadmium, cyanide, selenium, silver, TBT, vanadium, TPH, BTEX, OCPs, PCBs and Total phenolics concentrations were all reported at concentrations below the laboratory LOR in the sample collected from 'Site 3.2';
- Copper, lead, mercury, molybdenum and Total PAHs concentrations in 'Sample 3.2' were reported to exceed the ISQG-Low while none of these concentrations exceeded the ISQG-High (refer to **Table 4** below);
- A zinc concentration of 81 mg/kg was reported in the analysed sample; and
- An iron concentration of 9,100 mg/kg was reported in the analysed sample.

Table 4 presents a summary of all sample results together with the 'Site 3.2' sample analysis results.

Table 4: Summary of Harbour sediment sampling (Douglas Partners, 2002)

CoPC	ISQG-Low	' Site 3.2 ' results	Harbour mean	Harbour 95% UCL	Harbour maximum concentration
Arsenic	20	16	14	16	70
Cadmium	1.5	<0.5	2	2	10
Chromium	80	75	91	105	370
Copper	65	150	138	154	270
Iron	-	49,000	58,130	66,390	-
Lead	50	140	150	164	220
Mercury	0.15	0.27	0.3	0.4	1
Nickel	21	17	19.5	21	52
Silver	1	<2	2	2	3.7
Zinc	200	81	730	819	410
Benzo(a)pyrene	0.43	0.2	3.2	3.6	1.6
Total PAHs	4	4.46	52.6	59.8	45

CoPC	ISQG-Low	‘ Site 3.2 ’ results	Harbour mean	Harbour 95% UCL	Harbour maximum concentration
Cyanide	-	<0.5	2.1	2.5	Not provided
TBT	5 µg/kg	<1 µg/kg	36 µg/kg	45 µg/kg	72 µg/kg

Units – mg/kg unless otherwise indicated.

Shaded results exceed the ISQG-Low trigger values.

Discussion

- The distribution of contaminants was concluded to be relatively random within the Inner and Outer Harbour;
- Some hotspots were noted in the north western corner of the Inner Harbour (in proximity to the Allen’s Creek outfall) and at the northern end of the Cut (the deeper shipping lane in the middle of the harbour);
- The results of AVS and SEM were ‘weakly negative’ which indicated that the larger proportion of available metals would be bound by sulphides. It was suggested that those metals not bound in this way would not be significant due to the reported high iron concentrations; and
- Elutriate test results indicated that only zinc exceeded the ANZECC/ARMCANZ (2000) marine guidelines (95% level of protection). However, it was concluded that zinc was likely to have negligible environmental impact and the toxicological effects from this metal were relatively benign.

3.5 Port Kembla Harbour Water Quality Monitoring

3.5.1 Marnie Philips (2002) – Review of BHP water quality monitoring program

In November 2002 Marnie Philips a student from the University of Wollongong, NSW completed her BSc thesis for a Bachelors Degree in Environmental Science. The thesis was entitled “Monitoring and Assessing the Water and Sediment Quality of Port Kembla according to the ANZECC and ARMCANZ (2000) guidelines”.

Objectives

The objective of the study was to provide a framework that water managers can use to protect and enhance the local environment for future benefit. The ANZECC & ARMCANZ Guidelines (2000a, b) were used as a monitoring and assessment tool for Port Kembla Harbour, NSW.

Scope of Study

The scope of the study was to assess harbour water quality data collected between 1990 and 1999 by BHP from 16 sites within the Inner and Outer Harbours. Of the 16 sites only 8 were applicable to the Outer Harbour. Water Quality parameters measured during monitoring program included pH, temperature, Dissolved Oxygen (DO), nitrate, nitrite, ammonia, cyanide, phenol, aluminium, arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, tin and zinc. Harbour water samples were taken at surface and at 10 m below surface at each site on a bi-annual basis.
A summary of the sites is presented below in **Table 5**:

Table 5: Summary of harbour water quality sampling sites assessed (Marnie Phillips, 2002)

Site ID	Water sampling location and depth	Sample type
Site 1	Mouth of Allan’s Creek opposite RoRo berth	Surface
Site 2	Mouth of Allans Creek opposite RoRo berth	10 m depth
Site 3	Middle of Inner Harbour opposite Sinter Plant	Surface
Site 4	Middle of Inner Harbour opposite Sinter Plant	10 m depth
Site 5	Mouth of Town Drain opposite Grain Handling Terminal	Surface
Site 6	Mouth of Town Drain opposite Grain Handling Terminal	10 m depth
Site 7	Cut between Inner and Outer Harbour	Surface

Site ID	Water sampling location and depth	Sample type
Site 8	Cut between Inner and Outer Harbour	10 m depth
Site 9	Middle of Outer Harbour near No.6 Jetty	Surface
Site 10	Middle of Outer Harbour near No.6 Jetty	10 m depth
Site 11	Entrance to Outer Harbour	Surface
Site 12	Entrance to Outer Harbour	10 m depth
Site 13	100 metres north of harbour entrance	Surface
Site 14	100 metres north of harbour entrance	10 m depth
Site 18	Shellharbour Harbour, opposite boat ramp	Surface
Site 19	Belmore Basin	Surface

Results Summary

- For average pH, no significant difference was reported at the sampling locations. However, a significant difference between Site 1 and Sites 3, 7, 8, 9, 10, 12 and 13, and between Site 2 and Site 3, was evident;
- For average DO, a significant difference between Site 1 and Sites 12 and 13 was observed; and
- Compliance with site-specific trigger values calculated for physical-chemical stressors (temperature, pH and dissolved oxygen), revealed a low risk of adverse effects to biological ecosystems within the harbour. However, default and site-specific trigger values for toxicants (Al, Fe, Mn and Zn) in water, were exceeded at several sites within the Inner Harbour. In addition, sediments in the Inner and Outer Harbours were reported to be contaminated with a range of trace metals (As, Cd, Cr, Cu, Pb, Ni, Sn and Zn), in excess of the trigger values indicating a requirement for further investigation.

Conclusion and Recommendations

The thesis concluded that the previous long-term monitoring program of Port Kembla Harbour (1990 - 1999) did not accurately reflect the water quality conditions within the harbour for the following reasons:

- The laboratory results were consistently affected by low detection limits for several parameters which misrepresented ammonia and cyanide, did not give a true indication of the concentrations found and their effect on the water quality of the harbour;
- Detection limits were consistently above trigger values and therefore unreliable for assessment purposes; and
- Further monitoring is required for the purpose of reliable data collection, and to determine whether trigger values are currently being met, and to assess compliance with guidelines for the protection of aquatic ecosystems.

AECOM considers that the quality and accuracy of the work conducted during the thesis was not to the required standard to allow a suitable level of interpretation and assessment.

3.5.2 Port Kembla Harbour Water Quality Monitoring Program (PK Environment Group 2002-2005 and Blue Scope Steel 2007-2008)

In 2002 the Port Kembla Environment Group designed a monitoring program based on the outcomes and recommendations of the Marnie Philips thesis to detect both beneficial and detrimental changes in water quality. The program was considered to be critical to the environmental management of the harbour. Blue Scope Steel continued the monitoring program at the same sites between 2007 and 2008 analysing for the same parameters as the PK Environment Group (PKEG), with the exception of phenols and chlorinated phenols, as these analytes were not detected during previous rounds of monitoring by PKEG.

Objectives

The main objectives of the harbour water quality monitoring were to meet the following environmental values:

- Aquatic ecosystems;
- Recreational water quality and aesthetics; and

- Industrial water quality.

The harbour water quality monitoring program also aimed to establish trends in harbour water quality whilst assessing whether concentrations of contaminants of concern were moving towards meeting the environmental values detailed above. For the purpose of this review AECOM has only reviewed the results specific to aquatic ecosystems to maintain consistency with the harbour water sampling conducted at high and low tide as part of this Sediment Investigation.

Scope of Work

The scope of work undertaken by the PKEG to meet the objectives of the program comprised:

- Sampling for and testing physical and chemical indicators of water quality at a total of 18 separate sites within the Port Kembla Harbour of which 7 are specific to the Outer Harbour;
- Laboratory analysis of representative harbour water samples (including QC samples) for:
  - metals (Al, Cr, Mn, Fe, Ni, Cu, Zn, Cd, Cn, Sn, Pb, As, Se);
  - Water quality parameters (including NH_3 and TSS); and
  - Phenols and Cresols (Phenol, o-Cresol, m+p cresol, 2,4 – Dichlorophenol, 2,6 – Dichlorophenol, 2,4,6 – Trichlorophenol, 2,4,5 – Trichlorophenol, 2,3,4,6, Tetrachlorophenol, Pentachlorophenol (PKEG only);
- Sampling for and testing the abundance and structure of organisms living in the harbour as a direct measurement of ecosystem health; and
- Assessment of data collected during the study.

Water quality data was collected between December 2002 and March 2005. AECOM notes that Site 14 (Entrance to the Inner Harbour – 10m sample) was omitted from the monitoring program. Only data collected from the Outer Harbour sampling sites are presented in **Table 6** below:

Table 6: Outer harbour sampling sites (PKEG 2008)

Site ID	Sample site description	Sample type
7	The Cut	Surface water sample
8	The Cut	10 metre depth
9	No. 6 Jetty	Surface water sample
10	No. 6 Jetty	10 metre depth
11	Darcy Road Drain (Outer Harbour)	Surface water sample
12	Darcy Road Drain (Outer Harbour)	10 metre depth
13	Entrance to the Inner Harbour ("The Cut")	Surface water sample

Results

- The data was assessed against the ANZECC (2000) 95% marine water trigger values to ensure consistency with the investigation undertaken by AECOM. As all other analytes were reported at concentration less than their respective assessment criteria, only metal concentrations have been assessed as part of this review.
- A summary of the results is presented below:

Sites 7 and 8 ("The Cut")

- Concentrations of aluminium greater than the adopted SAC were reported for 12 of the 15 surface water samples collected between Dec 02 and Oct 08 with concentrations ranging between 3 -13 µg/l;
- Concentrations of aluminium greater than the adopted SAC were reported for 8 of the 13, deep (10 m) water samples collected between Dec 02 and Oct 08 with concentrations ranging between 1.4 -7 µg/l;
- AECOM notes that the LORs were greater than the adopted SAC for 7 of the 26 samples collected from "The Cut" and therefore the actual concentrations reported cannot be determined;
- In general, the concentrations of aluminium reported for both surface and deep samples (10 m) tend to fluctuate and generally decrease between Apr 03 and Jul 04 until Oct 04 where the concentrations peak before steadily decreasing until Mar 08 where a similar peak is observed;

- Concentrations of chromium reported were all less than the adopted SAC for all surface and deep (10 m) samples. However, it is noted that the LORs vary considerably throughout the data set;
- Concentrations of manganese reported were all less than the adopted SAC for all surface and deep (10 m) samples;
- Concentrations of iron reported were all less than the adopted SAC for all surface and deep (10 m) samples and it is noted that the LORs vary considerably throughout the data set;
- Concentrations of nickel reported were all less than the adopted SAC for all surface and deep (10 m) samples and it is noted that the LORs vary considerably throughout the data set;
- Concentrations of copper greater than the adopted SAC were reported for 12 of the 15 surface water samples collected between Dec 02 and Oct 08 with concentrations ranging between 1.6 -2.5 µg/l;
- A concentration of copper greater than the adopted SAC was reported in 1 of the 13 deeper (10 m) samples collected between Dec 02 and Oct 08 at a concentration of 1.3 µg/l;
- AECOM notes that the laboratory limits of detection were greater than the adopted SAC for 17 of the 26 samples collected from “The Cut” and therefore the actual concentrations reported cannot be determined or assessed;
- AECOM notes that samples from 10 m below surface were not collected in Dec 02 or Jan 03.   Laboratory limits of detection were greater than the adopted SAC for 5 of the 13 samples collected;
- In general copper concentrations remain fairly constant throughout the data set with no specific trends noted;
- A concentrations of zinc greater than the adopted SAC was reported for 2 of the 15 surface water samples collected from “The Cut” between Dec 02 and Oct 08. Zinc concentrations range between 0.5 -20.0 µg/l;
- Concentrations of zinc reported for all the deeper samples were less than the adopted SAC;
- It is noted that the LORs vary throughout the data set;
- No specific trends in the data were observed other than peak concentrations in surface water samples collected in Dec02 (20 µg/l), Apr03 (14.5 µg/l) and Oct 04 (15 µg/l), and peak concentrations for the deep (10 m) samples collected in Apr03 (10.5 µg/l) , and Jan05 (8.8 µg/l);
- A concentration of cadmium greater than the adopted SAC was reported in 1 of the 15, surface water samples collected between Dec 02 and Oct 08 at a concentration of 18.8 µg/l. It is noted that AECOM also collected a harbour water sample at this location during high and low tide. The concentration of cadmium reported for sample HS-H-02 collected at high tide was 10, 400 µg/l and is not consistent with the PKEG / Blue Scope steel data set and may be erroneous;
- Concentrations of cadmium greater than the adopted SAC also noted in surface water samples collected in Apr 04 and Jan 05;
- Concentrations of cadmium reported for all other samples were less than the adopted SAC;
- No specific trends in the data were observed, however it is noted that the LORs vary throughout the data set;
- Concentrations of tin reported were all less than the adopted SAC for all surface and deep (10 m) samples;
- No specific trends in the data were observed, however it is noted that the LORs vary significantly throughout the data set. The summary tables provided no justification for the variability of LOR’s which for certain surface water sampling events Jan03 and Oct04 are between <24 and <25 µg/l);
- A concentration of lead greater than the adopted SAC was reported in 1 of the 26, water samples collected between Dec 02 and Oct 08 at a concentration of 8.2 µg/l;
- The majority of the remaining lead concentrations reported could not be assessed as the LORs vary significantly throughout the data set and were generally greater than the adopted SAC. As a direct result, actual concentrations could not be determined or assessed. The summary tables provided no justification for the variability of LOR’s which for certain surface water sampling events (Dec02) were as high as <20 µg/l);
- Concentrations of arsenic reported for all samples collected were less than the SAC; and
- Concentrations of selenium reported for all samples collected were less than the adopted SAC.

Sites 9 and 10 (No. 6 Jetty – Port Kembla Outer Harbour)

- Concentrations of aluminium greater than the adopted SAC were reported for 10 of the 15 surface water samples collected between Dec 02 and Oct 08 with concentrations ranging between 1 -14 µg/l;

- Concentrations of aluminium greater than the adopted SAC were reported for 8 of the 13, deep (10 m) water samples collected between Dec 02 and Oct 08 with concentrations ranging between 0.9 -6.2 µg/l;
- AECOM notes that the LORs were greater than the adopted SAC for 9 of the 26 samples collected and therefore the actual concentrations reported cannot be determined or assessed;
- No specific trends in the data were observed as concentrations appeared to fluctuate;
- Concentrations of chromium reported were all less than the adopted SAC for all surface and deep (10 m) samples and it is noted that the LORs vary considerably throughout the data set;
- Concentrations of manganese reported were all less than the adopted SAC for all surface and deep (10 m) samples;
- Concentrations of iron reported were all less than the adopted SAC for all surface and deep (10 m) samples and it is noted that the LORs vary considerably throughout the data set;
- Concentrations of nickel reported were all less than the adopted SAC for all surface and deep (10 m) samples, and it is noted that the LORs vary considerably throughout the data set;
- Concentrations of copper greater than the adopted SAC were reported for 4 of the 15 surface water samples collected between Dec 02 and Oct 08 with concentrations ranging between 1.0 -3.0 µg/l. It is noted that the LORs vary the data set;
- Concentrations of copper greater than the adopted SAC were reported in 2 of the 13, deeper water samples collected between Dec 02 and Oct 08 with reported concentrations of 2 µg/l;
- AECOM notes that the laboratory limits of detection were greater than the adopted SAC for 12 of the 26 samples collected and therefore the actual concentrations reported cannot be determined or assessed;
- AECOM notes that samples from 10 m below surface were not collected in Dec 02 or Jan 03. Laboratory limits of detection were greater than the adopted SAC for 5 of the 13 samples collected;
- In general copper concentrations remain fairly constant throughout the data set with no specific trends noted;
- A concentration of zinc greater than the adopted SAC was reported for 1 of the 15 surface water samples collected between Dec 02 and Oct 08 at a reported concentration of 16 µg/l;
- Concentrations of zinc reported for all the deeper samples were less than the adopted SAC;
- It is noted that the LORs vary throughout the data set and no specific trends in the data were observed:
- A concentration of cadmium greater than the adopted S**A**C was reported in 2 of the 15, surface water samples collected. Cadmium concentrations for the data set ranged between 0.5 and 10.7 µg/l;
- Concentrations of cadmium reported for all the deeper samples were less than the adopted SAC;
- No specific trends in the data were observed, however it is noted that the LORs vary throughout the data set;
- Concentrations of tin reported were all less than the adopted SAC for all surface and deep (10 m) samples;
- No specific trends in the data were observed, however it is noted that the LORs vary significantly throughout the data set. The summary tables provided no justification for the variability of LOR's which for certain surface water sampling events Jan 03 and Oct 04 are between <24 and <25 µg/l);
- A concentration of lead greater than the adopted SAC was reported in 1 of the 15 surface water samples collected at a concentration of 10.0 µg/l;
- A concentration of lead greater than the adopted SAC was reported in 1 of the 13, deeper water samples collected between Dec 02 and Oct 08 with reported concentrations of 9 µg/l;
- The majority of the remaining lead concentrations reported could not be assessed as the LORs vary significantly throughout the data set and were generally greater than the adopted SAC and therefore actual concentrations could not be determined or assessed. The summary tables provided no justification for the variability of LOR's which for certain surface water sampling events (Dec 02) were as high as <20 µg/l);
- Concentrations of arsenic reported for all samples collected were less than the adopted SAC;
- Concentrations of selenium reported for all samples collected were less than the adopted SAC. Some variability in LORS was noted; and
- It should be noted that for all instances above where variability of LORs was reported, no justification was provided in the report.

Sites 11 and 12 (Darcy Road Drain – Outer Harbour)

- Concentrations of aluminium greater than the adopted SAC were reported for 11 of the 15 surface water samples collected between Dec 02 and Oct 08 with concentrations ranging between 1 -14 µg/l. LORs greater than the adopted SAC were noted for 4 samples and therefore actual concentrations could not be determined or assessed;
- Concentrations of aluminium greater than the adopted SAC were reported for 5 of the 13, deep (10 m) water samples collected between Dec 02 and Oct 08 with concentrations ranging between 1 -9 µg/l. LORs greater than the adopted SAC were noted for 8 samples and therefore actual concentrations could not be determined or assessed;
- In general, the concentrations of aluminium reported for both surface and deep samples (10 m) generally increased between Apr 03 and Mar 08 where the concentrations peak before steadily decreasing in Oct 08;
- Concentrations of chromium reported were all less than the adopted SAC for all surfaces and deep (10 m) samples however it is noted that the LORs vary considerably throughout the data set;
- Concentrations of manganese reported were all less than the adopted SAC for all surface and deep (10 m) samples;
- Concentrations of iron reported were all less than the adopted SAC for all surface and deep (10 m) samples, and it is noted that the LORs vary considerably throughout the data set.
- Concentrations of nickel reported were all less than the adopted SAC and less than the LORs for all surface and deep (10 m) samples, AECOM notes that the LORs vary considerably throughout the data set:
- Concentrations of copper greater than the adopted SAC were reported for 3 of the 15 surface water samples collected between Dec 02 and Oct 08 with concentrations ranging between 1.5 -4.0 µg/l. AECOM notes that the laboratory limits of detection were greater than the adopted SAC for 9 of the 15 samples collected and therefore the actual concentrations reported cannot be determined or assessed;
- Concentrations of copper for 6 of the 13 deeper (10 m) water samples could not be assessed as that the laboratory limits of detection were greater than the adopted SAC therefore the actual concentrations reported cannot be determined. The remaining samples had reported concentration of copper less than the adopted assessment criteria;
- In general copper concentrations remain fairly constant throughout the data set with no specific trends noted;
- Concentrations of zinc reported for all surface water and deep (10 m) water samples had reported concentrations less than the adopted SAC. It is noted that the LORs vary throughout the data set;
- A concentration of cadmium greater than the adopted SAC was reported in 2 of the 15, surface water samples collected at reported concentrations of 5.6 and 7.0 µg/l;
- Concentrations of cadmium reported for all other samples were less than the adopted SAC however it is noted that the LORs vary throughout the data set;
- Concentrations of tin reported were all less than the adopted SAC for all surface water and deep (10 m) samples;
- No specific trends in the data were observed, however it is noted that the LORs vary significantly throughout the data set. The summary tables provided no justification for the variability of LOR's which for certain surface water sampling events Jan03 and Oct04 are between <24 and <25 µg/l);
- A concentration of lead greater than the adopted SAC was reported in 1 of the 13 deep (10 m) water samples collected at a concentration of 8.2 µg/l;
- The majority of remaining surface and deep (10m) samples could either not be assessed as the LORs were greater than the adopted assessment criteria and therefore actual concentrations could not be determined or had reported concentration less than the adopted assessment criteria The summary tables provide no justification for the variability of LOR's which for certain surface water sampling events (Dec02) were as high as <20 µg/l);
- Concentrations of arsenic reported for all samples collected were less than the adopted assessment criteria. It is noted that the LORs vary throughout the data set;
- Concentrations of selenium reported for all samples collected were less than the adopted assessment criteria. It is noted that the LORs vary throughout the data set; and
- It should be noted that for all instances above where variability of LORs was reported, no justification was provided in the report.

Site 13 (Entrance to the Outer Harbour)

AECOM notes that only surface water samples were collected from Site 13.

- Concentrations of aluminium greater than the adopted site assessment criteria were reported for 8 of the 15 surface water samples collected between Dec 02 and Oct 08 with concentrations ranging between 1 -11 µg/l;
- AECOM notes that the LORs were greater than the adopted assessment criteria for 3 of the 15 samples collected and therefore the actual concentrations reported cannot be determined or assessed;
- Concentrations of Aluminium were greatest during autumn and winter when rainfall is likely to have been highest;
- Concentrations of chromium reported were all less than the adopted assessment criteria for all surfaces samples and it is noted that the LORs vary considerably throughout the data set;
- Concentrations of manganese reported were all less than the adopted assessment criteria for all surface samples;
- Concentrations of iron reported were all less than the adopted assessment criteria for all surface samples. It is noted that the LORs vary considerably throughout the data set;
- Concentrations of nickel reported were all less than the adopted assessment criteria for all surface samples and it is noted that the LORs vary considerably throughout the data set;
- Concentrations of copper greater than the adopted site assessment criteria were reported for 2 of the 15 surface water samples collected between Dec 02 and Oct 08 with concentrations of 2.0 µg/l. It is noted that the LORs vary the data set;
- AECOM notes that the laboratory limits of detection were greater than the adopted assessment criteria for 7 of the 15 samples collected therefore the actual concentrations reported cannot be determined or assessed;
- In general copper concentrations remain fairly constant throughout the data set with the highest concentrations reported in autumn and winter when rainfall is likely to have been highest;
- Concentrations of zinc reported for all surface samples were less than the adopted assessment criteria;
- A concentration of cadmium greater than the adopted site assessment criteria was reported in 1 of the 15, surface water samples collected at a concentration of 6 µg/l; It is noted that AECOM also collected a harbour water sample at this location during high and low tide. The concentration of cadmium reported for sample HS-H-03 collected at high tide was 65, 400 µg/l and is not consistent with the PKEG / Blue Scope steel data set and may be erroneous;
- Concentrations of tin reported were all less than the adopted assessment criteria for all surface and deep (10 m) samples;
- No specific trends in the data were observed, however it is noted that the LORs vary significantly throughout the data set. The summary tables provided no justification for the variability of LOR's which for the Oct04 sampling event where the LOR is stated as <24 µg/l);
- A concentration of lead greater than the adopted site assessment criterion was reported in 1 of the 15 surface water samples collected at a concentration of 18.0 µg/l;
- The majority of the remaining lead concentrations reported could had reported concentration less than the adopted assessment criteria or could not be assessed not as they were greater than the adopted assessment criteria. As a direct result actual concentrations could not be determined or assessed. The summary tables provided no justification for the variability of LOR's which for certain surface water sampling events (Dec02) were as high as <20 µg/l);
- Concentrations of arsenic reported for all samples collected were less than the adopted assessment criteria; and
- Concentrations of selenium reported for all samples collected were less than the adopted assessment criteria. Some variability in LORS was noted. The summary tables provide no justification for the variability.
- AECOM considers the data set to be unreliable for the follow reasons:
  - LORs were consistently variable and in many instances reported as greater than the adopted assessment criteria;
  - No details of sampling methodology, analytical quality or field quality were provided or assessed as part of the monitoring program;
  - Data was generally inconsistent and no significant trends were observed; and

- No details of QA/QC procedures were provided in the report and therefore it is unknown as to whether the data is reliable.

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4.0 Data Quality Objectives

AECOM adopted the USEPA published validation guidelines (USEPA SW-846) for setting the project data quality objectives (DQOs) and guidance for the review of analytical data produced from the laboratories. These guidelines along with the resultant DQOs have been used to evaluate the data for this report.

The DQO process is a systematic, seven-step process that defines the criteria that an investigation should satisfy. DQOs for this investigation have been developed based on the USEPA seven step DQO process (*Guidance for the Data Quality Objectives Process – EPA QA/G-4*, USEPA [August 2000]). These guidelines incorporate field quality control and laboratory analysis, methods and information on laboratory quality control data. They will be used to validate the field and analytical data for this investigation.

4.1 Step 1 - State the Problem

Previous investigations have determined that the historical activities within the Port have resulted in contamination of the bed sediments within the Outer (and Inner) Harbour. The bed sediments have been found to be impacted with metals, metalloids, organo-tins and PAHs at concentrations above the ANZECC/ARMCANZ (2000) ISQGs. Although there are currently no criteria for TPH, these were also reported in the sediments at significant concentrations.

4.2 Step 2 - Identify the Decisions

The aim of the SI is to collect sediment data to characterise the sediment quality within the proposed dredging footprint so that the requirement for management options during subsequent dredging and reclamation works can be assessed and implemented as appropriate.

The primary decisions requiring determination include:

- Is there sufficient data on the distribution and characteristics of the sediment contamination and to allow assessment of the potential environmental risks associated with dredging of, and reclamation with, potentially impacted sediments?
- Do the findings of the SI provide an understanding on the CoPC concentrations within the proposed development area?
- Is there sufficient data to enable management and/or remedial strategies to be developed, if required?

4.3 Step 3 - Identify Inputs to the Decision

The inputs required to make the above decisions are as follows:

- Historical data;
- Site condition data (sediment, water depth, etc.);
- Laboratory analysis of sediment samples;
- Comparison of the results with relevant assessment criteria;
- Assessment of the type and location of contamination; and
- Use of the DQO Process.

4.4 Step 4 - Define the Study Boundary

The boundaries of the SI have been identified as follows:

- Spatial boundaries – the SI boundary is limited to the dredging footprint, and adjacent historic emplacement area, associated with the proposed PKOH development area as defined in **Figure F5** and described following:
    - The SI area covers approximately 240,000 m^2;
    - Vertical extent will be limited to 2.0 m depth of sediment profile in the container berth dredging box and the majority of the multi-purpose berth box except where this intersects the existing underwater

emplacement area which contains previously dredged sediments from the Inner Harbour. This sampling approach was adopted to assess the worst case scenario. That is, due to the history of sediment deposition and the historical activities in the Outer Harbour, the more contaminated sediments would be expected to be present in the upper portion of the sediment profile;

  - Within the existing underwater emplacement area, the vertical extent will extend to approximately 7.0 m below existing bed level; and
  - The investigation will also target the Darcy Road Drain stormwater outlet area and the Salty Creek discharge point in the central section of the Site.

- Temporal Boundaries – the intention of the SI is to inform the EA required as part of the concurrent Concept Plan and Major Project approval for the proposed development area. The application (08_0249) expires on 27 January 2011 and the EA (which must address the associated DGRs and DECCW requirements) must be approved prior to this date; and
- Matrices - sediments and harbour water.

4.5 Step 5 - Develop a Decision Rule

Adopted decision rules for this investigation are as follows:

- The harbour water and elutriate analytical data generated will be compared to the ANZECC & ARMCANZ (2000) 95% trigger Levels for Marine Waters;
- The sediment analytical data generated will be compared to ANZECC/ARMCANZ (2000) ISQGs and Limits of Reporting (LORs) in the absence of guideline values;
- Comparison of the sediment analytical data to the SIL_4 (NEPC, 1999) criteria to assess suitability of use in land reclamation works; and
- Field and laboratory data quality indicators (DQIs) meeting acceptable limits for precision, accuracy, representativeness, comparability and completeness demonstrating that the data can be relied on.

4.6 Step 6 – Specify Limits of Decision Error

A decision error in the context of the decision rules presented above would lead to either underestimation or overestimation of the contamination present within the sediment (and harbour water) at the Site. Decision errors may include:

- Limitations in the site history information available;
- Errors in the sampling plan; and/or
- Data not representative of site conditions.

The potential for significant decision errors will be minimised by completing a robust QA/QC program and by completing an investigation that has an appropriate sampling and analytical density for the purposes of the investigation.

The acceptable limits on decision errors to be applied during the SI and the manner of addressing possible decision errors have been developed based on the Data Quality Indicators (DQIs) of precision, sensitivity (ensuring LOR's are low enough to meet the assessment criteria and therefore decision purposes), accuracy, representativeness, comparability and completeness. The DQIs adopted for the SI are presented in **Appendix A**.

4.7 Step 7 – Optimise the Design for Obtaining Data

This was achieved by the development of the SAQP (AECOM, 2009) to enable the collection of data required from appropriate locations, in appropriate quantities and of acceptable quality to allow the objectives of the study to be addressed.

The sampling design was optimised by:

- Undertaking a review of past and present investigations undertaken at the Site;
- Targeting the area of the proposed development area, which will be subject to dredging during future construction;

- Targeting potential contaminants of concern identified based on past soil, groundwater and sediment investigations;
- Use of available information, site observations and understanding sediment conditions and depth to sediment;
- The use of rigorous QA/QC procedures in field and laboratory; and
- Conduct an investigation that is consistent with DEC (2006).

The SAQP was presented and accepted by DEECW in August 2009.

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5.0 Screening Levels

The following sections describe the DECCW endorsed guidelines adopted by the SI assessment. It should be noted that the guidelines were adopted as screening tools for the purpose of characterising the presence and lateral and vertical extent of contamination only. As anticipated by guidelines, it is expected that management actions for the proposed PKOH development will ultimately be informed by risk assessment in the event that significant impact is identified by the SI.

5.1 Sediment Investigation Screening Levels

The ANZECC/ARMCANZ (2000) *Interim Sediment Quality Guidelines* (ISQGs) Low and High Trigger Values were adopted for screening of the sediment investigation results. The low (or 'trigger' value) concentrations are threshold concentrations below which the frequency of adverse biological effects is expected to be low. Conversely, the high concentrations are threshold concentrations above which the frequency of adverse biological effects is expected to be high. It should be noted that the ISQGs for sediments are interim, and aim at protecting sediment ecological health and remobilisation of contaminants into the water column and/or food chains.

The ISGQs were developed to serve three principal purposes:

- to identify sediments where contaminant concentrations are likely to result in adverse effects on sediment ecological health;
- to facilitate decisions about the potential remobilisation of contaminants into the water column and/or into aquatic food chains; and
- to identify and enable protection of uncontaminated sediments.

In summary, the ISQGs are trigger values that, if exceeded, prompt further action. The first-level screening recommended by the guidelines is to compare the ISQG trigger value (either low or high) with the measured value for the total contaminant concentration in the sediment. If the trigger value is exceeded, the guideline requires:

- further investigation to consider the fraction of the contaminant that is bioavailable or can be transformed and mobilised in a bioavailable form; or
- management/remedial action.

In the absence of an ISQG for cyanide, AECOM has adopted a screening level of 25 mg/kg. This screening level is derived from chronic marine equilibrium portioning threshold at 1% TOC (Bolton et al 1985 and cited in Macdonald et al 1999).

In the absence of the guideline values for other CoPC, laboratory LORs will be used as an initial screening level to assess the contaminant concentrations.

The adopted sediment screening levels are summarised in **Table 7** below.

Table 7: Adopted Sediment Screening Levels

Analyte	Units	ISQG-Low	ISQG-High
Major Ions			
Total Organic Carbon (TOC)	%	nc	nc
Free Cyanide	mg/kg	nc	nc
Total Cyanide	mg/kg	nc	nc
Total Cyanide – normalised to 1% TOC	mg/kg	25*	
Metals			
Antimony	mg/kg	2	25
Cadmium	mg/kg	1.5	10
Chromium	mg/kg	80	370
Copper	mg/kg	65	270
Lead	mg/kg	50	220

Analyte	Units	ISQG-Low	ISQG-High
Mercury	mg/kg	0.15	1
Nickel	mg/kg	21	52
Silver	mg/kg	1	3.7
Zinc	mg/kg	200	410
Metalloids			
Arsenic	mg/kg	20	70
Organ metallic's			
Tributyltin	µg/kg	5	70
Organics - normalised to 1% TOC			
Acenaphthene	mg/kg	0.016	0.5
Acenaphthylene	mg/kg	0.044	0.64
Anthracene	mg/kg	0.085	1.1
Benz(a)anthracene	mg/kg	0.261	1.6
Benzo(a)pyrene	mg/kg	0.43	1.6
Benzo(b)fluoranthene	mg/kg	nc	nc
Benzo(g.h.i)perylene	mg/kg	nc	nc
Benzo(k)fluoranthene	mg/kg	nc	nc
Chrysene	mg/kg	0.384	2.8
Dibenz(a.h)anthracene	mg/kg	0.063	0.26
Fluoranthene	mg/kg	0.6	5.1
Fluorene	mg/kg	0.019	0.54
Indeno(1.2.3-cd)pyrene	mg/kg	nc	nc
Naphthalene	mg/kg	0.16	2.1
Phenanthrene	mg/kg	0.24	1.5
Pyrene	mg/kg	0.665	2.6
Total PAHs	mg/kg	4	45
Low Molecular Weight PAHs	µg/kg	552	3160
High Molecular Weight PAHs	µg/kg	1700	9600
Total DDT	µg/kg	1.6	46
p.p'-DDE	mg/kg	2.2	27
o, p' - + p,p'- DDD	mg/kg	2	20
Chlordane	mg/kg	0.5	6
Dieldrin	mg/kg	0.02	8
Endrin	mg/kg	0.02	8
Lindane	mg/kg	0.32	1
Total PCB's	µg/kg	23	-
TPH			
C6-C9 Fraction	mg/kg	nc	nc
C10-C14 Fraction	mg/kg	nc	nc
C15-C28 Fraction	mg/kg	nc	nc
C29-C36 Fraction	mg/kg	nc	nc
BTEX			
Benzene	mg/kg	nc	nc
Ethyl Benzene	mg/kg	nc	nc

Analyte	Units	ISQG-Low	ISQG-High
meta- & para-Xylene	mg/kg	nc	nc
ortho-Xylene	mg/kg	nc	nc
Toluene	mg/kg	nc	nc

Notes:
* Bolton et al 1985 and cited in Macdonald et al 1999
nc no ISQG values are available, LORs will be used as screening levels

The distribution of sediment contamination was to be illustrated on maps in accordance with the Sediment Quality Guidelines (CSIRO Handbook, 2000).

5.2 Harbour Water

The ANZECC/ARMCANZ (2000) *Guidelines for Fresh and Marine Water Quality* provide 'trigger' levels 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. ANZECC/ARMCANZ (2000) indicates that an exceedance of a trigger level does not necessarily imply that there is an inherent risk, rather that further assessment and monitoring may be required prior to implementing appropriate management actions. In cases where low reliability Trigger Levels are described by ANZECC/ARMCANZ (2000), it is noted that their application is limited as the "*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 that "*low reliability values should not be used as default guidelines*".

ANZECC/ARMCANZ (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.

The Harbour water quality results have been compared to the ANZECC/ARMCANZ (2000) trigger levels for Marine Waters. Trigger levels with a 95% level of species protection have generally been adopted in recognition that the PKOH is a highly modified environment.

The adopted sediment screening levels are summarised in **Table 9** below.

5.3 Elutriate screening levels

According to the National Assessment Guidelines for Dredging (NADG), 2009 "*Elutriate testing is required where the dredged material data exceeds the Screening Level for any substance. The elutriate test is designed to simulate release of contaminants from a sediment during dredged material disposal. Release can occur by physical processes (e.g. directly from sediment pore water) or a variety of chemical changes, such as oxidation of metal sulfides and release of contaminants adsorbed to particles or organic matter. Testing is carried out using the USEPA's standard seawater elutriate test (USEPA 1991; Simpson et al., 2005).*

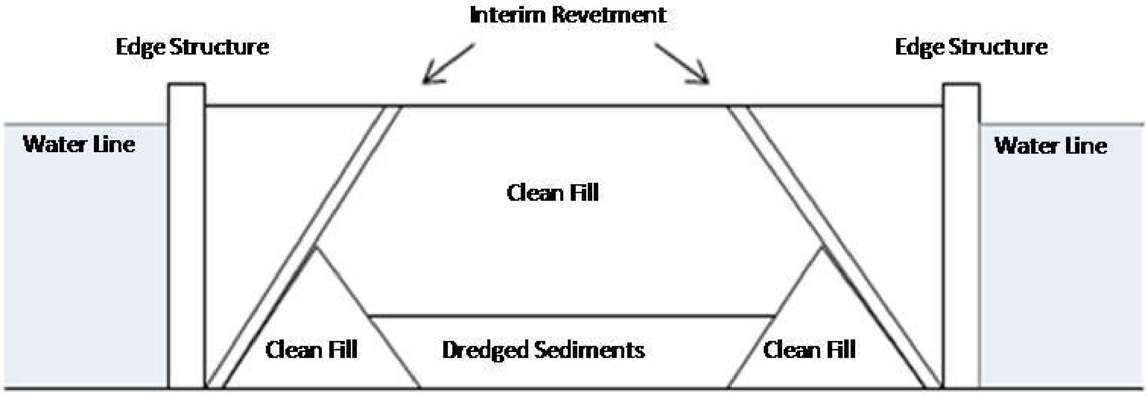
When assessing the results of the elutriate testing, the relevant guideline value should not be exceeded after allowing for initial dilution, defined as *"that mixing which occurs within four hours of dumping'. Initial dilution will depend on a number of factors, such as depth, layering in the water column, and current velocities and directions.*

If all contaminants are below the relevant guideline values after initial dilution (ie. after four hours), effects on organisms in the water column would not be expected during disposal. If any contaminants are present at levels above their relevant guideline values, loading and disposal could cause adverse effects on water quality, and loading and disposal controls are evaluated to determine if impacts can be mitigated." (NADG, 2009).

In considering the elutriate analysis results, consideration should be given to the following with respect to the reclamation works proposed as part of the PKOH development:

- Sediments deposited at the Site as part of the proposed reclamation will be contained in an engineered containment structure which will be constructed of higher quality and less contaminated material;
- The sediment will effectively be encapsulated and confined within the engineered structure;
- Dredged sediments will be placed at depth, likely below the depth of wave action at the base of the reclamation fill to maximise the opportunity for future consolidation and reduce the potential for further disturbance. The likely construction of this containment structure is outlined below in **Table 8**:

Table 8: Conceptual Design of Engineered Containment Structure



- It is unlikely that the quality of dredged sediments placed as part of the reclamation works would be required to meet the criteria for open water disposal as the PKOH is a semi enclosed (breakwaters) and highly disturbed environment.

The ANZECC/ARMCANZ (2000) 95% protection level trigger Levels for marine waters have been adopted for assessment of the elutriate results (presented in **Table 9** below).

Table 9: Elutriate and Harbour Water Screening Levels

Analyte	Units	ANZECC 95% level of species protection for marine water
Metals		
Antimony	µg/L	270 (LR IIWL)
Cadmium	µg/L	5.5
Chromium (VI)	µg/L	4.4
Copper	µg/L	1.3
Cobalt	µg/L	1
Lead	µg/L	4.4
Mercury	µg/L	0.4
Nickel	µg/L	70
Silver	µg/L	1.4
Selenium	µg/L	3 (LR)
Vanadium	µg/L	100
Zinc	µg/L	15
Metalloids		
Arsenic (V)	µg/L	4.5 (LR)
Polycyclic Aromatic Hydrocarbons		
Anthracene	µg/L	0.4 (MR)
Benzo(a)pyrene	µg/L	0.2 (LR)
Fluoranthene	µg/L	1.4 (LR)
Naphthalene	µg/L	70 (MR)
Phenanthrene	µg/L	2 (LR)

Notes:

LR	Low reliability Trigger level
MR	Moderate reliability Trigger Level
IIWL	indicative interim working level

5.4 Soil Assessment (dredged material used in reclamation)

Is proposed that sediment removed as part of the dredging program will be used to reclaim land for the proposed redevelopment. In light of this, the sediment sample results were also screened against the following DECCW endorsed soil investigation criteria with a view to informing decision making regarding their suitability for the proposed future land use. As noted above, the proposed future land use for the reclaimed areas will be industrial in the form of a container terminal and multi purpose terminal.

- NSW EPA, 1994. Guidelines for Assessing Service Station Sites;
- NSW DEC, 2006. Guidelines for the NSW Site Auditor Scheme (2^{nd} Edition); and
- NEPC, 1999. NEPM National Environment Protection (Assessment of Site Contamination) Measure.

Application of these guidelines for screening of the sediment samples results is described below.

5.4.1 Metals, Cyanide, PAHs, OCPs Phenols and PCBs

The assessment criteria adopted for metals, PAHs, OCPs, OPPs, phenol, and PCBs in soil are based on the NSW DEC (2006) guidelines which are, in turn, 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.

- $SIL_{(Column\ 1)}$ Residential with gardens and accessible soil (home-grown produce contributing less than 10% fruit and vegetable intake; no poultry), including children's day care centres, preschools and primary schools, or town houses or villas.
- $SIL_{(Column\ 2)}$ Residential with minimal access to soil including high-rise apartments and flats.
- $SIL_{(Column\ 3)}$ Parks, recreational open space, playing fields including secondary schools.
- $SIL_{(Column\ 4)}$ Commercial or industrial land use.

The proposed future land use of the reclaimed areas will be industrial in the form of a container terminal and multi purpose terminal. Therefore, the SIL_4 criteria has been adopted as the screening levels.

It is noted that the PILs are based on sandy loams with a pH 6 to 8. The sediments are generally characterised as silty clays with some sands. The application of the PILs has significant limitations as phytotoxicity depends on soil and species parameters in ways that are not fully understood. As such, the PILs are intended for use as a screening guide only.

5.4.2 TPH and BTEX

The assessment criteria adopted for TPH and BTEX in soil are based on the NSW EPA (1994) *Guidelines for Assessing Service Station Sites*. These guidelines provide investigation criteria to evaluate soil analytical results for TPH and BTEX compounds and have been developed for sensitive land use scenarios and are the only NSW DECCW endorsed criteria.

5.4.3 Acid Sulphate Soils

Current assessment guidelines for the assessment and management of PASS are provided in the Acid Sulphate Management Advisory Committee (ASSMAC) *Acid Sulphate Soil Manual* (August 1998). These guidelines have been developed primarily for proponents of activities that are likely to disturb acid sulphate soils. The guidelines provide action criteria that trigger the need for the preparation of a management plan for the acid sulphate soils and are based on the percentage of oxidisable sulfur for broad categories of different soil types.

Based on the results of previous investigations (refer to **Section 3.2**) and review of the acid sulphate maps for the Wollongong area (refer to **Section 2.5**), the action criteria for fine texture medium to heavy clays and silty clays stated in ASSMAC (1998) were applied to the assessment for acid sulphate soils across the Site.

AECOM notes that PASS identified by the SI within the proposed dredge footprints will be managed during the construction phase in accordance with an ASSMP. It is expected that management measures will include handling and transportation of PASS below water, for example by piping dredged sediment to the reclamation area or transporting materials in hopper barges filled with water, which would limit exposure to air, preventing oxidisation.

5.5 Background Concentrations

Available background sediment data is discussed in **Section 3.4** and is summarised in **Table 4**. The results indicate that antimony, cadmium, selenium, silver, TBT and vanadium were reported at concentrations below the laboratory LOR in the sample collected from the Outer Harbour (sample location 'Site 3.2' located to the south east of Jetty No. 6). Copper, lead, mercury, molybdenum and Total PAHs concentrations in this sample were reported to exceed the ISQG-Low. However, no CoPC concentrations exceeded the ISQG-High (refer to **Table 4**). A zinc concentration of 81 mg/kg (less than the ISQG-Low) and an iron concentration of 9,100 mg/kg (no ISQG currently available) were also reported in this sample. TPH, BTEX, OCPs, PCBs, Total phenolics and cyanide were all reported at concentrations below the laboratory LOR.

The results indicate that CoPC concentrations reported in the sample collected from the PKOH were generally significantly less than CoPC concentrations reported for samples collected within the Inner Harbour (refer to **Table 4**).

Harbour water sample results obtained from Sydney Water sampling events were available for review as part of this SI. However, these monitoring events did not include analysis for the CoPC and so are not discussed further in this report.

6.0 Field Investigation

The SI program was developed around the DGRs, as described by **Section 1.4**, and in consideration of limitations on the type, quantity and quality of data needed to satisfy the project objectives.

The SI was conducted in accordance with the Sampling, Analytical and Quality Plan (SAQP) prepared by AECOM (2009) and supplied to DECCW in August 2009.

6.1 Health and Safety

Prior to the commencement of the sampling works, a site specific health and safety plan was developed. This plan was prepared to protect the health and safety of the AECOM field staff and AECOM subcontractors involved in the collection of samples.

6.2 Rationale

To meet the requirements of DGRs, the SI focussed on assessment of sediment quality within the Major Project (Stage 1) footprint (refer to **Figure F2**):

- The proposed multi-purpose berth dredge box;
- The proposed container berth dredge box; and
- The existing underwater emplacement area.

Intrusive investigations were undertaken at a total of 110 locations distributed across these footprints. The rationale for the adopted investigation layout is described in the following sections.

6.2.1 Proposed container berth dredge box

A total of 33 piston core locations (PC1-PC33) were sampled at 50m intervals on a systematic grid basis across the proposed container berth dredge box. In addition 8 sediment grab samples (SG1-SG8), located on a stratified random sampling basis, and were also collected from across the proposed container berth dredge box. Sediment samples were collected at the surface of the sea bed (0.0 – 0.02 m), 0.02 – 0.5 m, 0.5, 1.0 and 2.0 m below the existing bed level. This sampling approach, which was focused on sampling the top 2.0 m of the sediment profile, was adopted to assess the worst case scenario. That is, due to the history of sediment deposition and the historical activities in the Outer Harbour, the more contaminated sediments would be expected to be present in this upper portion.

6.2.2 Proposed multi-purpose berth dredge box

A total of 33 piston core locations (PC34-PC66) were sampled at 50 m intervals on a systematic grid basis across the proposed multi-purpose berth dredge box. In addition 13 sediment grab samples (SG11-SG23), located on a stratified random sampling basis, and were also collected from across the proposed container berth dredge box. Sediment samples were also collected at the surface of the sea bed (0.0 – 0.02 m), 0.02 – 0.5 m, 0.5, 1.0 and 2.0 m below the existing bed level.

The Darcy Road Drain is a concrete lined storm water drain, located adjacent to lots currently occupied by Orica Chemnet, Brick and Block and Sydney Water. It receives surface water run off from the wider industrial catchment and may be a potential pathway for contamination to migrate into the Site. Six sediment grab samples were collected targeting the near shore sediments in the vicinity of the Darcy Road Drain outfall.

Salty Creek is located to the west of the central dredge footprint (refer to **Figure F2**) and extends from an area adjacent to the Port Kembla railway station and flows via culvert under Old Port Road and discharges at the Site. It may also be a potential pathway for contaminants to migrate from the wider industrial catchment to the Outer Harbour. Seven sediment grab samples were collected targeting the near shore sediments in the vicinity of the Salty Creek discharge point.

6.2.3 Existing Emplacement Area

The ‘emplacement area’ overlaps the western edge of the multi-purpose berth dredge box and the majority of it will eventually form part of the reclamation area for the multi-purpose terminal. The footprint of the emplacement area is approximately 8 ha. The emplaced material comprises contaminated sediment generated from dredging campaigns undertaken in the Inner Harbour approximately 5 - 10 years ago.

PAH contaminated sediment in the lower layers of the emplacement area is currently capped with less impacted sediments. It is expected that the underwater emplacement area will be disturbed by both the development works associated with the dredge footprint for the multi-purpose dredge box and reclamation for the multi-purpose terminal.

A total of 11 vibrocore locations were sampled within the existing underwater emplacement area. In addition, 2 vibrocore locations on the eastern boundary of the existing underwater emplacement area with the multi-purpose dredge box were also sampled.

6.2.4 Harbour Water Sampling

In addition to the sediment sampling program, and as required by the DGRs, harbour water samples were also collected at the following locations. The selected locations are consistent with Sydney Water's historic monitoring regime within the PKOH:

- A paired location (high and low tide) in the centre of the PKOH - HSL01 and HSH01;
- A paired location (high and low tide) at the entrance to Port Kembla Harbour - HSL02 and HSH02; and
- A paired location (high and low tide) in the centre of the Inner Harbour - HSL03 and HSH03.

6.3 Summary of Field Activities

The sequence of field activities undertaken is summarised in the following table. Sampling was undertaken by suitably qualified and trained AECOM environmental scientists and subcontractor Geochemical Assessments Pty Ltd (Geochemical Assessments) who specialise in the collection of sediment samples.

Table 10: Summary of Field Activities

Date	Activity	Sample Locations
6 July 2009	Collection of surface grabs (SG) and piston core (PC) samples from the eastern dredge footprint.	SG1-SG8 and PC22 and PC33
7 July 2009	Collection of piston core samples from the eastern dredge footprint.	PC1-PC7, PC21, PC31, PC32, PC18, PC30, PC16 and PC17
8 July 2009	Collection of piston core samples from the eastern dredge footprint and dredge box.	PC8, PC9, PC10, PC11, PC14, PC15, PC19 PC20, PC29, PC26, PC27, PC28, PC34 and PC35.
9 July 2009	Collection of piston core samples from the eastern dredge footprint and dredge box, and central dredge footprint.	PC13, PC36, PC37, PC38, PC39, PC23, PC24, PC25, PC40, PC41, PC42, PC43, PC44, PC55, PC45,
10 July 2009	Collection of piston core samples from the central dredge footprint.	PC46, PC47, PC48, PC49, PC50, PC51, PC52, PC53, PC54, PC56, PC57, PC58, PC59, PC60, PC61, PC62, PC63, PC64, PC65 and PC66
13 July 2009	Collection of surface grabs from the eastern dredge box and central dredge box.	SG9 – SG30
13 July 2009	Collection of Outer Harbour water samples.	HS-L-01, HS-H-01, HS-L-02, HS-H-02, HS-L-03 and HS-H-03.
14 July 2009	Collection of vibrocore samples from the central dredge footprint.	VC1 – VC5
15 July 2009	Collection of vibrocore samples from the central dredge footprint and the dredge box.	VC6, VC8, VC9, VC10, VC11 and VC12
16 July 2009	Collection of vibrocore samples from the central dredge footprint.	VC4 and VC7

Sample locations are presented on **Figure F5**.

6.4 Sediment Sampling Methodology

The sediment sampling program was undertaken between 6 July and 16 July 2009 by Geochemical Assessments under the supervision of suitably qualified and experienced AECOM Environmental Scientists and in accordance with the SAQP (AECOM, 2009).

Sediment samples were collected by a combination of piston corer, vibrocore and by a modified Smith-McIntyre grab. The sampling methods selected for the SI were designed to enable samples of the oxidic layer to be collected separately from anoxic sediments. This approach was designed to enable assessment of the potential bioavailability of contaminants as required by DECCW.

The sediment sampling methodology undertaken at the Site is summarised in **Table 11** below.

Table 11: Sediment Sampling Methodology

Activity	Details
Sediment Sampling - General	All sample locations were checked for services prior to the commencement of the sampling works by contacting the Dial-Before-You-Dig service, to ensure that the sample locations were free from submerged utilities. Enquiries were also made with PKPC regarding submerged utilities at the Site. All sampling points were located using a differential GPS system. A small boat with shallow draft was utilised to navigate to each sampling location in order to mitigate disturbance of the bed sediments.
Sediment Sampling – Surface Grabs	At each location designated for a Smyth McIntyre grab sample, samples retrieved comprised sediments within the upper 5 cm of the bed profile. The device was deployed from a small boat fitted with a davit to lower the grab to the desired depth (refer to **Photograph 5** and **6** in the **Plates** section). The jaws of the grab were kept open by a fastened hook until triggered using a weight trigger. Once triggered the jaws shut tight grabbing the sediment sample before the grab was hoisted to the surface. The jaws were left closed and the sediment sample retrieved from an opening at the top of the grab. The Smith McIntyre grab is particularly suitable for collecting undisturbed samples of the oxidic layer, and allows detailed inspection of the sediment samples retrieved for evidence of bioturbation, inclusions and bed surface characteristics. Sediment samples retrieved from the grab were homogenised and sub sampled and photographed. Sub samples were placed in laboratory supplied sampling containers with Teflon lids using stainless steel spatula and nitrile gloves. Jars were filled to minimise head space.
Sediment Sampling – Piston Cores	Sub-surface sediment samples from the anoxic layer were collected using piston coring as described below. Piston core samples were collected as follows: • Surface sediment (oxidic layer) (0.0 – 0.02 m); • Sub-surface sediment (anoxic layer) (0.02 – 0.5 m); and • Sub-surface sediment samples (anoxic layer) at 0.5 m 1.0 and 2.0 m below the existing bed level. Sediment cores collected using piston core techniques were collected using a manually-driven and weighted piston coring device with 80 mm ID polycarbonate barrels (refer to **Photograph 1** to **4** in the **Plates** section). This technique allowed the collection of undisturbed cores to +2.0 m length in soft unconsolidated sediment. The piston core was lowered from the side of the boat until the surface of the sea bed was reached. A weight located on top of the tube secured by a trip arm is released upon contact with the sea bed which causes the weight to fall driving the core barrel into the sediment. The vacuum suction created by the stopped piston and moving tube allows the sediment sample to enter the tube comparatively undisturbed. As soon as the sample is inside the core tube, the entire assembly is winched back to surface on board the boat for sub sampling. Sediment samples retrieved from the grab were homogenised and sub sampled and photographed. Sub samples were placed in laboratory supplied sampling containers with Teflon lids using stainless steel spatula and nitrile gloves. Jars were filled to minimise head

Activity	Details
	space.
Sediment Sampling - Vibrocoring	Sub-surface sediment samples from the anoxic layer within the emplacement area were collected using vibrocoring as described below. Vibrocore samples were collected as follows: • Surface sediment (0.0 – 0.5 m); and • Sub-surface sediment (Vibrocore samples will be taken at 0.5, 1.0 m 2.0 m 3.0 m, 4.0 m, 5.0 m, 6.0 m and 7.0 m below the existing sea bed level. Vibrocore samples were collected using a barge equipped with an onboard custom built marine crane to suspend the vibrocore head, assembly and barrels over the desired sampling location (refer to **Photographs 7** to **9** in the **Plates** section). Steel barrels were used to collect the samples as previous investigations encountered very stiff, consolidated clays, in the surficial layers the existing underwater emplacement area. Once positioned the crane was used to support the vibrocore head and sampling barrels while being lowered to the sea bed. A floating collar attachment was used on the vibrocore head to ensure that vertical penetration of the bed profile could be achieved. Once the core barrel was positioned vertically on the surface of the sea bed, the vibrocoring was commenced. The vibrocore works by emitting high amplitude low frequency waves that are transferred down the steel core barrel. The vibrations liquefy a 1-2 mm layer of sediments in contact with both the inside and the outside of the core barrel wall, which acts as a lubricant. The collected core samples remain relatively undisturbed as a result of the above. Once retrieved from the bed the barrels were winched back to surface on board the barge and taped at each end. Full core barrels were then transported to shore where they were opened, inspected, logged, photographed and sub sampled into laboratory supplied sampling containers with Teflon lids using a stainless steel spatula and nitrile gloves. Jars were filled to minimise head space.
Sediment logging	Sediment logging was conducted in general accordance with the Unified Soil Classification System (USCS) and the AECOM documented standard field procedures. Samples were logged and the following information was recorded in the field: soil/rock type, colour, grain size, sorting, angularity, inclusions, moisture conditions, staining and odour. The sediment core logs are provided in **Appendix B**. Photographs of the cores (with scale) were taken at each location and are presented in the **Plates** section of this report.
Field Screening	Sub-samples were placed in snap-locked plastic bags, and the headspace screened in the field for VOCs using a calibrated Photoionisation Detector (PID) with a 10.6 eV lamp. Calibration details are provided in **Appendix C**.
Decontamination	Decontamination of all sampling equipment (Piston Core and Smyth Mcintyre Grab samplers) was undertaken using a phosphate free detergent (Decon Solution) followed by a double rinse with deionised water. Dedicated vibrocore barrels were at each vibrocore location, eliminating the potential for cross contamination between sample locations.
Surplus Sediment	Surplus bed sediment was transferred to sealable drums for off site disposal.
QC samples	QC samples comprised collection of intra-laboratory and inter-laboratory duplicates collected at an approximate rate of 1 in 10 and 1 in 20 respectively. Rinsate Blanks were also generally collected at a rate of one sample per day. Data Quality Objectives and Indicators are presented in **Appendix A.** Tabulated QC results for the sediment samples are presented in **Table T8.**

6.5 Harbour Water Sampling Methodology

The harbour water sampling program was undertaken on 13 July 2009 by suitability qualified and experienced AECOM Environmental Scientist and in accordance with the SAQP (AECOM, 2009).

The harbour water sampling methodology undertaken at the Site is summarised in **Table 12** below.

Table 12: Harbour Water Sampling Methodology

Activity	Details
Collection of harbour water samples	All sampling points were located using a differential GPS system. A small boat with shallow draft was utilised to navigate to each sampling location in order to mitigate disturbance of the bed sediments. At each location the boat was anchored and steadied. Harbour water samples were collected on the same day at both low and high tides from three locations as described in **Section 6.2.4**Error! Reference source not found.. Harbour water samples were collected directly into laboratory supplied and appropriately preserved sampling bottles by fully submerging the sample containers in seawater and allowing them to fill completely in order to minimise headspace. Samples requiring field filtration were filtered through dedicated 0.45 µm disposable Stericup® filters.
QC samples	QC samples comprised collection of intra-laboratory and inter-laboratory duplicates were both collected at a rate of 1 in 6. Rinsate blanks were also collected at a rate of one sample per day. Data Quality Objectives and Indicators are presented in **Appendix A.** Tabulated QC results for the Habour waters samples are presented in **Table T9.**

6.6 Analytical Plan

Primary samples were submitted to the ALS (Sydney) Laboratory Group located in Smithfield, NSW. Inter-laboratory duplicate samples were submitted to the ALS (Brisbane) Laboratory group located in Stafford, QLD. The selected laboratories are both National Association of Testing Authorities (NATA) certified for the analysis required. Samples were scheduled for analysis of the identified CoPC based on visual and olfactory field observations and PID field screening and in accordance with the analytical program presented in the SAQP (AECOM, 2009). The soil sample analysis program is summarised in **Table 13.**

The CoPC analysed as part of the SI are generally consistent with the suite of analytes selected by Patterson Britton (2005) for previous assessments of sediments in the Inner and Outer Harbours and were selected based on a review of previous soil, sediment and groundwater investigations. The CoPC selected for the harbour water assessment are consistent with Sydney Water's historic monitoring regime and were also selected in consideration of previous investigation reports.

Table 13: Summary of Analytical Plan

Sample Matrix . Collection Method	No. of Sampling Locations	No. of Primary Samples to be Analysed	Analytical Program
Anoxic Sediment / Piston Core	33 locations within the proposed container berth dredge box to a maximum depth of 2.0 m below existing bed level.	99 primary samples based on three sub samples per location. QA/QC samples: 10 intra laboratory duplicates; 5 inter laboratory duplicates; 1 rinsate blank	**99 primary sediment samples** for: • Metals (M13) (Antimony, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Silver, Zinc, Cobalt, Vanadium, Selenium, and Arsenic) **64 samples for:** • TOC **49 samples for**:

Sample Matrix . Collection Method	No. of Sampling Locations	No. of Primary Samples to be Analysed	Analytical Program
			• 16 priority PAHs **50 samples for:** • TPH/BTEX **32 samples for:** • SPOCAS (Suspension Peroxide Oxidation Combined Acidity and Sulfate) Suite. • Grain Size • Elutriate Metals (M13) and PAH **9 samples for:** • Cyanide **33 samples for:** • TBT **15 samples for :** • Phenolic compounds • OCPs • PCBs
Anoxic Sediment / Vibrocores	10 locations targeting the existing underwater emplacement area containing previously dredged sediments from the Inner harbour and known to contain Metals and PAH impacted sediments (Patterson Britton 2005). 2 locations targeting the boundary between the emplacement area and the multi-purpose Berth	96 primary sediment samples based on four sub samples per location. QA/QC samples: 10 intra laboratory duplicates; 5 inter-laboratory duplicates. 3 rinsate samples were collected from the sampling spoon.	**96 primary sediment samples** for: • Metals M13 **41 samples for:** • TOC **38 samples for**: • PAH **36 samples for:** • TPH/BTEX • Grain Size **12 samples for:** • SPOCAS • Elutriate Metals (M13) and PAH • TBT **3 samples for:** • Phenols • OCP • PCB
Oxidic sediment / Smith McIntyre Grab samples	30 locations in total with 6 sample locations targeting sediments near the Darcy Road Drain stormwater outlet and 7 sample locations targeting the area where Salty Creek discharges into the Outer Harbour.	30 primary samples based on one sample per location. QA/QC samples: 3 intra laboratory duplicates; 2 inter-laboratory duplicates. 4 rinsate samples were collected from the sampling spoon.	**30 primary sediment samples for**: • Metals M13 **21 samples for:** • Total Organic carbon (TOC). **16 samples for**: • PAH **32 samples for:** • TPH/BTEX **8 samples for:**

Sample Matrix . Collection Method	No. of Sampling Locations	No. of Primary Samples to be Analysed	Analytical Program
			• SPOCAS Suite **11 samples for:** • Grain Size **12 samples for:** • Elutriate Metals (M13) and PAH • TCLP metals – Evaluation of the interaction between dredged sediments and PASS following emplacement • TCLP PAH - Evaluation of the interaction between dredged sediments and PASS following emplacement • PCB • Phenols **8 samples for:** • Cyanide • TBT **3 samples for :** • OCP
Harbour Water / Collected directly into laboratory supplied sample containers by submerging the container.	3 high tide and 3 low tide samples: • Centre of the Site; • Entrance to the Site; and • Entrance of the Inner Harbour.	6 primary samples QA/QC samples consisting of 1 intra laboratory duplicates and 1 inter-laboratory duplicates.	**6 primary harbour water samples for**: • Metals M13 • TSS • TDS • Free Cyanide • OCP • PAH • Phenol • PCB
Elutriate Water	Seawater was collected from the harbour in unused rinsed 20 L jerry cans and submitted with each batch requiring elutriate analysis to the laboratory.		

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7.0 Quality Assurance and Control

Analytical data validation is the process of assessing whether data are in compliance with method requirements and project specifications. The primary objectives of this process are to ensure that data of known quality are reported, and to identify if the data can be used to fulfil the overall project objectives.

The data validation guidelines are based upon data validation guidance document published by the United States Environmental Protection Agency (USEPA, 1999, 2002) and the National Environment Protection Council (NEPC,1999). The process involves the checking of analytical procedure compliance and an assessment of the accuracy and precision of analytical data from a range of QA/QC measures, generated from both the sampling and analytical programs.

7.1 Field Quality Assurance and Quality Control

The field quality assurance and quality control (QA/QC) procedures utilised for the sediment and harbour water sampling included:

- Use of standard sample procedures that were in compliance with the AECOM documented standard field procedures;
- Use of a new pair of disposable nitrile gloves for each sample collection event;
- Use of laboratory prepared and supplied sampling containers appropriate for each CoPC investigated;
- Intra laboratory field duplicates at a rate of one in 10 primary samples;
- Inter laboratory field duplicates at a rate of one in 20 primary samples;
- Collection of rinsate blank samples at a rate of one sample per day (as appropriate); and
- Use of appropriate sample Chain of Custody (COC) documentation. Copies of the COCs are included in the laboratory reports in **Appendix D**.

7.2 Laboratory Quality Control

The Data Quality Indicators (DQIs) defined for the assessment of the laboratory analytical data included:

- Maximum acceptable sample holding time (14 days for organic analyses and six months for metal analyses);
- Samples to be appropriately preserved and handled;
- LORs to be below the adopted assessment criteria;
- Laboratory method blank analyses required to be below the laboratory LORs;
- Laboratory duplicate samples to be analysed at a rate of one in 20 samples or one per batch where there are more than five samples;
- Matrix spike recoveries to be conducted by the laboratory at a rate of one in twenty samples;
- Laboratory control sample analysis to be conducted at a rate of one in twenty samples;
- Matrix and Surrogate recoveries; and
- The occurrence of apparently unusual or anomalous results (for example laboratory results that appear to be inconsistent with field observations or measurements).

7.3 Overall Assessment of Data Quality

An assessment of AECOM's field and laboratory QA/QC data is provided in **Appendix A**.

All samples collected and analysed complied with the predetermined Data Quality Indicators (DQIs), with the exception of the few (justified) deviations from the predetermined DQIs discussed in **Appendix A**.

Of particular note are the very high cadmium concentrations reported in two of the harbour water samples; specifically 10 400 µ/L and 65 400 µ/L at HS-H-02 and HS-H-03, respectively. The laboratory reanalysed these samples and reported very similar results (refer to laboratory report ES0910405, **Appendix D**). However, it appears that these harbour water results may be erroneous based on:

- The other harbour water analysis results which all reported cadmium concentrations less than the ANZECC (2000) 95% marine water, including the sample HS-H-01 that was collected from a location between the two elevated results;
- The generally less than LOR cadmium concentrations reported in the elutriate analytical results;
- The low cadmium concentrations reported in the sediment of the PKOH (a maximum concentration of 25.9 mg/kg at sampling location PC34); and
- The results of previous water quality assessments.

It is recommended that this conclusion be confirmed through additional harbour water quality monitoring.

Following review of the QA/QC results by AECOM it can be concluded that the QA/QC procedures were satisfactory and that the results can be relied upon for the purposes of this SI.

8.0 Investigation Results

8.1 Harbour Bed Conditions

Sediment Grab, Piston Core and Vibro-core logs describing the sediment profile encountered during the SI are included in **Appendix B**.

8.1.1 Sediment Grab Samples

Multi-Purpose Berth Dredge Box

Slight hydrogen sulphide odours were noted at SG12 to SG16, SG18 to SG21 with minor organic matter components in a Silty Clay or Sandy Clay. All of these sediment grab samples were located within close proximity to the outflow point of the Darcy Road Drain (refer to **Figure F5** for sampling locations).

Sediment grabs SG22, SG25, SG27 and SG29 were terminated without sample collection due to refusal on boulders and/or cobbles. All of these sediment grab samples were located within close proximity to each other and the shoreline at the outflow point for Salty Creek (refer to **Figure F5**).

8.1.2 Piston Core Samples

Container Berth Dredge Box

Large charcoal pieces (up to 5 cm) and a charcoal-like odour was noted at PC20 in a Gravelly Silty Clay from 0.0 to 0.17 m depth. Wood fragments and a sulphuric odour was noted at PC21 in a Sandy Gravelly Silty Clay from 0.0 to 0.35 m depth. Pieces of wood, aluminium fragments and large coal fragments, with a sulphurous odour and sheen, were noted at PC22 in a Silty Clay from 0.3 to 0.5 m depth. Each of these piston core samples were located along the eastern side of Jetty No. 4 (refer to **Figure F5**).

A slight hydrogen sulphide odour and minor organic matter components were noted at PC23 in a Silty Sandy Clay. PC23 was located at the north west corner of the container berth dredge box (refer to **Figure F5**).

A coal-like odour was noted in the surficial layer of Sandy Silty Clay at PC29 and a slight sulphuric odour was noted in a Sandy Silty Clay from 0.45 to 0.83 m depth. A sulphuric odour was noted in the surficial layer of Sandy Silty Clay at PC30 and an oily residue was observed on the piston core barrel and a sulphuric odour was noted in a Sandy Gravelly Silty Clay from 0.3 to 0.68 m depth. PC29 and PC30 were located along the western edge of the container berth dredge box (refer to **Figure F5**).

Some nylon fishing line and coal cobbles (up to 20 cm) were noted in a Silty Clay from 0.3 to 0.5 m depth at PC33. PC33 was located at the south west corner of the container berth dredge box (refer to **Figure F5**).

Multi Purpose Berth Dredge Box

Road base materials (blue metal gravels) were noted in a Silty Clay at the base of piston core PC34 from 0.26 m depth. Crushed road base materials were noted in a Silty Clay at the base of piston core PC36 from 0.45 m depth. PC34 and P36 were located at the south east corner of the Multi Purpose Berth Dredge Box (refer to **Figure F5**).

A nail was noted in the surficial layer of Sand in PC53. PC53 was located at the northern end of the multi purpose berth dredge box (refer to **Figure F5**).

Black staining, a slight tar-like odour and a slight sheen were noted in a Silty Clay from 0.3 to 0.63 m depth at PC55. PC55 was located at the southern end of the multi purpose berth dredge box, closest to the shoreline and outflow point of the Darcy Road Drain (refer to **Figure F5**).

A hydrocarbon and tar-like odour was noted from 0.0 to 0.42 m depth of Silty Clay at PC56. PC56 is located directly north of PC55 and is within the proposed dredged area directly north of the Darcy Road Drain (refer to **Figure F5**). A slight tar-like odour was noted at PC64 from 0.0 to 0.25 m depth in Sandy Gravel and from 0.25 to 0.65 m depth in Gravelly Sand. PC64 is located directly north-west of PC55 and the Darcy Road Drain and directly west of PC56. Piston cores PC46, PC47, PC59, PC60 and PC61 were all terminated without return of any sample after encountering bedrock at very shallow depths. All of these piston cores were located within close proximity of each other and within the north east portion of the multi-purpose berth dredge box (refer to **Figure F5**).

8.1.3 Vibro-cores

Multi Purpose Berth Dredge Box / Emplacement Area

A possible hydrocarbon/chemical and hydrogen sulphide odour was noted in a Gravelly Clay at VC01 from 1.3 to 1.4 m depth. VC01 was located within the emplacement area and at the edge of the multi-purpose berth dredge box (refer to **Figure F5**).

A slight swampy and possible hydrocarbon odour was noted in a Sandy Clay at VC02 from 0.6 to 0.9 m depth. A slight hydrogen sulphide odour was noted in a Sandy Clay at VC02 from 1.3 to 2.5 m depth. A slight hydrogen sulphide and slight hydrocarbon odour were noted in Clay at VC02 from 2.5 to 3.35 m depth. A moderate hydrocarbon odour was noted in a Sandy Clay at VC02 from 3.35 to 3.6 m depth. No odour was noted in the remainder of the vibro-core, possibly due to the presence of a stiff confining Clay layer from 3.6 to 4 m depth. VC02 was located within the emplacement are in the middle of the central dredge footprint (refer to **Figure F5**).

A very slight hydrogen sulphide odour was noted in a Sand at VC04 from 1.2 to 1.7 m depth. A slight hydrogen sulphide odour was noted in Clay to the base of VC04 from 1.7 to 2.6 m depth. VC04 was located outside the emplacement area and middle of the central dredge footprint (refer to **Figure F5**).

Some (suspected) black medium grained coal fragments were noted in surface sediments of Silty Clay at VC05 from 0.0 to 0.5 m depth. Clear/blue liquid crystals (possibly cyanide) were noted in a Silty Sandy Clay at VC05 from 0.5 to 1.6 m depth. VC05 was located inside the emplacement area at the southern end of the central dredge footprint (refer to **Figure F5**).

A slight hydrogen sulphide odour was noted at VC06 in a Clayey Gravel from 0.1 to 1.3 m depth. VC06 was located inside the emplacement area and in the middle of the central dredge footprint (refer to **Figure F5**).

A slight hydrogen sulphide odour was noted at VC07 in a Clayey Gravel from 0.2 to 0.6 m depth and a Clayey Sand from 0.6 to 0.9 m depth. VC07 was located at the northern end of the emplacement area, east of VC02 (refer to **Figure F2**).

A slight hydrogen sulphide odour was noted at VC08 in a Gravelly Silty Clay from 0.0 to 2.7 m depth and a tar-like odour was noted in Clay from 2.7 to 3.1 m depth. VC08 was located at the northern end of the emplacement area and north of VC02 (refer to **Figure F5**).

A slight hydrogen sulphide and possible hydrocarbon odour were noted at VC09 from 0.2 to 4.6 m depth across a range of lithologies including Sandy Clayey Gravel, Gravelly Clay and Clay. VC09 was located in the middle of the emplacement area and the central dredge footprint (refer to **Figure F5**).

A slight hydrogen sulphide odour was noted at VC11 from 0.0 to 3.1 m depth across a range of lithologies including Silty Sandy Clay, Clayey Gravelly Sand, Gravelly Clayey Sand and Sand. A possible hydrocarbon odour was also noted in Clayey Gravelly Sand from 0.4 to 1.0 m depth. VC11 was located at the western end of the emplacement area and the southern end of the central dredge box directly north-east of the Salty Creek out flow point (refer to **Figure F5**).

A slight hydrogen sulphide odour was noted in Sand at VC12 from 0.0 to 2.0 m depth. A very slight hydrogen sulphide odour was noted in a Sand at VC12 from 2.0 to 3.1 m depth. VC12 was located at the northern end of the emplacement area and is located directly north-east of VC11 and the Salty Creek out flow point (refer to **Figure F5**).

No samples were collected from VC10 due to refusal on unknown solid strata. Seven attempts were made to collect a vibrocore sample at VC10. VC10 was located within the emplacement area and just inside the proposed reclamation area for the multi purpose terminal (refer to **Figure F5**). It is noted that samples were also unable to be collected from sediment grabs within this area, located directly east and north-east of the Salty Creek out flow point.

8.2 Particle Size Distribution

The particle size distribution results were consistent with typical estuarine sediments. The results are generally indicative of Silty Clays with some Sands also present (refer to **Table T6**).

8.3 Field screening and visual observations

PID readings ranged from 0.0 parts per million (ppm) in various samples (e.g. VC9_0.7-0.8 m) to 53.1 ppm at PC28_0.9-1.4 m. The PID screening results are provided on the sediment core logs presented in **Appendix B**.

The field screening results indicate slight to moderate hydrocarbon impact at some sample locations and in general the screening results generally correlate with hydrocarbon odours and sheen observed during handling of the samples.

It should be noted that PID readings are not available for some sediment grab and piston core samples due to water damage to the PID. A second PID was used for screening of the vibro-core samples.

Photographic logs of the sediment grabs, piston cores and vibro-core samples are presented in the **Plates** section of this report.

Table 14 presents a summary of sampled locations where, hydrocarbon odours and sheen were noted.

Table 14: Field Screening and Observations

Sample location and depth (m)	PID Result (ppm)	Visual and Olfactory observations
PC22_0.30-0.50	17.0	Sheen noted.
PC30_0.30-0.68	6.8	Oily residue on piston core barrel noted.
PC55_0.30-0.63	NA	Slight tar-like odour and slight sheen noted.
PC56_0.0-0.42	NA	Hydrocarbon and tar-like odour noted.
PC64_0.0-0.25	NA	Slight tar-like odour.
PC64_0.25-0.65	NA	Slight tar-like odour.
VC1_1.3-1.4	0.3	Possible hydrocarbon/chemical odour noted.
VC2_2.7-2.8	0.4	Slight hydrocarbon odour noted.
VC8_2.7-2.8	0.3	Tar-like odour noted.
VC9_0.3-0.4	0.1	Possible hydrocarbon odour noted.
VC9_0.7-0.8	0.0	Possible hydrocarbon odour noted.
VC9_2.8-2.9	0.2	Possible hydrocarbon odour noted.
VC9_3.5-3.6	0.2	Possible hydrocarbon odour noted.
VC11_0.5-0.6	0.1	Possible hydrocarbon odour noted.

Notes: ND – Not Detected
NA – Not Available

8.4 Sediment Sample Analytical Results

The sediment analytical results were assessed against the adopted screening levels and are presented in **Table T1** in the Tables section of this report.

8.4.1 TPH/BTEX

TPH C_6-C_9 fraction concentrations were not detected at concentrations greater than the laboratory LOR in the 72 sediment samples analysed.

TPH C_{10}-C_{36} fraction concentrations greater than the NSW EPA (1994) guideline value (1 000 mg/kg) were detected in 12 of the 72 sediment samples analysed. TPH C_{10}-C_{36} fraction concentrations ranged from <250 to 2 080 mg/kg.

Benzene, Toluene, Ethylbenzene and Xylene (Total) were not detected at concentrations greater than the laboratory LOR in the 72 sediment samples analysed.

8.4.2 PAHs

Table 15 provides a summary of screening level exceedances for individual low and high molecular weight PAH and Total PAH. The PAH compound analysis results are presented in **Figure F6** to **F10**.

Table 15: PAH concentration ranges and number of guideline exceedances

Analyte	Concentration Range (µg/kg)		No. ISQG Exceedances		EPA	No. SIL_4 (NEPC, 1999) Criteria Exceedances
	Min	Max	Low	High		
Low Molecular Weight PAH Concentrations (Normalised to 1% TOC)						
Acenaphthene	<10	339	62	-	~	~
Acenaphthylene	<10	1 242	70	4	~	~
Anthracene	<10	1 129	72	0	~	~
Fluorene	<10	992	72	2	~	~
Naphthalene	<10	21 166	71	21	~	~
Phenanthrene	<10	3 089	59	2	~	~
High Molecular Weight PAH Concentrations (Normalised to 1% TOC)						
Benzo(k)Fluoranthene	<10	581	~	~	~	~
Benz(a)anthracene	<10	3 780	68	8	~	~
Benzo(a)pyrene	<10	1 508	12	1	1	0
Benzo(b)Fluoranthene	<10	1 806	~	~	~	~
Benzo(g.h.i)perylene	<10	908	~	~	~	~
Dibenz(a.h)anthracene	<10	247	16	1	~	~
Fluoranthene	<10	2 742	19	-	~	~
Indeno(1.2.3-cd)pyrene	<10	863	~	~	~	~
Pyrene	<10	2 694	10	1	~	~
Chrysene	<10	1 121	12	-	~	~
Total Low and High Molecular Weight PAH Concentrations (Normalised to 1% TOC)						
Low Molecular Weight PAHs	<LOR	27 016	71	21	~	~
High Molecular Weight PAHs	<LOR	8 935	25	-	~	~
Total PAH Concentrations (Normalised to 1% TOC)						
Total PAHs	<LOR	42 000	47	-	3	-

Notes:
- No exceedance
~ No guideline value

Low Molecular Weight PAH (LMWPAH)

The highest concentrations of LMWPAH, all exceeding the ISQG-High, were identified at VC05, VC08, and VC09. These three locations were in close proximity to each other and located within the emplacement area.

High Molecular Weight PAH (HMWPAH)

Concentrations of HMWPAH compounds benzo(a)pyrene and fluoranthene have been mapped and presented on **Figure F6** and **Figure F7** respectively.

Six areas between and beneath the proposed central dredge footprint were identified to have concentrations of HMVPAH exceeding the ISQG-Low to a maximum depth of 2.8 m bgs (at VC08).

One area located within the central portion of the proposed container berth dredge box, closest to the Eastern Breakwater, were identified to have concentrations of HMVPAH exceeding the ISQG-Low to a maximum depth of 0.53 m bgs at location PC19.

Total PAH

Concentrations of Total PAHs did not exceed the ISQG-High or the SIL_4 (NEPC, 1999) criteria. Total PAHs exceeding the ISQG-Low were randomly distributed across the investigation area with the highest concentrations located within the emplacement area from depths between the sediment surface to 2.8 m bgs.

8.4.3 Metals

The concentration ranges and the number of screening level exceedances are summarised in **Table 16** below. The various metals analysis results are presented in **Figure F11** to **F21**.

Table 16: Metal concentration ranges and number of guideline exceedances

Analyte	No. Samples Analysed	Concentration Range (mg/kg)		No. ISQG Exceedances		No. SIL_4 (NEPC, 1999) Criteria Exceedances
		Min	Max	Low	High	
Antimony	175	<0.5	47.4	35	1	~
Arsenic	175	<1	844	111	71	1
Cadmium	175	<0.1	25.9	70	6	-
Chromium (III+VI)	175	2.8	539	91	1	-
Copper	175	1.2	16 600	126	89	7
Lead	175	1.4	8 700	136	95	21
Mercury	175	<0.1	6.9	127	51	-
Nickel	175	1.1	423	72	12	-
Silver	175	<0.1	137	87	29	-
Zinc	175	4.5	6 420	139	127	-

Notes:
- No exceedance
~ No guideline value

8.4.4 Total Cyanide

Total Cyanide (normalised to 1% TOC) concentrations greater than the laboratory LOR (1 mg/kg) were detected in 1 of the 13 sediment samples analysed. The concentration reported in sample PC30_0.3-0.68 was 3 mg/kg and was less than the derived assessment criteria (refer to **Table T1**).

8.4.5 TBT

TBT concentrations ranged between <0.5 and 2 170 µgSn/kg in the 91 sediment samples analysed. TBT concentrations greater than the ISQG-Low (5 µgSn/kg) were detected in 15 of the samples. Two samples (PC20_0-0.17 m and PC21_0-0.35 m) reported concentrations greater than the ISQG-High (70 µgSn/kg). The TBT analysis results are presented in **Figure F19**.

8.4.6 PCBs and OCPs

OCPs and PCB concentrations in all 35 sediment samples analysed were less than the LOR.

8.4.7 TOC

TOC results ranged from 0.03 % to 40.1 % in the 114 samples analysed.

The TOC results were generally within the range expected for estuarine sediment (2-8%) with the exception of 31 samples. Three samples (PC9_0.8-1.12 m, PC64_0.25-0.65 m and PC63_0.95-1.05 m) had TOC values between 10.3% and 40.1% and 28 samples had values between 0.03% and 1.98%.

8.4.8 SPOCAS (Acid Sulfate)

The reported oxidisable sulphur values ranged between 0.05 to 2.18 % which were all above the ASSMAC (1998) action levels of 0.1 % (1-1 000 tonne) and 0.03 % (>1000 tonne) for medium to heavy clays and silt clay materials in all 52 samples tested.

8.5 Elutriate Results

8.5.1 Background Concentrations in Seawater

Bulk harbour water samples were collected to facilitate the laboratory based elutriate testing (refer to **Table T2** and **T3**). All heavy metals, PAH and Phenols concentrations in these bulk samples were less than the ANZECC (2000) 95% marine water. Heavy metals concentrations were generally non-detect with the exception of the following:

- Arsenic – ranged between 1.5 and 2.2 2 µ/L;
- Vanadium – ranged between 1 and 2.1 2 µ/L;
- Zinc - ranged between <5 to 9 2 µ/L.

8.5.2 Heavy Metals

All concentrations of heavy metals in the 51 elutriate samples analysed were less than the adopted elutriate screening levels (ANZECC [2000] 95% Marine Water), with the exception of the following:

- Copper concentrations in elutriate samples SG01 (2 µ/L), SG02 (2 µ/L), SG05 (2 µ/L), SG28_0.0-0.02 m (11 µ/L), SG23_0-0.03 m (2 µ/L), VC1_0.0-0.2 m (2 µ/L) and VC12_0.2-0.3 m (5 µ/L) exceeded the adopted criteria of 1.3 µ/L;
- Vanadium concentration in elutriate sample VC11_0.5-0.6 m (272 µ/L) exceeded the adopted criteria of 100 µ/L;
- Zinc concentration in elutriate sample VC12_0.2-0.3 m (18 µ/L) exceeded the adopted criteria of 15 µ/L;
- Arsenic – Concentrations of arsenic exceeded the adopted assessment criteria (4.5 µg/L) in 39 out of 51 elutriate samples analysed and ranged between 0.6 µg/L and 67.1 µg/L.

8.5.3 PAHs/Phenols

All concentrations of PAH and Phenols were less than the laboratory LOR and therefore the adopted assessment criteria in all elutriate samples analysed.

8.6 Harbour Water Results

8.6.1 Heavy Metals

All concentrations of heavy metals in the 6 harbour water samples analysed were less than the ANZECC (2000) 95% marine water, with the exception of the following:

- Cadmium - concentrations in harbour water samples HS-H-02 and HS-H0-03 (both collected at high tide) exceeded the adopted assessment criteria (5.5 µg/L) with concentrations of 10 400 µg/L and 65 400 µg/L respectively (refer to the discussion of these results in **Section 9.4**; and
- Copper – the concentration of copper in harbour water sample HS-H-01 (collected at high tide) of 2 µg/L exceeded the adopted assessment criteria of 1.3 µg/L.

8.6.2 Arsenic

Concentrations of arsenic in all harbour water samples were less than the adopted assessment criteria of 4.5 µg/L and ranged between 1.6 µg/L and 2.1 µg/L in the samples analysed.

8.6.3 OCPs, PAHs, Phenols and PCBs

OCPs, PAHs, Phenols and PCBs were not detected at concentrations greater than the adopted assessment criteria. To summarise:

- All OCPs, phenols and PCBs were all non-detect; and
- A maximum Total PAH concentration of 0.044 µg/L was reported in sample HS-H-01.

8.6.4 Free Cyanide

Free Cyanide was not detected at concentrations greater than the laboratory LOR in the harbour water samples analysed.

8.6.5 TDS and TSS

TDS concentrations ranged between 3 740 mg/L (HS-H-01) and 4 380 mg/L (HS-L-01). These concentrations are lower than typical seawater (generally 30 000 mg/L) and are likely to represent the influence of freshwater in the harbour.

TSS concentrations ranged between 2 mg/L (HS-H-01) and 20 mg/L (HS-L-01).

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9.0 Site Characterisation

9.1 Sediment Characteristics

Sediment within and around the proposed dredge footprints and emplacement area is predominantly composed of sandy silty clay, sandy clay and minor gravelly clay. Anthropogenic inclusions were observed within sediments across the dredge footprints and comprised predominantly coal, timber and aluminium fragments. Hydrocarbon, tar-like, hydrogen sulphide and chemical odours were observed in sediments located within the middle of the emplacement area (near the outlet of Salty Creek) and at the southern end of the proposed container berth dredge footprint near the eastern breakwater (adjacent to Jetty No. 4). A sheen was also observed within sediments collected between 0.3 and 0.5 m bgs from PC22 located near Jetty No. 4.

The majority of TOC results (83 samples out of 114) were consistent with typical estuarine sediments and there were no obvious patterns in TOC variation laterally or vertically throughout the sediments.

9.2 Acid Sulfate

The analytical results for SPOCAS analysis indicated the presence of acid sulphate material between 0 and 3.3 m (anoxic layer) at the sample locations tested.

These results are consistent with the Acid Sulfate Soil Risk Map (Edition 2) for Wollongong, published by the Department of Natural Resources (DNR, 2002) which indicated that:

- There is a 'High Probability' of potential acid sulphate soil (PASS) being present within the 'Estuarine Bottom Sediments' of the Inner Harbour (extrapolated to the PKOH which is categorised as Ocean by the Map and therefore not classified); and
- There is a potential for severe environmental risk if bottom sediments are disturbed by activities such as dredging.

9.3 Extent and Nature of Contamination

The analytical results are generally consistent with the findings of previous investigations on the contamination of sediments within the PKOH. The extent and nature of contamination identified within the sediments in this investigation is summarised below:

- Heavy metals contamination (concentrations exceeding the ISQG-Low) was identified across the majority of the dredge footprint within the shallow sediments (approximately 0-0.3 m bgs);
- The highest concentrations of heavy metals (with concentrations greater than the ISQG-High) were identified predominantly within the top 1.0 m of the emplacement area at locations VC03 (between 0 and 1.3 m bgs), VC04 (between 0.2 and 0.8 m bgs), VC07 (between 0.2 and 0.4 m bgs), VC08 (between 0.5 and 2.8 m bgs) and VC09 (between 0.3 and 0.8 m bgs);
- Copper and lead concentrations (and to a lesser degree arsenic) exceeded the SIL_4 (NEPC, 1999) criteria in localised areas at the southern end of the container berth dredge footprint (in the vicinity of PC22) and also in the vicinity of the Darcy Road Drain (the PC34 area);
- PAH contamination (concentrations exceeding the ISQG-Low) was identified across the majority of the dredge footprint within the shallow sediments (approximately 0-0.3 m bgs);
- The highest concentrations of PAHs (concentrations greater than their respective ISQG-High) were identified within the emplacement area at locations VC01, VC05, VC06, VC07, VC08, VC09, PC38, PC39, PC42, PC43, PC45, PC53, PC63 and PC64. The concentrations generally correlated with field observations within this area where possible hydrocarbon/chemical and hydrogen sulphide odours were noted during sampling activities;
- All benzo(a)pyrene and Total PAH concentrations were reported to be less than the SIL_4 (NEPC, 1999) criteria;
- Isolated PAH concentrations exceeding the ISQG-High were identified to the maximum investigation depths of 0.53 and 0.35 m bgs at PC19 and PC25 respectively, within the proposed container berth dredging box;

- PAH contamination was generally identified to the maximum depth of sediment sampling, which varied between 0.05 and 3.3 m bgs; and
- The extent of TBT contamination (concentrations greater than the ISQG-Low and High) appeared to confined to the southeast most corner of the container berth dredge box, adjacent to the eastern breakwater and centred around location PC20 and extending to PC19, PC22, PC31 and SG1 (refer **Figure F19**). Other isolated areas of TBT exceeding the ISQG-Low were identified at PC34, PC38, PC39, PC49, PC50, PC56 and PC54.

9.4 Harbour Water

The concentrations of CoPC within the harbour water samples were less than the adopted ANZECC (2000) 95% Marine trigger values with the exception of:

- Copper in the sample collected at high tide from the closest sampling point to land - between 1 and 2 µg/L; and
- Cadmium concentrations in the samples collected at high tide from within the inner and outer most portions of the PKOH (10 400 µg/L and 65 400 µg/L).

It appears that the cadmium harbour water results may be erroneous based on:

- The other (low and high tide) harbour water analysis results which all reported cadmium concentrations less than the ANZECC (2000) 95% marine water, including the sample collected from the middle of the PKOH;
- The generally less than LOR cadmium concentrations reported in the elutriate analytical results;
- The low cadmium concentrations reported in the sediment of the PKOH (a maximum concentration of 25.9 mg/kg at sampling location PC34);
- A review of historic harbour water quality monitoring data collected by the Port Kembla Harbour Water Quality Monitoring Group and Blue Scope Steel for a period of 6 years between 2002 and 2008 was conducted by AECOM. The review of this data revealed that maximum cadmium concentrations reported during the monitoring program was 21.9 µg/l in the Inner Harbour and 0.4 -10.7 µg/l in the Outer Harbour; and
- The results of previous water quality assessments.

9.5 Elutriates

Elutriate results indicated that there is a potential for copper, arsenic, vanadium and zinc to be released into the water column during dredging at concentrations which could exceed their respective ANZECC (2000) 95% Marine trigger values.

The vanadium and zinc elutriate exceedances were isolated (one out of 51 samples) and related to samples taken from sediments beneath the proposed multi purpose terminal that will not be subject to dredging.

The copper elutriate exceedances were also relatively isolated (seven out of 51 samples), but were more widely distributed throughout the dredge footprint. The concentrations of copper in the elutriate samples exceeding the trigger value (1.3 µg/L) typically ranged between 2 µg/L and 5 µg/L (between two and four times the trigger value), with one result of 11 µg/L.

The arsenic elutriate exceedances were wide spread (39 out of 51 elutriate samples) and corresponded with sediment samples with total concentrations which also exceeded the ISQG-High trigger values. As such, the arsenic elutriate exceedances are likely to represent the worst case scenario in terms of arsenic being mobilised to the water column during the proposed reclamation works. The concentrations of arsenic in the elutriate samples exceeding the trigger value (4.5 µg/L) were typically less than 20 µg/L (that is approximately four times the trigger value) with only seven results greater than 20 µg/L.

As noted in NADG (2009), the initial dilution ratio of 1:4 incorporated as part of the elutriate analysis is likely to ‘greatly overestimate water quality impacts given that, within the four-hour period, dilutions of the order of a hundred times or more (and often much more) would normally be expected’. Water quality impacts can be estimated as a function of the dredge footprint, water column depth, and dredging and reclamation methodology, including the capacity of the barge and the mass of sediment (and contaminant contained within it) placed at any one time. Therefore, a more detailed quantification of the actual water quality impacts is not possible until the dredging methodology is confirmed.

Notwithstanding, and in consideration of the likely dilution effects of dredging and reclamation, it is considered that the elutriate results for both arsenic and copper, which were typically three to four times the ANZECC (2000) 95% marine trigger value, indicate that the dredging and reclamation works would be unlikely to have a significant impact on the receiving environment.

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10.0 Conclusions and Recommendations

10.1 Conclusions

The following conclusions can be drawn from the SI:

- Sediment within and around the dredge footprints predominantly composed of sandy silty clay, sandy clay and minor gravelly clay. Anthropogenic inclusions were observed within sediments and comprised predominantly coal, timber and aluminium fragments. Some hydrocarbon, tar-like, hydrogen sulphide and chemical odours were noted in the sediments in parts of the dredge footprints and emplacement area;
- Heavy metals contamination (concentrations exceeding their respective ISQG-high and -low trigger values) was identified across the majority of the dredge footprint within the shallow sediments (approximately 0-0.3 m bgs);
- The highest concentrations of heavy metals (with concentrations greater than their respective ISQG-High trigger values) were identified predominantly within the top 1.0 m of the emplacement area;
- Copper and lead concentrations (and to a lesser degree arsenic) exceeded the SIL_4 (NEPC, 1999) criteria in relatively localised areas at the southern end of the container berth dredge box and also in the vicinity of the Darcy Road Drain (multi-purpose berth dredge box). Consequently, the sediment is considered to be suitable for reclamation works related to proposed commercial/industrial development with no significant risk to human health;
- PAH contamination (concentrations exceeding their respective ISQG-high and -low trigger values) was identified across the majority of the dredge footprint within the shallow sediments (approximately 0-0.3 m bgs). The highest concentrations of PAHs (concentrations greater than their respective ISQG-High trigger values) were identified within the emplacement area;
- The extent of TBT contamination (concentrations greater than the ISQG-High trigger values) appeared to be confined to the southern end of the container berth dredge box, adjacent to the eastern breakwater;
- The analytical results for SPOCAS analysis indicated that there is a potential for acid sulphate material between 0 and 3.3 m (anoxic layer) at the Site;
- The concentrations of CoPC within the harbour water samples were less than the adopted ANZECC (2000) 95% Marine trigger values with the exception of:
  - Copper for which one sample reported a concentration (2 µg/L) that exceeded the trigger value of 1.3 µg/L; and
  - Cadmium for which two samples reported concentrations (10,400 µg/L and 65 400 µg/L) which exceeded the trigger value of 5.5 µg/L but are considered to be erroneous based on other harbour surface water, sediment and elutriate analytical results reported as part of this investigation and historic harbour water quality results from the Port Kembla Harbour water quality monitoring program.
- The elutriate results for the key CoPCs (arsenic and copper) indicated that there is a potential impact to the water column during dredging and reclamation works at concentrations which could exceed the respective ANZECC (2000) 95% Marine trigger values. The exceedances generally corresponded with sediment samples with total concentrations which also exceeded the ISQG-High trigger values (that is hot spot materials). In consideration of the likely dilution effects of dredging and reclamation, it is considered that the results, which were typically three to four times the ANZECC (2000) 95% marine trigger value, indicate that the dredging and reclamation works would be unlikely to have a significant impact on the receiving environment. This will be confirmed as part of the further qualitative risk assessment which will assess whether or not hot spot materials are suitable for dredging and, consequently, require specific management via a Remedial Action Plan.
- AECOM concludes that the dredging and reclamation works are unlikely to have a significant impact on the receiving environment based on consideration of:
  - The typical elutriate results, using a conservative assessment of the likely dilution of CoPC during dredging and reclamation works.
  - Placement of dredged material at depth (where it will not be subject to a hydraulic gradient) within revetment structures and below other approved reclamation materials.

- Proposed mitigation measures including preparation of DEMP, ASSMP, SWMP and implementation of water quality and turbidity monitoring program.

10.2 Recommendations

Based on the above conclusions, AECOM recommends that:

- A Dredging Environmental Management Plan (DEMP) would be prepared (as a precursor to the dredging works) once the detailed design for the dredging works is finalised and a further qualitative sediment risk assessment has been undertaken. This will be based on the measures recommended by this SI and ensure that the recommended mitigation measures incorporated into the DEMP are appropriate and specific to the proposed dredging works, therefore minimising potential impacts to the environment;
- The sediments will be dredged and emplaced in the reclamation area at essentially the same time with this process occurring within the water column. This will negate the need for land storage and wastewater management;
- A Surface Water Management Plan will however be prepared to appropriately manage the accumulation of surface water from rainfall until the reclamation areas are finally paved. In the preparation of this plan, consideration will be given to potential surface water contamination issues during the construction phase, when the area is not capped, with contingency measures such as sediment basins being constructed. During the operational phase, contingency measures such as a first flush capture system would be also implemented;
- In considering the elutriate analysis results, the following mitigation measures would be detailed in the DEMP to minimise impact on the receiving environment of the Outer Harbour during the proposed dredging and placement works:
  - Dredged sediments deposited as part of the proposed reclamation will be contained in an engineered containment structure which will be constructed of higher quality and less impacted material;
  - The sediment will effectively be encapsulated and confined within the engineered structure;
  - Dredged sediments will be placed at depth, likely below the depth of wave action at the base of the reclamation fill to maximise the opportunity for future consolidation and reduce the potential for further disturbance;
  - It is unlikely that the quality of dredged sediments placed as part of the reclamation works would be required to meet the criteria for open water disposal as the Outer Harbour is a semi enclosed (breakwaters) and highly disturbed environment;
  - Dredging and reclamation would be undertaken within the protection of parallel silt curtains encompassing both the dredging and reclamation areas;
  - Dredging technologies will be selected in consideration of their ability to minimise the generation of turbidity;
  - Real time turbidity monitoring will be employed in conjunction with observations by personnel undertaking the dredging and reclamation activities to assist in early identification of problems and proactive implementation of mitigation measures;
  - Monthly flyovers will be conducted to assess the presence of potential sediment plumes and algal blooms from the dredging or placement areas; and
  - Contingency measures that can be implemented immediately in the event visible turbidity and harbour water quality impacts are identified during routine monitoring.
- The mitigation measures described above are based on AECOM's project experience on similar projects and involving similar contaminants (including the Hunter River remediation project) in which the measures proposed following successfully minimised adverse affects to the receiving environment. Also, many dredging campaigns have previously been undertaken in the Inner and Outer Harbours by PKPC. Consequently, AECOM considers that modelling/field trials to assess the potential mobilisation and/or dispersion of contaminants would not be required. Due to the large mobilisation costs associated with such field trials, these works are also likely to be impracticable and cost prohibitive;
- A harbour water quality ad turbidity monitoring plan should be developed to confirm that the discussed mitigation measures are successful in protecting the receiving aquatic ecosystem for the duration of the dredging works;

- An appropriate acid sulphate soil management plan will be required as a precursor to the dredging and reclamation works to ensure that these works either avoid exposing potential acid sulphate soils to oxygen or provide for appropriate management of the PASS;
- The risk to human health and the environment associated with the contaminated sediment identified by the SI (in particular the identified sediment contamination hotspots) should be evaluated by a further qualitative risk assessment. If the risk assessment concludes that the contamination hotspots present an unacceptable risk to the environment, a Remedial Action Plan will be prepared to appropriately manage the identified materials of concern. Remedial actions could include placing more contaminated materials at greater depths, encapsulation/stabilisation works or removal offsite. To this end, reference should be made to the qualitative human health and ecological risk assessment that has been prepared by AECOM based on the outcomes of this SI and in response to the DGRs;
- Based on the data obtained from this SI, AECOM anticipates that the sediments likely to be encountered by the proposed development can be managed appropriately using typical dredging technologies and standard mitigation measures as discussed above; and
- A sediment investigation should be conducted in the area north and south of the Gateway Berth and south of the northern breakwater (the swing basin) as dredging works will be required in these areas in the future as part of Stage 3 of the Concept Plan. Assuming that the additional SI demonstrates that the sediment in these areas has similar characteristics to that considered by this SI, it is likely that the proposed dredging and emplaced mitigation measures outlined in this document can also be applied to the other areas in the future and will appropriately protect the environment.

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11.0 Limitations

This document was prepared for the sole use of Port Kembla Port Corporation (PKPC) the only intended beneficiary of our work. Any advice, opinions or recommendations contained in this document should be read and relied upon only in the context of the document as a whole and are considered current to the date of this document. Any other party should satisfy themselves that the scope of work conducted and reported herein meets their specific needs. AECOM cannot be held liable for third party reliance on this document, as AECOM is not aware of the specific needs of the third party.

From a technical perspective, the subsurface environment at any site may present substantial uncertainty. It is a heterogeneous, complex environment, in which small subsurface features or changes in geologic conditions can have substantial impacts on water and chemical movement. Uncertainties may also affect source characterisation assessment of chemical fate and transport in the environment, assessment of exposure risks and health effects, and remedial action performance.

AECOM's professional opinions are based upon its professional judgement, experience, and training. These opinions are also based upon data derived from the testing and analysis described in this document. It is possible that additional testing and analysis might produce different results and/or different opinions. AECOM has limited its investigation to the scope agreed upon with its client. AECOM believes that its opinions are reasonably supported by the testing and analysis that have been done, and that those opinions have been developed according to the professional standard of care for the environmental consulting profession in this area at this time. That standard of care may change and new methods and practices of exploration, testing, analysis and remediation may develop in the future, which might produce different results. AECOM's professional opinions contained in this document are subject to modification if additional information is obtained, through further investigation, observations, or validation testing and analysis during remedial activities.

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