Summary of key outcomes:

The results of the risk analysis show that the proposed development would satisfy PlanningNSW risk criteria and the recommendations of the *Port Botany Land Use Safety Study* (DUAP 1996). In particular, the assessment showed that against the PlanningNSW risk criteria, based on a throughput of 1.5 million TEUs per year about 4% of which represents movement of dangerous goods:

- the fatality, injury and irritation risk from the proposed port expansion is considered acceptable;
- the contribution of the proposed facility to the risks to the biophysical environment would be very low relative to the background risk and the more likely accidental emissions would not threaten the long term viability of the ecosystem or any individual species since the effects would be localised and reversible;
- the risk to the surrounding communities along the identified road and rail transportation routes to and from the port area due to the transport of dangerous goods is acceptable for the combined port operations; and
- the individual fatality contour for residential criteria for the proposed expansion is within the relevant cumulative risk bounds.

28.1 Introduction

Det Norske Veritas (DNV) (which was acquired by QEST Consulting Group in May 2003) was commissioned by Sydney Ports Corporation to undertake a Preliminary Hazard Analysis (PHA) in order to assess the hazards and risks associated with the proposed expansion of facilities at Port Botany. The complete PHA is provided in **Appendix W**.

28.2 Scope and Methodology

The PHA was undertaken with reference to PlanningNSW's Hazardous Industry Planning Advisory Paper (HIPAP) No. 6 *Guidelines for Hazard Analysis* and HIPAP No. 4 *Risk Criteria for Land Use Planning*. The risk assessment also considered the findings and recommendations of the *Port Botany Land Use Safety Study* (DUAP, 1996).

The PHA assessed the full set of risks to the public and the biophysical environment arising from both normal operations and typical occurrences associated with the storage and handling of hazardous materials at the proposed container terminal. The PHA involved the consideration of cumulative impacts of the proposed Patrick terminal upgrade, based on the PHA risk model for the facility as developed by DNV in 2001/02.

The PHA methodology involved the following steps:

- projecting the movement of hazardous materials through the proposed facility based on the analysis of historical dangerous goods trade data from the existing Port Botany container terminals;
- identifying hazards arising from site and external events which may lead to the release of hazardous material;
- estimating the frequency (generally expressed as likelihood per year of occurrence) of each of the accidental events, based on historical failure data;
- modelling all possible consequences of each event; and
- calculating risks, by combining the frequencies and consequences of each event, to determine the levels of risk.

DNV used the software package SAFETI (Software for the Assessment of Fire, Explosion and Toxic Impact) for the PHA. This package was developed by DNV and is used by many chemical and petrochemical companies and government agencies in different countries around the world.

28.3 Dangerous Goods Trade Analysis

In conducting the PHA, an analysis of the dangerous goods trade passing through the existing Port Botany container terminals was undertaken using trade manifest information collected by Sydney Ports Corporation for the period 1 April 2001 to 31 March 2002. The manifest information has been taken as representative of an average year for the operation of the proposed new terminal.

Approximately 96% of containers transported to or from the container terminal carry no dangerous goods, therefore the PHA focused on the 4% of container movements that do contain dangerous goods.

The analysis broke down the number of movements for each dangerous goods class, per net movement weight (or Net Explosive Quantity for explosive materials).

Future trade movements of dangerous goods at the new terminal were forecast based on the projected increase of container movements to a throughput of 1.5 million TEUs. Simplifications in trade levels were undertaken in developing the risk models, with conservative assumptions made in relation to the number of movements of different quantities of different dangerous goods classes.

28.4 Hazard Identification

Hazards were identified based on a review of activities at and around the proposed Port Botany Expansion and a detailed consideration of the hazards associated with the different classes of dangerous goods that would be handled and stored in the facility.

The hazards associated with dangerous goods are summarised as follows:

- loss of containment due to handling at the new terminal;
- loss of containment during transport to and from the new terminal;
- loss of containment due to impact from an external event; and
- loss of containment whilst in transit at the port.

28.4.1 Loss of Containment from Handling at the Terminal

The following port activities may lead to the loss of containment of hazardous material:

- vessel loading/unloading via quay cranes;
- transportation of containers on site via terminal equipment, trucks and trains;
- stacking of containers; and
- loading/unloading of containers onto trucks or trains.

The major hazards associated with container handling on site would be:

- damage to containers and loss of containment caused by dropping of a container during a lift or impact of a container on a solid object during a lift;
- damage to containers and loss of containment occasioned by a vehicular accident on site, either by terminal equipment, trucks or trains; and
- "spontaneous" leak occurring from a container during the storage of a container on site.

These incidents may escalate if a fire occurs on site.

28.4.2 Loss of Containment during Transport to and from the Terminal

Hazards associated with the transport of dangerous goods to and from the proposed facility include the following:

- "spontaneous" leak occurring from a container during transport;

- potential for road vehicle accidents which could expose the members of the public, who may be in relatively close contact with these vehicles, either as occupants of other vehicles sharing the road or as pedestrians;
- potential for rail transport accidents. The risk of this may be lower than that of road transport, but may have significantly higher potential consequences due to the transport of multiple containers in a single movement; and
- potential for sea transport incidents like:
  - ship to ship collisions, which may be considered to be minimal given that current port controls limit the movement of vessels in the Bay to not more than one vessel at any one time,
  - penetration of containers or isotainers due to the direct impact from the grounding of a vessel or ship/berth strikes, resulting in structural and hull damage to the vessel (An *isotainer* is a tank in a standard ISO 6m by 2.4m by 2.5m frame, designed to be carried on board container vessels); and
  - movement of containers due to impact forces from grounding of a vessel or ship/berth strikes.

28.4.3 Loss of Containment from Impacts of External Events

The following sources of external impact have been identified among the hazards to the project site.

Aircraft impact

There exists the potential for impact from aircraft due to a crash landing, given the proximity of the proposed site to Sydney Airport. A consideration of the likelihood and possible consequences of such impact, but excluding the impact from the aircraft alone, is presented in **Appendix W** and summarised in Section 28.7.2.

Incident at adjacent hazardous facility

There are a number of industrial sites in the vicinity of the proposed new terminal. The potential for escalation (i.e. increase in intensity and extent) from incidents on any adjacent hazardous facility is considered unlikely given the distances physically separating the proposed site from the neighbouring hazardous facilities.

An exception would be incidents relating to major fuel pipelines running through and around the boundary of Port Botany. Loss of containment from these fuel pipelines may result in large pool or jet fires with the potential for escalation onto the project site. The assessment of this hazard is presented in **Appendix W** and summarised in Section 28.7.2.

Loss of containment at adjacent hazardous facility

The loss of containment from specific types and classes of hazardous cargoes handled at the adjacent Patrick Stevedores terminal could present a risk to people on the proposed Port Botany Expansion site. The potential initiating scenarios at Patrick Stevedores terminal that may lead to an escalation and possible release of dangerous goods stored or handled at the proposed new terminal are limited to fires and explosions.

However, the potential for escalation on the new terminal is considered limited due to the nature and dimension of potential initiating incidents and the distances involved.

28.5 Frequency Analysis

Frequency estimates are usually developed based on historical data at the site, similar experience in other locations or on developed fault trees. For the PHA, the two main initiators of incidents considered were:

- dropped or impacted containers associated with crane lifts (including straddle carriers and rail mounted gantries); and
- transportation accidents associated with vehicle movements, including terminal equipment, trucks and trains.

Other causes of incidents, such as 'spontaneous' leaks or fires are considered to be a lower order cause of incidents, as they occur much less frequently.

Details of the estimates of the likelihood of dropped containers, the total release frequency for various types of dangerous goods packing as a result of dropped containers, the likelihood of a container carrying explosives detonating during transfer, truck accidents, tanker/container leaks and fires are shown in **Appendix W**.

28.6 Risk Criteria

Risk is presented in the PHA as:

- *individual risk* - defined as the risk experienced by a single individual in a given time period. This is presented in the PHA report as fatality contours over a map of the proposed port expansion site and surrounds; and
- *societal risk* - defined as the risk experienced in a given time period by the whole group of exposed personnel. This is presented in the PHA report as a frequency-fatality plot (called F-N curve) showing the cumulative frequencies of events involving fatalities.

28.6.1 Individual Fatality Risk

The PlanningNSW individual fatality risk levels that should not be exceeded for different zones are shown in **Table 28.1**.

Table 28.1 Individual Fatality Risk Levels

ZONE	RISK LEVEL
Residential	One in a million (1×10^{-6}) per year
"Sensitive developments" such as hospitals, schools, child care facilities and aged care housing	Half in a million (0.5×10^{-6}) per year
Commercial developments including offices, retail centres, warehouses with showrooms, restaurants and entertainment centres	Five in a million (5×10^{-6}) per year
Sporting complexes and active open space areas	Ten in a million (10×10^{-6}) per year
Neighbouring industrial sites	Fifty in a million (50×10^{-6})* per year

* *Target only, HIPAP No. 4 allows flexibility in interpreting criterion.*

Injury Risk

A person offsite could sustain injury from heat radiation, explosion overpressure and toxic gas exposure. The effects of heat radiation and explosion overpressure tend to be localised. Therefore, the assessment of injury risk focuses on the potential for toxic gas exposure.

The criterion adopted for this assessment, as per HIPAP No 4, is that the risk of injury from toxic gas exposure to individuals in residential areas should not exceed a level which would be seriously injurious to sensitive members of the community following a relatively short period of exposure at a maximum frequency of ten in a million (10×10^{-6}) per year.

Irritation Risk

Exposure to lower concentrations of toxic gas may result in irritation rather than injury. The criterion adopted for this assessment, as per HIPAP No 4, is that the risk of irritation from toxic concentrations in residential areas should not cause irritation to eyes or throat, coughing or other acute physiological responses to sensitive members of the community over a maximum frequency of fifty in a million (50×10^{-6}) per year.

28.6.2 Societal Risk

There are no set criteria in NSW for assessment of societal risks. The PHA adopted criteria from the UK Health and Safety Executive (HSE) which is responsible for the regulation of almost all the risks to health and safety arising from work activity in Britain.

28.6.3 Consequence Criterion

Incident heat flux radiation should not exceed 4.7 kW/m^2 and incident explosion overpressure should not exceed 7 kPa at frequencies of more than fifty in a million (50×10^{-6}) per year at residential areas, based on HIPAP No. 4.

28.6.4 Risk of Property Damage and Accident Propagation

Heat radiation exceeding 23 kW/m^2 may cause unprotected steel to suffer thermal stress that may lead to structural damage. Explosion overpressure of 14 kPa can damage piping and low-pressure equipment. Based on HIPAP No. 4, the risk from incidents resulting in 23 kW/m^2 heat flux and 14 kPa explosion overpressure should not exceed fifty in a million (50×10^{-6}) per year at the boundary of adjacent industrial facilities.

28.6.5 Risk to the Biophysical Environment

The HIPAP No. 4 criteria for assessment of risk to the biophysical environment relate to risks from accidental events. Impacts due to planned changes or continuous/anticipated emissions are considered in other chapters of this EIS. The criteria are as follows:

- the consequences of the more likely accidental emissions must not threaten the "*long term viability of an individual species or the ecosystem*"; and

- the likelihood of impacts (which threaten the long term viability of the ecosystem or species) must be substantially lower than the background risk.

28.7 Risk Assessment

28.7.1 Key Modelling Assumptions

Since there would be a very large number of products that would be moved onsite and it is not possible to model all potential scenarios for all possible incidents, the PHA has only focussed on release events that would give rise to offsite risks. Therefore, events that pose onsite risks only or those posing minimal or negligible risks, either by their unlikely occurrence or minimal consequences, have not been analysed.

Other modelling assumptions which relate to package sizes for each dangerous goods class, choice of representative dangerous goods to model each dangerous goods class or subclass, and explosion fatal effect zones are discussed in detail in **Appendix W**.

28.7.2 External Impacts

Aircraft impacts

The assessment of risk to the surrounding community due to aircraft impact on the Port Botany Expansion site was limited to consideration of the escalation risk following a release of hazardous materials on the port at the time of aircraft impact. The impact considered does not include risks due to fire and explosion as a result of loss of containment of fuel and other flammable products on board the aircraft.

Escalation frequency was estimated based on the number of movements of dangerous goods per year and the probability of them being present on the terminal at the time of an aircraft impact.

The escalation frequency of an aircraft impact resulting in loss of containment has been represented in the risk model based on the frequency of a large leak of 20 tonnes of flammable liquid.

Fuel Pipelines

Buried flammable liquids fuel pipelines run from the Caltex terminal along both sides of Foreshore Road toward Sydney Airport. Releases from these pipelines may result in:

- fire on the road side from the fuel plume rising to the surface and forming a flammable liquid pool; and/or
- fire in the vicinity of the new terminal from leaking fuel reaching the Bay through the groundwater and carried by the movement of the tide and waves within the range of a number of potential ignition sources such as quay cranes and tug boats.

These releases are unlikely to result in impact to assets and/or cargo on the new terminal due to the separation distances.

Diesel Fuel Storage

A 150 tonne diesel fuel storage tank would be constructed for the proposed terminal, giving rise to the potential for diesel spills and the risk of pool fires should diesel spills ignite.

The consequence in terms of heat radiation capable of causing injury from a pool fire would be confined within the site boundary. Therefore, the diesel storage facility would present negligible risk to the surrounding community.

28.7.3 Risk Calculation

The level of risk is calculated by combining the frequencies and consequences of each event. SAFETI was used for the risk analysis. The outcome of the SAFETI analysis is presented in the form of Location Specific Individual Risk (LSIR) Contours and Societal Risk Curves (F/N curves) based on the projected volume of dangerous goods movement in an annual throughput of 1.5 million TEUs at the new terminal. LSIR is the risk for a hypothetical individual assumed to be continuously present at a specific location. The individual at that particular location is expected to sustain a given level of harm from the realisation of specified hazards. It is usually expressed in risk of death per year.

Individual Fatality Risk

The individual fatality risk contour (**Figure 28.1**) for residential zones (1×10^{-6} per year) does not extend to any residential area, while the risk contour for commercial developments (5×10^{-6} per year) does not extend beyond the foreshore and does not encroach onto commercial developments or open sporting complexes.

The risk contour for sensitive developments (0.5×10^{-6} per year) extends over the open space along the south side of Botany Road, but does not encroach on any sensitive facilities.

Based on the above assessment, the forecast future risk due to the trade in dangerous goods via the Port Botany Expansion would be acceptable in terms of the fatality risk criteria.

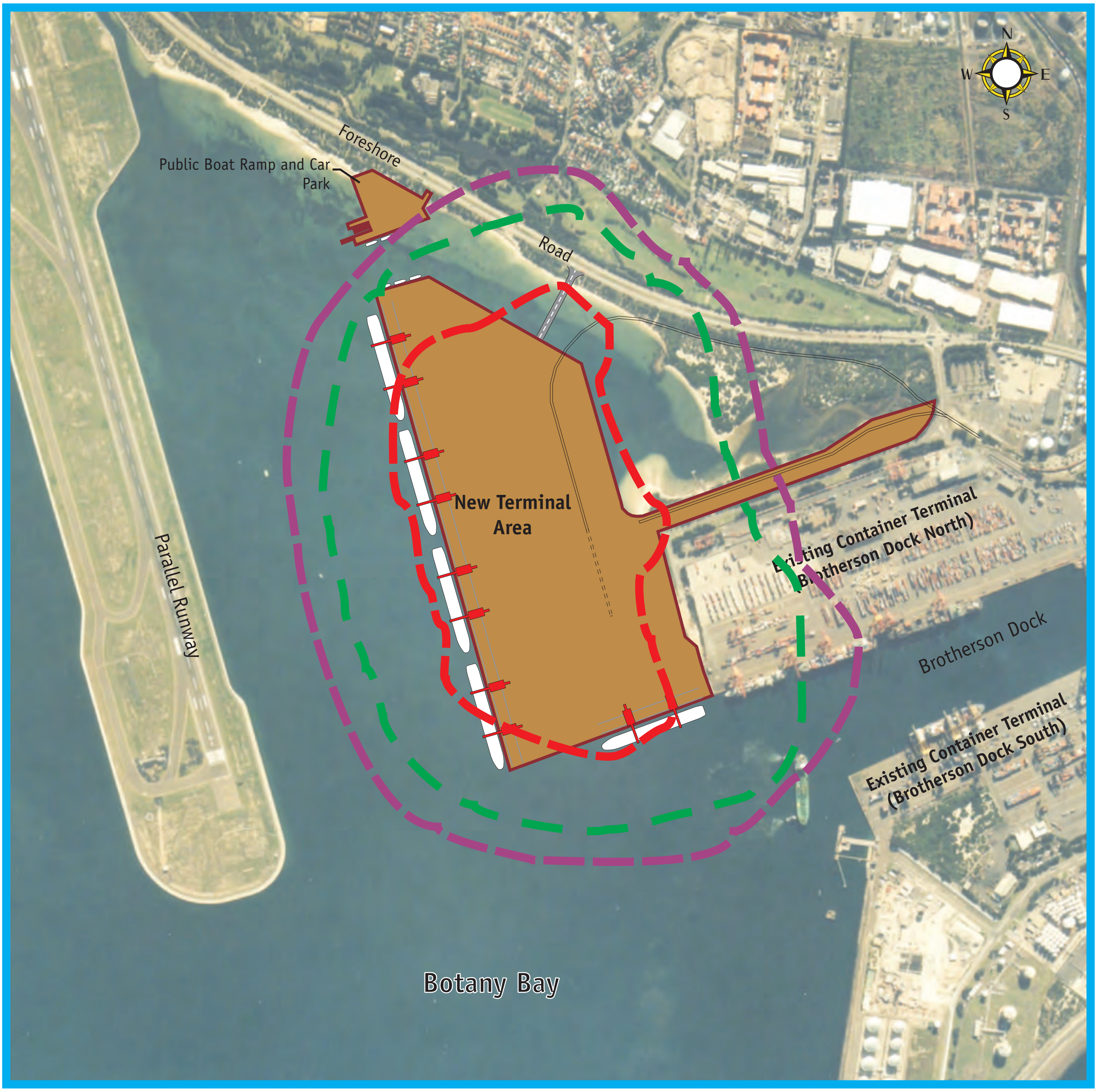
Injury Risk

The injury risk contour of ten in one million (10×10^{-6}) per year (**Figure 28.2**) which is the criterion adopted for the PHA, would encroach slightly into a residential area south of Botany Road to the north of the proposed site. Hence the risk criteria would not be met.

However, the extent of the exceedence would be minor, and given the conservatism built into the analysis and the margin of error inherent in the analysis, the injury risk is considered acceptable.

Irritation Risk

The irritation risk contour for the new terminal (**Figure 28.3**) would be centred over the Patrick Stevedores facilities due to the dominance of the low velocity, highly stable weather conditions over the west to west northwesterly direction. The irritation criteria risk criterion (50×10^{-6} per year) in residential areas would be met and therefore the irritation risk is considered acceptable.



Source: QEST Consulting Group, 2003

0 500m

Individual Fatality Risk Contours **Figure 28.1**

Risk Contour Legend

- 0.5×10^{-6}
- 1×10^{-6}
- 5×10^{-6}

Source: QEST Consulting Group, 2003

Individual Injury Risk Contour **Figure 28.2**

0 500m

Risk Contour Legend

10 x 10^{-6}

Source: QEST Consulting Group, 2003

Individual Irritation Risk Contours

Figure 28.3

0 400m

Risk Contour Legend

10 x 10^{-6}

30 x 10^{-6}

Societal Risk

Societal risk due to the operation of the proposed new terminal has been calculated based on the estimated offsite population and is presented in the form of an F-N curve (**Figure 28.4**).

Using HSE criteria lines, the societal risks associated with the proposed Port Botany Expansion would fall within the category of trivial. Thus, as long as the risks of the operation are managed effectively to ensure that they are kept as low as reasonably practicable, the operation would meet the UK criteria.

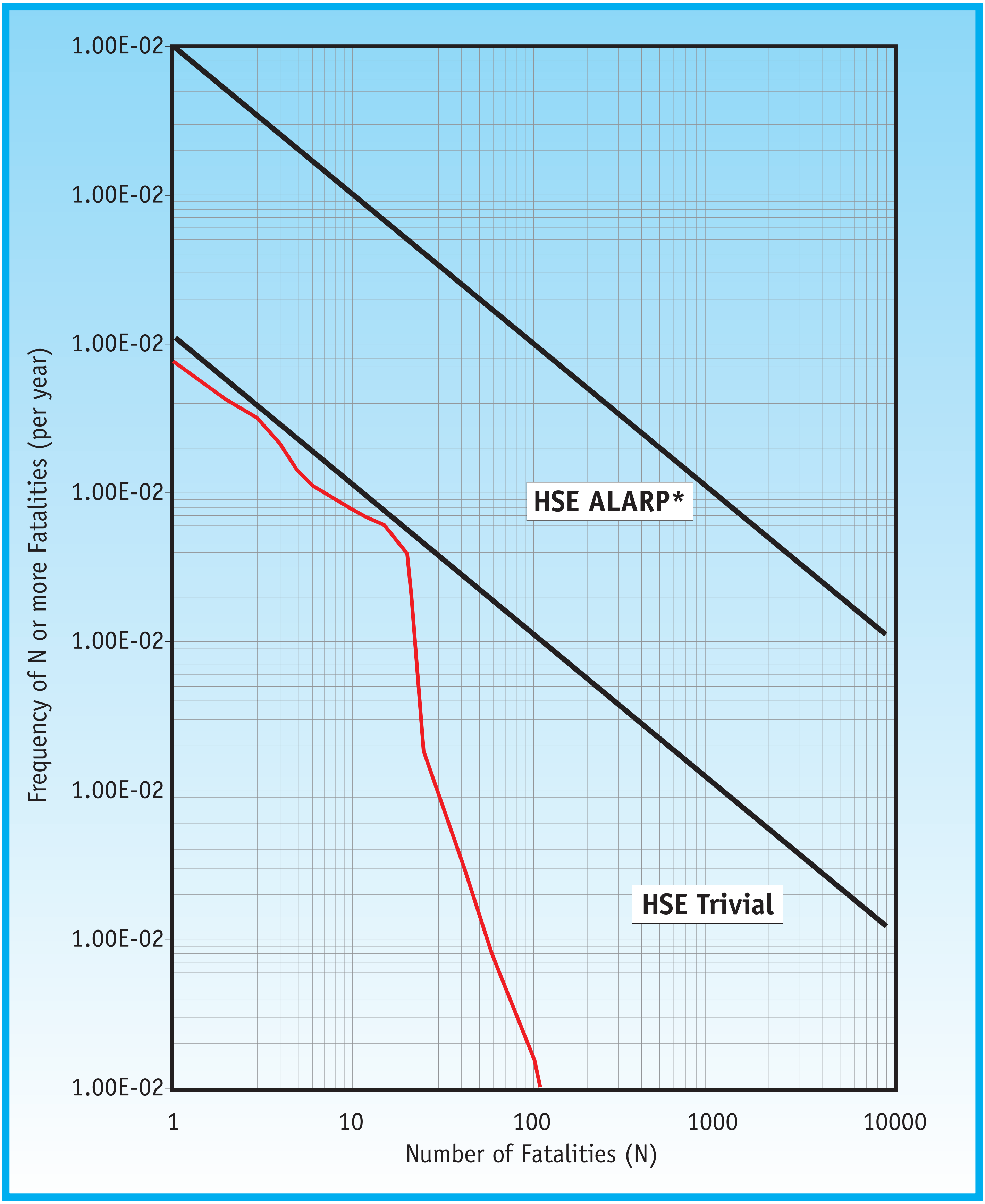
These results suggest that the risks would be acceptable to communities in NSW.

28.7.4 Biophysical Risk

Some of the material to be handled at the new terminal, particularly acidic/alkaline materials (Class 8), toxic chemicals (especially Class 6) and hydrocarbons, would have the potential to adversely impact on the natural environment if a spill finds its way into the Bay. An overview of the environmental risks from dangerous goods cargo is shown in **Table 28.2**.

Table 28.2 Overview of Environmental Risks of Dangerous Goods Cargoes

DG CLASS	DESCRIPTION	COMMENTS
1	Explosives	Limited environmental consequence potential.
2	Flammable, toxic and pressurised gases	Limited potential environmental consequences. Gases would mostly vaporise and could have a limited effect on bird life. Some potential for liquid runoff to dissolve in water, but this is low risk (both consequences and likelihood).
3	Flammable liquids	Generally incapable of mixing with water. Most spills would float on the surface and may cause limited damage to bird life and shoreline plant life. Containers have relatively low volumes. A container spill could be contained in the first flush system. Bunker fuel spills from ship impacts could be a major incident, but the effects are unlikely to result in the loss of an ecosystem and are reversible.
4	Flammable Solids, Spontaneously Combustible, Dangerous when Wet	Generally localised effects.
5	Oxidising Materials, Organic Peroxides	Generally localised effects.
6	Toxic Materials	Some of the materials could be environmentally hazardous in very low concentrations, for example active ingredients of pesticides or herbicides. This category is of greatest concern, however the majority of cargoes would only have limited environmental consequences if spilled.
7	Radioactive Materials	Generally low level radiation hazard. Very few cargoes handled (40 per year). Packaging standards are strict and so breach of packaging is very unlikely even if a container is breached.
8	Corrosives	Spills could result in temporary pH changes but would have relatively localised effects due to the large volume of water in the Bay. Effects would generally be expected to be reversible.
9	Miscellaneous	Many of these cargoes are containers under fumigation. Possible that some cargoes (environmental pollutants) could cause damage, but not a major risk.



Source: QEST Consulting Group, 2003

Societal Risk Shown as F-N Curve **Figure 28.4**

New Terminal Societal Risk

* As Low as Reasonably Practicable

The primary potential incident types for an accidental event that could cause major damage to the ecosystem or an individual species include:

- Loss of containment from container cargoes, especially Class 3 (flammable liquids), Class 6 (toxic and infectious substances) and Class 8 (corrosive substances). Harmful effects are also possible from other classes of dangerous goods, but the likelihood of major damage is very low.
- Potential spills of bunker fuel (e.g. in the event of a grounding or striking of wharf etc). (Bunker fuel refers to the most common fuel available for use in large diesel engines.) However, the effects of such a spill should be readily reversible with low risk of long term damage. Bunker spills from refueling activities are minor volume incidents with minor transient impacts. Incident response procedures in the event of a bunker fuel spill are provided in **Chapter 32** *Emergency and Incident Management*.
- Loss of containment from truck transportation on site. The likelihood of this is very low compared to spills on the road system offsite (which would be expected to find their way into the Bay, via the stormwater system). Hence the risk of this type of event at the port is much lower than the background risk.
- Introduction of foreign organisms via ballast water pump-out. This is an issue of national and international concern and whilst an international protocol for ballast water is nearing completion, mandatory ballast water management was introduced in Australia in July 2001 supported by a risk assessment system. This issue is managed by the Australian Quarantine Inspection Service (AQIS) and is discussed in more detail in **Chapter 19** *Aquatic Ecology*.
- Diesel spill from diesel storage. Effects would be reversible and fairly localised. The facility would be designed in accordance with AS 1940 with associated bunding requirements and clean-up capability to ensure that the likelihood of a major spill would be low. There are numerous fuel storage tanks of this type in various industrial facilities around the Bay so the risk is considered to be much lower than the background level of risk.
- Fire in container storage areas. Major fires in container stacks are very infrequent since there is little opportunity for initiating mechanisms and even if a fire starts in one container, it is very unlikely to spread to others since the container shell provides a fire barrier. The primary environmental concern is contaminated firewater runoff, in particular if a major fire develops involving containers of dangerous goods (especially Class 6). This issue would be addressed comprehensively as part of the fire safety and system design study to be completed during the detailed design phase.

Any of the above scenarios that occur on the proposed facility, except for the ballast water, would be captured by the first flush system installed for treatment of stormwater and for spill incidents. A more detailed description of this system is provided in **Chapter 16** *Hydrology and Water Quality*.

Of all the incidents identified above, the one of greatest concern would be the possibility of a spill from a cargo which is extremely toxic to the environment (in particular Class 6). In order to satisfy the HIPAP No. 4 risk criteria, the following two conditions must be satisfied:

1. *"The consequences of the more likely accidental emissions must not threaten the long term viability of the ecosystem or any individual species."*

   As discussed above, only a tiny fraction of dangerous goods cargoes (if any) would have the potential for widespread damage to the extent that the long term viability of the Bay ecosystem is threatened.

Whilst a detailed assessment is not practical, it is suggested that the percentage of dangerous goods cargoes with this potential would be less than 1%, and in all likelihood less than 0.1%. It was concluded that this condition is satisfied since the more likely emissions would certainly not threaten the long term viability of the ecosystem or any one species. Spills would be contained by the first flush system and even if they found their way into the Bay, the vast majority would have localised or reversible effects.

2. *"The likelihood of impacts (which threaten the long term viability of the ecosystem or species) must be substantially lower than the background risk."*

   In order to assess this risk, a rudimentary frequency calculation has been performed. As stated above, it is considered that the most likely source of an environmentally catastrophic event is a Class 6.1 cargo, for instance a large volume of active ingredient of pesticide/herbicide. It is acknowledged, however, that some Class 8 goods could also be a significant issue and these have been included in the frequency calculation to be conservative.

The risk analysis, shown in detail in **Appendix W**, indicates that the frequency of an environmentally catastrophic event which threatens the long term viability of the ecosystem is once every 125,000 years, using the dominant spill scenario of a dropped or damaged container during transfer (as has been confirmed in previous studies) and using conservative assumptions on container movement, spill frequency and spill control failures to counteract the significant uncertainties involved.

Even recognising some of the uncertainties involved, this likelihood would be considered very low compared to the background risk in this urban, industrialised environment. Some of the key background threats can be summarised as:

- major oil or chemical spills from oil and chemical tanker trade (e.g. deliveries to the Caltex refinery or the Bulk Liquids Berth);
- the plume of contaminants known to be moving through the water table towards Botany Bay from the former ICI site;
- spills from road transportation of dangerous goods throughout the area for many kilometres around the Bay (as spills would find their way through the stormwater system into the Bay). The likelihood of such a spill is much greater than at the port due to the uncontrolled environment and relatively high frequency of traffic accidents;
- general degradation of the aquatic environment due to increased urban runoff resulting from increasing development in the area (industrial, commercial and residential);
- major fuel spills from the fuel pipelines and other fuel lines in and around the Bay; and
- major industrial accidents/spills or contaminated firewater runoff at one of the many neighbouring chemical/industrial facilities.

While it is recognised that the addition of the port would involve a small increase in the risk of an environmentally damaging event, it is concluded, based on the above analysis that:

- the risk would be very low compared to the background risk; and

- the consequences of the more likely spill events would not threaten the long term viability of the ecosystem or any individual species as the effects of the more likely spills would generally be very localised and reversible.

Hence the HIPAP No. 4 risk criteria would be satisfied.

28.8 Transportation Risk Assessment

SEPP 33 requires a transportation study to be undertaken when the number of dangerous goods movements to or from a site exceeds screening thresholds (DUAP 1994). These thresholds are exceeded for the proposed Port Botany Expansion and a transportation study has been prepared (**Appendix W**) in the assessment of the proposed development.

A transportation risk model was developed which included the transportation of all dangerous goods with the potential for fatal impacts to the population lining the route and road users sharing the road with vehicles carrying dangerous goods. The model considered the main routes used by trucks and trains carrying dangerous goods to and from the port, and estimated the risk for the projected capacity of the entire port (i.e. 3.4 million TEUs) and not just the new terminal.

The dangerous goods movement by road and rail was projected by distributing the projected trade in accordance with **Table 28.3**.

28.8.1 Likelihood of Road Transportation Accidents

Transport options

There would be two possible land transport options for containers to be brought in or taken out of the proposed new terminal: trucks or trains.

The five main routes in and out of the Port Botany terminal area and the proportion of traffic projected for each route in the future are shown in **Table 28.3**.

Table 28.3 Traffic Movements

ROUTE	PROPORTION OF TRADE
Rail route	40%
Foreshore Road	43%
Botany Road	12%
Military Road	4%
Beauchamp Road	1%

Leaks from Flammable Liquid Tankers

The best available estimate of leak frequencies from tankers carrying non-pressurised liquids, shown in **Table 28.4**, is given by the UK Health and Safety Commission, based on spills from UK motor spirit tankers.

Table 28.4 Liquid Tanker Leak Frequencies

SPILL SIZE	LEAK FREQUENCY (Per Loaded Vehicle Km)
5 – 15 kg	6.0×10^{-9}
15 – 150 kg	2.6×10^{-8}
150 – 1500 kg	7.0×10^{-9}
> 1500 kg	2.1×10^{-8}
TOTAL	6.0×10^{-8}

Explosives Transportation Incidents

Explosives (Class 1 Dangerous Goods) may be detonated during road transport by the following mechanisms:

- spontaneous fire;
- fire after vehicle crash;
- impact in a crash; and
- detonation due to explosives being in an unsafe condition.

Based on a fault tree analysis, an explosive initiation frequency of 4.1×10^{-9} per vehicle per km has been applied in the PHA.

28.8.2 Transportation Risk Results

The transportation risk contours are shown in **Figure 28.5**. The rail and main road transport routes feature strongly in the risk contours. Higher risk levels are shown where the road and rail routes intersect, along the rear of the existing Patrick Stevedores terminal and where the rail line for the proposed Port Botany Expansion would be extended.

The risk contours show that the forecast combined dangerous goods trade would impose a fatality risk along a road carrying dangerous goods to or from Port Botany of less than 5×10^{-7} per year. This level of risk would be less than the lowest risk criteria used for risk surrounding industrial premises and would be less than 1% of the existing risk to road users due to road crashes not associated with dangerous goods. For the assessment of fixed installations in NSW, an acceptable limit of risk for residential area exposure of one in a million per year (1×10^{-6}) has been adopted.

These risk results should also be considered in line with other risks faced by road users and people living in the residences along the road route. The fatality risk due to all home accidents to people in general is 1 in a million (1×10^{-6}) per year. The fatality risk to all people using roads is 1 in ten thousand (1×10^{-4}) per year. Thus, the fatality risk to residents from dangerous goods movements along roads outside their residences would be less than one-tenth the risk of fatality from all other accidents. Similarly, the risk to road users due to dangerous goods movement through Port Botany would be only one thousandth of the risk of other road accidents.

Source: QEST Consulting Group, 2003

0 500m

Risk Contour Legend

- 1×10^{-7} (yellow)
- 5×10^{-7} (purple)
- 1×10^{-6} (green)
- 5×10^{-6} (red)

Transportation Risk Contours at Combined Port Capacity of 3.4M TEU's

Figure 28.5

28.9 Compliance with the Recommendations of the *Port Botany Land Use Safety Study*

The EIS is required to consider the recommendations of the *Port Botany Land Use Safety Study* (DUAP 1996). The PHA has concluded the following in response to these recommendations:

1. *"Future developments in the Port area should undergo early risk assessment and comprehensive environmental impact process to conclusively demonstrate that they will not contribute to any increase in cumulative risk as shown in Figure 2* [of the Port Botany Land Use Safety Study]. *Developments should also conclusively demonstrate that, consistent with the Department of Urban Affairs and Planning risk criteria, there will not be any propagation of risk to neighbouring facilities."*

   The *Port Botany Land Use Safety Study* considered a new container terminal in its assessment of cumulative individual risk contours from hazards in the Port Botany area. This is shown in Figure 2 of the *Port Botany Land Use Safety Study.* A comparison of these results with those of the PHA is not straightforward because Figure 2 shows results of a cumulative risk assessment. However, an examination of the individual fatality contour for residential criteria (1×10^{-6} per year) for the proposed expansion shows it is within the relevant bounds determined for cumulative risk by the *Port Botany Land Use Safety Study*.

   The proposed Port Botany Expansion's five in a million (5×10^{-6}) per year risk contour is essentially confined to the project site and does not extend to any neighbouring facility. Five in a million (5×10^{-6}) per year is the individual fatality risk criterion for zones classified as commercial developments while the criterion for neighbouring industrial sites is fifty in a million (50×10^{-6}) per year. The recommendation of the *Port Botany Land Use Safety Study* that there be no propagation of risk to neighbouring facilities is therefore satisfied by the proposal.

   It should also be noted that the *Port Botany Land Use Safety Study* features a 50 in a million (50×10^{-6}) per year risk contour. The highest risk level in the PHA for the Port Botany Expansion is more than an order of magnitude lower at 5 in a million per year. The difference represents a significant reduction in risks from the proposed Port Botany Expansion compared to the levels estimated in the *Port Botany Land Use Safety Study*.

2. *"Development controls should be put in place to ensure there is no significant increase in the number of people exposed to risk inside the residential risk contour in Figure 2 [of the Port Botany Land Use Safety Study]."*

   The proposed port expansion would not involve the addition of further residential populations. Therefore the proposed development would comply fully with the above recommendation.

3. *"Risk reduction and safety management measures, identified in the individual site studies, should be implemented in accordance with an agreed program and with particular emphasis on the following:*

   - *systematic program to identify, inspect and maintain safety critical equipment;*
   - *restrictions on roadside parking and queuing of heavy vehicles in the port area;*
   - *review, strengthening and monitoring of site safety management systems;*
   - *including management of change in site safety management systems;*

- *review of container handling procedures to minimise the time volatile and toxic dangerous goods spend on the port;*
- *review of training arrangements; and*
- *review of incident/accident recording and reporting systems."*

Where practical, means for reducing the risk from port operations and transport have been identified and considered in the analysis of risks from the proposed facilities.

The risk analysis undertaken as part of the PHA does not include any modification to the likelihood or consequences based on an assumed performance of the ports' management systems. The risk analysis for the proposed development is based on a trade level forecast beyond the year 2025. During the next twenty years, it would be reasonable to consider that improvements in management systems and performance would have an impact by reducing the likelihood and consequences of an incident on the port. Furthermore, improvements in dangerous goods handling, vessel design and construction, lifting and transfer equipment and road and rail safety would also have an impact in reducing the risks of port operations to the employees working at the port and the community on the neighbouring industrial and residential areas.

4. *"Emergency plans and procedures and fire prevention and protection systems should be kept up to date. Security arrangements for the Port area should be strengthened."*

   The EIS addresses emergency and incident management, including security arrangements, in **Chapter 32** *Emergency and Incident Management*. Detailed design and specifications for emergency, fire prevention and security systems would be formulated by future port operators.

5. *"Port users should adopt community-right-to know principles to ensure the community is adequately informed about port activities, associated risks and the safety management measures that are adopted. The* Responsible Care Program *adopted by the Plastics and Chemicals Industry Association (PACIA) is an appropriate model."*

   Sydney Ports Corporation is an active participant in many community and business forums which are used to provide information on port activities, risks and developments.

28.10 Risk Management

28.10.1 Mitigation Measures

The following mitigation measures would be implemented to manage the hazards and risks described above:

- containers with dangerous goods would be handled and transported in accordance with the Australian Standard 3846 (1998): *The Handling and Transport of Dangerous Goods in Port Areas* and the NSW Dangerous Goods (General) Regulation 1999*;*
- an Occupational Health and Safety Plan would be developed by the terminal operator(s) to address the handling and transport of dangerous goods during the operation of the new terminal;
- a notification system for the arrival or delivery of dangerous goods would be implemented;

- restrictions on the time dangerous goods are allowed to be held within the port would be applied, supported by a loading/unloading plan and arrangement of transport to/from the berths;
- various classes of dangerous goods would be separated by safe distances on the berth;
- suitable container handling equipment would be used to minimise risk of dropped containers;
- suitable container loading/unloading, handling and stacking systems would be employed to minimise double handling and attendant risk of damaging containers;
- the facility would be fitted with adequate yard signage and warning systems for mobile equipment;
- there would be adequate warning systems for ships moving in the vicinity of the facility;
- a first flush drainage system would be installed and maintained to contain spills and contaminated runoff;
- bunds would be constructed around diesel storage tanks;
- fire fighting equipment would be provided and personnel trained in fire fighting and evacuation procedures; and
- emergency and incident management procedures would be developed (refer to **Chapter 32** *Emergency and Incident Management*).

28.10.2 Radioactive Material

There are stringent requirements on manufacturers or consignors of radioactive materials (Class 7) that are transported by ship, particularly in the form of packaging and limits on quantity per package. These requirements are contained in the *International Maritime Dangerous Goods (IMDG) Code*.

Should an accident occur associated with the transportation of Class 7 material, the container body and the internal packing would reduce the likelihood of any escape of radioactive material. In the event of a significant accident, the Hazmat Team from the NSW Fire Brigade would immediately evacuate personnel around any package with a Class 7 label and call in experts to contain and recover the material.

Provided the labelling and documentation is adequate, the risk from transport of Class 7 materials through the proposed Port Botany Expansion would be low.

28.10.3 Construction Safety Study

Pursuant to and in accordance with SEPP 33 guidelines, following project approval Sydney Ports Corporation would conduct a construction safety study, incorporating comprehensive identification of potentially hazardous incidents that could arise during the construction of the Port Botany Expansion and setting out the organisational and operational safeguards proposed to address such incidents. The plan would be prepared in accordance with PlanningNSW's HIPAP No. 7 – *Construction Safety Study Guidelines*.

28.11 Conclusion

The assessment of risks from the proposed Port Botany Expansion against the PlanningNSW risk criteria, based on a throughput of 1.5 million TEUs per year, about 4% of which represents movement of dangerous goods, shows that:

- with respect to the fatality, injury and irritation risk criteria, the proposed port expansion is considered acceptable;
- the contribution of the proposed facility to the risks to the biophysical environment would be very low compared to the background risk, and the more likely accidental emissions would not threaten the long term viability of the ecosystem or any individual species since the effects would be localised and reversible. Hence the HIPAP No. 4 criteria would be satisfied;
- the risk to the surrounding communities along the identified road and rail transportation routes to and from the port area due to the transport of dangerous goods is acceptable for the combined port operations. The transportation risk for the combined future operation of the ports remains a fraction of the acceptable risk level for residential populations and is therefore considered acceptable.

The results of the risk analysis show that the proposed development would satisfy NSW risk criteria in general and the recommendations of the *Port Botany Land Use Safety Study* in particular.

Bird Hazard

CHAPTER 29

Summary of key outcomes:

With appropriate design and management, the proposed Port Botany Expansion would not increase the existing bird hazard to aircraft operating from Sydney Airport.

With better management and enclosed fish cleaning facilities, the replacement boat ramp at Foreshore Beach would be likely to attract fewer birds than the existing ramp at Penrhyn Estuary.

The enhancement of habitat for migratory shorebirds may increase the use of this area by shorebirds, however, as shorebirds currently pose a minimal threat to aircraft, the habitat would not pose a significant bird hazard.

29.1 Introduction

The assessment of the change in bird hazard, associated with the proposed Port Botany Expansion, to aircraft operating from Sydney Airport is based on a report prepared by Avifauna Research & Services titled *Proposed Port Botany Expansion: Assessment of Bird Hazards to Aircraft* (2003). This report is provided in **Appendix X**.

The hazard to aircraft posed by specific bird species was assessed based on the observed and reported occurrences of bird species in the Port Botany and Sydney Airport area, historical bird strikes, observed bird flight paths between roosting and foraging or feeding sites, flight altitudes, tendency to fly in a flock and typical bird body weight. Information was supplemented by predictions as to the type and number of birds that would occur based on the examination of the works to be undertaken as part of the proposed Port Botany Expansion. The assessment of impact focused on the likelihood of whether the proposed development would increase bird hazard to aircraft above current risk levels.

29.2 Existing Environment

29.2.1 Bird Hazard at Sydney Airport

Large numbers of birds, or any number of large birds, flying close to or across an airport on a regular basis are considered to be a bird hazard because of the potential for “bird strike”.

“Bird strike” is defined as a collision between a bird and an aircraft and is referred to as an air safety incident under Civil Aviation Regulation 89. While most bird strikes cause little or no damage to aircraft, some incidents can be fatal or very costly in terms of aircraft damage and aircraft downtime. Statistics show that 90% of bird strikes occur at or near airports.

The risk to an aircraft involved in a bird strike is greatest during take off while the engines are operating at full power. The current operational practices at Sydney Airport are for aircraft to climb steeply after take off to reduce noise, but also to reduce the period and distance over which an aircraft may encounter birds in flight. Aircraft approaching Sydney Airport, especially over Botany Bay, fly at a low altitude and are therefore more likely to encounter birds in flight, than after take off.

The most common species involved in bird strike at Sydney Airport are Silver Gull (43%), Nankeen Kestrel (19%), Feral Pigeon (6%), Galah (4%) and Fruit Bat (4%) based on Hutchinson (1999) who estimates 356 bird strikes at Sydney Airport between 1988 and 1999. Other species account for the rest of the incidents, including Black Swan, Australian Pelican, Australian White Ibis, Black-Shouldered Kite, White-Bellied Sea Eagle, and a range of species associated with grasslands and/or buildings.

Silver Gulls have been a notable hazard at Sydney Airport since the first north-south runway was constructed across the shoreline into Botany Bay (between 1965 and 1972). A primary reason for this is that the runway lies across major flight paths of Silver Gulls foraging along the shoreline or moving between roost sites in Botany Bay and foraging sites in metropolitan Sydney.

Nankeen Kestrels account for a significant portion of bird strikes because the species nests and forages in the grasslands at Sydney Airport

29.2.2 Bird Habitats in the Port Botany Area

By examining the nature and extent of different bird habitats in the vicinity of Port Botany, predictions can be made as to the type of birds likely to occur in a particular area. This information allows management measures to be implemented in specific locations to reduce the attraction of birds which may pose a risk to aircraft and hence to minimise the risk of bird strike at Sydney Airport. The habitat types in the Port Botany area are discussed below.

Estuarine

Many birds gather in estuaries to feed in the shallows and intertidal mudflats, or roost on exposed sand spits. These species include Silver Gulls, Australian White Ibis, Australian Pelican, Bar-tailed Godwits, Black Winged Stilts, Chestnut Teal, Pacific Black Duck and smaller numbers of migratory and non-migratory shorebirds.

Penrhyn Estuary continues to attract birds including Silver Gulls, Australian Pelican, cormorants (four species are recorded as occurring in the vicinity of Port Botany and Sydney Airport), migratory shorebirds and small numbers of other waterbirds and bush birds. However, bird hazard management studies at Sydney Airport between 1997 and 2001 did not identify distinct flight paths of birds across Sydney Airport towards or from Penrhyn Estuary.

The present study observed small flocks of Silver Gulls flying into Penrhyn Estuary from the south and west before sunrise where they congregated before dispersing towards the suburbs of Matraville and Hillsdale to the northeast. This process was reversed in the evening before the birds dispersed to the south and west after sunset. If birds crossed the Parallel or North-South Runways towards Penrhyn Estuary, the numbers would have been small. The Silver Gulls appear to be using Penrhyn Estuary as a “staging area” as no significant numbers were observed roosting overnight.

The primary concern at Port Botany, with respect to potential bird hazard, are the activities at the existing boat ramp at Penrhyn Road and associated fish cleaning facilities. These facilities attract large numbers of Silver Gulls, Australian Pelicans and other bird species, which may present a risk to aircraft due to the inadequate facilities for cleaning and disposal of fish scraps and little incentive not to feed the birds.

Beach

Beaches provide intertidal feeding habitat for Silver Gulls and a variety of shorebirds. Beaches also provide roosting sites for Silver Gulls, Australian Pelicans, Cormorants and various shorebirds.

The area of the beach on the northern side of Botany Bay has been reduced due to historical construction activities such as the construction of the Parallel Runway.

Grassland

Wide expanses of grasslands occur at Sydney Airport. In general, grasslands tend to attract a variety of birds, and the species attracted often relate to the height of vegetation, species composition and whether grasses or weeds are seeding or in flower. Currently, grasslands within Sydney Airport are managed, by mowing on a regular basis, to minimise attraction to birds that may pose a risk to aircraft.

Pavements

Areas of infrequently used open pavements can provide extensive loafing and roosting sites for species such as Silver Gulls. These areas may include parking areas and container terminal pavements.

Improperly drained open spaces where pools form after rain also provide added attraction to birds, particularly Silver Gulls.

An inspection of the existing port facilities at Port Botany and interviews with staff have revealed that very few birds have frequented the existing port facilities in recent years. This is due to the high level of activity at Port Botany, the large container handling equipment (scaring any birds inclined to land in the area) and the lack of open space within the operational port precinct.

Buildings

Buildings that provide nesting and roosting sites may attract birds in large numbers. Roofs of buildings may also provide undisturbed roosting sites for Silver Gulls and Feral Pigeons, as has been observed at port facilities elsewhere in Sydney and Melbourne.

29.3 Assessment of Impacts

29.3.1 Change in Risk

The effect of the proposed Port Botany Expansion on the risk posed to operations at Sydney Airport by specific bird species and their impact is provided in **Appendix X**.

Some of the high risk bird hazard species identified may be attracted to the new terminal and public recreation areas due to the creation of food sources and/or roost sites during construction and operation, as discussed below. These species include the Silver Gull, Australian White Ibis and Australian Pelican. These areas would therefore require appropriate management and monitoring.

Most migratory and non-migratory shorebird species have small body weights and tend to fly low over the water when in Botany Bay. Therefore, shorebirds are considered to pose a low bird strike risk.

29.3.2 Construction

Dredging operations invariably expose large amounts of shells and other marine organisms which provide food for birds such as Silver Gulls and shorebirds. As the material spills into the water other species, such as Australian Pelicans and Cormorants, may be attracted to the site. Bird attraction to dredge spoil has been observed at Sydney Airport during the construction of the Parallel Runway and during dredging operations at the Port of Brisbane.

During reclamation for the new terminal, large volumes of dredged spoil would be pumped in between embankment walls until the required ground levels are achieved. The reclaimed area may remain unused or undisturbed for a number of years before the new port facilities become operational. The reclaimed ground would provide a large expanse that may prove attractive as a roost site for birds such as Silver Gulls. Species such as Cormorants are also likely to use the edges of the reclamation as convenient roosting sites close to deep water. These undisturbed open spaces have the potential to attract significant numbers of birds to the site, thereby potentially increasing the risk of bird strike at Sydney Airport.

Pooling of water may occur on the reclaimed land from uneven surfaces. Birds may take advantage of the pools for bathing, especially if close to a roost site or feeding area. Pooling of water can attract birds to congregate and form large flocks.

Construction sites may also attract birds if workers feed birds and leave food scraps.

Areas illuminated at night are likely to attract birds, especially Silver Gulls. Such areas help to provide a secure roosting environment where potential predators, such as foxes or feral cats can be seen. Additionally, lights may also attract insects such as moths and other large insects, which in turn attract Silver Gulls.

29.3.3 Operation

The new terminal would have expanses of sealed surfaces, some of which may remain unused or undisturbed for some time before terminal facilities are built on that particular portion of the new terminal. Sealed surfaces often provide ideal roost sites for large numbers of birds especially Silver Gulls. Bitumen surfaces provide a warm surface for roosting and are particularly attractive where areas are not subject to regular disturbance. These undisturbed open spaces have the potential to attract significant numbers of birds to the site, thereby potentially increasing the risk of bird strike at Sydney Airport.

Areas illuminated at night are also likely to attract birds, especially Silver Gulls, as they provide a secure roosting environment and attract insects which birds feed upon.

The past roosting activities at Port Botany are strong indicators that the creation of additional port land and construction of buildings may, in the short term, attract birds in large numbers. Thousands of Silver Gulls previously roosted on the terminal at Port Botany until the port became fully utilised and started operating 24 hours a day, leaving no areas undisturbed.

The additional port land may provide large areas of suitable roosting habitat for the Silver Gull. Flat surfaces of buildings, such as roofs, may provide suitable places for Silver Gulls to roost. Openings and ledges may provide roosting and nesting habitat for Feral Pigeons, Common Starlings, Common Mynas and other bird species associated with buildings.

The pavements and buildings associated with the new terminal have the potential to attract significant numbers of birds to the site, thereby potentially increasing the risk of bird strike at Sydney Airport. It is therefore important to initiate deterrent strategies.

29.3.4 Public Recreation and Ecological Areas

Public recreation areas would be enhanced adjacent to Foreshore Road to the north of the new terminal as part of the Port Botany Expansion. The public recreation area would include the provision of a new boat ramp, car park, beach enhancement and landscaping. Penrhyn Estuary would be enhanced as a shorebird habitat.

Boat Ramp and Car Park

A new boat ramp facility would be constructed off Foreshore Road at the northern end of the new terminal. The facility would incorporate a boat ramp, car and trailer parking and a boarding/unloading jetty.

Boat ramps are a well known source of food for many birds, especially Silver Gulls and Australian Pelicans. The boat ramp has the potential to attract birds to the site as a result of increased litter, food scraps and fish remains if not managed appropriately.

Landscaping would influence the bird species that would be attracted to the replacement boat ramp. Shrubs would tend to attract small insectivorous or nectivorous birds that pose little risk of bird strike. Grassland on the other hand would attract larger high risk bird strike species such as Galahs, Australia Raven and Nankeen Kestrel.

Lighting, which would be required to allow safe use of the boat ramp after dark, may attract insects on which birds are likely to feed.

The location of the replacement boat ramp would, however, be less attractive to birds than the existing boat ramp in Penrhyn Estuary due to the absence of extensive feeding or roosting sites in the immediate vicinity.

The replacement boat ramp would be designed and managed to minimise the number of birds attracted to the facility.

Beach Enhancement

It is proposed that the beach between the Mill Stream and the new terminal, adjacent to the new boat ramp, be enhanced as part of the public recreation area works.

There appear to be no large concentrations of birds on the existing Foreshore Beach, possibly due to frequent disturbance from recreational activities such as people exercising dogs. There is therefore no reason that the improvements to the beach in this area would increase attraction to birds and therefore risk to aircraft at Sydney Airport. However, with the likely increased number of people using the enhanced beach over time, attention would be given to the control of litter and the education of users about avoiding feeding birds close to the airport.

Groynes

Two groynes would be constructed. One groyne would extend southward from the existing Mill Stream retaining wall and follow the general alignment of the Parallel Runway perimeter to the west. This groyne would prevent sediment from accumulating at the mouth of the Mill Stream. Another rock groyne is proposed next to the replacement boat ramp to protect the ramp from wave action. Either of these structures would likely attract amateur fishers, which may in turn attract Silver Gulls and Australian Pelicans.

Penrhyn Estuary

Penrhyn Estuary would be retained and enhanced as habitat for migratory shorebirds. The main objective would be to provide intertidal sand/mudflats suitable as foraging habitat for migratory shorebirds that probe into the mud for food. The attraction of more migratory shorebird species to Penrhyn Estuary would not increase the risk of bird strike at Sydney Airport because most migratory shorebird species have small body weights and tend to fly low over the water when in Botany Bay.

Silver Gulls, Australian Pelicans and Australian White Ibises have a much higher likelihood to pose a risk to aircraft safety due to their habit of moving in flocks and circling at relatively high altitudes when disturbed. The habitat to be created in Penrhyn Estuary would not be attractive to Silver Gulls and Australian Pelicans because these species feed visually and not by probing. They are therefore not expected to be attracted to the area unless food sources are available to them such as food discarded or given to the birds by members of the public or rubbish from stormwater drainage.

Cycleway/footpath

A cycleway/footpath would be constructed between Foreshore Road and Foreshore Beach and extending between Mill Stream and Penrhyn Road. Users of the cycleway/footpath may discard litter and food scraps. This corridor may attract birds if users discard litter or food scraps or feed birds.

29.4 Mitigation Measures

A Bird Hazard Management Plan would be prepared for the construction and operation of the Port Botany Expansion to reduce the risk of increasing bird hazards arising from the proposal. The plan would be incorporated in the Construction and Operational EMP and would include:

- measures to minimise the attraction of birds, especially high risk species such as Silver Gulls, Australian Pelicans and Australian White Ibises;
- use of deterrents to prevent the build up of birds;
- exclusion of activities that attract birds in certain areas;
- measures to minimise disturbance of birds at Penrhyn Estuary;
- education about bird hazards; and
- monitoring.

29.4.1 Minimising Attraction of Birds

Construction

Birds may be attracted to construction sites if workers feed birds and leave food scraps. Management measures for workers and visitors in construction sites which would minimise attraction to birds include site cleanliness, litter control, discouraging bird feeding, and appropriate training and guidance of workers and visitors to the site.

Pooling of water on uneven surfaces may attract birds to bathe, feed or roost. The construction areas would be finished in a way that would minimise pooling of water and appropriate drainage would be installed. Any unavoidable ponding (e.g. sedimentation ponds) where water is likely to be present for prolonged periods would be covered with netting.

Temporary construction lighting would use tinted lights where possible to minimise the attraction of insects on which birds are likely to feed.

Operation

The new terminal operator(s) would be responsible for implementing management measures to minimise roosting and nesting sites and food sources for birds on the new terminal.

Buildings may provide roosting or nesting sites for large numbers of birds. Any ledges used by roosting or nesting birds should be bird-proofed at the earliest opportunity before they become accustomed to a particular site. Roosting on roofs, especially by gulls, should be managed at the earliest opportunity to prevent a build up in numbers and possible initiation of a nesting colony.

Within the public recreation areas, strict litter control would be implemented in all areas including the use of appropriate litter bins, signage and enforcement to ensure that food items or fish remains are not left at the site to attract birds. Litter bins would be designed to be bird and vermin proof, easy to use, kept clean and tidy, and emptied on a regular basis.

Appropriately designed and placed signs to inform the public about the potential dangers of attracting birds close to Sydney Airport and the problems to bird health associated with feeding would be erected at public recreation areas and the new terminal.

Signs would also encourage people to place litter in the bins provided or take litter home for disposal.

The boat ramp and associated facilities would be designed so as to discourage birds from using the site for roosting. Posts or similar structures would be kept to a minimum and/or designed to prevent birds from roosting on them by using “bird spikes” similar to those used on channel markers and navigation beacons.

Lighting at the new boat ramp and public areas would be designed to minimise the attraction of insects on which birds are likely to feed. Lights would be of low intensity and diffuse in nature and the structures would be kept low in preference to high poles.

In the design of the new boat ramp, the car parking area and the approaches to the site, landscape planting that provides habitat to problem bird species would be minimised. Low level shrubs around the car parking areas would be provided to reduce the amount of litter blowing onto the site from Foreshore Road. Grassed trailer parking areas would be mown on a regular basis to minimise grass seeding and would be constructed and graded to minimise the formation of pools of water.

Enclosed fish cleaning facilities would be provided at the new boat ramp to prevent birds from entering the facility and to discourage people from cleaning fish on the new boat ramp or beach. The enclosed fish cleaning facility would be connected to the sewerage system.

Boat-washing facilities would not be provided at the new boat ramp to minimise the likelihood of food scraps, fish remains and other rubbish being washed onto the ground or into nearby waters. Drainage for the boat ramp and car parking areas would include swales to minimise the potential for rubbish and other pollutants entering the Bay.

A fishing exclusion zone in and around the sheltered bay formed by the Parallel Runway and Foreshore Beach would be maintained so as to minimise the attraction of birds. Fishing would not be allowed in Penrhyn Estuary.

Visitor access to the Estuary would be restricted to a boardwalk and observation platform which would allow viewing of the birds without disturbing them. Aside from discouraging feeding of birds, visitors to Penrhyn

Estuary would be encouraged not to unduly disturb the birds. Facilities for litter control would be provided. The issue of securing the site, especially at night, would be addressed during the design phase.

The cycleway/footpath would be landscaped and planted with appropriate shrubs and trees. Bins would be provided for control of litter.

29.4.2 Deterrent Action

Construction

Regular monitoring and reporting of birds attracted to the construction sites would be undertaken. Should birds be attracted to the site, attempts would be made to discourage them from feeding or roosting by using flagging material or other deterrent methods as described below. In implementing deterrent actions, consideration would be given to ensuring that a large number of birds are not frightened into taking flight at the same time.

Operation

Regular monitoring of the site, including after nightfall, would be undertaken to determine whether birds are attracted to the site. If required, deterrent systems would be employed to prevent the build up of birds in the new terminal and public recreation areas. Examples of deterrent systems include:

- flagging or streamers – this consists of material flapping in the wind and is fairly effective in deterring birds from landing close by. This method has been used successfully nearby at Molineux Point;
- perch spikes – can be installed on structures such as posts which provide roosts for species such as Cormorants, Australian Pelicans and Silver Gulls;
- fishing lines strung across bird landing paths – the lines frighten birds when they attempt to land and come into contact with the “invisible” line;
- distress calls – designed to scare birds away;
- cracker shells – are cartridges fired from a shotgun causing an explosion in mid-air to frighten birds. These have been known to be effective in most situations when used at random, but may need to be used in combination with other devices as a long term solution; and
- strobes or moving spotlights – work best in a dark environment and may be less effective where there is a lot of light from other sources, for example wharf areas which are illuminated during the night.

Bird deterrent methods like cracker shells, which are likely to have a significant deterrent impact on migratory shorebirds using Penrhyn Estuary, should only be used during periods when most migratory species are absent (i.e. from early May to late June), unless advised otherwise by an expert shorebird ecologist. In any case, these types of deterrents should be used only on advice from an expert shorebird ecologist.

At the first signs of a deterrent system failing to work, alternative methods would be used to supplement or replace the existing bird deterrent system.

29.5 Monitoring

The purpose of monitoring is to determine whether birds are starting to habituate or build up in large numbers so that this can be addressed at a very early stage rather than later when remedial action may be more difficult.

All areas would be patrolled during construction on a regular basis after nightfall to determine whether birds especially Silver Gulls, Australian Pelicans, Australian White Ibis or Feral Pigeons are attracted to the site to roost. Immediate bird deterrent action would be implemented if roosting of birds were observed on site.

Any build up of birds attracted to dredging and reclamation operations would be reported to an appropriate consultant for deterrent action as required.

The new terminal would be monitored on a regular basis to determine whether birds are roosting at the site. Bird roosting behaviour would be referred to an appropriate consultant for action if required.

The public recreation areas would be inspected at regular intervals to make sure they are kept clean and that birds are not attracted to the site (except for wader birds in Penrhyn Estuary) as a result of people feeding them or leaving food scraps or fish remains in the area.

29.6 Conclusion

Provided the proposed mitigation measures are implemented, the Port Botany Expansion would not increase the existing risk of bird strike to aircraft operating from Sydney Airport.

The enhancement of habitat for migratory shorebirds may increase the use of this area by shorebirds, however, as shorebirds currently pose a minimal threat to aircraft, the habitat would not pose a significant bird hazard.

With better management and enclosed fish cleaning facilities, the replacement boat ramp at Foreshore Beach would be likely to attract fewer birds than the existing ramp at Penrhyn Estuary.

All areas would be monitored during construction and operation of the Port Botany Expansion to ensure that they are kept clean and that birds are not attracted to the site. Any build up of birds attracted to the site would be reported to an appropriate consultant for deterrent action as required.

Summary of key outcomes:

The proposed Port Botany Expansion would not intrude into the protected airspace of Sydney Airport as defined by the Obstacle Limitation Surface. The effect of the proposed development on the airport's existing radar and navigation systems performance and coverage would be manageable using system tuning and site operating condition adjustments such that system safety would not be compromised. However, the proposed development could affect the Precision Approach Runway Monitor (PARM), with no change to the existing system or technology and could potentially introduce errors to the southern approach path.

The PARM is scheduled for replacement by about 2009, prior to commissioning of the first berth of the Port Botany Expansion in 2010. By this time there will have been significant development of PARM and other alternative technologies which would be able to eliminate any potential impacts resulting from the proposed Port Botany Expansion. The final solution to the anticipated PARM impacts would be dependant upon the selection of the future technology for achieving independent parallel approaches to be implemented at Sydney Airport. To address this issue, Sydney Ports Corporation would coordinate and work with CASA, Airservices Australia and SACL during the detailed design stage and the development/implementation of the future PARM system technologies to ensure that any impacts or interfaces as a result of the new terminal are satisfactorily addressed.

30.1 Introduction

This chapter assesses the potential impacts of the proposed Port Botany Expansion on operational aviation issues at Sydney Airport, in particular on the airport's protected airspace, radar capability and navigation systems. The assessment also covers light spill as it affects the identification of airport markers for landing purposes.

The assessment is based primarily on the following reports:

- Airservices Australia 2002. *Port Botany Expansion: Impact on Airservices Radar and Navigation Systems at Sydney Airport*, Canberra, July 2002 (**Appendix Y**); and
- Bassett Consulting Engineers 2002. *Proposed Port Botany Expansion Third Container Terminal Lighting Environmental Effects*, November 2002 (**Appendix Z**).

30.2 Existing Aviation Operational Environment

30.2.1 Air Space

The protected airspace around Sydney Airport has been defined using international standards. This space is defined by two sets of invisible surfaces above the ground namely the:

- Obstacle Limitation Surface (OLS); and
- Procedures for Air Navigational Services - Aircraft Operations (PANS-OPS) surface.

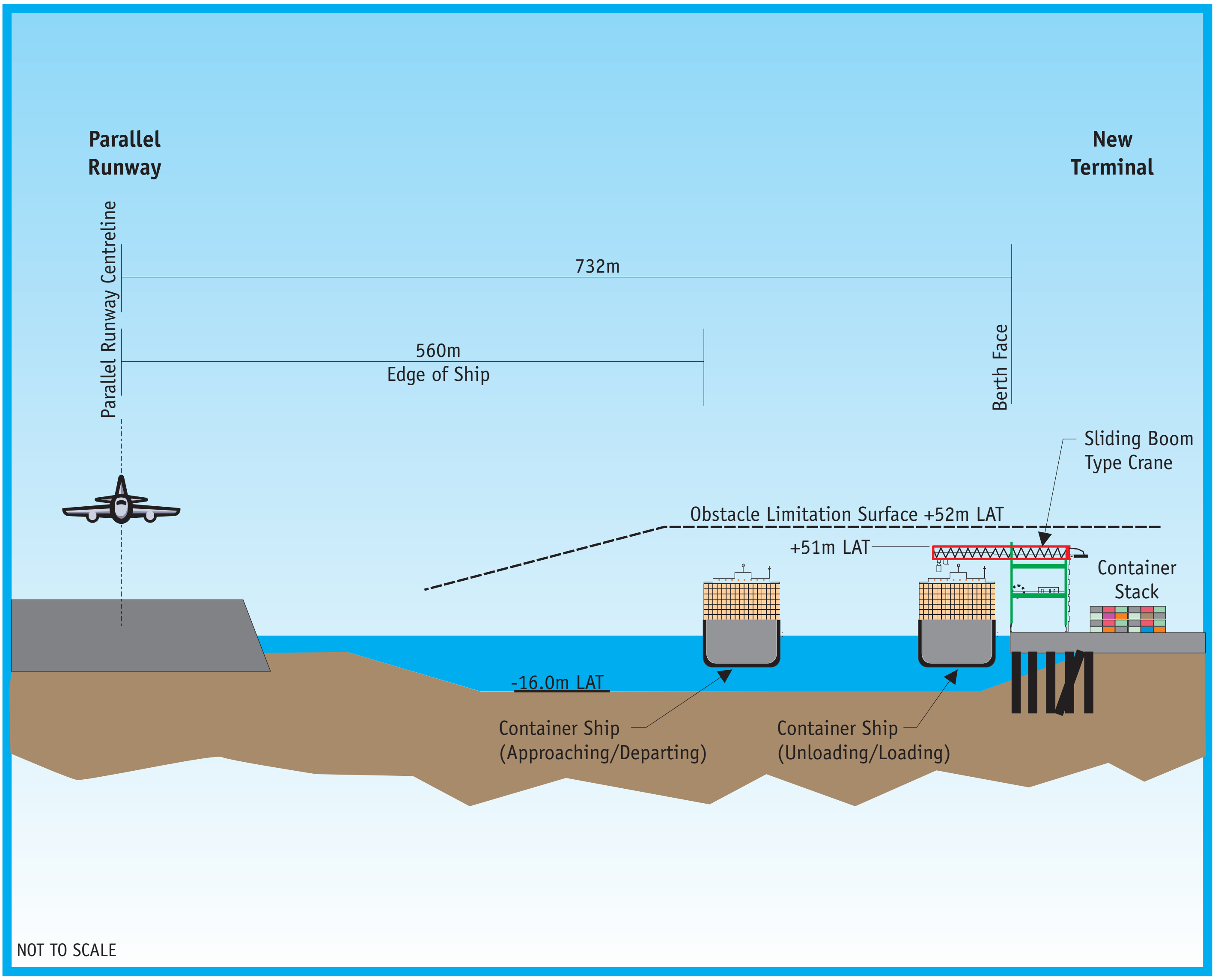
The OLS is generally the lowest surface and is designed to provide protection for aircraft flying into or out of the airport when the pilot is flying by sight. The PANS-OPS surface is generally above the OLS and is designed to safeguard an aircraft from collision with obstacles when the aircraft's flight may be guided solely by instruments in conditions of poor visibility.

The OLS affecting the new terminal is the imaginary surface rising at a 1:7 slope from the Parallel Runway to a plateau of 52 m above the Lowest Astronomical Tide (LAT) datum, as shown in **Figure 30.1**. This figure also shows the lateral separation of the new terminal and the navigation channel from the centreline of the Parallel Runway.

Any activity resulting in an intrusion into an airport's protected airspace cannot be carried out without approval under the Commonwealth *Airports Act* 1996 (refer to **Chapter 9** *Statutory Planning*) and long term intrusions of the PANS-OPS surface are prohibited.

30.2.2 Radar Services

The existing radar services and their uses at Sydney Airport are described in **Table 30.1**.



Obstacle Limitation Surface Over the Port Botany Expansion

Figure 30.1

Table 30.1 Radar Services at Sydney Airport

TYPE	RANGE	CRITICAL AREAS	MAIN TASKS
Surface Movement Radar	5 nm	Runway threshold[1] and airport movement areas	• To identify aircraft and monitor their position when operating on the airport manoeuvring area. • Interfaces with the Terminal Approach Radar to acquire data on arriving aircraft as they are about to land. • The Surface Movement Radar system is also used to monitor the position of airport equipment and vehicles on the airport manoeuvring area.
Terminal Approach Radar (TAR) (Primary)	40 nm	20 nm around Sydney Airport	• Process all aircraft arriving and departing Sydney Airport and some aircraft transitting Sydney Airport's airspace. • To detect intruders and process aircraft that are not equipped with transponders (a radar transmitter-receiver activated for transmission by reception of a predetermined signal).
Terminal Approach Radar (TAR) (Secondary)	255 nm	20 nm around Sydney Airport	• Process all aircraft arriving and departing Sydney Airport and some aircraft transitting Sydney Airport's airspace. • Provides secondary data activated by the aircraft transponder.
Route Surveillance Radar (Mount Boyce)	255 nm	40 nm around Sydney Airport	• Component of the Multi Radar Tracking process for Sydney. It covers some areas not adequately covered by the TAR and serves as a back-up for the TAR.
Precision Approach Runway Monitor (PARM)	32 nm	North and south approach paths to the North-South and Parallel Runways	• Used to monitor aircraft carrying out simultaneous parallel approaches. In conjunction with the existing navigation system, the PARM provides the capability to conduct approaches to the parallel runways independently of one another even in adverse weather conditions.

[1] Runway threshold refers to the beginning of that portion of the runway useable for landing.

30.2.3 Navigation System

Navigation systems provide for the safe and efficient operation of aircraft, including approach and landing. The international standard system for approach and landing guidance is called the Instrument Landing System (ILS). Any ILS equipped aircraft can expect to satisfactorily use the system at any airport.

An ILS normally comprises of:

- a "Localiser" aligned with the runway centreline and providing direction guidance;
- a "Glide Path" for elevation and descent angle guidance; and
- either "Marker Beacons" or distance measuring equipment (DME) for providing distance to touchdown information along the approach path.

The Sydney Airport's Parallel Runway ILS is equipped with DME co-located with the Glide Path transmitter.

30.2.4 Light Spill

Under the Civil Aviation Regulations 1988 (CAR) (Regulation 94), the Civil Aviation Safety Authority (CASA) has the power to require lights which may cause confusion, distraction or glare to pilots in the air, to be extinguished or modified. CASA may authorise a notice to be served for infringement of the regulation. Failure to comply with the directions contained in the notice constitutes an offence.

Lighting during construction and operation of the proposed Port Botany Expansion, if improperly designed and specified, has the potential to cause confusion or distraction by reason of colour, position, pattern or emission intensity above the horizontal plane.

CASA provides "Advice to Lighting Designers" for "Lighting in the Vicinity of Aerodromes." The advice defines lighting restriction zones within a 6 km radius of a runway. Within this area there exists a primary zone consisting of four light restriction zones, A, B, C and D, concentric to the runway axis as shown in **Figure 30.2**. The secondary zone consists of the area between the edge of zone D and the 6 km radius from the runway. These zones reflect the degree of interference ground lights can cause as a pilot approaches to land, with zone A requiring the least interference.

30.3 Methodology

Potential issues affecting the airport's radar and navigation systems were assessed by modelling the line of sight and reflection of radar targets. Calculations involving radar line of sight assumed maximum height to the top of the quay cranes as the worst case. In calculations involving reflection from radar targets, ship dimensions and container stacking heights were considered. The contribution of cranes to radar reflection was considered minor and was therefore not included in the modelling.

The assessment of potential light spill from the proposed development was based on the assessment of the existing container terminals at Port Botany and on the requirements of civil aviation regulations.

30.4 Assessment of Impacts

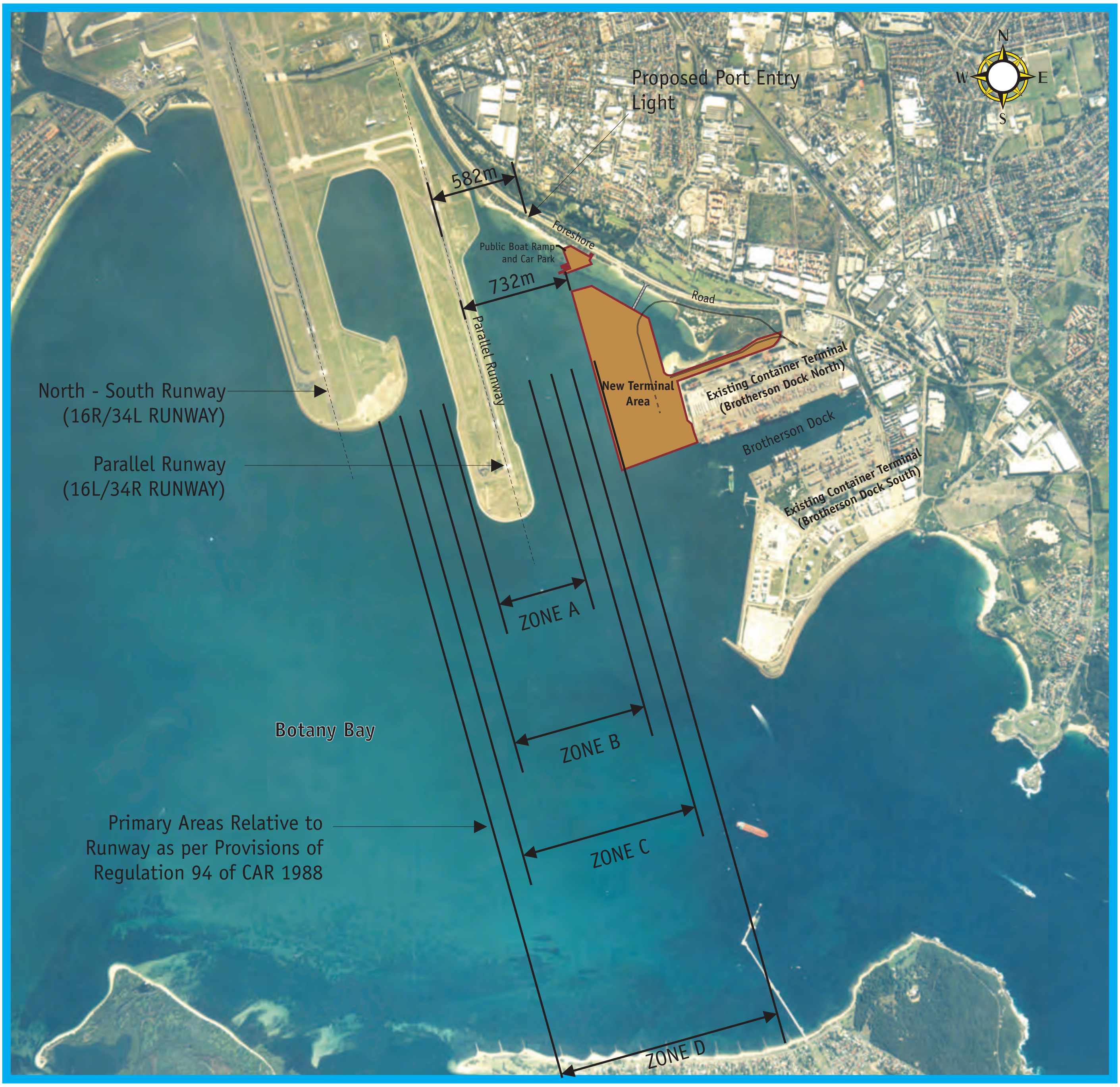
30.4.1 Construction

Air Space

There would be no anticipated impact on OLS during construction as equipment, including lighting masts and pile drivers, would be selected so as not to intrude into the OLS (i.e. less than 52 m LAT). Given that the OLS is the lower of the surfaces which control aircraft safety, the PAN-OPS would also not be compromised by the proposed development.

Radar and Navigation System

The potential impacts on radar and navigation systems during construction would be negligible as there would be no construction equipment of sufficient vertical or lateral dimension to mask radar signals, create significant radar reflectivity or cause signal interference.



Source: Bassett Consulting Engineers, 2002

0 2km

Lighting Restriction Zones **Figure 30.2**

Light Spill

Construction lighting would not be expected to result in light spill into restricted zones during construction, except possibly during night time dredging and reclamation work along the western edge of the new terminal which would lie in Zone D (**Figure 30.2**). However, lighting for night time dredging activities would be mounted at a low level and positioned to avoid light spill above the horizontal. There would generally be no other night time construction activities. Illumination of other construction areas would have minimal light spill as this would use low intensity, shielded, downward pointing lighting for perimeter and area security only.

30.4.2 Operation

Air Space

There would be no fixed or mobile structures in the new terminal that would intrude into the OLS. The most vertically prominent equipment would be the quay cranes. The new terminal would use sliding boom type quay cranes whose overall working and stowed height would be 47 m (or 51 m LAT when mounted on the new terminal) which would be less than the OLS, as shown schematically in **Figure 30.1**. This type of crane's boom slides back when in the stowed position instead of being raised up, allowing the crane to remain under the OLS at all times. An illustration of this type of crane and a comparative summary of key properties of the two types of cranes are shown in **Chapter 6** *Terminal Operations*.

Given that the OLS is lower than the PANS-OPS, there would be no intrusion into the PANS-OPS as a result of the Port Botany Expansion.

Radar Services

The proposed Port Botany Expansion could affect Sydney Airport's radar services through masking of the radars' line of sight and increased radar reflectivity from new structures and berthing ships. The potential impacts on each radar service are summarised in **Table 30.2**.

Table 30.2 Potential Impacts of the Proposed Port Botany Expansion on Radar Services

RADAR SERVICE	EFFECT ON LINE OF SIGHT	REFLECTIVITY IMPACTS
Surface Movement Radar	Minimal adverse impacts as the development is outside the coverage area.	Primary reflections not anticipated to cause problems.
TAR (Primary)	Reduction in primary coverage at low altitudes in the direction of the Port Botany Expansion. Masking by new structures (such as cranes) and vessels would render targets below 1,200 ft at 20 nm not visible.	Vessels in transit to berths at the new terminals would create false targets and reduce target detection sensitivity inside 10 nm.
TAR (Secondary)	Obstruction of low altitude targets along the direction of the new terminal. Masking by new structures and vessels would render targets below 1,200 ft at 14 nm not visible.	Increase in reflections due to large flat sides of ships and containers, but these reflecting signals could be detected and removed.

RADAR SERVICE	EFFECT ON LINE OF SIGHT	REFLECTIVITY IMPACTS
Route Surveillance Radar (Mount Boyce)	Impact on the existing coverage due to the proposed Port Botany Expansion is likely to be minimal.	Increase in reflections due to flat sides of stacked containers and ships, especially when adjacent ships provide a wide target, but these reflecting signals could be detected and removed.
PARM	Coverage not likely to be affected by the proposed Port Botany Expansion.	New port structures and berthing ships could introduce errors and adversely affect PARM capability to monitor simultaneous independent parallel approaches from the south onto the North-South and Parallel Runways. The unavailability of the PARM would adversely affect the rate of arrivals on both runways.

Navigation System

The components of the ILS at Sydney Airport likely to be affected by the proposed Port Botany Expansion by virtue of proximity to the proposed development are the following (**Figure 30.3**):

- 16L Localizer – located on the extended runway centreline approximately 250 m beyond the north stop end of the Parallel Runway;
- 34R Localizer – located on the extended runway centreline approximately 240 m beyond the south stop end of the Parallel Runway; and
- Runway 34R Glide Path – located 152 m west of the Parallel Runway centreline and 350 m from the runway south threshold.

Interference to the ILS would most likely be caused by container ships while they are transitting to and docked at the new terminal. The new cranes, by virtue of their distance from the Parallel Runway centreline and their substantially open lattice structure, would not cause interference to the ILS.

Modelling of the impact of the operation of the new terminal on the ILS showed that:

- ships of 1500 TEU class would have a negligible impact on the 16L and 34R Localizers if the ships are kept at least 500 m east of the Parallel Runway centreline;
- ships of 3000 TEU class would have a negligible impact on the 16L Localizer if the ships are kept at least 550 m east of the Parallel Runway centreline;
- ships of 3000 TEU class would create an unacceptable level of interference to the 34R Localizer when transitting to or docked at the new terminal;
- ships of 4500 and 6000 – 8000 TEU classes would create an unacceptable level of interference to the 16L and 34R Localizers when transitting to or docked at the new terminal;
- ships of 1500 TEU class would have a negligible impact on the 34R Glide Path if the ships are kept at least 400 m east of the Parallel Runway centreline; and
- ships of 3000, 4500 and 6000-8000 TEU classes would have a negligible impact on the 34R Glide Path if the ships are kept at least 500 m east of the Parallel Runway centreline.

The performance of the Parallel Runway ILS which communicates directly with the approaching aircraft, is not predicted to be affected by the proposed development.

Source: BJ Project Services Pty Ltd 2002

0 500m

Location of ILS Components on Parallel Runway

Figure 30.3

Light Spill

From **Figure 30.2** it can be seen that an 18 m wide strip along the western side of the new terminal, including quay cranes and berthing ships, would lie within Zone D. The proposed Port Entry Light (PEL) near the proposed Foreshore Road pedestrian overpass would lie within Zone C. The rest of the proposed development would lie within the 6 km radius secondary restriction zone.

It is anticipated that light spill from the Port Botany Expansion would not adversely impact operations at Sydney Airport due to the following lighting design measures:

- High masts – lighting would be directed down to the intended application area with minimal light spill outside the area boundaries, by using asymmetric distribution horizontal flat glass floodlights, and would comply with CASA requirements. Mast heights similar to those at the Patrick Stevedores terminal (40 m) would be used which are below the OLS height restrictions.
- Quay cranes –lighting of shuttle boom quay cranes would be specified as downlight type to meet civil aviation regulations. Lighting elements for access/egress stairs and gangways would be mounted horizontal (no tilt) and have internal shielding of the lamps to ensure correct cut off. Obstruction lights would be placed on cranes to mark these in accordance with civil aviation regulations (CAR Regulation 95).
- Straddle carriers – straddles carriers would move mostly in the secondary restriction zone but would pick up containers from beneath the quay cranes, thus entering Zone D for this period. The main task downlights would be specified to comply with civil aviation regulations. The impact of headlights and rotating beacon lights would need to be managed.
- Rail mounted gantries (RMGs) – RMGs would only operate in the secondary lighting restriction zone. Their lighting would be similar to straddle carriers.
- Buildings and associated areas – buildings and other external areas would be lit with floodlights that have a similar cut off lighting performance to those mounted on high masts. Internal building lighting would be similar to that used at the airport terminal and at the existing port facilities. Therefore, these areas would have a negligible impact on operations at Sydney Airport.
- Roads – cut off type road lighting and low level lighting elements would be used wherever possible to minimise light spill.
- Rail – the head light on any train would be in the secondary lighting restriction zone and would be unlikely to be more or less distracting than currently on Patrick Stevedores terminal.
- Ships - the floodlights on ships, once berthed, are used to provide working light on deck. Ships on the north south berths of the new terminal would fall within zone D. Floodlights and their direction of illumination could have the potential to affect use of the airport.
- Navigation – channel alignment would be achieved by a single unit PEL located north of the new terminal, pole mounted at an appropriate height for visibility from the bridge of ships. The PEL would be controlled optically and filtered internally to produce distinct bands of light (red, white and green). The PEL would be designed such that there was no light at 3 degrees above the horizontal whilst providing well defined bands of light in the horizontal. This technology is already in use in the vicinity of both the North-South and Parallel Runways.

- Recreation areas – areas such as tug berths and the public boat ramp would be well lit whilst complying with light restriction above the horizontal through the appropriate selection of lighting elements and the use of low level lighting.

30.5 Mitigation Measures

30.5.1 Radar and Navigation System

The potential impacts of the proposed Port Botany Expansion on radar services and navigation systems at Sydney Airport would be minimised through the measures described in **Table 30.3**.

Table 30.3 Measures to Mitigate Potential Impacts of Proposed Port Botany Expansion on Radar Services and Navigation Systems at Sydney Airport

SYSTEM	MITIGATION MEASURES
TAR (Primary)	• Reduction in primary coverage by masking can be remedied by increasing radar height or relocating the radar. • Tuning of track processing equipment to mitigate impacts. • The existing facility is likely to undergo a technology upgrade to a processing system that would improve performance under adverse conditions prior to terminal operations.
TAR (Secondary)	• Reduction in coverage by masking can be remedied by increasing radar height or relocating the radar. • System tuning to improve discrimination of real from "reflected" tracks, enhance long range performance.
Route Surveillance Radar (Mount Boyce)	• Tuning of track processing equipment to mitigate impacts.
PARM	The existing PARM is scheduled for major maintenance in 2004/05 and replacement by about 2009 (prior to the commissioning of the first berth of the new terminal). By 2010 there will have been significant development in PARM system technology. The final solution to the anticipated PARM impacts will be dependant upon the selection of the future technology for achieving independent parallel approaches to be implemented at Sydney Airport. Alternatives include: • If the existing PARM technology (also known as "E-scan") is replaced by a similar system it is anticipated that the next generation would have greater capacity to eliminate the anticipated impacts as a result of the proposed port expansion and other developments on or adjacent to Sydney Airport. If the existing E-scan technology is to be retained after its scheduled replacement date in 2009 Sydney Ports Corporation would, during the detailed design phase of the project, commission further modelling of the interfaces between the PARM and various configurations of the elements of the new terminal, including berthing ships, so that interference thresholds could be more accurately assessed and the appropriate amelioration measures identified. • Alternative Multilateration (MLAT) technology is currently being developed and tested at major US and European airports. MLAT technology offers benefits in that it is significantly cheaper and more flexible with respect to the siting of fixed land based receivers than the existing E-scan technology. The elimination of interferences due to the new terminal (and other potential obstructions) could be achieved by the use of alternative receiver sites or additional receiver units. Airservices Australia is currently reviewing MLAT technology and its expected certification by the US Federal Aviation Administration (FAA) in 2004 would simplify its certification by CASA for Australian use. The adoption of MLAT technology would eliminate any potential impacts resulting from

SYSTEM	MITIGATION MEASURES
	the proposed Port Botany Expansion. • Another alternative is Automatic Dependant Surveillance (ADS-B) technology which relies upon information transmitted from advanced aircraft transponders. The International Civil Aviation Organisation (ICAO) has recommended that ADS-B technology be globally implemented by 2006 however, as the technology utilises advanced transponder units that have only been installed as standard equipment in aircraft since 2003, there is likely to be a delay in the universal adoption of this technology for standard operation. Airservices Australia is currently conducting ADS-B trials and the technology has some significant potential operational and cost benefits for the Australian aviation industry. The adoption of ADS-B technology would also eliminate any potential impacts resulting from the proposed Port Botany Expansion. • Sydney Ports Corporation would coordinate and work with CASA, Airservices Australia and SACL during the detailed design stage and the development/implementation of the future PARM systems or alternative techniques to ensure that any impacts or interfaces as a result of the new terminal are satisfactorily addressed.
16L Localizer (Parallel Runway ILS)	• Ships less than 4500 TEU would achieve a lateral separation of at least 550 m from the centreline of the Parallel Runway therefore there would be no impact on the 16L Localizer from these ships. • Interference from ships of 4500 TEU or greater could be reduced to an acceptable level by upgrading the current antenna system to a higher category. • The International Civil Aviation Organisation (ICAO) has indicated that ILS systems will be decommissioned from 2010, as the implementation of replacement technology occurs.
34R Localizer (Parallel Runway ILS)	• Ships less than 3000 TEU would achieve a lateral separation of at least 500 m from the centreline of the Parallel Runway therefore there would be no impact on the 34R Localizer from these ships. • Interference from 3000 TEU class of ships could be reduced to an acceptable level by upgrading the current antenna system to a higher category. • Interference from ships of 4500 TEU or greater could be reduced to an acceptable level by upgrading the current antenna system to a higher category. • The International Civil Aviation Organisation (ICAO) has indicated that ILS systems will be decommissioned from 2010, as the implementation of replacement technology occurs.
34R Glide Path (Parallel Runway ILS)	• Lateral separation distance of 400 m east of the Parallel Runway centreline for 1500 TEU class of ships and 500 m east of the Parallel Runway centreline for classes of ships greater than or equal to 3000 TEU would be maintained. These lateral separation distances would be maintained for at least 1,000 m south of the 34R Glide Path. Therefore there would be no impact on the 34R Glide Path. • The International Civil Aviation Organisation (ICAO) has indicated that ILS systems will be decommissioned from 2010, as the implementation of replacement technology occurs.

30.5.2 Light Spill

Lighting during the construction and operation of the Port Botany Expansion would be carefully selected to ensure they would not infringe the provision of Regulation 94 of the Civil Aviation Regulations 1988. During the detailed design stage, CASA would be consulted for detailed guidance and appropriate restrictive controls.

While future terminal operators would have no direct control over the design of lighting on board ships, there are some options by which they would be able to minimise light spill, including:

- lighting on board ships whilst berthed to be provided primarily by the shuttle boom quay cranes with supplementary lighting on board only being provided where necessary;
- ships to be berthed facing a specific direction (e.g. north or south) and to only use floodlights mounted on the bridge. The appropriateness of this option could be tested by CASA through a fly-over of the existing Brotherson Dock; and
- provide restrictive temporary shielding to any permanent ship mounted floodlights whilst the ship was docked.

Standard operating procedures would be implemented at the new terminal, in consultation with SACL, to ensure that ship lighting does not affect operations at Sydney Airport.

30.6 Conclusion

The proposed Port Botany Expansion would not intrude into the protected airspace of Sydney Airport as defined by the OLS. The effect of the proposed development on the airport's existing radar and navigation systems performance and coverage would be manageable using system tuning and site operating condition adjustments such that system safety would not be compromised. However the proposed development could affect the PARM, with no change to the existing system or technology, and could potentially introduce errors to the southern approach path.

The PARM is scheduled for replacement by about 2009, prior to commissioning of the first berth of the Port Botany Expansion in 2010. By this time there will have been significant development of PARM and other alternative technologies which would be able to eliminate any potential impacts resulting from the proposed Port Botany Expansion. The final solution to the anticipated PARM impacts would be dependant upon the selection of the future technology for achieving independent parallel approaches to be implemented at Sydney Airport. To address this issue Sydney Ports Corporation would coordinate and work with CASA, Airservices Australia and SACL during the detailed design stage and the development/implementation of the future PARM system technologies to ensure that any impacts or interfaces as a result of the new terminal are satisfactorily addressed.

Summary of key outcomes:

No changes in existing water or sediment contaminant concentrations would be expected in Botany Bay, outside the confined area of Penrhyn Estuary, due to the proposed Port Botany Expansion.

The confinement of Penrhyn Estuary by the new terminal may increase contaminant concentrations in surface waters within Penrhyn Estuary, but the overall contaminant concentrations are not expected to change markedly from the present contaminated conditions. Therefore, the proposed development is not expected to significantly alter the risks to human health, or the environment.

The future discharge of groundwater contaminated by previous industrial activity is expected to increase the concentration of certain contaminants in Penrhyn Estuary. However, the proposed development would not affect the discharge of groundwater or contaminants into the Estuary.

Possible increased risks to human health, due to increased concentrations of contaminants in Penrhyn Estuary, would be offset by restricting public access to this area in order to protect shorebird habitat.

31.1 Introduction

URS Australia Pty Ltd (URS) has undertaken a review of ecotoxicology (the effects of chemicals on communities and ecosystems in the natural environment) and human health issues that may arise due to the proposed Port Botany Expansion. The assessment has focussed on changes in risks to the environment and human health due to the proposed development, rather than an evaluation of risks associated with existing conditions in Botany Bay.

The complete study titled *Review of Contamination Issues Associated with the Port Botany Expansion* (2003) is provided in **Appendix AA**. The review addressed the following questions:

- Will changes to the hydrodynamic regime between the Parallel Runway and the existing Port, associated with the proposed development, alter the risks to;
  - aquatic organisms; or
  - human health either through the consumption of fish caught by recreational anglers or the recreational use of this area (e.g. swimming or wading) ?
- Will disturbance of the marine sediments and subsequent drainage from the reclaimed areas during the construction of the proposed development, alter the risks to aquatic organisms and human health through consumption of fish caught from these areas?

The review has drawn on related studies undertaken for this EIS namely:

- water quality investigations by Lawson and Treloar Pty Ltd (**Appendix J**);
- groundwater studies by accessUTS Ltd (**Appendix L**);
- terrestrial ecology by URS (**Appendix O**); and
- marine ecology by The Ecology Lab Pty Ltd (TEL) (**Appendix N**).

31.2 Methodology

The study area included the northeastern embayment of Botany Bay bounded by the southern end of the Parallel Runway and Molineux Point.

Changes to ecotoxicological and human health risks associated with the proposed development, variation in the concentration and distribution of chemicals of concern and changes in environmental stressors that may occur as a consequence of the new terminal were identified.

Assessment of changes of risks to human health from the proposed development relied on a comparison with the risks identified in the Orica Australia Stage 2 risk assessment of contamination arising from industrial activity in the Penrhyn Estuary catchment (Woodward-Clyde 1996).

Environmental risks have been assessed on a qualitative basis, with reference to environmental quality indicators. Key factors contributing to significant changes in risk have been identified.

Numerous investigations have been undertaken in the study area in relation to contamination issues. These were also considered in the assessment of ecotoxicity and human health risk issues.

31.3 Existing Environment

The proposed development at Port Botany is located in the highly modified northeastern embayment of Botany Bay. The catchment surrounding the study area has a long history of industrial development and urbanisation. In common with many estuarine environments in built up areas, contaminants in Penrhyn Estuary are enriched above background concentrations and the existing environment is no longer in pristine condition (Birch 1996).

Contaminant input to the northeastern embayment of Botany Bay from the catchment affects the water and sediment quality. Sources include:

- major tributaries (e.g. Georges and Cooks Rivers and the Mill Stream);
- minor tributaries (e.g. Floodvale and Springvale Drains);
- surface runoff from foreshore catchments;
- infrastructure in, or around the Bay (e.g. Sydney Airport and Port Botany); and
- groundwater inflows.

The contaminant status of the study area is described below.

31.3.1 Groundwater

Groundwater quality to the north of Penrhyn Estuary and Foreshore Beach has been subject to extensive investigations since the early 1990's. Most of the available studies and data relate to investigations of groundwater issues associated with the Orica (formerly ICI) facility. These studies indicate the following:

- both shallow and deep groundwater has been contaminated as a result of historic operations at the Orica facility;
- the prime contamination issues relate to the presence of volatile halogenated compounds (VHCs);
- the source of VHCs in surface waters of Penrhyn Estuary is a result of the discharge of both shallow and deep groundwater; and
- the groundwater contamination is the subject of ongoing investigation and remediation programs by Orica.

Three deep groundwater plumes, characterised by high concentrations of VHCs, are predicted to ultimately discharge via intertidal zones to surface waters in Penrhyn Estuary and along Foreshore Beach (**Appendix L**). One of the plumes has already begun discharging into the Estuary.

The NSW EPA has recently issued a Clean Up Notice to Orica under the POEO Act. This notice requires Orica to establish a containment area to prevent further discharge of contaminated groundwater into Penrhyn Estuary and Botany Bay. The notice requires that this containment area be established by 31 October 2004. The assessment undertaken in this EIS, however, assumes a "worst case" scenario where the contaminated groundwater plumes do reach the Bay.

31.3.2 Surface Water

Penrhyn Estuary

The main contamination issue in the surface waters of Penrhyn Estuary is the discharge of contaminants from the groundwater plumes into Penrhyn Estuary either directly, or via Springvale and Floodvale Drains. Concentrations of VHCs in the Estuary (listed in **Appendix AA**) currently exceed ANZECC (2000) water quality guideline values, notably at low tide.

The water quality monitoring data collected by Orica indicates that surface water concentrations of 1, 2 dichloroethane (also known as EDC) and to a lesser extent vinyl chloride (VC) and carbon tetrachloride (CTC) have increased since sampling commenced in the early 1990's.

Monitoring undertaken by Orica also indicates that VHCs present at elevated concentrations within Penrhyn Estuary decrease to below laboratory detection limits in the open waters of northeastern Botany Bay. Mixing with Botany Bay waters and the volatility of many of the halogenated compounds restrict high concentrations of contaminants to the upper parts of Penrhyn Estuary, upstream of the present constriction. Tidal flushing influences concentrations of contaminants in Penrhyn Estuary waters and notably higher concentrations have been recorded at low tide conditions (Woodward-Clyde 1996).

Northeastern Botany Bay

Water quality issues within northeastern Botany Bay are dominated by the Mill Stream outflow and are influenced by overflows from the Southwestern Sydney Ocean Outfall Sewer (SWSOOS). The Harbourwatch monitoring program indicates that Foreshore Beach has, on a relative scale, poorer water quality with respect to indicators of sewage contamination than most other beaches monitored by Harbourwatch.

The available data indicates that VHCs in northeastern Botany Bay are below the laboratory detection limits within a short distance from the constriction in Penrhyn Estuary. Under current conditions, VHCs would not be expected to be detectable off Foreshore Beach and the discharge of VHCs in deep groundwater would not be expected to have a significant effect on the water quality outside of Penrhyn Estuary, due to rapid dispersion and volatilisation.

31.3.3 Sediment Quality

Hexachlorobenzene (HCB) and mercury present in the sediment of Penrhyn Estuary were derived from historical sources in the Floodvale and Springvale Drain catchments. Sources of HCB and mercury in the catchment have been mitigated and no longer provide a significant flux to Penrhyn Estuary; therefore concentrations of these contaminants in surface sediment are expected to decrease over time. However, Penrhyn Estuary is the receiving water for an industrialised and urbanised catchment and a flux of other contaminants, typical of developed catchments (e.g. copper, lead and zinc) would continue to accumulate in the Estuary. Sediment-bound contaminants are generally associated with fine grained material and contaminant concentrations of total sediment are "diluted" by higher sand content. Fine sediment initially deposited at the Estuary mouth is resuspended and redistributed to lower energy areas. Therefore, the steep seaward gradient of concentrations from Penrhyn Estuary to northeastern Botany Bay with increasing distance from source is accentuated by an increase in grain size.

31.3.4 Biota

There has been limited historical sampling and analysis of biota within Penrhyn Estuary and northeastern Botany Bay. Sampling has been undertaken by Orica to assess risks to human health associated with the consumption of fish. These studies have focussed primarily on those contaminants from the Orica facility that have the potential to bioaccumulate namely mercury, chromium and semi-volatile halogenated compounds. The biological monitoring has focused on potentially edible species of fish, but has also included a number of invertebrate species. The studies indicate accumulation of HCB in some species at concentrations greater than that found at reference sites elsewhere in Botany Bay (Woodward-Clyde 1996). In contrast, concentrations of mercury and chromium in biota have been generally found to be not significantly different from those found at reference sites.

31.4 Existing Risks

31.4.1 Existing Human Health Risks

The human receptor group relevant to the proposed port development is recreational users of Penrhyn Estuary and Foreshore Beach. Recreational users of Penrhyn Estuary and Foreshore Beach may be exposed to contaminants by contact with surface water or sediment (e.g. while swimming) or by consuming fish caught from Penrhyn Estuary.

The studies undertaken by Orica indicated that:

- the most significant exposure pathways for recreational users of Penrhyn Estuary are incidental ingestion of surface water and dermal contact with water during swimming. These pathways account for greater than 95% of the total risk;
- the VHCs that contribute most to health risk are 1, 2 dichloroethane (EDC), vinyl chloride (VC) and carbon tetrachloride (CTC);
- the most sensitive group is young children (5 to 12 years) due to their greater tendency to wade and swim, their potential greater sensitivity to chemicals and lower body weight; and
- consumption of fish caught from Penrhyn Estuary represented a negligible risk for both adults and children.

The concentrations of VHCs in surface water in the upper reaches of Penrhyn Estuary, upstream of the existing constricted area, have approached values that exceed commonly accepted risk goals for recreational use of this area, given regular exposure. Recreational use near the existing boat ramp, which lies outside of the constriction, did not present an unacceptable risk to human health. Due to the generally muddy and unattractive nature of the upper reaches of Penrhyn Estuary, most recreational use occurs on the sandy, open area near the existing boat ramp. The concentrations of VHCs in this area are lower than those measured within the confined area of Penrhyn Estuary and have been identified as being acceptable with respect to risk to human health.

The discharge of VHCs in groundwater plumes may result in increased concentrations of VHCs in Penrhyn Estuary and therefore increased risks to human health, however, this would occur irrespective of the Port

Botany Expansion. It is also important to note that the implementation of Orica's contingency plan should prevent most of the contaminated groundwater from reaching the Estuary.

The groundwater study (**Appendix L**) indicated no significant changes to groundwater levels north of Penrhyn Estuary and Foreshore Beach, and no change in the fate of the contaminated groundwater plumes, as a consequence of the development. Hence, there is no need to consider risks associated with VHCs in groundwater to receptors in the catchment as the existing risks would not be altered by the development.

A current risk to human health, notably during high rainfall conditions, is associated with high concentrations of faecal coliforms in surface waters adjacent to Foreshore Beach and within Penrhyn Estuary (**Appendix AA**).

The potential effects of sediment-bound contaminants have been assessed as part of the Orica risk assessment and show that sediment-bound contaminants within the project area do not pose a significant risk to human health. Despite concentrations of some contaminants exceeding guideline values, the risk assessment undertaken by Orica indicates exposure to sediments to be an insignificant exposure pathway.

31.4.2 Existing Ecological Risks

The available studies indicate an abundance of both benthic and aquatic organisms within Penrhyn Estuary, however, no historical studies have assessed existing risks to aquatic and terrestrial organisms within the Estuary.

Penrhyn Estuary provides both feeding and roosting grounds for birds including waders that feed on the mudflats and larger fish-eating species, such as pelicans. The baseline benthic study (**Appendix N**) determined that the assemblages of benthic invertebrates from intertidal and subtidal environments varied significantly within the study area and with respect to other areas within Botany Bay. Importantly, the observations show that Penrhyn Estuary provides habitat for both aquatic and terrestrial organisms and that intertidal and subtidal communities function successfully as ecological units.

Based on available data, it is not possible to state whether or not the existing contaminant concentrations are causing adverse effects to biota. The available environmental quality benchmarks and sediment quality guidelines indicate that some contaminants are present at concentrations that warrant further assessment to determine whether they cause adverse ecological effects (Section 31.5.2).

Meaningful assessment of risks to bird species, in particular waders, is confounded by many factors that influence the population of wading birds in Botany Bay. Assessment of the health of wild bird populations is very difficult, particularly for small and transient populations such as those visiting Penrhyn Estuary. In addition, because wading birds do not breed at Penrhyn Estuary it is not possible to determine whether exposure to contaminants is adversely affecting the reproductive ability of the birds.

Previous studies of fish and invertebrates (a small number of species) suggests only limited accumulation potential of mercury and HCB in higher order aquatic species, however, no assessment of potential accumulation in birds has been undertaken. Similar to risks to human health, the discharge of VHCs in groundwater plumes may result in increased concentrations of VHCs in Penrhyn Estuary and therefore increased risks to environmental receptors, irrespective of the development of the Port Botany Expansion.

31.5 Risk Assessment

The risk assessment of the study area has identified habitats, ecological receptor groups (aquatic organisms and water birds) and chemicals of potential concern (COPC). COPC are defined as chemicals present at concentrations above the environmental guideline values that therefore warrant further assessment of the potential to cause unacceptable risks to the environment, or human health.

The environmental quality guidelines relevant to the assessment of Penrhyn Estuary and northeastern Botany Bay are contained in the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC 2000).

The ANZECC (2000) guidelines provide "trigger values" relevant to the assessment of surface water quality. These trigger values for marine water are appropriate for the protection of aquatic species in estuaries. In addition, ANZECC (2000) also provides water quality guidelines for recreational use that are relevant to primary contact (e.g. swimming) and are considered appropriate to this assessment.

ANZECC (2000) has compiled interim sediment quality guidelines (ISQG), relevant to the protection of benthic (bottom dwelling) organisms. Contaminant concentrations are compared to guideline values and sediment with concentrations exceeding the interim sediment quality guidelines lower (ISQG-L) concentration, or "trigger value", being subject to further examination for availability of contaminants to biota.

The evaluation of surface water quality in relation to wildlife is based on Toxicological Benchmarks (US Department of Environmental Management 1996). That document provides several benchmark values for birds including contaminant concentrations in food, drinking water and water. There are a number of uncertainties in the derivation of the benchmark values and as such the benchmark values are intended to be used for broad screening purposes only.

31.5.1 Chemicals of Potential Concern Related to Human Health Risk

The following discussion of COPC relevant to the risk(s) to human health is based on contaminant concentrations in water, as the risk assessment undertaken by Orica indicates exposure to sediment to be an insignificant exposure pathway.

The following COPC in Penrhyn Estuary have been identified based on the ANZECC (2000) water quality guidelines for recreational purposes and the Orica risk assessment studies (Woodward-Clyde 1996):

- 1, 2 dichloroethane (EDC)
- 1, 1 dichloroethene,
- vinyl chloride (VC) or chloroethene;
- carbon tetrachloride (CTC);
- trichloroethene;
- tetrachloroethene;
- benzene;
- mercury; and
- sulphide.

Based on available data, no COPC have been identified in northeastern Botany Bay including along Foreshore Beach. However, the main focus of surface water quality monitoring outside Penrhyn Estuary to date has been the occurrence of sewage contamination indicators (e.g. faecal coliforms), determined as part of the Harbourwatch program. Whilst faecal coliforms are biological in nature, and hence not strictly COPC, they have been addressed in the human health risk assessment because of their potential to affect human health.

31.5.2 Chemicals of Potential Concern Related to Environmental Risk

Water

Volatile halogenated compounds are a group of chemicals with a wide range of densities, solubilities and chemical properties. These compounds are generally not bound to soil or sediment and are typically stable in groundwater, but are rapidly released to the atmosphere from surface waters. Due to their volatile nature, these chemicals do not generally accumulate in organisms. Based on available data, ANZECC (2000) aquatic ecosystem guideline values for marine waters were not exceeded in Penrhyn Estuary or off Foreshore Beach for VHCs, however, guideline values for other chemicals occurring in Penrhyn Estuary are not specified by the ANZECC (2000) guidelines, e.g. chloroform, CTC, EDC and trichloroethene.

The concentration of mercury in Penrhyn Estuary has exceeded the ANZECC (2000) guideline value on several occasions. Copper concentrations have exceeded the ANZECC (2000) guideline value in the Mill Stream, along Foreshore Beach and in northeastern Botany Bay.

Sediment

The primary sediment-bound contaminants of potential concern in the study area are:

- mercury;
- chromium; and
- hexachlorobenzene (HCB).

Mercury may be present as different species in the environment including elemental (metallic) and stable mineral forms, soluble inorganic salts (e.g. mercuric chloride), and amalgams with other elements (e.g. silver and gold). Organic complexes, especially methylated forms of mercury are highly toxic. The solubility, environmental fate and toxicity of mercury are dependent on the chemical form (speciation) of the element. Unlike the majority of heavy metals, mercury has the potential to bioaccumulate in organisms, hence increasing in concentration in species higher in the food chain. Mercury concentrations in the Penrhyn Estuary sediment are variable, but considerably in excess of the ANZECC (2000) ISQG-L value, at some locations.

The maximum chromium concentration in sediment exceeds the ANZECC (2000) ISQG-L value in Penrhyn Estuary. However, chromium is unlikely to constitute a COPC, as the mean concentration of chromium in the Penrhyn Estuary sediment is well below the ANZECC (2000) ISQG-L value.

HCB is typically strongly bound to sediment and is persistent in estuarine sediment. HCB has low solubility in water, is non-volatile, and can bioaccumulate in fish and other aquatic animals. ANZECC (2000) does not include a guideline value for HCB in sediment. Limited data indicates that maximum and mean concentrations of HCB in sediment in Penrhyn Estuary are higher than those of HCB in estuarine sediment in Port Jackson.

Available data on contaminant concentrations of sediment in the proposed dredged area were assessed to determine risks related to disturbance and possible dispersion of contaminants in Botany Bay during dredging and reclamation of the proposed new terminal. In some samples, mercury exceeded ANZECC (1996) guideline values for sea disposal of dredged and excavated material. Nine sediment samples contained mercury concentrations exceeding the ANZECC (2000) ISQG-L value, however, the mean concentration of mercury is below the guideline value.

Concentrations of organotin compounds exceeding ANZECC (1996) guideline values in the proposed dredge area were reported for eight sediment samples. Organotin compounds are highly toxic to marine organisms and have been effectively used to reduce/prevent fouling of vessels by marine organisms. However, organotin concentrations in sediments in the dredge area are unlikely to cause significant risk to aquatic organisms as:

- current concentrations are generally low;
- organotin compounds degrade in sediment; and
- the predominant contemporary source of these contaminants in northeastern Botany Bay, antifouling paint on commercial shipping, is being phased out (**Chapter 19** *Aquatic Ecology*).

31.6 Assessment of Impacts During Construction

Dredging operations for reclamation of the Port Botany Expansion have the potential to create risks to aquatic organisms from the release of contaminants from disturbed sediment and oxidation of sulphides.

The distribution of mercury and organotin compounds is irregular and does not indicate widespread enrichment in surficial sediment. Concentrations of mercury and organotin compounds are generally low and close to detection limits and exceed sediment quality guideline values only in a limited number of sites. Therefore, mobilisation of these contaminants during dredging of sediment in Botany Bay would not pose a significant risk to aquatic organisms.

Organic-rich, fine-grained sediment in the proposed dredged area may contain concentrations of sulphides that, if oxidised, could release acid leachate and heavy metals. The Botany Bay Acid Sulphate Soil Risk Map identifies the proposed dredge area as an area at high risk of containing acid generating sulphides (DLWC 1995). As discussed in **Chapter 18** *Geology, Soils and Geotechnical*, the potential for significant volumes of acid leachate being transported to Botany Bay from oxidised sulphitic material is considered to be low.

31.7 Assessment of Impacts During Operation

Changes to ecological risk as a result of the proposed development are related to changes in hydrodynamic conditions resulting from the confining of a larger area of Penrhyn Estuary. Under present conditions, the exchange of water is largely unrestricted between Botany Bay and the outer section of Penrhyn Estuary. Post-development water exchange between Botany Bay and Penrhyn Estuary would be via a 130 m channel approximately 700 m long, north of the new terminal and adjacent to Foreshore Beach.

31.7.1 Changes in Contaminant Concentrations

Surface Water

Modelling undertaken by Lawson and Treloar (**Appendix J**) indicates that concentrations of nutrients are highest in upper Penrhyn Estuary, but are predicted to increase by a factor of around 1.6 to 1.7 for both Total Nitrogen (TN) and Total Phosphorous (TP), due to a decrease in flushing of the Estuary. In line with the increase in nutrient concentrations, the restricted exchange of water in Penrhyn Estuary would be expected to result in the following:

- an increase in the concentrations of VHCs in the upper reaches of Penrhyn Estuary; and
- an increase in the total area of the Estuary where VHCs occur at concentrations above the laboratory level of reporting.

Higher concentrations of VHCs are expected throughout the majority of Penrhyn Estuary, including the outer estuary where concentrations are currently low. A rapid decline of concentrations is likely to occur along the proposed channel, due to volatilisation and mixing with Botany Bay waters.

In contrast to modelled results of nutrients, the concentrations of VHCs in Penrhyn Estuary are likely to decrease substantially during high rainfall events, due to dilution by stormwater and flushing of the Estuary. The effect of stormwater dilution on VHC concentrations has been observed in regular monitoring of water quality in Penrhyn Estuary.

The current source of VHCs in Penrhyn Estuary is predominantly from the discharge of shallow groundwater into Springvale and Floodvale Drains and subsequent flow to the Estuary. As reported by accessUTS (2003), monitoring by Orica shows that a deep groundwater plume currently discharges into Penrhyn Estuary. A substantial additional flux of halogenated compounds from the other deep groundwater plumes may discharge to the intertidal zone of Penrhyn Estuary within the next five years. Hence, irrespective of whether the development proceeds, the concentrations of VHCs are expected to increase within the confined area of Penrhyn Estuary, as a result of historical contamination of groundwater.

The future concentrations of VHCs in Penrhyn Estuary would depend on the amount of attenuation (by dilution and volatilisation) occurring during transport and at the point of discharge, as well as the effectiveness of the Clean Up Notice issued by the NSW EPA to Orica. The installation of a containment area, as required by the Notice, would significantly reduce any discharge of contaminated groundwater into Botany Bay or Penrhyn Estuary.

Sediment

The proposed new terminal would significantly reduce wave energies (particularly local sea waves) and sediment transport at the existing mouth of Penrhyn Estuary. The resultant lower ambient wave energies would allow fine grained sediment that is currently remobilised, to accumulate in the larger confined area of Penrhyn Estuary. Sediment in Penrhyn Estuary is enriched in mercury and HCB from historical sources, however, new sediment particles arriving in Penrhyn Estuary would be expected to have lower contaminant concentrations, due to a reduction of catchment contaminant sources.

The proposed enhancement of habitat for wading birds in Penrhyn Estuary requires relocation of dune sands and the creation of additional intertidal flats. The sand would be placed over existing contaminated sediment in some areas of the Estuary, but the stability of sediment in Penrhyn Estuary would be dependent on final design configuration and peak current velocities during high rainfall events. Creation of seagrass habitats within Penrhyn Estuary and the proposed channel adjacent to eastern Foreshore Beach may also assist in stabilising existing sediment-bound contaminants.

31.7.2 Changes in Human Health Risks

The proposed port development would change the risks to human health due to:

- the confinement of a larger area of Penrhyn Estuary and resultant reduction in flushing that would increase the area containing detectable concentrations of VHCs and other contaminants; and
- increased concentrations of VHCs within the upper reaches of Penrhyn Estuary.

The future concentrations of VHCs in Penrhyn Estuary would be related to flushing, contaminant volatility and discharge of VHCs into the Estuary. However, maximum and mean concentrations of VHCs are not expected to change substantially from the current (variable) concentrations as a result of the proposed port development. It is expected that the overall risks to human health following the port development would be reduced, as the changes in recreational use of the area would result in a net reduction in exposure to areas containing the highest concentrations of VHCs.

The proposed development would alter the current recreational use of Penrhyn Estuary and Foreshore Beach. Access to the current boat ramp would be removed, access to Penrhyn Estuary would be restricted to a boardwalk and viewing platform, and recreational use of Foreshore Beach east of the new boat ramp would be limited to passive activities (i.e. no swimming). This would reduce the potential for exposure to VHCs in the areas having the highest contaminant concentrations (i.e. upper Penrhyn Estuary) and could result in an overall reduction of risks to human health.

Whilst the development may result in the migration of fine sediments along Foreshore Beach into areas currently containing coarse sediments with low contaminant concentrations, the risk assessment undertaken by Orica indicates exposure to sediments to be an insignificant exposure pathway. Similarly, the larger confined area of Penrhyn Estuary would not be expected to result in increased accumulation of contaminants in edible biota. This exposure pathway was identified in the Orica risk assessment and calculated to be insignificant. No change to this conclusion is expected as a result of the proposed development.

Similar to increased nutrient and VHC concentrations, increased concentrations of faecal contaminants are predicted in the upper reaches of Penrhyn Estuary, post construction of the new terminal. However, restriction of access to Penrhyn Estuary, to a boardwalk and viewing platform only, is likely to result in an overall decrease in risks to human health from faecal contaminants.

The Harbourwatch monitoring program has indicated that Foreshore Beach has generally poorer water quality relative to other monitored beaches. Recreational activities on Foreshore Beach pose considerable human health risks due to contact with existing faecal contamination from the Mill Stream. Relocation of the existing boat ramp from Penrhyn Estuary to Foreshore Beach and creation of public recreation areas at the northwestern end of Foreshore Beach would bring the boating activities closer to a major source of the faecal contamination. Sydney Water Corporation is undertaking works to reduce the frequency of sewer overflows into the Mill Stream. This is likely to reduce the risk by the time the proposed new terminal is constructed. Modelling of concentrations of faecal coliforms (**Appendix J**) indicates that the concentrations would decrease slightly near the new boat ramp during high rainfall events after the construction of the Port Botany Expansion. The same modelling indicates that concentrations of faecal coliforms are likely to increase during high rainfall events in Penrhyn Estuary as a result of reduced flushing, but human exposure would be minimised by restricted access to the Estuary.

31.7.3 Changes in Ecological Risks

In contrast to human health risk assessment, there have been only limited studies on risks to ecological receptors associated with contamination of water and sediment at Penrhyn Estuary. The main factor to consider in relation to changes in ecological risks is the increased area of Penrhyn Estuary potentially affected by elevated concentrations of VHCs in surface water and a possible increase in the area of contaminated sediment.

Penrhyn Estuary currently supports diverse ecological communities and it is not possible to determine with certainty whether the existing estuarine habitat has been degraded by contamination. Although the concentration of VHCs is likely to increase throughout Penrhyn Estuary as a consequence of the development, concentrations are likely to be in the same order of magnitude as prior to development, in the absence of additional deep groundwater sources of VHCs. On this basis, the level of effects on organisms is not expected to be significantly altered by the proposed development.

The input of contaminants to Penrhyn Estuary that have potential to bioaccumulate (i.e. mercury and HCB) is primarily related to historic inputs from Springvale Drain. Some of the existing sediment-bound contaminants in Penrhyn Estuary would be covered by uncontaminated sand as an additional benefit of the habitat enhancement works. The possible redistribution of sediment-bound contaminants in the Estuary would not be expected to significantly increase the accumulation of these contaminants in higher order species.

The expected discharge of VHCs from the deep groundwater plumes is likely to increase VHC concentrations in Penrhyn Estuary. Accurate predictions of whether an increase in concentrations, as a result of the groundwater plumes entering the Estuary, would adversely affect aquatic and terrestrial species is not possible but would occur irrespective of the proposed expansion.

31.8 Mitigation Measures

31.8.1 Construction

Risks during construction of the new terminal are predominantly related to the potential for dispersion of sediment-bound contaminants and exposure of Potential Acid Sulphate Soils during dredging of estuarine sediment. Mitigation measures to protect ecological systems from adverse effects are proposed in **Chapter 16** *Hydrology and Water Quality* and **Chapter 18** *Geology, Soils and Geotechnical*.

31.8.2 Operation

Post development risks to human health and ecological systems are related to the concentrations of contaminants, notably VHCs in Penrhyn Estuary. Mitigation measures that would reduce the potential human health and ecological risks in Penrhyn Estuary and along Foreshore Beach include:

- restrictions to public access and recreational activities in Penrhyn Estuary, barriers, signage etc;

- no swimming in the new channel parallel to Foreshore Beach;
- stormwater quality improvement devices for the treatment of stormwater from Floodvale and Springvale Drains could be installed to further reduce the influx of sediment-bound contaminants into Penrhyn Estuary; and
- monitoring of the diversity and abundance of shorebirds in Penrhyn Estuary to ascertain the potential affects of COPC on shorebird populations.

These mitigation measures are described below.

Public Access

Public access to Penrhyn Estuary is currently not restricted although advisory signs are currently in place. Post development concentrations of dissolved COPC in Penrhyn Estuary would likely increase in the Estuary, but would decline markedly along the new channel. Due to the steep gradient in VHC concentrations, a reduction in risks to human health would be achieved by limiting access to Penrhyn Estuary for habitat protection purposes. Access to the Estuary would be restricted to a viewing platform to observe wading shorebirds. Swimming would not be allowed in the Estuary or the channel.

Stormwater Treatment

Sediment traps on Floodvale and Springvale Drains would be installed to reduce the influx of particulate-bound contaminants to Penrhyn Estuary. These measures would improve water quality by decreasing sediment-bound contaminants in Penrhyn Estuary and Botany Bay, however the sediment traps would not reduce the concentrations of VHCs discharging to the Estuary via deep groundwater and would be targeting catchment sources that are not related to Port Botany or the operations at the new terminal.

Habitat Monitoring

Intertidal areas in Penrhyn Estuary represent a valuable habitat for some species of migratory shorebird in northern Botany Bay. Risks to birds foraging and roosting in Penrhyn Estuary are not expected to be substantially different to present conditions, as a result of the Port Botany Expansion. Due to the volatility of many of the COPC present in Penrhyn Estuary, substantial bioaccumulation of contaminants in the food source of birds would be unlikely. However, the long term viability of Penrhyn Estuary as a habitat suitable for shorebirds cannot be established with certainty at this time, irrespective of the proposed expansion, due to the uncertainty in the concentrations of contaminants that may eventuate from existing sources, the concentrations at which shorebirds are likely to suffer adverse effects, and the range of feeding and roosting behaviours of different bird species.

Monitoring of the diversity and abundance of birds in Penrhyn Estuary would be undertaken as described in **Chapter 20** *Terrestrial Ecology*. The results of this monitoring would provide useful information on the potential effects of the COPC and the long term viability of Penrhyn Estuary as a suitable habitat for shorebirds, although it would be affected by the fact that the survival and breeding success of migratory shorebirds is influenced by the quality of their habitat in areas remote from Botany Bay. Should the results of this monitoring indicate that the long term viability of Penrhyn Estuary as a shorebird habitat is being compromised, offsite compensatory habitat options may be explored as described in **Chapter 20** *Terrestrial Ecology*.

31.9 Conclusion

No changes in contaminant concentrations due to the proposed development would be expected in Botany Bay, outside the confined area of Penrhyn Estuary. The confinement of Penrhyn Estuary would increase contaminant concentrations in the surface waters of the Estuary.

Risks to human health would potentially increase with higher concentrations of VHCs in the upper reaches of Penrhyn Estuary, if the current level of public access to the Estuary were maintained. However, public access to Penrhyn Estuary would be restricted to a boardwalk and viewing platform to protect habitat, and therefore risks to human health would be mitigated and potentially reduced. No swimming would be allowed on Foreshore Beach, east of the new boat ramp due to the potential for higher concentrations of VHCs in this area. No changes in risk due to potential increases in VHC concentrations are expected for recreational use of Foreshore Beach west of the new boat ramp.

No change in the concentrations of COPC that might bioaccumulate in edible fish species would be expected, thus the development would not alter the risks associated with the consumption of fish caught by recreational anglers.

It is apparent that Penrhyn Estuary currently provides a functioning habitat for wading shorebirds and estuarine aquatic species, however, it is not possible to determine whether the existing habitat has been significantly affected by the existing contaminants. Following the proposed development, the overall contamination conditions would not change markedly from the present conditions. However, the potential effects of the groundwater plumes on the functioning of the habitat, should the deep groundwater plumes discharge to Penrhyn Estuary, cannot be accurately determined, but would occur irrespective of the proposed expansion.