APPENDIX M

HAZARDS AND RISK ASSESSMENT (ADVITECH)

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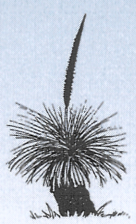
Risk Assessment

Proposed Extension of Shipping Channels, Port of Newcastle

GHD Pty Ltd
Sydney



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August 2003
Job No: 4929
Folder No: 4769
File No: 4769501h.doc

Project Title:

Risk Assessment
Proposed Extension to Shipping Channels, Port of Newcastle

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Date:	August, 2003
Job No.:	4929
Folder No.:	4769
File Name:	4769501h.doc
Issue Status:	FINAL REPORT FOR PUBLICATION
Copy No.:	1 of 1

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DISCLAIMER

EXECUTIVE SUMMARY

The Waterways Authority proposes to dredge the South Arm of the Hunter River (the South Arm) in Newcastle, NSW, to provide for future expansion of the port facilities.

GHD was engaged to prepare an Environmental Impact Statement (EIS) for the proposed extension to shipping channels (the proposed development). As a component of the EIS process Advitech Pty Limited was engaged to prepare a risk assessment for the proposed development to address the requirements of Planning NSW.

A screening level health risk assessment has identified no significant exposure pathways. The key exposure pathways identified were direct contact with sediment and localised inhalation of volatiles. These pathways were found to be not relevant for off-site workers or residents. The proposed techniques and barriers associated with the proposed development effectively prevent the identified exposure pathways being completed. On this basis the potential health risk to off-site receptors is negligible.

In characterising the risk posed to the environment by the proposed development, a qualitative assessment of potential ecological impacts was undertaken. Based on the implementation of best practice dredging techniques, appropriate project scheduling and recommended risk mitigation steps during the development, impacts on the identified ecological receptors are of low potential risk. Further, following removal of the sediments not suitable for ocean disposal from the riverbed, it would be expected that the current risk of contaminant release to the river water or re-deposition within the lower Hunter River estuary due to natural processes will be removed.

A preliminary screening assessment as described in *NSW State Environmental Planning Policy No 33 – Hazardous and Offensive Development (SEPP 33)* has been undertaken. The SEPP 33 screening indicates that the proposed development <u>is not potentially hazardous</u>, with respect to any of the dangerous goods to be stored as part of the proposed development.

A Hazard Identification Study has identified all relevant hazards. No credible hazard scenarios were identified with potential off-site consequences, that is, the consequences from all scenarios are contained within the proposed development area. No quantitative consequence calculations or estimations of likelihood have been made of these scenarios.

This risk assessment demonstrates that the risk levels during and after the proposed development are tolerable in relation to the surrounding land use, and that any risks identified will be appropriately managed.

The absence of any credible off-site effects also means that there will be no impact from the proposed development on the cumulative risk levels in the Kooragang Island industrial zones.

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GLOSSARY OF TERMS

Consequence
The outcome of an event or situation expressed qualitatively, being a loss, injury, disadvantage or gain.

Controls
The 'barriers' put in place or actions taken to eliminate a hazard and its associated dangers, or that render the consequence of an occurrence acceptable.

Deluge System
A water spray system designed to cool the outside surface of a storage vessel subject to fire or intense radiation. The system is so designed to maintain the temperature of the vessel below that which may lead to catastrophic failure.

Hazard
A source of potential harm, or a situation with a potential to cause loss.

Hazard Identification Study
A qualitative procedure by which risks are identified and assessed with respect to causes, consequences and mitigation measures.

Hazardous Industry (under SEPP 33)
A development for the purposes of an industry which, when the development is in operation and when all measures proposed to reduce or minimise its impact on the locality have been employed, would pose a significant risk in relation to the locality:
a) to human health, life or property; or
b) the biophysical environment.

Likelihood
Used as a qualitative description of probability or frequency.

Qualitative Risk Assessment
A systematic approach to risk assessment based on an appropriate methodology such as a hazard and operability study (HAZOP). Under the multi-level risk assessment protocol, developed by Planning NSW, a qualitative risk assessment is nominated to be a level 1 assessment. A level 1 assessment involves identification of all key scenarios with a realistic qualitative estimate of risk, comparison with qualitative criteria, and documentation of risk mitigating measures, which may include codes and standards.

Residual Risk
The remaining levels of risk after risk treatment measures have been taken.

Risk
The chance of something happening that will have an impact upon objectives. It is measured in terms of consequence and likelihood (see **Tables 3.1, 3.2** and **3.3**).

Risk Assessment
The formalised means by which hazards and associated dangers are systematically identified, assessed, ranked according to perceived risk and addressed by means of appropriate and effective controls.

Screening Distance
The distance, referred to in the SEPP 33 preliminary risk screening protocol, below which certain classes and quantities of dangerous goods are considered to be potentially hazardous with respect to off-site receptors and thus require a higher level of risk assessment.

Screening Threshold
The quantity, referred to in the SEPP 33 preliminary risk screening protocol, above which certain classes of dangerous goods are considered to be potentially hazardous with respect to off-site receptors and thus require a higher level of risk assessment.

Societal Risk
The societal risk concept comprises a number of components. Firstly the number of people exposed to levels of risk, and secondly that society is more averse to incidents that involve multiple fatalities or injuries than to the same number of deaths or injuries occurring through a large number of smaller incidents. Societal risk analysis combines the consequence and likelihood information with population information. It is usually presented in the form of a 'F-N curve', which is a graph indicating the cumulative frequency (F) of killing 'n' or more people (N).

ABBREVIATIONS AND UNITS

AS	Australian Standard
BLEVE	Boiling Liquid Expanding Vapour Explosion
DG	Dangerous Goods
DUAP	Department of Urban Affairs and Planning
EPA	Environment Protection Authority
ha	hectares
HAZOP	Hazard and Operability Study
HIPAP	Hazardous Industry Planning Advisory Paper
IBC	Intermediate Bulk Containers
km	kilometres
L	litres
m^3	cubic metres
Nm^3	normal cubic metres
PHA	Preliminary Hazard Analysis
SEPP	State Environmental Planning Policy
SOP	Standard Operating Procedure
t	metric tonne
UVCE	Unconfined Vapour Cloud Explosion

1. INTRODUCTION

The Waterways Authority proposes to dredge the South Arm of the Hunter River (the South Arm) in Newcastle, NSW, to provide for future expansion of the port facilities. GHD was engaged to prepare an Environmental Impact Statement (EIS) for the proposed South Arm dredging (the proposed development). As a component of the EIS process Advitech Pty Limited was engaged to prepare a risk assessment for the proposed development.

1.1 Objectives

The objectives of the risk assessment are:

- To demonstrate that the risk levels during and after the proposed development are tolerable in relation to the surrounding land use, and that risk will be appropriately managed;
- To determine if chemical contaminants on the site pose an unacceptable risk to human health or the environment during and after the proposed works; and
- To recommend mitigation strategies should unacceptable risks be identified.

1.2 Scope

This risk assessment is limited to the proposed development area and includes an assessment of:

- The proposed development, utilising a screening level and Preliminary Hazard Analysis (PHA) approach where appropriate;
- The nature and level of environmental risk associated with dredging, sediment transport and treatment, and on-site disposal activities;
- Potential health impacts arising from commercial and recreational fishing undertaken within the Hunter River, and consumption of seafood; and
- Public health risks associated with movement of materials, unauthorised access and accidental spillages.

2. STATUTORY REQUIREMENTS

The proposed development is a designated development as specified by the *Environmental Planning and Assessment Regulation 2000*. This means an EIS must accompany the Development Application. Matters to be considered in the EIS have been obtained from the Director-General of Planning NSW.

The Director General's Requirements for the EIS have identified, "environmental risk" as one of the "Issues of environmental planning importance for EIS preparation". In order to address this requirement an ecological risk assessment has been undertaken generally in accordance with the protocol outlined in the *National Environment Protection (Assessment of Site Contamination) Measure 1999* (NEPC, 1999) and with reference to the *Australian Water Quality Guidelines for Fresh and Marine Water* (AWQG) (ANZECC, 2000).

Additionally, *State Environmental Planning Policy No.33 – Hazardous and Offensive Development* (SEPP 33) is included in the Attachment No.2 specific requirements to be considered in the preparation of the risk assessment.

SEPP 33 requires developments which are potentially hazardous, to undertake a Preliminary Hazard Analysis (PHA) to determine the risk to people, property and the environment at the proposed location and in the presence of controls. This risk assessment has adopted a PHA methodology to ensure a conservative approach to capture any potential off-site impacts. Should such risk exceed the criteria of acceptability, the development is classified as 'hazardous industry' and may not be permissible within most industrial zones in NSW.

For developments identified as potentially offensive the minimum test for such developments is meeting the requirements for licensing by the Environment Protection Authority (EPA). If a development cannot obtain the necessary pollution control licenses, then it may be classified as offensive industry, and may not be permissible within most industrial zones in NSW.

The requirements of SEPP 33 primarily consider the impact on off-site receptors due to on-site incidents such as loss of containment, fire and explosions. It was considered that a screening level health risk assessment would also be of value to identify potential pathways that may lead to contaminant toxicity impacts on receptors, including the proposed development employees, employees of surrounding industry, and commercial and recreational river users, to ensure that the exposure risk with respect to pathways such as inhalation, ingestion, and dermal contact are managed and mitigated where appropriate.

In addition to applying SEPP 33, this risk assessment was prepared generally in accordance with the publications *Hazardous Industry Planning Advisory Paper No. 6 - Guidelines for Hazard Analysis* (DUAP, 1992) and *Multi-Level Risk Assessment* (DUAP, 1997).

The risk assessment has considered the development in terms of accidental loss scenarios and their potential for hazardous incidents. General handling of waste materials and emissions produced during normal operations is dealt with elsewhere in the EIS.

3. METHODOLOGY

3.1 Preliminary Hazard Analysis

3.1.1 General

A Preliminary Hazard Analysis aims to provide sufficient information and assessment of risks to demonstrate that a project satisfies the risk management requirements of the proponent and the relevant public authorities. Within this context, the primary role of the PHA is to demonstrate that the residual risk levels are tolerable in relation to the surrounding land use, and that risk will be appropriately managed.

In summary the purpose of a PHA is to:

- Identify all potential hazards, and abnormal process conditions that could lead to hazards, associated with the proposal;
- Analyse both their consequences (effects) for people and the environment, and their probability (likelihood or frequency) of occurrence;
- Estimate the resultant risk to the surrounding land uses and environment; and
- Ensure that the proposed safeguards are adequate and identify opportunities to reduce the risks by elimination, minimisation and/or incorporation of additional protective measures and thus demonstrate that the operation will not impose a level of risk, which is intolerable with respect to its surroundings.

The PHA should be carefully and clearly documented with the assumptions and uncertainties of final design and operation defined.

3.1.2 Preliminary Risk Screening

A preliminary risk screening of the proposed development is required under SEPP 33. The preliminary screening methodology concentrates on the storage of specific dangerous goods classes that have the potential for significant off-site effects. Specifically the assessment involves the identification of classes and quantities of all dangerous goods to be used, stored or produced on-site with an indication of storage depot locations. Details of the methodology are described in *Applying SEPP 33 – Hazardous and Offensive Development Application Guidelines* (DUAP, 1994).

3.1.3 Risk Classification and Prioritisation

Multi-Level Risk Assessment (DUAP, 1997) suggests the use of preliminary analysis of the risks related to a proposed development, to enable the selection of the most appropriate level of risk analysis in the PHA. This preliminary analysis includes risk classification and prioritisation using a technique adapted from the *Manual for Classification of Risk due to Major Accidents in*

Process and Related Industries (IAEA, 1993). This technique is detailed in the *Multi-Level Risk Assessment* (DUAP, 1997) document and is briefly explained below.

3.1.4 Analysis and Assessment Levels

The hazard analysis and quantified risk assessment regime promoted in NSW relies on a systematic and analytical approach to the identification and analysis of hazards and the quantification of off-site risks to assess risk tolerability and land use safety implications.

Two key objectives are emphasised in the implementation of this process:

> **Objective 1** – the systematic and analytical nature of the assessment process enables the nature of the hazards, and risks and the leading risk contributors and events, to be identified and understood from design, operational and organisational viewpoints.
>
> **Objective 2** – the quantification of off-site risks, where applicable, enables judgements to be made on locational safety implications with regard to people, the biophysical environment and other land uses.

The conceptual rationale for the multi-level risk assessment regime is that:

- Preliminary analyses, which indicate minor land use safety implications, may justify a qualitative level of assessment (Level 1). The emphasis for such cases should be on the identification of key risk elements and optimising safety management regimes, thus fulfilling Objective 1 above.
- Preliminary analyses, which indicate significant potential risk impacts to surrounding land uses, should be subjected to a more detailed level of analysis including partial or total quantification (Levels 2 and 3). For such cases there should be increased emphasis on Objective 2 above, relating to land use safety and risk tolerability.

The *Multi-Level Risk Assessment* (DUAP, 1997) document prescribes three levels of risk assessment, which can be undertaken. The choice of an appropriate technique is based on the results of preliminary screening, risk classification and prioritisation, and the potential for significant off-site consequences arising from hazards identified for the proposed development.

> **Level 1 Assessment** - This is a qualitative assessment using word descriptions to approximately assess and rank risks.
>
> **Level 2 Assessment** - A semi-quantitative assessment that utilises the hazards identified in Level 1 and provides a focused quantification of key potential off-site risk contributors to demonstrate that risk criteria will be met.
>
> **Level 3 Assessment** - This involves a full quantitative risk assessment and is undertaken whenever the scale and nature of an activity creates a significant risk of a major accident. A full-scale analysis should also be carried out if partial quantification cannot sufficiently demonstrate that relevant criteria will be met.

Multi-Level Risk Assessment (DUAP, 1997) provides guidance on choosing the level of assessment required based on dangerous goods classes. This document suggests that a Level 1 - Qualitative Analysis would be suitable for Dangerous Goods Classes 1-3 and 6.1 (covering explosive, flammable and toxic materials), as long as the qualitative risk assessment indicates a negligible level of societal risk. However, if the qualitative analysis cannot demonstrate there will be no significant risk, a higher level of analysis is required.

3.1.5 Qualitative Analysis

Qualitative analysis uses words and descriptive scales to determine the likelihood of each identified hazard and its consequences. This provides an estimate of the likely rate of occurrence of hazardous events and their severity, from which a measure of the risk may be obtained through a simple matrix format of the equation:

Risk = Likelihood x Consequence

The risk associated with a proposed development is determined by combining the likelihood of the potentially hazardous events and their consequences using **Tables 3.1**, **3.2** and **3.3** below, which are adapted from *Australian/New Zealand Standard 4360: 1999 Risk Management.* The process of combining consequences and frequencies gives appropriate weight to the range between small consequence events (which are relatively frequent) and events of major consequence (which are very infrequent).

Table 3.1 - Qualitative Measures of Consequence or Impact or Severity

	Level	People Losses	Environmental Harm
1	Insignificant	No injuries	No-off-site effects
2	Minor	First aid treatment	On-site release immediately contained
3	Moderate	Medical treatment	On-site release contained with outside assistance
4	Major	Extensive injuries	Off-site release with no detrimental effects
5	Catastrophic	Death	Toxic release off-site with detrimental effect

Table 3.2 - Qualitative Measures of Likelihood

	Level	Description
A	Almost Certain	The event is expected to occur in most circumstances
B	Likely	The event will probably occur in most circumstances
C	Possible	The event might occur at some time
D	Unlikely	The event could occur at some time
E	Rare	The event may occur only in exceptional circumstances

Table 3.3 - Qualitative Risk Analysis Matrix

	Consequences				
Likelihood Level	**Insignificant 1**	**Minor 2**	**Moderate 3**	**Major 4**	**Catastrophic 5**
A (almost certain)	High	High	Extreme	Extreme	Extreme
B (likely)	Moderate	High	High	Extreme	Extreme
C (moderate)	Low	Moderate	High	Extreme	Extreme
D (unlikely)	Low	Low	Moderate	High	Extreme
E (rare)	Low	Low	Moderate	High	High

Legend:

EXTREME RISK; detailed research and management planning required at senior levels;
HIGH RISK; senior management attention needed;
MODERATE RISK; management responsibility must be specified; and
LOW RISK; managed by routine procedures.

** Adapted from AS/NZS 4360:1999 - Risk Management and Mineral Resources MDG 1010*

3.1.6 Quantitative Analysis

Quantitative analysis uses numerical values for both likelihood and consequences using data from a variety of sources including modelling, extrapolation from experimental studies or past data. A quantitative analysis can be used to estimate:

- Thermal radiation distances;
- Explosion overpressure;
- Toxic exposure levels; and
- Fatality risk levels.

3.1.7 Risk Assessment

Risk assessment involves comparing the level of risk found during the qualitative and quantitative analyses with previously established risk criteria, and deciding whether or not that level of risk can be accepted. Such decisions take into account the wider context of the risk and include consideration of the tolerability of the risks borne by external parties.

Low and acceptable moderate risks can be allowed with minimal further treatment, however, they should be monitored and periodically reviewed to ensure they remain at this level. Higher-level risks should be treated using safeguards (see **Section 3.1.8**).

3.1.8 Risk Treatment

A complete range of safeguards should be incorporated into the design and operation of the proposed development as prevention or protection measures for higher-level risks. These measures may include plant design features, organisational safety controls, emergency and counter disaster principles and approval processes. Options should be evaluated on the basis of the extent of risk reduction and the extent of benefits or opportunities they create. In general, the cost of managing risks should be commensurate with the benefits obtained.

3.1.9 Monitoring and Review

Risks and the effectiveness of control measures need to be continually monitored to ensure changing circumstances do not alter risk priorities. Factors which may affect the likelihood and consequences of an outcome may change, as may the factors which affect suitability or cost of various treatment options. Ongoing review is, therefore, essential to ensure that risk management activities remain relevant.

3.2 Human Health and Ecological Risk Assessment

The *National Environment Protection (Assessment of Site Contamination) Measure 1999* (NEPM) was made by the National Environmental Protection Council on the 10^{th} December 1999. The methodology followed in this risk assessment is generally consistent with the NEPM and has utilised US EPA approaches and data as required.

3.2.1 Human Health Risk

There are various models for the health risk assessment of contaminated sites (US EPA, 1989; National Academy of Sciences, 1983). This work has used the NEPM (1999), and protocols and guidelines recommended by the Australian and New Zealand Environment and Conservation Council (ANZECC) and the National Health and Medical Research Council (NHMRC), which generally draw on the USEPA guidelines.

Based on the US EPA (1989) model the following objectives are relevant to this risk assessment:

- To enable comparison of potential health impacts of various treatment techniques; and
- To provide a consistent method of appraising and recording public health risks.

The framework of risk assessment usually involves four stages, which are described by the US EPA (1989) as:

- Data collection and evaluation of the chemical condition of the site;
- Toxicity assessment of contaminants;
- Exposure assessment for the population on or near the site; and
- Risk characterisation.

The relationships between these stages are shown in **Figure 3.1**.

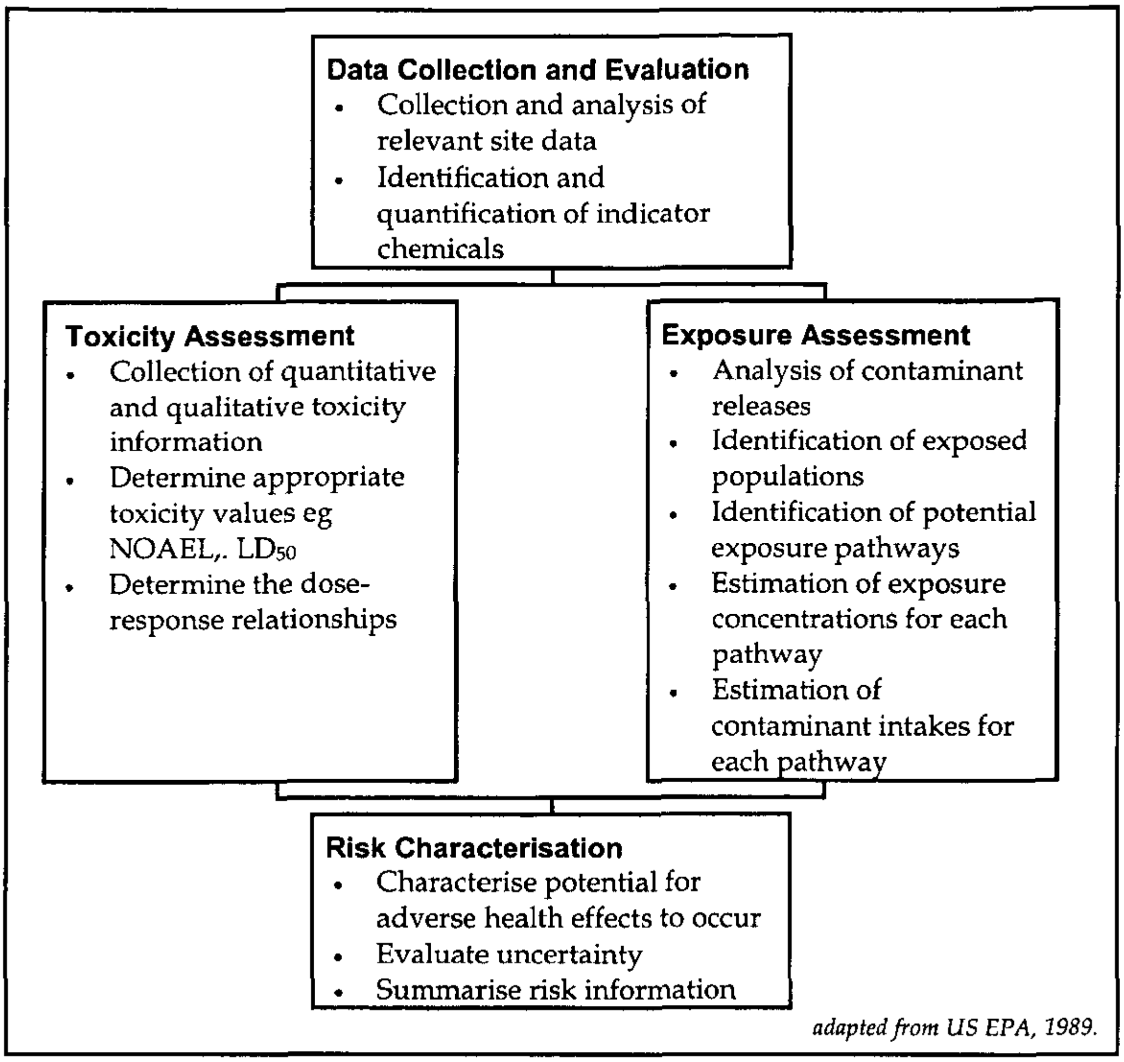

Figure 3.1 – Risk Assessment Model (NEPM, 1999)

Data collection entails the acquisition and analysis of information about chemicals on a site that may affect human health and which will be the focus for the particular risk assessment.

Toxicity assessment considers:

- The nature of adverse effects related to the exposure;
- The dose-response relationship for various effects; and
- The weight of evidence for effects such as carcinogenicity.

Both qualitative and quantitative toxicity information is evaluated to estimate the incidence of adverse effects occurring in humans at different exposure levels.

Exposure assessment involves estimating the frequency, extent and duration of exposures in the past, present, and in the future. It also identifies exposed populations and particularly sensitive sub-populations, and potential exposure pathways.

For the proposed development activities there is difficulty in assessing exposure concentrations and estimating the bioavailability and concentrations of contaminants of concern that may be released from the sediments during handling. It was considered that an alternative 'screening level' approach might best serve the proposed development in assessing human health risk.

This approach will consider that a contaminant can only pose a potential risk if a complete exposure pathway exists. Such a pathway usually consists of a contaminant traveling from its source via some release mechanism and/or transport medium and ultimately making contact with a potential receptor. Upon contact with the receptor there must also exist an exposure route (e.g. dermal contact, inhalation or ingestion) for the exposure pathway to be complete. An incomplete pathway therefore poses no risk to human health.

Based on the screening level approach suggested, the assessment will focus on identifying any significant exposure pathways. Should any significant pathways be identified then further investigation based on established methodology will be undertaken to assess the level of risk.

3.2.2 Ecological Risk

Traditionally Ecological Risk Assessment (ERA) is used to assess a contaminated site as a means of estimating the environmental impacts caused by, or likely to be caused by, the in-situ contamination (NEPM, 1999). The proposed development however, is in effect a voluntary remediation program for the contaminated river sediments, which should lead to an overall reduction in environmental risk across the development area. Hence with respect to this aspect of this ERA the focus will primarily be on the potential release of contaminants during extraction, handling, storage, processing and final disposal.

It should also be noted that whilst the ERA framework focuses on the sediment contaminants as the primary risk to ecological receptors, other development activities would also be considered in terms of their potential to pose significant ecological risk.

The objective of this ERA is:

- To identify the ecological receptors at risk;
- To qualitatively assess the impact of the proposed development on the identified ecological receptors;
- To consider the proposed mitigation strategies to minimise these effects, specifically with respect to minimising exposure risk; and
- To ensure that the development does not lead to ongoing environmental stressors (where stressors may include release of contaminants, other human activities and natural catastrophes).

Whilst the NEPM (1999) ERA approach is focussed primarily on terrestrial biota with a separate protocol in place for groundwater, the underlying framework for the assessment process provides a workable approach to the specific requirements of this proposed development.

Broadly the NEPM (1999) ERA approach identifies ecological receptors of concern, estimates the concentration that the ecological receptors are exposed to and, based on the magnitude of this concentration, determines whether the identified ecological receptors and ecological values may be at risk.

The framework utilises an 'Ecological Impact Level' (EIL), which is the concentration of a contaminant, which, if exceeded, may adversely impact upon site-specific ecological values.

The protection of ecological values is based on the question: 'What do we want to protect?' Clearly the ecological values to be protected will vary according to the societal relevance and the ecological and economic significance of biota that inhabit the site. The existing and proposed land use will also influence the ecological values selected and contribute to the development of site-specific contaminant investigation and response levels. Additionally, where site-specific data are unavailable, explicit, conservative, protective and scientifically reasonable assumptions may be made to fill the data gaps to ensure protection of ecological values.

The framework (**Figure 3.2**) is an iterative process that has three levels of ERA. Each level consists of the same basic components but incorporates an increasing degree of data collection and complexity and decreasing uncertainty as an assessment progresses through Level 1 to Level 3. The appropriate level of assessment can be determined by statutory requirements, type and concentration of contaminants, the availability of appropriate receptors, exposure and toxicity data, ecological sensitivity and the economic value of the site. This staged approach creates a flexible framework applicable to sites of varying complexity.

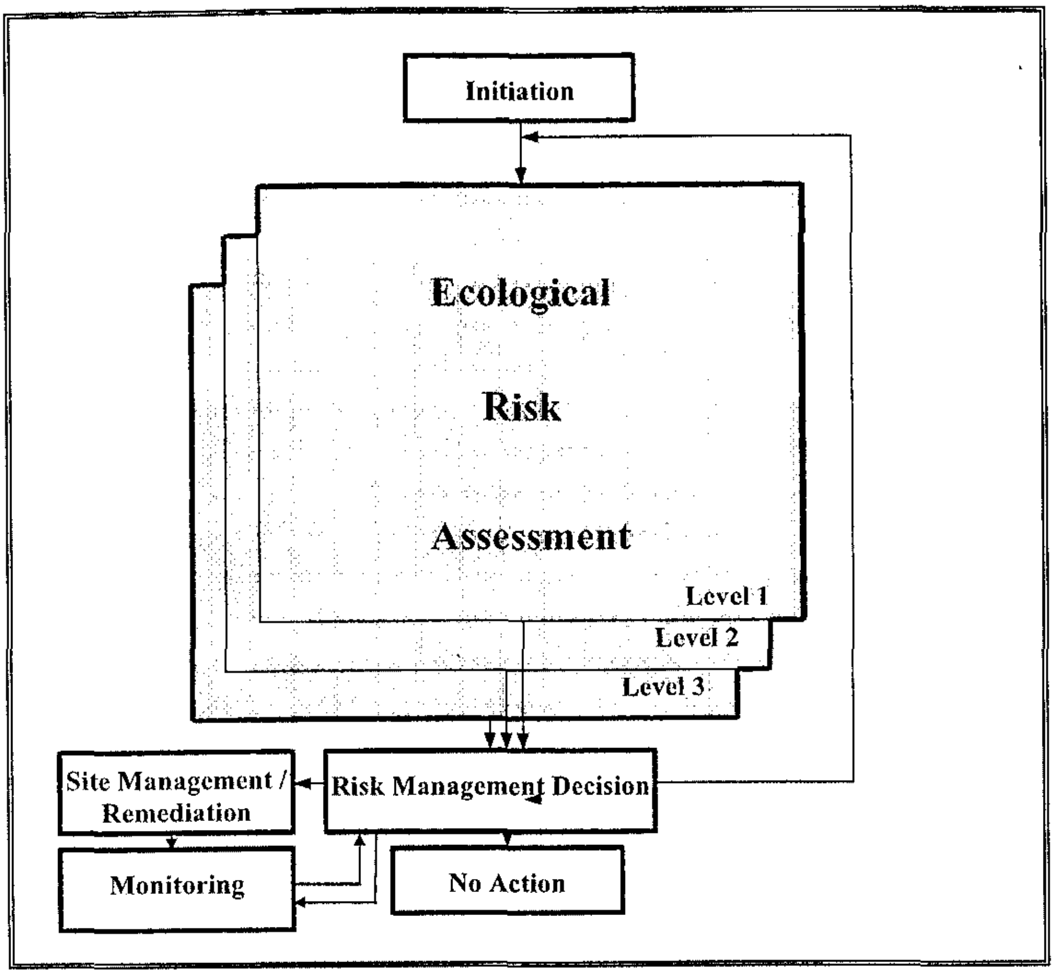

Figure 3.2 – Framework for Ecological Risk Assessment (NEPM, 1999)

In summary the ERA levels of assessment are:

Level 1

- Simple screening method designed to suit generic situations and protect all biota likely to inhabit the proposed development area and adjacent potentially impacted environments; and
- Involves comparison of the on-site contaminant concentrations with existing generic EILs.

Level 2

- Largely a desktop study with some field studies that provide an increased level of detail to components of the ERA process;
- Derives modified (site-specific) EILs for contaminants of concern; and
- On-site contaminant concentrations of concern are compared with the modified EILs to characterise the risk.

Level 3

- Field studies and use of sophisticated computer models to quantify exposure levels;
- Detailed site-specific information gathered as part of receptor identification, exposure assessment and toxicity assessment;
- Derives modified (site specific) EILs for contaminants of concern that take into account ecological values at the site; and
- On-site concentrations of contaminants of concern are compared with the modified EILs to characterise the risk.

Regardless of the level of assessment, an ERA is broken into five basic components (**Figure 3.3**).

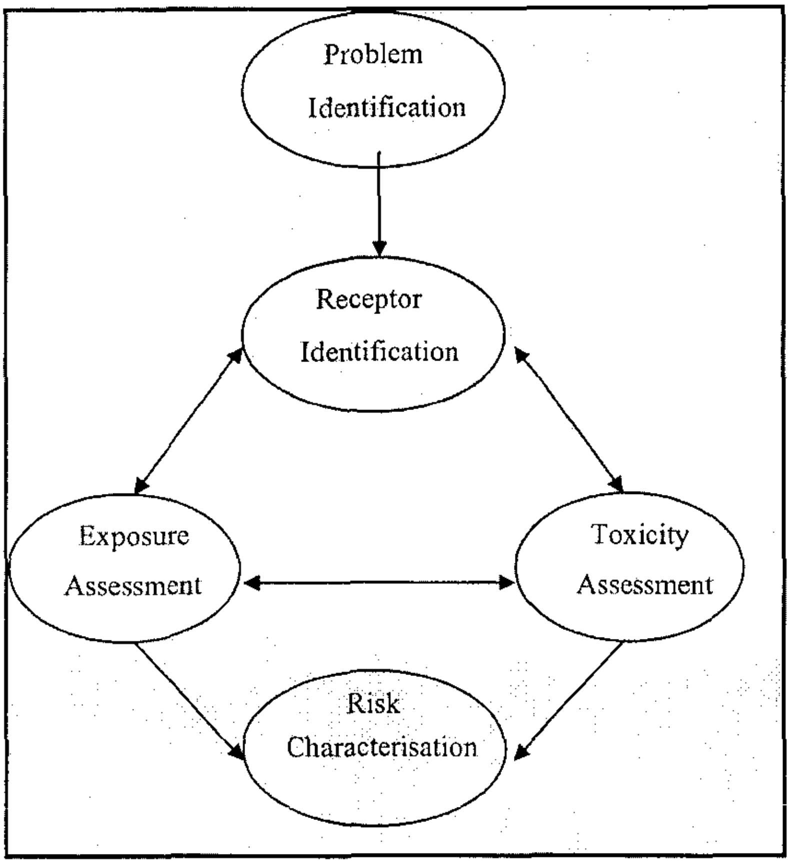

Figure 3.3 – Components of an Ecological Risk Assessment (NEPM, 1999)

Problem Identification

- Scoping phase to identify objectives, and the data required to achieve objectives.

Receptor Identification

- Identifies species' at risk and establishes those that require protection. This includes identification of local species, communities and ecological processes that may be of ecological value, taking into consideration societal relevance, ecological and economic significance; and

- The concept proposes that not every organism is at risk and not every organism can be protected. Acceptable (and unacceptable) ecological risk is developed in terms of protecting ecological values.

Exposure Assessment

- Characterises the physical setting, identifies potential exposure pathways and estimates exposure duration, concentrations and intakes; and
- Considers the influence of physical and chemical properties of the contaminants and toxicological properties on the potential exposure pathways thus providing a more site-specific estimate of the dose received.

Toxicity Assessment

- Determines the ecological toxicity effects of the contaminants and establishes the sensitivity of the receptors; and
- Determines the impact to the ecological values identified for the site.

Risk Characterisation

- Combines the exposure and toxicity information to determine the contaminant level that may impact upon the identified receptors.

The relationships between these components (**Figure 3.3**) indicates that the receptor identification, exposure assessment and toxicity assessment components are interrelated, as the assessment of any of these components is dependent upon the characteristics of the other two. Characterisation includes the combination of information gained in the exposure and toxicity assessments.

Toxicity assessment of the sediment, and filtrate of the sediments not suitable for ocean disposal, was undertaken by others (Simpson et al., 2001; Stauber et al., 2003). This ERA will use a similar approach to that adopted for the health risk assessment by considering the completeness of potential pathways before any in depth consideration is made of specific impacts utilising the results of the toxicity assessment reports.

3.2.2.1 Groundwater

The NEPM (1999) provides a *Guideline on Risk Based Assessment of Groundwater Contamination*. In this guideline groundwater is assessed based on its suitability for current or realistic future use and the risk that use may pose on human health and/or the environment.

This approach is not applicable for the proposed development since no immediate intention exists to use the groundwater. However, the potential discharge of contaminated groundwater into the South Arm from the former BHP site via disturbance of the existing bank is to be considered.

Additionally, due to the transfer of the sediments not suitable for ocean disposal onshore for processing, potential pathways for contaminant transfer back to the South Arm are possible, namely surface water runoff and infiltration into groundwater.

The trigger levels for these potential scenarios will be determined in line with the National Water Quality Management Strategy, *Australian Water Quality Guidelines for Fresh and Marine Waters* (AWQG) (ANZECC, 2000). The AWQG set out criteria for water quality relating to a number of environmental values, four (out of six) of which are relevant to this study:

- Aquatic ecosystems;
- Aquaculture and human consumers of food;
- Recreation and aesthetics; and
- Industrial water.

4. RISK ASSESSMENT

4.1 Existing Environment

Advitech has not attempted to reproduce the description of the existing environment: the reader is referred to the main EIS document. In summary the development area would generally be considered to be highly disturbed on both sides of the river. It is surrounded mainly by industrial users, excepting the public road corridor on the north side of the river and the Tourle Street Bridge to the west. Public access to the proposed development area is currently possible to the north side of the river from Cormorant Road. River access to the proposed development area is also obtained by commercial and recreational boats.

4.2 Facility Description

4.2.1 Location and Surrounding Land Uses

Again, Advitech has not attempted to reproduce the description of the location and surrounding land uses: the reader is referred to the main EIS document.

4.2.2 Process Description

Due to the number and nature of operations for the proposed development, Advitech has not attempted to reproduce a separate version of the process description in this report. The reader is referred to the full process description contained within the main body of the EIS.

4.3 Preliminary Hazard Analysis

4.3.1 Hazardous Materials

The proponent has advised that a range of hazardous substances would be stored and utilised on-site, some of which are defined as Dangerous Goods (DG) in accordance with the *Australian Code for the Transport of Dangerous Goods by Road and Rail* (ADG Code). **Table 4.1** summarises the substances and proposed inventories. It was assumed that only one weeks' worth of explosives would be stored on the site. This assumption was based on the number of blasts and area to be blasted. A usage rate of up to 2.9 t per day is possible based on a 24/7 operation to be able to complete blasting within the proposed project time frame. If a larger storage or less frequent deliveries are required the boundary separation distance requirement will increase not only for this screening but also under DG licensing requirements.

Table 4.1 – Hazardous Substances Inventories

Substance	Proposed Inventory	DG Class (subsidiary risk)	Plant Area	Storage Facility Type
Diesel	20,000 L	C1	Machinery area	Above ground tank
Lubrication oil	1,000 L	C2	Onshore	IBC*
Hydraulic fluid	1,000 L	C2	Onshore	IBC*
Explosives – Powergel Buster (including detonators)	20 tonne	1.1D	Onshore magazines as per AS 2187 series.	Mounded magazine

*IBC – Intermediate Bulk Container

4.3.2 Preliminary Risk Screening

A preliminary risk screening of the proposed development is required under SEPP 33. The methodology is described in Applying *SEPP33 - Hazardous and Offensive Development Application Guidelines* (DUAP, 1994).

The preliminary screening methodology concentrates on storage of specific dangerous goods classes that have the potential for significant off-site effects. For the proposed development these are:

- Class 1.1D explosives with a mass explosion hazard.

Diesel used to fuel machines involved in onshore excavation and materials handling will be stored in a bunded 20,000 L above ground tank. Combustible liquids such as diesel do not form part of the risk screening procedure unless stored with Class 3 goods. The diesel tanks and bunds will be installed in accordance with *AS 1940-1993: The storage and handling of flammable and combustible liquids*. It has been assumed that no Class 3 dangerous goods will be stored with the diesel.

The on-site machines will use a range of oils and hydraulic fluids. As noted above, any such combustible liquids do not form part of the risk screening procedure unless stored with Class 3 goods. It has been assumed that no Class 3 dangerous goods will be stored with the oils and hydraulic fluids. Therefore the risk screening was performed on the dangerous goods listed in **Table 4.2**.

Table 4.2 – Dangerous Goods Inventories for Risk Screening

Substance	Quantity	Location	Distance From Boundary	SEPP33 Screening Method	Breach Screening Threshold?
Class 1.1	Max. of 20 tonne	Former BHP steelworks site	At least 405m from Class A protected works and 610m from Class B protected works	Figure 5	No

Delivery frequencies have been estimated based on experience with similar industries and the proposed storage inventories and consumption rates. **Table 4.3** summarises the assumed number of annual vehicle movements for the various dangerous goods.

Table 4.3 – Estimated Vehicle Movements of Dangerous Goods

Substance	Annual Deliveries	Breach Screening Threshold?
Class 1.1	45	No. Proponent to prepare a transport safety study once explosive source location is known.

From these figures and the guidelines, the following conclusions can be drawn:

- The 'screening distance' from the boundary of the site for the 20 tonnes of Powergel Buster, Class 1.1D (explosives) is approximately 350 m (SEPP33 Figure 5). Since the storage area will be greater than this distance from the nearest boundary and the storage of the explosives will comply with the ADG Code (ADGC) and Australian Standards, specifically the 2187 series, the proposal is <u>not potentially hazardous</u> on the basis of explosive risk.
- Once the source of explosives is known, the proponent should prepare a Transport Safety Study. The study outcomes will determine the route and transportation requirements to ensure the delivery of explosives to the site is <u>not potentially hazardous</u> with respect to transportation issues.

In summary, the proposed development is not considered potentially hazardous on the basis of the explosive storage risk or any other hazardous substance listed in **Table 4.1** and a Preliminary Hazard Analysis (PHA) is not required, pursuant to Clause 12 of SEPP 33.

4.3.3 Level of Risk Assessment

The *Multi-Level Risk Assessment* (DUAP, 1997) guidelines indicate that a Level 1 qualitative assessment is appropriate as the preliminary risk screening has not identified any significant risk contributors, and the likelihood of an event with significant off-site consequences is negligible.

4.4 Hazard Identification

4.4.1 General

Hazard identification represents a Level 1 or qualitative risk assessment and involves documenting all possible events that could lead to a hazardous incident. It is a systematic process listing potential causes and consequences (in qualitative terms). Reference is also made to proposed operational and organisational safeguards (and their basis) that would prevent such hazardous events from occurring, or should they occur, that would protect the plant, its equipment, people and the environment. This process enables the establishment, at least in principle, of the adequacy and relevance of proposed safeguards.

The aim of the Hazard Identification Study process is to highlight risks associated with the interaction of the proposed development (as a whole) with the surrounding environment. A range of possible hazard scenarios were primarily developed by Advitech based on the results of previous risk assessments and industrial experience. Further development and ranking of scenarios in terms of consequence and likelihood was undertaken in consultation with the relevant stakeholders.

4.4.2 Risk Assessment Team

An objective assessment requires a team having a variety of skills so that discussion is stimulated, and the system is assessed from various points of view. The study team for this risk assessment consisted of six members with a wide range of experience, as listed in **Table 4.4**.

The role of Advitech during the study was to facilitate and document the outcomes. The Study Team provided their expertise and technical input with regard to the hazards and risks associated with the proposed facility.

Table 4.4 – Study Team Members

Attendee	Company	Position
Peter Tapp	Advitech	Senior Process Engineer
David Waddell	GHD	Manager Environment
Sophie Diller	The Ecology Lab	Ecologist
Tim Ellingham	Patterson Britton	Marine Engineer
Lyndon Bell	GHD	Hydrogeologist
David Hickie	GHD	Principal process engineer treatment technologies
David Gamble	GHD	Environmental Engineer
Ian Dawson	GHD	Dredging and marine engineering

4.4.3 Hazard Identification Tables

The hazard scenarios identified are presented in **Tables 4.5, 4.6** and **4.7**. Each hazard scenario was evaluated in terms of consequence and likelihood using the scoring methodology from **Tables 3.1** and **3.2**. A qualitative assessment of the resultant risk was then made using **Table 3.3**. The hazards identified are a result of deviation from normal operations and the qualitative risk assigned to each scenario takes into account the inherent and proposed physical, operational and organisational safeguards designed to reduce the consequence and likelihood of these hazards. Risks identified as high or extreme by the risk-ranking matrix were carried forward for further analysis *if the incident posed significant off-site risk.*

It is important to understand that the selection of the qualitative **consequence score (Table 3.1)** of the hazards identified is based on the *most likely* consequence given the *existing physical safeguards only*; it does not consider the soft barriers such as control systems, training or standard operating procedures.

The **likelihood score (Table 3.2)** is an estimation of the likelihood of the nominated consequence occurring. Alternatively, the likelihood score may be considered as an estimation of the effectiveness of the inherent and proposed physical, operational and organisational safeguards.

4.4.4 Assumptions

In undertaking the Hazard Identification Study a number of assumptions were made. These include:

- Preliminary hazard scenarios are based on information gathered from documentation provided by GHD to Advitech and verbal communications between Advitech, GHD and other sub consultants;
- All plant and equipment is operated and installed in accordance with appropriate Australian Standards, codes and guidelines;
- Dangerous goods quantities and locations are as notified/supplied by GHD and Patterson Britton;
- Dangerous goods are stored in accordance with the ADG Code, relevant standards and guidelines even if not of a licensable quantity;
- The onshore treatment area stormwater system is based on a first flush system with the remainder to run off; and
- All equipment and systems are designed to be inherently safe.

Table 4.5 – Hazard Identification – Human Receptors

Company: Newcastle Port Corporation **Date:** 8-2-03

Drawing No: **Page:** 1 of 4

Receptor Group: Human

Ref.	Hazard / Incident Scenario	Potential Receptors	Cause	Consequence	Protection Measures / Barriers	C	L	Risk
1.1	Contaminant exposure via ingestion, skin contact with sediment, sediment water mixture, dewatered sediment, water removed from sediment	Barge employees, treatment plant employees, machine operators	Loss of containment (leak, spill, rupture)	Skin complaint, acute/chronic effects	PPE, sheet pile wall, double turbidity curtain, restricted access to development works, procedural, design of equipment, remote work stations, dilution	2	D	Low
1.2	Odour/gas inhalation from volatiles in sediment	Barge employees, treatment plant employees, machine operators, employees of surrounding industry, general public	Release from dredge grab, dewatering equipment, treatment plant stack, geobags, return drains, confined spaces, striking unknown item in onshore excavation,	Headache, nausea, overcome by odour	Procedural, restricted access, enclosed nature of process, confined space regulations, odour control measures, process control on treatment plant, PPE	2	D	Low

Ref.	Hazard / Incident Scenario	Potential Receptors	Cause	Consequence	Protection Measures / Barriers	C	L	Risk
1.3	Dust inhalation	Barge employees, treatment plant employees, machine operators, employees of surrounding industry, general public	Truck, excavator movements/ operations, dispersed from stockpiling of fine sediments (contaminated or uncontaminated)	Respiratory, eye, dermal irritation	No sediments not suitable for ocean disposal stored in open, covered trucks, dust suppression, minimal storage	1	D	Low
1.4	Fire	Barge employees, treatment plant employees, machine operators, employees of surrounding industry, general public	Diesel storage	Pollution from plume, odours, particulates etc. Headache, nausea, overcome by odour	DG regulations, storage size and distance from receptors, installation compliant to AS1940	1	E	Low
1.5	*Explosives*	*Barge employees,* treatment plant employees, machine operators, employees of surrounding industry, general public	Accidental detonation of storage magazine	Uncontrolled blast injury	DG Regulations, Australian Standards (AS 2187 series), storage size and distance from receptors, procedures, secure enclosure & security patrols	3	E	Moderate
1.6	Explosives	Barge employees, treatment plant employees, machine *operators, employees* of surrounding industry, general public	Premature detonation after placement	Injury, uncontrolled explosion, vibration impacts on *surrounding structures*	Safety procedures, handling, training, etc	3	E	Moderate
1.7	Explosives	Barge employees, treatment plant employees, machine operators, employees of surrounding industry, general public	Insufficient warning or notice given of intended blasting	Injury, annoyance	Safety procedures, handling, training, etc	2	E	Low

Ref.	Hazard / Incident Scenario	Potential Receptors	Cause	Consequence	Protection Measures / Barriers	C	L	Risk
1.8	Explosives	Barge employees, treatment plant employees, machine operators, employees of surrounding industry, general public	Noise, vibration	Annoyance to residents	Advertising, notification, hours of operation, safety procedures, handling, training, etc	1	D	Low
1.9	Explosives	General public	Proximity of public to blast due to inadequate barriers	Injury	Safety procedures, handling, training, site security, exclusion zones, etc	3	E	Moderate
1.10	Explosives	Barge employees, treatment plant employees, machine operators, employees of surrounding industry, general public	Projectiles from blast	Injury	Safety procedures, handling, training, site security, exclusion zones, etc	3	E	Moderate
1.11	Night time navigation	Barge employees, Commercial Fisherman, Recreational fisherman, Public river users, tug and line boat operators	Lack of adequate marking and publication of navigational changes	Vessels striking the sheet pile wall, another dredge or barge etc, breach of sheet pile wall (loss of integrity)	Port corp to give new design for navigation. Navigational aids, advertising, channel closure as required	2	D	Low
1.12	Vessel collision with dredges, pipeline, sheet pile wall, etc	Barge employees, Commercial Fisherman, Recreational fisherman, Public river users, tug and line boat operators	Lack of marking, weather conditions, etc. loss of control,	Potential injury, sinking of one or both vessels, loss of sediment to river	Marking of vessels, procedures, training, scheduling	2	D	Low

Ref.	Hazard / Incident Scenario	Potential Receptors	Cause	Consequence	Protection Measures / Barriers	C	L	Risk
1.13	Consumption of organisms	Food consumers	Recreational or commercial sources	Nausea, chronic or acute sickness	Silt curtains, sheet pile, environmental monitoring and sampling, scheduling of activities, avoidance of prawn migration period	2	E	Low
1.14	*Dredge/ barge* sink/overturn and lose load of sediment (contaminated or not)	*Barge employees*	*Poor loading, collision*	Personal injury, loss of load to river	Training, regulations, procedures, etc	3	E	Moderate
1.15	Floating or submerged debris, coming down the river or being discharged to river	Barge employees, Commercial Fisherman, Recreational fisherman, Public river users, commercial divers, tug and line boat operators	High river flow, accidental loss	Potential injury due to navigational hazard, loss of silt curtain, loss of production,	Naturally occurring in waterway, removed if possible prior to works	1	D	Low
1.16	Slump of river banks during excavation	Excavation machine drivers, excavation workers	Loss of structural integrity	Engulfment/ release of toxic gas	Procedures, excavation practices, containment of area	2	D	Low

C – consequence
L – likelihood

Table 4.6 – Hazard Identification – Environmental Receptors

Company: Newcastle Port Corporation
Drawing No:
Receptor Group: Environment

Date: 8-2-03
Page: 1 of 4

Ref.	Hazard / Incident Scenario	Potential Receptors	Cause	Consequence	Protection Measures / Barriers	C	L	Risk
2.1	Release of sediments not suitable for ocean disposal/ uncontaminated sediment/water mix from inside sheet pile wall	Aquatic organisms (fish, molluscs, crustaceans, macro/micro algae, benthic invertebrates, mangroves), river water, river bed, RAMSAR wetlands, Hexham Swamp	Breach of sheet pile wall - due to boat/barge/ship collision, structural failure, high river flow, external dredging weakening support	Increased turbidity, relocation of contaminants, bioaccumulation, contaminant release	Procedures, environmental monitoring, dredge procedures, turbidity curtain, sheet pile wall structural integrity, scheduling, timing, navigational marking	3	E	Moderate
2.2	Release of high turbidity water from main river dredging	Aquatic organisms (fish, molluscs, crustaceans, macro/micro algae, benthic invertebrates, mangroves), river water, river bed, RAMSAR wetlands, Hexham Swamp	Failure of turbidity curtain, reduced mitigation measures, blasting	Increased turbidity, relocation of low level contamination, bioaccumulation	Procedural, environmental monitoring, dredge procedures, turbidity curtain, scheduling, timing	2	C	Moderate

Ref.	Hazard / Incident Scenario	Potential Receptors	Cause	Consequence	Protection Measures / Barriers	C	L	Risk
2.3	Explosive residues	Aquatic organisms (fish, molluscs, crustaceans, macro/micro algae, benthic invertebrates, mangroves), river water, river bed, RAMSAR wetlands, Hexham Swamp, disposal sites	Release of products of explosions or potentially unexploded explosive into the river	Potential toxicity impact on aquatic organisms, potential for explosive to be contained in resulting rock to be dredged, could be transferred to disposal site	Procedures to ensure complete blasting has occurred and techniques to dispose of unexploded explosive material in line with AS2187 requirement, use appropriate blast quantity	1	C	Low
2.4	Release of sediments not suitable for ocean disposal or water or a mixture from onshore treatment site – contained on treatment site	Terrestrial organisms (birds, plants), groundwater, disposal sites	High rainfall event, process failure - overflow/ burst pipe etc, storage facility failure or undersized or loss of integrity of liner, blocked dredge pipes required to be broken down to find blockages, truck spillage	Groundwater pollution, health impacts for treatment workers	On shore management of dewatering process, spill management procedures, bunding, site drainage	1	D	Low
2.4a	Release of sediments not suitable for ocean disposal or water or a mixture from onshore treatment site – released to river	Aquatic organisms (fish, molluscs, crustaceans, macro/micro algae, benthic invertebrates, mangroves), river water, river bed, RAMSAR wetlands, Hexham Swamp	High rainfall event and failure of stormwater management system, process failure - overflow/ burst pipe etc, storage facility failure or undersized or loss of integrity of liner, blocked dredge pipes required to be broken down to find blockages	Increased turbidity, contaminant release	On shore management of dewatering process, and stormwater management system	2	D	Low

Ref.	Hazard / Incident Scenario	Potential Receptors	Cause	Consequence	Protection Measures / Barriers	C	L	Risk
2.5	Explosive use	Aquatic organisms (fish, molluscs, crustaceans, benthic invertebrates)	Routine blasting, shockwaves	Impact on nearby aquatic organisms	Set off lesser charge to scare animals from area prior to major blast	2	D	Low
2.6	Disturbance of sediments not suitable for ocean disposal outside sheet pile wall	Aquatic organisms (fish, molluscs, crustaceans, macro/micro algae, benthic invertebrates, mangroves), river water, river bed, RAMSAR wetlands, Hexham Swamp	Normal dredging uncovering unknown contaminants and releasing to river (may go undetected or may be detected by regular monitoring around dredge and in river control sites)	Potential toxicity to organisms, relocation of contamination, bioaccumulation, contaminant release	Regular sampling, turbidity curtain, procedures to stop dredging immediately on detection	2	C	Moderate
2.7	Slump of river banks during excavation/ dredging	Aquatic organisms, river water	Loss of structural integrity	Release/ disturbance of toxic sediment or increase in turbidity	Containment of excavation site, excavation procedures	2	D	Low
2.8	Unknown contaminant discovery in north/south bank excavation	River, aquatic organisms	Lack of sampling in area, unknown contents	Contaminant release to river/ air/ groundwater	Adequate mapping of potential contaminants in area to be excavated, procedures, response techniques, planning, contingency	2	E	Low
2.9	Change in hydrology of river	Travelling aquatic organisms (prawns fish)	Increased water velocity	No migration upstream, disorientation, death	Scheduled works around migration			
2.10	Accelerated dispersion of contaminants from the BHP site both soil and groundwater borne	River water and aquatic organisms	Disturbance of river banks, change to groundwater hydrology	Increased COPC in river water, toxicity to aquatic organisms	Reduced surface water infiltration on former BHP steelworks site due to capping			

Ref.	Hazard / Incident Scenario	Potential Receptors	Cause	Consequence	Protection Measures / Barriers	C	L	Risk
2.11	Potential to increase contaminant levels or introduce new one at the site of treatment plant on the old BHP site	Groundwater, existing site	Release of contaminants from treatment plant	Increase in levels of COPC to existing site and groundwater aquifer	Procedures, bunding, hard surface paving/low permeability and contained drainage in treatment plant area	1	D	Low
2.12	Release of contaminants during installation of sheet pile wall	Aquatic organisms, river water	Disturbance of sediment, vibration	Potential toxicity to organisms, relocation of contamination, bioaccumulation, contaminant release	Turbidity curtain, driven into sediment of low contaminant concentration	2	C	Low
2.13	Nutrient release leading to algal bloom	Aquatic organisms, river water	Disturbance of sediment during dredging	Potential toxicity to organisms, algal bloom	Turbidity curtain, dilution, scheduling to minimise upstream migration	2	C	Moderate
2.14	Change to flooding characteristics	Mangroves	Proposed development dredging			1	E	Low
2.15	Saline intrusion to groundwater	Groundwater aquifers on existing BHP site	Change in bank location, deepening of river bed	Change to groundwater hydrology		1	E	Low
2.16	Release of acid sulphate soils	River water and aquatic organisms, disposal area	Dredging and excavation of bank areas to the north and south and in the swing basin area	Release to river water	Potential areas for generation have been identified and material will be handled using established techniques	2	C	Moderate

C – consequence
L – likelihood

Table 4.7 – Hazard Identification – Plant and Equipment Receptors

Company: Newcastle Port Corporation
Drawing No:
Receptor Group: Plant and Equipment

Date: 8-2-03
Page: 1 of 1

Ref.	Hazard / Incident Scenario	Potential Receptors	Cause	Consequence	Protection Measures / Barriers	C	L.	Risk
3.1	Explosive use	Onshore buildings, plant and equipment, adjacent industry, residential houses	Routine blasting, high charge blasting, two charges set off at once	Damage to structures such as sheet pile wall, bank slump, dredges, other on shore structures, pipelines, etc	Scheduling of blasting, blast size maintained below quantity that may cause off site impact/damage (Richard Heggie Associates, 2003)	1	E	Low
3.2	Release of sediments not suitable for ocean disposal, high turbidity incident	Other river water users such as other industry for cooling, hose down, process water, etc.	Loss of containment (leak, spill, rupture)	Process upset, equipment damage etc	Sheet pile wall, turbidity curtains, procedures, dilution, minimal migration away from site	1	E	Low

C – consequence
L – likelihood

4.5 Consequence Analysis

The preliminary risk screening has identified no instances where the screening thresholds have been exceeded; consequently, there are no credible scenarios that may lead to off-site effects as a result of explosives storage. Additionally, the Hazard Identification Study has not detailed any scenarios with significant off-site impacts. Since no credible off-site impacts are evident, a quantitative consequence analysis is not required.

4.6 Likelihood Estimation

Since there are no credible hazard scenarios from the proposed development with significant off-site consequences it is not necessary to provide an estimation of event likelihood.

4.7 Conclusions

The relative significance of quantified risk estimates can be assessed by comparison with other risks that people experience in everyday life. In setting risk criteria, the underlying principle is that people should not involuntarily be subject to a risk from development that is significant in relation to the background risk associated with the exposed land use.

The area surrounding the proposed development site is characterised by ongoing industrial use. The current population density is low due to the nature of the current land-use. The nearest residential properties are located some distance away from the proposed development area, on the opposite site of adjoining industrial operations. They are also significantly beyond the maximum fatal extent of all credible hazard scenarios considered. The risk classification and prioritisation in **Section 4** determined no credible off-site effects.

4.7.1 Risk Evaluation – Qualitative Criteria

The methodology used to review the risks associated with the proposed development addressed the following qualitative criteria:

1. *All avoidable risks have been avoided and remaining risks have been reduced to as low as reasonably practicable.*

The Hazard Identification Study has sought to identify all avoidable risks. As a result the proponent has accepted the findings of this study, and undertaken to carry out the proposed development works in such a way as to minimise identified risks. The proposed development should effectively mitigate the identified risks through appropriate safeguards and barriers.

2. *Consequences of the more likely hazardous events are, wherever possible, contained within site boundaries.*

All hazard scenarios considered are expected to be contained within the site boundaries.

3. *Where there is an existing high risk, then the additional hazardous development does not add significantly to the risk.*

The proposed development does not result in any significant off-site consequences and therefore cannot add significantly to any identified cumulative risks in the Kooragang Island industrial zone. The risk assessment process has demonstrated that the proposed development will not result in a higher off-site risk.

5. DATA FOR HUMAN HEALTH AND ENVIRONMENTAL RISK ASSESSMENT

Contaminants of potential concern (COPC) are those contaminants which are known, or suspected to be present at the site in sufficient amounts or concentrations, to warrant further consideration with respect to risks to human health or the environment.

Data used to complete this component of the risk assessment was gathered from sediment sampling investigations carried out since 1990 by Dames and Moore (1990), GHD (1996, 2001), Patterson Britton (2000, 2001), and Robert Carr and Associates (1995, 2000, 2002). These works included sediment sampling at various locations and at a range of depths across the proposed dredging area.

Additionally, sampling carried out as part of the CSIRO toxicity impact assessments for sediment and elutriate (sediment filtrate) has given indicative results for the likely concentrations of contaminants that may be dissolved in the water column as a result of dredging. The conclusions of the toxicity assessments have also been utilised in determining the impacts of the contaminants on human health and the environment. The results of these reports have allowed a better understanding of the impacts of the identified contaminants.

It has been assumed that each company has carried out their own assessment of data quality as an integral part of their sediment contamination investigation reporting.

5.1 Nature and Extent of Contaminants

COPC have been identified by comparison of values of maximum concentration across the proposed dredging area with appropriate sediment and water quality guidelines based on health and environment (**Table 5.1 and 5.2**). In addition to adopting this highly conservative approach, the results of the CSIRO toxicity impact assessments have been considered with respect to ecotoxicological effects where appropriate.

5.1.1 Sediment

The available sediment quality guidelines are not for the protection of human health but are based on disturbances to biological receptors (**Table 5.1**).

Table 5.1 Sediment Quality Guideline Values (ANZECC 2000)[a]

Analyte	Environmental Sediment Quality Guideline Trigger Values	
	Low	High
Metals and Metalloids (mg/kg dry wt)		
Arsenic	20	70
Cadmium	1.5	10
Chromium	80	370
Copper	65	270
Lead	50	220
Manganese		
Mercury	0.15	1
Nickel	21	52
Silver	1	3.7
Tributyltin (µg Sn/kg dry wt)	5	70
Zinc	200	410
Organics (µg/kg dry wt) [b]		
Acenapthene	16	500
Acenapthalene	44	640
Anthracene	85	1100
Fluorene	19	540
Napthalene	160	2100
Phenanthrene	240	1500
Low molecular weight PAHs [c]	552	3160
Benzo(a)anthracene	261	1600
Benzo(a)pyrene	430	1600
Dibenzo(a,h)anthracene	63	260
Chrysene	384	2800
Fluoranthene	600	5100
Pyrene	665	2600
High molecular weight PAHs [c]	1700	9600
Total PAHs	4000	45000
Total DDT	1.6	46
p.p' – DDE	2.2	27
O,p'-+p,p'-DDD	2	20
Chlordane	0.5	6
Dieldrin	0.02	8
Endrin	0.02	8
Lindane	0.32	1
Total PCBs	23	-

a Primarily adapted from Long et al. (1995)

b Normalised to 1 % organic carbon

c Low molecular weight PAHs are the sum of concentrations of acenapthene, acenapthalene, anthracene, fluorene, 2-methylnathalene, naphthalene and phenanthrene; high molecular weight PAHs are the sum of concentrations of benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, fluoranthene and pyrene.

5.1.2 Surface Water

Environmental and health based guidelines have been used to assess South Arm river water. Health based guidelines are relevant due to the potential recreational use of the Hunter River, hence water quality guidelines for recreational use have been adopted. Environmental guidelines are relevant to the aquatic ecosystem and values for a *slightly-moderately disturbed system* have been adopted.

Table 5.2 – Water Quality Guideline Values (ANZECC, 2000)

Analyte	Human health based water quality guideline (recreational) (µg/L)	Environmental water quality guideline (slightly-moderately disturbed systems) (µg/L)
Metals and Metalloids		
Arsenic	50	ID
Cadmium	5	5.5
Chromium (VI)	50	4.4
Copper	1000	1.3
Lead	50	4.4
Manganese	100	80
Mercury	1	0.1 (inorganic)
Nickel	100	7
Silver	50	1.4
Tributyltin	-	0.006 (as µg/L Sn)
Zinc	5000	15
General		
Ammonia (as Total NH_3)	12	910
Cyanide	100	4
Organics		
Phenol	-	400
Total PAHs	-	3 [1]
Benzene	10	500
Toluene	-	ID
Ethylbenzene	-	ID
Total Xylenes	-	-
TPH C6-C9	-	-
TPH C10-C40	-	-
Acenapthene	-	-
Acenapthalene	-	-

Analyte	Human health based water quality guideline (recreational) (µg/L)	Environmental water quality guideline (slightly-moderately disturbed systems) (µg/L)
Anthracene	-	ID
Fluorene	-	-
Napthalene	-	50
Phenanthrene	-	-
Benzo (a) anthracene	-	-
Benzo(a)pyrene	0.01	ID
Dibenzo (a,h) anthracene	-	-
Chrysene	-	-
Fluoranthene	-	ID
Pyrene	-	-
Total DDT	3	ID
p.p' – DDE	-	ID
O,p'-+p,p'-DDD	-	-
Chlordane	6	ID
Dieldrin	1	ID
Endrin	1	0.004
Lindane	10	ID
Total PCBs	0.1	ID

1 ANZECC, 1992

ID Insufficient data to derive a reliable trigger value

- no data available

Where gaps appear in the data, it is because insufficient data is available to set an appropriate guideline.

5.2 Site Contaminants of Potential Concern

Using the method described in **Section 5.1** COPC have been identified (**Table 5.3**). In establishing COPC no distinction was made between sediment sample depths.

In addition to the ANZECC guidelines, the COPC have been determined with reference to the ecotoxicology information presented in the CSIRO work (Simpson et al., 2001; Stauber et al., 2003) to determine site-specific impacts.

Based on the relative trigger levels (**Tables 5.1 and 5.2**) the environmental receptors are more likely to be impacted by the development than the human receptors.

Table 5.3 – Site Contaminants of Potential Concern

Species	Media		
	Sediment	**River water – Relevant to the Environment**	**River water – Relevant to Human Health (recreational use)**
Metals	None*	None*	None*
Non-metallic inorganics	None	None^	Ammonia
Organics	PAHs	PAHs	PAHs
Pesticides	None#	None#	None#

* Whilst the concentrations of a number of metals exceed the ANZECC guidelines, CSIRO studies have indicated that the metals in these sediments would not be bioavailable to organisms (Simpson et al., 2001).

^ CSIRO ecotoxicological studies have indicated that the ammonia levels in the *geobag filtrate* (water removed from the sediment once it has been transferred to shore) may be acutely toxic and a dilution factor of 100 to 1 would be required to minimise the risk of impact should the water be reintroduced to the river. Based on field sampling carried out during dredging operations the levels of ammonia released into the water column during dredging within the turbidity curtain *are* greater than 100 times *less* than the toxic levels reported by the CSIRO work (Stauber et al., 2003) and an order of magnitude below ANZECC, 2000 guideline values.

Concentrations of organochlorine pesticides were below the detection limit in all sediment elutriates, indicating that these contaminants were not likely to contribute to toxic effects (Simpson et al., 2001).

6. HUMAN HEALTH RISK ASSESSMENT

6.1 Introduction

This screening level human health risk assessment was undertaken in accordance with the methodology presented in **Section 3** and where applicable is consistent with the approach outlined in the *National Environment Protection (Assessment of Site Contamination) Measure 1999* (NEPC, 1999).

This health risk screening assessment has focused on identifying potential pathways that could expose receptors to contaminants. Conservative assumptions were used to over estimate the actual risks posed in order to clearly identify COPC with the potential to cause unacceptable risks to human health.

Pathways available for contaminants to reach receptors are largely dependent on the nature of activities conducted on the site. In undertaking this human health risk assessment it is understood that the proposed development is expected to reduce the overall level of contamination in the river and that the risks identified are specific to and will remain current, only during the proposed development period.

6.2 Potential Exposure Pathways

A contaminant can only pose a potential risk if a complete exposure pathway exists. Such a pathway usually consists of a contaminant traveling from its source via some release mechanism and/or transport medium and ultimately making contact with a potential receptor. Upon contact with the receptor there must also exist an exposure route (e.g. inhalation, ingestion or dermal absorption) for the exposure pathway to be complete. An incomplete pathway therefore poses no risk to human health.

The receptor groups identified for this health risk assessment include:

- Barge / dredge workers;
- Treatment plant workers;
- Onshore machine operators;
- Off site workers (those that work in the near vicinity);
- River users (recreational and professional);
- Consumers of aquatic organisms taken from the development area;
- Public users of adjacent public roadways and the north bank of the river; and
- Off site residents.

Generally COPC would be regarded as more likely to affect those working on or close to the site rather than those off site. However, due to the ability of commercial and recreational river users (shore and water based) to obtain access to the development area these will be considered as potential receptors also.

Having identified the potential receptors we must also identify the potential pathways and assess their significance in this context. For this site these include:

- Direct contact with extracted sediment materials;
- Inhalation of dusts generated from sediment stockpiles;
- Inhalation of volatile chemicals present in extracted sediment and released during extraction, handling or processing;
- Direct contact with a highly turbid river water plume released via an uncontrolled release from dredging the area containing sediments not suitable for ocean disposal;
- Direct contact with water removed from dredged sediment; and
- Consumption of aquatic organisms that have bioaccumulated contaminants.

6.2.1 Exposure to Tar Pits

Contact and exposure are most likely during shore based earthwork activities. The excavation of the south bank swing basin may potentially expose old tar disposal pits. This may expose workers via ingestion, direct contact or inhalation. In considering these potential exposure routes, the entry of workers into excavations may require the application of such safety considerations as confined space regulations.

Worker exposure is considered insignificant for these shore-based activities when the relevant protocols are considered and implemented as part of the site safety plan.

6.2.2 Ingestion or Dermal Contact with Sediments

Direct contact with sediment material via ingestion or dermal contact is considered insignificant due to the remote nature of the material handling techniques. Workers will generally be confined to enclosed cabins either in barge mounted or shore based excavators or in barge wheelhouses.

Incidents such as truck spillage, which may require manual handling of sediments not suitable for ocean disposal, are considered insignificant due to the low frequency of occurrence and the use of appropriate techniques and PPE to minimise exposure to the sediment material. There will be no onshore manual handling of the sediments not suitable for ocean disposal. Machine operators transferring the material to the treatment plant would be adequately separated from these potential exposure pathways in enclosed cabins fitted with appropriately filtered air conditioning. Driver entry and exit of the machines is likely to be away from the sediment handling area.

6.2.3 Inhalation of Volatile Contaminants

Similarly, the inhalation by on site workers of volatile contaminants residing in the sediment will be minimised due to the remote nature of the handling procedures developed for the sediments not suitable for ocean disposal. Odour modelling results (Environmental Odour Laboratory, 2003) have indicated that the odour levels at the nominated off-site receptors are below offensive levels. Sampling of volatile organics and species such as hydrogen sulphide has determined that exposure levels are below the relevant exposure standards (Environmental Odour Laboratory, 2003). Appropriate PPE and procedures to mitigate impacts on workers as required will be implemented as part of the site safety plan.

In addition to the odour assessment, GHD has investigated ground level concentrations (GLC) of Naphthalene at offsite receptor locations to ensure that the proposal will not exceed acceptable levels. The reader is referred to the main body of the EIS for these results.

6.2.4 Dust Inhalation

The inhalation of contaminated dusts from sediment stockpiles as a result of wind, excavation and treatment activities is considered insignificant. This is due to the proposed implementation of dust suppression controls and minimisation of exposed stockpiling of either uncontaminated or sediments not suitable for ocean disposal. Water trucks would be used throughout the works in accordance with the site environmental management plan.

The shore-based works to be carried out as part of the proposed development are similarly considered an insignificant pathway and will be managed via appropriate dust suppression techniques.

6.2.5 Ingestion of Shellfish

The human health risk due to ingestion of shellfish from the river, that may be affected via contaminants being remobilised and migrating away from the development area, is considered insignificant due to the proposed mitigation techniques. These techniques effectively form physical barriers to the migration of contaminants into the surrounding aquatic environment.

The clear identification and effective encapsulation of the sediments not suitable for ocean disposal via a sheet pile wall will effectively form a physical barrier to prevent the escape of sediments not suitable for ocean disposal and potentially affected water. Within the sheet pile wall a double turbidity curtain will be used around the dredge(s) extracting the sediments not suitable for ocean disposal thus effectively forming a second barrier. Whilst elevated levels of contaminants have been recorded in river biota from the area, the source of these contaminants has been generally apportioned to process water discharge from the former steelworks operations (Robert Carr, & Associates 1999). Additionally, there is a ban on the taking of shellfish from the South Arm thus making this pathway insignificant.

6.2.6 Consumption of Fish

The likelihood of the proposed development altering the levels of bioaccumulated contaminants in fish and crustaceans taken from the river by recreational and commercial fisherman is considered insignificant due to the proposed mitigation barriers outlined previously (**Section 6.2.5**). The occasional nature of fishing in the South Arm area, the migratory movement of fish and crustaceans over the period of the development works and the scheduling of the works to minimise impact on these resources also minimises the likelihood of this pathway being significant.

6.2.7 Recreational Use

Similarly, the effect on human health of potentially elevated contaminant levels in the Hunter River due to disturbance via dredging is considered insignificant, since the South Arm is not a primary recreational area and any exposure would be of a short-term incidental nature. Receptor groups include fishermen (recreational and professional), other boat users and professional divers required to inspect wharfs, ship hulls, etc.

The generation of water from onshore dewatering operations will be minimised and carefully controlled. The process will consist of a holding facility that is sampled prior to specific batch treatment and discharge. As this will minimise any potential impact this pathway is considered insignificant.

The stormwater management system for the treatment plant area will include sedimentation basins to contain run-off prior to water being discharged to existing drains and back to the river. Treatment plant process spills will be contained in separate bunded areas specific to the plant unit operations at risk. Hence the risk of contaminant release via this pathway is considered insignificant.

It should be noted that whilst ammonia was identified as a COPC for recreational water, the guideline value has been derived to prevent the excessive growth of algae in recreational areas, rather than to protect humans from toxic effects. Hence for the class of use as outlined above it has negligible risk impacts.

6.3 Conclusions

No significant human health exposure pathways were identified. However, a number of potential deviations from normal operations that may lead to isolated potential health impacts have been identified (**Section 4, Table 4.5**) and their risk of occurrence has been assessed. The proposed techniques and barriers associated with the proposed development operations effectively prevent the identified exposure pathways being completed. Hence the human health risk is negligible.

The key exposure pathways identified were direct contact with sediment and localised inhalation of volatiles from potential tar pits on-site. These pathways are not relevant for off-site workers, residents or the public. On this basis the potential risks to off-site receptors are negligible.

7. ECOLOGICAL RISK ASSESSMENT

This assessment was conducted qualitatively and in line with the Guideline where applicable. The following steps have been taken:

- Identification of appropriate environmental quality guidelines (see **Section 5**);
- Assessment of the potential for contaminant migration beyond the proposed development area boundaries; and
- Assessment of the potential for contaminant migration to adversely affect the quality of the river water and biota in the Hunter River.

7.1 Potential Exposure Pathways

It is understood that the future land use surrounding the river will be industrial and the river channel altered from a shallow riverbed environment to a deepwater shipping channel. Currently the shoreline to the south does not contain significant areas of natural vegetation, and there are no on-site terrestrial environments that warrant consideration with respect to environmental risks. The northern shoreline contains an area of mangroves and salt marsh, which will be removed as part of the proposed development.

Therefore the potential ecological receptors considered include:

- River water;
- River bed;
- Nearby wetlands;
- Aquatic organisms; and
- Groundwater.

As in the human health risk assessment, a complete pathway must exist for environmental harm to occur. The pathway must contain a source from which a contaminant can be released and transported to the receptor where, depending on contaminant concentration and form, the receptor may or may not be harmed.

The potential transport pathways for contaminants contained within the proposed development area include direct release during dredging or discharge to the river following onshore handling and processing. The contaminants of concern may be transported in a number of forms: dissolved in water; carried on sediments suspended in water; or carried on air borne dried sediments.

Dried sediments may also represent a possible mechanism to disperse contaminants beyond the site boundary. However, as discussed in the health risk assessment this pathway is considered insignificant since during onshore materials handling appropriate dust control measures will be implemented in line with the site environmental management plan, and stockpiling of sediments not suitable for ocean disposal will be minimised if required.

7.1.1 River Water

The levels of contamination in the sediments in the area outside the sheet pile wall are consistent with the remainder of the dredged riverbed in the South Arm. Based on similar previous works carried out during the Kooragang Island coal loader expansion, an increase in the turbidity of the water column adjacent to operating dredges outside the sheet pile wall is likely. However, since the lower Hunter River is subject to large scale natural disturbances due to flooding, and artificial disturbance such as maintenance dredging and prop-wash from manoeuvring vessels, the potential impacts of these short term events are expected to be within the range of usual variability and thus insignificant.

Additionally, the impact of the identified sediments not suitable for ocean disposal and waters will be minimised through the effective isolation of these contaminated areas of sediment by a sheet pile wall. The use of turbidity curtains will also minimise the dispersion and relocation within the sheet pile wall zone and thus the potential for release into the South Arm would be further minimised.

7.1.2 Surface Water Runoff

The treatment plant and interconnecting roadways that link the riverside unloading facility to the processing site will be located on the former BHP steelworks site. The stormwater management system will include sedimentation basins to contain runoff prior to water being discharged to existing drains and back to the river. Treatment plant process spills will be contained in separate bunded areas specific to the plant unit operations at risk, and recycled through the plant. Truck spills and leakage on the interconnecting roadway will be minimised through the use of watertight trucks and low permeability roadways with contained surface water runoff drainage. Hence, as with the human health component of this risk assessment, the risk of contaminant release via this pathway is considered insignificant.

7.1.3 River Bed

The South Arm of the Hunter River is considered to be a highly disturbed environment. The existing riverbed adjacent to the former BHP site is significantly contaminated, with the remainder of the proposed dredging area demonstrating contaminant levels consistent with the remainder of the nearby harbour area. The proposed development plans to remove and treat the sediments not suitable for ocean disposal whilst dredging the river for future expansion of the port facilities. The estimated quantity of sediments not suitable for ocean disposal will be over dredged to ensure complete removal before continuing the dredging to the working final depth. The removal of the sediments not suitable for ocean disposal should then minimise the potential for remobilisation and redistribution of the contaminants within the Hunter River estuary by natural processes, thus removing any future ecological risk.

With respect to the replacement of the shallow subtidal environment with a deep subtidal environment, no prior studies have determined the ecology of the existing sediments, consequently the impact of current maintenance dredging and the existing contaminants on the existing environment is unknown. However since the proposed development would lead to the complete removal of this shallow subtidal environment the impact on the existing environment, from a risk assessment perspective, cannot be made.

The *Assessment of Aquatic Ecology* (The Ecology Lab Pty Ltd, 2002) suggests that previous studies of other similar dredging works have found that the re-establishment of benthic ecology occurs over a period of months to years and that the assemblage may change significantly. This receptor will not be assessed since complete removal is proposed and the removal of these organisms reduces the likelihood of bioaccumulation higher in the food chain.

7.1.4 Nearby Wetlands

The *Assessment of Aquatic Ecology* (The Ecology Lab Pty Ltd, 2002) has detailed that the probable impacts on the aquatic environment will include the removal of foreshore mangroves, salt marsh, sand flats and the shallow subtidal riverbed.

The *Assessment of Aquatic Ecology* (The Ecology Lab Pty Ltd, 2002) also suggests that the impact on the salt marsh behind the mangrove stand to be removed is unclear, but more importantly the effect on the Hexham Swamp and Ironbark Creek should be minimal.

Removal of the mangroves on the northern shoreline of the proposed development was considered to have an insignificant ecological impact in the context of the Hunter estuary system (The Ecology Lab Pty Ltd, 2002). Whilst the intertidal mangrove habitats on Kooragang Island were considered potentially vulnerable due to changes in water flow or quality caused by the proposed development, the hydrological modelling undertaken for the EIS indicates generally insignificant impacts. However, the hydrological modelling has also predicted that the dispersion of sediment upstream of the dredging area may lead to sediment deposition up to 3 cm deep in the vicinity of Iron Bark Creek. Whilst it has been noted that sediment deposition can be beneficial to mangroves, rapid deposition may lead to smothering of pneumatophores. In this context the dredging operation should be controlled and the rate of deposition in the wetlands between the dredging site and Ironbark Creek monitored so that operations are conducted in such a way as to minimise impacts due to sedimentation on the Kooragang wetlands adjoining the south arm.

7.1.5 Aquatic Organisms

The aquatic organisms that move through the water column in the South Arm include fish, molluscs (e.g. squid) and crustaceans (e.g. prawns). The *Aquatic Ecology Report* (The Ecology Lab Pty Ltd, 2002) suggests that in general, the potential localised increase in turbidity and noise may lead to changes in the foraging behaviour of fish, and abrasion or clogging of gills leading to an increased risk of disease and suffocation respectively. Noise may lead to disorientation.

The generation of a turbidity gradient due to sediment suspension was suggested to inhibit fish passage. Although given that the lower Hunter River experiences large-scale flood events, such effects are believed to be of minor significance. The impacts on the migration of aquatic organisms through the South Arm caused by changes in river velocity due to the installation of the sheet pile wall are discussed in the *Assessment of Aquatic Ecology* (The Ecology Lab Pty Ltd, 2002).

The *Assessment of Aquatic Ecology* (The Ecology Lab Pty Ltd, 2002) has considered the impacts of the proposed development on the fishing industry in the lower Hunter River and suggested that prawns, being benthic feeders, could potentially bioaccumulate any contaminants mobilised during the dredging operation. It was suggested that the timing/scheduling of dredging of certain areas should be co-ordinated to minimise the potential for this impact and thus the potential for contaminant transfer to consumers. This pathway was considered insignificant in the health risk assessment (**Section 6.2.6**). Additionally the potential impact on the prawn migration will be minimised through dredge management.

The *Assessment of Aquatic Ecology* (The Ecology Lab Pty Ltd, 2002) also suggests that the dredging activities of the proposed development are 'probably unlikely' to have an impact on the commercial oyster industry located upstream of the Stockton Bridge. The hydrological modelling of plume dispersion was limited to considering tidal effects only. The results of this modelling indicate that deposition of sediment released during dredging outside the sheet pile wall is limited to the South Arm development area. Hence the risk of potential impact on the commercial oyster industry in the North Arm is considered negligible.

7.1.6 Groundwater

Previous groundwater contaminant flux investigations (Robert Carr and Associates, 1999) have established the flow patterns for groundwater across the entire former BHP site.

The aquifer system consists of an upper unconfined aquifer within the fill material, underlain by a lower partially confined aquifer located in estuarine sand and clay deposits. Sedimentary strata of the Tomago Coal Measures underlie this (Robert Carr and Associates, 1999).

Potential intrusion into the groundwater aquifer may have two effects: saline intrusion or the release of contaminants to the river. As outlined in the process description contained in the EIS, processing areas will be located on low permeability hard surface areas. The material holding basin and sediment dewatering areas will be lined with impermeable membranes, with the captured water to be sampled and batch treated prior to discharge. Hence it is considered that the risk of contaminated saline process water entering the groundwater is negligible.

The works to be carried out in the proposed swing basin area are likely to penetrate two former tar waste disposal areas. These disposal areas will be managed via physical isolation from the river through the use of sheet pile walls. The potential for ongoing future discharge of the contaminants contained within these pits would then be minimised. Should the extent or expected impact of these pits be assessed to be greater than initially predicted then alternative means of containment should be considered. For example, if the levels of contaminants prove significantly greater than those contained in the sheet pile walled area separate containment may be necessary, however, if the level is assessed to be of the same magnitude removal may proceed without the risk of increasing the level of contamination within the sheet pile walled area. The operation may include the complete removal of the affected area adjacent to the land-water interface for treatment with the remainder of the sediments not suitable for ocean disposal. The careful management of these pits during excavation will effectively minimise any potential ecological impact.

7.2 Conclusions

No significant transport pathways have been identified. However, a number of potential deviations from normal operations that may lead to isolated potential environmental impacts have been identified (**Section 4, Table 4.6**) and their risk of occurrence has been assessed. In all cases the techniques, work practices and incident response procedures have been assessed to be sufficient to prevent significant harm to the identified off-site ecological receptors.

In characterising the risk posed to the environment by the proposed development operations, a qualitative assessment of the likelihood of contaminants being transported off-site and contacting receptors has been made.

It has been assessed that, based on adequate planning and precautionary steps being taken during the development, release of contaminants to the identified ecological receptors is of low potential risk. Further it would be expected that due to the removal of the sediments not suitable for ocean disposal from the riverbed, the risk of release to the river water or re-deposition within the lower Hunter River estuary due to natural processes would be removed.

It is recommended that groundwater bore monitoring and river water sampling, especially in the swing basin area, continue to allow mapping of any potential contaminant migration towards the river. It should also be made clear that subsequent to capping, infiltration of surface water into the *underlying aquifers will be reduced. This will further reduce the risk of* contaminants present in groundwater migrating into the river water.

Based on the available data and with adequate site management with respect to the issues discussed, it is concluded that the proposed development would not be expected to have an adverse effect on the off-site environment.

8. MANAGEMENT OF RESIDUAL RISK

The Hazard Identification Study and qualitative risk assessment both identified control measures, safeguards and procedures that will be implemented to further reduce the level of risk associated with the proposed development. These actions are summarised in the Hazard Identification Study tables, included in **Section 4**. Generic mitigation measures may also include:

Management Policies:

- Health and safety plan;
- Operator training and induction;
- Standard operating procedures;
- Contractor induction;
- Dedicated smoking and non-smoking areas;
- Work permits;
- Safety audits and inspections;
- Safety procedures;
- Control of plant modifications;
- Emergency procedures; and
- Site security.

Engineering Design:

- Design of hardware systems;
- Use of safe electrical equipment;
- Preventative maintenance; and
- Plant monitoring.

One of the most effective means of ensuring the ongoing safe operation of a facility is through implementing a comprehensive Safety Management System, as recommended in the *Draft National Code of Practice for the Storage and Handling of Dangerous Goods (*NOHSC, 1998). Such a system should ensure that hazards associated with the site are identified and managed, so that all activities are undertaken in a safe manner.

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