Appendix A

Eight Part Test Submitted to NSW NPWS and Environment Australia

The table shown below, lists the twenty-four (24) species of resident and migratory shorebirds and seabirds listed under the TSC and/or EPBC Acts that are known to occur or have been previously recorded at Penrhyn Estuary and thus have been assessed under Section 5A of the NSW *Environmental Planning and Assessment Act* 1979 in relation to the Port Botany Expansion.

Shorebird and Seabird Species Known to Occur and Previously Recorded at Penrhyn Estuary requiring TSC/EPBC (Section 5A Assessment) Consideration

Species	TSC Act (E=Endangered V=Vulnerable)	Migratory/non migratory Species listed under EPBC Act	JAMBA	CAMBA	Bonn
Scolopacidae					
Curlew Sandpiper *Calidris ferruginea*	-	X	X	X	
Common Sandpiper *Tringa hypoleucos*	-	X	X	X	
Eastern Curlew *Numenius madagascariensis*	-	X	X	X	
Sanderling *Calidris alba*	V	X	X	X	
Sharp-tailed Sandpiper *Calidris acuminata*	-	X	X	X	
Great Knot *Calidris tenuirostris*	V	X	X	X	
Greenshank *Tringa nebularia*	-	X	X	X	
Grey-tailed Tattler *Tringa brevipes*	-	X	X	X	
Bar-tailed Godwit *Limosa lapponica*	-	X	X	X	
Black-tailed Godwit *Limosa limosa*		X	X	X	
Broad-billed Sandpiper *Limicola falcinellus*	V	X	X	X	
Marsh Sandpiper *Tringa stagnatilis*	-	X	X	X	
Red Knot *Calidris canutus*	-	X	X	X	
Red-necked Stint *Calidris ruficollis*	-	X	X	X	
Ruddy Turnstone *Arenaria interpres*	-	X	X	X	

Species	TSC Act (E=Endangered V=Vulnerable)	Migratory/non migratory Species listed under EPBC Act	JAMBA	CAMBA	Bonn
Terek Sandpiper *Tringa cinerea*	V	X	X	X	
Whimbrel *Numenius phaeopus*	-	X	X	X	
Haematopodidae					
Pied Oystercatcher *Haematopus longirostris*	V	-	-	-	
Charadriidae					
Large (Greater) Sand Plover *Charadrius leschenaultii*	V	X	X	X	
Grey Plover *Pluvialis squatarola*	-	X	X	X	
Mongolian (Lesser Sand) Plover *Charadrius mongolus*	V	X	X	X	
Double-banded Plover** *Charadrius bicinctus*	-	X			
Pacific Golden Plover *Pluvialis dominica*	-	X	X	X	
Laridae					
Little Tern *Sterna albifrons*	E	X	X	X	

* non migratory species
** trans Tasman migrant

Section 5A Assessments (8 Part Tests)

Descriptions of the ecology and biology of the 23 shorebird and 1 seabird species (feeding, roosting, breeding, movement) are provided in Appendix F and are not reproduced here. The Section 5A Assessments should be read in conjunction with these descriptions.

Calidris ferruginea (Curlew Sandpiper)

(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

This species presently feeds and roosts at Penrhyn Estuary largely on intertidal mudflats (feeding) and sandflats at the Estuary mouth and on the north side of the channel (roosts). This species also roosts on steel barges and a wooden jetty near Shell Point in Woolooware Bay (pers. comm., Phil Straw). Straw (1996) notes that this species was formerly relatively abundant in Botany Bay prior to 1986 (counts between 300 and 700 were regularly made) and that since then numbers have declined significantly down to around 100 (NSW Wader Study counts 1994-2001; NPWS Botany Bay Estuary Shorebird Action Plan 2001/2002 counts; pers.obs.). Only small numbers of this species have been recorded on the southern shores of the Bay during a 20 year count (Straw 1996) and are mostly used for roosting only. Penryhn Estuary is thus a site of major significance for this species in the Botany Bay estuary. The loss of foraging habitat at the northern end of Botany Beach as a result of the Parallel Runway is certainly one factor contributing to this species decline. Remaining areas of Foreshore Beach have not become significant feeding areas for the species given the volume of pedestrian traffic (dog walking) on the beach and the erosion and associated increasing steepness of the shoreline in this area, which is unsuitable habitat.

Predicted key impacts from the proposal on this species comprise disturbance to feeding and roosting from a change in lighting regime, increased noise and vibration (human and machinery) from the construction and operation of the port (and associated infrastructure such as railway lines) and potential entry/exit psychological flyway barrier due to the enclosure of Penrhyn Estuary. Disturbance issues are discussed below and are based on the author's general knowledge of shorebirds in New South Wales estuaries and from a desktop literature review of shorebird disturbance studies and other generalist bird studies (Paton et al 2000; Burger 1991; Goss-Custard and Verboven 1993; Smit and Visser 1993; Goss-Custard *et al* 1982; Goss-Custard 1980; Lawler 1996; Roberts and Evans 1993; Batten 1977; Straw 1996; Nelson 1994; Metcalfe and Furness 1984; Weston *et al* 2000).

There is little quantified and experimental assessment of the effects of disturbance to waders and little understanding of the extent of such impacts. Disturbance is defined as a disruption to normal activity patterns. Disturbances to waders may vary in their intensity, frequency, duration, coverage and predictability and there is often inter-specific and intra-specific variation in susceptibility of birds to disturbance which is likely to vary with age, season, weather, location and the degree of habituation to disturbance. There are two potential consequences of sustained, localised disturbance to migratory waders, these being birds may have to shift to alternative, perhaps less favourable feeding grounds and secondly may have their feeding rate reduced by having to devote time to vigilence and anti-predator behaviour. Disturbed shorebirds may spend less time foraging whilst increasing energy-expending behaviours such as fleeing (running, flying). It has also been suggested that migratory birds may be more prone to disturbance than non-migratory species as they are only present in a particular area for part of the year and so have little opportunity to become habituated to the disturbance.

Waders preferably forage in areas where prey density, prey availability and intake rates are relatively high and where energy expenditure is low. Shorebird densities, therefore, tend to reach a maximum in the most preferred feeding areas (Penrhyn Estuary for this species) and where disturbances force birds to shift to alternative feeding areas, questions arise as to whether such areas are adequate, whether they can accommodate displaced individuals and what effect increased bird density has on intake rates and the fitness of those birds that move. As bird density increases, average intake rates decline in many species as a result of increased competition, increased prey depletion and a greater proportion of the population feeding in sub-optimal areas. Where populations are limited, or are close to limitation by the quality and availability of habitat (such as for this species in Penrhyn Estuary and in Botany Bayestuary in total), disturbance can have a negative impact on wader populations by affecting fitness, ability to fatten adequately during pre-migratory periods and increased mortality.

Some studies that have attempted to experimentally asses the impact of disturbance on waterbirds have predominantly used the bird's flight response as an index of disturbance whilst others have only crudely estimated alert distances. In such studies, a disturbance is introduced and the distance of the birds from the disturbance at the point of flight is measured. Buffer distances given for many shorebirds as part of past studies, including the Curlew Sandpiper, are in the order of 100-400 metres.

Many foraging migratory waders are often disrupted from their typical behaviour well before a flight response is elicited with some birds shown to be alerted at distances on average 30-95% greater than those at which they take flight. Following detection of a disturbance the bird may spend time assessing the degree of threat it is under and may balance the risk with the benefits of continued foraging or roosting. As discussed above, this may be particularly significant to migratory shorebirds during the pre-migratory period of fat accumulation (and post migratory period of recuperation and moulting) where an increase in food requirements during this period results in waders trying to maximise their net rate of resource acquisition and thus invest more time in foraging at the expense of vigilance and anti-predator behaviour. This is particularly significant for shorebirds whose feeding times are regulated by tidal flow (and even more significant for small billed waders such as plovers and stints where foraging areas are further limited by amount of intertidal area not covered with water at low tide). Frequent and intense disturbance is likely to affect wader behaviour and reduce the time they spend foraging. Reductions in feeding may then affect the capacity of waders to fatten at an adequate rate and therefore prolong the pre-migratory feeding period and departure delay. Such delays in migration departure from wintering grounds can seriously affect breeding success of migratory birds, where individuals arriving late at the summer breeding grounds may be at a disadvantage in the competition for mates and territories.

A change in lighting regime (predicted increase in ambient lighting at night) Estuary in Penrhyn Estuary may result in an increase in vigilant behaviour (area scans) at the expense of foraging as many shorebirds, particularly those that have been observed to forage nocturnally in “relatively dark” areas (such as sand plovers), may feel that they are more visible to potential predators (feral dogs, cats, birds of prey). Increased ambient lighting and flashes of light from railway lines may result in the displacement of the shorebirds to sub-optimal (less preferred) habitat elsewhere in the Botany Bay estuary, such as Boat Harbour and Taren Point.

The current design essentially encloses Penrhyn Estuary and thus may represent a psychological entry/exit flyway barrier into and out of the shorebird feeding and roosting habitat at the Estuary. Despite their physical capabilities, waders are very reluctant to enter an area that does not have an open aspect (mainly to enable them to have a clear view of potential predators). Based on both the observed current flyways of the shorebirds into and out of the Estuaryand on standard wader flyway behaviour, waders currently utilising Penrhyn Estuary fly into the area either from the south over water or from the west by flying south around the runways and turning north-east into the Estuary over water. Based on casual recent and historical URS observations over the years at the site and on discussions with Geoff Ross (NPWS), Phil Straw (Avifauna Research) and local bird naturalists, waders have not been observed flying over docks or runways to or from the Estuary (whereas other suite of bird strike species such as gulls regularly do).

Discussions with Doug Watkins at Wetlands International (Environment Australia) indicate that Yatsu-Higata a landlocked RAMSAR wetland in Tokyo Bay (surrounded by industrial development) Japan is reportedly being used by a number of migratory waders for part of their life cycle requirements. Watkins indicated that the waders roost at the site and may also feed there at a later stage in a flood tide (that is, when the tide is coming in) when their primary feeding habitat (exposed mudflats elsewhere in the Bay) is flooded. Watkins indicated that the waders are flying over industrialised land because of the absence of any other suitable roost sites in the Bay (as a result of 80-90% of the Bay being reclaimed). This would suggest that some waders at Penrhyn Estuary may fly into the Estuary over the operational docks or negotiate along the 130 metre wide channel parallel to Foreshore Beach particularly if they are forced to due to a lack of remaining suitable habitat in the Bay. The waders would not be expected to have any difficulty in negotiating over the proposed road and rail bridges.

Exclusion fencing, public access restriction to Penrhyn Estuary and boat ramp relocation associated with the proposal may minimise part of the human disturbance element to shorebirds. Shorebirds are often seen at Penryhn Estuary fleeing from roosting on the sandy point on the Penrhyn Road side of the channel to the sandy foothill of the dune on the opposite side of the channel (pers. obs.).

The other key potential impact to consider is the effect of any hydrological changes to the Estuary, which may result in changes to shorebird feeding and roosting habitat. Hydrodynamic modelling studies of Penrhyn Estuaryare currently being undertaken although the results of these studies are not yet complete or available for review. Nevertheless, SPC have indicated that no significant change in tidal regime, water levels and elevation profiles of the sand and mudflats are predicted to occur at Penrhyn Estuary (pers. comm., SPC). SPC also note that no hydrodynamic changes to other important shorebird habitat areas in the Bay (Towra Point, Taren and Shell Points) are predicted to occur (pers. comm., SPC).

The proposal will also result in the loss of remaining areas of shorebird foraging habitat on Foreshore Beach. The predicted impact on shorebirds however is considered to be negligible due to the volume of pedestrian traffic and dog walking on the beach (disturbance issue) and due to the increased beach erosion and resulting steepness in the elevation profile which has drastically reduced the suitableness of the bird habitat in this area (less intertidal flats on neap tides).

(b) *in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.*

Not Applicable

(c) *in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.*

The proposal may result in a significant modification to shorebird habitat and behaviour at Penryhn Estuary, considered to be an important shorebird habitat for the species on a local and regional basis.

It should be noted that few nocturnal shorebird surveys in the Botany Bay estuary have been undertaken to date and thus data on nocturnal feeding and roosting habitat for shorebirds is not yet available. Nocturnal feeding is just as important (sometimes more important) than diurnal feeding for shorebirds and should not be underestimated in terms of a species life cycle requirements.

(d) *whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community*

The proposal may result in the isolation of shorebird feeding and roosting habitat at Penrhyn Estuary from other known roost sites on the southern shores of the Bay and from general Bay wide bird movements which are undertaken over water.

(e) *whether critical habitat will be affected.*

The study area is not listed as critical habitat under Part 3 Division 1 of the Threatened Species Conservation Act 1995.

(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

No resident or migratory shorebirds in NSW are considered to be adequately conserved due to the unique location of their intertidal habitat. Smith (1991) notes that reservation of wader habitat on intertidal lands has posed a particular problem for NPWS as few coastal reserves include any areas below the high water mark which are generally Crown land. There has been some success, however, in establishing aquatic reserves in NSW such as the Towra Point Aquatic Reserve adjacent to Towra Point Nature Reserve in the Botany Bay estuary which supports important habitat for many waders such as the Eastern Curlew and Whimbrel. Kooragang Nature Reserve in the Hunter estuary is one of the few present examples within an extensive representation of intertidal wader feeding grounds. This species is regularly recorded in relatively high numbers in the Hunter estuary.

(g) *whether the development or activity proposed is of a class of development or activity that is recognised as a threatening processes.*

Not Applicable

(h) *whether any threatened species, populations or ecological community is at the limit of its known distribution*

This species is regularly recorded in many estuaries on the north and south NSW coasts as well as inland and is thus not considered to be at its limit of distribution in the Botany Bay estuary.

Section 5A Assessment Conclusion

Given that the proposal presently represents potential significant impacts on shorebird habitat at Penrhyn Estuary and given that many of the impacts (particularly those relating to disturbance) are difficult to predict, the precautionary approach must therefore be taken and thus the preparation of a Species Impact Statement for the species is required.

Should the development proceed, and should the proposed enhancement of shorebird habitat at Penrhyn Estuary not prove feasible, off-site enhancement of existing shorebird habitat elsewhere in Botany Bay (such as H1 lands at Woolooware Bay) should be considered. Proposed enhancement of shorebird habitat at Penrhyn Estuary will be addressed in the SIS for the proposal.

Common Sandpiper (*Tringa hypoleucos*)

(a) *in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.*

A total of two (2) individuals of this solitary species occur on the edge of mangrove-lined creek channels in the Parramatta River estuary at Bicentennial Park, Homebush Bay, roosting on broken barges. This species also occurs at Newington wetlands. This species occurs most years in very low numbers in the bay (probably 1or 2) and presently roosts on a wooden jetty at Shell Point which illustrates the severe lack of suitable high tide roosts for shorebirds in the bay. Whilst only 1 or 2 individuals probably use the bay, the NSW estimated population for the species is 80 and thus the bay is considered important habitat for this shorebird species. Foraging habitat in the bay is unconfirmed. A single sighting of the species at Penrhyn Estuary was recorded by the NSW Wader Study group in 1994 and thus the site should not be discounted as a possible important foraging and roosting site for the species in the bay.

Predicted key impacts from the proposal on this species comprise disturbance to feeding and roosting from a change in lighting regime, increased noise and vibration (human and machinery) from the construction and operation of the port (and associated infrastructure such as railway lines) and potential entry/exit psychological flyway barrier due to the enclosure of Penrhyn Estuary. Disturbance issues are discussed below and are based on the author's general knowledge of shorebirds in New South Wales estuaries and from a desktop literature review of shorebird disturbance studies and other generalist bird studies (Paton et al 2000; Burger 1991; Goss-Custard and Verboven 1993; Smit and Visser 1993; Goss-Custard *et al* 1982; Goss-Custard 1980; Lawler 1996; Roberts and Evans 1993; Batten 1977; Straw 1996; Nelson 1994; Metcalfe and Furness 1984; Weston *et al* 2000).

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Waders preferably forage in areas where prey density, prey availability and intake rates are relatively high and where energy expenditure is low. Shorebird densities, therefore, tend to reach a maximum in the most preferred feeding areas (Penrhyn Estuary for this species) and where disturbances force birds to shift to alternative feeding areas, questions arise as to whether such areas are adequate, whether they can accommodate displaced individuals and what effect increased bird density has on intake rates and the fitness of those birds that move. As bird density increases, average intake rates decline in many species as a result of increased competition, increased prey depletion and a greater proportion of the population feeding in sub-optimal areas. Where populations are limited, or are close to limitation by the quality and availability of habitat (such as for this species in Penrhyn Estuary and in Botany Bay estuary in total), disturbance can have a negative impact on wader populations by affecting fitness, ability to fatten adequately during pre-migratory periods and increased mortality.

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Many foraging migratory waders are often disrupted from their typical behaviour well before a flight response is elicited with some birds shown to be alerted at distances on average 30-95% greater than those at which they take flight. Following detection of a disturbance the bird may spend time assessing the degree of threat it is under and may balance the risk with the benefits of continued foraging or roosting. As discussed above, this may be particularly significant to migratory shorebirds during the pre-migratory period of fat accumulation (and post migratory period of recuperation and moulting) where an increase in food requirements during this period results in waders trying to maximise their net rate of resource acquisition and thus invest more time in foraging at the expense of vigilance and anti-predator behaviour. This is particularly significant for shorebirds whose feeding times are regulated by tidal flow (and even more significant for small billed waders such as plovers and stints where foraging areas are further limited by amount of intertidal area not covered with water at low tide). Frequent and intense disturbance is likely to affect wader behaviour and reduce the time they spend foraging. Reductions in feeding may then affect the capacity of waders to fatten at an adequate rate and therefore prolong the pre-migratory feeding period and departure delay. Such delays in migration departure from wintering grounds can seriously affect breeding success of migratory birds, where individuals arriving late at the summer breeding grounds may be at a disadvantage in the competition for mates and territories.

A change in lighting regime (predicted increase in ambient lighting at night) in Penrhyn Estuary may result in an increase in vigilant behaviour (area scans) at the expense of foraging as many shorebirds, particularly those that have been observed to forage nocturnally in “relatively dark” areas (such as sand plovers), may feel that they are more visible to potential predators (feral dogs, cats, birds of prey).

Increased ambient lighting and flashes of light from railway lines may result in the displacement of the shorebirds to sub-optimal (less preferred) habitat elsewhere in the Botany Bay estuary.

The current design essentially encloses Penrhyn Estuary and thus may represent a psychological entry/exit flyway barrier into and out of the shorebird feeding and roosting habitat at the Estuary. Despite their physical capabilities, waders are very reluctant to enter an area that does not have an open aspect (mainly to enable them to have a clear view of potential predators). Based on both the observed current flyways of the shorebirds into and out of the Estuary and on standard wader flyway behaviour, waders currently utilising Penrhyn Estuary fly into the area either from the south over water or from the west by flying south around the runways and turning north-east into the Estuary over water. Based on casual recent and historical URS observations over the years at the site and on discussions with Geoff Ross (NPWS), Phil Straw (Avifauna Research) and local bird naturalists, waders have not been observed flying over docks or runways to or from the Estuary (whereas other suite of bird strike species such as gulls regularly do).

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Exclusion fencing, public access restriction to Penrhyn Estuary and boat ramp relocation associated with the proposal may minimise part of the human disturbance element to shorebirds. Shorebirds are often seen at Penryhn Estuary fleeing from roosting on the sandy point on the Penrhyn Road side of the channel to the sandy foothill of the dune on the opposite side of the channel (pers. obs.).

The other key potential impact to consider is the effect of any hydrological changes to the Estuary which may result in changes to shorebird feeding and roosting habitat. Hydrodynamic modelling studies of Penrhyn Estuary are currently being undertaken although the results of these studies are not yet complete or available for review. Nevertheless, SPC have indicated that no significant change in tidal regime, water levels and elevation profiles of the sand and mudflats are predicted to occur at Penrhyn Estuary (pers. comm., SPC). SPC also note that no hydrodynamic changes to other important shorebird habitat areas in the Bay (Towra Point, Taren and Shell Points) are predicted to occur (pers. comm., SPC).

The proposal will also result in the loss of remaining areas of shorebird foraging habitat on Foreshore Beach. The predicted impact on shorebirds however is considered to be negligible due to the volume of pedestrian traffic and dog walking on the beach (disturbance issue) and due to the increased beach erosion and resulting steepness in the elevation profile which has drastically reduced the suitableness of the bird habitat in this area (less intertidal flats on neap tides).

(b) *in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.*

Not Applicable

(c) *in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.*

The proposal may result in a significant modification to shorebird habitat and behaviour at Penryhn Estuary, considered to be an important shorebird habitat for the species on a local and regional basis.

It should be noted that few nocturnal shorebird surveys in the Botany Bay estuary have been undertaken to date and thus data on nocturnal feeding and roosting habitat for shorebirds is not yet available. Nocturnal feeding is just as important (sometimes more important) than diurnal feeding for shorebirds and should not be underestimated in terms of a species life cycle requirements.

(d) *whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community*

The proposal may result in the isolation of shorebird feeding and roosting habitat at Penrhyn Estuary from other known roost sites on the southern shores of the Bay and from general Bay wide bird movements which are undertaken over water.

(e) *whether critical habitat will be affected.*

The study area is not listed as critical habitat under Part 3 Division 1 of the Threatened Species Conservation Act 1995.

(f) *whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.*

No resident or migratory shorebirds in NSW are considered to be adequately conserved due to the unique location of their intertidal habitat. Smith (1991) notes that reservation of wader habitat on intertidal lands has posed a particular problem for NPWS as few coastal reserves include any areas below the high water mark which are generally Crown land. There has been some success, however, in establishing aquatic reserves in NSW such as the Towra Point Aquatic Reserve adjacent to Towra Point Nature Reserve in the Botany Bay estuary which supports

important habitat for many waders such as the Eastern Curlew and Whimbrel. Kooragang Nature Reserve in the Hunter estuary is one of the few present examples within an extensive representation of intertidal wader feeding grounds. This species is regularly recorded in relatively high numbers in the Hunter estuary.

The known roost site for the species in the bay is currently unreserved.

(g) *whether the development or activity proposed is of a class of development or activity that is recognised as a threatening processes.*

Not Applicable

(h) *whether any threatened species, populations or ecological community is at the limit of its known distribution*

This species is regularly recorded in low numbers many estuaries on the north and south NSW coasts and is thus not considered to be at its limit of distribution in the Botany Bay estuary.

Section 5A Assessment Conclusion

Given that the proposal presently represents potential significant impacts on shorebird habitat at Penrhyn Estuary and given that many of the impacts (particularly those relating to disturbance) are difficult to predict, the precautionary approach must therefore be taken and thus the preparation of a Species Impact Statement for the species is required.

Should the development proceed, and should the proposed enhancement of shorebird habitat at Penrhyn Estuary not prove feasible, off-site enhancement of existing shorebird habitat elsewhere in Botany Bay (such as H1 lands at Woolooware Bay) should be considered. Proposed enhancement of shorebird habitat at Penrhyn Estuary will be addressed in the SIS for the proposal.

Numenius madagascariensis (Eastern Curlew)

(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

This species presently feeds over much of the intertidal mudflats of the southern parts of the Bay, including Woolooware, Quibray, Weeney and Stinkpot Bays and Towra Point. Preferred roost sites on the southern shores of the Bay include sand spits and shoals (Straw 1996; pers. comm., Geoff Ross; pers. obs.). Thick wooden poles marking the limits of oyster leases are used as alternative roosts. Numbers of this species in the Bay are presently around 200 and no significant decline of the species in the bay has been noted to date. The species does not normally use the northern shoreline of the bay to feed or roost but may do so on occasion.

Predicted key impacts from the proposal on this species comprise disturbance to feeding and roosting from a change in lighting regime, increased noise and vibration (human and machinery) from the construction and operation of the port (and associated infrastructure such as railway lines) and potential entry/exit psychological flyway barrier due to the enclosure of Penrhyn Estuary. Disturbance issues are discussed below and are based on the author's general knowledge of shorebirds in New South Wales estuaries and from a desktop literature review of shorebird disturbance studies and other generalist bird studies (Paton et al 2000; Burger 1991; Goss-Custard and Verboven 1993; Smit and Visser 1993; Goss-Custard *et al* 1982; Goss-Custard 1980; Lawler 1996; Roberts and Evans 1993; Batten 1977; Straw 1996; Nelson 1994; Metcalfe and Furness 1984; Weston *et al* 2000).

There is little quantified and experimental assessment of the effects of disturbance to waterbirds and little understanding of the extent of such impacts. Disturbance is defined as a disruption to normal activity patterns. Disturbances to waders may vary in their intensity, frequency, duration, coverage and predictability and there is often inter-specific and intra-specific variation in susceptibility of birds to disturbance which is likely to vary with age, season, weather, location and the degree of habituation to disturbance. There are two potential consequences of sustained, localised disturbance to migratory waders, these being birds may have to shift to alternative, perhaps less favourable feeding grounds and secondly may have their feeding rate reduced by having to devote time to vigilance and anti-predator behaviour. Disturbed shorebirds may spend less time foraging whilst increasing energy-expending behaviours such as fleeing (running, flying). It has also been suggested that migratory birds may be more prone to disturbance than non-migratory species as they are only present in a particular area for part of the year and so have little opportunity to become habituated to the disturbance.

Waders preferably forage in areas where prey density, prey availability and intake rates are relatively high and where energy expenditure is low. Shorebird densities, therefore, tend to reach a maximum in the most preferred feeding areas (Towra Point for this species) and where disturbances force birds to shift to alternative feeding areas, questions arise as to whether such areas are adequate, whether they can accommodate displaced individuals and what effect increased bird density has on intake rates and the fitness of those birds that move. As bird density increases, average intake rates decline in many species as a result of increased competition, increased prey depletion and a greater proportion of the population feeding in sub-optimal areas. Where populations are limited, or are close to limitation by the quality and availability of habitat, disturbance can have a negative impact on wader populations by affecting fitness, ability to fatten adequately during pre-migratory periods and increased mortality.

Some studies that have attempted to experimentally asses the impact of disturbance on waterbirds have predominantly used the bird’s flight response as an index of disturbance whilst others have only crudely estimated alert distances. In such studies, a disturbance is introduced and the distance of the birds from the disturbance at the point of flight is measured. Buffer distances given for many shorebirds as part of past studies, including the Eastern Curlew, are in the order of 100-400 metres.

Many foraging migratory waders are often disrupted from their typical behaviour well before a flight response is elicited with some birds shown to be alerted at distances on average 30-95% greater than those at which they take flight. Following detection of a disturbance the bird may spend time assessing the degree of threat it is under and may balance the risk with the benefits of continued foraging or roosting. As discussed above, this may be particularly significant to migratory shorebirds during the pre-migratory period of fat accumulation (and post migratory period of recuperation and moulting) where an increase in food requirements during this period results in waders trying to maximise their net rate of resource acquisition and thus invest more time in foraging at the expense of vigilance and anti-predator behaviour. This is particularly significant for shorebirds whose feeding times are regulated by tidal flow (and even more significant for small billed waders such as plovers and stints where foraging areas are further limited by amount of intertidal area not covered with water at low tide). Frequent and intense disturbance is likely to affect wader behaviour and reduce the time they spend foraging. Reductions in feeding may then affect the capacity of waders to fatten at an adequate rate and therefore prolong the pre-migratory feeding period and departure delay. Such delays in migration departure from wintering grounds can seriously affect breeding success of migratory birds, where individuals arriving late at the summer breeding grounds may be at a disadvantage in the competition for mates and territories.

A change in lighting regime (predicted increase in ambient lighting at night) in Penrhyn Estuary may result in an increase in vigilant behaviour (area scans) at the expense of foraging as many shorebirds, particularly those that have been observed to forage nocturnally in “relatively dark” areas (such as sand plovers), may feel that they are more visible to potential predators (feral dogs, cats, birds of prey). Increased ambient lighting and flashes of light from railway lines may result in the displacement of the shorebirds to sub-optimal (less preferred) habitat elsewhere in the Botany Bay estuary, such as Penrhyn Estuary.

The current design essentially encloses Penrhyn Estuary and thus may represent a psychological entry/exit flyway barrier into and out of the shorebird feeding and roosting habitat at the Estuary. Despite their physical capabilities, waders are very reluctant to enter an area that does not have an open aspect (mainly to enable them to have a clear view of potential predators). Based on both the observed current flyways of the shorebirds into and out of the Estuary and on standard wader flyway behaviour, waders currently utilising Penrhyn Estuary fly into the area either from the south over water or from the west by flying south around the runways and turning north-east into the Estuary over water. Based on casual recent and historical URS observations over the years at the site and on discussions with Geoff Ross (NPWS), Phil Straw (Avifauna Research) and local bird naturalists, waders have not been observed flying over docks or runways to or from the Estuary (whereas other suite of bird strike species such as gulls regularly do).

Discussions with Doug Watkins at Wetlands International (Environment Australia) indicate that Yatsu-Higata a landlocked RAMSAR wetland in Tokyo Bay (surrounded by industrial development) Japan is reportedly being used by a number of migratory waders for part of their life cycle requirements. Watkins indicated that the waders roost at the site and may also feed there at a later stage in a flood tide (that is, when the tide is coming in) when their primary feeding habitat (exposed mudflats elsewhere in the Bay) is flooded. Watkins indicated that the waders are flying over industrialised land because of the absence of any other suitable roost sites in the Bay (as a result of 80-90% of the Bay being reclaimed). This would suggest that some waders at Penrhyn Estuary may fly into the Estuary over the operational docks or negotiate along the 130 metre wide channel parallel to Foreshore Beach particularly if they are forced to due to a lack of remaining suitable habitat in the Bay. The waders would not be expected to have any difficulty in negotiating over the proposed road and rail bridges.

Exclusion fencing, public access restriction to Penrhyn Estuary and boat ramp relocation associated with the proposal may minimise part of the human disturbance element to shorebirds. Shorebirds are often seen at Penryhn Estuary fleeing from roosting on the sandy point on the Penrhyn Road side of the channel to the sandy foothill of the dune on the opposite side of the channel (pers. obs.).

The other key potential impact to consider is the effect of any hydrological changes to the Estuary which may result in changes to shorebird feeding and roosting habitat. Hydrodynamic modelling studies of Penrhyn Estuary are currently being undertaken although the results of these studies are not yet complete or available for review. Nevertheless, SPC have indicated that no significant change in tidal regime, water levels and elevation profiles of the sand and mudflats are predicted to occur at Penrhyn Estuary (pers. comm., SPC). SPC also note that no hydrodynamic changes to other important shorebird habitat areas in the Bay (Towra Point, Taren and Shell Points) are predicted to occur (pers. comm., SPC).

The proposal will also result in the loss of remaining areas of shorebird foraging habitat on Foreshore Beach. The predicted impact on shorebirds however is considered to be negligible due to the volume of pedestrian traffic and dog walking on the beach (disturbance issue) and due to the increased beach erosion and resulting steepness in the elevation profile which has drastically reduced the suitableness of the bird habitat in this area (less intertidal flats on neap tides).

(b) *in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.*

Not Applicable

(c) *in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.*

The proposal may result in a significant modification to shorebird habitat and behaviour at Penryhn Estuary, considered to be an important occasional shorebird habitat for the species on a local and regional basis.

It should be noted that few nocturnal shorebird surveys in the Botany Bay estuary have been undertaken to date and thus data on nocturnal feeding and roosting habitat for shorebirds is not yet available. Nocturnal feeding is just as important (sometimes more important) than diurnal feeding for shorebirds and should not be underestimated in terms of a species life cycle requirements.

(d) *whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community*

The proposal may result in the isolation of shorebird feeding and roosting habitat at Penrhyn Estuary from other known roost sites on the southern shores of the Bay and from general Bay wide bird movements which are undertaken over water.

(e) *whether critical habitat will be affected.*

The study area is not listed as critical habitat under Part 3 Division 1 of the Threatened Species Conservation Act 1995.

(f) *whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.*

No resident or migratory shorebirds in NSW are considered to be adequately conserved due to the unique location of their intertidal habitat. Smith (1991) notes that reservation of wader habitat on intertidal lands has posed a particular problem for NPWS as few coastal reserves include any areas below the high water mark which are generally Crown land. There has been some success, however, in establishing aquatic reserves in NSW such as the Towra Point Aquatic Reserve adjacent to Towra Point Nature Reserve in the Botany Bay estuary which supports

important habitat for many waders such as the Eastern Curlew and Whimbrel. Kooragang Nature Reserve in the Hunter estuary is one of the few present examples within an extensive representation of intertidal wader feeding grounds. This species is regularly recorded in relatively high numbers in the Hunter estuary.

(g) *whether the development or activity proposed is of a class of development or activity that is recognised as a threatening processes.*

Not Applicable

(h) *whether any threatened species, populations or ecological community is at the limit of its known distribution*

This species is regularly recorded in many estuaries on the north and south NSW coasts and is thus not considered to be at its limit of distribution in the Botany Bay estuary.

Section 5A Assessment Conclusion

Given that the proposal presently represents potential significant impacts on shorebird habitat at Penrhyn Estuary and given that many of the impacts (particularly those relating to disturbance) are difficult to predict, the precautionary approach must therefore be taken and thus the preparation of a Species Impact Statement for the species is required.

Should the development proceed, and should the proposed enhancement of shorebird habitat at Penrhyn Estuary not prove feasible, off-site enhancement of existing shorebird habitat elsewhere in Botany Bay (such as H1 lands at Woolooware Bay) should be considered. Proposed enhancement of shorebird habitat at Penrhyn Estuary will be addressed in the SIS for the proposal.

Calidris alba (Sanderling)

(a) *in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.*

Single birds of this species are occasionally seen in Botany Bay estuary. This species typically feeds in the wave zone of ocean beaches at Boat Harbour and will generally flee to the northern shores of the Bay during rough weather for shelter and feeding (Penrhyn Estuary). Straw (1996) notes that in the 1940s and 1950s the species was regularly present in summer at Boat Harbour, in numbers of up to 15 or more, with counts post 1970 revealing no more than one or two individuals. Remaining areas of Botany Beach and the southern shores of the Bay (with the exception of Spit Island) have not become significant feeding areas for the species given the level of human disturbance (recreational fishers, dog walking) on the beach and the erosion and associated increasing steepness of the shoreline in this area which is unsuitable habitat.

Predicted key impacts from the proposal on this species comprise disturbance to feeding and roosting from a change in lighting regime, increased noise and vibration (human and machinery) from the construction and operation of the port (and associated infrastructure such as railway lines) and potential entry/exit psychological flyway barrier due to the enclosure of Penrhyn Estuary. Disturbance issues are discussed below and are based on the author's general knowledge of shorebirds in New South Wales estuaries and from a desktop literature review of shorebird disturbance studies and other generalist bird studies (Paton et al 2000; Burger 1991; Goss-Custard and Verboven 1993; Smit and Visser 1993; Goss-Custard *et al* 1982; Goss-Custard 1980; Lawler 1996; Roberts and Evans 1993; Batten 1977; Straw 1996; Nelson 1994; Metcalfe and Furness 1984; Weston *et al* 2000).

There is little quantified and experimental assessment of the effects of disturbance to waterbirds and little understanding of the extent of such impacts. Disturbance is defined as a disruption to normal activity patterns. Disturbances to waders may vary in their intensity, frequency, duration, coverage and predictability and there is often inter-specific and intra-specific variation in susceptibility of birds to disturbance which is likely to vary with age, season, weather, location and the degree of habituation to disturbance. There are two potential consequences of sustained, localised disturbance to migratory waders, these being birds may have to shift to alternative, perhaps less favourable feeding grounds and secondly may have their feeding rate reduced by having to devote time to vigilance and anti-predator behaviour. Disturbed shorebirds may spend less time foraging whilst increasing energy-expending behaviours such as fleeing (running, flying). It has also been suggested that migratory birds may be more prone to disturbance than non-migratory species as they are only present in a particular area for part of the year and so have little opportunity to become habituated to the disturbance.

Waders preferably forage in areas where prey density, prey availability and intake rates are relatively high and where energy expenditure is low. Shorebird densities, therefore, tend to reach a maximum in the most preferred feeding areas (Boat Harbour and Penrhyn Estuary for this species) and where disturbances force birds to shift to alternative feeding areas, questions arise as to whether such areas are adequate, whether they can accommodate displaced individuals and what effect increased bird density has on intake rates and the fitness of those birds that move. As bird density increases, average intake rates decline in many species as a result of increased competition, increased prey depletion and a greater proportion of the population feeding in sub-optimal areas. Where populations are limited, or are close to limitation by the quality and availability of habitat (such as for this species in Penrhyn Estuary and in Botany Bay estuary in total), disturbance can have a negative impact on wader populations by affecting fitness, ability to fatten adequately during pre-migratory periods and increased mortality.

Some studies that have attempted to experimentally asses the impact of disturbance on waterbirds have predominantly used the bird’s flight response as an index of disturbance whilst others have only crudely estimated alert distances. In such studies, a disturbance is introduced and the distance of the birds from the disturbance at the point of flight is measured. Buffer distances given for many shorebirds as part of past studies are in the order of 100-400 metres.

Many foraging migratory waders are often disrupted from their typical behaviour well before a flight response is elicited with some birds shown to be alerted at distances on average 30-95% greater than those at which they take flight. Following detection of a disturbance the bird may spend time assessing the degree of threat it is under and may balance the risk with the benefits of continued foraging or roosting. As discussed above, this may be particularly significant to migratory shorebirds during the pre-migratory period of fat accumulation (and post migratory period of recuperation and moulting) where an increase in food requirements during this period results in waders trying to maximise their net rate of resource acquisition and thus invest more time in foraging at the expense of vigilance and anti-predator behaviour. This is particularly significant for shorebirds whose feeding times are regulated by tidal flow (and even more significant for small billed waders such as plovers and stints where foraging areas are further limited by amount of intertidal area not covered with water at low tide). Frequent and intense disturbance is likely to affect wader behaviour and reduce the time they spend foraging. Reductions in feeding may then affect the capacity of waders to fatten at an adequate rate and therefore prolong the pre-migratory feeding period and departure delay. Such delays in migration departure from wintering grounds can seriously affect breeding success of migratory birds, where individuals arriving late at the summer breeding grounds may be at a disadvantage in the competition for mates and territories.

A change in lighting regime (predicted increase in ambient lighting at night) in Penrhyn Estuary may result in an increase in vigilant behaviour (area scans) at the expense of foraging as many shorebirds, particularly those that have been observed to forage nocturnally in “relatively dark” areas (such as sand plovers), may feel that they are more visible to potential predators (feral dogs, cats, birds of prey).

Increased ambient lighting and flashes of light from railway lines may result in the displacement of the shorebirds to sub-optimal (less preferred) habitat elsewhere in the Botany Bay estuary (possibly Spit Island).

The current design essentially encloses Penrhyn Estuary and thus may represent a psychological entry/exit flyway barrier into and out of the shorebird feeding and roosting habitat at the Estuary. Despite their physical capabilities, waders are very reluctant to enter an area that does not have an open aspect (mainly to enable them to have a clear view of potential predators). Based on both the observed current flyways of the shorebirds into and out of the Estuary and on standard wader flyway behaviour, waders currently utilising Penrhyn Estuary fly into the area either from the south over water or from the west by flying south around the runways and turning north-east into the Estuary over water. Based on casual recent and historical URS observations over the years at the site and on discussions with Geoff Ross (NPWS), Phil Straw (Avifauna Research) and local bird naturalists, waders have not been observed flying over docks or runways to or from the Estuary (whereas other suite of bird strike species such as gulls regularly do).

Discussions with Doug Watkins at Wetlands International (Environment Australia) indicate that Yatstu-Higata a landlocked RAMSAR wetland in Tokyo Bay (surrounded by industrial development) Japan is reportedly being used by a number of migratory waders for part of their life cycle requirements. Watkins indicated that the waders roost at the site and may also feed there at a later stage in a flood tide (that is, when the tide is coming in) when their primary feeding habitat (exposed mudflats elsewhere in the Bay) is flooded. Watkins indicated that the waders are flying over industrialised land because of the absence of any other suitable roost sites in the Bay (as a result of 80-90% of the Bay being reclaimed). This would suggest that some waders at Penrhyn Estuary may fly into the Estuary over the operational docks or negotiate along the 130 metre wide channel parallel to Foreshore Beach particularly if they are forced to due to a lack of remaining suitable habitat in the Bay. The waders would not be expected to have any difficulty in negotiating over the proposed road and rail bridges.

Exclusion fencing, public access restriction to Penrhyn Estuary and boat ramp relocation associated with the proposal may minimise part of the human disturbance element to shorebirds. Shorebirds are often seen at Penryhn Estuary fleeing from roosting on the sandy point on the Penrhyn Road side of the channel to the sandy foothill of the dune on the opposite side of the channel (pers. obs.).

The other key potential impact to consider is the effect of any hydrological changes to the Estuary which may result in changes to shorebird feeding and roosting habitat. Hydrodynamic modelling studies of Penrhyn Estuary are currently being undertaken although the results of these studies are not yet complete or available for review. Nevertheless, SPC have indicated that no significant change in tidal regime, water levels and elevation profiles of the sand and mudflats are predicted to occur at Penrhyn Estuary (pers. comm., SPC). SPC also note that no hydrodynamic changes to other important shorebird habitat areas in the Bay (Towra Point, Taren and Shell Points) are predicted to occur (pers. comm., SPC).

The proposal will also result in the loss of remaining areas of shorebird foraging habitat on Foreshore Beach. The predicted impact on shorebirds however is considered to be negligible due to the volume of pedestrian traffic and dog walking on the beach (disturbance issue) and due to the increased beach erosion and resulting steepness in the elevation profile which has drastically reduced the suitableness of the bird habitat in this area (less intertidal flats on neap tides).

(b) *in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.*

Not Applicable

(c) *in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.*

The proposal may result in a significant modification to shorebird habitat and behaviour at Penryhn Estuary, considered to be an important shorebird habitat for the species on a local and regional basis.

It should be noted that few nocturnal shorebird surveys in the Botany Bay estuary have been undertaken to date and thus data on nocturnal feeding and roosting habitat for shorebirds is not yet available. Nocturnal feeding is just as important (sometimes more important) than diurnal feeding for shorebirds and should not be underestimated in terms of a species life cycle requirements.

(d) *whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community*

The proposal may result in the isolation of shorebird feeding and roosting habitat at Penrhyn Estuary from other known roost sites on the southern shores of the Bay and from general Bay wide bird movements which are undertaken over water.

(e) *whether critical habitat will be affected.*

The study area is not listed as critical habitat under Part 3 Division 1 of the Threatened Species Conservation Act 1995.

(f) *whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.*

No resident or migratory shorebirds in NSW are considered to be adequately conserved due to the unique location of their intertidal habitat. Smith (1991) notes that reservation of wader habitat on intertidal lands has posed a particular problem for NPWS as few coastal reserves include any areas below the high water mark which are generally Crown land. There has been some success, however, in establishing aquatic reserves in NSW such as the Towra Point Aquatic Reserve adjacent to Towra Point Nature Reserve in the Botany Bay estuary which supports

important habitat for many waders such as the Eastern Curlew and Whimbrel. Kooragang Nature Reserve in the Hunter estuary is one of the few present examples within an extensive representation of intertidal wader feeding grounds. This species is regularly recorded in relatively high numbers in the Hunter estuary.

(g) *whether the development or activity proposed is of a class of development or activity that is recognised as a threatening processes.*

Not Applicable

(h) *whether any threatened species, populations or ecological community is at the limit of its known distribution*

This species is regularly recorded in many estuaries on the north and south NSW coasts and is thus not considered to be at its limit of distribution in the Botany Bay estuary.

Section 5A Assessment Conclusion

Given that the proposal presently represents potential significant impacts on shorebird habitat at Penrhyn Estuary and given that many of the impacts (particularly those relating to disturbance) are difficult to predict, the precautionary approach must therefore be taken and thus the preparation of a Species Impact Statement for the species is required.

Should the development proceed, and should the proposed enhancement of shorebird habitat at Penrhyn Estuary not prove feasible, off-site enhancement of existing shorebird habitat elsewhere in Botany Bay (such as H1 lands at Woolooware Bay) should be considered. Proposed enhancement of shorebird habitat at Penrhyn Estuary will be addressed in the SIS for the proposal.

Calidris tenuirostris (Great Knot)

(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

This species is a mudflat feeder and is occasionally recorded roosting and feeding at Penrhyn Estuary, particularly since it was displaced from its preferred habitat at the former Pilots Embayment which was lost due the Parallel Runway construction. The species is now restricted to Penrhyn Estuary in the Botany Bay estuary. The numbers of this species using the Bay are low (probably less than 4 or 5) although they are significant given the small size of the population on the east coast.

Predicted key impacts from the proposal on this species comprise disturbance to feeding and roosting from a change in lighting regime, increased noise and vibration (human and machinery) from the construction and operation of the port (and associated infrastructure such as railway lines) and potential entry/exit psychological flyway barrier due to the enclosure of Penrhyn Estuary. Disturbance issues are discussed below and are based on the author's general knowledge of shorebirds in New South Wales estuaries and from a desktop literature review of shorebird disturbance studies and other generalist bird studies (Paton et al 2000; Burger 1991; Goss-Custard and Verboven 1993; Smit and Visser 1993; Goss-Custard *et al* 1982; Goss-Custard 1980; Lawler 1996; Roberts and Evans 1993; Batten 1977; Straw 1996; Nelson 1994; Metcalfe and Furness 1984; Weston *et al* 2000).

There is little quantified and experimental assessment of the effects of disturbance to waterbirds and little understanding of the extent of such impacts. Disturbance is defined as a disruption to normal activity patterns. Disturbances to waders may vary in their intensity, frequency, duration, coverage and predictability and there is often inter-specific and intra-specific variation in susceptibility of birds to disturbance which is likely to vary with age, season, weather, location and the degree of habituation to disturbance. There are two potential consequences of sustained, localised disturbance to migratory waders, these being birds may have to shift to alternative, perhaps less favourable feeding grounds and secondly may have their feeding rate reduced by having to devote time to vigilance and anti-predator behaviour. Disturbed shorebirds may spend less time foraging whilst increasing energy-expending behaviours such as fleeing (running, flying). It has also been suggested that migratory birds may be more prone to disturbance than non-migratory species as they are only present in a particular area for part of the year and so have little opportunity to become habituated to the disturbance.

Waders preferably forage in areas where prey density, prey availability and intake rates are relatively high and where energy expenditure is low. Shorebird densities, therefore, tend to reach a maximum in the most preferred feeding areas (Penrhyn Estuary for this species) and where disturbances force birds to shift to alternative feeding areas, questions arise as to whether such areas are adequate, whether they can accommodate displaced individuals and what effect increased bird density has on intake rates and the fitness of those birds that move. As bird density increases, average intake rates decline in many species as a result of increased competition, increased prey depletion and a greater proportion of the population feeding in sub-optimal areas. Where populations are limited, or are close to limitation by the quality and availability of habitat (such as for this species in Penrhyn Estuary and in Botany Bay estuary in total), disturbance can have a negative impact on wader populations by affecting fitness, ability to fatten adequately during pre-migratory periods and increased mortality.

Some studies that have attempted to experimentally asses the impact of disturbance on waterbirds have predominantly used the bird’s flight response as an index of disturbance whilst others have only crudely estimated alert distances. In such studies, a disturbance is introduced and the distance of the birds from the disturbance at the point of flight is measured. Buffer distances given for many shorebirds as part of past studies are in the order of 100-400 metres.

Many foraging migratory waders are often disrupted from their typical behaviour well before a flight response is elicited with some birds shown to be alerted at distances on average 30-95% greater than those at which they take flight. Following detection of a disturbance the bird may spend time assessing the degree of threat it is under and may balance the risk with the benefits of continued foraging or roosting. As discussed above, this may be particularly significant to migratory shorebirds during the pre-migratory period of fat accumulation (and post migratory period of recuperation and moulting) where an increase in food requirements during this period results in waders trying to maximise their net rate of resource acquisition and thus invest more time in foraging at the expense of vigilance and anti-predator behaviour. This is particularly significant for shorebirds whose feeding times are regulated by tidal flow (and even more significant for small billed waders such as plovers and stints where foraging areas are further limited by amount of intertidal area not covered with water at low tide). Frequent and intense disturbance is likely to affect wader behaviour and reduce the time they spend foraging. Reductions in feeding may then affect the capacity of waders to fatten at an adequate rate and therefore prolong the pre-migratory feeding period and departure delay. Such delays in migration departure from wintering grounds can seriously affect breeding success of migratory birds, where individuals arriving late at the summer breeding grounds may be at a disadvantage in the competition for mates and territories.

A change in lighting regime (predicted increase in ambient lighting at night) in Penrhyn Estuary may result in an increase in vigilant behaviour (area scans) at the expense of foraging as many shorebirds, particularly those that have been observed to forage nocturnally in “relatively dark” areas (such as sand plovers), may feel that they are more visible to potential predators (feral dogs, cats, birds of prey). Increased ambient lighting and flashes of light from railway lines may result in the displacement of the shorebirds to sub-optimal (less preferred) habitat elsewhere in the Botany Bay estuary.

The current design essentially encloses Penrhyn Estuary and thus may represent a psychological entry/exit flyway barrier into and out of the shorebird feeding and

roosting habitat at the Estuary. Despite their physical capabilities, waders are very reluctant to enter an area that does not have an open aspect (mainly to enable them to have a clear view of potential predators). Based on both the observed current flyways of the shorebirds into and out of the Estuary and on standard wader flyway behaviour, waders currently utilising Penrhyn Estuary fly into the area either from the south over water or from the west by flying south around the runways and turning north-east into the Estuary over water. Based on casual recent and historical URS observations over the years at the site and on discussions with Geoff Ross (NPWS), Phil Straw (Avifauna Research) and local bird naturalists, waders have not been observed flying over docks or runways to or from the Estuary (whereas other suite of bird strike species such as gulls regularly do).

Exclusion fencing, public access restriction to Penrhyn Estuary and boat ramp relocation associated with the proposal may minimise part of the human disturbance element to shorebirds. Shorebirds are often seen at Penryhn Estuary fleeing from roosting on the sandy point on the Penrhyn Road side of the channel to the sandy foothill of the dune on the opposite side of the channel (pers. obs.).

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The other key potential impact to consider is the effect of any hydrological changes to the Estuary which may result in changes to shorebird feeding and roosting habitat. Hydrodynamic modelling studies of Penrhyn Estuary are currently being undertaken although the results of these studies are not yet complete or available for review. Nevertheless, SPC have indicated that no significant change in tidal regime, water levels and elevation profiles of the sand and mudflats are predicted to occur at Penrhyn Estuary (pers. comm., SPC). SPC also note that no hydrodynamic changes to other important shorebird habitat areas in the Bay (Towra Point, Taren and Shell Points) are predicted to occur (pers. comm., SPC).

The proposal will also result in the loss of remaining areas of shorebird foraging habitat on Foreshore Beach. The predicted impact on shorebirds however is considered to be negligible due to the volume of pedestrian traffic and dog walking on the beach (disturbance issue) and due to the increased beach erosion and

resulting steepness in the elevation profile which has drastically reduced the suitableness of the bird habitat in this area (less intertidal flats on neap tides).

(b) *in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.*

Not Applicable

(c) *in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.*

The proposal may result in a significant modification to shorebird habitat and behaviour at Penryhn Estuary, considered to be an important shorebird habitat for the species on a local and regional basis.

It should be noted that few nocturnal shorebird surveys in the Botany Bay estuary have been undertaken to date and thus data on nocturnal feeding and roosting habitat for shorebirds is not yet available. Nocturnal feeding is just as important (sometimes more important) than diurnal feeding for shorebirds and should not be underestimated in terms of a species life cycle requirements.

(d) *whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community*

The proposal may result in the isolation of shorebird feeding and roosting habitat at Penrhyn Estuary from other known roost sites on the southern shores of the Bay and from general Bay wide bird movements which are undertaken over water.

(e) *whether critical habitat will be affected.*

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No resident or migratory shorebirds in NSW are considered to be adequately conserved due to the unique location of their intertidal habitat. Smith (1991) notes that reservation of wader habitat on intertidal lands has posed a particular problem for NPWS as few coastal reserves include any areas below the high water mark which are generally Crown land. There has been some success, however, in establishing aquatic reserves in NSW such as the Towra Point Aquatic Reserve adjacent to Towra Point Nature Reserve in the Botany Bay estuary which supports important habitat for many waders such as the Eastern Curlew and Whimbrel. Kooragang Nature Reserve in the Hunter estuary is one of the few present examples within an extensive representation of intertidal wader feeding grounds. This species is regularly recorded in relatively high numbers in the Hunter estuary.

(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening processes.

Not Applicable

(h) whether any threatened species, populations or ecological community is at the limit of its known distribution

This species is regularly recorded in some estuaries on the north and south NSW coasts (particularly the Richmond and Clarence estuaries) and is thus not considered to be at its limit of distribution in the Botany Bay estuary.

Section 5A Assessment Conclusion

Given that the proposal presently represents potential significant impacts on shorebird habitat at Penrhyn Estuary and given that many of the impacts (particularly those relating to disturbance) are difficult to predict, the precautionary approach must therefore be taken and thus the preparation of a Species Impact Statement for the species is required.

Should the development proceed, and should the proposed enhancement of shorebird habitat at Penrhyn Estuary not prove feasible, off-site enhancement of existing shorebird habitat elsewhere in Botany Bay (such as H1 lands at Woolooware Bay) should be considered. Proposed enhancement of shorebird habitat at Penrhyn Estuary will be addressed in the SIS for the proposal.

Tringa nebularia (Greenshank)

(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

This species has been recorded on the mangrove lined shores of Woolooware Bay and use to favour the pond site at H1 (former sand quarry at Kurnell) although was not recorded there last season. The numbers of this species in the Bay at present is in the order of 7 or 8 although this may be an underestimate due the difficulty in gaining access to Woolooware Bay by land or boat (due the number of oyster leases in the area). This species may be an occasional visitor to Penrhyn Estuary.

Predicted key impacts from the proposal on this species comprise disturbance to feeding and roosting from a change in lighting regime, increased noise and vibration (human and machinery) from the construction and operation of the port (and associated infrastructure such as railway lines) and potential entry/exit psychological flyway barrier due to the enclosure of Penrhyn Estuary. Disturbance issues are discussed below and are based on the author's general knowledge of shorebirds in New South Wales estuaries and from a desktop literature review of shorebird disturbance studies and other generalist bird studies (Paton et al 2000; Burger 1991; Goss-Custard and Verboven 1993; Smit and Visser 1993; Goss-Custard *et al* 1982; Goss-Custard 1980; Lawler 1996; Roberts and Evans 1993; Batten 1977; Straw 1996; Nelson 1994; Metcalfe and Furness 1984; Weston *et al* 2000).

There is little quantified and experimental assessment of the effects of disturbance to waterbirds and little understanding of the extent of such impacts. Disturbance is defined as a disruption to normal activity patterns. Disturbances to waders may vary in their intensity, frequency, duration, coverage and predictability and there is often inter-specific and intra-specific variation in susceptibility of birds to disturbance which is likely to vary with age, season, weather, location and the degree of habituation to disturbance. There are two potential consequences of sustained, localised disturbance to migratory waders, these being birds may have to shift to alternative, perhaps less favourable feeding grounds and secondly may have their feeding rate reduced by having to devote time to vigilance and anti-predator behaviour. Disturbed shorebirds may spend less time foraging whilst increasing energy-expending behaviours such as fleeing (running, flying). It has also been suggested that migratory birds may be more prone to disturbance than non-migratory species as they are only present in a particular area for part of the year and so have little opportunity to become habituated to the disturbance.

Waders preferably forage in areas where prey density, prey availability and intake rates are relatively high and where energy expenditure is low. Shorebird densities, therefore, tend to reach a maximum in the most preferred feeding areas and where disturbances force birds to shift to alternative feeding areas, questions arise as to whether such areas are adequate, whether they can accommodate displaced individuals and what effect increased bird density has on intake rates and the fitness

of those birds that move. As bird density increases, average intake rates decline in many species as a result of increased competition, increased prey depletion and a greater proportion of the population feeding in sub-optimal areas. Where populations are limited, or are close to limitation by the quality and availability of habitat (such as for this species in Penrhyn Estuary and in Botany Bay estuary in total), disturbance can have a negative impact on wader populations by affecting fitness, ability to fatten adequately during pre-migratory periods and increased mortality.

Some studies that have attempted to experimentally asses the impact of disturbance on waterbirds have predominantly used the bird’s flight response as an index of disturbance whilst others have only crudely estimated alert distances. In such studies, a disturbance is introduced and the distance of the birds from the disturbance at the point of flight is measured. Buffer distances given for many shorebirds as part of past studies, including the Curlew Sandpiper, are in the order of 100-400 metres.

Many foraging migratory waders are often disrupted from their typical behaviour well before a flight response is elicited with some birds shown to be alerted at distances on average 30-95% greater than those at which they take flight. Following detection of a disturbance the bird may spend time assessing the degree of threat it is under and may balance the risk with the benefits of continued foraging or roosting. As discussed above, this may be particularly significant to migratory shorebirds during the pre-migratory period of fat accumulation (and post migratory period of recuperation and moulting) where an increase in food requirements during this period results in waders trying to maximise their net rate of resource acquisition and thus invest more time in foraging at the expense of vigilance and anti-predator behaviour. This is particularly significant for shorebirds whose feeding times are regulated by tidal flow (and even more significant for small billed waders such as plovers and stints where foraging areas are further limited by amount of intertidal area not covered with water at low tide). Frequent and intense disturbance is likely to affect wader behaviour and reduce the time they spend foraging. Reductions in feeding may then affect the capacity of waders to fatten at an adequate rate and therefore prolong the pre-migratory feeding period and departure delay. Such delays in migration departure from wintering grounds can seriously affect breeding success of migratory birds, where individuals arriving late at the summer breeding grounds may be at a disadvantage in the competition for mates and territories.

A change in lighting regime (predicted increase in ambient lighting at night) in Penrhyn Estuary may result in an increase in vigilant behaviour (area scans) at the expense of foraging as many shorebirds, particularly those that have been observed to forage nocturnally in “relatively dark” areas (such as sand plovers), may feel that they are more visible to potential predators (feral dogs, cats, birds of prey). Increased ambient lighting and flashes of light from railway lines may result in the displacement of the shorebirds to sub-optimal (less preferred) habitat elsewhere in the Botany Bay estuary, such as Boat Harbour and Taren Point.

The current design essentially encloses Penrhyn Estuary and thus may represent a psychological entry/exit flyway barrier into and out of the shorebird feeding and roosting habitat at the Estuary. Despite their physical capabilities, waders are very reluctant to enter an area that does not have an open aspect (mainly to enable them to have a clear view of potential predators). Based on both the observed current flyways of the shorebirds into and out of the Estuary and on standard wader flyway behaviour, waders currently utilising Penrhyn Estuary fly into the area either from the south over water or from the west by flying south around the runways and turning north-east into the Estuary over water. Based on casual recent and historical URS observations over the years at the site and on discussions with Geoff Ross (NPWS), Phil Straw (Avifauna Research) and local bird naturalists, waders have not been observed flying over docks or runways to or from the Estuary (whereas other suite of bird strike species such as gulls regularly do).

Exclusion fencing, public access restriction to Penrhyn Estuary and boat ramp relocation associated with the proposal may minimise part of the human disturbance element to shorebirds. Shorebirds are often seen at Penryhn fleeing from roosting on the sandy point on the Penrhyn Road side of the channel to the sandy foothill of the dune on the opposite side of the channel (pers. obs.).

Discussions with Doug Watkins at Wetlands International (Environment Australia) indicate that Yatsu-Higata a landlocked RAMSAR wetland in Tokyo Bay (surrounded by industrial development) Japan is reportedly being used by a number of migratory waders for part of their life cycle requirements. Watkins indicated that the waders roost at the site and may also feed there at a later stage in a flood tide (that is, when the tide is coming in) when their primary feeding habitat (exposed mudflats elsewhere in the Bay) is flooded. Watkins indicated that the waders are flying over industrialised land because of the absence of any other suitable roost sites in the Bay (as a result of 80-90% of the Bay being reclaimed). This would suggest that some waders at Penrhyn Estuary may fly into the Estuary over the operational docks or negotiate along the 130 metre wide channel parallel to Foreshore Beach particularly if they are forced to due to a lack of remaining suitable habitat in the Bay. The waders would not be expected to have any difficulty in negotiating over the proposed road and rail bridges.

The other key potential impact to consider is the effect of any hydrological changes to the Estuary which may result in changes to shorebird feeding and roosting habitat. Hydrodynamic modelling studies of Penrhyn Estuary are currently being undertaken although the results of these studies are not yet complete or available for review. Nevertheless, SPC have indicated that no significant change in tidal regime, water levels and elevation profiles of the sand and mudflats are predicted to occur at Penrhyn Estuary (pers. comm., SPC). SPC also note that no hydrodynamic changes to other important shorebird habitat areas in the Bay (Towra Point, Taren and Shell Points) are predicted to occur (pers. comm., SPC).

The proposal will also result in the loss of remaining areas of shorebird foraging habitat on Foreshore Beach. The predicted impact on shorebirds however is considered to be negligible due to the volume of pedestrian traffic and dog walking

on the beach (disturbance issue) and due to the increased beach erosion and resulting steepness in the elevation profile which has drastically reduced the suitableness of the bird habitat in this area (less intertidal flats on neap tides).

(b) *in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.*

Not Applicable

(c) *in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.*

The proposal may result in a significant modification to shorebird habitat and behaviour at Penryhn Estuary, considered to be an important shorebird habitat for the species on a local and regional basis.

It should be noted that few nocturnal shorebird surveys in the Botany Bay estuary have been undertaken to date and thus data on nocturnal feeding and roosting habitat for shorebirds is not yet available. Nocturnal feeding is just as important (sometimes more important) than diurnal feeding for shorebirds and should not be underestimated in terms of a species life cycle requirements.

(d) *whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community*

The proposal may result in the isolation of shorebird feeding and roosting habitat at Penrhyn Estuary from other known roost sites on the southern shores of the Bay and from general Bay wide bird movements which are undertaken over water.

(e) *whether critical habitat will be affected.*

The study area is not listed as critical habitat under Part 3 Division 1 of the Threatened Species Conservation Act 1995.

(f) *whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.*

No resident or migratory shorebirds in NSW are considered to be adequately conserved due to the unique location of their intertidal habitat. Smith (1991) notes that reservation of wader habitat on intertidal lands has posed a particular problem for NPWS as few coastal reserves include any areas below the high water mark which are generally Crown land. There has been some success, however, in establishing aquatic reserves in NSW such as the Towra Point Aquatic Reserve adjacent to Towra Point Nature Reserve in the Botany Bay estuary which supports important habitat for many waders such as the Eastern Curlew and Whimbrel. Kooragang Nature Reserve in the Hunter estuary is one of the few present examples

within an extensive representation of intertidal wader feeding grounds. This species is regularly recorded in relatively high numbers in the Hunter estuary.

(g) *whether the development or activity proposed is of a class of development or activity that is recognised as a threatening processes.*

Not Applicable

(h) *whether any threatened species, populations or ecological community is at the limit of its known distribution*

This species is regularly recorded in many estuaries on the north and south NSW coasts as well as inland and is thus not considered to be at its limit of distribution at Botany Bay estuary.

Section 5A Assessment Conclusion

Given that the proposal presently represents potential significant impacts on shorebird habitat at Penrhyn Estuary and given that many of the impacts (particularly those relating to disturbance) are difficult to predict, the precautionary approach must therefore be taken and thus the preparation of a Species Impact Statement for the species is required.

Should the development proceed, and should the proposed enhancement of shorebird habitat at Penrhyn Estuary not prove feasible, off-site enhancement of existing shorebird habitat elsewhere in Botany Bay (such as H1 lands at Woolooware Bay) should be considered. Proposed enhancement of shorebird habitat at Penrhyn Estuary will be addressed in the SIS for the proposal.

Tringa brevipes (Grey-tailed Tattler)

(a) *in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.*

This species presently feeds on exposed mudflats on the southern parts of the Bay and has been recorded roosting at a number of locations including the groynes at Kurnell, the old rocky wharf at the mouth of Quibray Bay, in mature spreading mangroves and on platforms in mangroves at Quibray Bay. This species may occasionally feed in small numbers at Penrhyn Estuary. The numbers of the species in the Bay in present times is around 180-190 maximum and do not seem to have varied significantly since the 1950s. These numbers may as well be an underestimate due to the difficulty in detecting the species at their roost sites.

Predicted key impacts from the proposal on this species comprise disturbance to feeding and roosting from a change in lighting regime, increased noise and vibration (human and machinery) from the construction and operation of the port (and associated infrastructure such as railway lines) and potential entry/exit psychological flyway barrier due to the enclosure of Penrhyn Estuary. Disturbance issues are discussed below and are based on the author’s general knowledge of shorebirds in New South Wales estuaries and from a desktop literature review of shorebird disturbance studies and other generalist bird studies (Paton et al 2000; Burger 1991; Goss-Custard and Verboven 1993; Smit and Visser 1993; Goss-Custard *et al* 1982; Goss-Custard 1980; Lawler 1996; Roberts and Evans 1993; Batten 1977; Straw 1996; Nelson 1994; Metcalfe and Furness 1984; Weston *et al* 2000).

There is little quantified and experimental assessment of the effects of disturbance to waterbirds and little understanding of the extent of such impacts. Disturbance is defined as a disruption to normal activity patterns. Disturbances to waders may vary in their intensity, frequency, duration, coverage and predictability and there is often inter-specific and intra-specific variation in susceptibility of birds to disturbance which is likely to vary with age, season, weather, location and the degree of habituation to disturbance. There are two potential consequences of sustained, localised disturbance to migratory waders, these being birds may have to shift to alternative, perhaps less favourable feeding grounds and secondly may have their feeding rate reduced by having to devote time to vigilance and anti-predator behaviour. Disturbed shorebirds may spend less time foraging whilst increasing energy-expending behaviours such as fleeing (running, flying). It has also been suggested that migratory birds may be more prone to disturbance than non-migratory species as they are only present in a particular area for part of the year and so have little opportunity to become habituated to the disturbance.

Waders preferably forage in areas where prey density, prey availability and intake rates are relatively high and where energy expenditure is low. Shorebird densities, therefore, tend to reach a maximum in the most preferred feeding areas (Woolooware Bay for this species) and where disturbances force birds to shift to alternative feeding areas, questions arise as to whether such areas are adequate, whether they can accommodate displaced individuals and what effect increased bird density has on intake rates and the fitness of those birds that move. As bird density increases, average intake rates decline in many species as a result of increased competition, increased prey depletion and a greater proportion of the population feeding in sub-optimal areas. Where populations are limited, or are close to limitation by the quality and availability of habitat (such as for this species in Penrhyn Estuary and in Botany Bay estuary in total), disturbance can have a negative impact on wader populations by affecting fitness, ability to fatten adequately during pre-migratory periods and increased mortality.

Some studies that have attempted to experimentally asses the impact of disturbance on waterbirds have predominantly used the bird’s flight response as an index of disturbance whilst others have only crudely estimated alert distances. In such studies, a disturbance is introduced and the distance of the birds from the disturbance at the point of flight is measured. Buffer distances given for many shorebirds as part of past studies are in the order of 100-400 metres.

Many foraging migratory waders are often disrupted from their typical behaviour well before a flight response is elicited with some birds shown to be alerted at distances on average 30-95% greater than those at which they take flight. Following detection of a disturbance the bird may spend time assessing the degree of threat it is under and may balance the risk with the benefits of continued foraging or roosting. As discussed above, this may be particularly significant to migratory shorebirds during the pre-migratory period of fat accumulation (and post migratory period of recuperation and moulting) where an increase in food requirements during this period results in waders trying to maximise their net rate of resource acquisition and thus invest more time in foraging at the expense of vigilance and anti-predator behaviour. This is particularly significant for shorebirds whose feeding times are regulated by tidal flow (and even more significant for small billed waders such as plovers and stints where foraging areas are further limited by amount of intertidal area not covered with water at low tide). Frequent and intense disturbance is likely to affect wader behaviour and reduce the time they spend foraging. Reductions in feeding may then affect the capacity of waders to fatten at an adequate rate and therefore prolong the pre-migratory feeding period and departure delay. Such delays in migration departure from wintering grounds can seriously affect breeding success of migratory birds, where individuals arriving late at the summer breeding grounds may be at a disadvantage in the competition for mates and territories.

A change in lighting regime (predicted increase in ambient lighting at night) in Penrhyn Estuary may result in an increase in vigilant behaviour (area scans) at the expense of foraging as many shorebirds, particularly those that have been observed to forage nocturnally in “relatively dark” areas (such as sand plovers), may feel that they are more visible to potential predators (feral dogs, cats, birds of prey). Increased ambient lighting and flashes of light from railway lines may result in the displacement of the shorebirds to sub-optimal (less preferred) habitat elsewhere in the Botany Bay estuary, such as Penrhyn Estuary.

The current design essentially encloses Penrhyn Estuary and thus may represent a psychological entry/exit flyway barrier into and out of the shorebird feeding and roosting habitat at the Estuary. Despite their physical capabilities, waders are very reluctant to enter an area that does not have and open aspect (mainly to enable them to have a clear view of potential predators). Based on both the observed current flyways of the shorebirds into and out of the Estuary and on standard wader flyway behaviour, waders currently utilising Penrhyn Estuary fly into the area either from the south over water or from the west by flying south around the runways and turning north-east into the Estuary over water. Based on casual recent and historical URS observations over the years at the site and on discussions with Geoff Ross (NPWS), Phil Straw (Avifauna Research) and local bird naturalists, waders have not been observed flying over docks or runways to or from the Estuary (whereas other suite of bird strike species such as gulls regularly do).

Exclusion fencing, public access restriction to Penrhyn Estuary and boat ramp relocation associated with the proposal may minimise part of the human disturbance element to shorebirds. Shorebirds are often seen at Penryhn Estuary fleeing from roosting on the sandy point on the Penrhyn Road side of the channel to the sandy foothill of the dune on the opposite side of the channel (pers. obs.).

Discussions with Doug Watkins at Wetlands International (Environment Australia) indicate that Yatsu-Higata a landlocked RAMSAR wetland in Tokyo Bay (surrounded by industrial development) Japan is reportedly being used by a number of migratory waders for part of their life cycle requirements. Watkins indicated that the waders roost at the site and may also feed there at a later stage in a flood tide (that is, when the tide is coming in) when their primary feeding habitat (exposed mudflats elsewhere in the Bay) is flooded. Watkins indicated that the waders are flying over industrialised land because of the absence of any other suitable roost sites in the Bay (as a result of 80-90% of the Bay being reclaimed). This would suggest that some waders at Penrhyn Estuary may fly into the Estuary over the operational docks or negotiate along the 130 metre wide channel parallel to Foreshore Beach particularly if they are forced to due to a lack of remaining suitable habitat in the Bay. The waders would not be expected to have any difficulty in negotiating over the proposed road and rail bridges.

The other key potential impact to consider is the effect of any hydrological changes to the Estuary which may result in changes to shorebird feeding and roosting habitat. Hydrodynamic modelling studies of Penrhyn Estuary are currently being undertaken although the results of these studies are not yet complete or available for review. Nevertheless, SPC have indicated that no significant change in tidal regime, water levels and elevation profiles of the sand and mudflats are predicted to occur at Penrhyn Estuary (pers. comm., SPC). SPC also note that no hydrodynamic changes to other important shorebird habitat areas in the Bay (Towra Point, Taren and Shell Points) are predicted to occur (pers. comm., SPC).

The proposal will also result in the loss of remaining areas of shorebird foraging habitat on Foreshore Beach. The predicted impact on shorebirds however is considered to be negligible due to the volume of pedestrian traffic and dog walking

on the beach (disturbance issue) and due to the increased beach erosion and resulting steepness in the elevation profile which has drastically reduced the suitableness of the bird habitat in this area (less intertidal flats on neap tides).

(b) *in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.*

Not Applicable

(c) *in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.*

The proposal may result in a significant modification to shorebird habitat and behaviour at Penryhn Estuary, considered to be an important secondary shorebird habitat for the species on a local and regional basis.

It should be noted that few nocturnal shorebird surveys in the Botany Bay estuary have been undertaken to date and thus data on nocturnal feeding and roosting habitat for shorebirds is not yet available. Nocturnal feeding is just as important (sometimes more important) than diurnal feeding for shorebirds and should not be underestimated in terms of a species life cycle requirements.

(d) *whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community*

The proposal may result in the isolation of shorebird feeding and roosting habitat at Penrhyn Estuary from other known roost sites on the southern shores of the Bay and from general Bay wide bird movements which are undertaken over water.

(e) *whether critical habitat will be affected.*

The study area is not listed as critical habitat under Part 3 Division 1 of the Threatened Species Conservation Act 1995.

(f) *whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.*

No resident or migratory shorebirds in NSW are considered to be adequately conserved due to the unique location of their intertidal habitat. Smith (1991) notes that reservation of wader habitat on intertidal lands has posed a particular problem for NPWS as few coastal reserves include any areas below the high water mark which are generally Crown land. There has been some success, however, in establishing aquatic reserves in NSW such as the Towra Point Aquatic Reserve adjacent to Towra Point Nature Reserve in the Botany Bay estuary which supports important habitat for many waders such as the Eastern Curlew and Whimbrel. Kooragang Nature Reserve in the Hunter estuary is one of the few present examples

within an extensive representation of intertidal wader feeding grounds. This species is regularly recorded in relatively high numbers in the Hunter estuary.

(g) *whether the development or activity proposed is of a class of development or activity that is recognised as a threatening processes.*

Not Applicable

(h) *whether any threatened species, populations or ecological community is at the limit of its known distribution*

This species is regularly recorded in many estuaries on the east coast of NSW as well as inland and is thus not considered to be at its limit of distribution in the Botany Bay estuary.

Section 5A Assessment Conclusion

Given that the proposal presently represents potential significant impacts on shorebird habitat at Penrhyn Estuary and given that many of the impacts (particularly those relating to disturbance) are difficult to predict, the precautionary approach must therefore be taken and thus the preparation of a Species Impact Statement for the species is required.

Should the development proceed, and should the proposed enhancement of shorebird habitat at Penrhyn Estuary not prove feasible, off-site enhancement of existing shorebird habitat elsewhere in Botany Bay (such as H1 lands at Woolooware Bay) should be considered. Proposed enhancement of shorebird habitat at Penrhyn Estuary will be addressed in the SIS for the proposal.

Limosa lapponica (Bar-tailed Godwit)

(a) *in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.*

This species presently feeds on intertidal sandflats at Penrhyn Estuary and at Rocky Point in the Bay (prefers Rocky Point) and roosts on beaches at Penrhyn Estuary and Sandringham Bay. The numbers of this species in the Bay in recent times are in the order of 200-400 and have thus shown a moderate decline in numbers in the last 10 years (when numbers have been in the order of 600-800).

Predicted key impacts from the proposal on this species comprise disturbance to feeding and roosting from a change in lighting regime, increased noise and vibration (human and machinery) from the construction and operation of the port (and associated infrastructure such as railway lines) and potential entry/exit psychological flyway barrier due to the enclosure of Penrhyn Estuary. Disturbance issues are discussed below and are based on the author's general knowledge of shorebirds in New South Wales estuaries and from a desktop literature review of shorebird disturbance studies and other generalist bird studies (Paton et al 2000; Burger 1991; Goss-Custard and Verboven 1993; Smit and Visser 1993; Goss-Custard *et al* 1982; Goss-Custard 1980; Lawler 1996; Roberts and Evans 1993; Batten 1977; Straw 1996; Nelson 1994; Metcalfe and Furness 1984; Weston *et al* 2000).

There is little quantified and experimental assessment of the effects of disturbance to waterbirds and little understanding of the extent of such impacts. Disturbance is defined as a disruption to normal activity patterns. Disturbances to waders may vary in their intensity, frequency, duration, coverage and predictability and there is often inter-specific and intra-specific variation in susceptibility of birds to disturbance which is likely to vary with age, season, weather, location and the degree of habituation to disturbance. There are two potential consequences of sustained, localised disturbance to migratory waders, these being birds may have to shift to alternative, perhaps less favourable feeding grounds and secondly may have their feeding rate reduced by having to devote time to vigilance and anti-predator behaviour. Disturbed shorebirds may spend less time foraging whilst increasing energy-expending behaviours such as fleeing (running, flying). It has also been suggested that migratory birds may be more prone to disturbance than non-migratory species as they are only present in a particular area for part of the year and so have little opportunity to become habituated to the disturnance.

Waders preferably forage in areas where prey density, prey availability and intake rates are relatively high and where energy expenditure is low. Shorebird densities, therefore, tend to reach a maximum in the most preferred feeding areas (Penrhyn Estuary for this species) and where disturbances force birds to shift to alternative feeding areas, questions arise as to whether such areas are adequate, whether they can accommodate displaced individuals and what effect increased bird density has on intake rates and the fitness of those birds that move. As bird density increases,

average intake rates decline in many species as a result of increased competition, increased prey depletion and a greater proportion of the population feeding in sub-optimal areas. Where populations are limited, or are close to limitation by the quality and availability of habitat (such as for this species in Penrhyn Estuary and in Botany Bay estuary in total), disturbance can have a negative impact on wader populations by affecting fitness, ability to fatten adequately during pre-migratory periods and increased mortality.

Some studies that have attempted to experimentally asses the impact of disturbance on waterbirds have predominantly used the bird's flight response as an index of disturbance whilst others have only crudely estimated alert distances. In such studies, a disturbance is introduced and the distance of the birds from the disturbance at the point of flight is measured. Buffer distances given for many shorebirds as part of past studies are in the order of 100-400 metres.

Many foraging migratory waders are often disrupted from their typical behaviour well before a flight response is elicited with some birds shown to be alerted at distances on average 30-95% greater than those at which they take flight. Following detection of a disturbance the bird may spend time assessing the degree of threat it is under and may balance the risk with the benefits of continued foraging or roosting. As discussed above, this may be particularly significant to migratory shorebirds during the pre-migratory period of fat accumulation (and post migratory period of recuperation and moulting) where an increase in food requirements during this period results in waders trying to maximise their net rate of resource acquisition and thus invest more time in foraging at the expense of vigilance and anti-predator behaviour. This is particularly significant for shorebirds whose feeding times are regulated by tidal flow (and even more significant for small billed waders such as plovers and stints where foraging areas are further limited by amount of intertidal area not covered with water at low tide). Frequent and intense disturbance is likely to affect wader behaviour and reduce the time they spend foraging. Reductions in feeding may then affect the capacity of waders to fatten at an adequate rate and therefore prolong the pre-migratory feeding period and departure delay. Such delays in migration departure from wintering grounds can seriously affect breeding success of migratory birds, where individuals arriving late at the summer breeding grounds may be at a disadvantage in the competition for mates and territories.

A change in lighting regime (predicted increase in ambient lighting at night) in Penrhyn Estuary may result in an increase in vigilant behaviour (area scans) at the expense of foraging as many shorebirds, particularly those that have been observed to forage nocturnally in "relatively dark" areas (such as sand plovers), may feel they are more visible to potential predators (feral dogs, cats, birds of prey). Increased ambient lighting and flashes of light from railway lines may result in the displacement of the shorebirds to sub-optimal (less preferred) habitat elsewhere in the Botany Bay estuary.

The current design essentially encloses Penrhyn Estuary and thus may represent a psychological entry/exit flyway barrier into and out of the shorebird feeding and roosting habitat at the Estuary. Despite their physical capabilities, waders are very

reluctant to enter an area that does not have an open aspect (mainly to enable them to have a clear view of potential predators). Based on both the observed current flyways of the shorebirds into and out of the Estuary and on standard wader flyway behaviour, waders currently utilising Penrhyn Estuary fly into the area either from the south over water or from the west by flying south around the runways and turning north-east into the Estuary over water. Based on casual recent and historical URS observations over the years at the site and on discussions with Geoff Ross (NPWS), Phil Straw (Avifauna Research) and local bird naturalists, waders have not been observed flying over docks or runways to or from the Estuary (whereas other suite of bird strike species such as gulls regularly do).

Exclusion fencing, public access restriction to Penrhyn Estuary and boat ramp relocation associated with the proposal may minimise part of the human disturbance element to shorebirds. Shorebirds are often seen at Penryhn Estuary fleeing from roosting on the sandy point on the Penrhyn Road side of the channel to the sandy foothill of the dune on the opposite side of the channel (pers. obs.).

Discussions with Doug Watkins at Wetlands International (Environment Australia) indicate that Yatsu-Higata a landlocked RAMSAR wetland in Tokyo Bay (surrounded by industrial development) Japan is reportedly being used by a number of migratory waders for part of their life cycle requirements. Watkins indicated that the waders roost at the site and may also feed there at a later stage in a flood tide (that is, when the tide is coming in) when their primary feeding habitat (exposed mudflats elsewhere in the Bay) is flooded. Watkins indicated that the waders are flying over industrialised land because of the absence of any other suitable roost sites in the Bay (as a result of 80-90% of the Bay being reclaimed). This would suggest that some waders at Penrhyn Estuary may fly into the Estuary over the operational docks or negotiate along the 130 metre wide channel parallel to Foreshore Beach particularly if they are forced to due to a lack of remaining suitable habitat in the Bay. The waders would not be expected to have any difficulty in negotiating over the proposed road and rail bridges.

The other key potential impact to consider is the effect of any hydrological changes to the Estuary which may result in changes to shorebird feeding and roosting habitat. Hydrodynamic modelling studies of Penrhyn Estuary are currently being undertaken although the results of these studies are not yet complete or available for review. Nevertheless, SPC have indicated that no significant change in tidal regime, water levels and elevation profiles of the sand and mudflats are predicted to occur at Penrhyn Estuary (pers. comm., SPC). SPC also note that no hydrodynamic changes to other important shorebird habitat areas in the Bay (Towra Point, Taren and Shell Points) are predicted to occur (pers. comm., SPC).

The proposal will also result in the loss of remaining areas of shorebird foraging habitat on Foreshore Beach. The predicted impact on shorebirds however is considered to be negligible due to the volume of pedestrian traffic and dog walking on the beach (disturbance issue) and due to the increased beach erosion and resulting steepness in the elevation profile which has drastically reduced the suitableness of the bird habitat in this area (less intertidal flats on neap tides).

(b) *in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.*

Not Applicable

(c) *in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.*

The proposal may result in a significant modification to shorebird habitat and behaviour at Penryhn Estuary, considered to be an important shorebird habitat for the species on a local and regional basis.

It should be noted that few nocturnal shorebird surveys in the Botany Bay estuary have been undertaken to date and thus data on nocturnal feeding and roosting habitat for shorebirds is not yet available. Nocturnal feeding is just as important (sometimes more important) than diurnal feeding for shorebirds and should not be underestimated in terms of a species life cycle requirements.

(d) *whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community*

The proposal may result in the isolation of shorebird feeding and roosting habitat at Penrhyn Estuary from other known roost sites on the southern shores of the Bay and from general Bay wide bird movements which are undertaken over water.

(e) *whether critical habitat will be affected.*

The study area is not listed as critical habitat under Part 3 Division 1 of the Threatened Species Conservation Act 1995.

(f) *whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.*

No resident or migratory shorebirds in NSW are considered to be adequately conserved due to the unique location of their intertidal habitat. Smith (1991) notes that reservation of wader habitat on intertidal lands has posed a particular problem for NPWS as few coastal reserves include any areas below the high water mark which are generally Crown land. There has been some success, however, in establishing aquatic reserves in NSW such as the Towra Point Aquatic Reserve adjacent to Towra Point Nature Reserve in the Botany Bay estuary which supports important habitat for many waders such as the Eastern Curlew and Whimbrel. Kooragang Nature Reserve in the Hunter estuary is one of the few present examples within an extensive representation of intertidal wader feeding grounds. This species is regularly recorded in relatively high numbers in the Hunter estuary.

(g) *whether the development or activity proposed is of a class of development or activity that is recognised as a threatening processes.*

Not Applicable

(h) whether any threatened species, populations or ecological community is at the limit of its known distribution

This species is regularly recorded in many estuaries on the north and south NSW coasts as well as inland and is thus not considered to be at its limit of distribution in the Botany Bay estuary.

Section 5A Assessment Conclusion

Given that the proposal presently represents potential significant impacts on shorebird habitat at Penrhyn Estuary and given that many of the impacts (particularly those relating to disturbance) are difficult to predict, the precautionary approach must therefore be taken and thus the preparation of a Species Impact Statement for the species is required.

Should the development proceed, and should the proposed enhancement of shorebird habitat at Penrhyn Estuary not prove feasible, off-site enhancement of existing shorebird habitat elsewhere in Botany Bay (such as H1 lands at Woolooware Bay) should be considered. Proposed enhancement of shorebird habitat at Penrhyn Estuary will be addressed in the SIS for the proposal.

Limicola falcinellus (Broad-billed Sandpiper)

(a) *in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.*

Mostly single individuals of this species have been recorded in the Bay on an occasional basis since the mid 1970s (northern shoreline) and up to 17 birds were recorded on the northern shores of the Bay in 1953 (Straw 1996). No recent records of the species in the Bay exist, nevertheless the species may occasionally feed and roost at Penrhyn Estuary.

Predicted key impacts from the proposal on this species comprise disturbance to feeding and roosting from a change in lighting regime, increased noise and vibration (human and machinery) from the construction and operation of the port (and associated infrastructure such as railway lines) and potential entry/exit psychological flyway barrier due to the enclosure of Penrhyn Estuary. Disturbance issues are discussed below and are based on the author's general knowledge of shorebirds in New South Wales estuaries and from a desktop literature review of shorebird disturbance studies and other generalist bird studies (Paton et al 2000; Burger 1991; Goss-Custard and Verboven 1993; Smit and Visser 1993; Goss-Custard *et al* 1982; Goss-Custard 1980; Lawler 1996; Roberts and Evans 1993; Batten 1977; Straw 1996; Nelson 1994; Metcalfe and Furness 1984; Weston *et al* 2000).

There is little quantified and experimental assessment of the effects of disturbance to waterbirds and little understanding of the extent of such impacts. Disturbance is defined as a disruption to normal activity patterns. Disturbances to waders may vary in their intensity, frequency, duration, coverage and predictability and there is often inter-specific and intra-specific variation in susceptibility of birds to disturbance which is likely to vary with age, season, weather, location and the degree of habituation to disturbance. There are two potential consequences of sustained, localised disturbance to migratory waders, these being birds may have to shift to alternative, perhaps less favourable feeding grounds and secondly may have their feeding rate reduced by having to devote time to vigilance and anti-predator behaviour. Disturbed shorebirds may spend less time foraging whilst increasing energy-expending behaviours such as fleeing (running, flying). It has also been suggested that migratory birds may be more prone to disturbance than non-migratory species as they are only present in a particular area for part of the year and so have little opportunity to become habituated to the disturbance.

Waders preferably forage in areas where prey density, prey availability and intake rates are relatively high and where energy expenditure is low. Shorebird densities, therefore, tend to reach a maximum in the most preferred feeding areas (Penrhyn Estuary for this species) and where disturbances force birds to shift to alternative feeding areas, questions arise as to whether such areas are adequate, whether they can accommodate displaced individuals and what effect increased bird density has on intake rates and the fitness of those birds that move. As bird density increases,

average intake rates decline in many species as a result of increased competition, increased prey depletion and a greater proportion of the population feeding in sub-optimal areas. Where populations are limited, or are close to limitation by the quality and availability of habitat (such as for this species in Penrhyn Estuary and in Botany Bay estuary in total), disturbance can have a negative impact on wader populations by affecting fitness, ability to fatten adequately during pre-migratory periods and increased mortality.

Some studies that have attempted to experimentally asses the impact of disturbance on waterbirds have predominantly used the bird’s flight response as an index of disturbance whilst others have only crudely estimated alert distances. In such studies, a disturbance is introduced and the distance of the birds from the disturbance at the point of flight is measured. Buffer distances given for many shorebirds as part of past studies are in the order of 100-400 metres.

Many foraging migratory waders are often disrupted from their typical behaviour well before a flight response is elicited with some birds shown to be alerted at distances on average 30-95% greater than those at which they take flight. Following detection of a disturbance the bird may spend time assessing the degree of threat it is under and may balance the risk with the benefits of continued foraging or roosting. As discussed above, this may be particularly significant to migratory shorebirds during the pre-migratory period of fat accumulation (and post migratory period of recuperation and moulting) where an increase in food requirements during this period results in waders trying to maximise their net rate of resource acquisition and thus invest more time in foraging at the expense of vigilance and anti-predator behaviour. This is particularly significant for shorebirds whose feeding times are regulated by tidal flow (and even more significant for small billed waders such as plovers and stints where foraging areas are further limited by amount of intertidal area not covered with water at low tide). Frequent and intense disturbance is likely to affect wader behaviour and reduce the time they spend foraging. Reductions in feeding may then affect the capacity of waders to fatten at an adequate rate and therefore prolong the pre-migratory feeding period and departure delay. Such delays in migration departure from wintering grounds can seriously affect breeding success of migratory birds, where individuals arriving late at the summer breeding grounds may be at a disadvantage in the competition for mates and territories.

A change in lighting regime (predicted increase in ambient lighting at night) in Penrhyn Estuary may result in an increase in vigilant behaviour (area scans) at the expense of foraging as many shorebirds, particularly those that have been observed to forage nocturnally in “relatively dark” areas (such as sand plovers), may feel that they are more visible to potential predators (feral dogs, cats, birds of prey). Increased ambient lighting and flashes of light from railway lines may result in the displacement of the shorebirds to sub-optimal (less preferred) habitat elsewhere in the estuary.

The current design essentially encloses Penrhyn Estuary and thus may represent a psychological entry/exit flyway barrier into and out of the shorebird feeding and roosting habitat at the Estuary. Despite their physical capabilities, waders are very

reluctant to enter an area that does not have an open aspect (mainly to enable them to have a clear view of potential predators). Based on both the observed current flyways of the shorebirds into and out of the Estuary and on standard wader flyway behaviour, waders currently utilising Penrhyn Estuary fly into the area either from the south over water or from the west by flying south around the runways and turning north-east into the Estuary over water. Based on casual recent and historical URS observations over the years at the site and on discussions with Geoff Ross (NPWS), Phil Straw (Avifauna Research) and local bird naturalists, waders have not been observed flying over docks or runways to or from the Estuary (whereas other suite of bird strike species such as gulls regularly do).

Exclusion fencing, public access restriction to Penrhyn Estuary and boat ramp relocation associated with the proposal may minimise part of the human disturbance element to shorebirds. Shorebirds are often seen at Penryhn Estuary fleeing from roosting on the sandy point on the Penrhyn Road side of the channel to the sandy foothill of the dune on the opposite side of the channel (pers. obs.).

Discussions with Doug Watkins at Wetlands International (Environment Australia) indicate that Yatsu-Higata a landlocked RAMSAR wetland in Tokyo Bay (surrounded by industrial development) Japan is reportedly being used by a number of migratory waders for part of their life cycle requirements. Watins indicated that the waders roost at the site and may also feed there at a later stage in a flood tide (that is, when the tide is coming in) when their primary feeding habitat (exposed mudflats elsewhere in the Bay) is flooded. Watkins indicated that the waders are flying over industrialised land because of the absence of any other suitable roost sites in the Bay (as a result of 80-90% of the Bay being reclaimed). This would suggest that some waders at Penrhyn Estuary may fly into the Estuary over the operational docks or negotiate along the 130 metre wide channel parallel to Foreshore Beach particularly if they are forced to due to a lack of remaining suitable habitat in the Bay. The waders would not be expected to have any difficulty in negotiating over the proposed road and rail bridges.

The other key potential impact to consider is the effect of any hydrological changes to the Estuary which may result in changes to shorebird feeding and roosting habitat. Hydrodynamic modelling studies of Penrhyn Estuary are currently being undertaken although the results of these studies are not yet complete or available for review. Nevertheless, SPC have indicated that no significant change in tidal regime, water levels and elevation profiles of the sand and mudflats are predicted to occur at Penrhyn Estuary (pers. comm., SPC). SPC also note that no hydrodynamic changes to other important shorebird habitat areas in the Bay (Towra Point, Taren and Shell Points) are predicted to occur (pers. comm., SPC).

The proposal will also result in the loss of remaining areas of shorebird foraging habitat on Foreshore Beach. The predicted impact on shorebirds however is considered to be negligible due to the volume of pedestrian traffic and dog walking on the beach (disturbance issue) and due to the increased beach erosion and resulting steepness in the elevation profile which has drastically reduced the suitableness of the bird habitat in this area (less intertidal flats on neap tides).

(b) *in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.*

Not Applicable

(c) *in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.*

The proposal may result in a significant modification to shorebird habitat and behaviour at Penryhn Estuary, considered to be an important shorebird habitat for the species on a local and regional basis.

It should be noted that few nocturnal shorebird surveys in the Botany Bay estuary have been undertaken to date and thus data on nocturnal feeding and roosting habitat for shorebirds is not yet available. Nocturnal feeding is just as important (sometimes more important) than diurnal feeding for shorebirds and should not be underestimated in terms of a species life cycle requirements.

(d) *whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community*

The proposal may result in the isolation of shorebird feeding and roosting habitat at Penrhyn Estuary from other known roost sites on the southern shores of the Bay and from general Bay wide bird movements which are undertaken over water.

(e) *whether critical habitat will be affected.*

The study area is not listed as critical habitat under Part 3 Division 1 of the Threatened Species Conservation Act 1995.

(f) *whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.*

No resident or migratory shorebirds in NSW are considered to be adequately conserved due to the unique location of their intertidal habitat. Smith (1991) notes that reservation of wader habitat on intertidal lands has posed a particular problem for NPWS as few coastal reserves include any areas below the high water mark which are generally Crown land. There has been some success, however, in establishing aquatic reserves in NSW such as the Towra Point Aquatic Reserve adjacent to Towra Point Nature Reserve in the Botany Bay estuary which supports important habitat for many waders such as the Eastern Curlew and Whimbrel. Kooragang Nature Reserve in the Hunter estuary is one of the few present examples within an extensive representation of intertidal wader feeding grounds. This species is regularly recorded in relatively high numbers in the Hunter estuary.

(g) *whether the development or activity proposed is of a class of development or activity that is recognised as a threatening processes.*

Not Applicable

(h) *whether any threatened species, populations or ecological community is at the limit of its known distribution*

This species is occasionally recorded in some estuaries on the north and south NSW coasts (including the Hunter and Shoalhaven) and is thus not considered to be at its limit of distribution in the Botany Bay estuary.

Section 5A Assessment Conclusion

Given that the proposal presently represents potential significant impacts on shorebird habitat at Penrhyn Estuary and given that many of the impacts (particularly those relating to disturbance) are difficult to predict, the precautionary approach must therefore be taken and thus the preparation of a Species Impact Statement for the species is required.

Should the development proceed, and should the proposed enhancement of shorebird habitat at Penrhyn Estuary not prove feasible, off-site enhancement of existing shorebird habitat elsewhere in Botany Bay (such as H1 lands at Woolooware Bay) should be considered. Proposed enhancement of shorebird habitat at Penrhyn Estuary will be addressed in the SIS for the proposal.

Tringa stagnatilis (Marsh Sandpiper)

(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

This species presently feeds and roosts in the Hawkesbury Swamps and at the waterbird refuge at Homebush and Newington Wetlands in the Parramatta River estuary in relatively low numbers (up to 17 birds have been recorded in the Hawkesbury Swamps). No recent records exist for this species in the Bay. One historical record for this species in the Bay was identified (in 1983 at the old mouth of the Cooks River). This species may feed on estuarine mudflats at Penrhyn Estuary on an occasional basis.

Predicted key impacts from the proposal on this species comprise disturbance to feeding and roosting from a change in lighting regime, increased noise and vibration (human and machinery) from the construction and operation of the port (and associated infrastructure such as railway lines) and potential entry/exit psychological flyway barrier due to the enclosure of Penrhyn Estuary. Disturbance issues are discussed below and are based on the author's general knowledge of shorebirds in New South Wales estuaries and from a desktop literature review of shorebird disturbance studies and other generalist bird studies (Paton et al 2000; Burger 1991; Goss-Custard and Verboven 1993; Smit and Visser 1993; Goss-Custard *et al* 1982; Goss-Custard 1980; Lawler 1996; Roberts and Evans 1993; Batten 1977; Straw 1996; Nelson 1994; Metcalfe and Furness 1984; Weston *et al* 2000).

There is little quantified and experimental assessment of the effects of disturbance to waterbirds and little understanding of the extent of such impacts. Disturbance is defined as a disruption to normal activity patterns. Disturbances to waders may vary in their intensity, frequency, duration, coverage and predictability and there is often inter-specific and intra-specific variation in susceptibility of birds to disturbance which is likely to vary with age, season, weather, location and the degree of habituation to disturbance. There are two potential consequences of sustained, localised disturbance to migratory waders, these being birds may have to shift to alternative, perhaps less favourable feeding grounds and secondly may have their feeding rate reduced by having to devote time to vigilance and anti-predator behaviour. Disturbed shorebirds may spend less time foraging whilst increasing energy-expending behaviours such as fleeing (running, flying). It has also been suggested that migratory birds may be more prone to disturbance than non-migratory species as they are only present in a particular area for part of the year and so have little opportunity to become habituated to the disturbance.

Waders preferably forage in areas where prey density, prey availability and intake rates are relatively high and where energy expenditure is low. Shorebird densities, therefore, tend to reach a maximum in the most preferred feeding areas and where disturbances force birds to shift to alternative feeding areas, questions arise as to whether such areas are adequate, whether they can accommodate displaced individuals and what effect increased bird density has on intake rates and the fitness of those birds that move. As bird density increases, average intake rates decline in many species as a result of increased competition, increased prey depletion and a greater proportion of the population feeding in sub-optimal areas. Where populations are limited, or are close to limitation by the quality and availability of habitat (such as for this species in Penrhyn Estuary and in Botany Bay estuary in total), disturbance can have a negative impact on wader populations by affecting fitness, ability to fatten adequately during pre-migratory periods and increased mortality.

Some studies that have attempted to experimentally asses the impact of disturbance on waterbirds have predominantly used the bird's flight response as an index of disturbance whilst others have only crudely estimated alert distances. In such studies, a disturbance is introduced and the distance of the birds from the disturbance at the point of flight is measured. Buffer distances given for many shorebirds as part of past studies are in the order of 100-400 metres.

Many foraging migratory waders are often disrupted from their typical behaviour well before a flight response is elicited with some birds shown to be alerted at distances on average 30-95% greater than those at which they take flight. Following detection of a disturbance the bird may spend time assessing the degree of threat it is under and may balance the risk with the benefits of continued foraging or roosting. As discussed above, this may be particularly significant to migratory shorebirds during the pre-migratory period of fat accumulation (and post migratory period of recuperation and moulting) where an increase in food requirements during this period results in waders trying to maximise their net rate of resource acquisition and thus invest more time in foraging at the expense of vigilance and anti-predator behaviour. This is particularly significant for shorebirds whose feeding times are regulated by tidal flow (and even more significant for small billed waders such as plovers and stints where foraging areas are further limited by amount of intertidal area not covered with water at low tide). Frequent and intense disturbance is likely to affect wader behaviour and reduce the time they spend foraging. Reductions in feeding may then affect the capacity of waders to fatten at an adequate rate and therefore prolong the pre-migratory feeding period and departure delay. Such delays in migration departure from wintering grounds can seriously affect breeding success of migratory birds, where individuals arriving late at the summer breeding grounds may be at a disadvantage in the competition for mates and territories.

A change in lighting regime (predicted increase in ambient lighting at night) in Penrhyn Estuary may result in an increase in vigilant behaviour (area scans) at the expense of foraging as many shorebirds, particularly those that have been observed to forage nocturnally in "relatively dark" areas (such as sand plovers), may feel that they are more visible to potential predators (feral dogs, cats, birds of prey). Increased ambient lighting and flashes of light from railway lines may result in the displacement of the shorebirds to sub-optimal (less preferred) habitat elsewhere in the Botany Bay estuary, such as Boat Harbour and Taren Point.

The current design essentially encloses Penrhyn Estuary and thus may represent a psychological entry/exit flyway barrier into and out of the shorebird feeding and roosting habitat at the Estuary. Despite their physical capabilities, waders are very reluctant to enter an area that does not have an open aspect (mainly to enable them to have a clear view of potential predators). Based on both the observed current flyways of the shorebirds into and out of the Estuary and on standard wader flyway behaviour, waders currently utilising Penrhyn Estuary fly into the area either from the south over water or from the west by flying south around the runways and turning north-east into the Estuary over water. Based on casual recent and historical URS observations over the years at the site and on discussions with Geoff Ross (NPWS), Phil Straw (Avifauna Research) and local bird naturalists, waders have not been observed flying over docks or runways to or from the Estuary (whereas other suite of bird strike species such as gulls regularly do).

Exclusion fencing, public access restriction to Penrhyn Estuary and boat ramp relocation associated with the proposal may minimise part of the human disturbance element to shorebirds. Shorebirds are often seen at Penryhn Estuary fleeing from roosting on the sandy point on the Penrhyn Road side of the channel to the sandy foothill of the dune on the opposite side of the channel (pers. obs.).

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The other key potential impact to consider is the effect of any hydrological changes to the Estuary which may result in changes to shorebird feeding and roosting habitat. Hydrodynamic modelling studies of Penrhyn Estuary are currently being undertaken although the results of these studies are not yet complete or available for review. Nevertheless, SPC have indicated that no significant change in tidal regime, water levels and elevation profiles of the sand and mudflats are predicted to occur at Penrhyn Estuary (pers. comm., SPC). SPC also note that no hydrodynamic changes to other important shorebird habitat areas in the Bay (Towra Point, Taren and Shell Points) are predicted to occur (pers. comm., SPC).

The proposal will also result in the loss of remaining areas of shorebird foraging habitat on Foreshore Beach. The predicted impact on shorebirds however is considered to be negligible due to the volume of pedestrian traffic and dog walking

on the beach (disturbance issue) and due to the increased beach erosion and resulting steepness in the elevation profile which has drastically reduced the suitableness of the bird habitat in this area (less intertidal flats on neap tides).

(b) *in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.*

Not Applicable

(c) *in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.*

The proposal may result in a significant modification to shorebird habitat and behaviour at Penryhn Estuary, considered to be an important shorebird habitat for the species on a local and regional basis.

It should be noted that few nocturnal shorebird surveys in the Botany Bay estuary have been undertaken to date and thus data on nocturnal feeding and roosting habitat for shorebirds is not yet available. Nocturnal feeding is just as important (sometimes more important) than diurnal feeding for shorebirds and should not be underestimated in terms of a species life cycle requirements.

(d) *whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community*

The proposal may result in the isolation of shorebird feeding and roosting habitat at Penrhyn Estuary from other known roost sites on the southern shores of the Bay and from general Bay wide bird movements which are undertaken over water.

(e) *whether critical habitat will be affected.*

The study area is not listed as critical habitat under Part 3 Division 1 of the Threatened Species Conservation Act 1995.

(f) *whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.*

No resident or migratory shorebirds in NSW are considered to be adequately conserved due to the unique location of their intertidal habitat. Smith (1991) notes that reservation of wader habitat on intertidal lands has posed a particular problem for NPWS as few coastal reserves include any areas below the high water mark which are generally Crown land. There has been some success, however, in establishing aquatic reserves in NSW such as the Towra Point Aquatic Reserve adjacent to Towra Point Nature Reserve in the Botany Bay estuary which supports important habitat for many waders such as the Eastern Curlew and Whimbrel. Kooragang Nature Reserve in the Hunter estuary is one of the few present examples within an extensive representation of intertidal wader feeding grounds. This species is regularly recorded in relatively high numbers in the Hunter estuary.

(g) *whether the development or activity proposed is of a class of development or activity that is recognised as a threatening processes.*

Not Applicable

(h) *whether any threatened species, populations or ecological community is at the limit of its known distribution*

This species is regularly recorded in many estuaries on the north and south NSW coasts as well as inland and is thus not considered to be at its limit of distribution in the Botany Bay estuary.

Section 5A Assessment Conclusion

Given that the proposal presently represents potential significant impacts on shorebird habitat at Penrhyn Estuary and given that many of the impacts (particularly those relating to disturbance) are difficult to predict, the precautionary approach must therefore be taken and thus the preparation of a Species Impact Statement for the species is required.

Should the development proceed, and should the proposed enhancement of shorebird habitat at Penrhyn Estuary not prove feasible, off-site enhancement of existing shorebird habitat elsewhere in Botany Bay (such as H1 lands at Woolooware Bay) should be considered. Proposed enhancement of shorebird habitat at Penrhyn Estuary will be addressed in the SIS for the proposal.

Calidris canutus (Red Knot)

(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

This species presently feeds on intertidal sand and mudflats (tactile probing) at Penrhyn Estuary and at Rocky Point and roosts at Penrhyn Estuary (typically in association with the godwits). Six individuals of the species have been recorded feeding on bivalve molluscs at H1 lands in Woolooware Bay on the southern shores of the Bay (pers. com., Phil Straw). Up to about 200 individuals of the species may be present in the bay in present times.

Predicted key impacts from the proposal on this species comprise disturbance to feeding and roosting from a change in lighting regime, increased noise and vibration (human and machinery) from the construction and operation of the port (and associated infrastructure such as railway lines) and potential entry/exit psychological flyway barrier due to the enclosure of Penrhyn Estuary. Disturbance issues are discussed below and are based on the author's general knowledge of shorebirds in New South Wales estuaries and from a desktop literature review of shorebird disturbance studies and other generalist bird studies (Paton et al 2000; Burger 1991; Goss-Custard and Verboven 1993; Smit and Visser 1993; Goss-Custard *et al* 1982; Goss-Custard 1980; Lawler 1996; Roberts and Evans 1993; Batten 1977; Straw 1996; Nelson 1994; Metcalfe and Furness 1984; Weston *et al* 2000).

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Waders preferably forage in areas where prey density, prey availability and intake rates are relatively high and where energy expenditure is low. Shorebird densities, therefore, tend to reach a maximum in the most preferred feeding areas (Penrhyn Estuary for this species) and where disturbances force birds to shift to alternative feeding areas, questions arise as to whether such areas are adequate, whether they can accommodate displaced individuals and what effect increased bird density has on intake rates and the fitness of those birds that move. As bird density increases, average intake rates decline in many species as a result of increased competition, increased prey depletion and a greater proportion of the population feeding in sub-optimal areas. Where populations are limited, or are close to limitation by the quality and availability of habitat (such as for this species in Penrhyn Estuary and in Botany Bay estuary in total), disturbance can have a negative impact on wader populations by affecting fitness, ability to fatten adequately during pre-migratory periods and increased mortality.

Some studies that have attempted to experimentally asses the impact of disturbance on waterbirds have predominantly used the bird’s flight response as an index of disturbance whilst others have only crudely estimated alert distances. In such studies, a disturbance is introduced and the distance of the birds from the disturbance at the point of flight is measured. Buffer distances given for many shorebirds as part of past studies are in the order of 100-400 metres.

Many foraging migratory waders are often disrupted from their typical behaviour well before a flight response is elicited with some birds shown to be alerted at distances on average 30-95% greater than those at which they take flight. Following detection of a disturbance the bird may spend time assessing the degree of threat it is under and may balance the risk with the benefits of continued foraging or roosting. As discussed above, this may be particularly significant to migratory shorebirds during the pre-migratory period of fat accumulation (and post migratory period of recuperation and moulting) where an increase in food requirements during this period results in waders trying to maximise their net rate of resource acquisition and thus invest more time in foraging at the expense of vigilance and anti-predator behaviour. This is particularly significant for shorebirds whose feeding times are regulated by tidal flow (and even more significant for small billed waders such as plovers and stints where foraging areas are further limited by amount of intertidal area not covered with water at low tide). Frequent and intense disturbance is likely to affect wader behaviour and reduce the time they spend foraging. Reductions in feeding may then affect the capacity of waders to fatten at an adequate rate and therefore prolong the pre-migratory feeding period and departure delay. Such delays in migration departure from wintering grounds can seriously affect breeding success of migratory birds, where individuals arriving late at the summer breeding grounds may be at a disadvantage in the competition for mates and territories.

A change in lighting regime (predicted increase in ambient lighting at night) in Penrhyn Estuary may result in an increase in vigilant behaviour (area scans) at the expense of foraging as many shorebirds, particularly those that have been observed to forage nocturnally in “relatively dark” areas (such as sand plovers), may feel that they are more visible to potential predators (feral dogs, cats, birds of prey). Increased ambient lighting and flashes of light from railway lines may result in the displacement of the shorebirds to sub-optimal (less preferred) habitat elsewhere in the Botany Bay estuary, such as Boat Harbour and Taren Point.

The current design essentially encloses Penrhyn Estuary and thus may represent a psychological entry/exit flyway barrier into and out of the shorebird feeding and

roosting habitat at the Estuary. Despite their physical capabilities, waders are very reluctant to enter an area that does not have an open aspect (mainly to enable them to have a clear view of potential predators). Based on both the observed current flyways of the shorebirds into and out of the Estuary and on standard wader flyway behaviour, waders currently utilising Penrhyn Estuary fly into the area either from the south over water or from the west by flying south around the runways and turning north-east into the Estuary over water. Based on casual recent and historical URS observations over the years at the site and on discussions with Geoff Ross (NPWS), Phil Straw (Avifauna Research) and local bird naturalists, waders have not been observed flying over docks or runways to or from the Estuary (whereas other suite of bird strike species such as gulls regularly do).

Exclusion fencing, public access restriction to Penrhyn Estuary and boat ramp relocation associated with the proposal may minimise part of the human disturbance element to shorebirds. Shorebirds are often seen at Penryhn Estuary fleeing from roosting on the sandy point on the Penrhyn Road side of the channel to the sandy foothill of the dune on the opposite side of the channel (pers. obs.).

Discussions with Doug Watkins at Wetlands International (Environment Australia) indicate that Yatsu-Higata a landlocked RAMSAR wetland in Tokyo Bay (surrounded by industrial development) Japan is reportedly being used by a number of migratory waders for part of their life cycle requirements. Watkins indicated that the waders roost at the site and may also feed there at a later stage in a flood tide (that is, when the tide is coming in) when their primary feeding habitat (exposed mudflats elsewhere in the Bay) is flooded. Watkins indicated that the waders are flying over industrialised land because of the absence of any other suitable roost sites in the Bay (as a result of 80-90% of the Bay being reclaimed). This would suggest that some waders at Penrhyn Estuary may fly into the Estuary over the operational docks or negotiate along the 130 metre wide channel parallel to Foreshore Beach particularly if they are forced to due to a lack of remaining suitable habitat in the Bay. The waders would not be expected to have any difficulty in negotiating over the proposed road and rail bridges.

The other key potential impact to consider is the effect of any hydrological changes to the Estuary which may result in changes to shorebird feeding and roosting habitat. Hydrodynamic modelling studies of Penrhyn Estuary are currently being undertaken although the results of these studies are not yet complete or available for review. Nevertheless, SPC have indicated that no significant change in tidal regime, water levels and elevation profiles of the sand and mudflats are predicted to occur at Penrhyn Estuary (pers. comm., SPC). SPC also note that no hydrodynamic changes to other important shorebird habitat areas in the Bay (Towra Point, Taren and Shell Points) are predicted to occur (pers. comm., SPC).

The proposal will also result in the loss of remaining areas of shorebird foraging habitat on Foreshore Beach. The predicted impact on shorebirds however is considered to be negligible due to the volume of pedestrian traffic and dog walking on the beach (disturbance issue) and due to the increased beach erosion and

resulting steepness in the elevation profile which has drastically reduced the suitableness of the bird habitat in this area (less intertidal flats on neap tides).

(b) *in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.*

Not Applicable

(c) *in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.*

The proposal may result in a significant modification to shorebird habitat and behaviour at Penryhn Estuary, considered to be an important shorebird habitat for the species on a local and regional basis.

It should be noted that few nocturnal shorebird surveys in the Botany Bay estuary have been undertaken to date and thus data on nocturnal feeding and roosting habitat for shorebirds is not yet available. Nocturnal feeding is just as important (sometimes more important) than diurnal feeding for shorebirds and should not be underestimated in terms of a species life cycle requirements.

(d) *whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community*

The proposal may result in the isolation of shorebird feeding and roosting habitat at Penrhyn Estuary from other known roost sites on the southern shores of the Bay and from general Bay wide bird movements which are undertaken over water.

(e) *whether critical habitat will be affected.*

The study area is not listed as critical habitat under Part 3 Division 1 of the Threatened Species Conservation Act 1995.

(f) *whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.*

No resident or migratory shorebirds in NSW are considered to be adequately conserved due to the unique location of their intertidal habitat. Smith (1991) notes that reservation of wader habitat on intertidal lands has posed a particular problem for NPWS as few coastal reserves include any areas below the high water mark which are generally Crown land. There has been some success, however, in establishing aquatic reserves in NSW such as the Towra Point Aquatic Reserve adjacent to Towra Point Nature Reserve in the Botany Bay estuary which supports important habitat for many waders such as the Eastern Curlew and Whimbrel. Kooragang Nature Reserve in the Hunter estuary is one of the few present examples within an extensive representation of intertidal wader feeding grounds. This species is regularly recorded in relatively high numbers in the Hunter estuary.

(g) *whether the development or activity proposed is of a class of development or activity that is recognised as a threatening processes.*

Not Applicable

(h) *whether any threatened species, populations or ecological community is at the limit of its known distribution*

This species is regularly recorded in many estuaries on the north and south NSW coasts as well as inland and is thus not considered to be at its limit of distribution in the Botany Bay estuary.

Section 5A Assessment Conclusion

Given that the proposal presently represents potential significant impacts on shorebird habitat at Penrhyn Estuary and given that many of the impacts (particularly those relating to disturbance) are difficult to predict, the precautionary approach must therefore be taken and thus the preparation of a Species Impact Statement for the species is required.

Should the development proceed, and should the proposed enhancement of shorebird habitat at Penrhyn Estuary not prove feasible, off-site enhancement of existing shorebird habitat elsewhere in Botany Bay (such as H1 lands at Woolooware Bay) should be considered. Proposed enhancement of shorebird habitat at Penrhyn Estuary will be addressed in the SIS for the proposal.

Calidris ruficollis (Red-necked Stint)

(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

This species presently feeds and roosts at Penrhyn Estuary and occasionally at Boat Harbour and Spit Island. The species also roosts on barges at Shell Point which demonstrates the general lack of adequate high tide roosts for shorebirds utilising the Bay. Straw (1996) notes that the birds roosting at Boatharbour are likely a result of the displacement of these birds from Penrhyn Estuary due to disturbance in the area. The species used to roost on the end of the original runway but this habitat has since been removed. Numbers of this species in the Bay have markedly declined from several hundred (1940s – 1980s) to about 50-100 on average during the summer period based on recent counts.

Predicted key impacts from the proposal on this species comprise disturbance to feeding and roosting from a change in lighting regime, increased noise and vibration (human and machinery) from the construction and operation of the port (and associated infrastructure such as railway lines) and potential entry/exit psychological flyway barrier due to the enclosure of Penrhyn Estuary. Disturbance issues are discussed below and are based on the author’s general knowledge of shorebirds in New South Wales estuaries and from a desktop literature review of shorebird disturbance studies and other generalist bird studies (Paton et al 2000; Burger 1991; Goss-Custard and Verboven 1993; Smit and Visser 1993; Goss-Custard *et al* 1982; Goss-Custard 1980; Lawler 1996; Roberts and Evans 1993; Batten 1977; Straw 1996; Nelson 1994; Metcalfe and Furness 1984; Weston *et al* 2000).

There is little quantified and experimental assessment of the effects of disturbance to waterbirds and little understanding of the extent of such impacts. Disturbance is defined as a disruption to normal activity patterns. Disturbances to waders may vary in their intensity, frequency, duration, coverage and predictability and there is often inter-specific and intra-specific variation in susceptibility of birds to disturbance which is likely to vary with age, season, weather, location and the degree of habituation to disturbance. There are two potential consequences of sustained, localised disturbance to migratory waders, these being birds may have to shift to alternative, perhaps less favourable feeding grounds and secondly may have their feeding rate reduced by having to devote time to vigilance and anti-predator behaviour. Disturbed shorebirds may spend less time foraging whilst increasing energy-expending behaviours such as fleeing (running, flying). It has also been suggested that migratory birds may be more prone to disturbance than non-migratory species as they are only present in a particular area for part of the year and so have little opportunity to become habituated to the disturbance.

Waders preferably forage in areas where prey density, prey availability and intake rates are relatively high and where energy expenditure is low. Shorebird densities, therefore, tend to reach a maximum in the most preferred feeding areas (Penrhyn

Estuary for this species) and where disturbances force birds to shift to alternative feeding areas, questions arise as to whether such areas are adequate, whether they can accommodate displaced individuals and what effect increased bird density has on intake rates and the fitness of those birds that move. As bird density increases, average intake rates decline in many species as a result of increased competition, increased prey depletion and a greater proportion of the population feeding in sub-optimal areas. Where populations are limited, or are close to limitation by the quality and availability of habitat (such as for this species in Penrhyn Estuary and in Botany Bay estuary in total), disturbance can have a negative impact on wader populations by affecting fitness, ability to fatten adequately during pre-migratory periods and increased mortality.

Some studies that have attempted to experimentally asses the impact of disturbance on waterbirds have predominantly used the bird's flight response as an index of disturbance whilst others have only crudely estimated alert distances. In such studies, a disturbance is introduced and the distance of the birds from the disturbance at the point of flight is measured. Buffer distances given for many shorebirds as part of past studies are in the order of 100-400 metres.

Many foraging migratory waders are often disrupted from their typical behaviour well before a flight response is elicited with some birds shown to be alerted at distances on average 30-95% greater than those at which they take flight. Following detection of a disturbance the bird may spend time assessing the degree of threat it is under and may balance the risk with the benefits of continued foraging or roosting. As discussed above, this may be particularly significant to migratory shorebirds during the pre-migratory period of fat accumulation (and post migratory period of recuperation and moulting) where an increase in food requirements during this period results in waders trying to maximise their net rate of resource acquisition and thus invest more time in foraging at the expense of vigilance and anti-predator behaviour. This is particularly significant for shorebirds whose feeding times are regulated by tidal flow (and even more significant for small billed waders such as plovers and stints where foraging areas are further limited by amount of intertidal area not covered with water at low tide). Frequent and intense disturbance is likely to affect wader behaviour and reduce the time they spend foraging. Reductions in feeding may then affect the capacity of waders to fatten at an adequate rate and therefore prolong the pre-migratory feeding period and departure delay. Such delays in migration departure from wintering grounds can seriously affect breeding success of migratory birds, where individuals arriving late at the summer breeding grounds may be at a disadvantage in the competition for mates and territories.

A change in lighting regime (predicted increase in ambient lighting at night) in Penrhyn Estuary may result in an increase in vigilant behaviour (area scans) at the expense of foraging as many shorebirds, particularly those that have been observed to forage nocturnally in "relatively dark" areas (such as sand plovers), may feel that they are more visible to potential predators (feral dogs, cats, birds of prey). Increased ambient lighting and flashes of light from railway lines may result in the displacement of the shorebirds to sub-optimal (less preferred) habitat elsewhere in the Botany Bay estuary, such as Boat Harbour.

The current design essentially encloses Penrhyn Estuary and thus may represent a psychological entry/exit flyway barrier into and out of the shorebird feeding and roosting habitat at the Estuary. Despite their physical capabilities, waders are very reluctant to enter an area that does not have an open aspect (mainly to enable them to have a clear view of potential predators). Based on both the observed current flyways of the shorebirds into and out of the Estuary and on standard wader flyway behaviour, waders currently utilising Penrhyn Estuary fly into the area either from the south over water or from the west by flying south around the runways and turning north-east into the Estuary over water. Based on casual recent and historical URS observations over the years at the site and on discussions with Geoff Ross (NPWS), Phil Straw (Avifauna Research) and local bird naturalists, waders have not been observed flying over docks or runways to or from the Estuary (whereas other suite of bird strike species such as gulls regularly do).

Exclusion fencing, public access restriction to Penrhyn Estuary and boat ramp relocation associated with the proposal may minimise part of the human disturbance element to shorebirds. Shorebirds are often seen at Penryhn Estuary fleeing from roosting on the sandy point on the Penrhyn Road side of the channel to the sandy foothill of the dune on the opposite side of the channel (pers. obs.).

Discussions with Doug Watkins at Wetlands International (Environment Australia) indicate that Yatsu-Higata a landlocked RAMSAR wetland in Tokyo Bay (surrounded by industrial development) Japan is reportedly being used by a number of migratory waders for part of their life cycle requirements. Watkins indicated that the waders roost at the site and may also feed there at a later stage in a flood tide (that is, when the tide is coming in) when their primary feeding habitat (exposed mudflats elsewhere in the Bay) is flooded. Watkins indicated that the waders are flying over industrialised land because of the absence of any other suitable roost sites in the Bay (as a result of 80-90% of the Bay being reclaimed). This would suggest that some waders at Penrhyn Estuary may fly into the Estuary over the operational docks or negotiate along the 130 metre wide channel parallel to Foreshore Beach particularly if they are forced to due to a lack of remaining suitable habitat in the Bay. The waders would not be expected to have any difficulty in negotiating over the proposed road and rail bridges.

The other key potential impact to consider is the effect of any hydrological changes to the Estuary which may result in changes to shorebird feeding and roosting habitat. Hydrodynamic modelling studies of Penrhyn Estuary are currently being undertaken although the results of these studies are not yet complete or available for review. Nevertheless, SPC have indicated that no significant change in tidal regime, water levels and elevation profiles of the sand and mudflats are predicted to occur at Penrhyn Estuary (pers. comm., SPC). SPC also note that no hydrodynamic changes to other important shorebird habitat areas in the Bay (Towra Point, Taren and Shell Points) are predicted to occur (pers. comm., SPC).

The proposal will also result in the loss of remaining areas of shorebird foraging habitat on Foreshore Beach. The predicted impact on shorebirds however is considered to be negligible due to the volume of pedestrian traffic and dog walking

on the beach (disturbance issue) and due to the increased beach erosion and resulting steepness in the elevation profile which has drastically reduced the suitableness of the bird habitat in this area (less intertidal flats on neap tides).

(b) *in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.*

Not Applicable

(c) *in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.*

The proposal may result in a significant modification to shorebird habitat and behaviour at Penryhn Estuary, considered to be an important shorebird habitat for the species on a local and regional basis.

It should be noted that few nocturnal shorebird surveys in the Botany Bay estuary have been undertaken to date and thus data on nocturnal feeding and roosting habitat for shorebirds is not yet available. Nocturnal feeding is just as important (sometimes more important) than diurnal feeding for shorebirds and should not be underestimated in terms of a species life cycle requirements.

(d) *whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community*

The proposal may result in the isolation of shorebird feeding and roosting habitat at Penrhyn Estuary from other known roost sites on the southern shores of the Bay and from general Bay wide bird movements which are undertaken over water.

(e) *whether critical habitat will be affected.*

The study area is not listed as critical habitat under Part 3 Division 1 of the Threatened Species Conservation Act 1995.

(f) *whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.*

No resident or migratory shorebirds in NSW are considered to be adequately conserved due to the unique location of their intertidal habitat. Smith (1991) notes that reservation of wader habitat on intertidal lands has posed a particular problem for NPWS as few coastal reserves include any areas below the high water mark which are generally Crown land. There has been some success, however, in establishing aquatic reserves in NSW such as the Towra Point Aquatic Reserve adjacent to Towra Point Nature Reserve in the Botany Bay estuary which supports important habitat for many waders such as the Eastern Curlew and Whimbrel. Kooragang Nature Reserve in the Hunter estuary is one of the few present examples

within an extensive representation of intertidal wader feeding grounds. This species is regularly recorded in relatively high numbers in the Hunter estuary.

(g) *whether the development or activity proposed is of a class of development or activity that is recognised as a threatening processes.*

Not Applicable

(h) *whether any threatened species, populations or ecological community is at the limit of its known distribution*

This species is regularly recorded in many estuaries on the north and south NSW coasts as well as inland and is thus not considered to be at its limit of distribution in the Botany Bay estuary.

Section 5A Assessment Conclusion

Given that the proposal presently represents potential significant impacts on shorebird habitat at Penrhyn Estuary and given that many of the impacts (particularly those relating to disturbance) are difficult to predict, the precautionary approach must therefore be taken and thus the preparation of a Species Impact Statement for the species is required.

Should the development proceed, and should the proposed enhancement of shorebird habitat at Penrhyn Estuary not prove feasible, off-site enhancement of existing shorebird habitat elsewhere in Botany Bay (such as H1 lands at Woolooware Bay) should be considered. Proposed enhancement of shorebird habitat at Penrhyn Estuary will be addressed in the SIS for the proposal.

Arenaria interpres (Ruddy Turnstone)

(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

This species (about 20 individuals on average in the Bay) presently feeds and roosts on rock platforms at Boat Harbour and also roosts on wooden barges at Shell Point. This species is seldom seen on estuarine mudflats (more often on rocky platforms and ocean beaches) and thus is considered to have a low likelihood of occurrence at Penrhyn (although the occurrence at Penrhyn Estuary for the species remains a possibility).

Predicted key impacts from the proposal on this species comprise disturbance to feeding and roosting from a change in lighting regime, increased noise and vibration (human and machinery) from the construction and operation of the port (and associated infrastructure such as railway lines) and potential entry/exit psychological flyway barrier due to the enclosure of Penrhyn Estuary. Disturbance issues are discussed below and are based on the author’s general knowledge of shorebirds in New South Wales estuaries and from a desktop literature review of shorebird disturbance studies and other generalist bird studies (Paton et al 2000; Burger 1991; Goss-Custard and Verboven 1993; Smit and Visser 1993; Goss-Custard *et al* 1982; Goss-Custard 1980; Lawler 1996; Roberts and Evans 1993; Batten 1977; Straw 1996; Nelson 1994; Metcalfe and Furness 1984; Weston *et al* 2000).

There is little quantified and experimental assessment of the effects of disturbance to waterbirds and little understanding of the extent of such impacts. Disturbance is defined as a disruption to normal activity patterns. Disturbances to waders may vary in their intensity, frequency, duration, coverage and predictability and there is often inter-specific and intra-specific variation in susceptibility of birds to disturbance which is likely to vary with age, season, weather, location and the degree of habituation to disturbance. There are two potential consequences of sustained, localised disturbance to migratory waders, these being birds may have to shift to alternative, perhaps less favourable feeding grounds and secondly may have their feeding rate reduced by having to devote time to vigilance and anti-predator behaviour. Disturbed shorebirds may spend less time foraging whilst increasing energy-expending behaviours such as fleeing (running, flying). It has also been suggested that migratory birds may be more prone to disturbance than non-migratory species as they are only present in a particular area for part of the year and so have little opportunity to become habituated to the disturbance.

Waders preferably forage in areas where prey density, prey availability and intake rates are relatively high and where energy expenditure is low. Shorebird densities, therefore, tend to reach a maximum in the most preferred feeding areas (Boat Harbour for this species) and where disturbances force birds to shift to alternative feeding areas, questions arise as to whether such areas are adequate, whether they can accommodate displaced individuals and what effect increased bird density has on intake rates and the fitness of those birds that move. As bird density increases, average intake rates decline in many species as a result of increased competition, increased prey depletion and a greater proportion of the population feeding in sub-optimal areas. Where populations are limited, or are close to limitation by the quality and availability of habitat, disturbance can have a negative impact on wader populations by affecting fitness, ability to fatten adequately during pre-migratory periods and increased mortality.

Some studies that have attempted to experimentally asses the impact of disturbance on waterbirds have predominantly used the bird's flight response as an index of disturbance whilst others have only crudely estimated alert distances. In such studies, a disturbance is introduced and the distance of the birds from the disturbance at the point of flight is measured. Buffer distances given for many shorebirds as part of past studies are in the order of 100-400 metres.

Many foraging migratory waders are often disrupted from their typical behaviour well before a flight response is elicited with some birds shown to be alerted at distances on average 30-95% greater than those at which they take flight. Following detection of a disturbance the bird may spend time assessing the degree of threat it is under and may balance the risk with the benefits of continued foraging or roosting. As discussed above, this may be particularly significant to migratory shorebirds during the pre-migratory period of fat accumulation (and post migratory period of recuperation and moulting) where an increase in food requirements during this period results in waders trying to maximise their net rate of resource acquisition and thus invest more time in foraging at the expense of vigilance and anti-predator behaviour. This is particularly significant for shorebirds whose feeding times are regulated by tidal flow (and even more significant for small billed waders such as plovers and stints where foraging areas are further limited by amount of intertidal area not covered with water at low tide). Frequent and intense disturbance is likely to affect wader behaviour and reduce the time they spend foraging. Reductions in feeding may then affect the capacity of waders to fatten at an adequate rate and therefore prolong the pre-migratory feeding period and departure delay. Such delays in migration departure from wintering grounds can seriously affect breeding success of migratory birds, where individuals arriving late at the summer breeding grounds may be at a disadvantage in the competition for mates and territories.

A change in lighting regime (predicted increase in ambient lighting at night) in Penrhyn Estuary may result in an increase in vigilant behaviour (area scans) at the expense of foraging as many shorebirds, particularly those that have been observed to forage nocturnally in "relatively dark" areas (such as sand plovers), may feel that they are more visible to potential predators (feral dogs, cats, birds of prey). Increased ambient lighting and flashes of light from railway lines may result in the displacement of the shorebirds to sub-optimal (less preferred) habitat elsewhere in the Botany Bay estuary, such as southern shores of the Bay and possibly at Penrhyn Estuary.

The current design essentially encloses Penrhyn Estuary and thus may represent a psychological entry/exit flyway barrier into and out of the shorebird feeding and

roosting habitat at the Estuary. Despite their physical capabilities, waders are very reluctant to enter an area that does not have an open aspect (mainly to enable them to have a clear view of potential predators). Based on both the observed current flyways of the shorebirds into and out of the Estuary and on standard wader flyway behaviour, waders currently utilising Penrhyn Estuary fly into the area either from the south over water or from the west by flying south around the runways and turning north-east into the Estuary over water. Based on casual recent and historical URS observations over the years at the site and on discussions with Geoff Ross (NPWS), Phil Straw (Avifauna Research) and local bird naturalists, waders have not been observed flying over docks or runways to or from the Estuary (whereas other suite of bird strike species such as gulls regularly do).

Exclusion fencing, public access restriction to Penrhyn Estuary and boat ramp relocation associated with the proposal may minimise part of the human disturbance element to shorebirds. Shorebirds are often seen at Penryhn Estuary fleeing from roosting on the sandy point on the Penrhyn Road side of the channel to the sandy foothill of the dune on the opposite side of the channel (pers. obs.).

Discussions with Doug Watkins at Wetlands International (Environment Australia) indicate that Yatsu-Higata a landlocked RAMSAR wetland in Tokyo Bay (surrounded by industrial development) Japan is reportedly being used by a number of migratory waders for part of their life cycle requirements. Watkins indicated that the waders roost at the site and may also feed there at a later stage in a flood tide (that is, when the tide is coming in) when their primary feeding habitat (exposed mudflats elsewhere in the Bay) is flooded. Watkins indicated that the waders are flying over industrialised land because of the absence of any other suitable roost sites in the Bay (as a result of 80-90% of the Bay being reclaimed). This would suggest that some waders at Penrhyn Estuary may fly into the Estuary over the operational docks or negotiate along the 130 metre wide channel parallel to Foreshore Beach particularly if they are forced to due to a lack of remaining suitable habitat in the Bay. The waders would not be expected to have any difficulty in negotiating over the proposed road and rail bridges.

The other key potential impact to consider is the effect of any hydrological changes to the Estuary which may result in changes to shorebird feeding and roosting habitat. Hydrodynamic modelling studies of Penrhyn Estuary are currently being undertaken although the results of these studies are not yet complete or available for review. Nevertheless, SPC have indicated that no significant change in tidal regime, water levels and elevation profiles of the sand and mudflats are predicted to occur at Penrhyn Estuary (pers. comm., SPC). SPC also note that no hydrodynamic changes to other important shorebird habitat areas in the Bay (Towra Point, Taren and Shell Points) are predicted to occur (pers. comm., SPC).

The proposal will also result in the loss of remaining areas of shorebird foraging habitat on Foreshore Beach. The predicted impact on shorebirds however is considered to be negligible due to the volume of pedestrian traffic and dog walking on the beach (disturbance issue) and due to the increased beach erosion and

resulting steepness in the elevation profile which has drastically reduced the suitableness of the bird habitat in this area (less intertidal flats on neap tides).

(b) *in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.*

Not Applicable

(c) *in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.*

The proposal may result in a significant modification to shorebird habitat and behaviour at Penryhn Estuary, considered to be an important shorebird habitat for the species on a local and regional basis.

It should be noted that few nocturnal shorebird surveys in the Botany Bay estuary have been undertaken to date and thus data on nocturnal feeding and roosting habitat for shorebirds is not yet available. Nocturnal feeding is just as important (sometimes more important) than diurnal feeding for shorebirds and should not be underestimated in terms of a species life cycle requirements.

(d) *whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community*

The proposal may result in the isolation of shorebird feeding and roosting habitat at Penrhyn Estuary from other known roost sites on the southern shores of the Bay and from general Bay wide bird movements which are undertaken over water.

(e) *whether critical habitat will be affected.*

The study area is not listed as critical habitat under Part 3 Division 1 of the Threatened Species Conservation Act 1995.

(f) *whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.*

No resident or migratory shorebirds in NSW are considered to be adequately conserved due to the unique location of their intertidal habitat. Smith (1991) notes that reservation of wader habitat on intertidal lands has posed a particular problem for NPWS as few coastal reserves include any areas below the high water mark which are generally Crown land. There has been some success, however, in establishing aquatic reserves in NSW such as the Towra Point Aquatic Reserve adjacent to Towra Point Nature Reserve in the Botany Bay estuary which supports important habitat for many waders such as the Eastern Curlew and Whimbrel. Kooragang Nature Reserve in the Hunter estuary is one of the few present examples within an extensive representation of intertidal wader feeding grounds. This species is regularly recorded in relatively high numbers in the Hunter estuary.

(g) *whether the development or activity proposed is of a class of development or activity that is recognised as a threatening processes.*

Not Applicable

(h) *whether any threatened species, populations or ecological community is at the limit of its known distribution*

This species is regularly recorded in many estuaries on the north and south NSW coasts as well as inland and is thus not considered to be at its limit of distribution at Botany Bay estuary.

Section 5A Assessment Conclusion

This species is seldom recorded on estuarine mudflats and is considered a low likelihood of occurrence at Penrhyn Estuary. Consequently, the proposal is not expected to have a significant impact on the life cycle requirements of the species and thus an SIS is not required.

Tringa cinerea (Terek Sandpiper)

(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

This species (9 individuals in the Bay based on recent counts) presently feeds on intertidal mudflats between Taren Point and Woolooware Bay on the southern shores of the Bay and roosts on a disused jetty at Shell Point. This species may occasionally forage at Penrhyn Estuary (although no recent records exist of. this species on the northern shores of the Bay).

Predicted key impacts from the proposal on this species comprise disturbance to feeding and roosting from a change in lighting regime, increased noise and vibration (human and machinery) from the construction and operation of the port (and associated infrastructure such as railway lines) and potential entry/exit psychological flyway barrier due to the enclosure of Penrhyn Estuary. Disturbance issues are discussed below and are based on the author's general knowledge of shorebirds in New South Wales estuaries and from a desktop literature review of shorebird disturbance studies and other generalist bird studies (Paton et al 2000; Burger 1991; Goss-Custard and Verboven 1993; Smit and Visser 1993; Goss-Custard *et al* 1982; Goss-Custard 1980; Lawler 1996; Roberts and Evans 1993; Batten 1977; Straw 1996; Nelson 1994; Metcalfe and Furness 1984; Weston *et al* 2000).

There is little quantified and experimental assessment of the effects of disturbance to waterbirds and little understanding of the extent of such impacts. Disturbance is defined as a disruption to normal activity patterns. Disturbances to waders may vary in their intensity, frequency, duration, coverage and predictability and there is often inter-specific and intra-specific variation in susceptibility of birds to disturbance which is likely to vary with age, season, weather, location and the degree of habituation to disturbance. There are two potential consequences of sustained, localised disturbance to migratory waders, these being birds may have to shift to alternative, perhaps less favourable feeding grounds and secondly may have their feeding rate reduced by having to devote time to vigilance and anti-predator behaviour. Disturbed shorebirds may spend less time foraging whilst increasing energy-expending behaviours such as fleeing (running, flying). It has also been suggested that migratory birds may be more prone to disturbance than non-migratory species as they are only present in a particular area for part of the year and so have little opportunity to become habituated to the disturbance.

Waders preferably forage in areas where prey density, prey availability and intake rates are relatively high and where energy expenditure is low. Shorebird densities, therefore, tend to reach a maximum in the most preferred feeding areas (Woolooware Bay for this species) and where disturbances force birds to shift to alternative feeding areas, questions arise as to whether such areas are adequate, whether they can accommodate displaced individuals and what effect increased bird density has on intake rates and the fitness of those birds that move. As bird density increases, average intake rates decline in many species as a result of increased competition, increased prey depletion and a greater proportion of the population feeding in sub-optimal areas. Where populations are limited, or are close to limitation by the quality and availability of habitat (such as for this species in Penrhyn Estuary and in Botany Bay estuary in total), disturbance can have a negative impact on wader populations by affecting fitness, ability to fatten adequately during pre-migratory periods and increased mortality.

Some studies that have attempted to experimentally asses the impact of disturbance on waterbirds have predominantly used the bird's flight response as an index of disturbance whilst others have only crudely estimated alert distances. In such studies, a disturbance is introduced and the distance of the birds from the disturbance at the point of flight is measured. Buffer distances given for many shorebirds as part of past studies are in the order of 100-400 metres.

Many foraging migratory waders are often disrupted from their typical behaviour well before a flight response is elicited with some birds shown to be alerted at distances on average 30-95% greater than those at which they take flight. Following detection of a disturbance the bird may spend time assessing the degree of threat it is under and may balance the risk with the benefits of continued foraging or roosting. As discussed above, this may be particularly significant to migratory shorebirds during the pre-migratory period of fat accumulation (and post migratory period of recuperation and moulting) where an increase in food requirements during this period results in waders trying to maximise their net rate of resource acquisition and thus invest more time in foraging at the expense of vigilance and anti-predator behaviour. This is particularly significant for shorebirds whose feeding times are regulated by tidal flow (and even more significant for small billed waders such as plovers and stints where foraging areas are further limited by amount of intertidal area not covered with water at low tide). Frequent and intense disturbance is likely to affect wader behaviour and reduce the time they spend foraging. Reductions in feeding may then affect the capacity of waders to fatten at an adequate rate and therefore prolong the pre-migratory feeding period and departure delay. Such delays in migration departure from wintering grounds can seriously affect breeding success of migratory birds, where individuals arriving late at the summer breeding grounds may be at a disadvantage in the competition for mates and territories.

A change in lighting regime (predicted increase in ambient lighting at night) in Penrhyn Estuary may result in an increase in vigilant behaviour (area scans) at the expense of foraging as many shorebirds, particularly those that have been observed to forage nocturnally in "relatively dark" areas (such as sand plovers), may feel that they are more visible to potential predators (feral dogs, cats, birds of prey). Increased ambient lighting and flashes of light from railway lines may result in the displacement of the shorebirds to sub-optimal (less preferred) habitat elsewhere in the Botany Bay estuary.

The current design essentially encloses Penrhyn Estuary and thus may represent a psychological entry/exit flyway barrier into and out of the shorebird feeding and roosting habitat at the Estuary. Despite their physical capabilities, waders are very

reluctant to enter an area that does not have an open aspect (mainly to enable them to have a clear view of potential predators). Based on both the observed current flyways of the shorebirds into and out of the Estuary and on standard wader flyway behaviour, waders currently utilising Penrhyn Estuary fly into the area either from the south over water or from the west by flying south around the runways and turning north-east into the Estuary over water. Based on casual recent and historical URS observations over the years at the site and on discussions with Geoff Ross (NPWS), Phil Straw (Avifauna Research) and local bird naturalists, waders have not been observed flying over docks or runways to or from the Estuary (whereas other suite of bird strike species such as gulls regularly do).

Exclusion fencing, public access restriction to Penrhyn Estuary and boat ramp relocation associated with the proposal may minimise part of the human disturbance element to shorebirds. Shorebirds are often seen at Penryhn Estuary fleeing from roosting on the sandy point on the Penrhyn Road side of the channel to the sandy foothill of the dune on the opposite side of the channel (pers. obs.).

Discussions with Doug Watkins at Wetlands International (Environment Australia) indicate that Yatsu-Higata a landlocked RAMSAR wetland in Tokyo Bay (surrounded by industrial development) Japan is reportedly being used by a number of migratory waders for part of their life cycle requirements. Watkins indicated that the waders roost at the site and may also feed there at a later stage in a flood tide (that is, when the tide is coming in) when their primary feeding habitat (exposed mudflats elsewhere in the Bay) is flooded. Watkins indicated that the waders are flying over industrialised land because of the absence of any other suitable roost sites in the Bay (as a result of 80-90% of the Bay being reclaimed). This would suggest that some waders at Penrhyn Estuary may fly into the Estuary over the operational docks or negotiate along the 130 metre wide channel parallel to Foreshore Beach particularly if they are forced to due to a lack of remaining suitable habitat in the Bay. The waders would not be expected to have any difficulty in negotiating over the proposed road and rail bridges.

The other key potential impact to consider is the effect of any hydrological changes to the Estuary which may result in changes to shorebird feeding and roosting habitat. Hydrodynamic modelling studies of Penrhyn Estuary are currently being undertaken although the results of these studies are not yet complete or available for review. Nevertheless, SPC have indicated that no significant change in tidal regime, water levels and elevation profiles of the sand and mudflats are predicted to occur at Penrhyn Estuary (pers. comm., SPC). SPC also note that no hydrodynamic changes to other important shorebird habitat areas in the Bay (Towra Point, Taren and Shell Points) are predicted to occur (pers. comm., SPC).

The proposal will also result in the loss of remaining areas of shorebird foraging habitat on Foreshore Beach. The predicted impact on shorebirds however is considered to be negligible due to the volume of pedestrian traffic and dog walking on the beach (disturbance issue) and due to the increased beach erosion and resulting steepness in the elevation profile which has drastically reduced the suitableness of the bird habitat in this area (less intertidal flats on neap tides).

(b) *in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.*

Not Applicable

(c) *in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.*

The proposal may result in a significant modification to shorebird habitat and behaviour at Penryhn Estuary, considered to be an important shorebird habitat for the species on a local and regional basis.

It should be noted that few nocturnal shorebird surveys in the Botany Bay estuary have been undertaken to date and thus data on nocturnal feeding and roosting habitat for shorebirds is not yet available. Nocturnal feeding is just as important (sometimes more important) than diurnal feeding for shorebirds and should not be underestimated in terms of a species life cycle requirements.

(d) *whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community*

The proposal may result in the isolation of shorebird feeding and roosting habitat at Penrhyn Estuary from other known roost sites on the southern shores of the Bay and from general Bay wide bird movements which are undertaken over water.

(e) *whether critical habitat will be affected.*

The study area is not listed as critical habitat under Part 3 Division 1 of the Threatened Species Conservation Act 1995.

(f) *whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.*

No resident or migratory shorebirds in NSW are considered to be adequately conserved due to the unique location of their intertidal habitat. Smith (1991) notes that reservation of wader habitat on intertidal lands has posed a particular problem for NPWS as few coastal reserves include any areas below the high water mark which are generally Crown land. There has been some success, however, in establishing aquatic reserves in NSW such as the Towra Point Aquatic Reserve adjacent to Towra Point Nature Reserve in the Botany Bay estuary which supports important habitat for many waders such as the Eastern Curlew and Whimbrel. Kooragang Nature Reserve in the Hunter estuary is one of the few present examples within an extensive representation of intertidal wader feeding grounds. This species is regularly recorded in relatively high numbers in the Hunter estuary.

(g) *whether the development or activity proposed is of a class of development or activity that is recognised as a threatening processes.*

Not Applicable

(h) *whether any threatened species, populations or ecological community is at the limit of its known distribution*

This species is regularly recorded in some estuaries on the north and south NSW coasts and is thus not considered to be at its limit of distribution at in the Botany Bay estuary.

Section 5A Assessment Conclusion

Given that the proposal presently represents potential significant impacts on shorebird habitat at Penrhyn Estuary and given that many of the impacts (particularly those relating to disturbance) are difficult to predict, the precautionary approach must therefore be taken and thus the preparation of a Species Impact Statement for the species is required.

Should the development proceed, and should the proposed enhancement of shorebird habitat at Penrhyn Estuary not prove feasible, off-site enhancement of existing shorebird habitat elsewhere in Botany Bay (such as H1 lands at Woolooware Bay) should be considered. Proposed enhancement of shorebird habitat at Penrhyn Estuary will be addressed in the SIS for the proposal.

Numenius phaeopus (Whimbrel)

(a) *in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.*

This species (about 50-60 species in the Bay in present times) presently feeds on exposed mudflats near and under mangrove trees at Towra Point Aquatic Reserve and roosts in mangrove trees at Woolooware, Weeney and Stinkpot Bays. This species may occasionally feed at Penrhyn Estuary.

Predicted key impacts from the proposal on this species comprise disturbance to feeding and roosting from a change in lighting regime, increased noise and vibration (human and machinery) from the construction and operation of the port (and associated infrastructure such as railway lines) and potential entry/exit psychological flyway barrier due to the enclosure of Penrhyn Estuary. Disturbance issues are discussed below and are based on the author's general knowledge of shorebirds in New South Wales estuaries and from a desktop literature review of shorebird disturbance studies and other generalist bird studies (Paton et al 2000; Burger 1991; Goss-Custard and Verboven 1993; Smit and Visser 1993; Goss-Custard *et al* 1982; Goss-Custard 1980; Lawler 1996; Roberts and Evans 1993; Batten 1977; Straw 1996; Nelson 1994; Metcalfe and Furness 1984; Weston *et al* 2000).

There is little quantified and experimental assessment of the effects of disturbance to waterbirds and little understanding of the extent of such impacts. Disturbance is defined as a disruption to normal activity patterns. Disturbances to waders may vary in their intensity, frequency, duration, coverage and predictability and there is often inter-specific and intra-specific variation in susceptibility of birds to disturbance which is likely to vary with age, season, weather, location and the degree of habituation to disturbance. There are two potential consequences of sustained, localised disturbance to migratory waders, these being birds may have to shift to alternative, perhaps less favourable feeding grounds and secondly may have their feeding rate reduced by having to devote time to vigilance and anti-predator behaviour. Disturbed shorebirds may spend less time foraging whilst increasing energy-expending behaviours such as fleeing (running, flying). It has also been suggested that migratory birds may be more prone to disturbance than non-migratory species as they are only present in a particular area for part of the year and so have little opportunity to become habituated to the disturbances.

Waders preferably forage in areas where prey density, prey availability and intake rates are relatively high and where energy expenditure is low. Shorebird densities, therefore, tend to reach a maximum in the most preferred feeding areas (mangroves on the southern shores) and where disturbances force birds to shift to alternative feeding areas, questions arise as to whether such areas are adequate, whether they can accommodate displaced individuals and what effect increased bird density has on intake rates and the fitness of those birds that move. As bird density increases, average intake rates decline in many species as a result of increased competition, increased prey depletion and a greater proportion of the population feeding in sub-optimal areas. Where populations are limited, or are close to limitation by the quality and availability of habitat, disturbance can have a negative impact on wader populations by affecting fitness, ability to fatten adequately during pre-migratory periods and increased mortality.

Some studies that have attempted to experimentally asses the impact of disturbance on waterbirds have predominantly used the bird’s flight response as an index of disturbance whilst others have only crudely estimated alert distances. In such studies, a disturbance is introduced and the distance of the birds from the disturbance at the point of flight is measured. Buffer distances given for many shorebirds as part of past studies are in the order of 100-400 metres.

Many foraging migratory waders are often disrupted from their typical behaviour well before a flight response is elicited with some birds shown to be alerted at distances on average 30-95% greater than those at which they take flight. Following detection of a disturbance the bird may spend time assessing the degree of threat it is under and may balance the risk with the benefits of continued foraging or roosting. As discussed above, this may be particularly significant to migratory shorebirds during the pre-migratory period of fat accumulation (and post migratory period of recuperation and moulting) where an increase in food requirements during this period results in waders trying to maximise their net rate of resource acquisition and thus invest more time in foraging at the expense of vigilance and anti-predator behaviour. This is particularly significant for shorebirds whose feeding times are regulated by tidal flow (and even more significant for small billed waders such as plovers and stints where foraging areas are further limited by amount of intertidal area not covered with water at low tide). Frequent and intense disturbance is likely to affect wader behaviour and reduce the time they spend foraging. Reductions in feeding may then affect the capacity of waders to fatten at an adequate rate and therefore prolong the pre-migratory feeding period and departure delay. Such delays in migration departure from wintering grounds can seriously affect breeding success of migratory birds, where individuals arriving late at the summer breeding grounds may be at a disadvantage in the competition for mates and territories.

A change in lighting regime (predicted increase in ambient lighting at night) in Penrhyn Estuary may result in an increase in vigilant behaviour (area scans) at the expense of foraging as many shorebirds, particularly those that have been observed to forage nocturnally in “relatively dark” areas (such as sand plovers), may feel that they are more visible to potential predators (feral dogs, cats, birds of prey). Increased ambient lighting and flashes of light from railway lines may result in the displacement of the shorebirds to sub-optimal (less preferred) habitat elsewhere in the Botany Bay estuary.

The current design essentially encloses Penrhyn Estuary and thus may represent a psychological entry/exit flyway barrier into and out of the shorebird feeding and roosting habitat at the Estuary. Despite their physical capabilities, waders are very reluctant to enter an area that does not have an open aspect (mainly to enable them to have a clear view of potential predators). Based on both the observed current flyways of the shorebirds into and out of the Estuary and on standard wader flyway behaviour, waders currently utilising Penrhyn Estuary fly into the area either from the south over water or from the west by flying south around the runways and turning north-east into the Estuary over water. Based on casual recent and historical URS observations over the years at the site and on discussions with Geoff Ross (NPWS), Phil Straw (Avifauna Research) and local bird naturalists, waders have not been observed flying over docks or runways to or from the Estuary (whereas other suite of bird strike species such as gulls regularly do).

Exclusion fencing, public access restriction to Penrhyn Estuary and boat ramp relocation associated with the proposal may minimise part of the human disturbance element to shorebirds. Shorebirds are often seen at Penryhn Estuary fleeing from roosting on the sandy point on the Penrhyn Road side of the channel to the sandy foothill of the dune on the opposite side of the channel (pers. obs.).

Discussions with Doug Watkins at Wetlands International (Environment Australia) indicate that Yatsu-Higata a landlocked RAMSAR wetland in Tokyo Bay (surrounded by industrial development) Japan is reportedly being used by a number of migratory waders for part of their life cycle requirements. Watkins indicated that the waders roost at the site and may also feed there at a later stage in a flood tide (that is, when the tide is coming in) when their primary feeding habitat (exposed mudflats elsewhere in the Bay) is flooded. Watkins indicated that the waders are flying over industrialised land because of the absence of any other suitable roost sites in the Bay (as a result of 80-90% of the Bay being reclaimed). This would suggest that some waders at Penrhyn Estuary may fly into the Estuary over the operational docks or negotiate along the 130 metre wide channel parallel to Foreshore Beach particularly if they are forced to due to a lack of remaining suitable habitat in the Bay. The waders would not be expected to have any difficulty in negotiating over the proposed road and rail bridges.

The other key potential impact to consider is the effect of any hydrological changes to the Estuary which may result in changes to shorebird feeding and roosting habitat. Hydrodynamic modelling studies of Penrhyn Estuary are currently being undertaken although the results of these studies are not yet complete or available for review. Nevertheless, SPC have indicated that no significant change in tidal regime, water levels and elevation profiles of the sand and mudflats are predicted to occur at Penrhyn Estuary (pers. comm., SPC). SPC also note that no hydrodynamic changes to other important shorebird habitat areas in the Bay (Towra Point, Taren and Shell Points) are predicted to occur (pers. comm., SPC).

The proposal will also result in the loss of remaining areas of shorebird foraging habitat on Foreshore Beach. The predicted impact on shorebirds however is considered to be negligible due to the volume of pedestrian traffic and dog walking on the beach (disturbance issue) and due to the increased beach erosion and resulting steepness in the elevation profile which has drastically reduced the suitableness of the bird habitat in this area (less intertidal flats on neap tides).

(b) *in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.*

Not Applicable

(c) *in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.*

The proposal may result in a significant modification to shorebird habitat and behaviour at Penryhn Estuary, considered to be an important shorebird habitat for the species on a local and regional basis.

It should be noted that few nocturnal shorebird surveys in the Botany Bay estuary have been undertaken to date and thus data on nocturnal feeding and roosting habitat for shorebirds is not yet available. Nocturnal feeding is just as important (sometimes more important) than diurnal feeding for shorebirds and should not be underestimated in terms of a species life cycle requirements.

(d) *whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community*

The proposal may result in the isolation of shorebird feeding and roosting habitat at Penrhyn Estuary from other known roost sites on the southern shores of the Bay and from general Bay wide bird movements which are undertaken over water.

(e) *whether critical habitat will be affected.*

The study area is not listed as critical habitat under Part 3 Division 1 of the Threatened Species Conservation Act 1995.

(f) *whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.*

No resident or migratory shorebirds in NSW are considered to be adequately conserved due to the unique location of their intertidal habitat. Smith (1991) notes that reservation of wader habitat on intertidal lands has posed a particular problem for NPWS as few coastal reserves include any areas below the high water mark which are generally Crown land. There has been some success, however, in establishing aquatic reserves in NSW such as the Towra Point Aquatic Reserve adjacent to Towra Point Nature Reserve in the Botany Bay estuary which supports important habitat for many waders such as the Eastern Curlew and Whimbrel. Kooragang Nature Reserve in the Hunter estuary is one of the few present examples within an extensive representation of intertidal wader feeding grounds. This species is regularly recorded in relatively high numbers in the Hunter estuary.

(g) *whether the development or activity proposed is of a class of development or activity that is recognised as a threatening processes.*

Not Applicable

(h) *whether any threatened species, populations or ecological community is at the limit of its known distribution*

This species is regularly recorded in many estuaries on the north and south NSW coasts as well as inland and is thus not considered to be at its limit of distribution in the Botany Bay estuary.

Section 5A Assessment Conclusion

Given that the proposal presently represents potential significant impacts on shorebird habitat at Penrhyn Estuary and given that many of the impacts (particularly those relating to disturbance) are difficult to predict, the precautionary approach must therefore be taken and thus the preparation of a Species Impact Statement for the species is required.

Should the development proceed, and should the proposed enhancement of shorebird habitat at Penrhyn Estuary not prove feasible, off-site enhancement of existing shorebird habitat elsewhere in Botany Bay (such as H1 lands at Woolooware Bay) should be considered. Proposed enhancement of shorebird habitat at Penrhyn Estuary will be addressed in the SIS for the proposal.

Charadrius leschenaulti (Large (Greater) Sand Plover)

(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

This species is an occasional visitor to Penrhyn Estuary and Boat Harbour (often in association with the Lesser Sand Plover) where it feeds on intertidal sand flats. Only 1 or 2 individuals are recorded in the Bay on an occasional basis (this is significant given the NSW estimate population for this species is only 80 birds with the majority occurring in the Clarence and Richmond estuaries).

Predicted key impacts from the proposal on this species comprise disturbance to feeding and roosting from a change in lighting regime, increased noise and vibration (human and machinery) from the construction and operation of the port (and associated infrastructure such as railway lines) and potential entry/exit psychological flyway barrier due to the enclosure of Penrhyn Estuary. Disturbance issues are discussed below and are based on the author's general knowledge of shorebirds in New South Wales estuaries and from a desktop literature review of shorebird disturbance studies and other generalist bird studies (Paton et al 2000; Burger 1991; Goss-Custard and Verboven 1993; Smit and Visser 1993; Goss-Custard *et al* 1982; Goss-Custard 1980; Lawler 1996; Roberts and Evans 1993; Batten 1977; Straw 1996; Nelson 1994; Metcalfe and Furness 1984; Weston *et al* 2000).

There is little quantified and experimental assessment of the effects of disturbance to waterbirds and little understanding of the extent of such impacts. Disturbance is defined as a disruption to normal activity patterns. Disturbances to waders may vary in their intensity, frequency, duration, coverage and predictability and there is often inter-specific and intra-specific variation in susceptibility of birds to disturbance which is likely to vary with age, season, weather, location and the degree of habituation to disturbance. There are two potential consequences of sustained, localised disturbance to migratory waders, these being birds may have to shift to alternative, perhaps less favourable feeding grounds and secondly may have their feeding rate reduced by having to devote time to vigilance and anti-predator behaviour. Disturbed shorebirds may spend less time foraging whilst increasing energy-expending behaviours such as fleeing (running, flying). It has also been suggested that migratory birds may be more prone to disturbance than non-migratory species as they are only present in a particular area for part of the year and so have little opportunity to become habituated to the disturbance.

Waders preferably forage in areas where prey density, prey availability and intake rates are relatively high and where energy expenditure is low. Shorebird densities, therefore, tend to reach a maximum in the most preferred feeding areas (Penrhyn Estuary for this species) and where disturbances force birds to shift to alternative feeding areas, questions arise as to whether such areas are adequate, whether they can accommodate displaced individuals and what effect increased bird density has on intake rates and the fitness of those birds that move. As bird density increases,

average intake rates decline in many species as a result of increased competition, increased prey depletion and a greater proportion of the population feeding in sub-optimal areas. Where populations are limited, or are close to limitation by the quality and availability of habitat (such as for this species in Penrhyn Estuary and in the Botany Bay estuary in total), disturbance can have a negative impact on wader populations by affecting fitness, ability to fatten adequately during pre-migratory periods and increased mortality.

Some studies that have attempted to experimentally asses the impact of disturbance on waterbirds have predominantly used the bird’s flight response as an index of disturbance whilst others have only crudely estimated alert distances. In such studies, a disturbance is introduced and the distance of the birds from the disturbance at the point of flight is measured. Buffer distances given for many shorebirds as part of past studies are in the order of 100-400 metres.

Many foraging migratory waders are often disrupted from their typical behaviour well before a flight response is elicited with some birds shown to be alerted at distances on average 30-95% greater than those at which they take flight. Following detection of a disturbance the bird may spend time assessing the degree of threat it is under and may balance the risk with the benefits of continued foraging or roosting. As discussed above, this may be particularly significant to migratory shorebirds during the pre-migratory period of fat accumulation (and post migratory period of recuperation and moulting) where an increase in food requirements during this period results in waders trying to maximise their net rate of resource acquisition and thus invest more time in foraging at the expense of vigilance and anti-predator behaviour. This is particularly significant for shorebirds whose feeding times are regulated by tidal flow (and even more significant for small billed waders such as plovers and stints where foraging areas are further limited by amount of intertidal area not covered with water at low tide). Frequent and intense disturbance is likely to affect wader behaviour and reduce the time they spend foraging. Reductions in feeding may then affect the capacity of waders to fatten at an adequate rate and therefore prolong the pre-migratory feeding period and departure delay. Such delays in migration departure from wintering grounds can seriously affect breeding success of migratory birds, where individuals arriving late at the summer breeding grounds may be at a disadvantage in the competition for mates and territories.

A change in lighting regime (predicted increase in ambient lighting at night) Penrhyn Estuary may result in an increase in vigilant behaviour (area scans) at the expense of foraging as many shorebirds, particularly those that have been observed to forage nocturnally in “relatively dark” areas (such as sand plovers), may feel that they are more visible to potential predators (feral dogs, cats, birds of prey). Increased ambient lighting and flashes of light from railway lines may result in the displacement of the shorebirds to sub-optimal (less preferred) habitat elsewhere in the Botany Bay estuary.

The current design essentially encloses Penrhyn Estuary and thus may represent a psychological entry/exit flyway barrier into and out of the shorebird feeding and roosting habitat at the Estuary. Despite their physical capabilities, waders are very

reluctant to enter an area that does not have an open aspect (mainly to enable them to have a clear view of potential predators). Based on both the observed current flyways of the shorebirds into and out of the Estuary and on standard wader flyway behaviour, waders currently utilising Penrhyn Estuary fly into the area either from the south over water or from the west by flying south around the runways and turning north-east into the Estuary over water. Based on casual recent and historical URS observations over the years at the site and on discussions with Geoff Ross (NPWS), Phil Straw (Avifauna Research) and local bird naturalists, waders have not been observed flying over docks or runways to or from the Estuary (whereas other suite of bird strike species such as gulls regularly do).

Exclusion fencing, public access restriction to Penrhyn Estuary and boat ramp relocation associated with the proposal may minimise part of the human disturbance element to shorebirds. Shorebirds are often seen at Penryhn Estuary fleeing from roosting on the sandy point on the Penrhyn Road side of the channel to the sandy foothill of the dune on the opposite side of the channel (pers. obs.).

Discussions with Doug Watkins at Wetlands International (Environment Australia) indicate that Yatsu-Higata a landlocked RAMSAR wetland in Tokyo Bay (surrounded by industrial development) Japan is reportedly being used by a number of migratory waders for part of their life cycle requirements. Watkins indicated that the waders roost at the site and may also feed there at a later stage in a flood tide (that is, when the tide is coming in) when their primary feeding habitat (exposed mudflats elsewhere in the Bay) is flooded. Watkins indicated that the waders are flying over industrialised land because of the absence of any other suitable roost sites in the Bay (as a result of 80-90% of the Bay being reclaimed). This would suggest that some waders at Penrhyn Estuary may fly into the Estuary over the operational docks or negotiate along the 130 metre wide channel parallel to Foreshore Beach particularly if they are forced to due to a lack of remaining suitable habitat in the Bay. The waders would not be expected to have any difficulty in negotiating over the proposed road and rail bridges.

The other key potential impact to consider is the effect of any hydrological changes to the Estuary which may result in changes to shorebird feeding and roosting habitat. Hydrodynamic modelling studies of Penrhyn Estuary are currently being undertaken although the results of these studies are not yet complete or available for review. Nevertheless, SPC have indicated that no significant change in tidal regime, water levels and elevation profiles of the sand and mudflats are predicted to occur at Penrhyn Estuary (pers. comm., SPC). SPC also note that no hydrodynamic changes to other important shorebird habitat areas in the Bay (Towra Point, Taren and Shell Points) are predicted to occur (pers. comm., SPC).

The proposal will also result in the loss of remaining areas of shorebird foraging habitat on Foreshore Beach. The predicted impact on shorebirds however is considered to be negligible due to the volume of pedestrian traffic and dog walking on the beach (disturbance issue) and due to the increased beach erosion and resulting steepness in the elevation profile which has drastically reduced the suitableness of the bird habitat in this area (less intertidal flats on neap tides).

(b) *in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.*

Not Applicable

(c) *in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.*

The proposal may result in a significant modification to shorebird habitat and behaviour at Penryhn Estuary, considered to be an important shorebird habitat for the species on a local and regional basis.

It should be noted that few nocturnal shorebird surveys in the Botany Bay estuary have been undertaken to date and thus data on nocturnal feeding and roosting habitat for shorebirds is not yet available. Nocturnal feeding is just as important (sometimes more important) than diurnal feeding for shorebirds and should not be underestimated in terms of a species life cycle requirements.

(d) *whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community*

The proposal may result in the isolation of shorebird feeding and roosting habitat at Penrhyn Estuary from other known roost sites on the southern shores of the Bay and from general Bay wide bird movements which are undertaken over water.

(e) *whether critical habitat will be affected.*

The study area is not listed as critical habitat under Part 3 Division 1 of the Threatened Species Conservation Act 1995.

(f) *whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.*

No resident or migratory shorebirds in NSW are considered to be adequately conserved due to the unique location of their intertidal habitat. Smith (1991) notes that reservation of wader habitat on intertidal lands has posed a particular problem for NPWS as few coastal reserves include any areas below the high water mark which are generally Crown land. There has been some success, however, in establishing aquatic reserves in NSW such as the Towra Point Aquatic Reserve adjacent to Towra Point Nature Reserve in the Botany Bay estuary which supports important habitat for many waders such as the Eastern Curlew and Whimbrel. Kooragang Nature Reserve in the Hunter estuary is one of the few present examples within an extensive representation of intertidal wader feeding grounds. This species is regularly recorded in relatively high numbers in the Hunter estuary.

(g) *whether the development or activity proposed is of a class of development or activity that is recognised as a threatening processes.*

Not Applicable

(h) *whether any threatened species, populations or ecological community is at the limit of its known distribution*

This species is regularly recorded in many estuaries on the north and south NSW coasts (majority in the Clarence and Richmond estuaries on the north coast) and is thus not considered to be at its limit of distribution in the Botany Bay estuary.

Section 5A Assessment Conclusion

Given that the proposal presently represents potential significant impacts on shorebird habitat at Penrhyn Estuary and given that many of the impacts (particularly those relating to disturbance) are difficult to predict, the precautionary approach must therefore be taken and thus the preparation of a Species Impact Statement for the species is required.

Should the development proceed, and should the proposed enhancement of shorebird habitat at Penrhyn Estuary not prove feasible, off-site enhancement of existing shorebird habitat elsewhere in Botany Bay (such as H1 lands at Woolooware Bay) should be considered. Proposed enhancement of shorebird habitat at Penrhyn Estuary will be addressed in the SIS for the proposal.

Pluvialis squatarola (Grey Plover)

(a) *in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.*

1 or 2 individuals of this species are occasionally recorded feeding on intertidal sand and mudflats at Penrhyn Estuary, Quibray Bay and west of Taren Point. One known roost of the species in the Bay is on the sandy points on either side of the channel at Penrhyn Estuary. The species was historically recorded from the original mouth of the Cooks River.

Predicted key impacts from the proposal on this species comprise disturbance to feeding and roosting from a change in lighting regime, increased noise and vibration (human and machinery) from the construction and operation of the port (and associated infrastructure such as railway lines) and potential entry/exit psychological flyway barrier due to the enclosure of Penrhyn Estuary. Disturbance issues are discussed below and are based on the author's general knowledge of shorebirds in New South Wales estuaries and from a desktop literature review of shorebird disturbance studies and other generalist bird studies (Paton et al 2000; Burger 1991; Goss-Custard and Verboven 1993; Smit and Visser 1993; Goss-Custard *et al* 1982; Goss-Custard 1980; Lawler 1996; Roberts and Evans 1993; Batten 1977; Straw 1996; Nelson 1994; Metcalfe and Furness 1984; Weston *et al* 2000).

There is little quantified and experimental assessment of the effects of disturbance to waterbirds and little understanding of the extent of such impacts. Disturbance is defined as a disruption to normal activity patterns. Disturbances to waders may vary in their intensity, frequency, duration, coverage and predictability and there is often inter-specific and intra-specific variation in susceptibility of birds to disturbance which is likely to vary with age, season, weather, location and the degree of habituation to disturbance. There are two potential consequences of sustained, localised disturbance to migratory waders, these being birds may have to shift to alternative, perhaps less favourable feeding grounds and secondly may have their feeding rate reduced by having to devote time to vigilance and anti-predator behaviour. Disturbed shorebirds may spend less time foraging whilst increasing energy-expending behaviours such as fleeing (running, flying). It has also been suggested that migratory birds may be more prone to disturbance than non-migratory species as they are only present in a particular area for part of the year and so have little opportunity to become habituated to the disturbance.

Waders preferably forage in areas where prey density, prey availability and intake rates are relatively high and where energy expenditure is low. Shorebird densities, therefore, tend to reach a maximum in the most preferred feeding areas (Penrhyn Estuary for this species) and where disturbances force birds to shift to alternative feeding areas, questions arise as to whether such areas are adequate, whether they can accommodate displaced individuals and what effect increased bird density has on intake rates and the fitness of those birds that move. As bird density increases,

average intake rates decline in many species as a result of increased competition, increased prey depletion and a greater proportion of the population feeding in sub-optimal areas. Where populations are limited, or are close to limitation by the quality and availability of habitat (such as for this species in Penrhyn Estuary and in the Botany Bay estuary in total), disturbance can have a negative impact on wader populations by affecting fitness, ability to fatten adequately during pre-migratory periods and increased mortality.

Some studies that have attempted to experimentally asses the impact of disturbance on waterbirds have predominantly used the bird’s flight response as an index of disturbance whilst others have only crudely estimated alert distances. In such studies, a disturbance is introduced and the distance of the birds from the disturbance at the point of flight is measured. Buffer distances given for many shorebirds as part of past studies are in the order of 100-400 metres.

Many foraging migratory waders are often disrupted from their typical behaviour well before a flight response is elicited with some birds shown to be alerted at distances on average 30-95% greater than those at which they take flight. Following detection of a disturbance the bird may spend time assessing the degree of threat it is under and may balance the risk with the benefits of continued foraging or roosting. As discussed above, this may be particularly significant to migratory shorebirds during the pre-migratory period of fat accumulation (and post migratory period of recuperation and moulting) where an increase in food requirements during this period results in waders trying to maximise their net rate of resource acquisition and thus invest more time in foraging at the expense of vigilance and anti-predator behaviour. This is particularly significant for shorebirds whose feeding times are regulated by tidal flow (and even more significant for small billed waders such as plovers and stints where foraging areas are further limited by amount of intertidal area not covered with water at low tide). Frequent and intense disturbance is likely to affect wader behaviour and reduce the time they spend foraging. Reductions in feeding may then affect the capacity of waders to fatten at an adequate rate and therefore prolong the pre-migratory feeding period and departure delay. Such delays in migration departure from wintering grounds can seriously affect breeding success of migratory birds, where individuals arriving late at the summer breeding grounds may be at a disadvantage in the competition for mates and territories.

A change in lighting regime (predicted increase in ambient lighting at night) in Penrhyn Estuary may result in an increase in vigilant behaviour (area scans) at the expense of foraging as many shorebirds, particularly those that have been observed to forage nocturnally in “relatively dark” areas (such as sand plovers), may feel that they are more visible to potential predators (feral dogs, cats, birds of prey). Increased ambient lighting and flashes of light from railway lines may result in the displacement of the shorebirds to sub-optimal (less preferred) habitat elsewhere in the Botany Bay estuary, such as Boat Harbour and Taren Point.

The current design essentially encloses Penrhyn Estuary and thus may represent a psychological entry/exit flyway barrier into and out of the shorebird feeding and roosting habitat at the Estuary. Despite their physical capabilities, waders are very

reluctant to enter an area that does not have an open aspect (mainly to enable them to have a clear view of potential predators). Based on both the observed current flyways of the shorebirds into and out of the Estuary and on standard wader flyway behaviour, waders currently utilising Penrhyn Estuary fly into the area either from the south over water or from the west by flying south around the runways and turning north-east into the Estuary over water. Based on casual recent and historical URS observations over the years at the site and on discussions with Geoff Ross (NPWS), Phil Straw (Avifauna Research) and local bird naturalists, waders have not been observed flying over docks or runways to or from the Estuary (whereas other suite of bird strike species such as gulls regularly do).

Exclusion fencing, public access restriction to Penrhyn Estuary and boat ramp relocation associated with the proposal may minimise part of the human disturbance element to shorebirds. Shorebirds are often seen at Penryhn Estuary fleeing from roosting on the sandy point on the Penrhyn Road side of the channel to the sandy foothill of the dune on the opposite side of the channel (pers. obs.).

Discussions with Doug Watkins at Wetlands International (Environment Australia) indicate that Yatsu-Higata a landlocked RAMSAR wetland in Tokyo Bay (surrounded by industrial development) Japan is reportedly being used by a number of migratory waders for part of their life cycle requirements. Watkins indicated that the waders roost at the site and may also feed there at a later stage in a flood tide (that is, when the tide is coming in) when their primary feeding habitat (exposed mudflats elsewhere in the Bay) is flooded. Watkins indicated that the waders are flying over industrialised land because of the absence of any other suitable roost sites in the Bay (as a result of 80-90% of the Bay being reclaimed). This would suggest that some waders at Penrhyn Estuary may fly into the Estuary over the operational docks or negotiate along the 130 metre wide channel parallel to Foreshore Beach particularly if they are forced to due to a lack of remaining suitable habitat in the Bay. The waders would not be expected to have any difficulty in negotiating over the proposed road and rail bridges.

The other key potential impact to consider is the effect of any hydrological changes to the Estuary which may result in changes to shorebird feeding and roosting habitat. Hydrodynamic modelling studies of Penrhyn Estuary are currently being undertaken although the results of these studies are not yet complete or available for review. Nevertheless, SPC have indicated that no significant change in tidal regime, water levels and elevation profiles of the sand and mudflats are predicted to occur at Penrhyn Estuary (pers. comm., SPC). SPC also note that no hydrodynamic changes to other important shorebird habitat areas in the Bay (Towra Point, Taren and Shell Points) are predicted to occur (pers. comm., SPC).

The proposal will also result in the loss of remaining areas of shorebird foraging habitat on Foreshore Beach. The predicted impact on shorebirds however is considered to be negligible due to the volume of pedestrian traffic and dog walking on the beach (disturbance issue) and due to the increased beach erosion and resulting steepness in the elevation profile which has drastically reduced the suitableness of the bird habitat in this area (less intertidal flats on neap tides).

(b) *in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.*

Not Applicable

(c) *in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.*

The proposal may result in a significant modification to shorebird habitat and behaviour at Penryhn Estuary, considered to be an important shorebird habitat for the species on a local and regional basis.

It should be noted that few nocturnal shorebird surveys in the Botany Bay estuary have been undertaken to date and thus data on nocturnal feeding and roosting habitat for shorebirds is not yet available. Nocturnal feeding is just as important (sometimes more important) than diurnal feeding for shorebirds and should not be underestimated in terms of a species life cycle requirements.

(d) *whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community*

The proposal may result in the isolation of shorebird feeding and roosting habitat at Penrhyn Estuary from other known roost sites on the southern shores of the Bay and from general Bay wide bird movements which are undertaken over water.

(e) *whether critical habitat will be affected.*

The study area is not listed as critical habitat under Part 3 Division 1 of the Threatened Species Conservation Act 1995.

(f) *whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.*

No resident or migratory shorebirds in NSW are considered to be adequately conserved due to the unique location of their intertidal habitat. Smith (1991) notes that reservation of wader habitat on intertidal lands has posed a particular problem for NPWS as few coastal reserves include any areas below the high water mark which are generally Crown land. There has been some success, however, in establishing aquatic reserves in NSW such as the Towra Point Aquatic Reserve adjacent to Towra Point Nature Reserve in the Botany Bay estuary which supports important habitat for many waders such as the Eastern Curlew and Whimbrel. Kooragang Nature Reserve in the Hunter estuary is one of the few present examples within an extensive representation of intertidal wader feeding grounds. This species is regularly recorded in relatively high numbers in the Hunter estuary.

(g) *whether the development or activity proposed is of a class of development or activity that is recognised as a threatening processes.*

Not Applicable

(h) *whether any threatened species, populations or ecological community is at the limit of its known distribution*

This species is regularly recorded in many estuaries on the north and south NSW coasts as well as inland and is thus not considered to be at its limit of distribution in the Botany Bay estuary.

Section 5A Assessment Conclusion

Given that the proposal presently represents potential significant impacts on shorebird habitat at Penrhyn Estuary and given that many of the impacts (particularly those relating to disturbance) are difficult to predict, the precautionary approach must therefore be taken and thus the preparation of a Species Impact Statement for the species is required.

Should the development proceed, and should the proposed enhancement of shorebird habitat at Penrhyn Estuary not prove feasible, off-site enhancement of existing shorebird habitat elsewhere in Botany Bay (such as H1 lands at Woolooware Bay) should be considered. Proposed enhancement of shorebird habitat at Penrhyn Estuary will be addressed in the SIS for the proposal.

Charadrius mongolus (Mongolian (Lesser Sand) Plover)

(a) *in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.*

This species roosts every year on intertidal sand flats at Boat Harbour (up to about 10 individuals) and feeds occasionally at Penrhyn Estuary and possibly elsewhere in the Bay.

Predicted key impacts from the proposal on this species comprise disturbance to feeding and roosting from a change in lighting regime, increased noise and vibration (human and machinery) from the construction and operation of the port (and associated infrastructure such as railway lines) and potential entry/exit psychological flyway barrier due to the enclosure of Penrhyn Estuary. Disturbance issues are discussed below and are based on the author's general knowledge of shorebirds in New South Wales estuaries and from a desktop literature review of shorebird disturbance studies and other generalist bird studies (Paton et al 2000; Burger 1991; Goss-Custard and Verboven 1993; Smit and Visser 1993; Goss-Custard *et al* 1982; Goss-Custard 1980; Lawler 1996; Roberts and Evans 1993; Batten 1977; Straw 1996; Nelson 1994; Metcalfe and Furness 1984; Weston *et al* 2000).

There is little quantified and experimental assessment of the effects of disturbance to waterbirds and little understanding of the extent of such impacts. Disturbance is defined as a disruption to normal activity patterns. Disturbances to waders may vary in their intensity, frequency, duration, coverage and predictability and there is often inter-specific and intra-specific variation in susceptibility of birds to disturbance which is likely to vary with age, season, weather, location and the degree of habituation to disturbance. There are two potential consequences of sustained, localised disturbance to migratory waders, these being birds may have to shift to alternative, perhaps less favourable feeding grounds and secondly may have their feeding rate reduced by having to devote time to vigilance and anti-predator behaviour. Disturbed shorebirds may spend less time foraging whilst increasing energy-expending behaviours such as fleeing (running, flying). It has also been suggested that migratory birds may be more prone to disturbance than non-migratory species as they are only present in a particular area for part of the year and so have little opportunity to become habituated to the disturbance.

Waders preferably forage in areas where prey density, prey availability and intake rates are relatively high and where energy expenditure is low. Shorebird densities, therefore, tend to reach a maximum in the most preferred feeding areas (Penrhyn Estuary and Boat Harbour for this species) and where disturbances force birds to shift to alternative feeding areas, questions arise as to whether such areas are adequate, whether they can accommodate displaced individuals and what effect increased bird density has on intake rates and the fitness of those birds that move. As bird density increases, average intake rates decline in many species as a result of increased competition, increased prey depletion and a greater proportion of the population feeding in sub-optimal areas. Where populations are limited, or are close to limitation by the quality and availability of habitat (such as for this species in Penrhyn Estuary and in the Botany Bay estuary in total), disturbance can have a negative impact on wader populations by affecting fitness, ability to fatten adequately during pre-migratory periods and increased mortality.

Some studies that have attempted to experimentally asses the impact of disturbance on waterbirds have predominantly used the bird’s flight response as an index of disturbance whilst others have only crudely estimated alert distances. In such studies, a disturbance is introduced and the distance of the birds from the disturbance at the point of flight is measured. Buffer distances given for many shorebirds as part of past studies are in the order of 100-400 metres.

Many foraging migratory waders are often disrupted from their typical behaviour well before a flight response is elicited with some birds shown to be alerted at distances on average 30-95% greater than those at which they take flight. Following detection of a disturbance the bird may spend time assessing the degree of threat it is under and may balance the risk with the benefits of continued foraging or roosting. As discussed above, this may be particularly significant to migratory shorebirds during the pre-migratory period of fat accumulation (and post migratory period of recuperation and moulting) where an increase in food requirements during this period results in waders trying to maximise their net rate of resource acquisition and thus invest more time in foraging at the expense of vigilance and anti-predator behaviour. This is particularly significant for shorebirds whose feeding times are regulated by tidal flow (and even more significant for small billed waders such as plovers and stints where foraging areas are further limited by amount of intertidal area not covered with water at low tide). Frequent and intense disturbance is likely to affect wader behaviour and reduce the time they spend foraging. Reductions in feeding may then affect the capacity of waders to fatten at an adequate rate and therefore prolong the pre-migratory feeding period and departure delay. Such delays in migration departure from wintering grounds can seriously affect breeding success of migratory birds, where individuals arriving late at the summer breeding grounds may be at a disadvantage in the competition for mates and territories.

A change in lighting regime (predicted increase in ambient lighting at night) in Penrhyn Estuary may result in an increase in vigilant behaviour (area scans) at the expense of foraging as many shorebirds, particularly those that have been observed to forage nocturnally in “relatively dark” areas (such as sand plovers), may feel that they are more visible to potential predators (feral dogs, cats, birds of prey). Increased ambient lighting and flashes of light from railway lines may result in the displacement of the shorebirds to sub-optimal (less preferred) habitat elsewhere in the Botany Bay estuary.

The current design essentially encloses Penrhyn Estuary and thus may represent a psychological entry/exit flyway barrier into and out of the shorebird feeding and roosting habitat at the Estuary. Despite their physical capabilities, waders are very reluctant to enter an area that does not have an open aspect (mainly to enable them to have a clear view of potential predators). Based on both the observed current flyways of the shorebirds into and out of the Estuary and on standard wader flyway behaviour, waders currently utilising Penrhyn Estuary fly into the area either from the south over water or from the west by flying south around the runways and turning north-east into the Estuary over water. Based on casual recent and historical URS observations over the years at the site and on discussions with Geoff Ross (NPWS), Phil Straw (Avifauna Research) and local bird naturalists, waders have not been observed flying over docks or runways to or from the Estuary (whereas other suite of bird strike species such as gulls regularly do).

Exclusion fencing, public access restriction to Penrhyn Estuary and boat ramp relocation associated with the proposal may minimise part of the human disturbance element to shorebirds. Shorebirds are often seen at Penryhn Estuary fleeing from roosting on the sandy point on the Penrhyn Road side of the channel to the sandy foothill of the dune on the opposite side of the channel (pers. obs.).

Discussions with Doug Watkins at Wetlands International (Environment Australia) indicate that Yatsu-Higata a landlocked RAMSAR wetland in Tokyo Bay (surrounded by industrial development) Japan is reportedly being used by a number of migratory waders for part of their life cycle requirements. Watkins indicated that the waders roost at the site and may also feed there at a later stage in a flood tide (that is, when the tide is coming in) when their primary feeding habitat (exposed mudflats elsewhere in the Bay) is flooded. Watkins indicated that the waders are flying over industrialised land because of the absence of any other suitable roost sites in the Bay (as a result of 80-90% of the Bay being reclaimed). This would suggest that some waders at Penrhyn Estuary may fly into the Estuary over the operational docks or negotiate along the 130 metre wide channel parallel to Foreshore Beach particularly if they are forced to due to a lack of remaining suitable habitat in the Bay. The waders would not be expected to have any difficulty in negotiating over the proposed road and rail bridges.

The other key potential impact to consider is the effect of any hydrological changes to the Estuary which may result in changes to shorebird feeding and roosting habitat. Hydrodynamic modelling studies of Penrhyn Estuary are currently being undertaken although the results of these studies are not yet complete or available for review. Nevertheless, SPC have indicated that no significant change in tidal regime, water levels and elevation profiles of the sand and mudflats are predicted to occur at Penrhyn Estuary (pers. comm., SPC). SPC also note that no hydrodynamic changes to other important shorebird habitat areas in the Bay (Towra Point, Taren and Shell Points) are predicted to occur (pers. comm., SPC).

The proposal will also result in the loss of remaining areas of shorebird foraging habitat on Foreshore Beach. The predicted impact on shorebirds however is considered to be negligible due to the volume of pedestrian traffic and dog walking on the beach (disturbance issue) and due to the increased beach erosion and resulting steepness in the elevation profile which has drastically reduced the suitableness of the bird habitat in this area (less intertidal flats on neap tides).

(b) *in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.*

Not Applicable

(c) *in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.*

The proposal may result in a significant modification to shorebird habitat and behaviour at Penryhn Estuary, considered to be an important shorebird habitat for the species on a local and regional basis.

It should be noted that few nocturnal shorebird surveys in the Botany Bay estuary have been undertaken to date and thus data on nocturnal feeding and roosting habitat for shorebirds is not yet available. Nocturnal feeding is just as important (sometimes more important) than diurnal feeding for shorebirds and should not be underestimated in terms of a species life cycle requirements.

(d) *whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community*

The proposal may result in the isolation of shorebird feeding and roosting habitat at Penrhyn Estuary from other known roost sites on the southern shores of the Bay and from general Bay wide bird movements which are undertaken over water.

(e) *whether critical habitat will be affected.*

The study area is not listed as critical habitat under Part 3 Division 1 of the Threatened Species Conservation Act 1995.

(f) *whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.*

No resident or migratory shorebirds in NSW are considered to be adequately conserved due to the unique location of their intertidal habitat. Smith (1991) notes that reservation of wader habitat on intertidal lands has posed a particular problem for NPWS as few coastal reserves include any areas below the high water mark which are generally Crown land. There has been some success, however, in establishing aquatic reserves in NSW such as the Towra Point Aquatic Reserve adjacent to Towra Point Nature Reserve in the Botany Bay estuary which supports important habitat for many waders such as the Eastern Curlew and Whimbrel. Kooragang Nature Reserve in the Hunter estuary is one of the few present examples within an extensive representation of intertidal wader feeding grounds. This species is regularly recorded in relatively high numbers in the Hunter estuary.

(g) *whether the development or activity proposed is of a class of development or activity that is recognised as a threatening processes.*

Not Applicable

(h) *whether any threatened species, populations or ecological community is at the limit of its known distribution*

This species is regularly recorded in many estuaries on the north and south NSW coasts as well as inland and is thus not considered to be at its limit of distribution at Botany Bay estuary.

Section 5A Assessment Conclusion

Given that the proposal presently represents potential significant impacts on shorebird habitat at Penrhyn Estuary and given that many of the impacts (particularly those relating to disturbance) are difficult to predict, the precautionary approach must therefore be taken and thus the preparation of a Species Impact Statement for the species is required.

Should the development proceed, and should the proposed enhancement of shorebird habitat at Penrhyn Estuary not prove feasible, off-site enhancement of existing shorebird habitat elsewhere in Botany Bay (such as H1 lands at Woolooware Bay) should be considered. Proposed enhancement of shorebird habitat at Penrhyn Estuary will be addressed in the SIS for the proposal.

Charadrius bicinctus (Double-banded Plover)

(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

About 50-60 species of this trans Tasman winter migrant presently feed on intertidal sand flats at Penrhyn (Penrhyn Road side of channel). The species also roosts at Penrhyn Estuary, Boat Harbour and reportedly at Molineux Point and on the end of the Parallel Runway (pers. comm., Geoff Ross). This species is thus quite vulnerable to disturbance due to recreational fishers, dogs and beach walkers given its key habitat at Penrhyn Estuary and Boat Harbour. This species used to feed at the former stockpile site and northern sections of Foreshore Beach which were both lost due to the Parallel Runway construction and have thus experienced a critical decline in their Bay habitat. Based on counts since the 1970s, Botany Bay is one of the three most important estuaries for the species in NSW (along with the Hunter and Shoalhaven River estuaries).

Predicted key impacts from the proposal on this species comprise disturbance to feeding and roosting from a change in lighting regime, increased noise and vibration (human and machinery) from the construction and operation of the port (and associated infrastructure such as railway lines) and potential entry/exit psychological flyway barrier due to the enclosure of Penrhyn Estuary. Disturbance issues are discussed below and are based on the author's general knowledge of shorebirds in New South Wales estuaries and from a desktop literature review of shorebird disturbance studies and other generalist bird studies (Paton et al 2000; Burger 1991; Goss-Custard and Verboven 1993; Smit and Visser 1993; Goss-Custard *et al* 1982; Goss-Custard 1980; Lawler 1996; Roberts and Evans 1993; Batten 1977; Straw 1996; Nelson 1994; Metcalfe and Furness 1984; Weston *et al* 2000).

There is little quantified and experimental assessment of the effects of disturbance to waterbirds and little understanding of the extent of such impacts. Disturbance is defined as a disruption to normal activity patterns. Disturbances to waders may vary in their intensity, frequency, duration, coverage and predictability and there is often inter-specific and intra-specific variation in susceptibility of birds to disturbance which is likely to vary with age, season, weather, location and the degree of habituation to disturbance. There are two potential consequences of sustained, localised disturbance to migratory waders, these being birds may have to shift to alternative, perhaps less favourable feeding grounds and secondly may have their feeding rate reduced by having to devote time to vigilance and anti-predator behaviour. Disturbed shorebirds may spend less time foraging whilst increasing energy-expending behaviours such as fleeing (running, flying). It has also been suggested that migratory birds may be more prone to disturbance than non-migratory species as they are only present in a particular area for part of the year and so have little opportunity to become habituated to the disturbance.

Waders preferably forage in areas where prey density, prey availability and intake rates are relatively high and where energy expenditure is low. Shorebird densities, therefore, tend to reach a maximum in the most preferred feeding areas (Penrhyn Estuary for this species) and where disturbances force birds to shift to alternative feeding areas, questions arise as to whether such areas are adequate, whether they can accommodate displaced individuals and what effect increased bird density has on intake rates and the fitness of those birds that move. As bird density increases, average intake rates decline in many species as a result of increased competition, increased prey depletion and a greater proportion of the population feeding in sub-optimal areas. Where populations are limited, or are close to limitation by the quality and availability of habitat (such as for this species in Penrhyn Estuary and in Botany Bay estuary in total), disturbance can have a negative impact on wader populations by affecting fitness, ability to fatten adequately during pre-migratory periods and increased mortality.

Some studies that have attempted to experimentally asses the impact of disturbance on waterbirds have predominantly used the bird's flight response as an index of disturbance whilst others have only crudely estimated alert distances. In such studies, a disturbance is introduced and the distance of the birds from the disturbance at the point of flight is measured. Buffer distances given for many shorebirds as part of past studies are in the order of 100-400 metres.

Many foraging migratory waders are often disrupted from their typical behaviour well before a flight response is elicited with some birds shown to be alerted at distances on average 30-95% greater than those at which they take flight. Following detection of a disturbance the bird may spend time assessing the degree of threat it is under and may balance the risk with the benefits of continued foraging or roosting. As discussed above, this may be particularly significant to migratory shorebirds during the pre-migratory period of fat accumulation (and post migratory period of recuperation and moulting) where an increase in food requirements during this period results in waders trying to maximise their net rate of resource acquisition and thus invest more time in foraging at the expense of vigilance and anti-predator behaviour. This is particularly significant for shorebirds whose feeding times are regulated by tidal flow (and even more significant for small billed waders such as plovers and stints where foraging areas are further limited by amount of intertidal area not covered with water at low tide). Frequent and intense disturbance is likely to affect wader behaviour and reduce the time they spend foraging. Reductions in feeding may then affect the capacity of waders to fatten at an adequate rate and therefore prolong the pre-migratory feeding period and departure delay. Such delays in migration departure from wintering grounds can seriously affect breeding success of migratory birds, where individuals arriving late at the summer breeding grounds may be at a disadvantage in the competition for mates and territories.

A change in lighting regime (predicted increase in ambient lighting at night) in Penrhyn Estuary may result in an increase in vigilant behaviour (area scans) at the expense of foraging as many shorebirds, particularly those that have been observed to forage nocturnally in "relatively dark" areas (such as sand plovers), may feel that they are more visible to potential predators (feral dogs, cats, birds of prey).

Increased ambient lighting and flashes of light from railway lines may result in the displacement of the shorebirds to sub-optimal (less preferred) habitat elsewhere in the estuary.

The current design essentially encloses Penrhyn Estuary and thus may represent a psychological entry/exit flyway barrier into and out of the shorebird feeding and roosting habitat at the Estuary. Despite their physical capabilities, waders are very reluctant to enter an area that does not have an open aspect (mainly to enable them to have a clear view of potential predators). Based on both the observed current flyways of the shorebirds into and out of the Estuary and on standard wader flyway behaviour, waders currently utilising Penrhyn Estuary fly into the area either from the south over water or from the west by flying south around the runways and turning north-east into the Estuary over water. Based on casual recent and historical URS observations over the years at the site and on discussions with Geoff Ross (NPWS), Phil Straw (Avifauna Research) and local bird naturalists, waders have not been observed flying over docks or runways to or from the Estuary (whereas other suite of bird strike species such as gulls regularly do).

Exclusion fencing, public access restriction to Penrhyn Estuary and boat ramp relocation associated with the proposal may minimise part of the human disturbance element to shorebirds. Shorebirds are often seen at Penryhn Estuary fleeing from roosting on the sandy point on the Penrhyn Road side of the channel to the sandy foothill of the dune on the opposite side of the channel (pers. obs.).

Discussions with Doug Watkins at Wetlands International (Environment Australia) indicate that Yatsu-Higata a landlocked RAMSAR wetland in Tokyo Bay (surrounded by industrial development) Japan is reportedly being used by a number of migratory waders for part of their life cycle requirements. Watkins indicated that the waders roost at the site and may also feed there at a later stage in a flood tide (that is, when the tide is coming in) when their primary feeding habitat (exposed mudflats elsewhere in the Bay) is flooded. Watkins indicated that the waders are flying over industrialised land because of the absence of any other suitable roost sites in the Bay (as a result of 80-90% of the Bay being reclaimed). This would suggest that some waders at Penrhyn Estuary may fly into the Estuary over the operational docks or negotiate along the 130 metre wide channel parallel to Foreshore Beach particularly if they are forced to due to a lack of remaining suitable habitat in the Bay. The waders would not be expected to have any difficulty in negotiating over the proposed road and rail bridges.

The other key potential impact to consider is the effect of any hydrological changes to the Estuary which may result in changes to shorebird feeding and roosting habitat. Hydrodynamic modelling studies of Penrhyn Estuary are currently being undertaken although the results of these studies are not yet complete or available for review. Nevertheless, SPC have indicated that no significant change in tidal regime, water levels and elevation profiles of the sand and mudflats are predicted to occur at Penrhyn Estuary (pers. comm., SPC). SPC also note that no hydrodynamic changes to other important shorebird habitat areas in the Bay (Towra Point, Taren and Shell Points) are predicted to occur (pers. comm., SPC).

The proposal will also result in the loss of remaining areas of shorebird foraging habitat on Botany Beach. The predicted impact on shorebirds however is considered to be negligible due to the volume of pedestrian traffic and dog walking on the beach (disturbance issue) and due to the increased beach erosion and resulting steepness in the elevation profile which has drastically reduced the suitableness of the bird habitat in this area (less intertidal flats on neap tides).

(b) *in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.*

Not Applicable

(c) *in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.*

The proposal may result in a significant modification to shorebird habitat and behaviour at Penryhn Estuary, considered to be an important shorebird habitat for the species on a local and regional basis.

It should be noted that few nocturnal shorebird surveys in the Botany Bay estuary have been undertaken to date and thus data on nocturnal feeding and roosting habitat for shorebirds is not yet available. Nocturnal feeding is just as important (sometimes more important) than diurnal feeding for shorebirds and should not be underestimated in terms of a species life cycle requirements.

(d) *whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community*

The proposal may result in the isolation of shorebird feeding and roosting habitat at Penrhyn Estuary from other known roost sites on the southern shores of the Bay and from general Bay wide bird movements which are undertaken over water.

(e) *whether critical habitat will be affected.*

The study area is not listed as critical habitat under Part 3 Division 1 of the Threatened Species Conservation Act 1995.

(f) *whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.*

No resident or migratory shorebirds in NSW are considered to be adequately conserved due to the unique location of their intertidal habitat. Smith (1991) notes that reservation of wader habitat on intertidal lands has posed a particular problem for NPWS as few coastal reserves include any areas below the high water mark which are generally Crown land. There has been some success, however, in establishing aquatic reserves in NSW such as the Towra Point Aquatic Reserve adjacent to Towra Point Nature Reserve in the Botany Bay estuary which supports

important habitat for many waders such as the Eastern Curlew and Whimbrel. Kooragang Nature Reserve in the Hunter estuary is one of the few present examples within an extensive representation of intertidal wader feeding grounds. This species is regularly recorded in relatively high numbers in the Hunter estuary.

(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening processes.

Not Applicable

(h) whether any threatened species, populations or ecological community is at the limit of its known distribution

This species is regularly recorded in many estuaries on the north and south NSW coasts as well as inland and is thus not considered to be at its limit of distribution in the Botany Bay estuary.

Section 5A Assessment Conclusion

Given that the proposal presently represents potential significant impacts on shorebird habitat at Penrhyn Estuary and given that many of the impacts (particularly those relating to disturbance) are difficult to predict, the precautionary approach must therefore be taken and thus the preparation of a Species Impact Statement for the species is required.

Should the development proceed, and should the proposed enhancement of shorebird habitat at Penrhyn Estuary not prove feasible, off-site enhancement of existing shorebird habitat elsewhere in Botany Bay (such as H1 lands at Woolooware Bay) should be considered. Proposed enhancement of shorebird habitat at Penrhyn Estuary will be addressed in the SIS for the proposal.

Pluvialis dominica (*Pacific Golden Plover*)

(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

This species regularly feeds on intertidal mudflats at Penrhyn Estuary and roosts in saltmarsh at Penrhyn Estuary and on wooden barges at Shell Point (up to 6 birds use the barges on the southern side). Straw (1996) notes that small number of birds also feed and roost at Boat Harbour which may be the result of disturbance to the birds at Penrhyn Estuary. Key feeding habitat of the species at the mouth of the Mill Stream and Runway Beach have been lost due to the Parallel Runway construction and may explain, in part, the marked decline in numbers of this species in the Bay since the mid 1980s. The erosion of intertidal sands off Towra Beach and increased usage of the Boat Harbour area for 4WD usage may similarly explain the marked decline in usage of the southern part of the Bay by the species.

Predicted key impacts from the proposal on this species comprise disturbance to feeding and roosting from a change in lighting regime, increased noise and vibration (human and machinery) from the construction and operation of the port (and associated infrastructure such as railway lines) and potential entry/exit psychological flyway barrier due to the enclosure of Penrhyn Estuary. Disturbance issues are discussed below and are based on the author's general knowledge of shorebirds in New South Wales estuaries and from a desktop literature review of shorebird disturbance studies and other generalist bird studies (Paton et al 2000; Burger 1991; Goss-Custard and Verboven 1993; Smit and Visser 1993; Goss-Custard *et al* 1982; Goss-Custard 1980; Lawler 1996; Roberts and Evans 1993; Batten 1977; Straw 1996; Nelson 1994; Metcalfe and Furness 1984; Weston *et al* 2000).

There is little quantified and experimental assessment of the effects of disturbance to waterbirds and little understanding of the extent of such impacts. Disturbance is defined as a disruption to normal activity patterns. Disturbances to waders may vary in their intensity, frequency, duration, coverage and predictability and there is often inter-specific and intra-specific variation in susceptibility of birds to disturbance which is likely to vary with age, season, weather, location and the degree of habituation to disturbance. There are two potential consequences of sustained, localised disturbance to migratory waders, these being birds may have to shift to alternative, perhaps less favourable feeding grounds and secondly may have their feeding rate reduced by having to devote time to vigilance and anti-predator behaviour. Disturbed shorebirds may spend less time foraging whilst increasing energy-expending behaviours such as fleeing (running, flying). It has also been suggested that migratory birds may be more prone to disturbance than non-migratory species as they are only present in a particular area for part of the year and so have little opportunity to become habituated to the disturbance.

Waders preferably forage in areas where prey density, prey availability and intake rates are relatively high and where energy expenditure is low. Shorebird densities, therefore, tend to reach a maximum in the most preferred feeding areas (Penrhyn Estuary for this species) and where disturbances force birds to shift to alternative feeding areas, questions arise as to whether such areas are adequate, whether they can accommodate displaced individuals and what effect increased bird density has on intake rates and the fitness of those birds that move. As bird density increases, average intake rates decline in many species as a result of increased competition, increased prey depletion and a greater proportion of the population feeding in sub-optimal areas. Where populations are limited, or are close to limitation by the quality and availability of habitat (such as for this species in Penrhyn Estuary and in Botany Bay estuary in total), disturbance can have a negative impact on wader populations by affecting fitness, ability to fatten adequately during pre-migratory periods and increased mortality.

Some studies that have attempted to experimentally asses the impact of disturbance on waterbirds have predominantly used the bird's flight response as an index of disturbance whilst others have only crudely estimated alert distances. In such studies, a disturbance is introduced and the distance of the birds from the disturbance at the point of flight is measured. Buffer distances given for many shorebirds as part of past studies are in the order of 100-400 metres.

Many foraging migratory waders are often disrupted from their typical behaviour well before a flight response is elicited with some birds shown to be alerted at distances on average 30-95% greater than those at which they take flight. Following detection of a disturbance the bird may spend time assessing the degree of threat it is under and may balance the risk with the benefits of continued foraging or roosting. As discussed above, this may be particularly significant to migratory shorebirds during the pre-migratory period of fat accumulation (and post migratory period of recuperation and moulting) where an increase in food requirements during this period results in waders trying to maximise their net rate of resource acquisition and thus invest more time in foraging at the expense of vigilance and anti-predator behaviour. This is particularly significant for shorebirds whose feeding times are regulated by tidal flow (and even more significant for small billed waders such as plovers and stints where foraging areas are further limited by amount of intertidal area not covered with water at low tide). Frequent and intense disturbance is likely to affect wader behaviour and reduce the time they spend foraging. Reductions in feeding may then affect the capacity of waders to fatten at an adequate rate and therefore prolong the pre-migratory feeding period and departure delay. Such delays in migration departure from wintering grounds can seriously affect breeding success of migratory birds, where individuals arriving late at the summer breeding grounds may be at a disadvantage in the competition for mates and territories.

A change in lighting regime (predicted increase in ambient lighting at night) in Penrhyn Estuary may result in an increase in vigilant behaviour (area scans) at the expense of foraging as many shorebirds, particularly those that have been observed to forage nocturnally in "relatively dark" areas (such as sand plovers), may feel that they are more visible to potential predators (feral dogs, cats, birds of prey). Increased ambient lighting and flashes of light from railway lines may result in the displacement of the shorebirds to sub-optimal (less preferred) habitat elsewhere in the estuary, such as Boatharbour.

The current design essentially encloses Penrhyn Estuary and thus may represent a psychological entry/exit flyway barrier into and out of the shorebird feeding and roosting habitat at the Estuary. Despite their physical capabilities, waders are very reluctant to enter an area that does not have an open aspect (mainly to enable them to have a clear view of potential predators). Based on both the observed current flyways of the shorebirds into and out of the Estuary and on standard wader flyway behaviour, waders currently utilising Penrhyn Estuary fly into the area either from the south over water or from the west by flying south around the runways and turning north-east into the Estuary over water. Based on casual recent and historical URS observations over the years at the site and on discussions with Geoff Ross (NPWS), Phil Straw (Avifauna Research) and local bird naturalists, waders have not been observed flying over docks or runways to or from the Estuary (whereas other suite of bird strike species such as gulls regularly do).

Exclusion fencing, public access restriction to Penrhyn Estuary and boat ramp relocation associated with the proposal may minimise part of the human disturbance element to shorebirds. Shorebirds are often seen at Penryhn Estuary fleeing from roosting on the sandy point on the Penrhyn Road side of the channel to the sandy foothill of the dune on the opposite side of the channel (pers. obs.).

Discussions with Doug Watkins at Wetlands International (Environment Australia) indicate that Yatsu-Higata a landlocked RAMSAR wetland in Tokyo Bay (surrounded by industrial development) Japan is reportedly being used by a number of migratory waders for part of their life cycle requirements. Watkins indicated that the waders roost at the site and may also feed there at a later stage in a flood tide (that is, when the tide is coming in) when their primary feeding habitat (exposed mudflats elsewhere in the Bay) is flooded. Watkins indicated that the waders are flying over industrialised land because of the absence of any other suitable roost sites in the Bay (as a result of 80-90% of the Bay being reclaimed). This would suggest that some waders at Penrhyn Estuary may fly into the Estuary over the operational docks or negotiate along the 130 metre wide channel parallel to Foreshore Beach particularly if they are forced to due to a lack of remaining suitable habitat in the Bay. The waders would not be expected to have any difficulty in negotiating over the proposed road and rail bridges.

The other key potential impact to consider is the effect of any hydrological changes to the Estuary which may result in changes to shorebird feeding and roosting habitat. Hydrodynamic modelling studies of Penrhyn Estuary are currently being undertaken although the results of these studies are not yet complete or available for review. Nevertheless, SPC have indicated that no significant change in tidal regime, water levels and elevation profiles of the sand and mudflats are predicted to occur at Penrhyn Estuary (pers. comm., SPC). SPC also note that no hydrodynamic changes to other important shorebird habitat areas in the Bay (Towra Point, Taren and Shell Points) are predicted to occur (pers. comm., SPC).

The proposal will also result in the loss of remaining areas of shorebird foraging habitat on Foreshore Beach. The predicted impact on shorebirds however is considered to be negligible due to the volume of pedestrian traffic and dog walking on the beach (disturbance issue) and due to the increased beach erosion and resulting steepness in the elevation profile which has drastically reduced the suitableness of the bird habitat in this area (less intertidal flats on neap tides).

(b) *in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.*

Not Applicable

(c) *in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.*

The proposal may result in a significant modification to shorebird habitat and behaviour at Penryhn Estuary, considered to be an important shorebird habitat for the species on a local and regional basis.

It should be noted that few nocturnal shorebird surveys in the Botany Bay estuary have been undertaken to date and thus data on nocturnal feeding and roosting habitat for shorebirds is not yet available. Nocturnal feeding is just as important (sometimes more important) than diurnal feeding for shorebirds and should not be underestimated in terms of a species life cycle requirements.

(d) *whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community*

The proposal may result in the isolation of shorebird feeding and roosting habitat at Penrhyn Estuary from other known roost sites on the southern shores of the Bay and from general Bay wide bird movements which are undertaken over water.

(e) *whether critical habitat will be affected.*

The study area is not listed as critical habitat under Part 3 Division 1 of the Threatened Species Conservation Act 1995.

(f) *whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.*

No resident or migratory shorebirds in NSW are considered to be adequately conserved due to the unique location of their intertidal habitat. Smith (1991) notes that reservation of wader habitat on intertidal lands has posed a particular problem for NPWS as few coastal reserves include any areas below the high water mark which are generally Crown land. There has been some success, however, in establishing aquatic reserves in NSW such as the Towra Point Aquatic Reserve adjacent to Towra Point Nature Reserve in the Botany Bay estuary which supports

important habitat for many waders such as the Eastern Curlew and Whimbrel. Kooragang Nature Reserve in the Hunter estuary is one of the few present examples within an extensive representation of intertidal wader feeding grounds. This species is regularly recorded in relatively high numbers in the Hunter estuary.

(g) *whether the development or activity proposed is of a class of development or activity that is recognised as a threatening processes.*

Not Applicable

(h) *whether any threatened species, populations or ecological community is at the limit of its known distribution*

This species is regularly recorded in many estuaries on the north and south NSW coasts as well as inland and is thus not considered to be at its limit of distribution in the Botany Bay estuary.

Section 5A Assessment Conclusion

Given that the proposal presently represents potential significant impacts on shorebird habitat at Penrhyn Estuary and given that many of the impacts (particularly those relating to disturbance) are difficult to predict, the precautionary approach must therefore be taken and thus the preparation of a Species Impact Statement for the species is required.

Should the development proceed, and should the proposed enhancement of shorebird habitat at Penrhyn Estuary not prove feasible, off-site enhancement of existing shorebird habitat elsewhere in Botany Bay (such as H1 lands at Woolooware Bay) should be considered. Proposed enhancement of shorebird habitat at Penrhyn Estuary will be addressed in the SIS for the proposal.

Haematopus longirostris (Pied Oystercatcher)

(a) *in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.*

This Australian resident wader presently occurs in relatively large numbers (up to 60 individuals) in the Bay at Sandringham Bay where it feeds and roosts and at Penryhn Estuary where it occasionally feeds on intertidal sandflats. Presently 5 or 6 pairs nest at H1 lands at Woolooware Bay, Towra Spit Island and at the airport. The volume of pedestrian traffic on Foreshore Beach would be expected to preclude this from being used by the species for its life cycle requirements, particularly nesting activity.

Predicted key impacts from the proposal on this species comprise disturbance to feeding and roosting from a change in lighting regime, increased noise and vibration (human and machinery) from the construction and operation of the port (and associated infrastructure such as railway lines) and potential entry/exit psychological flyway barrier due to the enclosure of Penrhyn Estuary. Disturbance issues are discussed below and are based on the author’s general knowledge of shorebirds in New South Wales estuaries and from a desktop literature review of shorebird disturbance studies and other generalist bird studies (Paton et al 2000; Burger 1991; Goss-Custard and Verboven 1993; Smit and Visser 1993; Goss-Custard *et al* 1982; Goss-Custard 1980; Lawler 1996; Roberts and Evans 1993; Batten 1977; Straw 1996; Nelson 1994; Metcalfe and Furness 1984; Weston *et al* 2000).

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Waders preferably forage in areas where prey density, prey availability and intake rates are relatively high and where energy expenditure is low. Shorebird densities, therefore, tend to reach a maximum in the most preferred feeding areas (Penrhyn Estuary for this species) and where disturbances force birds to shift to alternative feeding areas, questions arise as to whether such areas are adequate, whether they can accommodate displaced individuals and what effect increased bird density has on intake rates and the fitness of those birds that move. As bird density increases, average intake rates decline in many species as a result of increased competition, increased prey depletion and a greater proportion of the population feeding in sub-optimal areas. Where populations are limited, or are close to limitation by the quality and availability of habitat (such as for this species in Penrhyn Estuary and in the Botany Bay estuary in total), disturbance can have a negative impact on wader populations by affecting fitness and increased mortality.

Some studies that have attempted to experimentally asses the impact of disturbance on waterbirds have predominantly used the bird's flight response as an index of disturbance whilst others have only crudely estimated alert distances. In such studies, a disturbance is introduced and the distance of the birds from the disturbance at the point of flight is measured. Buffer distances given for many shorebirds as part of past studies are in the order of 100-400 metres.

Many foraging migratory waders are often disrupted from their typical behaviour well before a flight response is elicited with some birds shown to be alerted at distances on average 30-95% greater than those at which they take flight. Following detection of a disturbance the bird may spend time assessing the degree of threat it is under and may balance the risk with the benefits of continued foraging or roosting. This is particularly significant for shorebirds whose feeding times are regulated by tidal flow (and even more significant for small billed waders such as plovers and stints where foraging areas are further limited by amount of intertidal area not covered with water at low tide).

A change in lighting regime (predicted increase in ambient lighting at night) at the Estuary may result in an increase in vigilant behaviour (area scans) at the expense of foraging as many shorebirds, particularly those that have been observed to forage nocturnally in "relatively dark" areas (such as sand plovers), may feel that they are more visible to potential predators (feral dogs, cats, birds of prey). Increased ambient lighting and flashes of light from railway lines may result in the displacement of the shorebirds to sub-optimal (less preferred) habitat elsewhere in the estuary, such as Boat Harbour and Taren Point.

The current design essentially encloses Penrhyn Estuary and thus may represent a psychological entry/exit flyway barrier into and out of the shorebird feeding and roosting habitat at the Estuary. Despite their physical capabilities, waders are very reluctant to enter an area that does not have an open aspect (mainly to enable them to have a clear view of potential predators). Based on both the observed current flyways of the shorebirds into and out of the Estuary and on standard wader flyway behaviour, waders currently utilising Penrhyn Estuary fly into the area either from the south over water or from the west by flying south around the runways and turning north-east into the Estuary over water. Based on casual recent and historical URS observations over the years at the site and on discussions with Geoff Ross (NPWS), Phil Straw (Avifauna Research) and local bird naturalists, waders have not been observed flying over docks or runways to or from the Estuary (whereas other suite of bird strike species such as gulls regularly do).

Exclusion fencing, public access restriction to Penrhyn Estuary and boat ramp relocation associated with the proposal may minimise part of the human disturbance element to shorebirds. Shorebirds are often seen at Penryhn Estuary fleeing from roosting on the sandy point on the Penrhyn Road side of the channel to the sandy foothill of the dune on the opposite side of the channel (pers. obs.).

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The proposal will also result in the loss of remaining areas of shorebird foraging habitat on Foreshore Beach. The predicted impact on shorebirds however is considered to be negligible due to the volume of pedestrian traffic and dog walking on the beach (disturbance issue) and due to the increased beach erosion and resulting steepness in the elevation profile which has drastically reduced the suitableness of the bird habitat in this area (less intertidal flats on neap tides).

(b) *in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.*

Not Applicable

(c) *in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.*

The proposal may result in a significant modification to shorebird habitat and behaviour at Penryhn Estuary, considered to be an important shorebird habitat for the species on a local and regional basis.

It should be noted that few nocturnal shorebird surveys in the Botany Bay estuary have been undertaken to date and thus data on nocturnal feeding and roosting habitat for shorebirds is not yet available. Nocturnal feeding is just as important (sometimes more important) than diurnal feeding for shorebirds and should not be underestimated in terms of a species life cycle requirements.

(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community

The proposal may result in the isolation of shorebird feeding and roosting habitat at Penrhyn Estuary from other known roost sites on the southern shores of the Bay and from general Bay wide bird movements which are undertaken over water.

(e) whether critical habitat will be affected.

The study area is not listed as critical habitat under Part 3 Division 1 of the Threatened Species Conservation Act 1995.

(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.

No resident or migratory shorebirds in NSW are considered to be adequately conserved due to the unique location of their intertidal habitat. Smith (1991) notes that reservation of wader habitat on intertidal lands has posed a particular problem for NPWS as few coastal reserves include any areas below the high water mark which are generally Crown land. There has been some success, however, in establishing aquatic reserves in NSW such as the Towra Point Aquatic Reserve adjacent to Towra Point Nature Reserve in the Botany Bay estuary which supports important habitat for many waders such as the Eastern Curlew and Whimbrel. Kooragang Nature Reserve in the Hunter estuary is one of the few present examples within an extensive representation of intertidal wader feeding grounds. This species is regularly recorded in relatively high numbers in the Hunter estuary.

(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening processes.

Not Applicable

(h) whether any threatened species, populations or ecological community is at the limit of its known distribution

This species is regularly recorded in many estuaries on the north and south NSW coasts and is thus not considered to be at its limit of distribution in the Botany Bay estuary.

Section 5A Assessment Conclusion

Given that the proposal presently represents potential significant impacts on shorebird habitat at Penrhyn Estuary and given that many of the impacts (particularly those relating to disturbance) are difficult to predict, the precautionary approach must therefore be taken and thus the preparation of a Species Impact Statement for the species is required.

Should the development proceed, and should the proposed enhancement of shorebird habitat at Penrhyn Estuary not prove feasible, off-site enhancement of existing shorebird habitat elsewhere in Botany Bay (such as H1 lands at Woolooware Bay) should be considered. Proposed enhancement of shorebird habitat at Penrhyn Estuary will be addressed in the SIS for the proposal.

Black-tailed **Godwit *(Limosa limosa)***

(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

This species feeds on intertidal mudflats and on muddy margins of wetlands. The species occurs in very small numbers (1 or 2 individuals) in the Parramatta River estuary at Homebush Bay and may occasionally forage and roost at Penryhyn Estuary although no recent sightings of this species have been recorded in Botany Bay in recent years. The species is regularly recorded in the hundreds in the Hunter River and north coast estuaries (eg, Clarence River).

Predicted key impacts from the proposal on this species comprise disturbance to feeding and roosting from a change in lighting regime, increased noise and vibration (human and machinery) from the construction and operation of the port (and associated infrastructure such as railway lines) and potential entry/exit psychological flyway barrier due to the enclosure of Penrhyn Estuary. Disturbance issues are discussed below and are based on the author’s general knowledge of shorebirds in New South Wales estuaries and from a desktop literature review of shorebird disturbance studies and other generalist bird studies (Paton et al 2000; Burger 1991; Goss-Custard and Verboven 1993; Smit and Visser 1993; Goss-Custard *et al* 1982; Goss-Custard 1980; Lawler 1996; Roberts and Evans 1993; Batten 1977; Straw 1996; Nelson 1994; Metcalfe and Furness 1984; Weston *et al* 2000).

There is little quantified and experimental assessment of the effects of disturbance to waterbirds and little understanding of the extent of such impacts. Disturbance is defined as a disruption to normal activity patterns. Disturbances to waders may vary in their intensity, frequency, duration, coverage and predictability and there is often inter-specific and intra-specific variation in susceptibility of birds to disturbance which is likely to vary with age, season, weather, location and the degree of habituation to disturbance. There are two potential consequences of sustained, localised disturbance to migratory waders, these being birds may have to shift to alternative, perhaps less favourable feeding grounds and secondly may have their feeding rate reduced by having to devote time to vigilance and anti-predator behaviour. Disturbed shorebirds may spend less time foraging whilst increasing energy-expending behaviours such as fleeing (running, flying). It has also been suggested that migratory birds may be more prone to disturbance than non-migratory species as they are only present in a particular area for part of the year and so have little opportunity to become habituated tothe disturbance.

Waders preferably forage in areas where prey density, prey availability and intake rates are relatively high and where energy expenditure is low. Shorebird densities, therefore, tend to reach a maximum in the most preferred feeding areas and where disturbances force birds to shift to alternative feeding areas, questions arise as to whether such areas are adequate, whether they can accommodate displaced individuals and what effect increased bird density has on intake rates and the fitness

of those birds that move. As bird density increases, average intake rates decline in many species as a result of increased competition, increased prey depletion and a greater proportion of the population feeding in sub-optimal areas. Where populations are limited, or are close to limitation by the quality and availability of habitat, disturbance can have a negative impact on wader populations by affecting fitness, ability to fatten adequately during pre-migratory periods and increased mortality.

Some studies that have attempted to experimentally asses the impact of disturbance on waterbirds have predominantly used the bird’s flight response as an index of disturbance whilst others have only crudely estimated alert distances. In such studies, a disturbance is introduced and the distance of the birds from the disturbance at the point of flight is measured. Buffer distances given for many shorebirds as part of past studies are in the order of 100-400 metres.

Many foraging migratory waders are often disrupted from their typical behaviour well before a flight response is elicited with some birds shown to be alerted at distances on average 30-95% greater than those at which they take flight. Following detection of a disturbance the bird may spend time assessing the degree of threat it is under and may balance the risk with the benefits of continued foraging or roosting. As discussed above, this may be particularly significant to migratory shorebirds during the pre-migratory period of fat accumulation (and post migratory period of recuperation and moulting) where an increase in food requirements during this period results in waders trying to maximise their net rate of resource acquisition and thus invest more time in foraging at the expense of vigilance and anti-predator behaviour. This is particularly significant for shorebirds whose feeding times are regulated by tidal flow (and even more significant for small billed waders such as plovers and stints where foraging areas are further limited by amount of intertidal area not covered with water at low tide). Frequent and intense disturbance is likely to affect wader behaviour and reduce the time they spend foraging. Reductions in feeding may then affect the capacity of waders to fatten at an adequate rate and therefore prolong the pre-migratory feeding period and departure delay. Such delays in migration departure from wintering grounds can seriously affect breeding success of migratory birds, where individuals arriving late at the summer breeding grounds may be at a disadvantage in the competition for mates and territories.

A change in lighting regime (predicted increase in ambient lighting at night) in Penrhyn Estuary may result in an increase in vigilant behaviour (area scans) at the expense of foraging as many shorebirds, particularly those that have been observed to forage nocturnally in “relatively dark” areas (such as sand plovers), may feel that they are more visible to potential predators (feral dogs, cats, birds of prey). Increased ambient lighting and flashes of light from railway lines may result in the displacement of the shorebirds to sub-optimal (less preferred) habitat elsewhere in the estuary.

The current design essentially encloses Penrhyn Estuary and thus may represent a psychological entry/exit flyway barrier into and out of the shorebird feeding and roosting habitat at the Estuary. Despite their physical capabilities, waders are very

reluctant to enter an area that does not have an open aspect (mainly to enable them to have a clear view of potential predators). Based on both the observed current flyways of the shorebirds into and out of the Estuary and on standard wader flyway behaviour, waders currently utilising Penrhyn Estuary fly into the area either from the south over water or from the west by flying south around the runways and turning north-east into the Estuary over water. Based on casual recent and historical URS observations over the years at the site and on discussions with Geoff Ross (NPWS), Phil Straw (Avifauna Research) and local bird naturalists, waders have not been observed flying over docks or runways to or from the Estuary (whereas other suite of bird strike species such as gulls regularly do).

Exclusion fencing, public access restriction to Penrhyn Estuary and boat ramp relocation associated with the proposal may minimise part of the human disturbance element to shorebirds. Shorebirds are often seen at Penryhn Estuary fleeing from roosting on the sandy point on the Penrhyn Road side of the channel to the sandy foothill of the dune on the opposite side of the channel (pers. obs.).

Discussions with Doug Watkins at Wetlands International (Environment Australia) indicate that Yatsu-Higata a landlocked RAMSAR wetland in Tokyo Bay (surrounded by industrial development) Japan is reportedly being used by a number of migratory waders for part of their life cycle requirements. Watkins indicated that the waders roost at the site and may also feed there at a later stage in a flood tide (that is, when the tide is coming in) when their primary feeding habitat (exposed mudflats elsewhere in the Bay) is flooded. Watkins indicated that the waders are flying over industrialised land because of the absence of any other suitable roost sites in the Bay (as a result of 80-90% of the Bay being reclaimed). This would suggest that some waders at Penrhyn Estuary may fly into the Estuary over the operational docks or negotiate along the 130 metre wide channel parallel to Foreshore Beach particularly if they are forced to due to a lack of remaining suitable habitat in the Bay. The waders would not be expected to have any difficulty in negotiating over the proposed road and rail bridges.

The other key potential impact to consider is the effect of any hydrological changes to the Estuary which may result in changes to shorebird feeding and roosting habitat. Hydrodynamic modelling studies of Penrhyn Estuary are currently being undertaken although the results of these studies are not yet complete or available for review. Nevertheless, SPC have indicated that no significant change in tidal regime, water levels and elevation profiles of the sand and mudflats are predicted to occur at Penrhyn Estuary (pers. comm., SPC). SPC also note that no hydrodynamic changes to other important shorebird habitat areas in the Bay (Towra Point, Tarenand Shell Points) are predicted to occur (pers. comm., SPC).

The proposal will also result in the loss of remaining areas of shorebird foraging habitat on Foreshore Beach. The predicted impact on shorebirds however is considered to be negligible due to the volume of pedestrian traffic and dog walking on the beach (disturbance issue) and due to the increased beach erosion and resulting steepness in the elevation profile which has drastically reduced the suitableness of the bird habitat in this area (less intertidal flats on neap tides).

(b) *in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.*

Not Applicable

(c) *in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.*

The proposal may result in a significant modification to shorebird habitat and behaviour at Penryhn Estuary, considered to be an important shorebird habitat for the species on a local and regional basis.

It should be noted that few nocturnal shorebird surveys in the Botany Bay estuary have been undertaken to date and thus data on nocturnal feeding and roosting habitat for shorebirds is not yet available. Nocturnal feeding is just as important (sometimes more important) than diurnal feeding for shorebirds and should not be underestimated in terms of a species life cycle requirements.

(d) *whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community*

The proposal may result in the isolation of shorebird feeding and roosting habitat at Penrhyn Estuary from other known roost sites on the southern shores of the Bay and from general Bay wide bird movements which are undertaken over water.

(e) *whether critical habitat will be affected.*

The study area is not listed as critical habitat under Part 3 Division 1 of the Threatened Species Conservation Act 1995.

(f) *whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.*

No resident or migratory shorebirds in NSW are considered to be adequately conserved due to the unique location of their intertidal habitat. Smith (1991) notes that reservation of wader habitat on intertidal lands has posed a particular problem for NPWS as few coastal reserves include any areas below the high water mark which are generally Crown land. There has been some success, however, in establishing aquatic reserves in NSW such as the Towra Point Aquatic Reserve adjacent to Towra Point Nature Reserve in the Botany Bay estuary which supports important habitat for many waders such as the Eastern Curlew and Whimbrel. Kooragang Nature Reserve in the Hunter estuary is one of the few present examples within an extensive representation of intertidal wader feeding grounds. This species is regularly recorded in relatively high numbers in the Hunter estuary.

(g) *whether the development or activity proposed is of a class of development or activity that is recognised as a threatening processes.*

Not Applicable

(i) *whether any threatened species, populations or ecological community is at the limit of its known distribution*

This species is regularly recorded in many estuaries on the north and south NSW coasts (albeit in scarcer numbers further south) and is thus not considered to be at its limit of distribution in the Botany Bay estuary.

Section 5A Assessment Conclusion

Given that the proposal presently represents potential significant impacts on shorebird habitat at Penrhyn Estuary and given that many of the impacts (particularly those relating to disturbance) are difficult to predict, the precautionary approach must therefore be taken and thus the preparation of a Species Impact Statement for the species is required.

Should the development proceed, and should the proposed enhancement of shorebird habitat at Penrhyn Estuary not prove feasible, off-site enhancement of existing shorebird habitat elsewhere in Botany Bay (such as H1 lands at Woolooware Bay) should be considered. Proposed enhancement of shorebird habitat at Penrhyn Estuary will be addressed in the SIS for the proposal.

Sharp-tailed Sandpiper (Calidris acuminata)

(a) *in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.*

This species typically feeds and roosts in saltmarsh at the Barton Park (Eve Street) wetland and may occasionally forage and roost in the upper reaches of Penrhyn Estuary in mudflats and saltmarsh. The species has been recorded at Penrhyn Estuary in 1995, 1996 (68 individuals) and 1997 (32 individuals). This species is regularly recorded in the low thousands in the Hunter estuary (Kooragang) and is abundant inland west of Bourke.

Predicted key impacts from the proposal on this species comprise disturbance to feeding and roosting from a change in lighting regime, increased noise and vibration (human and machinery) from the construction and operation of the port (and associated infrastructure such as railway lines) and potential entry/exit psychological flyway barrier due to the enclosure of Penrhyn Estuary. Disturbance issues are discussed below and are based on the author's general knowledge of shorebirds in New South Wales estuaries and from a desktop literature review of shorebird disturbance studies and other generalist bird studies (Paton et al 2000; Burger 1991; Goss-Custard and Verboven 1993; Smit and Visser 1993; Goss-Custard *et al* 1982; Goss-Custard 1980; Lawler 1996; Roberts and Evans 1993; Batten 1977; Straw 1996; Nelson 1994; Metcalfe and Furness 1984; Weston *et al* 2000).

There is little quantified and experimental assessment of the effects of disturbance to waterbirds and little understanding of the extent of such impacts. Disturbance is defined as a disruption to normal activity patterns. Disturbances to waders may vary in their intensity, frequency, duration, coverage and predictability and there is often inter-specific and intra-specific variation in susceptibility of birds to disturbance which is likely to vary with age, season, weather, location and the degree of habituation to disturbance. There are two potential consequences of sustained, localised disturbance to migratory waders, these being birds may have to shift to alternative, perhaps less favourable feeding grounds and secondly may have their feeding rate reduced by having to devote time to vigilance and anti-predator behaviour. Disturbed shorebirds may spend less time foraging whilst increasing energy-expending behaviours such as fleeing (running, flying). It has also been suggested that migratory birds may be more prone to disturbance than non-migratory species as they are only present in a particular area for part of the year and so have little opportunity to become habituated to the disturbance.

Waders preferably forage in areas where prey density, prey availability and intake rates are relatively high and where energy expenditure is low. Shorebird densities, therefore, tend to reach a maximum in the most preferred feeding areas and where disturbances force birds to shift to alternative feeding areas, questions arise as to whether such areas are adequate, whether they can accommodate displaced individuals and what effect increased bird density has on intake rates and the fitness

of those birds that move. As bird density increases, average intake rates decline in many species as a result of increased competition, increased prey depletion and a greater proportion of the population feeding in sub-optimal areas. Where populations are limited, or are close to limitation by the quality and availability of habitat, disturbance can have a negative impact on wader populations by affecting fitness, ability to fatten adequately during pre-migratory periods and increased mortality.

Some studies that have attempted to experimentally asses the impact of disturbance on waterbirds have predominantly used the bird's flight response as an index of disturbance whilst others have only crudely estimated alert distances. In such studies, a disturbance is introduced and the distance of the birds from the disturbance at the point of flight is measured. Buffer distances given for many shorebirds as part of past studies are in the order of 100-400 metres.

Many foraging migratory waders are often disrupted from their typical behaviour well before a flight response is elicited with some birds shown to be alerted at distances on average 30-95% greater than those at which they take flight. Following detection of a disturbance the bird may spend time assessing the degree of threat it is under and may balance the risk with the benefits of continued foraging or roosting. As discussed above, this may be particularly significant to migratory shorebirds during the pre-migratory period of fat accumulation (and post migratory period of recuperation and moulting) where an increase in food requirements during this period results in waders trying to maximise their net rate of resource acquisition and thus invest more time in foraging at the expense of vigilance and anti-predator behaviour. This is particularly significant for shorebirds whose feeding times are regulated by tidal flow (and even more significant for small billed waders such as plovers and stints where foraging areas are further limited by amount of intertidal area not covered with water at low tide). Frequent and intense disturbance is likely to affect wader behaviour and reduce the time they spend foraging. Reductions in feeding may then affect the capacity of waders to fatten at an adequate rate and therefore prolong the pre-migratory feeding period and departure delay. Such delays in migration departure from wintering grounds can seriously affect breeding success of migratory birds, where individuals arriving late at the summer breeding grounds may be at a disadvantage in the competition for mates and territories.

A change in lighting regime (predicted increase in ambient lighting at night) in Penrhyn Estuary may result in an increase in vigilant behaviour (area scans) at the expense of foraging as many shorebirds, particularly those that have been observed to forage nocturnally in "relatively dark" areas (such as sand plovers), may feel that they are more visible to potential predators (feral dogs, cats, birds of prey). Increased ambient lighting and flashes of light from railway lines may result in the displacement of the shorebirds to sub-optimal (less preferred) habitat elsewhere in the estuary.

The current design essentially encloses Penrhyn Estuary and thus may represent a psychological entry/exit flyway barrier into and out of the shorebird feeding and roosting habitat at the Estuary. Despite their physical capabilities, waders are very

reluctant to enter an area that does not have and open aspect (mainly to enable them to have a clear view of potential predators). Based on both the observed current flyways of the shorebirds into and out of the Estuary and on standard wader flyway behaviour, waders currently utilising Penrhyn Estuary fly into the area either from the south over water or from the west by flying south around the runways and turning north-east into the Estuary over water. Based on casual recent and historical URS observations over the years at the site and on discussions with Geoff Ross (NPWS), Phil Straw (Avifauna Research) and local bird naturalists, waders have not been observed flying over docks or runways to or from the Estuary (whereas other suite of bird strike species such as gulls regularly do).

Exclusion fencing, public access restriction to Penrhyn Estuary and boat ramp relocation associated with the proposal may minimise part of the human disturbance element to shorebirds. Shorebirds are often seen at Penryhn Estuary fleeing from roosting on the sandy point on the Penrhyn Road side of the channel to the sandy foothill of the dune on the opposite side of the channel (pers. obs.).

Discussions with Doug Watkins at Wetlands International (Environment Australia) indicate that Yatsu-Higata a landlocked RAMSAR wetland in Tokyo Bay (surrounded by industrial development) Japan is reportedly being used by a number of migratory waders for part of their life cycle requirements. Watkins indicated that the waders roost at the site and may also feed there at a later stage in a flood tide (that is, when the tide is coming in) when their primary feeding habitat (exposed mudflats elsewhere in the Bay) is flooded. Watkins indicated that the waders are flying over industrialised land because of the absence of any other suitable roost sites in the Bay (as a result of 80-90% of the Bay being reclaimed). This would suggest that some waders at Penrhyn Estuary may fly into the Estuary over the operational docks or negotiate along the 130 metre wide channel parallel to Foreshore Beach particularly if they are forced to due to a lack of remaining suitable habitat in the Bay. The waders would not be expected to have any difficulty in negotiating over the proposed road and rail bridges.

The other key potential impact to consider is the effect of any hydrological changes to the Estuary which may result in changes to shorebird feeding and roosting habitat. Hydrodynamic modelling studies in Penrhyn Estuary are currently being undertaken although the results of these studies are not yet complete or available for review. Nevertheless, SPC have indicated that no significant change in tidal regime, water levels and elevation profiles of the sand and mudflats are predicted to occur at Penrhyn Estuary (pers. comm., SPC). SPC also note that no hydrodynamic changes to other important shorebird habitat areas in the Bay (Towra, Taren-Shell Point) are predicted to occur (pers. comm., SPC).

The proposal will also result in the loss of remaining areas of shorebird foraging habitat on Foreshore Beach. The predicted impact on shorebirds however is considered to be negligible due to the volume of pedestrian traffic and dog walking on the beach (disturbance issue) and due to the increased beach erosion and resulting steepness in the elevation profile which has drastically reduced the suitableness of the bird habitat in this area (less intertidal flats on neap tides).

(b) *in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.*

Not Applicable

(c) *in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.*

The proposal may result in a significant modification to shorebird habitat and behaviour at Penryhn Estuary, considered to be an important shorebird habitat for the species on a local and regional basis.

It should be noted that few nocturnal shorebird surveys in the Botany Bay estuary have been undertaken to date and thus data on nocturnal feeding and roosting habitat for shorebirds is not yet available. Nocturnal feeding is just as important (sometimes more important) than diurnal feeding for shorebirds and should not be underestimated in terms of a specie's life cycle requirements.

(d) *whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community*

The proposal may result in the isolation of shorebird feeding and roosting habitat at Penrhyn Estuary from other known roost sites on the southern shores of the Bay and from general Bay wide bird movements which are undertaken over water.

(e) *whether critical habitat will be affected.*

The study area is not listed as critical habitat under Part 3 Division 1 of the Threatened Species Conservation Act 1995.

(f) *whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.*

No resident or migratory shorebirds in NSW are considered to be adequately conserved due to the unique location of their intertidal habitat. Smith (1991) notes that reservation of wader habitat on intertidal lands has posed a particular problem for NPWS as few coastal reserves include any areas below the high water mark which are generally Crown land. There has been some success, however, in establishing aquatic reserves in NSW such as the Towra Point Aquatic Reserve adjacent to Towra Point Nature Reserve in the Botany Bay estuary which supports important habitat for many waders such as the Eastern Curlew and Whimbrel. Kooragang Nature Reserve in the Hunter estuary is one of the few present examples within an extensive representation of intertidal wader feeding grounds. This species is regularly recorded in relatively high numbers in the Hunter estuary.

(g) *whether the development or activity proposed is of a class of development or activity that is recognised as a threatening processes.*

Not Applicable

(j) *whether any threatened species, populations or ecological community is at the limit of its known distribution*

This species is regularly recorded in many estuaries on the north and south NSW coasts as well as inland and is thus not considered to be at its limit of distribution in the Botany Bay estuary.

Section 5A Assessment Conclusion

Given that the proposal presently represents potential significant impacts on shorebird habitat at Penrhyn Estuary and given that many of the impacts (particularly those relating to disturbance) are difficult to predict, the precautionary approach must therefore be taken and thus the preparation of a Species Impact Statement for the species is required.

Should the development proceed, and should the proposed enhancement of shorebird habitat at Penrhyn Estuary not prove feasible, off-site enhancement of existing shorebird habitat elsewhere in Botany Bay (such as H1 lands at Woolooware Bay) should be considered. Proposed enhancement of shorebird habitat at Penrhyn Estuary will be addressed in the SIS for the proposal.

Sterna albifrons (Little Tern)

(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

This assessment refers to the south-eastern Australian population of the Little Tern subspecies *sinensis* which migrates down the east coast of Australia during spring and summer to nest as solitary pairs or in small colonies (Smith 1991).

This species forages at the mouth of Penrhyn Estuary for small fish and also roosts at the Estuary. This species has successfully nested in recent years on Towra Spit Island but was unsuccessful last season to due predators (ravens, gulls). The species aborted nesting on Towra Spit Island last season and fled to Molineux Point to nest where roughly 30 chicks fledged, although no data on numbers of nesting pairs were recorded (pers. comm., Geoff Ross). NPWS note that upwards of 60 pairs of the bird nested on Towra Spit Island during the past 10 years (pers. comm., Geoff Ross). Enhancement of habitat at Penrhyn Estuarycoupled with public access restrictions associated with the proposal may attract the species to nest in the area. Fox baiting is reportedly underway throughout all areas at Towra Point Nature/Aquatic reserve in an attempt to minimise the chances of foxes predating on future Little Tern nesting sites on Towra Spit Island (a concern given that the island is moving south and the foxes may be able to access the island via mangroves at Towra Point).

Predicted key impacts from the proposal on this species comprise disturbance to feeding and roosting from a change in lighting regime, increased noise and vibration (human and machinery) from the construction and operation of the port (and associated infrastructure such as railway lines) and potential entry/exit psychological flyway barrier due to the enclosure of Penrhyn Estuary. Disturbance issues are discussed below and are based on the author's general knowledge of shorebirds in New South Wales estuaries and from a desktop literature review of shorebird disturbance studies and other generalist bird studies (Paton et al 2000; Burger 1991; Goss-Custard and Verboven 1993; Smit and Visser 1993; Goss-Custard *et al* 1982; Goss-Custard 1980; Lawler 1996; Roberts and Evans 1993; Batten 1977; Straw 1996; Nelson 1994; Metcalfe and Furness 1984; Weston *et al* 2000).

There is little quantified and experimental assessment of the effects of disturbance to waterbirds and seabirds and little understanding of the extent of such impacts. Disturbance is defined as a disruption to normal activity patterns. There are two potential consequences of sustained, localised disturbance to the Little Tern, these being birds may have to shift to alternative, perhaps less favourable feeding grounds and secondly may have their feeding rate reduced by having to devote time to vigilance and anti-predator behaviour. Disturbed shorebirds may spend less time foraging whilst increasing energy-expending behaviours such as fleeing (flying). The birds may also be disrupted from diurnal and nocturnal roosting activity.

The current design essentially encloses Penrhyn Estuary and thus may represent a psychological entry/exit flyway barrier into and out of the shorebird feeding and roosting habitat at the Estuary. Despite their physical capabilities, waders are very reluctant to enter an area that does not have and open aspect (mainly to enable them to have a clear view of potential predators). Based on both the observed current flyways of the shorebirds into and out of the Estuary and on standard wader flyway behaviour, waders currently utilising Penrhyn Estuary fly into the area either from the south over water or from the west by flying south around the runways and turning north-east into the Estuary over water. Based on casual recent and historical URS observations over the years at the site and on discussions with Geoff Ross (NPWS), Phil Straw (Avifauna Research) and local bird naturalists, waders have not been observed flying over docks or runways to or from the Estuary (whereas other suite of bird strike species such as gulls regularly do).

Discussions with Doug Watkins at Wetlands International (Environment Australia) indicate that Yatsu-Higata a landlocked RAMSAR wetland in Tokyo Bay (surrounded by industrial development) Japan is reportedly being used by a number of migratory waders for part of their life cycle requirements. Watkins indicated that the waders roost at the site and may also feed there at a later stage in a flood tide (that is, when the tide is coming in) when their primary feeding habitat (exposed mudflats elsewhere in the Bay) is flooded. Watkins indicated that the waders are flying over industrialised land because of the absence of any other suitable roost sites in the Bay (as a result of 80-90% of the Bay being reclaimed). This would suggest that some waders at Penrhyn Estuary may fly into the Estuary over the operational docks or negotiate along the 130 metre wide channel parallel to Foreshore Beach particularly if they are forced to due to a lack of remaining suitable habitat in the Bay. The waders would not be expected to have any difficulty in negotiating over the proposed road and rail bridges.

The other key potential impact to consider is the effect of any hydrological changes to the Estuary which may result in changes to shorebird feeding and roosting habitat. Hydrodynamic modelling studies of Penrhyn Estuary are currently being undertaken although the results of these studies are not yet complete or available for review. Nevertheless, SPC have indicated that no significant change in tidal regime, water levels and elevation profiles of the sand and mudflats are predicted to occur at Penrhyn Estuary (pers. comm., SPC). SPC also note that no hydrodynamic changes to other important shorebird habitat areas in the Bay (Towra Point, Taren and Shell Points) are predicted to occur (pers. comm., SPC).

Exclusion fencing, public access restriction to Penrhyn Estuary and boat ramp relocation associated with the proposal may minimise part of the human disturbance element to the Little Tern.

The loss of shallow water areas at Foreshore Beach is not considered to be a significant issue for this species as this area currently provides little habitat for the species due to the level of disturbance.

(b) *in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.*

Not Applicable

(c) *in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.*

The proposal may result in a significant modification to Little Tern habitat and behaviour at Penryhn Estuary, considered to be an important habitat for the species on a local and regional basis.

(d) *whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community*

The proposal may result in the isolation of feeding and roosting habitat at Penrhyn Estuary from other known feeding and roost sites on the southern shores of the Bay and from general Bay wide bird movements which are undertaken over water.

(e) *whether critical habitat will be affected.*

The study area is not listed as critical habitat under Part 3 Division 1 of the Threatened Species Conservation Act 1995.

(f) *whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region.*

Whilst the specie's main nesting site at Towra Spit Island does fall under the NPWS estate and is reserved, the constant threat to nesting sites from natural and human disturbance which cause the bird to seek alternative sites in the Bay on unreserved land needs to be considered when assessing the conservation status of the species in the locality and region.

(g) *whether the development or activity proposed is of a class of development or activity that is recognised as a threatening processes.*

Not Applicable

(h) *whether any threatened species, populations or ecological community is at the limit of its known distribution*

This species is regularly recorded in many estuaries on the north and south NSW coasts and is thus not considered to be at its limit of distribution at Botany Bay estuary.

Section 5A Assessment Conclusion

Given that the proposal presently represents potential significant impacts on feeding and roosting habitat at Penrhyn Estuary and given that many of the impacts (particularly those relating to disturbance) are difficult to predict, the precautionary approach must therefore be taken and thus the preparation of a Species Impact Statement for the species is required.

Appendix B

Director General (NPWS) Requirements and other SIS Requirements

NSW
NATIONAL
PARKS AND
WILDLIFE
SERVICE
ABN 30 841 387 271

Barrie Turner
Manager Development & Statutory Planning
Sydney Ports Corporation
PO Box 25
MILLERS POINT NSW 2000

our ref:CPPD/PG/98/31
your ref: F1992

Dear Mr Turner

DIRECTOR-GENERAL'S REQUIREMENTS FOR THE PROPOSED EXPANSION OF PORT FACILITIES PORT BOTANY

Thank you for your letter dated 21 June 2002 requesting the Director-General's requirements for a Species Impact Statement (SIS) for the proposal cited above.

The National Parks and Wildlife Service (NPWS) understands that this proposal is State Significant Development and that the Minister for Planning is the consent authority under Part 4 of the Environmental Planning and Assessment (EP&A Act) and has not yet determined whether a SIS is required or not. The NPWS notes that in your letter you conclude that a SIS is required. However, this decision is the responsibility of the consent authority, planningNSW.

As the Minister for Planning will be the consent authority, the Minister for the Environment will have and advisory role should threatened, species, populations or ecological communities be significantly impacted by the proposal.

The NPWS suggests you discuss your proposal with PlanningNSW prior to commencing the SIS, to determine whether in PlanningNSW's opinion, a SIS is required.

Notwithstanding the above, the following Director-General's requirements are issued.

Conservation Program
& Planning Division
Central Directorate
Level 6
43 Bridge Street
P.O. Box 1967
Hurstville NSW
2220 Australia
Tel: (02) 9585 667-
Fax: (02) 9585 644-
www.npws.nsw.gov.au

The purpose of a SIS is to:

- allow the applicant or proponent to identify threatened species issues and provide appropriate amelioration for adverse impacts resulting from the proposal;
- assist consent and determining authorities in the assessment of a development application under Part 4 or request for Part 5 approval under the *Environmental Planning and Assessment Act 1979* (EP&A Act); assist the Director-General of National Parks and Wildlife in deciding whether or not concurrence should be granted for the purposes of Parts 4 or 5 of the EP&A Act;
- assist the Director-General of National Parks and Wildlife or the Minister for the Environment when consulted for the purposes of Parts 4 or 5 of the EP&A Act; and
- assist the Director-General of National Parks and Wildlife in the assessment of Section 91 Licence applications lodged under the TSC Act.

Definitions

The definitions given below are relevant to these requirements:

development has the same meaning as in the *Environmental Planning and Assessment Act 1979.*
activity has the same meaning as in the *Environmental Planning and Assessment Act 1979.*
proposal is the development, activity or action proposed
subject site means the area directly affected by the proposal.
study area is the subject site and any additional areas which are likely to be affected by the proposal, either directly or indirectly.
locality is the area within a 10 km radius of the subject site.
subject species means those threatened species which are known or considered likely to occur in the study area.

All other definitions are the same as those contained in the TSC Act.

Matters which have been limited or modified

I consider that the following Section 110 matters need not be addressed by your SIS.

- Section 110(2)(e). This section is a replication of Section 110(2)(a).
- Section 110(2)(g) and 110(3)(d). The matters raised in these sections of the TSC Act have been clarified by the requirements below.

I consider that the following Section 110 matters need only be addressed where relevant:

- All reference to threat abatement plans. No threat abatement plans have currently been approved in accordance with the TSC Act which are relevant to this proposal.
- Recovery plans: the Draft Little Tern Recovery Plan is relevant to this proposal and can be found on the NPWS web site at www.npws.nsw.gov.au.
- Key threatening processes. The following key threatening processes are considered relevant to this proposal:

- ➢ High frequency fire resulting in the disruption of life cycle processes in plants, animals, and loss of vegetation structure and composition.
- ➢ Clearing of native vegetation.
- ➢ Anthropogenic climate change.
- All reference to critical habitat. At the time of printing, the areas of declared critical habitat are not relevant to this proposal.

The proponent should be aware that recovery plans may be approved, critical habitat may be declared and key threatening processes may be listed between the issue of these requirements and the granting of consent. If this occurs these additional matters will need to be addressed in the SIS and considered by the consent, determining or concurrence authority.

Matters to be Addressed

The TSC Act provides that the SIS must meet all the matters specified in Sections 109 and 110 of the TSC Act with the exception of those matters limited above. The requirements outlined in Sections 109 and 110 (excluding the matters limited above) have been repeated below (italics) along with the specific Director-General's Requirements for your proposal.

1 Form of the species impact statement

1.1 *A species impact statement must be in writing (Section 109 (1))*

1.2 *A species impact statement must be signed by the principal author of the statement and by:*

(a) *the applicant for the licence, or*

(b) *if the species impact statement is prepared for the purposes of the Environmental Planning and Assessment Act 1979, the applicant for development consent or the proponent of the activity proposed to be carried out (as the case requires) Section 109(2))*

2 Contextual information

2.1 Description of proposal, subject site and study area

A species impact statement must include a full description of the action proposed, including its nature, extent, location, timing and layout (Section 110 (1))

A full description of the action includes a description of all associated actions, including, but not restricted to: installation and maintenance of utilities, fire protection zones, access and egress routes; and changes in surface water flows. These actions may occur on or off the subject land.

2.2 Provision of relevant plans and maps

A plan of the subject area, including the scale of the plan, shall be provided. An aerial photograph (preferably colour) of the locality (or reproduction of such a photograph) shall also be provided, if possible. This aerial photograph should clearly show the subject site and the scale of the photograph.

A topographic map of the site and immediate surrounds at a scale of 1:25000 should be provided. This map should detail the location of the proposal and location of works on site. The map should also show forested and cleared areas in the immediate area and current activities/usage of this land including rural and agricultural.

A map of the locality, showing any locally significant areas for threatened species such as parks and reserves, and areas of high human activity such as townships, regional centres and major roads will also be provided. The location, size and dimensions of study area shall be provided.

2.3 Land tenure information

Information about the land tenure across the study area shall be provided. Any limitations to sampling across the study area (eg denied access to private land) shall be noted.

3 Initial assessment

A general description of the threatened species or populations known or likely to be present in the area that is the subject of the action and in any area that is likely to be affected by the action (Section 110 (2)(a))

3.1 Identifying subject species

3.1.1 Assessment of available information

In determining these species (the subject species), consideration shall be given to the habitat types present within the study area, recent records of threatened species or populations in the locality and the known distribution of threatened species.

Databases such as the NPWS Atlas of NSW Wildlife, Australian Museum and Royal Botanic Gardens should be consulted to assist in compiling the list. It should be noted that if the NPWS Atlas is the only database which is referred to, due to data exchange agreements, the data provided by the NPWS will only include that which the NPWS is a custodian for. In many cases this may only be a small subset of the data available. Other databases must also be consulted to create a comprehensive list of subject species.

The following shall be considered for inclusion in the list of subject species:

Threatened Species

Fauna

*Sanderling	*Calidris alba*
*Great Knot	*Calidris tenuiorstris*
*Large (Greater) Sand Plover	*Charadrius leschenaultii*
*Mongolian Plover	*Charadrius mongolus*
*Broad-billed Sandpiper	*Limicola falcinellus*
Pied Oystercatcher	*Haematopus longirostris*
Sooty Oystercatcher	*Haematopus fulinginosus*
*Terek Sandpiper	*Xenus cinereus*

*Little Tern *Sterna albifrons*

* indicates species that are listed on the *Environment Protection and Biodiversity Conservation Act 1999* as migratory waders.

Endangered populations

None

Endangered ecological communities

Taren Point Shorebird Community (NSW Scientific Committee 1998).

The characteristic assemblage of shorebird species in the community is:

Latham's Snipe	*Gallinago hardwickii*	(Gray, 1831)
Bar-tailed Godwit	*Limosa lapponica*	(Linnaeus, 1758)
Whimbrel	*Numenius phaeopus*	(Linnaeus, 1758)
Eastern Curlew	*Numenius madagascariensis*	(Linnaeus, 1766)
Marsh Sandpiper	*Tringa stagnatilis*	(Bechstein, 1803)
Common Greenshank	*Tringa nebularia*	(Gunnerus, 1767)
Terek Sandpiper	*Xenus cinereus*	(Guldenstädt, 1775)
Common Sandpiper	*Actitis hypoleucos*	(Linnaeus, 1758)
Grey-tailed Tattler	*Heteroscelus brevipes*	(Vieillot, 1816)
Ruddy Turnstone	*Arenaria interpres*	(Linnaeus, 1758)
Great Knot	*Calidris tenuirostris*	(Horsfield, 1821)
Red Knot	*Calidris canutus*	(Linnaeus, 1758)
Red-necked Stint	*Calidris ruficollis*	(Pallas, 1776)
Sharp-tailed Sandpiper	*Calidris acuminata*	(Horsfield, 1821)
Curlew Sandpiper	*Calidris ferruginea*	(Pontoppidan, 1763)
Pied Oystercatcher	*Haematopus longirostris*	Vieillot, 1817
Sooty Oystercatcher	*Haematopus fuliginosus*	Gould, 1845
Pacific Golden Plover	*Pluvialis fulva*	(Gmelin, 1789)
Grey Plover	*Pluvialis squatarola*	(Linnaeus, 1758)
Masked Lapwing	*Vanellus miles*	(Boddaert, 1783)

This list is not exhaustive. One of the roles of an SIS is to determine which species may be utilising a development site given the limitations of existing databases. Justification for excluding any of the threatened species, endangered populations or endangered ecological communities from the list of subject species must be given in the SIS.

4 Survey

4.1 Requirement to survey

A fauna and flora survey is to be conducted in the study area. Targeted surveys shall be conducted for all subject species determined in accordance with Section 3 above. Previous surveys and assessments may be used to assist in addressing this requirement. Species of taxonomic uncertainty shall be confirmed by a recognised authority such as the Australian Museum or National Herbarium at the Royal Botanic Gardens, Sydney.

4.2 Documentation of survey effort and technique

4.2.1 Description of survey techniques and survey sites

Survey technique(s) should be described and a reference given, where available, outlining the survey technique employed.

Survey site(s) should be identified on a clearly keyed map. The size, orientation and dimensions of quadrat or length of transect should be clearly noted for each type of survey technique undertaken. Full AMG grid references for the survey site(s) should be noted.

4.2.2 Documenting survey effort and results

Attachment 1 provides survey proformas for use by field staff when applying a range of standard fauna survey techniques. Digital copies of these proformas are available by electronic mail. Please contact the nominated contact officer below. These proformas should be used by field staff when undertaking fauna surveys and completed data sheets are to be included as an appendix to the SIS.

The time invested each time a survey technique is applied shall be summarised in the SIS, based on completed proformas. eg - Number of person hours/transect, duration of call playback, number of nights traps set.

It is not sufficient to aggregate all time spent on all survey techniques. Effort must be expressed each time a survey technique is applied.

Personnel details including name of surveyor(s) and contact phone number. The person who identified records (eg, anabat, hair tubes, scat analysis) should also be identified.

Environmental conditions during the survey should be noted at the commencement of each survey technique.

5 Assessment of likely impacts on threatened species and populations

Section 5 needs only be addressed if threatened species or endangered populations are likely to be affected.

Assessment of impacts should include the assessment of indirect impacts and those of associated activities, including, but not restricted to: installation and maintenance of utilities, access and egress routes; and changes in surface water flows. These actions or impacts may occur on or off the subject land.

Assessment of impacts should also include impacts from the provision of fire protection zones. If, as part of the development, there will be a requirement to provide fuel free and/or fuel reduced zones in retained bushland, the impacts of this on any threatened species and/or populations must be addressed as part of the impacts of the overall proposal. Proponents should also consider recommendations in 'Planning for Bushfire Protection' (PlanningNSW

2002) and consider the use of perimeter roads as an option in providing fuel free zones and reducing impacts on retained bushland.

From the information provided for this proposal, it would appear that the direct impacts include removal of wader roosting and foraging habitat on site, disruption of existing natural flyways and disturbance to foraging, nesting and roosting behaviours on remaining habitat. Indirect impacts of the proposal include displacement of individuals to other foraging areas in Botany Bay where habitats may be at capacity, changes to hydrological regimes and influences on prey availability.

5.1 Assessment of species likely to be affected

An assessment of which threatened species or population known or likely to be present in the area are likely to be affected by the action (Section 110(2)(c))

This requirement is asking you to refine your list of subject species and populations (given the outcome of survey and analysis of likely impacts) in order to identify which threatened species or endangered populations may be affected and the nature of the impact.

The remaining requirements in this section need only be addressed for those species which are likely to be affected by the proposal.

5.2 Discussion of local and regional abundance

An estimate for the local and regional abundance of those species or populations (Section 110 (2)(d))

5.2.1 Discussion of other known local populations

A discussion of other known populations in the locality shall be provided. The long term security of other habitats shall be examined as part of this discussion. The relative significance of the subject site for threatened species or endangered population in the locality shall be discussed.

5.2.2 Discussion of habitat utilisation

An estimate of the numbers of individuals utilising the area and how these individuals use the area (eg residents, transients, adults, juveniles, nesting, roosting, foraging) and discussion of the significance of these individuals to the viability of the threatened species or endangered population in the locality.

5.2.3 Description of vegetation

The vegetation present within the study area and the area covered by each vegetation community should be mapped and described. Include reference to the vegetation classification system used (eg Specht). Classification must have regard to both structural and floristic elements.

5.2.2 Discussion of corridors

If movement corridors for threatened species or endangered community are present within the subject site, the impact of the proposal on these areas shall be discussed.

5.3 Assessment of habitat

A full description of the type, location, size and condition of the habitat (including critical habitat) of those species and populations and details of the distribution and condition of similar habitats in the region (Section 110 (2)(f))

5.3.1 Description of habitat values

Specific habitat features shall be described (eg frequency and location of stags, hollow bearing trees, culverts, rock shelters, rock outcrops, crevices, caves, drainage lines, soaks etc) and the density of understorey vegetation and groundcover.

The condition of the habitat within the study area shall be discussed, including the prevalence of introduced species, species of weeds present and an estimate of the total weed cover as a percentage of each vegetation community, whether trampling or grazing is apparent, effects of erosion, prevalence of rubbish dumping, history of resource extraction or logging and proximity to roads.

Details of the subject site's fire history (eg frequency, time since last fire, intensity) and the source of fire history (eg observation, local records), shall be provided.

5.4 Discussion of conservation status

For each species or population likely to be affected, details of its local, regional and State-wide conservation status,...[and]... its habitat requirements ... (Section 110(2)(c))

Assessment should include reference to the threatening processes which are generally accepted by the scientific community as affecting the species or population and are likely to be caused or exacerbated by the proposal. Assessment should also include reference to any approved or draft recovery plans (See Attachment 2 and Draft Little Tern Recovery Plan at www.npws.nsw.gov.au) which may be relevant to the proposal.

5.5 Description of feasible alternatives

A description of any feasible alternatives to the action that are likely to be of lesser effect and the reasons justifying the carrying out of the action in the manner proposed, having regard to the biophysical, economic and social considerations and the principles of ecologically sustainable development (Section 110(2)(h))

Where a Statement of Environmental Effects, Environmental Impact Statement or Review of Environmental Factors deals with these matters, the SIS may refer to the relevant section of the SEE, EIS or REF.

This condition must include details of the condition and use of other parts of the subject area and why these can or cannot be considered as feasible alternatives.

.6 Assessment of likely impacts on endangered ecological communities

Section 6 need only be addressed when endangered ecological communities are likely to be affected.

Assessment of impacts should include the assessment of indirect impacts and those of associated activities, including, but not restricted to: installation and maintenance of utilities, access and egress routes; and changes in surface water flows. These actions or impacts may occur on or off the subject land.

Assessment of impacts should also include impacts from the provision of fire protection zones. If, as part of the development, there will be a requirement to provide fuel free and/or fuel reduced zones in retained bushland, the impacts of this on any endangered ecological communities must be addressed as part of the impacts of the overall proposal. Proponents should also consider recommendations in 'Planning for Bushfire Protection' (PlanningNSW 2002) and consider the use of perimeter roads as an option in providing fuel free zones and reducing impacts on retained bushland.

From the information provided for this proposal, it would appear that the direct impacts include removal of wader roosting and foraging habitat on site, disruption of existing natural flyways and disturbance to foraging and roosting behaviours on remaining habitat. Indirect impacts of the proposal include displacement of individuals to other foraging areas in Botany Bay where habitats may be at capacity, changes to hydrological regimes and influences on prey availability.

6.1 Assessment of endangered ecological communities likely to be affected

A general description of the ecological community present in the area that is the subject of the action and in any area that is likely to be affected by the action (Section 110(3)(a))

6.2 Assessment of habitat

A full description of the type, location, size and condition of the habitat of the ecological community and details of the distribution and condition of similar habitats in the region (Section 110 (3)(c))

6.2.1 Description of disturbance history

If the site shows signs of disturbance, details should be provided of the site's disturbance history and an assessment should be made of the ability of the ecological community to recover to a pre-disturbance condition.

6.2.2 Extent of habitat removal

The location, nature and extent of habitat removal or modification which may result from the proposed action should be provided, including the cumulative loss of habitat (roosting nesting and foraging) from the study area (including all those areas in the subject area already with development consent or identified for development) and the impacts of this on the viability of the endangered ecological community in the locality.

6.3 Discussion of conservation status

For each ecological community present, details of its local, regional and State-wide conservation status...[and]... its habitat requirements...(Section 110(3)(b))

Assessment should include reference to the threatening processes which are generally accepted by the scientific community as affecting the endangered ecological community and are likely to be caused or exacerbated by the proposal. Assessment should also include reference to any approved or draft recovery plans (See Attachment 2) which may be relevant to the proposal.

6.3.1 Significance within a local context

An assessment of the community on the site in relation to other sites in the study area and in the locality. The tenure and long term security of other localities shall be examined as part of this discussion.

The relative significance of the subject site for the endangered ecological community shall be discussed. The assessment of the community should be considered in terms of the following features including. the size of the remnant, the quality of the habitat and the level of disturbance on this site in comparison to other sites in the locality.

6.3.2 Discussion of corridor values

The potential of the proposal to increase fragmentation of the community and increase edge effects.

If corridors that allow connectivity between localities of endangered ecological communities are present within the subject site, the impact of the proposal on these areas shall also be discussed.

6.4 Description of feasible alternatives

A description of any feasible alternatives to the action that are likely to be of lesser effect and the reasons justifying the carrying out of the action in the manner proposed having regard to the biophysical, economic and social considerations and the principles of ecologically sustainable development (Section 110(3)(e))

Where a Statement of Environmental Effects, Environmental Impact Statement or Review of Environmental Factors deals with these matters, the SIS may refer to the relevant section of the SEE, EIS or REF.

This condition must include details of the condition and use of other parts of the subject area and why these can or cannot be considered as feasible alternatives.

7 Ameliorative measures

7.1 Description of ameliorative measures

A full description and justification of the measures proposed to mitigate any adverse effect of the action on the species and populations and ecological community including a compilation (in a single section of the statement) of those measures (Section 110 (2)(i) and Section 110 (3)(f))

7.1.1 Long term management strategies

Consideration shall be given to developing long term management strategies to protect areas within the study area which are of particular importance for the threatened species or endangered populations likely to be affected. This may include proposals to restore or improve habitat on site where possible.

7.1.2 Compensatory strategies

Where significant modification of the proposal to minimise impacts on threatened species or endangered communities is not possible then compensatory strategies should be considered. These may include other offsite or local area proposals that contribute to long term conservation of the threatened species, population or endangered ecological community.

Where such proposals involve other lands, or where involvement of community groups is envisaged in such proposals, such groups are to be consulted and proposals should contain evidence of support from these stakeholders and relevant land managers.

Compensatory benefits likely to result from such measures proposed for alternative sites are to be discussed and evaluated along with a discussion of mechanisms of how they might best occur.

7.1.3 Ongoing monitoring

Any proposed pre-construction monitoring plans or on-going monitoring of the effectiveness of the mitigation measures shall be outlined in detail, including the objectives of the monitoring program, method of monitoring, reporting framework, duration and frequency. Generally, ameliorative strategies which have not been proved effective should be undertaken under experimental design conditions and appropriately monitored.

7.1.4 Translocation

The NPWS does not consider that translocation of threatened species, populations and ecological communities is an appropriate ameliorative strategy for the purposes of considering impacts of a particular development/activity. The NPWS strongly supports the view that development proposals which may impact on a significant local population of threatened species, populations or ecological communities as determined by the SIS should aim to:

i. Minimise the impacts by considering all possible alternatives to the development, such that a significant impact is not likely; and
ii. Manage the remaining habitat (if any) to ensure that the local population continues to exist in the long term.

The translocation of threatened species, populations and ecological communities is only supported by the NPWS in specific conservation programs (eg. recovery planning) but only as a last resort, and only when in-situ conservation options have been exhausted. Such programs should only be reconsidered following extensive investigation of a demonstrated long term financial commitment on behalf of the applicant.

8 Assessment of significance of likely effect of proposed action

An eight part test assessment (s5A EP&A Act) is to be provided for each of the affected species (threatened species, populations or ecological communities) identified in the SIS, incorporating relevant information from sections 5.1 to 7 of the SIS. On the basis of these assessments a conclusion is to be provided concerning whether, based on more detailed assessment through the SIS process and consideration of alternatives and/or ameliorative measures proposed in the SIS, the proposal is still considered likely to have a significant effect on threatened species, populations or ecological communities or their habitats.

9 Additional Information

9.1 Qualifications and experience

A species impact statement must include details of the qualifications and experience in threatened species conservation of the person preparing the statement and of any other person who has conducted research or investigations relied on in preparing the statement (Section 110(4))

9.2 Other approvals required for the development or activity

A list of any approvals that must be obtained under any other Act or law before the action may be lawfully carried out, including details of the conditions of any existing approvals that are relevant to the species or population or ecological community (Sections 110(2)(j) and 110(3)(g)))

In providing a list of other approvals the following shall be included:

- Where a consent is required under Part 4 of the *Environmental Planning and Assessment Act 1979*, the name of the consent authority and the timing of the development application should be included; or

- Where an approval(s) is required under Part 5 of the *Environmental Planning and Assessment Act 1979*, the name of the determining authority(ies), the basis for the approval and when these approvals are proposed to be obtained should be included.

Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)
An action will require the approval of the Federal Minister for the Environment (in addition to any State or Local Government approval or determination) if that action will have, or is likely to have, a significant impact on a matter of national environmental significance. Threatened species and communities listed in the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) are considered to be a matter of national environmental significance.

Many of the species and ecological communities listed in the NSW *Threatened Species Conservation Act* 1995 (NSW) are also listed in the Commonwealth EPBC Act. Further information regarding the operation of the EPBC Act (including Federally listed threatened species and communities) may be obtained from Environment Australia's website www.ea.gov.au or by contacting Environment Australia on 1800 803 772.

It should be noted that Environment Australia has declared the proposed expansion, and all associated and operation activities, to be a controlled action under the EPBC Act.

9.3 Licensing matters relating to the survey

Persons conducting flora and fauna surveys must have appropriate licences or approvals under relevant legislation. The relevant legislation and associated licences and approvals that may be required are listed below:

National Parks and Wildlife Act 1974:
- General Licence (Section 120) to harm or obtain protected fauna (this may include threatened fauna).
- Licence to pick protected native plants (Section 131).

Threatened Species Conservation Act 1995:
- Licence to harm threatened animal species, and/or pick threatened plants and/or damage the habitat of a threatened species (Section 91).

Animal Research Act 1985:
- Animal Research Authority to undertake fauna surveys.

9.4 Section 110 (5) reports

Section 110(5) of the *Threatened Species Conservation Act 1995* has the effect of requiring the NPWS to provide that information regarding the State-wide conservation status of the subject species as it has available, in order to satisfy ss.110(2)&(3) of the Act. To this end, a number of publications have been produced:

A. The NPWS Biodiversity Management Unit (Biodiversity Research and Management Division) has produced a set of profiles for a number of threatened species, populations and ecological communities and are available on the NPWS website (www.npws.nsw.gov.au). Some of these are relevant to the suggested list of subject species for this development.

B. The Central Directorate Threatened Species Unit has also produced a number of profiles and environmental assessment guidelines for species, populations and ecological communities (Refer to Attachment 3).

The profiles and/or guidelines listed in attachment 3, along with an LGA by LGA listing of known threatened species within Central Directorate, are also available as a folder for purchase from the Central Directorate Threatened Species Unit for $110. Registration to this folder entitles the owner to periodic updates, including new profiles and EIA guidelines. A copy of the order form for this resource is also attached.

Proponents and consultants should note that the NPWS has no further published information available to satisfy s.110(5) of the Act and that purchase or receipt and use of the above profiles can be taken to have satisfied the requirements of ss.110(2)&(3) in relation to the State-wide conservation status of the listed species, populations and ecological communities.

Should you require any further information on these requirements please contact Phil Glass on 02 9585 6619 or by email at *philip.glass@npws.nsw.gov.au.*

Yours sincerely

17/7/02

Robert Humphries
Manager, Threatened Species Unit
Central Directorate
as delegate to the Director-General

Attachment 1:

DIURNAL HERPETOFAUNA NOCTURNAL STREAMSIDE CENSUS SURVEY PROFORMA

Survey Details

Date of survey ____________________

Name of surveyor ____________________ Contact number ____________________

Name of person analysing calls ____________________ Contact number ____________________

Total effort expressed in person hours ____________________

Location Details

Location (including basic habitat) description ____________________

____

____

____

Map number ____________________ Map name ____________________

Type of survey, eg. transect or quadrat ____________________ AMG Zone ____________________

Active or passive search ____________________ Size of survey area (ha) ____________________

Survey area
Eastings (6 digits) ____________________ Northings (7 digits) ____________________

Eastings (6 digits) ____________________ Northings (7 digit) ____________________

Start time (24hr) ____________________ End time (24 hr) ____________________

Weather Details

At start of survey, record: Cloud cover* ____________________

Wind direction and speed* ____________________ Rain* ____________________

Temperature (°C) ____________________ Moon* ____________________

Comments ____________________

____

Attachment 1:

Species name (Scientific/Common)	Ob. type*	MH type*	Grid reference (full AMAs ie Eastings and Northings)	Accuracy

* See Appendix 1: Standard reporting codes

DIURNAL BIRD CENSUS SURVEY PROFORMA

Survey Details

Name of surveyor ____________ Contact number ____________

Number of surveyors ____________ Date of survey ____________

Total effort expressed in person hours ____________ Number of hectares covered or transect or point dimensions ____________

Location Details

Location description ____________

Map number ____________ Map name ____________

Full AMG reference(s) for survey site or transect AMG Zone ____________

Start details ____________ Finish details ____________

Easting (6 digits) ____________ Easting (6 digits) ____________

Northing (7 digits) ____________ Northing (7 digits) ____________

Start time (24hr) ____________ End time (24 hr) ____________

Weather Details

At start of survey, record: Cloud cover* ____________

Wind direction and speed* ____________ Rain* ____________

Temperature (°C) ____________ Moon* ____________

Comments ____________

Species name	Ob. type*	MH type*	Grid reference (full AMGs)	Accuracy

* See Appendix 1: Standard reporting codes

Attachment 1:

Species name	Ob. type*	MH type*	Grid reference (full AMGs)	Accuracy

* See Appendix 1: Standard reporting codes

NOCTURNAL CALL PLAYBACK SURVEY PROFORMA

Survey Details

Name of surveyor ______________ Contact number ______________

Date of survey ______________ Type of amplification (loudhaler, tape deck only) ______________

Duration of call playback (minutes) ______________ Duration of listening (minutes) ______________

Location Details

Location description ______________________________

____

Map name ______________ Map number ______________

Full AMG reference(s) for survey site or transect AMG Zone ______________

Easting (6 digits) ______________ Northing (7 digits) ______________

Start time (24 hr) ______________ End time (24 hr) ______________

Weather Details

Temperature (°C)

At start of survey, record ______________

Cloud cover* ______________ Moon* ______________

Wind direction and speed* ______________ Rain*

Comments ______________________________

____

Playback details		Species response			
Time (24hr)	Call Species Name	Time (24hr)	Species name	No Ind	Comments

* See Appendix A Standard reporting codes

Playback details		Species response			
Time (24hr)	Call Species Name	Time (24hr)	Species name	No Ind	Comments

* See Appendix A Standard reporting codes

ULTRASONIC CALL ('ANABAT') SURVEY PROFORMA

Survey Details

Name of principle surveyor ____________ Contact number ____________

Name of person analysing calls ____________ Contact number ____________

Date of survey ____________ GMA handheld or set and left ____________

Location Details

Location description ____________

____

Time delay used - yes/no ____________

Start details or point location Finish details

Map name ____________ Map number ____________

Full AMG reference(s) for survey site or transects AMG Zone ____________

Easting (6 digits) ____________ Northing (7 digits) ____________

Start time (24 hr) ____________ Finish time (24hr) ____________

Weather Details

At start of survey, record

Temperature (°C) ____________

Cloud cover* ____________ Moon* ____________

Wind direction and speed* ____________ Rain* ____________

Comments ____________

____

DATE	TIME	AMGs	DEFINITE	PROBABLE	POSSIBLE
	(24 hr)	if used	Species name	Species name	Species name

* See Appendix A Standard reporting codes

TRIPLINE/HARP TRAPPING/MIST NETTING SURVEY PROFORMAS

Survey Details

Name of principle surveyor ______________ Contact number ______________

Location description ______________________________

____

Start date ______________ End date ______________

Type of trap ______________

Time/date trap checked ______________________________

Location Details

Map number ______________ Map name ______________

AMG Zone ______________

Survey site
Eastings (6 digits) ______________ Northing (7 digits)

Weather Details

At start of survey, record
Cloud cover* ______________ Moon* ______________

Wind direction and speed* ______________ Rain* ______________

Temperature (°C) ______________

Comments ______________________________

____

Date	Species name	Sex	Wt (g)	Forearm (mm)	Comments

* See Appendix A Standard reporting codes

ELLIOTT / PITFALL / CAGE TRAPPING SURVEY PROFORMAS

Survey Details

Name of surveyor ________________ Contact number ________________

Date traps set ________________ Date traps collected ________________

Type of trap (e.g. Elliot type B cage) ________________ Dimensions of trap (length x breadth x width) ________________

Number of traps ________________ Intervals between traps ________________

Length of transect or grid dimensions ________________ Bait used (e.g. meat type, peanut butter/oats) ________________

Location Details

Location description ________________________________

____

AMG Zone ________________

Transect start or grid corner Easting (6 digits) ________________ Transect end or grid corner Eastings (6 digits) ________________

Northing (7 digits) ________________ Northing (7 digits) ________________

Comments ________________________________

____

____

Date trap checked	Trap No*	Trap position**	Species name	Sex	Comments

* Trap number should correspond to map outlining location of traps
**For example ground or tree mounted

Date trap checked	Trap No*	Trap position**	Species name	Sex	Comments

* Trap number should correspond to map outlining location of traps

**For example ground or tree mounted

SPOTLIGHTING SURVEY PROFORMA

Survey Details

Name of surveyor ____________________ Contact number ____________________

Date of survey ____________________ On foot or in vehicle ____________________

Number of surveyors ____________________ Total effort expressed in person hours ____________________

Length of transect or grid dimensions ____________________ Number of lights ____________________

Wattage of spotlight ____________________

Location Details

Location (including basic habitat) description ____________________

____

____

Map name ____________________ Map number ____________________

AMG Zone ____________________ ____________________

Start details
Easting (6 digits) ____________________

Finish details
Eastings (6 digits) ____________________

Northing (7 digits) ____________________ Northing (7 digits) ____________________

Start time (24 hr) ____________________ End time (24 hr) ____________________

Weather Details

At start of survey, record
Cloud cover* ____________________ Moon* ____________________

Wind direction and speed* ____________________ Rain* ____________________

Temperature (°C) ____________________

Comments ____________________

____

____

Date, time (24h)	Species Name	Ob type	No Indi	Grid reference (full AMGs)	Accuracy	Comments

* See Appendix A Standard reporting codes

HAIR TUBE SAMPLING ANALYSIS SURVEY PROFORMA

Survey Details

Name of surveyor ____________________ Contact number ____________________

Name of person analysing hairs ____________________ Contact number ____________________

Date traps set ____________________ Date traps collected ____________________

Size of tube (diameter and length) ____________________ Number of tube ____________________

Spacing between tubes ____________________ Bait used (e.g. meat type, peanut butter & oats) ____________________

Length of transect or grid dimensions ____________________

Location Details

Location description ____

____

AMG Zone ____________________

Map name ____________________ Map number ____________________

Transect start Easting (6 digits) ____________________ Transect end Eastings (6 digits) ____________________

Northing (7 digits) ____________________ Northing (7 digits) ____________________

Comments ____

____

Tube No*	Tube position **	Definite	Probable	Possible

* Tube number should correspond to map outlining location of tubes

**For example ground or tree mounted

Appendix 1: Standard reporting codes

Cloud cover. Record cloud cover in eights of sky.

Moon. Record using the following codes. 0=None, 1=1/4 moon, 2=1/2 moon, 3=3/4 moon, 4=full moon.

Wind direction and speed. Record wind direction to nearest cardinal point. Record wind speed using the following codes. 0=calm 1= Light, leaves rustle 2= Moderate, branches move 3=Strong, tops of trees move

Rain. Record using the following codes. 0=none, 1=drizzle - light, 2=drizzle - heavy 3=heavy rain

Observation type. Use the following codes.

O	Observed (sighted)	R	Road kill	F	Tracks, scratching
W	Heard call	D	Dog kill	Z	In raptor/owl pellet
X	In scat	C	Cat kill	M	Miscellaneous
T	Trapped or netted	V	Fox kill	E	Nest or roost
H	Hair or feathers	S	Shot	Y	Bones or teeth
A	Stranded/beached	I	Fossil/sub-fossil	N	Not located

Microhabitat type. Use the following codes

AC	Flying above canopy	IB	In burrow	OB	On beach sand
BR	In/on bridge	IC	In cave	OL	On log
BU	In building	IG	In grass	OR	On rock
CK	Crevice in rock	IH	In tree hollow	OW	Over water
CL	Crevice in log	IL	In litter	RD	On road
DA	Farm/fire dam	IR	In reeds	TK	On trunk
DT	In dead tree (stag)	IS	In soil	UB	Under bark
EW	Edge of water	IT	In live tree	UC	Upper canopy
FC	In/on post or stump	IW	In water	UG	Undergrowth
FL	Flying within canopy	LC	Lower canopy	UL	Under log
GR	On ground	LS	Low shrub	UR	Under rock
HS	High shrub	MC	Mid canopy	WH	Waterhole

VERTEBRATE FAUNA SURVEY OPPORTUNISTIC RECORDS OFF SITE

Survey name ______________________ Fauna surveyors ______________________
Surveyor's contact details ______________________ Call analysis ______________________

AGM Zone ______________________

Date	Time	Site #	Easting (full 6 digits)	Northing (full 7 digits)	Species Name	No Ind	Ob. type*	MH* type*	Notes/Field No**

* See over ** Include initials of observer and any other information that will help relocation of site.

Notes on Opportunistic records off site

Observation type

Use the following codes:

O	Observed (sighted)	R	Road kill	F	Tracks, scratching
W	Heard call	D	Dog kill	Z	In raptor/owl pellet
X	In scat	C	Cat kill	M	Miscellaneous
P	Scat	V	Fox kill	E	Nest or roost
T	Trapped or netted	K	Dead	B	Burnt
H	Hair or feathers	S	Shot	Y	Bones or teeth
A	Stranded/beached	I	Fossil/subfossil	N	Not located

MH (microhabitat) type

Use the following codes:

AC	Flying above canopy	IB	In burrow	OB	On (beach) sand
BR	In/on bridge	IC	In cave	OL	On log
BU	In building	IG	In grss	OR	On rock
CK	Crevice in rock	IH	In tree hollow	OW	Over water
CL	Crevice in log	IL	In litter	RD	On road
DA	Farm/fire dam	IR	In reeds	TK	On trunk
DT	In dead tree (stag)	IS	In soil	UB	Under bark
EW	Edge of water	IT	In (live) tree	UC	Upper canopy
FC	In/on post or stump	IW	In water	UG	Undergrowth
FL	Flying within canopy	LC	Lower canopy	UL	Under log
GR	On ground	LS	Low shrub	UR	Under rock
HS	High shrub	MC	Mid canopy	UT	Under iron
				WH	Waterhole

VERTEBRATE FAUNA SURVEY OPPORTUNISTIC RECORDS AT STANDARD SURVEY SITES

AGM Zone ______________________ Map number ______________________

Map name ______________________ Grid references ______________________

For fauna and threatened flora detected opportunistically from standard survey sites.
One area per sheet.

Area: ____

Date/ time (24 h)	Site	Sp. Code	Species Name	No Ind	Obs type*	MH type*	Breed. type* *	Notes**

* See over

**Please include initials of observer.

Notes on Opportunistic records off site

Observation type

Use the following codes:

O	Observed (sighted)	R	Road kill	F	Tracks, scratching
W	Heard call	D	Dog kill	Z	In raptor/owl pellet
X	In scat	C	Cat kill	M	Miscellaneous
P	Scat	V	Fox kill	E	Nest or roost
T	Trapped or netted	K	Dead	B	Burnt
H	Hair or feathers	S	Shot	Y	Bones or teeth
A	Stranded/beached	I	Fossil/subfossil	N	Not located

MH (microhabitat) type

Use the following codes:

AC	Flying above canopy	IB	In burrow	OB	On (beach) sand
BR	In/on bridge	IC	In cave	OL	On log
BU	In building	IG	In grss	OR	On rock
CK	Crevice in rock	IH	In tree hollow	OW	Over water
CL	Crevice in log	IL	In litter	RD	On road
DA	Farm/fire dam	IR	In reeds	TK	On trunk
DT	In dead tree (stag)	IS	In soil	UB	Under bark
EW	Edge of water	IT	In (live) tree	UC	Upper canopy
FC	In/on post or stump	IW	In water	UG	Undergrowth
FL	Flying within canopy	LC	Lower canopy	UL	Under log
GR	On ground	LS	Low shrub	UR	Under rock
HS	High shrub	MC	Mid canopy	UT	Under iron
				WH	Waterhole

Breeding type

Use the following codes:

-	not breeding	G	Gravid	M	Nestling
D	Distraction display	I	Immature	N	Nesting
E	Eggs	J	Juveniles	P	Pregnant
		L	Lactating	Y	Yes, but no details

Attachment 2: RECOVERY PLANS

Approved Recovery Plans under the TSC Act 1995:

As at 30th June 2002.

Species	Common Name	Approval Date
Allocasuarina portuensis	Nielsen Park Sheoak	10/05/00
Angiopterus evecta	Giant Fern	23/1/02
Cercartetus concinnus	Western Pygmy Possum	31/5/02
Egernia margaretae	Centralian Ranges Rock-skink	30/06/00
Eleocharis tetraquetra		01/12/99
Emydura macquarii	Bellinger River Emydura'	29/06/01
Epacris hamiltonii		29/06/01
Eulamprus leuraensis	Blue Mountains Water Skink	29/06/01
Grevillea kennedyana	Flame Spider-flower	07/06/00
Grevillea obtusiflora ssp. obtusiflora and ssp. fecunda		29/06/01
Grevillea wilkinsonii	Tumut Grevillea	24/08/01
Hakea pulvinifera		25/05/00
Leionema lachnaeoides		01/10/01
Litoria castanea & L. piperata	Yellow-spotted Bell Frog and Peppered Frog	29/06/01
Litoria spenceri	Spotted Tree Frog	29/06/01
Lost Threatened Flora of SE NSW		28/2/01
Neobatrachus pictus	Painted Burrowing Frog	17/05/00
Paralucia spinifera	Bathurst Copper Butterfly	29/06/01
Persoonia mollis ssp. *maxima*		15/05/00
Placostylus bivaricosus	Lord Howe Island Large land Snail	14/12/01
Pterostylis sp Botany Bay (A. Bishop J221/1-3)	Botany Bay Bearded Greenhood	07/09/01
Prostanthera junonis	Somersby Mintbush	01/12/00
Pseudophryne corroboree	Southern Corroboree Frog	29/06/01
Thersites mitchelliae	Mitchell's Rainforest Snail	29/06/01
Threatened Alpine Plant Species: Ranunculus anemoneus, Erythranthera pumila, Carex raleghii & Euchiton nitidulus	Anemone Buttercup, Feldmark Grass, Raleigh Sedge & Shining Cudweed	29/06/01
Wollemia nobilis	Wollemi Pine	01/09/98
Zieria adenophora	Araluen Zieria	29/06/01
Zieria prostrata		23/01/99

Endangered Populations	Approval Date
Manly Point population of Little Penguin (*Eudyptula minor)*	28/08/00

Approved Threat Abatement Plans under the TSC Act 1995:

As at 30th June 2002.

Threat Abatement Plans	Approval Date
Predation by the Red Fox (Vulpes vulpes)	18/1/02

Draft Recovery Plans exhibited under the TSC Act 1995:

As at 30th June 2002.

Species	Common Name	Exhibition Date
Acacia pubescens	Downy Wattle	6/4/01
Amytorma textilis	Thick-billed Grass-wren	23/11/01
Antechinomys laniger	Kultarr	23/11/01
Bertya sp. A Cobar-Coolabah		23/11/01
Boronia granitica	Granite Boronia	18/2/02
Burramys parvus	Mountain Pygmy Possum	27/8/01
Caladenia arenaria		24/6/02
Elaeocarpus sp. Rocky Creek (syn E. sp. 2 "Minyon")		28/6/02
Eriocaulon carsonii	Salt Pipewort	3/6/02
Gallirallus sylvestris	Lord Howe Woodhen	17/12/01
Genoplusium plumosum	Tallong Midge Orchid	16/11/01
Genoplesium vernale	East Lynne Midge Orchid	16/11/01
Grevillea caleyi		5/10/01
Leggadina forresti	Forrest's Mouse	23/11/01
Manorina melanotis	Black-eared Miner	17/6/02
Potorous longipes	Long-footed Potoroo	27/8/01
Pseudomys apodemoides	Silky Mouse	09/06/00
Pseudomys hermannsburgensis	Sandy Inland Mouse	23/11/01
Pseudomys bolami	Bolam's Mouse	09/06/00
Pterodroma leucoptera	Gould's Petrel	28/10/00
Pterostylis gibbosa	Illawarra Greenhood Orchid	13/01/01
Sterna albifrons	Little Tern	05/06/00
Zieria formosa, Zieria buxijugam & Zieria parrisiae		16/11/01
Zieria lasiocaulis		23/11/01

Endangered Populations	Exhibition Date
Warrumbungle Brush-tailed Rock-wallaby Population	3/6/02

Threat Abatement Plans	Exhibition Date
Predation by *Gambusia holbrooki*-The Plague Minnow	2/4/02

All the above approved and draft recovery plans can be viewed on the NPWS WebPage at www.npws.nsw.gov.au or purchased for $8.25 (including GST) from the NPWS Head Office Information Centre.

Attachment 3: PROFILES & EIA GUIDELINES

As at 1 March 2002.

Scientific Name	Common Name	TSC Act	Profile	EIA
Amphibians				
Heleioporus australicus	Giant Burrowing Frog	E1	✓	✓
Pseudophryne australis	Red-crowned Toadlet	V	✓	✓
Birds				
Pterodroma leucoptera leucoptera	Gould's Petrel	E1	✓	N/A
Invertebrates				
Meridolum corneovirens	Cumberland Land Snail	E1	✓*	✓
Paralucia spinifera	Bathurst Copper Butterfly	E1	✓*	✓
Reptiles				
Eulamprus leuraensis	Blue Mountains Water Skink	E1	✓	✓
Flora				
Acacia baueri subsp. *aspera* (Maiden & E. Betche) Pedley		V	✓	✓
Acacia clunies rossiae Maiden		V	✓	✓
Acacia pubescens (Vent.) R. Br.		V	✓*	✓
Darwinia biflora (Cheel) B. Briggs		V	✓*	✓
Epacris hamiltonii Maiden & E. Betche		E1	✓	✓
Epacris sparsa R. Br.		V	✓	✓
Eucalyptus benthamii Maiden & Cambage		V	✓	✓
Eucalyptus cannonii R. Baker		V	✓	✓
Eucalyptus copulans L. Johnson & K. Hill		E1	✓	✓
Eucalyptus sp. Howes Swamp Creek (M. Doherty 19/7/85, NSW 207054)		E1	✓	✓
Euphrasia bowdeniae W.R. Barker		V	✓	✓
Grevillea evansiana McKee		V	✓	✓
Grevillea obtusiflora R. Br.		E1	✓	✓
Irenepharsus trypherus Hewson		E1	✓	✓
Kennedia retrorsa Hemsley		V	✓	✓
Kunzea cambagei Maiden & E. Betche		V	✓	✓
Leionema lachnaeoides Cunn.		E1	✓	✓
Leionema sympetalum Paul G. Wilson		V	✓	✓
Olearia cordata Lander		V	✓	✓
Persoonia acerosa Sieber ex Schultes & Schultes f.		V	✓	✓
Persoonia bargoensis P. Weston & L. Johnson		V	✓	✓
Persoonia glaucescens Sieber ex Sprengel		V	✓	✓
Persoonia marginata Cunn. ex R. Br.		V	✓	✓
Persoonia mollis subsp. *maxima* Krauss & L. Johnson		E1	✓*	✓
Persoonia nutans		E!	✓	✓
Persoonia pauciflora		E1	✓*	✓
Pimelea spicata		E1	✓	✓
Prostanthera cryptandroides Cunn. ex Benth.		V	✓	✓
Prostanthera discolor R. Baker		V	✓	✓
Prostanthera junonis (=sp. Somersby)		E1	✓	✓

Prostanthera stricta R. Baker	V	✓	✓
Syzygium paniculatum	V	✓	✓
Tetratheca glandulosa Smith	V	✓	✓
Tetratheca juncea Smith	V	✓	✓
Zieria covenyi J.A. Armstrong ms	E1	✓	✓

Scientific Name	Common Name	TSC Act	Profile	EIA
Endangered Populations (Fauna)				
Eudyptula minor	Manly Cove Little Penguin	E2	N/A	✓
Perameles nasuta	North Head Long-nosed Bandicoot	E2	N/A	✓
Endangered Ecological Communities				
Agnes Banks Woodland		E3	✓	
Blue Gum High Forest		E3	✓	
Castlereagh Ironbark Forest		N/A	✓	
Castlereagh Swamp Woodland		E3	✓	
Cooks River Clay Plain Scrub Forest		E3	✓*	✓
Cumberland Plain Woodland		E3	✓	
Duffy's Forest Vegetation Community		E3	✓	✓
Eastern Suburbs Banksia Scrub		E3	✓*	✓
Elderslie *Banksia* Scrub Forest		E3	✓	
Moist Shale Woodland		N/A	✓	
Shale/Sandstone Transition Forest		E3	✓	
Shale/Gravel Transition Forest		N/A	✓	
Sydney Coastal River Flat Forest		E3	✓	
Sydney Turpentine Ironbark Forest		E3	✓	
Western Sydney Dry Rainforest		E3	✓	

✓* denotes species profiles that have been published in the *Threatened Species Management – Species Information*, they have not been reproduced in colour here. For these and other colour species profiles please refer to the above manual via the NPWS Information Centre, or the NPWS website, www.npws.nsw.gov.au.

Profiles and EIA Guidelines that will be available in June 2002

Scientific Name	Common Name	TSC Act	Profile	EIA
Flora			✓	✓
Acacia bynoeana		V	✓	✓
Angophora inopina		V	✓	✓
Cynanchum elegans	White-flowered Wax Plant	E1	✓	✓
Daphnandra sp. C (Illawarra)	Illawarra Socketwood	V	✓	✓
Dillwynia tenuifolia		V	✓	✓
Epacris purpurascens var. purpurascens		V	✓	✓
Eucalyptus parramattensis subsp. decadens		V	✓	✓
Eucalyptus pumila		V	✓	✓
Grevillea juniperina spp. juniperina		V	✓	✓
Grevillea parviflora ssp. parviflora		V	✓	✓
Melaleuca biconvexa		V	✓	✓
Prostanthera askania		E1	✓	✓
Pterostylis gibbosa	Illawarra Greenhood	E1	✓	✓
Pultenaea parviflora		E1	✓	✓
Pultenaea peduncultata		E1	✓	✓
Zieria granulata	Illawarra Zieria	E1	✓	✓
Endangered Populations				
Dillwynia tenuifolia at Kemps Creek, Baulkham Hills LGA		E2	✓	✓
Endangered Ecological Communities				
Taren Point Shorebird Community		E3	✓	✓

EP&BC Act administratively approved plans:

The following recovery plans have been prepared in conjunction with Environment Australia. Under the NSW *Threatened Species Conservation Act 1995*, these plans are considered as working drafts and will go through the process as outlined in the TSC Act.

Species	Common name	Date
Acrophyllum australe		1994
Allocasuarina defungens		1992
Allocasuarina glareicola		1996
Apatophyllum constablei		1994
Asterolasia elegans		1994
Cynanchum elegans	White Cynanchum	1993
Elaeocarpus williamsianus	Hairy Quandong	
Grevillea iaspicula	Wee Jasper Grevillea	
Haloragodendron lucasii		1994
Kunzea rupestris		1993
Lathamus discolor	Swift Parrot	2001
Owenia cepiodora		1995
Persoonia nutans		1996
Pimelea spicata	Pink Pimelea	1996
Thesium australe	Austral Toadflax	1992
Velleia perfoliata		1994
Zieria involucrata		1994

ENDANGERED ECOLOGICAL COMMUNITY INFORMATION

Taren Point Shorebird Community

Conservation Status
The Taren Point Shorebird Community is listed as an endangered ecological community on Schedule 1, Part 3 of the T*hreatened Species Conservation Act 1995.*

Description
The Community is a group of shorebirds (also called waders) which occupy a particular area of Botany Bay and includes the characteristic assemblage of 20 species listed below:

- Bar-tailed Godwit *Limosa lapponica*
- Red knot *Calidris canutus*
- Great Knot Calidris tenuirostris:
- Sharp-tailed Sandpiper *Calidris acuminata*
- Curlew Sandpiper *Calidris ferruginea*
- Red-necked Stint *Calidris ruficollis*
- Common Sandpiper *Actitis hypoleucos*
- Terek sandpiper *Xenus cinereus*:
- Latham's Snipe *Gallinago hardwickii*
- Grey-tailed tattler *Heteroscelus brevipes*
- Grey plover *Pluvialis squatarola*
- Pacific Golden Plover Pluvialis fulva
- Common Greenshank *Tringa nebularia*
- Masked Lapwing *Vanellus miles*
- Marsh Sandpipers *Tringa stagnatilis*
- Ruddy Turnstone Arenaria interpres
- Pied Oystercatcher *Haematopus longirostris*
- Sooty Oystercatcher *Haematopus fulinginosus*
- Whimbrel *Numenius phaeopus*
- Eastern Curlew *Numenius madagascariensis*

A full description of each species can be found in Higgins and Davies 1996.

Distribution
The Taren Point Shorebird community occurs on the relict marginal shoal of the Georges River between Taren Point and Shell Point in Botany Bay (NSW Scientific Committee 1998). (Map 1).

Some species identified within this community can also be found foraging and roosting at other locations within Botany Bay. Penrhyn Inlet, Sandringham and the shoreline adjacent to the northeastern side of the Captain Cook Bridge are three sites on the Northern side of the Bay that provide important roosting and forging areas for the assemblage of species that makes up the endangered community. Some of the species found at these locations include:

- Bar-tailed Godwit *Limosa lapponica*
- Curlew Sandpiper *Calidris ferruginea*
- Red-necked Stint *Calidris ruficollis*
- Masked Lapwing *Vanellus miles*
- Pied Oystercatcher *Haematopus longirostris*

With the exception of the Pied Oystercatcher, Sooty Oystercatcher and Masked lapwing, the species that characterise the endangered community arrive in Australia during August-September and remain until April-May.

Individually, species identified within the community may be found at other locations along the NSW coastline and inland to west of the Great Dividing Range.

Recorded occurrences in conservation reserves
The individual species that constitute the Taren Point Shorebird community have been recorded in National Parks, State Recreation Areas and Nature Reserves throughout NSW. These include the Clarence, Hastings, Hunter, Port Stephens and Tweed estuaries. However, the assemblage of species that forms the listed endangered community found at Taren point is exclusive to this area.

Habitat
In Botany Bay the shorebird community utilises roosting and foraging habitat (intertidal mud flats and sand flats) not only at the relic marginal shoal at Taren Point but at other sites including Penrhyn Inlet, Sandringham and the shoreline adjacent to the north-east side of the

NSW NATIONAL PARKS AND WILDLIFE SERVICE

Captain Cook Bridge. For some species (Terek Sandpiper, Grey-tailed Tattler), the proximity of Mangroves *Avicennia marina* is important as roosting habitat.

Ecology

A majority of the species of the Taren Point Shorebird community breed in the northern hemisphere, including northeast Siberia and Alaska. They breed during June-July then leave the breeding grounds and migrate south between August and September. They spend the austral summer in Australia, New Zealand, Indonesia, southern Asia and Africa. Upon arrival in Australia, they generally return to traditional feeding and roosting locations, such as those found at Taren Point and elsewhere in Botany Bay. They leave Australia between April and May. However juveniles, non-breeders or under-weight individuals often will not migrate north, remaining in their southern foraging grounds over winter (McNeil *et al.* 1994, Readers Digest, 1997).

The community usually forage as separate guilds (groups of species) during low tide in locations adjacent to the roost site.

Threats

The main threat to these shorebirds is loss of habitat. Other threats include disturbance to foraging and roosting behaviours, pollution and predation by animals including the feral fox and feral cat (Lawler, 1996).

Management

Management activities involve the protection of existing habitat, creation of new suitable habitat, the reduction of disturbance and threatening processes.

Recovery Plans

There is currently no Recovery Plan for the Taren Point Shorebird Community.

For Further Information contact

Threatened Species Unit, Central Directorate, NSW NPWS PO Box 1967, Hurstville NSW 2220 Phone 02 9585 6678
www.npws.nsw.gov.au

REFERENCES

Higgins P.J. & Davies S.J.J.F., 1996, *Handbook of Australian, New Zealand & Antarctic birds, Vol3*, Oxford University Press, Melbourne

Lawler W., 1996, *Guidelines for management of migratory Shorebird habitat in South East Coast estuaries, Australia.* Masters Thesis, University of Armidale.

McNeil, R., Tulio Diaz, M., & Villeneuve A., 1994. The mystery of Shorebird over-summering: A new hypothesis. *Ardea* 82: 143-152.

NSW Scientific Committee (1998). Final determination for the Taren Point Shorebird Community as an endangered ecological community. NSW Scientific Committee, Hurstville.

Pringle J.D, 1987, *The Shorebirds of Australia*, Angus & Robertson Publishers, UK

Readers Digest, 1997, *Complete book of Australian Birds*, Readers Digest, Sydney

WORKING DRAFT

(2) If the Director-General fails to grant, but does not refuse, a licence application by the expiry of the period of 120 days referred to in section 99 (2) or of any extension of that period agreed to by the Director-General and the applicant for the licence, the application is taken to have been granted.

108 Stay of operation of licence pending appeal

(1) If an appeal relates to the grant of a licence, the licence has no operation until the expiration of the period within which a person entitled to lodge an appeal may do so or, if an appeal has been lodged, until the appeal is finally determined.

(2) If no written submissions about an application of a licence are received at the specified place and by the specified date and the applicant informs the Director-General in writing that the applicant does not wish to lodge an appeal but that the applicant wishes the licence to commence, the licence is to operate from a date stipulated by the Director-General.

Division 2 Species impact statements

109 Form of species impact statements

(1) A species impact statement must be in writing.

(2) A species impact statement must be signed by the principal author of the statement and by:

(a) the applicant for the licence, or

(b) if the species impact statement is prepared for the purposes of the *Environmental Planning and Assessment Act 1979*, the applicant for development consent or the proponent of the activity proposed to be carried out (as the case requires).

110 Content of species impact statement

(1) A species impact statement must include a full description of the action proposed, including its nature, extent, location, timing and layout and, to the fullest extent reasonably practicable, the information referred to in this section.

(2) A species impact statement must include the following information as to threatened species and populations:

(a) a general description of the threatened species or populations known or likely to be present in the area that is the subject of the action and in any area that is likely to be affected by the action,

(b) an assessment of which threatened species or populations known or likely to be present in the area are likely to be affected by the action,

(c) for each species or population likely to be affected, details of its local, regional and State-wide conservation status, the key threatening processes generally affecting it, its habitat requirements and any recovery plan or threat abatement plan applying to it,

(d) an estimate of the local and regional abundance of those species or populations,

(e) (Repealed)

(f) a full description of the type, location, size and condition of the habitat (including critical habitat) of those species and populations and details of the distribution and condition of similar habitats in the region,

(g) a full assessment of the likely effect of the action on those species and populations, including, if possible, the quantitative effect of local populations in the cumulative effect in the region,

(h) a description of any feasible alternatives to the action that are likely to be of lesser effect and the reasons justifying the carrying out of the action in the manner proposed, having regard to the biophysical, economic and social considerations and the principles of ecologically sustainable development,

(i) a full description and justification of the measures proposed to mitigate any adverse effect of the action on the species and populations, including a compilation (in a single section of the statement) of those measures,

(j) a list of any approvals that must be obtained under any other Act or law before the action may be lawfully carried out, including details of the conditions of any existing approvals that are relevant to the species or population.

(3) A species impact statement must include the following information as to ecological communities:

(a) a general description of the ecological community present in the area that is the subject of the action and in any area that is likely to be affected by the action,

(b) for each ecological community present, details of its local, regional and State-wide conservation status, the key threatening processes generally affecting it, its habitat requirements and any recovery plan or any threat abatement plan applying to it,

(c) a full description of the type, location, size and condition of the habitat of the ecological community and details of the distribution and condition of similar habitats in the region,

(d) a full assessment of the likely effect of the action on the ecological community, including, if possible, the quantitative effect of local populations in the cumulative effect in the region,

(e) a description of any feasible alternatives to the action that are likely to be of lesser effect and the reasons justifying the carrying out of the action in the manner proposed, having regard to the biophysical, economic and social considerations and the principles of ecologically sustainable development,

(f) a full description and justification of the measures proposed to mitigate any adverse effect of the action on the ecological community, including a compilation (in a single section of the statement) of those measures,

(g) a list of any approvals that must be obtained under any other Act or law before the action may be lawfully carried out, including details of the conditions of any existing approvals that are relevant to the ecological community.

(4) A species impact statement must include details of the qualifications and experience in threatened species conservation of the person preparing the statement and of any other person who has conducted research or investigations relied on in preparing the statement.

(5) The requirements of subsections (2) and (3) in relation to information concerning the State-wide conservation status of any species or population, or any ecological community, are taken to be satisfied by the information in that regard supplied to the principal author of the species impact statement by the National Parks and Wildlife Service, which information that Service is by this subsection authorised and required to provide.

111 Director-General's requirements

(1) The person applying for the licence (or, if the species impact statement is being prepared for the purposes of the *Environmental Planning and Assessment Act 1979*, the applicant for development consent or the proponent of the activity) must request from the Director-General and must, in preparing the species impact statement, comply with any requirements notified to the person by the Director-General concerning the form and content of the statement.

(2) The Director-General must notify any requirements under this section within 28 days after having been requested to provide them.

(3) Despite the other provisions of this Division, the Director-General may, having regard to the circumstances of a particular case, limit or modify (or limit and modify) the matters to be included in a species impact statement in such manner as may be specified by the Director-General in the particular case.

(4) Despite anything in this Act or the *Environmental Planning and Assessment Act 1979*, the Director-General may, having regard to the circumstances of a particular case, dispense with the requirement for a species impact statement in the particular case if the Director-General is satisfied that the impact of the activity concerned will be trivial or negligible.

Appendix C
Environment Australia Requirements

CORRESPONDENCE
No. 02/0010

Environment Australia

Department of the Environment and Heritage

SYDNEY PORTS CORPORATION
23 JAN 2002
2002/0004/7

Mr Barrie Turner
Sydney Ports Corporation
Level 8, 207 Kent Street
SYDNEY NSW 2000

RECEIVED
S.P.C. RECORDS
23 JAN 2002

Dear Mr Turner

Sydney Ports Corporation/Water transport/Botany Bay/NSW/
Expansion of Port Botany facilities
(Reference: 2002/543)

The above action was referred by Sydney Ports Corporation, and received on 3 January 2002, for decision whether or not approval is needed under Chapter 4 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The referral documentation nominated the Sydney Ports Corporation as the person proposing to undertake the action.

The referral has now been considered under the EPBC Act and I have decided that the action *is a controlled action*. Approval is therefore needed under Part 9 of the Act before the action can proceed.

A copy of the document recording my decision is attached for your information.

The referral documentation nominated the Sydney Ports Corporation as the designated proponent for the action. The first step in the assessment process is for the proponent to provide preliminary information as the basis for determining the level of assessment.

In this case, we note that you provided the prescribed information on 3 January 2002. The Department is currently considering the level of assessment needed and you will be advised of the outcome in the near future.

Yours sincerely

Gerard Early

Gerard Early
First Assistant Secretary
Approvals and Legislation Division

17 January 2002

GPO Box 787 Canberra ACT 2601 Telephone 02 6274 1111 Facsimile 02 6274 1666
Internet: www.environment.gov.au

Appendix D

Floristic List

Appendix D
Plant Species List

1 = Plant Community No. 1 (Coastal Dune Heath)
2 = Plant Community No. 2 (Saltmarsh Herbland)
3 = Plant Community No. 3 (Mangrove Swamp)
* = introduced or non-endemic species

The flora list represents species recorded on the site during the botanical survey and should not be interpreted as a comprehensive list of all species present, given the ephemeral nature of many plant species (that is, surveys over many years would be required to obtain a comprehensive list of all species occurring in an area).

Grouping and Family	Botanical Name	Common Name	1	2	3
Monocotyledons					
Cyperaceae	*Isolepis nodosa*		✕	✕	
Poaceae	*Sporobolus virginicus*	Sand Couch	✕	✕	
	Spinifex sericeus		✕		
	*Pennisetum clandestinum**	Kikuyu Grass	✕		
	*Melinus repens**	Dune Red Grass	✕		
	*Erharta erecta**	Panic Veldtgrass	✕		
Dicotyledons					
Aizoaceae	*Carpobrotus glaucescens**	Pig Face	✕		
	Tetragonia tetragonioides	New Zealand Spinach	✕	✕	
Apiaceae	*Hydrocotyle bonariensis**	Kurnell Curse	✕		
Asteraceae	*Chrysanthemoides monilifera ssp monilifera**	Bitou Bush	✕		
	*Senecio madagascariensis**		✕		
Avicenniaceae	*Avicennia marina var. australasica*	Grey Mangrove		✕	✕
Brassicaceae	*Cakile maritima* ssp *maritima*	Sea Rocket	✕		
	Cakile edentula ssp *edentula**	Sea Rocket	✕		

Grouping and Family	Botanical Name	Common Name	1	2	3
Casuarinaceae	*Allocasuarina distyla*		✕		
	Allocasuarina littoralis		✕		
Chenopodiaceae	*Atriplex semibaccata*	Half-berried Salt-bush	✕		
	Sarcocornia quinqueflora	Glasswort		✕	✕
	Suaeda australis	Austral Seablite		✕	✕
Juncaceae	*Juncus kraussii*	Sea Rush		✕	
Mimosaceae	*Acacia longifolia* var *sophorae*		✕		
	*Acacia saligna**		✕		
	Acacia longifolia var *longifolia*	Sydney Golden Wattle	✕		
Myrtaceae	*Leptospermum laevigatum*	Coastal Tea Tree	✕		
	Melaleuca armillaris	Giant Honeymyrtle	✕		
	Melaleuca ericifolia	Swamp Paperbark	✕		
Plantaginaceae	*Plantago lanceolata**		✕		
	*Acetosa sagittata**	Rambling Dock	✕		
Proteaceae	*Banksia integrifolia*	Coastal Banksia	✕		
	Banksia serrata	Old Man Banksia	✕		
Sapindaceae	*Dodonaea triquetra*	Common Hop Bush	✕		
Verbenaceae	*Lantana camara**	Lantana	✕		

Appendix E

Wader Count Data

Birds Australia - Atlas of Australian Birds 1998 - April 2002

Waders in Botany Bay area (For total records in NSW and Australia scroll to the right)

Record Form#	Obs#	Species	Common_name	Breeding	Counts	Location	Latdeg	Latmin
1705	9448	133	Masked Lapwing			Cooks River, Earlwood	33	56
3234	9448	146	Black-winged Stilt			Barton Park, Earlwood	33	56
3234	9448	161	Curlew Sandpiper			Barton Park, Earlwood	33	56
3234	9448	163	Sharp-tailed Sandpiper			Barton Park, Earlwood	33	56
3774	14210	153	Bar-tailed Godwit			Penrhyn Road, Botany	33	57
3774	14210	161	Curlew Sandpiper			Penrhyn Road, Botany	33	57
3774	14210	162	Red-necked Stint			Penrhyn Road, Botany	33	57
6012	12233	168	Latham's Snipe			Sydney Airport	33	57
6013	12233	143	Red-capped Plover			Sydney Airport	33	56
6013	12233	152	Black-tailed Godwit			Sydney Airport	33	56
10182	3659	133	Masked Lapwing			Gunnamatta Park	34	3
10182	3659	138	Hooded Plover			Gunnamatta Park	34	3
12776	9448	133	Masked Lapwing			Cooks River, Earlwood	33	56
15734	9448	146	Black-winged Stilt			Barton Park, Arncliffe	33	56
15738	7539	130	Pied Oystercatcher			Botany Bay Historic Park	34	0
15738	7539	133	Masked Lapwing			Botany Bay Historic Park	34	0
16406	4080	133	Masked Lapwing			Eve Street Wetland, Rockdale	33	56
16406	4080	146	Black-winged Stilt	1	16	Eve Street Wetland, Rockdale	33	56
16406	4080	163	Sharp-tailed Sandpiper		1	Eve Street Wetland, Rockdale	33	56
16407	4080	146	Black-winged Stilt		11	Eve Street Wetland, Rockdale	33	56
16408	4080	146	Black-winged Stilt		18	Eve Street Wetland, Rockdale	33	56
28447	4080	146	Black-winged Stilt		2	Eve Street Wetland, Rockdale	33	56
28451	4080	133	Masked Lapwing		1	Metromix Swamp, Kurnell	34	2
29324	26398	149	Eastern Curlew			Towra Point, Botany Bay	34	0
46838	11556	143	Red-capped Plover			Penryhn Road, Botany	33	57
46838	11556	153	Bar-tailed Godwit			Penryhn Road, Botany	33	57
46838	11556	161	Curlew Sandpiper			Penryhn Road, Botany	33	57
46838	11556	164	Red Knot		15	Penryhn Road, Botany	33	57
47769	4080	146	Black-winged Stilt		1	Eve Street Wetland, Rockdale	33	56

47770	4080	146	Black-winged Stilt	1	14	Riverine Park Wetland, Arncliffe	33	57
47770	4080	163	Sharp-tailed Sandpiper		24	Riverine Park Wetland, Arncliffe	33	57
56205	4080	146	Black-winged Stilt		3	Eve Street Wetland, Rockdale	33	56
56206	4080	146	Black-winged Stilt	1	14	Riverine Park Wetland, Arncliffe	33	57
56206	4080	163	Sharp-tailed Sandpiper		20	Riverine Park Wetland, Arncliffe	33	57
69574	4080	146	Black-winged Stilt		4	Eve Street Wetland, Rockdale	33	56
84831	4080	146	Black-winged Stilt		7	Riverine Park Wetland, Arncliffe	33	57
84832	4080	129	Ruddy Turnstone		4	Oyster farms, Tarren Point	34	1
84832	4080	130	Pied Oystercatcher		16	Oyster farms, Tarren Point	34	1
84832	4080	131	Sooty Oystercatcher		1	Oyster farms, Tarren Point	34	1
84832	4080	149	Eastern Curlew		1	Oyster farms, Tarren Point	34	1
84832	4080	153	Bar-tailed Godwit		16	Oyster farms, Tarren Point	34	1
84832	4080	155	Grey-tailed Tattler		3	Oyster farms, Tarren Point	34	1
92941	4080	146	Black-winged Stilt		2	Eve Street Wetland, Rockdale	33	56
92942	4080	146	Black-winged Stilt		9	Riverine Park Wetland, Arncliffe	33	57
103848	4080	146	Black-winged Stilt		2	Eve Street Wetland, Rockdale	33	56
103849	4080	146	Black-winged Stilt		2	Eve Street Wetland, Rockdale	33	56
103850	4080	146	Black-winged Stilt		6	Riverine Park Wetland, Arncliffe	33	57
124137	4080	131	Sooty Oystercatcher		2	Caltex Wetland, Kurnell	34	2
124137	4080	144	Black-fronted Dotterel		1	Caltex Wetland, Kurnell	34	2
124137	4080	146	Black-winged Stilt		2	Caltex Wetland, Kurnell	34	2
124137	4080	153	Bar-tailed Godwit		3	Caltex Wetland, Kurnell	34	2
125695	2910	130	Pied Oystercatcher			Metomix Wetland, Kurnell	34	2
125695	2910	144	Black-fronted Dotterel			Metomix Wetland, Kurnell	34	2
125695	2910	149	Eastern Curlew			Metomix Wetland, Kurnell	34	2
125695	2910	153	Bar-tailed Godwit			Metomix Wetland, Kurnell	34	2
125696	2910	149	Eastern Curlew			Metomix Wetland, Kurnell	34	2
125696	2910	153	Bar-tailed Godwit			Metomix Wetland, Kurnell	34	2
129696	4080	144	Black-fronted Dotterel		2	Riverine Park Wetland, Arncliffe	33	57
129696	4080	146	Black-winged Stilt	1	35	Riverine Park Wetland, Arncliffe	33	57
129696	4080	161	Curlew Sandpiper		3	Riverine Park Wetland, Arncliffe	33	57
129696	4080	163	Sharp-tailed Sandpiper		1	Riverine Park Wetland, Arncliffe	33	57
129700	4080	146	Black-winged Stilt		2	Eve Street Wetland, Rockdale	33	56
129701	4080	133	Masked Lapwing		7	Metromix Wetland, Kurnell	34	2
129703	4080	133	Masked Lapwing			Bonna Point, Kurnell	34	0
129703	4080	149	Eastern Curlew		1	Bonna Point, Kurnell	34	0

129703	4080	155	Grey-tailed Tattler		1	Bonna Point, Kurnell	34	0
130723	12811	133	Masked Lapwing			Penrhyn Road, Botany	33	58
130723	12811	149	Eastern Curlew			Penrhyn Road, Botany	33	58
130723	12811	152	Black-tailed Godwit			Penrhyn Road, Botany	33	58
130723	12811	153	Bar-tailed Godwit			Penrhyn Road, Botany	33	58
130723	12811	161	Curlew Sandpiper			Penrhyn Road, Botany	33	58
130723	12811	162	Red-necked Stint			Penrhyn Road, Botany	33	58
130723	12811	164	Red Knot			Penrhyn Road, Botany	33	58
131118	16383	129	Ruddy Turnstone			Carters Island, Towra Spit Nature Reserve	34	0
131118	16383	130	Pied Oystercatcher	1		Carters Island, Towra Spit Nature Reserve	34	0
131118	16383	131	Sooty Oystercatcher			Carters Island, Towra Spit Nature Reserve	34	0
131118	16383	143	Red-capped Plover	1		Carters Island, Towra Spit Nature Reserve	34	0
131118	16383	146	Black-winged Stilt			Carters Island, Towra Spit Nature Reserve	34	0
131118	16383	149	Eastern Curlew			Carters Island, Towra Spit Nature Reserve	34	0
131118	16383	153	Bar-tailed Godwit			Carters Island, Towra Spit Nature Reserve	34	0
131118	16383	162	Red-necked Stint			Carters Island, Towra Spit Nature Reserve	34	0
136149	16797	130	Pied Oystercatcher			Bonna Point, Kurnell	34	0
136149	16797	133	Masked Lapwing			Bonna Point, Kurnell	34	0
136149	16797	149	Eastern Curlew			Bonna Point, Kurnell	34	0
136149	16797	153	Bar-tailed Godwit			Bonna Point, Kurnell	34	0
136149	16797	155	Grey-tailed Tattler			Bonna Point, Kurnell	34	0
140434	12448	133	Masked Lapwing			Bonna Point, Kurnell	34	0
140435	12448	131	Sooty Oystercatcher			Boat Harbour, Botany Bay NP	34	2
145994	4080	144	Black-fronted Dotterel		4	Metromix Wetland, Kurnell	34	2
145994	4080	153	Bar-tailed Godwit		3	Metromix Wetland, Kurnell	34	2
145995	4080	130	Pied Oystercatcher		2	Metromix Wetland, Kurnell	34	2
145995	4080	153	Bar-tailed Godwit		2	Metromix Wetland, Kurnell	34	2
145996	4080	146	Black-winged Stilt		5	Eve Street Wetland, Rockdale	33	56
145998	4080	144	Black-fronted Dotterel		4	Riverine Park Wetland, Arncliffe	33	57
145998	4080	146	Black-winged Stilt		6	Riverine Park Wetland, Arncliffe	33	57
145999	4080	144	Black-fronted Dotterel		2	Riverine Park Wetland, Arncliffe	33	57
145999	4080	146	Black-winged Stilt		6	Riverine Park Wetland, Arncliffe	33	57
146000	4080	130	Pied Oystercatcher			Bonna Point, Kurnell	34	0
146000	4080	131	Sooty Oystercatcher			Bonna Point, Kurnell	34	0
146000	4080	155	Grey-tailed Tattler		12	Bonna Point, Kurnell	34	0
150546	12448	133	Masked Lapwing			Kurnell	34	0

153343	4080	144	Black-fronted Dotterel		1	Riverine Park Wetland, Arncliffe	33	56
153343	4080	146	Black-winged Stilt		10	Riverine Park Wetland, Arncliffe	33	56
162630	4080	133	Masked Lapwing		2	Metromix Wetland, Kurnell	34	2
162633	4080	146	Black-winged Stilt		2	Eve Street Wetland, Rockdale	33	56
162634	4080	146	Black-winged Stilt		7	Riverine Park Wetland, Arncliffe	33	56
162635	4080	146	Black-winged Stilt		8	Riverine Park Wetland, Arncliffe	33	56
178371	6692	133	Masked Lapwing			Mill Pond, Botany	33	56
178371	6692	144	Black-fronted Dotterel	1		Mill Pond, Botany	33	56
181295	4080	144	Black-fronted Dotterel		2	Riverine Park Wetland, Arncliffe	33	56
181295	4080	146	Black-winged Stilt		9	Riverine Park Wetland, Arncliffe	33	56
181295	4080	163	Sharp-tailed Sandpiper		2	Riverine Park Wetland, Arncliffe	33	56
192579	4080	133	Masked Lapwing		4	Riverine Park Wetland, Arncliffe	33	56
192579	4080	146	Black-winged Stilt		4	Riverine Park Wetland, Arncliffe	33	56
192579	4080	161	Curlew Sandpiper		5	Riverine Park Wetland, Arncliffe	33	56
192579	4080	163	Sharp-tailed Sandpiper		14	Riverine Park Wetland, Arncliffe	33	56
351695		146	Black-winged Stilt			Sir Joseph Banks Park & foreshore, Botany	33	57
351695		153	Bar-tailed Godwit			Sir Joseph Banks Park & foreshore, Botany	33	57
351909		130	Pied Oystercatcher			Sandringham Beach	34	0
351909		153	Bar-tailed Godwit			Sandringham Beach	34	0
351910		153	Bar-tailed Godwit			Sandringham Beach	34	0
351911		130	Pied Oystercatcher			Sandringham Beach	34	0
351911		149	Eastern Curlew			Sandringham Beach	34	0
351911		153	Bar-tailed Godwit			Sandringham Beach	34	0
351912		130	Pied Oystercatcher			Sandringham Beach	34	0
351912		149	Eastern Curlew			Sandringham Beach	34	0
351912		153	Bar-tailed Godwit			Sandringham Beach	34	0
351913		153	Bar-tailed Godwit			Sandringham Beach	34	0
351974		130	Pied Oystercatcher			Sandringham Beach	34	0
351974		153	Bar-tailed Godwit			Sandringham Beach	34	0
351975		133	Masked Lapwing			Sandringham Beach	34	0
351975		149	Eastern Curlew			Sandringham Beach	34	0
351975		153	Bar-tailed Godwit			Sandringham Beach	34	0
351976		149	Eastern Curlew			Sandringham Beach	34	0
351976		153	Bar-tailed Godwit			Sandringham Beach	34	0
351977		149	Eastern Curlew			Sandringham Beach	34	0
351977		153	Bar-tailed Godwit			Sandringham Beach	34	0

352394		133	Masked Lapwing			Boat Harbour, Botany Bay NP	34	2
352394		140	Double-banded Plover			Boat Harbour, Botany Bay NP	34	2
352394		153	Bar-tailed Godwit			Boat Harbour, Botany Bay NP	34	2
352394		162	Red-necked Stint			Boat Harbour, Botany Bay NP	34	2
352402		129	Ruddy Turnstone			Boat Harbour, Botany Bay NP	34	2
352402		131	Sooty Oystercatcher			Boat Harbour, Botany Bay NP	34	2
352402		133	Masked Lapwing			Boat Harbour, Botany Bay NP	34	2
352408		129	Ruddy Turnstone			Boat Harbour, Botany Bay NP	34	2
352408		131	Sooty Oystercatcher			Boat Harbour, Botany Bay NP	34	2
352408		140	Double-banded Plover			Boat Harbour, Botany Bay NP	34	2
352408		144	Black-fronted Dotterel			Boat Harbour, Botany Bay NP	34	2
352408		162	Red-necked Stint			Boat Harbour, Botany Bay NP	34	2
352417		130	Pied Oystercatcher			Woodlands Road Reserve, Taren Point	34	1
352417		149	Eastern Curlew			Woodlands Road Reserve, Taren Point	34	1
352426		129	Ruddy Turnstone			Boat Harbour, Botany Bay NP	34	2
352426		131	Sooty Oystercatcher			Boat Harbour, Botany Bay NP	34	2
352426		140	Double-banded Plover			Boat Harbour, Botany Bay NP	34	2
352426		162	Red-necked Stint			Boat Harbour, Botany Bay NP	34	2
353322		130	Pied Oystercatcher			Towra Point Nature Reserve	34	1
353322		133	Masked Lapwing			Towra Point Nature Reserve	34	1
353322		149	Eastern Curlew			Towra Point Nature Reserve	34	1
353322		153	Bar-tailed Godwit			Towra Point Nature Reserve	34	1
353322		155	Grey-tailed Tattler			Towra Point Nature Reserve	34	1
353517		133	Masked Lapwing			Port Of Botany, Botany	33	57
353517		137	Pacific Golden Plover			Port Of Botany, Botany	33	57
353517		146	Black-winged Stilt			Port Of Botany, Botany	33	57
353517		153	Bar-tailed Godwit			Port Of Botany, Botany	33	57
353517		161	Curlew Sandpiper			Port Of Botany, Botany	33	57
353517		162	Red-necked Stint			Port Of Botany, Botany	33	57
353523		129	Ruddy Turnstone			Boat Harbour, Botany Bay NP	34	2
353523		131	Sooty Oystercatcher			Boat Harbour, Botany Bay NP	34	2
353523		137	Pacific Golden Plover			Boat Harbour, Botany Bay NP	34	2
353523		155	Grey-tailed Tattler			Boat Harbour, Botany Bay NP	34	2
353523		162	Red-necked Stint			Boat Harbour, Botany Bay NP	34	2
353825		130	Pied Oystercatcher			Taren Point	34	1
353825		133	Masked Lapwing			Taren Point	34	1

353825		149	Eastern Curlew			Taren Point	34	1
353825		153	Bar-tailed Godwit			Taren Point	34	1
353825		155	Grey-tailed Tattler			Taren Point	34	1
353825		162	Red-necked Stint			Taren Point	34	1
353826		143	Red-capped Plover			Port Of Botany, Botany	33	57
353826		152	Black-tailed Godwit			Port Of Botany, Botany	33	57
353826		153	Bar-tailed Godwit			Port Of Botany, Botany	33	57
353826		161	Curlew Sandpiper			Port Of Botany, Botany	33	57
353826		162	Red-necked Stint			Port Of Botany, Botany	33	57
354125		133	Masked Lapwing			Port Of Botany, Botany	33	57
354125		137	Pacific Golden Plover			Port Of Botany, Botany	33	57
354125		143	Red-capped Plover			Port Of Botany, Botany	33	57
354125		144	Black-fronted Dotterel			Port Of Botany, Botany	33	57
354125		146	Black-winged Stilt			Port Of Botany, Botany	33	57
354125		153	Bar-tailed Godwit			Port Of Botany, Botany	33	57
354126		130	Pied Oystercatcher			Taren Point	34	1
354126		133	Masked Lapwing			Taren Point	34	1
354126		149	Eastern Curlew			Taren Point	34	1
354126		153	Bar-tailed Godwit			Taren Point	34	1
354126		155	Grey-tailed Tattler			Taren Point	34	1
354126		160	Terek Sandpiper			Taren Point	34	1
354430		133	Masked Lapwing			Port Of Botany, Botany	33	57
354430		143	Red-capped Plover			Port Of Botany, Botany	33	57
354430		153	Bar-tailed Godwit			Port Of Botany, Botany	33	57
354430		161	Curlew Sandpiper			Port Of Botany, Botany	33	57
354430		163	Sharp-tailed Sandpiper			Port Of Botany, Botany	33	57
354434		129	Ruddy Turnstone			Boat Harbour, Botany Bay NP	34	2
354434		131	Sooty Oystercatcher			Boat Harbour, Botany Bay NP	34	2
354434		136	Grey Plover			Boat Harbour, Botany Bay NP	34	2
354434		137	Pacific Golden Plover			Boat Harbour, Botany Bay NP	34	2
354434		162	Red-necked Stint			Boat Harbour, Botany Bay NP	34	2
354985		133	Masked Lapwing			Coolabah Reserve, Bardwell Park	33	56
355145		130	Pied Oystercatcher			Port of Botany, Botany	33	57
355145		133	Masked Lapwing			Port of Botany, Botany	33	57
355145		144	Black-fronted Dotterel			Port of Botany, Botany	33	57
355145		146	Black-winged Stilt			Port of Botany, Botany	33	57

355145		153	Bar-tailed Godwit			Port of Botany, Botany	33	57
355145		161	Curlew Sandpiper			Port of Botany, Botany	33	57
355150		129	Ruddy Turnstone			Boat Harbour, Botany Bay NP	34	2
355150		131	Sooty Oystercatcher			Boat Harbour, Botany Bay NP	34	2
355150		133	Masked Lapwing			Boat Harbour, Botany Bay NP	34	2
355150		140	Double-banded Plover			Boat Harbour, Botany Bay NP	34	2
355150		162	Red-necked Stint			Boat Harbour, Botany Bay NP	34	2
356007		129	Ruddy Turnstone			Boat Harbour, Botany Bay NP	34	2
356007		131	Sooty Oystercatcher			Boat Harbour, Botany Bay NP	34	2
356007		136	Grey Plover			Boat Harbour, Botany Bay NP	34	2
356007		137	Pacific Golden Plover			Boat Harbour, Botany Bay NP	34	2
356007		139	Lesser Sand Plover			Boat Harbour, Botany Bay NP	34	2
356007		162	Red-necked Stint			Boat Harbour, Botany Bay NP	34	2
356007		166	Sanderling			Boat Harbour, Botany Bay NP	34	2
356008		137	Pacific Golden Plover			Port Of Botany, Botany	33	57
356008		143	Red-capped Plover			Port Of Botany, Botany	33	57
356008		144	Black-fronted Dotterel			Port Of Botany, Botany	33	57
356008		153	Bar-tailed Godwit			Port Of Botany, Botany	33	57
356008		161	Curlew Sandpiper			Port Of Botany, Botany	33	57
356008		162	Red-necked Stint			Port Of Botany, Botany	33	57
356014		149	Eastern Curlew			Taren Point	34	1
356014		153	Bar-tailed Godwit			Taren Point	34	1
356014		155	Grey-tailed Tattler			Taren Point	34	1
356015		133	Masked Lapwing			Port Of Botany, Botany	33	57
356015		153	Bar-tailed Godwit			Port Of Botany, Botany	33	57
356015		161	Curlew Sandpiper			Port Of Botany, Botany	33	57
356015		162	Red-necked Stint			Port Of Botany, Botany	33	57
356016		129	Ruddy Turnstone			Boat Harbour, Botany Bay NP	34	2
356016		131	Sooty Oystercatcher			Boat Harbour, Botany Bay NP	34	2
356016		133	Masked Lapwing			Boat Harbour, Botany Bay NP	34	2
356016		137	Pacific Golden Plover			Boat Harbour, Botany Bay NP	34	2
356016		142	Oriental Plover			Boat Harbour, Botany Bay NP	34	2
356016		162	Red-necked Stint			Boat Harbour, Botany Bay NP	34	2
356016		166	Sanderling			Boat Harbour, Botany Bay NP	34	2
356273		139	Lesser Sand Plover			Port of Botany, Botany	33	57
356273		143	Red-capped Plover			Port of Botany, Botany	33	57

356273		153	Bar-tailed Godwit			Port of Botany, Botany	33	57
356273		157	Common Sandpiper			Port of Botany, Botany	33	57
356273		161	Curlew Sandpiper			Port of Botany, Botany	33	57
356273		162	Red-necked Stint			Port of Botany, Botany	33	57
356273		164	Red Knot			Port of Botany, Botany	33	57
356274		130	Pied Oystercatcher			Cook Park, Sans Souci	34	0
356274		153	Bar-tailed Godwit			Cook Park, Sans Souci	34	0
356274		160	Terek Sandpiper			Cook Park, Sans Souci	34	0
356274		164	Red Knot			Cook Park, Sans Souci	34	0
356275		130	Pied Oystercatcher			Taren Point	34	1
356275		133	Masked Lapwing			Taren Point	34	1
356275		149	Eastern Curlew			Taren Point	34	1
356275		150	Whimbrel			Taren Point	34	1
356275		153	Bar-tailed Godwit			Taren Point	34	1
356275		155	Grey-tailed Tattler			Taren Point	34	1
356607		149	Eastern Curlew			SANDRINGHAM BEACH BOTANY BAY	34	0
356607		153	Bar-tailed Godwit			SANDRINGHAM BEACH BOTANY BAY	34	0
356608		153	Bar-tailed Godwit			SANDRINGHAM BEACH BOTANY BAY	34	0
356609		153	Bar-tailed Godwit			SANDRINGHAM BEACH BOTANY BAY	34	0
356610		153	Bar-tailed Godwit			SANDRINGHAM BEACH BOTANY BAY	34	0
356611		153	Bar-tailed Godwit			SANDRINGHAM BEACH	34	0
356612		130	Pied Oystercatcher			SANDRINGHAM BEACH	34	0
356612		153	Bar-tailed Godwit			SANDRINGHAM BEACH	34	0
356613		130	Pied Oystercatcher			SANDRINGHAM	34	0
356613		153	Bar-tailed Godwit			SANDRINGHAM	34	0
356614		130	Pied Oystercatcher			SANDRINGHAM	34	0
356614		149	Eastern Curlew			SANDRINGHAM	34	0
356614		153	Bar-tailed Godwit			SANDRINGHAM	34	0
356615		153	Bar-tailed Godwit			SANDRINGHAM	34	0
356616		130	Pied Oystercatcher			SANDRINGHAM BEACH	34	0
356616		149	Eastern Curlew			SANDRINGHAM BEACH	34	0
356616		153	Bar-tailed Godwit			SANDRINGHAM BEACH	34	0
356617		149	Eastern Curlew			SANDRINGHAM BEACH	34	0
356617		153	Bar-tailed Godwit			SANDRINGHAM BEACH	34	0
356618		130	Pied Oystercatcher			SANDRINGHAM BEACH	34	0
356618		149	Eastern Curlew			SANDRINGHAM BEACH	34	0

356618		153	Bar-tailed Godwit			SANDRINGHAM BEACH	34	0
356619		149	Eastern Curlew			SANDRINGHAM BEACH	34	0
356619		153	Bar-tailed Godwit			SANDRINGHAM BEACH	34	0
356621		149	Eastern Curlew			SANDRINGHAM BEACH	34	0
356621		153	Bar-tailed Godwit			SANDRINGHAM BEACH	34	0
356622		149	Eastern Curlew			SANDRINGHAM BEACH	34	0
356622		153	Bar-tailed Godwit			SANDRINGHAM BEACH	34	0
356623		153	Bar-tailed Godwit			SANDRINGHAM BEACH	34	0
356625		153	Bar-tailed Godwit			SANDRINGHAM BEACH	34	0
356627		130	Pied Oystercatcher			SANDRINGHAM BEACH	34	0
356627		153	Bar-tailed Godwit			SANDRINGHAM BEACH	34	0
356628		130	Pied Oystercatcher			SANDRINGHAM BEACH	34	0
356628		153	Bar-tailed Godwit			SANDRINGHAM BEACH	34	0
356629		149	Eastern Curlew			SANDRINGHAM BEACH	34	0
356629		153	Bar-tailed Godwit			SANDRINGHAM BEACH	34	0
356630		130	Pied Oystercatcher			SANDRINGHAM BEACH	34	0
357180		146	Black-winged Stilt			BOTANY WETLANDS	33	56
357656		129	Ruddy Turnstone			BOAT HARBOUR	34	2
357656		139	Lesser Sand Plover			BOAT HARBOUR	34	2
357656		162	Red-necked Stint			BOAT HARBOUR	34	2
357678		129	Ruddy Turnstone			KURNELL	34	2
357678		131	Sooty Oystercatcher			KURNELL	34	2
357678		139	Lesser Sand Plover			KURNELL	34	2
357678		162	Red-necked Stint			KURNELL	34	2
357687		149	Eastern Curlew			SANDRINGHAM BEACH PORT HACKING	34	0
357687		153	Bar-tailed Godwit			SANDRINGHAM BEACH PORT HACKING	34	0
357688		153	Bar-tailed Godwit			SANDRINGHAM BEACH PORT HACKING	34	0
357689		149	Eastern Curlew			SANDRINGHAM BEACH PORT HACKING	34	0
357689		153	Bar-tailed Godwit			SANDRINGHAM BEACH PORT HACKING	34	0
357690		149	Eastern Curlew			SANDRINGHAM BEACH PORT HACKING	34	0
357690		153	Bar-tailed Godwit			SANDRINGHAM BEACH PORT HACKING	34	0
357691		149	Eastern Curlew			SANDRINGHAM BEACH PORT HACKING AREA	34	0
357691		153	Bar-tailed Godwit			SANDRINGHAM BEACH PORT HACKING AREA	34	0
357692		153	Bar-tailed Godwit			SANDRINGHAM BEACH PORT HACKING GRID	34	0
357692		163	Sharp-tailed Sandpiper			SANDRINGHAM BEACH PORT HACKING GRID	34	0
357693		149	Eastern Curlew			SANDRINGHAM BEACH PORT HACKING GRID	34	0

357693		153	Bar-tailed Godwit			SANDRINGHAM BEACH PORT HACKING GRID	34	0
357694		149	Eastern Curlew			SANDRINGHAM BEACH PORT HACKING GRID	34	0
357694		153	Bar-tailed Godwit			SANDRINGHAM BEACH PORT HACKING GRID	34	0
357695		130	Pied Oystercatcher			SANDRINGHAM BEACH PORT HACKING GRID	34	0
357695		149	Eastern Curlew			SANDRINGHAM BEACH PORT HACKING GRID	34	0
357695		153	Bar-tailed Godwit			SANDRINGHAM BEACH PORT HACKING GRID	34	0
357878		129	Ruddy Turnstone			Boat Harbour, Botany Bay NP	34	2
357878		131	Sooty Oystercatcher			Boat Harbour, Botany Bay NP	34	2
357878		133	Masked Lapwing			Boat Harbour, Botany Bay NP	34	2
357878		139	Lesser Sand Plover			Boat Harbour, Botany Bay NP	34	2
357878		142	Oriental Plover			Boat Harbour, Botany Bay NP	34	2
357878		162	Red-necked Stint			Boat Harbour, Botany Bay NP	34	2
357878		166	Sanderling			Boat Harbour, Botany Bay NP	34	2
357881		137	Pacific Golden Plover			BOTANY BAY. BANKSMEADOW NEAR CONTAINER DEPOT	33	58
357881		153	Bar-tailed Godwit			BOTANY BAY. BANKSMEADOW NEAR CONTAINER DEPOT	33	58
357881		161	Curlew Sandpiper			BOTANY BAY. BANKSMEADOW NEAR CONTAINER DEPOT	33	58
357881		162	Red-necked Stint			BOTANY BAY. BANKSMEADOW NEAR CONTAINER DEPOT	33	58
358221		131	Sooty Oystercatcher			BOAT HARBOUR ROCKS	34	3
358221		139	Lesser Sand Plover			BOAT HARBOUR ROCKS	34	3
358221		162	Red-necked Stint			BOAT HARBOUR ROCKS	34	3
358222		129	Ruddy Turnstone			ROCKS WEST OF POINT PLOMER	34	3
358222		131	Sooty Oystercatcher			ROCKS WEST OF POINT PLOMER	34	3
358234		149	Eastern Curlew			SANDRINGHAM BEACH (PORT HACKING	34	0
358234		153	Bar-tailed Godwit			SANDRINGHAM BEACH (PORT HACKING	34	0
358235		153	Bar-tailed Godwit			SANDRINGHAM BEACH (PORT HACKING)	34	0
358236		130	Pied Oystercatcher			SANDRINGHAM BEACH (PORT HACKING)	34	0
358236		133	Masked Lapwing			SANDRINGHAM BEACH (PORT HACKING)	34	0
358237		133	Masked Lapwing			SANDRINGHAM BEACH (PORT HACKING)	34	0
358237		153	Bar-tailed Godwit			SANDRINGHAM BEACH (PORT HACKING)	34	0
400503	4710	149	Eastern Curlew		310	Towra Island, Towra Point Nature Reserve	34	0
401024	7225	146	Black-winged Stilt			Eve Street Wetland, Rockdale	33	56
401024	7225	163	Sharp-tailed Sandpiper			Eve Street Wetland, Rockdale	33	56
401067	9050	130	Pied Oystercatcher		20	Towra Point	34	1
500020	600019	130	Pied Oystercatcher			Towra Point, Shell Point	34	1
500020	600019	137	Pacific Golden Plover			Towra Point, Shell Point	34	1
500020	600019	149	Eastern Curlew			Towra Point, Shell Point	34	1

500020	600019	150	Whimbrel			Towra Point, Shell Point	34	1
500020	600019	153	Bar-tailed Godwit			Towra Point, Shell Point	34	1
500020	600019	155	Grey-tailed Tattler			Towra Point, Shell Point	34	1
500020	600019	160	Terek Sandpiper			Towra Point, Shell Point	34	1
500020	600019	161	Curlew Sandpiper			Towra Point, Shell Point	34	1
500164	600003	140	Double-banded Plover			Penrhyn Road, Botany	33	58
500164	600003	143	Red-capped Plover			Penrhyn Road, Botany	33	58
500164	600003	146	Black-winged Stilt			Penrhyn Road, Botany	33	58
500164	600003	153	Bar-tailed Godwit			Penrhyn Road, Botany	33	58
500164	600003	161	Curlew Sandpiper			Penrhyn Road, Botany	33	58
500454	8419	149	Eastern Curlew			Towra Point Nature Reserve, Kurnell	34	0
500454	8419	153	Bar-tailed Godwit			Towra Point Nature Reserve, Kurnell	34	0
500464	8419	168	Latham's Snipe			Metromix Bird Sanctuary, Kurnell	34	2
500500	600010	146	Black-winged Stilt			Eve Street wetlands, Rockdale	33	56
500501	600010	146	Black-winged Stilt			Riverine Park Wetland, Arncliffe	33	56
500501	600010	163	Sharp-tailed Sandpiper			Riverine Park Wetland, Arncliffe	33	56
500502	600010	146	Black-winged Stilt			Penryhn Road, Botany	33	57
500502	600010	153	Bar-tailed Godwit		90	Penryhn Road, Botany	33	57
500502	600010	161	Curlew Sandpiper		11	Penryhn Road, Botany	33	57
500502	600010	163	Sharp-tailed Sandpiper		2	Penryhn Road, Botany	33	57
500503	600010	133	Masked Lapwing			Bonna Point, Kurnell	34	0
500503	600010	164	Red Knot			Bonna Point, Kurnell	34	0
500658	9213	155	Grey-tailed Tattler			Bonna Point, Kurnell	34	0
500659	9213	133	Masked Lapwing			Penryhn Road, Botany	33	57
500659	9213	143	Red-capped Plover			Penryhn Road, Botany	33	57
500659	9213	146	Black-winged Stilt			Penryhn Road, Botany	33	57
500659	9213	153	Bar-tailed Godwit			Penryhn Road, Botany	33	57
500677	600003	143	Red-capped Plover			Penryhn Road, Botany	33	57
500677	600003	146	Black-winged Stilt			Penryhn Road, Botany	33	57
500677	600003	153	Bar-tailed Godwit			Penryhn Road, Botany	33	57
500931	600049	143	Red-capped Plover			Penrhyn Road, Botany	33	58
500931	600049	146	Black-winged Stilt			Penrhyn Road, Botany	33	58
500931	600049	153	Bar-tailed Godwit			Penrhyn Road, Botany	33	58
501015	9213	146	Black-winged Stilt			Penryhn Road, Botany	33	57
501015	9213	153	Bar-tailed Godwit			Penryhn Road, Botany	33	57
501015	9213	161	Curlew Sandpiper			Penryhn Road, Botany	33	57

501071	600003	153	Bar-tailed Godwit			Penryhn Road, Botany	33	57
501311	600003	133	Masked Lapwing		1	Penryhn Road, Botany	33	57
501311	600003	143	Red-capped Plover		1	Penryhn Road, Botany	33	57
501311	600003	153	Bar-tailed Godwit			Penryhn Road, Botany	33	57
501311	600003	161	Curlew Sandpiper			Penryhn Road, Botany	33	57
501311	600003	162	Red-necked Stint			Penryhn Road, Botany	33	57
501853	9050	133	Masked Lapwing			Towra Point Nature Reserve, Kurnell	34	0
502265	9050	144	Black-fronted Dotterel			Riverine Park Wetland, Arncliffe	33	56
502265	9050	146	Black-winged Stilt			Riverine Park Wetland, Arncliffe	33	56
502267	9050	146	Black-winged Stilt			Riverine Park Wetland, Arncliffe	33	56
502267	9050	163	Sharp-tailed Sandpiper			Riverine Park Wetland, Arncliffe	33	56
502428	4080	146	Black-winged Stilt		7	Riverine Park Wetland, Arncliffe	33	56
502429	4080	129	Ruddy Turnstone		4	Oyster farms, Taren Point	34	1
502429	4080	130	Pied Oystercatcher		16	Oyster farms, Taren Point	34	1
502429	4080	131	Sooty Oystercatcher		1	Oyster farms, Taren Point	34	1
502429	4080	149	Eastern Curlew		1	Oyster farms, Taren Point	34	1
502429	4080	153	Bar-tailed Godwit		16	Oyster farms, Taren Point	34	1
502429	4080	155	Grey-tailed Tattler		3	Oyster farms, Taren Point	34	1
502482	4080	146	Black-winged Stilt		2	Eve Street Wetland, Banksia	33	56
502483	4080	146	Black-winged Stilt		9	Riverine Park Wetland, Arncliffe	33	56
502584	4080	146	Black-winged Stilt		2	Eve Street Wetland, Banksia	33	56
502585	4080	146	Black-winged Stilt		2	Eve Street Wetland, Banksia	33	56
502586	4080	146	Black-winged Stilt		6	Riverine Park Wetland, Arncliffe	33	56
502708	8419	130	Pied Oystercatcher		2	Metromix Wetland, Kurnell	34	2
502708	8419	133	Masked Lapwing		2	Metromix Wetland, Kurnell	34	2
502708	8419	144	Black-fronted Dotterel		1	Metromix Wetland, Kurnell	34	2
502708	8419	146	Black-winged Stilt		3	Metromix Wetland, Kurnell	34	2
502742	9213	133	Masked Lapwing		6	H1 Lake, Metromix Wetland, Kurnell	34	2
502742	9213	149	Eastern Curlew		15	H1 Lake, Metromix Wetland, Kurnell	34	2
502742	9213	153	Bar-tailed Godwit		2	H1 Lake, Metromix Wetland, Kurnell	34	2
502743	9213	133	Masked Lapwing		15	H1 Lake, Metromix Wetland, Kurnell	34	2
502743	9213	144	Black-fronted Dotterel		1	H1 Lake, Metromix Wetland, Kurnell	34	2
502743	9213	149	Eastern Curlew		3	H1 Lake, Metromix Wetland, Kurnell	34	2
502764	7225	130	Pied Oystercatcher		2	Metromix Wetland, Kurnell	34	2
502764	7225	144	Black-fronted Dotterel		4	Metromix Wetland, Kurnell	34	2
502764	7225	149	Eastern Curlew		9	Metromix Wetland, Kurnell	34	2

502764	7225	153	Bar-tailed Godwit		2	Metromix Wetland, Kurnell	34	2
502765	7225	149	Eastern Curlew		50	Bonna Point, Kurnell	34	0
502765	7225	155	Grey-tailed Tattler		20	Bonna Point, Kurnell	34	0
502866	600003	130	Pied Oystercatcher		8	Metromix Reserve & Shellpoint, Kurnell	34	2
502866	600003	133	Masked Lapwing		4	Metromix Reserve & Shellpoint, Kurnell	34	2
502866	600003	149	Eastern Curlew		6	Metromix Reserve & Shellpoint, Kurnell	34	2
502866	600003	153	Bar-tailed Godwit		3	Metromix Reserve & Shellpoint, Kurnell	34	2
502866	600003	155	Grey-tailed Tattler		3	Metromix Reserve & Shellpoint, Kurnell	34	2
502866	600003	159	Marsh Sandpiper		7	Metromix Reserve & Shellpoint, Kurnell	34	2
502881	600003	155	Grey-tailed Tattler		22	Bonna Point, Kurnell	34	0
502882	600003	137	Pacific Golden Plover		52	Penrhyn Road, Botany	33	57
502882	600003	153	Bar-tailed Godwit		80	Penrhyn Road, Botany	33	57
502882	600003	161	Curlew Sandpiper		1	Penrhyn Road, Botany	33	57
502882	600003	162	Red-necked Stint		7	Penrhyn Road, Botany	33	57
502882	600003	164	Red Knot		2	Penrhyn Road, Botany	33	57
502883	600003	130	Pied Oystercatcher		1	Penrhyn Road, Botany	33	57
502883	600003	137	Pacific Golden Plover		26	Penrhyn Road, Botany	33	57
502883	600003	146	Black-winged Stilt		2	Penrhyn Road, Botany	33	57
502883	600003	153	Bar-tailed Godwit		135	Penrhyn Road, Botany	33	57
502883	600003	161	Curlew Sandpiper		40	Penrhyn Road, Botany	33	57
502883	600003	162	Red-necked Stint		40	Penrhyn Road, Botany	33	57
502883	600003	164	Red Knot		9	Penrhyn Road, Botany	33	57
502909	16032	153	Bar-tailed Godwit		2	Cooks River, Cahill Park, Arncliffe	33	56
502967	600003	131	Sooty Oystercatcher			Penrhyn Road, Botany	33	57
502967	600003	140	Double-banded Plover		22	Penrhyn Road, Botany	33	57
502967	600003	143	Red-capped Plover		20	Penrhyn Road, Botany	33	57
502967	600003	153	Bar-tailed Godwit			Penrhyn Road, Botany	33	57
502967	600003	162	Red-necked Stint		2	Penrhyn Road, Botany	33	57
502977	600033	146	Black-winged Stilt		1	Metromix Wetland, Kurnell	34	2
502977	600033	153	Bar-tailed Godwit		2	Metromix Wetland, Kurnell	34	2
503061	600003	130	Pied Oystercatcher		2	Metromix Reserve & Shellpoint, Kurnell	34	2
503061	600003	144	Black-fronted Dotterel		2	Metromix Reserve & Shellpoint, Kurnell	34	2
503062	600003	130	Pied Oystercatcher		2	Penrhyn Road, Botany	33	57
503062	600003	133	Masked Lapwing		2	Penrhyn Road, Botany	33	57
503062	600003	143	Red-capped Plover		5	Penrhyn Road, Botany	33	57
503062	600003	149	Eastern Curlew		1	Penrhyn Road, Botany	33	57

503062	600003	153	Bar-tailed Godwit		25	Penrhyn Road, Botany		33	57
503103	600033	130	Pied Oystercatcher		2	Metromix Wetland, Kurnell		34	2
503321	9213	153	Bar-tailed Godwit		115	Penrhyn Road, Port Botany		33	57
503321	9213	161	Curlew Sandpiper		25	Penrhyn Road, Port Botany		33	57
503321	9213	162	Red-necked Stint		5	Penrhyn Road, Port Botany		33	57
671378		155	Grey-tailed Tattler		27	Bonna Point, Kurnell		34	0
671379		130	Pied Oystercatcher		32	Georges River, Towra Point Aquatic Reserve		34	0
671379		143	Red-capped Plover		3	Georges River, Towra Point Aquatic Reserve		34	0
671379		149	Eastern Curlew		92	Georges River, Towra Point Aquatic Reserve		34	0
671379		153	Bar-tailed Godwit		200	Georges River, Towra Point Aquatic Reserve		34	0
671379		164	Red Knot		1	Georges River, Towra Point Aquatic Reserve		34	0
671381		149	Eastern Curlew		1	Tarren Point		34	0
671381		153	Bar-tailed Godwit		29	Tarren Point		34	0
671619		149	Eastern Curlew		1	Weeney Bay, Towra Point Nature Reserve		34	1
671621		158	Common Greenshank		1	Towra Point Nature Reserve		34	1

Latsec	Londeg	Lonmin	Lonsec	Lat	Lon	Accuracy (km)	Start date	Finish Date	Search Method	Comment	Species
	151	8		-33.93333	151.1333	0.5	24-11-98	25-11-98	Area search <5 km		129
	151	9		-33.93333	151.15	0.5	14-12-98	14-12-98	Area search <500 m		130
	151	9		-33.93333	151.15	0.5	14-12-98	14-12-98	Area search <500 m		131
	151	9		-33.93333	151.15	0.5	14-12-98	14-12-98	Area search <500 m		132
57	151	12	22	-33.96583	151.2061	0.1	11-10-98	11-10-98	2-ha search		133
57	151	12	22	-33.96583	151.2061	0.1	11-10-98	11-10-98	2-ha search		135
57	151	12	22	-33.96583	151.2061	0.1	11-10-98	11-10-98	2-ha search		136
	151	11		-33.95	151.1833	0.5	12-12-98	12-12-98	Incidental search	Other comments	137
47	151	11	51	-33.94639	151.1975	0.1	18-01-99	18-01-99	Area search <5 km		138
47	151	11	51	-33.94639	151.1975	0.1	18-01-99	18-01-99	Area search <5 km		139
	151	8		-34.05	151.1333	0.5	31-01-99	31-01-99	Area search <500 m		140
	151	8		-34.05	151.1333	0.5	31-01-99	31-01-99	Area search <500 m		141
	151	8		-33.93333	151.1333	0.5	24-04-99	26-04-99	Area search <5 km		142
	151	9		-33.93333	151.15	0.5	18-05-99	18-05-99	Area search <500 m		143
	151	11		-34	151.1833	0.5	22-05-99	22-05-99	Area search <500 m		144
	151	11		-34	151.1833	0.5	22-05-99	22-05-99	Area search <500 m		145
54	151	9	15	-33.94833	151.1542	0.1	9-02-99	9-02-99	2-ha search		146
54	151	9	15	-33.94833	151.1542	0.1	9-02-99	9-02-99	2-ha search		147
54	151	9	15	-33.94833	151.1542	0.1	9-02-99	9-02-99	2-ha search		148
54	151	9	15	-33.94833	151.1542	0.1	26-03-99	26-03-99	2-ha search		149
54	151	9	15	-33.94833	151.1542	0.1	29-05-99	29-05-99	2-ha search		150
54	151	9	15	-33.94833	151.1542	0.1	8-08-99	8-08-99	2-ha search	Other comments	151
30	151	9	30	-34.04167	151.1583	0.1	22-08-99	22-08-99	Area search <500 m		152
8	151	9	39	-34.00222	151.1608	0.5	8-09-98	8-09-98	Area search <5 km		153
57	151	12	45	-33.96583	151.2125	0.1	3-10-99	3-10-99	2-ha search	Other comments	154
57	151	12	45	-33.96583	151.2125	0.1	3-10-99	3-10-99	2-ha search		155
57	151	12	45	-33.96583	151.2125	0.1	3-10-99	3-10-99	2-ha search		156
57	151	12	45	-33.96583	151.2125	0.1	3-10-99	3-10-99	2-ha search		157
54	151	9	15	-33.94833	151.1542	0.1	13-11-99	13-11-99	2-ha search		158

0	151	9	0	-33.95	151.15	0.1	13-11-99	13-11-99	Area search <500 m		159
0	151	9	0	-33.95	151.15	0.1	13-11-99	13-11-99	Area search <500 m		160
54	151	9	15	-33.94833	151.1542	0.1	30-01-00	30-01-00	2-ha search		161
0	151	9	0	-33.95	151.15	0.1	30-01-00	30-01-00	2-ha search	Breeding	162
0	151	9	0	-33.95	151.15	0.1	30-01-00	30-01-00	2-ha search		163
54	151	9	15	-33.94833	151.1542	0.1	2-04-00	2-04-00	2-ha search		164
0	151	9	0	-33.95	151.15	0.1	3-06-00	3-06-00	2-ha search		165
15	151	7	40	-34.02083	151.1278	1	3-06-00	3-06-00	Area search <500 m		166
15	151	7	40	-34.02083	151.1278	1	3-06-00	3-06-00	Area search <500 m		167
15	151	7	40	-34.02083	151.1278	1	3-06-00	3-06-00	Area search <500 m		168
15	151	7	40	-34.02083	151.1278	1	3-06-00	3-06-00	Area search <500 m		170
15	151	7	40	-34.02083	151.1278	1	3-06-00	3-06-00	Area search <500 m		171
15	151	7	40	-34.02083	151.1278	1	3-06-00	3-06-00	Area search <500 m		172
54	151	9	15	-33.94833	151.1542	0.1	6-08-00	6-08-00	2-ha search		173
0	151	9	0	-33.95	151.15	0.1	6-08-00	6-08-00	2-ha search		174
54	151	9	15	-33.94833	151.1542	0.1	3-09-00	3-09-00	2-ha search		175
54	151	9	15	-33.94833	151.1542	0.1	8-10-00	8-10-00	2-ha search		744
0	151	9	0	-33.95	151.15	0.1	3-09-00	3-09-00	2-ha search		809
15	151	9	30	-34.0375	151.1583	0.5	6-01-01	6-01-01	2-ha search		822
15	151	9	30	-34.0375	151.1583	0.5	6-01-01	6-01-01	2-ha search		887
15	151	9	30	-34.0375	151.1583	0.5	6-01-01	6-01-01	2-ha search		891
15	151	9	30	-34.0375	151.1583	0.5	6-01-01	6-01-01	2-ha search		895
7	151	9	37	-34.03528	151.1603	0.1	20-01-01	20-01-01	2-ha search		934
7	151	9	37	-34.03528	151.1603	0.1	20-01-01	20-01-01	2-ha search		939
7	151	9	37	-34.03528	151.1603	0.1	20-01-01	20-01-01	2-ha search		965
7	151	9	37	-34.03528	151.1603	0.1	20-01-01	20-01-01	2-ha search		978
6	151	9	37	-34.035	151.1603	0.1	30-01-01	30-01-01	2-ha search		
6	151	9	37	-34.035	151.1603	0.1	30-01-01	30-01-01	2-ha search		
0	151	9	0	-33.95	151.15	0.1	4-02-01	4-02-01	2-ha search		
0	151	9	0	-33.95	151.15	0.1	4-02-01	4-02-01	2-ha search		
0	151	9	0	-33.95	151.15	0.1	4-02-01	4-02-01	2-ha search		
0	151	9	0	-33.95	151.15	0.1	4-02-01	4-02-01	2-ha search		
54	151	9	15	-33.94833	151.1542	0.1	3-03-01	3-03-01	2-ha search		
	151	9	30	-34.03333	151.1583	0.1	3-03-01	3-03-01	2-ha search		
45	151	11	10	-34.0125	151.1861	0.5	3-03-01	3-03-01	Area search <500 m		
45	151	11	10	-34.0125	151.1861	0.5	3-03-01	3-03-01	Area search <500 m		

45	151	11	10	-34.0125	151.1861	0.5	3-03-01	3-03-01	Area search <500 m	
0	151	12	0	-33.96667	151.2	0.5	3-11-99	3-11-99	2-ha search	
0	151	12	0	-33.96667	151.2	0.5	3-11-99	3-11-99	2-ha search	
0	151	12	0	-33.96667	151.2	0.5	3-11-99	3-11-99	2-ha search	
0	151	12	0	-33.96667	151.2	0.5	3-11-99	3-11-99	2-ha search	
0	151	12	0	-33.96667	151.2	0.5	3-11-99	3-11-99	2-ha search	
0	151	12	0	-33.96667	151.2	0.5	3-11-99	3-11-99	2-ha search	
0	151	12	0	-33.96667	151.2	0.5	3-11-99	3-11-99	2-ha search	
40	151	9	14	-34.01111	151.1539	0.1	2-12-98	21-12-98	Area search <500 m	
40	151	9	14	-34.01111	151.1539	0.1	2-12-98	21-12-98	Area search <500 m	
40	151	9	14	-34.01111	151.1539	0.1	2-12-98	21-12-98	Area search <500 m	
40	151	9	14	-34.01111	151.1539	0.1	2-12-98	21-12-98	Area search <500 m	
40	151	9	14	-34.01111	151.1539	0.1	2-12-98	21-12-98	Area search <500 m	
40	151	9	14	-34.01111	151.1539	0.1	2-12-98	21-12-98	Area search <500 m	
40	151	9	14	-34.01111	151.1539	0.1	2-12-98	21-12-98	Area search <500 m	
40	151	9	14	-34.01111	151.1539	0.1	2-12-98	21-12-98	Area search <500 m	
27	151	11	25	-34.0075	151.1903	0.1	16-03-01	16-03-01	Area search <500 m	
27	151	11	25	-34.0075	151.1903	0.1	16-03-01	16-03-01	Area search <500 m	
27	151	11	25	-34.0075	151.1903	0.1	16-03-01	16-03-01	Area search <500 m	
27	151	11	25	-34.0075	151.1903	0.1	16-03-01	16-03-01	Area search <500 m	
27	151	11	25	-34.0075	151.1903	0.1	16-03-01	16-03-01	Area search <500 m	
20	151	11	22	-34.00555	151.1894	0.1	2-03-01	2-03-01	2-ha search	
22	151	12	11	-34.03944	151.203	0.1	2-03-01	2-03-01	Area search <500 m	
30	151	9	30	-34.04167	151.1583	0.5	1-04-01	1-04-01	Area search <500 m	
30	151	9	30	-34.04167	151.1583	0.5	1-04-01	1-04-01	Area search <500 m	
30	151	9	30	-34.04167	151.1583	0.5	13-05-01	13-05-01	2-ha search	
30	151	9	30	-34.04167	151.1583	0.5	13-05-01	13-05-01	2-ha search	
54	151	9	15	-33.94833	151.1542	0.1	1-04-01	1-04-01	2-ha search	
0	151	9	0	-33.95	151.15	0.1	1-04-01	1-04-01	2-ha search	
0	151	9	0	-33.95	151.15	0.1	1-04-01	1-04-01	2-ha search	
0	151	9	0	-33.95	151.15	0.1	13-05-01	13-05-01	2-ha search	
0	151	9	0	-33.95	151.15	0.1	13-05-01	13-05-01	2-ha search	
45	151	11	10	-34.0125	151.1861	0.5	13-05-01	13-05-01	Area search <500 m	
45	151	11	10	-34.0125	151.1861	0.5	13-05-01	13-05-01	Area search <500 m	
45	151	11	10	-34.0125	151.1861	0.5	13-05-01	13-05-01	Area search <500 m	
26	151	12	59	-34.00722	151.2164	0.1	20-05-01	20-05-01	Area search <500 m	

50	151	9	10	-33.94722	151.1528	0.1	16-06-01	16-06-01	2-ha search	
50	151	9	10	-33.94722	151.1528	0.1	16-06-01	16-06-01	2-ha search	
15	151	9	30	-34.0375	151.1583	0.5	6-07-01	6-07-01	Area search <500 m	
54	151	9	15	-33.94833	151.1542	0.1	18-08-01	18-08-01	2-ha search	
50	151	9	10	-33.94722	151.1528	0.5	7-07-01	7-07-01	2-ha search	
50	151	9	10	-33.94722	151.1528	0.5	18-08-01	18-08-01	2-ha search	
26	151	11	44	-33.94056	151.1956	0.1	9-10-01	9-10-01	Area search <500 m	
26	151	11	44	-33.94056	151.1956	0.1	9-10-01	9-10-01	Area search <500 m	Breeding
50	151	9	10	-33.94722	151.1528	0.5	8-09-01	8-09-01	2-ha search	
50	151	9	10	-33.94722	151.1528	0.5	8-09-01	8-09-01	2-ha search	
50	151	9	10	-33.94722	151.1528	0.5	8-09-01	8-09-01	2-ha search	
50	151	9	10	-33.94722	151.1528	0.1	9-12-01	9-12-01	2-ha search	
50	151	9	10	-33.94722	151.1528	0.1	9-12-01	9-12-01	2-ha search	
50	151	9	10	-33.94722	151.1528	0.1	9-12-01	9-12-01	2-ha search	
50	151	9	10	-33.94722	151.1528	0.1	9-12-01	9-12-01	2-ha search	
45	151	12	0	-33.9625	151.2	1	8-05-99	8-05-99		
45	151	12	0	-33.9625	151.2	1	8-05-99	8-05-99		
0	151	8	30	-34	151.1417	1	23-07-98	31-07-98		
0	151	8	30	-34	151.1417	1	23-07-98	31-07-98		
0	151	8	30	-34	151.1417	1	4-08-98	4-08-98		
0	151	8	30	-34	151.1417	1	4-09-98	4-09-98		
0	151	8	30	-34	151.1417	1	4-09-98	4-09-98		
0	151	8	30	-34	151.1417	1	4-09-98	4-09-98		
0	151	8	30	-34	151.1417	1	1-10-98	1-10-98		
0	151	8	30	-34	151.1417	1	1-10-98	1-10-98		
0	151	8	30	-34	151.1417	1	1-10-98	1-10-98		
0	151	8	30	-34	151.1417	1	12-11-98	12-11-98		
0	151	8	30	-34	151.1417	1	19-11-98	19-11-98		
0	151	8	30	-34	151.1417	1	19-11-98	19-11-98		
0	151	8	30	-34	151.1417	1	10-12-98	10-12-98		
0	151	8	30	-34	151.1417	1	10-12-98	10-12-98		
0	151	8	30	-34	151.1417	1	10-12-98	10-12-98		
0	151	8	30	-34	151.1417	1	23-12-98	23-12-98		
0	151	8	30	-34	151.1417	1	23-12-98	23-12-98		
0	151	8	30	-34	151.1417	1	11-01-98	11-01-98		
0	151	8	30	-34	151.1417	1	11-01-98	11-01-98		

30	151	12	0	-34.04167	151.2	1	4-06-99	4-06-99		
30	151	12	0	-34.04167	151.2	1	4-06-99	4-06-99		
30	151	12	0	-34.04167	151.2	1	4-06-99	4-06-99		
30	151	12	0	-34.04167	151.2	1	4-06-99	4-06-99		
30	151	12	0	-34.04167	151.2	1	10-09-99	10-09-99		
30	151	12	0	-34.04167	151.2	1	10-09-99	10-09-99		
30	151	12	0	-34.04167	151.2	1	10-09-99	10-09-99		
30	151	12	0	-34.04167	151.2	1	5-09-99	5-09-99		
30	151	12	0	-34.04167	151.2	1	5-09-99	5-09-99		
30	151	12	0	-34.04167	151.2	1	5-09-99	5-09-99		
30	151	12	0	-34.04167	151.2	1	5-09-99	5-09-99		
30	151	12	0	-34.04167	151.2	1	5-09-99	5-09-99		
0	151	7	30	-34.01667	151.125	1	25-08-99	25-08-99		
0	151	7	30	-34.01667	151.125	1	25-08-99	25-08-99		
30	151	12	0	-34.04167	151.2	1	2-08-99	2-08-99		
30	151	12	0	-34.04167	151.2	1	2-08-99	2-08-99		
30	151	12	0	-34.04167	151.2	1	2-08-99	2-08-99		
30	151	12	0	-34.04167	151.2	1	2-08-99	2-08-99		
	151	10		-34.01667	151.1667	1	1-08-98	31-08-98		
	151	10		-34.01667	151.1667	1	1-08-98	31-08-98		
	151	10		-34.01667	151.1667	1	1-08-98	31-08-98		
	151	10		-34.01667	151.1667	1	1-08-98	31-08-98		
	151	10		-34.01667	151.1667	1	1-08-98	31-08-98		
50	151	12	30	-33.96389	151.2083	1	4-10-99	4-10-99		
50	151	12	30	-33.96389	151.2083	1	4-10-99	4-10-99		
50	151	12	30	-33.96389	151.2083	1	4-10-99	4-10-99		
50	151	12	30	-33.96389	151.2083	1	4-10-99	4-10-99		
50	151	12	30	-33.96389	151.2083	1	4-10-99	4-10-99		
50	151	12	30	-33.96389	151.2083	1	4-10-99	4-10-99		
25	151	12	0	-34.04028	151.2	1	12-10-99	12-10-99		
25	151	12	0	-34.04028	151.2	1	12-10-99	12-10-99		
25	151	12	0	-34.04028	151.2	1	12-10-99	12-10-99		
25	151	12	0	-34.04028	151.2	1	12-10-99	12-10-99		
25	151	12	0	-34.04028	151.2	1	12-10-99	12-10-99		
20	151	7	30	-34.02222	151.125	1	3-11-99	17-11-99		
20	151	7	30	-34.02222	151.125	1	3-11-99	17-11-99		

20	151	7	30	-34.02222	151.125	1	3-11-99	17-11-99		
20	151	7	30	-34.02222	151.125	1	3-11-99	17-11-99		
20	151	7	30	-34.02222	151.125	1	3-11-99	17-11-99		
20	151	7	30	-34.02222	151.125	1	3-11-99	17-11-99		
50	151	12	30	-33.96389	151.2083	1	3-11-99	17-11-99		
50	151	12	30	-33.96389	151.2083	1	3-11-99	17-11-99		
50	151	12	30	-33.96389	151.2083	1	3-11-99	17-11-99		
50	151	12	30	-33.96389	151.2083	1	3-11-99	17-11-99		
50	151	12	30	-33.96389	151.2083	1	3-11-99	17-11-99		
50	151	12	30	-33.96389	151.2083	1	29-03-00	29-03-00		
50	151	12	30	-33.96389	151.2083	1	29-03-00	29-03-00		
50	151	12	30	-33.96389	151.2083	1	29-03-00	29-03-00		
50	151	12	30	-33.96389	151.2083	1	29-03-00	29-03-00		
50	151	12	30	-33.96389	151.2083	1	29-03-00	29-03-00		
50	151	12	30	-33.96389	151.2083	1	29-03-00	29-03-00		
20	151	7	30	-34.02222	151.125	1	29-03-00	29-03-00		
20	151	7	30	-34.02222	151.125	1	29-03-00	29-03-00		
20	151	7	30	-34.02222	151.125	1	29-03-00	29-03-00		
20	151	7	30	-34.02222	151.125	1	29-03-00	29-03-00		
20	151	7	30	-34.02222	151.125	1	29-03-00	29-03-00		
20	151	7	30	-34.02222	151.125	1	29-03-00	29-03-00		
50	151	12	30	-33.96389	151.2083	1	14-02-00	14-02-00		
50	151	12	30	-33.96389	151.2083	1	14-02-00	14-02-00		
50	151	12	30	-33.96389	151.2083	1	14-02-00	14-02-00		
50	151	12	30	-33.96389	151.2083	1	14-02-00	14-02-00		
50	151	12	30	-33.96389	151.2083	1	14-02-00	14-02-00		
25	151	12	0	-34.04028	151.2	1	4-02-00	4-02-00		
25	151	12	0	-34.04028	151.2	1	4-02-00	4-02-00		
25	151	12	0	-34.04028	151.2	1	4-02-00	4-02-00		
25	151	12	0	-34.04028	151.2	1	4-02-00	4-02-00		
25	151	12	0	-34.04028	151.2	1	4-02-00	4-02-00		
0	151	7	57	-33.93333	151.1325	1	20-02-00	20-02-00		
50	151	12	30	-33.96389	151.2083	1	7-08-00	7-08-00		
50	151	12	30	-33.96389	151.2083	1	7-08-00	7-08-00		
50	151	12	30	-33.96389	151.2083	1	7-08-00	7-08-00		
50	151	12	30	-33.96389	151.2083	1	7-08-00	7-08-00		

50	151	12	30	-33.96389	151.2083	1	7-08-00	7-08-00		
50	151	12	30	-33.96389	151.2083	1	7-08-00	7-08-00		
15	151	12	0	-34.0375	151.2	1	3-07-00	3-07-00		
15	151	12	0	-34.0375	151.2	1	3-07-00	3-07-00		
15	151	12	0	-34.0375	151.2	1	3-07-00	3-07-00		
15	151	12	0	-34.0375	151.2	1	3-07-00	3-07-00		
15	151	12	0	-34.0375	151.2	1	3-07-00	3-07-00		
15	151	12	0	-34.0375	151.2	1	10-01-00	10-01-00		
15	151	12	0	-34.0375	151.2	1	10-01-00	10-01-00		
15	151	12	0	-34.0375	151.2	1	10-01-00	10-01-00		
15	151	12	0	-34.0375	151.2	1	10-01-00	10-01-00		
15	151	12	0	-34.0375	151.2	1	10-01-00	10-01-00		
15	151	12	0	-34.0375	151.2	1	10-01-00	10-01-00		
15	151	12	0	-34.0375	151.2	1	10-01-00	10-01-00		
50	151	12	30	-33.96389	151.2083	1	29-01-00	29-01-00		
50	151	12	30	-33.96389	151.2083	1	29-01-00	29-01-00		
50	151	12	30	-33.96389	151.2083	1	29-01-00	29-01-00		
50	151	12	30	-33.96389	151.2083	1	29-01-00	29-01-00		
50	151	12	30	-33.96389	151.2083	1	29-01-00	29-01-00		
50	151	12	30	-33.96389	151.2083	1	29-01-00	29-01-00		
0	151	7	30	-34.01667	151.125	1	15-12-99	15-12-99		
0	151	7	30	-34.01667	151.125	1	15-12-99	15-12-99		
0	151	7	30	-34.01667	151.125	1	15-12-99	15-12-99		
50	151	12	30	-33.96389	151.2083	1	15-12-99	31-12-99		
50	151	12	30	-33.96389	151.2083	1	15-12-99	31-12-99		
50	151	12	30	-33.96389	151.2083	1	15-12-99	31-12-99		
50	151	12	30	-33.96389	151.2083	1	15-12-99	31-12-99		
15	151	12	0	-34.0375	151.2	1	8-12-99	8-12-99		
15	151	12	0	-34.0375	151.2	1	8-12-99	8-12-99		
15	151	12	0	-34.0375	151.2	1	8-12-99	8-12-99		
15	151	12	0	-34.0375	151.2	1	8-12-99	8-12-99		
15	151	12	0	-34.0375	151.2	1	8-12-99	8-12-99		
15	151	12	0	-34.0375	151.2	1	8-12-99	8-12-99		
15	151	12	0	-34.0375	151.2	1	8-12-99	8-12-99		
50	151	12	30	-33.96389	151.2083	1	5-11-00	20-11-00		
50	151	12	30	-33.96389	151.2083	1	5-11-00	20-11-00		

50	151	12	30	-33.96389	151.2083	1	5-11-00	20-11-00		
50	151	12	30	-33.96389	151.2083	1	5-11-00	20-11-00		
50	151	12	30	-33.96389	151.2083	1	5-11-00	20-11-00		
50	151	12	30	-33.96389	151.2083	1	5-11-00	20-11-00		
50	151	12	30	-33.96389	151.2083	1	5-11-00	20-11-00		
30	151	8	0	-34.00834	151.1333	1	20-11-00	20-11-00		
30	151	8	0	-34.00834	151.1333	1	20-11-00	20-11-00		
30	151	8	0	-34.00834	151.1333	1	20-11-00	20-11-00		
30	151	8	0	-34.00834	151.1333	1	20-11-00	20-11-00		
0	151	7	30	-34.01667	151.125	1	5-11-00	20-11-00		
0	151	7	30	-34.01667	151.125	1	5-11-00	20-11-00		
0	151	7	30	-34.01667	151.125	1	5-11-00	20-11-00		
0	151	7	30	-34.01667	151.125	1	5-11-00	20-11-00		
0	151	7	30	-34.01667	151.125	1	5-11-00	20-11-00		
0	151	7	30	-34.01667	151.125	1	5-11-00	20-11-00		
2	151	8	2	-34.00056	151.1339	1	11-03-99	11-03-99		
2	151	8	2	-34.00056	151.1339	1	11-03-99	11-03-99		
2	151	8	2	-34.00056	151.1339	1	25-03-99	25-03-99		
2	151	8	2	-34.00056	151.1339	1	21-05-99	21-05-99		
2	151	8	2	-34.00056	151.1339	1	8-07-99	8-07-99		
2	151	8	2	-34.00056	151.1339	1	23-07-99	23-07-99		
5	151	8	2	-34.00139	151.1339	1	29-07-99	29-07-99		
5	151	8	2	-34.00139	151.1339	1	29-07-99	29-07-99		
2	151	8	2	-34.00056	151.1339	1	13-08-99	13-08-99		
2	151	8	2	-34.00056	151.1339	1	13-08-99	13-08-99		
2	151	8	2	-34.00056	151.1339	1	25-08-99	25-08-99		
2	151	8	2	-34.00056	151.1339	1	25-08-99	25-08-99		
2	151	8	2	-34.00056	151.1339	1	25-08-99	25-08-99		
2	151	8	2	-34.00056	151.1339	1	3-10-99	3-10-99		
2	151	8	2	-34.00056	151.1339	1	3-11-99	3-11-99		
2	151	8	2	-34.00056	151.1339	1	3-11-99	3-11-99		
2	151	8	2	-34.00056	151.1339	1	3-11-99	3-11-99		
2	151	8	2	-34.00056	151.1339	1	5-11-99	5-11-99		
2	151	8	2	-34.00056	151.1339	1	5-11-99	5-11-99		
2	151	8	2	-34.00056	151.1339	1	15-12-99	15-12-99		
2	151	8	2	-34.00056	151.1339	1	15-12-99	15-12-99		

2	151	8	2	-34.00056	151.1339	1	15-12-99	15-12-99		
2	151	8	2	-34.00056	151.1339	1	12-01-00	12-01-00		
2	151	8	2	-34.00056	151.1339	1	12-01-00	12-01-00		
32	151	8	6	-34.00889	151.135	1	18-02-00	18-02-00		
32	151	8	6	-34.00889	151.135	1	18-02-00	18-02-00		
32	151	8	6	-34.00889	151.135	1	1-03-00	1-03-00		
32	151	8	6	-34.00889	151.135	1	1-03-00	1-03-00		
32	151	8	6	-34.00889	151.135	1	17-03-00	17-03-00		
32	151	8	6	-34.00889	151.135	1	16-06-00	16-06-00		
32	151	8	6	-34.00889	151.135	1	21-06-00	21-06-00		
32	151	8	6	-34.00889	151.135	1	21-06-00	21-06-00		
32	151	8	6	-34.00889	151.135	1	6-07-00	6-07-00		
32	151	8	6	-34.00889	151.135	1	6-07-00	6-07-00		
32	151	8	6	-34.00889	151.135	1	28-07-00	28-07-00		
32	151	8	6	-34.00889	151.135	1	28-07-00	28-07-00		
32	151	8	6	-34.00889	151.135	1	2-08-00	2-08-00		
47	151	9	11	-33.94639	151.1531	1	14-04-99	14-04-99		
	151	11		-34.03333	151.1833	1	7-11-00	7-11-00		
	151	11		-34.03333	151.1833	1	7-11-00	7-11-00		
	151	11		-34.03333	151.1833	1	7-11-00	7-11-00		
	151	11		-34.03333	151.1833	1	16-01-01	31-01-01		
	151	11		-34.03333	151.1833	1	16-01-01	31-01-01		
	151	11		-34.03333	151.1833	1	16-01-01	31-01-01		
	151	11		-34.03333	151.1833	1	16-01-01	31-01-01		
20	151	8	1	-34.00555	151.1336	1	8-01-01	8-01-01		
20	151	8	1	-34.00555	151.1336	1	8-01-01	8-01-01		
20	151	8	1	-34.00555	151.1336	1	18-01-01	18-01-01		
20	151	8	1	-34.00555	151.1336	1	30-01-01	30-01-01		
20	151	8	1	-34.00555	151.1336	1	30-01-01	30-01-01		
20	151	8	1	-34.00555	151.1336	1	1-02-01	1-02-01		
20	151	8	1	-34.00555	151.1336	1	1-02-01	1-02-01		
32	151	8	6	-34.00889	151.135	1	10-08-00	10-08-00		
32	151	8	6	-34.00889	151.135	1	10-08-00	10-08-00		
32	151	8	6	-34.00889	151.135	1	11-09-00	11-09-00		
32	151	8	6	-34.00889	151.135	1	11-09-00	11-09-00		
32	151	8	6	-34.00889	151.135	1	25-09-00	25-09-00		

32	151	8	6	-34.00889	151.135	1	25-09-00	25-09-00		
32	151	8	6	-34.00889	151.135	1	5-10-00	5-10-00		
32	151	8	6	-34.00889	151.135	1	5-10-00	5-10-00		
32	151	8	6	-34.00889	151.135	1	27-10-00	27-10-00		
32	151	8	6	-34.00889	151.135	1	27-10-00	27-10-00		
32	151	8	6	-34.00889	151.135	1	27-10-00	27-10-00		
	151	12		-34.03333	151.2	1	11-12-00	11-12-00		
	151	12		-34.03333	151.2	1	11-12-00	11-12-00		
	151	12		-34.03333	151.2	1	11-12-00	11-12-00		
	151	12		-34.03333	151.2	1	11-12-00	11-12-00		
	151	12		-34.03333	151.2	1	11-12-00	11-12-00		
	151	12		-34.03333	151.2	1	11-12-00	11-12-00		
	151	12		-34.03333	151.2	1	11-12-00	11-12-00		
	151	13		-33.96667	151.2167	1	17-01-01	17-01-01		
	151	13		-33.96667	151.2167	1	17-01-01	17-01-01		
	151	13		-33.96667	151.2167	1	17-01-01	17-01-01		
	151	13		-33.96667	151.2167	1	17-01-01	17-01-01		
	151	12		-34.05	151.2	1	25-03-01	25-03-01		
	151	12		-34.05	151.2	1	25-03-01	25-03-01		
	151	12		-34.05	151.2	1	25-03-01	25-03-01		
	151	13		-34.05	151.2167	1	25-03-01	25-03-01		
	151	13		-34.05	151.2167	1	25-03-01	25-03-01		
20	151	8	1	-34.00555	151.1336	1	8-02-01	8-02-01		
20	151	8	1	-34.00555	151.1336	1	8-02-01	8-02-01		
20	151	8	1	-34.00555	151.1336	1	31-03-01	31-03-01		
20	151	8	1	-34.00555	151.1336	1	10-05-01	10-05-01		
20	151	8	1	-34.00555	151.1336	1	10-05-01	10-05-01		
20	151	8	1	-34.00555	151.1336	1	17-05-01	17-05-01		
20	151	8	1	-34.00555	151.1336	1	17-05-01	17-05-01		
	151	9		-34	151.15	0.5	23-11-98	23-11-98	Incidental search	
40	151	9	10	-33.94444	151.1528	0.1	23-01-99	23-01-99	2-ha search	
40	151	9	10	-33.94444	151.1528	0.1	23-01-99	23-01-99	2-ha search	
	151	9		-34.01667	151.15	5	2-02-99	2-02-99	Incidental search	
15	151	7	30	-34.02083	151.125	0.5	1-02-98	1-02-98	Area search <5 km	
15	151	7	30	-34.02083	151.125	0.5	1-02-98	1-02-98	Area search <5 km	
15	151	7	30	-34.02083	151.125	0.5	1-02-98	1-02-98	Area search <5 km	

15	151	7	30	-34.02083	151.125	0.5	1-02-98	1-02-98	Area search <5 km	
15	151	7	30	-34.02083	151.125	0.5	1-02-98	1-02-98	Area search <5 km	
15	151	7	30	-34.02083	151.125	0.5	1-02-98	1-02-98	Area search <5 km	
15	151	7	30	-34.02083	151.125	0.5	1-02-98	1-02-98	Area search <5 km	
15	151	7	30	-34.02083	151.125	0.5	1-02-98	1-02-98	Area search <5 km	
0	151	12	45	-33.96667	151.2125	0.5	29-05-98	29-05-98	Area search <500 m	
0	151	12	45	-33.96667	151.2125	0.5	29-05-98	29-05-98	Area search <500 m	
0	151	12	45	-33.96667	151.2125	0.5	29-05-98	29-05-98	Area search <500 m	
0	151	12	45	-33.96667	151.2125	0.5	29-05-98	29-05-98	Area search <500 m	
0	151	12	45	-33.96667	151.2125	0.5	29-05-98	29-05-98	Area search <500 m	
14	151	9	14	-34.00389	151.1539	0.5	12-12-98	12-12-98	Area search <500 m	
14	151	9	14	-34.00389	151.1539	0.5	12-12-98	12-12-98	Area search <500 m	
30	151	9		-34.04167	151.15	0.5	12-12-98	12-12-98	Area search <500 m	
29	151	9	8	-33.94139	151.1522	0.5	23-01-99	23-01-99	Area search <500 m	
48	151	9	15	-33.94667	151.1542	0.5	23-01-99	23-01-99	Area search <500 m	
48	151	9	15	-33.94667	151.1542	0.5	23-01-99	23-01-99	Area search <500 m	
55	151	12	47	-33.96528	151.2131	0.5	23-01-99	23-01-99	Area search <500 m	
55	151	12	47	-33.96528	151.2131	0.5	23-01-99	23-01-99	Area search <500 m	
55	151	12	47	-33.96528	151.2131	0.5	23-01-99	23-01-99	Area search <500 m	
55	151	12	47	-33.96528	151.2131	0.5	23-01-99	23-01-99	Area search <500 m	
30	151	11	19	-34.00834	151.1886	0.5	23-01-99	23-01-99	Area search <500 m	
30	151	11	19	-34.00834	151.1886	0.5	23-01-99	23-01-99	Area search <500 m	
33	151	11	23	-34.00917	151.1897	0.5	25-07-99	25-07-99	Area search <500 m	
59	151	12	26	-33.96639	151.2072	0.5	25-07-99	25-07-99	2-ha search	
59	151	12	26	-33.96639	151.2072	0.5	25-07-99	25-07-99	2-ha search	
59	151	12	26	-33.96639	151.2072	0.5	25-07-99	25-07-99	2-ha search	
59	151	12	26	-33.96639	151.2072	0.5	25-07-99	25-07-99	2-ha search	
57	151	12	45	-33.96583	151.2125	0.5	1-06-99	12-06-99	Area search <500 m	
57	151	12	45	-33.96583	151.2125	0.5	1-06-99	12-06-99	Area search <500 m	
57	151	12	45	-33.96583	151.2125	0.5	1-06-99	12-06-99	Area search <500 m	
0	151	12	46	-33.96667	151.2128	0.5	12-06-99	12-06-99	2-ha search	
0	151	12	46	-33.96667	151.2128	0.5	12-06-99	12-06-99	2-ha search	
0	151	12	46	-33.96667	151.2128	0.5	12-06-99	12-06-99	2-ha search	
59	151	12	26	-33.96639	151.2072	0.5	15-09-99	15-09-99	2-ha search	
59	151	12	26	-33.96639	151.2072	0.5	15-09-99	15-09-99	2-ha search	
59	151	12	26	-33.96639	151.2072	0.5	15-09-99	15-09-99	2-ha search	

57	151	12	45	-33.96583	151.2125	0.5	14-08-99	14-08-99	2-ha search
57	151	12	45	-33.96583	151.2125	0.5	17-11-99	17-11-99	Area search <500 m
57	151	12	45	-33.96583	151.2125	0.5	17-11-99	17-11-99	Area search <500 m
57	151	12	45	-33.96583	151.2125	0.5	17-11-99	17-11-99	Area search <500 m
57	151	12	45	-33.96583	151.2125	0.5	17-11-99	17-11-99	Area search <500 m
57	151	12	45	-33.96583	151.2125	0.5	17-11-99	17-11-99	Area search <500 m
40	151	9	14	-34.01111	151.1539	0.5	16-09-00	16-09-00	Area search <500 m
29	151	9	8	-33.94139	151.1522	0.5	18-10-00	18-10-00	Area search <500 m
29	151	9	8	-33.94139	151.1522	0.5	18-10-00	18-10-00	Area search <500 m
29	151	9	8	-33.94139	151.1522	0.5	22-10-00	22-10-00	Area search <500 m
29	151	9	8	-33.94139	151.1522	0.5	22-10-00	22-10-00	Area search <500 m
45	151	9	15	-33.94584	151.1542	1	3-06-00	3-06-00	2-ha search
15	151	7	40	-34.02083	151.1278	1	3-06-00	3-06-00	Area search <500 m
15	151	7	40	-34.02083	151.1278	1	3-06-00	3-06-00	Area search <500 m
15	151	7	40	-34.02083	151.1278	1	3-06-00	3-06-00	Area search <500 m
15	151	7	40	-34.02083	151.1278	1	3-06-00	3-06-00	Area search <500 m
15	151	7	40	-34.02083	151.1278	1	3-06-00	3-06-00	Area search <500 m
15	151	7	40	-34.02083	151.1278	1	3-06-00	3-06-00	Area search <500 m
54	151	9	15	-33.94833	151.1542	1	6-08-00	6-08-00	2-ha search
45	151	9	15	-33.94584	151.1542	1	6-08-00	6-08-00	2-ha search
54	151	9	15	-33.94833	151.1542	1	3-09-00	3-09-00	2-ha search
54	151	9	15	-33.94833	151.1542	1	8-10-00	8-10-00	2-ha search
45	151	9	15	-33.94584	151.1542	1	3-09-00	3-09-00	2-ha search
12	151	9	33	-34.03667	151.1592	1	1-01-01	1-01-01	2-ha search
12	151	9	33	-34.03667	151.1592	1	1-01-01	1-01-01	2-ha search
12	151	9	33	-34.03667	151.1592	1	1-01-01	1-01-01	2-ha search
12	151	9	33	-34.03667	151.1592	1	1-01-01	1-01-01	2-ha search
10	151	9	24	-34.03611	151.1567	1	15-02-01	15-02-01	Area search <500 m
10	151	9	24	-34.03611	151.1567	1	15-02-01	15-02-01	Area search <500 m
10	151	9	24	-34.03611	151.1567	1	15-02-01	15-02-01	Area search <500 m
10	151	9	24	-34.03611	151.1567	1	16-02-01	16-02-01	Area search <500 m
10	151	9	24	-34.03611	151.1567	1	16-02-01	16-02-01	Area search <500 m
10	151	9	24	-34.03611	151.1567	1	16-02-01	16-02-01	Area search <500 m
10	151	9	24	-34.03611	151.1567	1	20-01-01	20-01-01	Area search <500 m
10	151	9	24	-34.03611	151.1567	1	20-01-01	20-01-01	Area search <500 m
10	151	9	24	-34.03611	151.1567	1	20-01-01	20-01-01	Area search <500 m

10	151	9	24	-34.03611	151.1567	1	20-01-01	20-01-01	Area search <500 m	
30	151	11	19	-34.00834	151.1886	1	20-01-01	20-01-01	Area search <500 m	
30	151	11	19	-34.00834	151.1886	1	20-01-01	20-01-01	Area search <500 m	
10	151	9	24	-34.03611	151.1567	1	5-02-01	10-02-01	Area search <500 m	
10	151	9	24	-34.03611	151.1567	1	5-02-01	10-02-01	Area search <500 m	
10	151	9	24	-34.03611	151.1567	1	5-02-01	10-02-01	Area search <500 m	
10	151	9	24	-34.03611	151.1567	1	5-02-01	10-02-01	Area search <500 m	
10	151	9	24	-34.03611	151.1567	1	5-02-01	10-02-01	Area search <500 m	
10	151	9	24	-34.03611	151.1567	1	5-02-01	10-02-01	Area search <500 m	
26	151	11	16	-34.00722	151.1878	1	10-02-01	10-02-01	Incidental search	
53	151	12	30	-33.96472	151.2083	1	5-02-01	10-02-01	Area search <500 m	
53	151	12	30	-33.96472	151.2083	1	5-02-01	10-02-01	Area search <500 m	
53	151	12	30	-33.96472	151.2083	1	5-02-01	10-02-01	Area search <500 m	
53	151	12	30	-33.96472	151.2083	1	5-02-01	10-02-01	Area search <500 m	
53	151	12	30	-33.96472	151.2083	1	5-02-01	10-02-01	Area search <500 m	
50	151	12	38	-33.96389	151.2106	1	3-11-00	3-11-00	Area search <500 m	
50	151	12	38	-33.96389	151.2106	1	3-11-00	3-11-00	Area search <500 m	
50	151	12	38	-33.96389	151.2106	1	3-11-00	3-11-00	Area search <500 m	
50	151	12	38	-33.96389	151.2106	1	3-11-00	3-11-00	Area search <500 m	
50	151	12	38	-33.96389	151.2106	1	3-11-00	3-11-00	Area search <500 m	
50	151	12	38	-33.96389	151.2106	1	3-11-00	3-11-00	Area search <500 m	
50	151	12	38	-33.96389	151.2106	1	3-11-00	3-11-00	Area search <500 m	
0	151	9	20	-33.93333	151.1555	1	8-04-01	8-04-01	2-ha search	
53	151	12	28	-33.96472	151.2078	1	24-04-01	24-04-01	Area search <500 m	
53	151	12	28	-33.96472	151.2078	1	24-04-01	24-04-01	Area search <500 m	
53	151	12	28	-33.96472	151.2078	1	24-04-01	24-04-01	Area search <500 m	
53	151	12	28	-33.96472	151.2078	1	24-04-01	24-04-01	Area search <500 m	
53	151	12	28	-33.96472	151.2078	1	24-04-01	24-04-01	Area search <500 m	
10	151	9	24	-34.03611	151.1567	1	29-04-01	29-04-01	2-ha search	
10	151	9	24	-34.03611	151.1567	1	29-04-01	29-04-01	2-ha search	
4	151	9	33	-34.03444	151.1592	1	26-05-01	26-05-01	Area search <500 m	
4	151	9	33	-34.03444	151.1592	1	26-05-01	26-05-01	Area search <500 m	
53	151	12	28	-33.96472	151.2078	1	26-05-01	26-05-01	Area search <500 m	
53	151	12	28	-33.96472	151.2078	1	26-05-01	26-05-01	Area search <500 m	
53	151	12	28	-33.96472	151.2078	1	26-05-01	26-05-01	Area search <500 m	
53	151	12	28	-33.96472	151.2078	1	26-05-01	26-05-01	Area search <500 m	

53	151	12	28	-33.96472	151.2078	1	26-05-01	26-05-01	Area search <500 m	
1	151	9	36	-34.03361	151.16	1	14-06-01	14-06-01	2-ha search	
59	151	12	26	-33.96639	151.2072	1	28-10-01	28-10-01	Area search <500 m	
59	151	12	26	-33.96639	151.2072	1	28-10-01	28-10-01	Area search <500 m	
59	151	12	26	-33.96639	151.2072	1	28-10-01	28-10-01	Area search <500 m	
33	151	11	38	-34.00917	151.1939	0.1	2-02-99	2-02-99	2-ha search	
34	151	8	57	-34.00945	151.1492	0.1	2-02-99	2-02-99	2-ha search	
34	151	8	57	-34.00945	151.1492	0.1	2-02-99	2-02-99	2-ha search	
34	151	8	57	-34.00945	151.1492	0.1	2-02-99	2-02-99	2-ha search	
34	151	8	57	-34.00945	151.1492	0.1	2-02-99	2-02-99	2-ha search	
34	151	8	57	-34.00945	151.1492	0.1	2-02-99	2-02-99	2-ha search	
59	151	7	30	-34.01639	151.125	0.1	2-02-99	2-02-99	2-ha search	
59	151	7	30	-34.01639	151.125	0.1	2-02-99	2-02-99	2-ha search	
20	151	9	49	-34.02222	151.1636	0.1	20-02-99	20-02-99	2-ha search	
21	151	9	16	-34.0225	151.1544	0.1	20-02-99	20-02-99	Incidental search	

	Total Surveys for NSW	Total Surveys for Australia
	57635	256658

Common_name	Total Records for NSW	Total Records for Australia
Ruddy Turnstone	453	2378
Pied Oystercatcher	1873	7715
Sooty Oystercatcher	1215	3853
Red-kneed Dotterel	409	2186
Masked Lapwing	13143	44124
Banded Lapwing	352	2108
Grey Plover	22	971
Pacific Golden Plover	841	1914
Hooded Plover	97	2079
Lesser Sand Plover	160	813
Double-banded Plover	304	972
Greater Sand Plover	53	965
Oriental Plover	3	135
Red-capped Plover	733	6578
Black-fronted Dotterel	2220	10996
Inland Dotterel	17	153
Black-winged Stilt	2438	10027
Banded Stilt	47	990
Red-necked Avocet	243	1872
Eastern Curlew	2201	4851
Whimbrel	1453	4070
Little Curlew	3	227
Black-tailed Godwit	96	544
Bar-tailed Godwit	2135	4502
Wood Sandpiper	35	610
Grey-tailed Tattler	740	2300
Wandering Tattler	101	143
Common Sandpiper	82	2412
Common Greenshank	599	4378

Marsh Sandpiper	268	1477
Terek Sandpiper	01	649
Curlew Sandpiper	397	2277
Red-necked Stint	552	4559
Sharp-tailed Sandpiper	437	2668
Red Knot	158	752
Great Knot	99	1033
Sanderling	61	587
Broad-billed Sandpiper	1	65
Latham's Snipe	667	1764
Painted Snipe	20	17
Comb-crested Jacana	443	81
Oriental Pratincole	7	2652
Australian Pratincole	55	114
Bush Stone-curlew	88	1137
Beach Stone-curlew	139	2976
South Island Pied Oystercatcher	11	864
Lesser Yellowlegs	3	17
Cox's Sandpiper	1	3
Buff-breasted Sandpiper	1	12
Common Redshank	2	2
Ringed Plover	1	1
Ruff	3	1
Asian Dowitcher	1	20
Long-toed Stint	1	1
Pectoral Sandpiper	20	9

BOTANY BAY WADER POPULATION MONITORING SITES & TRANSECTS

Penrhyn Road

T1 From beach on Botany Bay in line with western end of Penrhyn Road, east to and including the jetty and 1st boat ramp.
T2 From T1 east to and incl 2nd boat ramp. Includes the same length of opposite shore.
T3 Everything east of T2, incl both shores of upper reaches of Penrhyn bay & mangrove covered creek entrance.
T4 Foreshore Rd beach opposite jetty where T2 finishes, northwest to and incl old Wharf.

Kyeemagh

T1 From retaining wall on western side of Cooks River southwest to swimming enclosure.
T2 The swimming enclosure and beach, southwest to the steps in line with Bestic Street.

Sandringham Bay

T1 From Georges River Sailing Club, white cones, southwest to Ida Street.
T2 From Ida Street south to the sea wall, including the swimming enclosure.

Riverside Drive (Sans Souci)

T1 From St Georges Sailing Club, adjacent to Capt. Cook bridge, east to pine tree.
T2 From pine tree east to the drain near Waldron Street.
T3 From drain east to the point.

Taren Point

T1 Woodlands Rd Reserve, from rock wall southeast to mangroves at oyster lease 83-156.
T2 From T1 southeast to the fishermen's co-op, including the boat ramp.
T3 From T2 to the Shell Point (Atkinson Road) jetty, including the jetty.
T4 From the jetty to Shell Point, excluding the barges.
T5 The Shell Point barges

Towra Point Nature Reserve

1 Pelican Point.
2 Towra Spit Island.
3 Towra Spit Island, northern end, adjacent to the mangroves.
4 Stinkpot Bay
5 Elephants trunk
6 Towra Point

Weeney Bay

1 Oyster leases opposite Bonna Point, at northern side of entrance to Weeney Bay.
2 Oyster leases on southern edge of Weeney Bay entrance channel.
3 Inside Weeney Bay.

Quibray Bay

T1 Southern sandy shore of bay from mangroves at western end, east 200 mtrs.
T2 From T1, east a further 200 metres.
T3 From T2, east a further 200 metres, to the point.
4 Oyster leases on northern side of Quibray Bay.

Kurnell, rock groynes

Boat Harbour

Note, transects (ref T...) are approx 200 metres long and extend 100 metres from shoreline.

BOTANY BAY WADER COUNT

SHOREBIRDS

DATE	Sat 12th January 02	TIDE	High 8.21am, 1.8mtrs	WEATHER	4,3,2	REF.
START TIME		FINISH TIME		OBSERVERS	Boat: PS, KG, JS. Penrhyn: BP, BS. Boat Harbour: GF, EC.	

RAOU No.	SPECIES	SITE/TRANSECT TAREN POINT						RIVERSIDE DR				SANDRINGHAM			KYEEMAGH			TOWRA POINT							WEENEY BAY				QUIBRAY BAY					KURNELL	PENRHYN ROAD					BOAT HARBOUR	TOTAL
		T1	T2	T3	T4	T5	TOT	T1	T2	T3	TOT	T1	T2	TOT	T1	T2	TOT	1	2	3	4	5	6	TOT	1	2	3	TOT	T1	T2	T3	4	TOT		T1	T2	T3	T4	TOT		ALL SITES
129	Ruddy Turnstone						8																																	15	23
130	Pied Oystercatcher						12											1	7				2	10									2	2							26
131	Sooty Oystercatcher																		1					1																11	12
133	Masked Lapwing						2																																		2
136	Grey Plover																																								
137	Pacific Golden Plover						2																																	3	5
139	Lesser Sandplover																																							1	1
140	Double-banded Plover																																								
141	Greater Sandplover																																								
143	Red-capped Plover																																								
144	Black-fronted Dotterel																																								
146	Black-winged Stilt																																								
149	Eastern Curlew																	43	85					128									58	13							199
150	Whimbrel																																								
152	Black-tailed Godwit																																								
153	Bar-tailed Godwit																		140					140									13						88		241
155	Grey-tailed Tattler						44																																		44
157	Common Sandpiper																																								
158	Greenshank																																								
160	Terek Sandpiper																																								
161	Curlew Sandpiper						11																																		11
162	Red-necked Stint						11																																	55	66
163	Sharp-tailed Sandpiper																																								
164	Red Knot																																								
165	Great Knot																																								
	TOTAL BIRDS						90																	279									73	15					88	85	630

BOTANY BAY WADER COUNT

SHOREBIRDS

DATE	Sat 13th April 02	TIDE	High 8.34am, 1.5 mtrs
START TIME		FINISH TIME	

WEATHER	4,2,1	REF.
OBSERVERS	NPWS Boat: GD, DA, BS. Penrhyn: MH, CS. Boat Harbour: PS, KG, BR.	

RAOU No.	SPECIES	SITE/TRANSECT TAREN POINT						RIVERSIDE DR				SANDRINGHAM			KYEEMAGH		
		T1	T2	T3	T4	T5	TOT	T1	T2	T3	TOT	T1	T2	TOT	T1	T2	TOT
129	Ruddy Turnstone					8	8										
130	Pied Oystercatcher				48		48										
131	Sooty Oystercatcher																
133	Masked Lapwing				5	2	7										
136	Grey Plover																
137	Pacific Golden Plover																
139	Lesser Sandplover																
140	Double-banded Plover																
141	Greater Sandplover																
143	Red-capped Plover																
144	Black-fronted Dotterel																
146	Black-winged Stilt																
149	Eastern Curlew																
150	Whimbrel																
152	Black-tailed Godwit																
153	Bar-tailed Godwit																
155	Grey-tailed Tattler					67	67										
157	Common Sandpiper																
158	Greenshank																
160	Terek Sandpiper					1	1										
161	Curlew Sandpiper					3	3										
162	Red-necked Stint																
163	Sharp-tailed Sandpiper																
164	Red Knot																
165	Great Knot																
	TOTAL BIRDS				53	81	134										

RAOU No.	SPECIES	TOWRA POINT							WEENEY BAY				QUIBRAY BAY					KURNELL	PENRHYN ROAD					BOAT HARBOUR	TOTAL
		1	2	3	4	5	6	TOT	1	2	3	TOT	T1	T2	T3	4	TOT		T1	T2	T3	T4	TOT		ALL SITES
129	Ruddy Turnstone																							12	20
130	Pied Oystercatcher	2	2					4																	52
131	Sooty Oystercatcher																							15	15
133	Masked Lapwing																		1				1		8
136	Grey Plover																								
137	Pacific Golden Plover																								
139	Lesser Sandplover																							1	1
140	Double-banded Plover																		48				48	14	62
141	Greater Sandplover																								
143	Red-capped Plover																		10				10		10
144	Black-fronted Dotterel																								
146	Black-winged Stilt																			10			10		10
149	Eastern Curlew	14	11					25																	25
150	Whimbrel										23	23													23
152	Black-tailed Godwit																								
153	Bar-tailed Godwit																		68				68		68
155	Grey-tailed Tattler																								67
157	Common Sandpiper																								
158	Greenshank																								
160	Terek Sandpiper																								1
161	Curlew Sandpiper																								3
162	Red-necked Stint																							15	15
163	Sharp-tailed Sandpiper																								
164	Red Knot																								
165	Great Knot																								
	TOTAL BIRDS	16	13					29			23	23							127	10			137	57	380

BOTANY BAY WADER COUNT

SHOREBIRDS

DATE	Sat 15th December 01	TIDE	High 9.19am, 1.8mtrs.
START TIME		FINISH TIME	

WEATHER	3,3,4	REF.
OBSERVERS	NPWS Boat: GR, KG, BS. Penrhyn: MH, CS. Boat Harbour: GF, EC.	

RAOU No.	SPECIES	TAREN POINT T1	T2	T3	T4	T5	TOT	RIVERSIDE DR T1	T2	T3	TOT	SANDRINGHAM T1	T2	TOT	KYEEMAGH T1	T2	TOT
129	Ruddy Turnstone					13	13										
130	Pied Oystercatcher				12		12										
131	Sooty Oystercatcher																
133	Masked Lapwing					1	1										
136	Grey Plover																
137	Pacific Golden Plover					2	2										
139	Lesser Sandplover																
140	Double-banded Plover																
141	Greater Sandplover																
143	Red-capped Plover																
144	Black-fronted Dotterel																
146	Black-winged Stilt																
149	Eastern Curlew																
150	Whimbrel																
152	Black-tailed Godwit																
153	Bar-tailed Godwit				4		4				12			160			
155	Grey-tailed Tattler																
157	Common Sandpiper																
158	Greenshank																
160	Terek Sandpiper																
161	Curlew Sandpiper					6	6										
162	Red-necked Stint					6	6										
163	Sharp-tailed Sandpiper																
164	Red Knot																
165	Great Knot																
	TOTAL BIRDS						44				12			160			

RAOU No.	SPECIES	TOWRA POINT 1	2	3	4	5	6	TOT	WEENEY BAY 1	2	3	TOT
129	Ruddy Turnstone											
130	Pied Oystercatcher	2	2			3		7				
131	Sooty Oystercatcher											
133	Masked Lapwing											
136	Grey Plover											
137	Pacific Golden Plover											
139	Lesser Sandplover											
140	Double-banded Plover											
141	Greater Sandplover											
143	Red-capped Plover											
144	Black-fronted Dotterel											
146	Black-winged Stilt											
149	Eastern Curlew	25	92			6		123	13			13
150	Whimbrel				42			42			34	34
152	Black-tailed Godwit											
153	Bar-tailed Godwit		229					229				
155	Grey-tailed Tattler											
157	Common Sandpiper											
158	Greenshank											
160	Terek Sandpiper											
161	Curlew Sandpiper											
162	Red-necked Stint		6					6				
163	Sharp-tailed Sandpiper											
164	Red Knot											
165	Great Knot											
	TOTAL BIRDS							407				47

RAOU No.	SPECIES	QUIBRAY BAY T1	T2	T3	4	TOT	KURNELL	PENRHYN ROAD T1	T2	T3	T4	TOT	BOAT HARBOUR	TOTAL ALL SITES
129	Ruddy Turnstone												6	19
130	Pied Oystercatcher													19
131	Sooty Oystercatcher												5	5
133	Masked Lapwing													1
136	Grey Plover												1	1
137	Pacific Golden Plover												3	5
139	Lesser Sandplover												2	2
140	Double-banded Plover													
141	Greater Sandplover													
143	Red-capped Plover													
144	Black-fronted Dotterel													
146	Black-winged Stilt													
149	Eastern Curlew				38	38								174
150	Whimbrel													76
152	Black-tailed Godwit													
153	Bar-tailed Godwit						3					167		575
155	Grey-tailed Tattler													
157	Common Sandpiper													
158	Greenshank													
160	Terek Sandpiper													
161	Curlew Sandpiper											25		31
162	Red-necked Stint												43	55
163	Sharp-tailed Sandpiper													
164	Red Knot											2		2
165	Great Knot													
	TOTAL BIRDS					38	3					194	60	965

BOTANY BAY WADER COUNT

SHOREBIRDS

DATE	Sat 16th February 02	TIDE	High 11.37am, 1.5 mtrs.	WEATHER		REF.
START TIME		FINISH TIME		OBSERVERS	NPWS Boat: GR, DA, JS. Penrhyn: MH, CS Boat Harbour: BR, KG.	

RAOU No.	SPECIES	SITE/TRANSECT TAREN POINT						RIVERSIDE DR				SANDRINGHAM			KYEEMAGH			TOWRA POINT							WEENEY BAY				QUIBRAY BAY					KURNELL	PENRHYN ROAD					BOAT HARBOUR	TOTAL ALL SITES
		T1	T2	T3	T4	T5	TOT	T1	T2	T3	TOT	T1	T2	TOT	T1	T2	TOT	1	2	3	4	5	6	TOT	1	2	3	TOT	T1	T2	T3	4	TOT		T1	T2	T3	T4	TOT		
129	Ruddy Turnstone					16	16																																		16	32
130	Pied Oystercatcher			26	7		33												7				2	9	2			2													44
131	Sooty Oystercatcher																																							11	11
133	Masked Lapwing					6	6																																		6
136	Grey Plover																																								
137	Pacific Golden Plover					5	5																																	4	9
139	Lesser Sandplover																																							3	3
140	Double-banded Plover																																							5	5
141	Greater Sandplover																					2		2																	2
143	Red-capped Plover																																								
144	Black-fronted Dotterel																																								
146	Black-winged Stilt																																						8		8
149	Eastern Curlew																	30	102	65				197	35	7		42	2			7	9								248
150	Whimbrel																		1					1			30	30													31
152	Black-tailed Godwit																																								
153	Bar-tailed Godwit							3			3	176		176					2					2															133		314
155	Grey-tailed Tattler					40	40																											58							98
157	Common Sandpiper																																								
158	Greenshank																																								
160	Terek Sandpiper					1	1																																		1
161	Curlew Sandpiper					2	2																																		2
162	Red-necked Stint					5	5																																	61	66
163	Sharp-tailed Sandpiper																																								
164	Red Knot																																								
165	Great Knot																																								
	TOTAL BIRDS			26	7	75	108	3			3	176		176				30	112	65		2	2	211	37	7	30	74	2			7	9	58					141	100	880

BOTANY BAY WADER COUNT

SHOREBIRDS

DATE	Sat 16th March 02	TIDE	High, 10.36am, 1.6mtrs.	WEATHER	4,2,1	REF.
START TIME		FINISH TIME		OBSERVERS	NPWS Boat: PS, DA, GD, BS. Boat Harbour: KG, BR, GF, EC. Penrhyn: MH, CS.	

RAOU No.	SPECIES	SITE/TRANSECT																																							
		TAREN POINT						RIVERSIDE DR				SANDRINGHAM			KYEEMAGH			TOWRA POINT							WEENEY BAY				QUIBRAY BAY					KURNELL	PENRHYN ROAD					BOAT HARBOUR	TOTAL ALL SITES
		T1	T2	T3	T4	T5	TOT	T1	T2	T3	TOT	T1	T2	TOT	T1	T2	TOT	1	2	3	4	5	6	TOT	1	2	3	TOT	T1	T2	T3	4	TOT		T1	T2	T3	T4	TOT		
129	Ruddy Turnstone					12	12																																	12	24
130	Pied Oystercatcher			27	26		53													2				2	2			2						1							58
131	Sooty Oystercatcher																																							16	16
133	Masked Lapwing					6	6																													2			2		8
136	Grey Plover																																								
137	Pacific Golden Plover					6	6																																	3	9
139	Lesser Sandplover																																		1				1	3	4
140	Double-banded Plover																																							18	18
141	Greater Sandplover																																								
143	Red-capped Plover																																		7				7		7
144	Black-fronted Dotterel																																	1							1
146	Black-winged Stilt																																			8			8		8
149	Eastern Curlew																	11		93				104	10			10				5	5	11							130
150	Whimbrel																										31	31				14	14								45
152	Black-tailed Godwit																																								
153	Bar-tailed Godwit							78		36	114		179	179																					117				117		410
155	Grey-tailed Tattler					64	64																																		64
157	Common Sandpiper																																								
158	Greenshank																																	2							2
160	Terek Sandpiper					4	4																																		4
161	Curlew Sandpiper					3	3																																	1	4
162	Red-necked Stint					3	3																												1				1	37	41
163	Sharp-tailed Sandpiper																																								
164	Red Knot																																								
165	Great Knot																																								
	TOTAL BIRDS			27	26	98	151	78		36	114		179	179				11		95				106	12		31	43				19	19	15	126	10			136	90	853

BOTANY BAY WADER COUNT

SHOREBIRDS

DATE	Sat 17th November 01	TIDE	High 10.22am, 1.8mtrs.	WEATHER	4,2,1	REF.
START TIME		FINISH TIME		OBSERVERS	NPWS Boat: GD, DA, EL, BS. Penrhyn: MH,CS, PS. Boat Harbour: BR, KG,GF,EC.	

RAOU No.	SPECIES	SITE/TRANSECT TAREN POINT						RIVERSIDE DR				SANDRINGHAM			KYEEMAGH			TOWRA POINT							WEENEY BAY				QUIBRAY BAY					KURNELL	PENRHYN ROAD					BOAT HARBOUR	TOTAL ALL SITES
		T1	T2	T3	T4	T5	TOT	T1	T2	T3	TOT	T1	T2	TOT	T1	T2	TOT	1	2	3	4	5	6	TOT	1	2	3	TOT	T1	T2	T3	4	TOT		T1	T2	T3	T4	TOT		
129	Ruddy Turnstone					3	3																																	19	22
130	Pied Oystercatcher			13			13												2					2								2	2								17
131	Sooty Oystercatcher																																	1						4	5
133	Masked Lapwing																																								
136	Grey Plover																																						1		1
137	Pacific Golden Plover					9	9																																		9
139	Lesser Sandplover																																							3	3
140	Double-banded Plover																																								
141	Greater Sandplover																																								
143	Red-capped Plover																																								
144	Black-fronted Dotterel																																								
146	Black-winged Stilt																																								
149	Eastern Curlew																	33	120			14		167								51	51								218
150	Whimbrel																										6	6													6
152	Black-tailed Godwit																																								
153	Bar-tailed Godwit				2		2				151			90					95					95															162		500
155	Grey-tailed Tattler																																	41							41
157	Common Sandpiper																																								
158	Greenshank																																								
160	Terek Sandpiper																																								
161	Curlew Sandpiper					1	1																																33		34
162	Red-necked Stint					4	4																																	77	81
163	Sharp-tailed Sandpiper																																								
164	Red Knot																																						3		3
165	Great Knot																																						1		1
	TOTAL BIRDS						32				151			90										264				6					53	42					200	103	941

BOTANY BAY WADER COUNT
SHOREBIRDS

DATE	Sat 20th October 01	TIDE	High 10.32am, 1.7mtrs.
START TIME		FINISH TIME	

WEATHER	3,3,1	REF.	
OBSERVERS	NPWS Boat: KG, BS. Penrhyn: MH, CS. Boat Harbour: DA, BR.		

SITE/TRANSECT

RAOU No.	SPECIES	TAREN POINT						RIVERSIDE DR				SANDRINGHAM			KYEEMAGH		
		T1	T2	T3	T4	T5	TOT	T1	T2	T3	TOT	T1	T2	TOT	T1	T2	TOT
129	Ruddy Turnstone			1		8	9										
130	Pied Oystercatcher			12			12										
131	Sooty Oystercatcher																
133	Masked Lapwing																
136	Grey Plover																
137	Pacific Golden Plover					6	6										
139	Lesser Sandplover																
140	Double-banded Plover																
141	Greater Sandplover																
143	Red-capped Plover																
144	Black-fronted Dotterel																
146	Black-winged Stilt																
149	Eastern Curlew																
150	Whimbrel																
152	Black-tailed Godwit																
153	Bar-tailed Godwit	31			7		38						48	48			
155	Grey-tailed Tattler					57	57										
157	Common Sandpiper																
158	Greenshank																
160	Terek Sandpiper					2	2										
161	Curlew Sandpiper					2	2										
162	Red-necked Stint					10	10										
163	Sharp-tailed Sandpiper																
164	Red Knot																
165	Great Knot																
	TOTAL BIRDS						136							48			

RAOU No.	SPECIES	TOWRA POINT							WEENEY BAY				QUIBRAY BAY					KURNELL	PENRHYN ROAD					BOAT HARBOUR	TOTAL
		1	2	3	4	5	6	TOT	1	2	3	TOT	T1	T2	T3	4	TOT		T1	T2	T3	T4	TOT		ALL SITES
129	Ruddy Turnstone																							14	23
130	Pied Oystercatcher		2					2	2			2						2							18
131	Sooty Oystercatcher																							2	2
133	Masked Lapwing																								
136	Grey Plover																								
137	Pacific Golden Plover																							3	9
139	Lesser Sandplover																							2	2
140	Double-banded Plover																								
141	Greater Sandplover																								
143	Red-capped Plover																								
144	Black-fronted Dotterel																								
146	Black-winged Stilt																								
149	Eastern Curlew		170					170										6							176
150	Whimbrel		29					29																	29
152	Black-tailed Godwit																								
153	Bar-tailed Godwit		183					183															216		485
155	Grey-tailed Tattler																								57
157	Common Sandpiper																								
158	Greenshank																								
160	Terek Sandpiper																								2
161	Curlew Sandpiper																						18		20
162	Red-necked Stint																						14	25	49
163	Sharp-tailed Sandpiper																						1		1
164	Red Knot																								
165	Great Knot																								
	TOTAL BIRDS							384				2						8					249	46	873

BOTANY BAY WADER COUNT
SHOREBIRDS

DATE	Sat 23rd September 01	TIDE	High 12.45pm, 1.5mtrs.
START TIME		FINISH TIME	

WEATHER		REF.
OBSERVERS	NPWS Boat: GR, PS, BS. Penrhyn: MH, CS. Boat Harbour: N/A	

RAOU No.	SPECIES	SITE/TRANSECT TAREN POINT						RIVERSIDE DR				SANDRINGHAM			KYEEMAGH			TOWRA POINT							WEENEY BAY				QUIBRAY BAY					KURNELL	PENRHYN ROAD					BOAT HARBOUR	TOTAL
		T1	T2	T3	T4	T5	TOT	T1	T2	T3	TOT	T1	T2	TOT	T1	T2	TOT	1	2	3	4	5	6	TOT	1	2	3	TOT	T1	T2	T3	4	TOT		T1	T2	T3	T4	TOT		ALL SITES
129	Ruddy Turnstone			1		8	9																																		9
130	Pied Oystercatcher			17			17											1				4		5	2			2						2							26
131	Sooty Oystercatcher																								1			1													1
133	Masked Lapwing																																								
136	Grey Plover																																								
137	Pacific Golden Plover					2	2																																		2
139	Lesser Sandplover																																								
140	Double-banded Plover																																								
141	Greater Sandplover																																								
143	Red-capped Plover																																						3		3
144	Black-fronted Dotterel																																								
146	Black-winged Stilt																																						2		2
149	Eastern Curlew																	48	92					140								2	2	3							145
150	Whimbrel																															10	10								10
152	Black-tailed Godwit																																								
153	Bar-tailed Godwit			65			65												90					90								29	29						84		268
155	Grey-tailed Tattler					44	44																																		44
157	Common Sandpiper																																								
158	Greenshank																																								
160	Terek Sandpiper																																								
161	Curlew Sandpiper																																						13		13
162	Red-necked Stint					8	8																																3		11
163	Sharp-tailed Sandpiper																																								
164	Red Knot																																						14		14
165	Great Knot																																								
	TOTAL BIRDS						145																	235				3					41	5					119		548

Appendix F

Ecological Descriptions of Threatened Wader Species

The following descriptions of the ecology and biology of 24 species of shorebirds known to occur or previously recorded at Penrhyn Estuary have been taken from Smith (1991) and Watkins (1993).

Pied Oystercatcher (*Haematopus longirostris*)

Conservation Status: The Pied Oystercatcher is listed as Vulnerable under the TSC Act.

Distribution: The Pied Oystercatcher is found around the entire coast of Australia in association with sandy beaches. Closely related (possibly conspecific) forms occur in Europe, Asia, Africa, New Zealand and North America.

Movements*:* The Pied Oystercatcher occurs around the coast of Australia. During the October to January period adult Pied Oystercatchers disperse from non-breeding flocks to breed along the coast, on estuaries and coastal lagoons. Adults return to breed at the same site each year. Local seasonal movements between sites are recorded at Hobart . Some age segregation of flocks occurs in the area. The breeding season in Tasmania runs from October to January. Young birds move away from the breeding area and form flocks.

In Victoria, resightings of colour-banded birds and recoveries of banded birds indicate that considerable movement occurs. Some of the movements recorded are Port Phillip Bay to Westernport Bay, Werribee to Corner Inlet, Queenscliff to Port Albert (in 15 days), and Shallow Inlet to King Island. Preliminary results show that birds from along the Victorian coast may move into flocks on Corner Inlet, Westernport Bay and Port Phillip Bay during the non-breeding season.

Habitat: The Pied Oystercatcher is entirely coastal in NSW, favouring ocean beaches and estuarine sand and mudflats. It has been recorded inland on rare occasions elsewhere in Australia and regularly occurs inland in New Zealand.

This Australian resident wader presently occurs in relatively large numbers (up to 60 individuals) in Botany Bay at Sandringham Bay where it feeds and roosts and at Penrhyn Estuary where it occasionally feeds on intertidal sandflats. Presently 5 or 6 pairs nest at Woolooware Shorebird Lagoon, Towra Spit Island and at the airport. The volume of pedestrian traffic and shoreline steepness of Foreshore Beach would be expected to preclude the use of this area by the species for its life cycle requirements, particularly nesting activity.

Feeding: There have been no detailed feeding studies in Australia, but the chief prey appears to be molluscs (bivalves and gastropods). The birds also take marine worms and small fish.

Breeding: The nest is a scrape in sand or shingle on coastal or estuarine beaches, typically near the high-tide mark. The birds occasionally nest in saltmarsh or grassy areas. The usual clutch is two, sometimes one or three, rarely four. A second and occasionally a third clutch will be laid if earlier ones are lost, but only one brood is raised per season. The incubation period is 28 – 32 days. The young fledge six to seven weeks after hatching and stay with the parents in the breeding territory for between one and six months. In a Tasmanian study, the average number of young raised by a pair was one every two years. A pair will stay together and breed at the same site in successive years. Eggs have been recorded September-January in NSW.

Population:

Estimated Minimum Population Estimates (Smith 1991 and Watkins 1993)	
Eastern Asian-Australasian Flyway:	125 000
Australia	12 000
NSW	10

Pacific Golden Plover (*Pluvialis fulva*)

Conservation Status: The Pacific Golden Plover is listed as a migratory species under the EPBC Act and is listed under the JAMBA and CAMBA agreements.

Distribution: The Pacific Golden Plover breeds on arctic tundra and migrates through Asia and the Pacific Islands to India, Australia and east as far as New Zealand. Evidence from banding recoveries indicate that the NSW population breeds in Alaska, and migrates across the Pacific Ocean. It occurs in the largest numbers in coastal areas of north eastern Australia. There are occasional inland records of Pacific Golden Plovers in passage.

***Movements**:* The Pacific Golden Plover arrives on the east coast of Australia in late August and September. Numbers build up along the east coast and birds are recorded in inland south-eastern Australia between September and December with the species arriving in South Australia in October and November. Numbers are fairly stable in south-eastern Australia from November to January. From late February to April there is a northwards movement up the east coast which does not appear to involve any stopovers at inland sites. It has been estimated that the species can fly 10 000 km non-stop, and birds departing southern Victoria have sufficient fat reserves to fly directly out of Australia. Some non-breeding birds remain in Australia over winter. The Pacific Golden Plover has been recorded in every month in NSW, but mainly September-April.

Habitat: The Pacific Golden Plover occurs in NSW mainly on estuarine sand and mudflats and nearby saltmarsh and short, moist pasture. The birds typically roost at high tide in saltmarsh and pasture, and often feed in these areas as well. At some sites they feed on rocky intertidal areas, roosting at high tide on sandy beaches or rocks. Occasionally they visit coastal freshwater wetlands. Sporadic records at inland wetlands would seem to be only birds in passage.

This species regularly feeds on intertidal mudflats and roosts in saltmarsh at Penrhyn Estuary and on wooden barges at Shell Point (up to 6 birds use the barges on the southern side). Straw (1996) notes that small number of birds also feed and roost at Boat Harbour which may be the result of disturbance to the birds at Penrhyn Estuary. Key feeding habitat of the species at the mouth of the Mill Stream and Runway Beach have been lost due to the parallel runway construction and may explain, in part, the marked decline in numbers of this species in the Bay since the mid 1980s. The erosion of intertidal sands off Towra Beach and increased usage of the Boat Harbour area for 4WD usage may similarly explain the marked decline in usage of the southern part of the Bay by the species.

Feeding: The birds forage individually or in small parties over intertidal sand, mud or rocks, or in short, moist vegetation. They locate their prey by sight. The diet includes a variety of molluscs, insects, crustaceans and spiders.

Population:

Estimated Minimum Population Estimates (Smith 1991 and Watkins 1993)	
Eastern Asian-Australasian Flyway:	100 000
Australia	9 000
NSW	1 800

Lesser Sand (Mongolian) Plover (*Charadrius mongolus*)

Conservation Status: The Lesser Sand Plover is listed as Vulnerable under the TSC Act and is listed as a migratory species under the EPBC Act. The species is listed under the JAMBA and CAMBA agreements.

Distribution: There are five subspecies of the Lesser Sand Plover recognised as breeding in Siberia, western China, the Himalayas and southern Mongolia. Morphometric studies of this species in Australia suggests that birds occurring in Australia are largely of the subspecies *C.m. mongolus* in the north-west, and *C.m. stegmanni* in south eastern Australia.

Movements*:* The Lesser Sand Plover occurs on the northern and eastern coasts of Australia, being most numerous in Queensland and New South Wales. The species first arrives on the northern and eastern coasts of Australia in September. Numbers continue to increase in a sporadic fashion between September and December. Numbers then remain stable at some sites until early February, but fluctuate at others, possibly due to local movements. Influxes occur at sites in northern Australia from late February to May, suggesting that birds stopover in the north before departing Australia. Some non-breeding birds remain in Australia over winter. The species has been recorded in every month in NSW, and is most numerous in September-May.

Habitat: Lesser Sand Plovers in NSW feed chiefly on intertidal sand and mudflats in estuaries, roosting on sandy beaches or rocky shores at high tide, and sometimes feeding at these sites.

This species roosts every year on intertidal sand flats at Boat Harbour (up to about 10 individuals) and feeds occasionally at Penrhyn Estuary and possibly elsewhere in Botany Bay.

Feeding: The birds typically forage in loose flocks on wet intertidal flats, usually away from the water's edge. Prey is detected visually, the birds making short, quick runs, with abrupt stops to lunge at the ground or to look for prey. The diet includes molluscs and crustaceans.

Population:

Estimated Minimum Population Estimates (Smith 1991 and Watkins 1993)	
Eastern Asian-Australasian Flyway:	27 000
Australia	20 000
NSW	800

Double-banded Plover (*Charadrius bicinctus*)

Conservation Status: The Double-banded Plover is listed as a migratory species under the EPBC Act.

Distribution: The Double-banded Plover is the only trans-Tasman migrant species of wader that migrates between New Zealand and Australia. Birds migrating to Australia are of the subspecies *C.b. bicinctus* and breed in the highlands of central South Island, New Zealand. After breeding a substantial proportion of the population migrates to south eastern Australia for the winter. In NSW the Double-banded Plover is mainly found along the coast, with the greatest numbers usually between the Shoalhaven estuary and Port Stephens. Double-banded Plovers also occur regularly at some inland wetlands.

Movements*:* The Double-banded Plover first arrives in Australia in early February. Many arrive in March and maximum numbers are reached in April in southern NSW, Victoria and Tasmania. Numbers decline slightly by May, presumably because some birds move further north or west. Numbers then remain stable until early July. The species departs from Tasmania and South Australia in July, but in Victoria and southern NSW it is present until mid-August and sometimes until early September. Temporary influxes occur in NSW and Victoria in August, suggesting that birds from elsewhere in Australia use sites in these states as staging areas before their return migration to New Zealand. Some non-breeding birds remain in Australia over summer. The species has been recorded in every month in NSW, but is most numerous March-September.

Habitat: In Australia, the Double-banded Plover is mainly found on intertidal sand and mudflats in estuaries, often preferring sites near saltmarsh or other low, moist vegetation, where the birds roost and feed at high tide. They also feed and roost on ocean beaches and rocky shores. Inland, they inhabit the margins of both saline and freshwater wetlands.

About 50-60 species of this migrant presently feed on intertidal sand flats at Penrhyn Estuary (Penrhyn Road side of channel). The species also roosts at Penrhyn Estuary, Boat Harbour and reportedly at present at Molineaux Point and on the end of the parallel runway (pers. comm., Geoff Ross). This species is thus quite vulnerable to disturbance due to recreational fishers, dogs and beach walkers given its key habitat at Penrhyn Estuary and Boat Harbour. This species used to feed at the former stockpile site and northern sections of Foreshore Beach which were both lost due to the parallel runway construction and have thus experienced a critical decline in their Bay habitat. Based on counts since the 1970s, Botany Bay is one of the three most important estuaries for the species in NSW (along with the Hunter and Shoalhaven).

Feeding: The Double-banded Plover forages on both wet and dry ground, typically in loose flocks. The birds display the typical stop/start foraging behaviour of small plovers, locating prey while stationary, then running to capture it. Most prey is picked off the surface of the ground. When feeding on low tide at night, however, they seem to switch from visual to tactile methods, walking rather than running over the surface, then pausing to probe repeatedly into the mud. The diet includes molluscs, insects, crustaceans and spiders.

Population:

Estimated Minimum Population Estimates (Smith 1991 and Watkins 1993)	
Eastern Asian-Australasian Flyway:	50 000
Australia	30 000
NSW	750

Large (Greater) Sand Plover (*Charadrius leschenaultii*)

Conservation Status: The Large (Greater) Sand Plover is listed as Vulnerable under the TSC Act and is listed as a migratory species under the EPBC Act. The species is listed under the JAMBA and CAMBA agreements.

Distribution: The subspecies *C.l. leschenaultii* of this migratory wader breeds in western China, Mongolia and adjacent parts of Russia while the other two recognised subspecies breed further to the east in central Asia and the Middle East. Most birds migrate during the non-breeding season to the coasts of eastern and southern Africa, the Middle East, India, South east Asia and Australasia. The bulk of the population of subspecies *leschenaultii* comes to Australia, where is occurs around the entire coastline, but most abundantly in Western Australia, the Northern Territory and Queensland. There have been no inland records. The main NSW sites are the Clarence and Richmond estuaries.

Movements*:* The Large Sand Plover arrives in north-western Australia in late August and September. Most of the population remains there, but some have left the north-west by October and November. A migratory movement takes place down the east coast between September and November, and a movement up the coast in March and April. Most birds have departed from north-western Australia by mid-April. In NSW the species has been recorded July-May.

Habitat: The Large Sand Plover is entirely coastal in NSW foraging on intertidal sand and mudflats in estuaries, and roosting during high tide on sand beaches or rocky shores.

This species is an occasional visitor to Penrhyn Estuary and Boat Harbour (often in association with the Lesser Sand Plover) where it feeds on intertidal sand flats. Only 1 or 2 individuals are recorded in Botany Bay on an occasional basis (this is significant given the NSW estimate population for this species is only 80 birds with the majority occurring in the Clarence and Richmond estuaries).

Feeding: The birds feed at low tide on wet ground, usually away from the water's edge. They detect prey visually, running short distances, stopping to look, then running to peck at the surface. The diet includes insects, crustaceans and molluscs.

Population:

Estimated Minimum Population Estimates (Smith 1991 and Watkins 1993)	
Eastern Asian-Australasian Flyway:	99 000
Australia	74 000
NSW	80

Ruddy Turnstone (*Arenaria interpres*)

Conservation Status: The Ruddy Turnstone is listed as a migratory species under the EPBC Act and is listed under the JAMBA and CAMBA agreements.

Distribution: The Ruddy Turnstone breeds on arctic coasts around the pole, and occurs on the coasts of every continent during the non-breeding season. Ruddy Turnstones occur around the entire Australian coastline, with occasional records from inland south eastern Australia of birds in passage.

Movements: The Ruddy Turnstone first arrives in Western Australia and the Northern Territory in August. It arrives on the east coast in September and the passage of birds continues until October in Queensland and November in NSW. It arrives in Victoria and South Australia in September and reaches maximum numbers in November or December. Inland records in south-eastern Australia indicate movement across the continent, as well as around the coast, in September, October and November.

Large numbers stay in north-western Australia all summer. In the south-east, numbers are stable from December to February at most sites. Numbers remain high at some sites in southern Australia until well into April, but most birds depart in March. Influxes occur in coastal NSW sites in March and April. There are also influxes at this time in northern Australia, especially in the north-west. However, birds departing Victoria have sufficient fat reserves to fly directly out of Australia, without needing to stop over in the north. Some non-breeding birds remain in Australia over winter. Ruddy Turnstones have been recorded in NSW in every month, but most numerous September – April.

Habitat: Ruddy Turnstones occur in NSW mainly on rocky coasts, sometimes on ocean beaches, seldom on estuarine mudflats. In northern Australia, by contrast, they favour coasts with wide intertidal mudflats.

This species (about 20 individuals on average in Botany Bay) presently feeds and roosts on rock platforms at Boat Harbour and also roosts on wooden barges at Shell Point. This species is seldom seen on estuarine mudflats (more often on rocky platforms and ocean beaches) and thus is considered to have a low likelihood of occurrence at Penrhyn Estuary (although the occurrence at Penrhyn Estuary for the species remains a possibility).

Feeding: The birds often flick over seaweed, stones and shells and probe under rocks. In Victoria they forage over exposed intertidal rock platforms, where they mostly take small gastropod molluscs and some barnacles, and on ocean beaches, where they feed on sandhoppers obtained by foraging in beach-washed seaweed. They also feed on beetles and ants, and have been observed preying on tern eggs.

Population:

Estimated Minimum Population Estimates (Smith 1991 and Watkins 1993)	
Eastern Asian-Australasian Flyway:	28 000
Australia	14 000
NSW	800

Eastern Curlew (*Numenius madagascariensis*)

Conservation Status: The Eastern Curlew is listed as a migratory species under the EPBC Act and is listed under the JAMBA and CAMBA agreements.

Distribution: The Eastern Curlew breeds in bogs and marshes in eastern Siberia and northern Mongolia. Most of the population migrate to Australia where it is distributed round the entire coastline. It is most abundant on the eastern and south eastern coasts, and during southern migration, in the north west. The species is rare in south western Australia, and there are very few inland records.

Movements: The Eastern Curlew is the largest of the shorebirds that migrate to Australia. Birds arrive in both north-western and eastern Australia as early as late July. The major influxes occur in August along the eastern and south-eastern coasts. Birds in the north-west move on by October, and there is a general southwards movement down the east coast in September to November, and even into early February. However, numbers reach a maximum at most sites in south-eastern Australia in November.

The birds leave eastern and south-eastern Australia between late February and April. There is some evidence of movements up the east coast at this time, but no major influx in the north-west. It appears that most birds fly directly out of Australia during winter and many of these appear to move north into northern NSW and Queensland after the adults depart. Eastern Curlews are common in NSW in every month, but are most numerous in November.

Habitat: The Eastern Curlew is associated chiefly with intertidal sand and mudflats in estuaries, particularly where there are extensive seagrass beds and stands of mangroves. It usually roosts at high tide on beaches or in saltmarshes.

This species presently feeds over much of the intertidal mudflats of the southern parts of Botany Bay, including Woolooware, Quibray, Weeney and Stinkpot Bays and Towra Point. Preferred roost sites on the southern shores of the Bay include sand spits and shoals (Straw 1996; pers. comm., Geoff Ross; pers. obs.). Thick wooden poles marking the limits of oyster leases are used as alternative roosts. Numbers of this species in Botany Bay are presently around 200 and thus no significant decline of the species in the Bay has been noted to date. The species does not normally use the northern shoreline of the Bay to feed or roost but may do so on occasion.

Feeding: The birds forage on exposed intertidal flats at low tide, spreading out to feed singly or in loose feeding flocks. A major prey item in Victoria is the Ghost Shrimp (*Callianassa australiensis)*, which they gather by probing the burrow with their long bills. There is a marked difference in bill length between the sexes, with the female's being the longer. This is associated with differences in foraging behaviour. Many of the longer-billed females feed alone and defend territories on sandbanks and mudflats, where much of their prey inhabits deep burrows. In contrast, the majority of males feed in loose flocks in areas of mudflat pools and seagrass, where their prey lives nearer the surface. Other dietary items include molluscs, grasshoppers, prawns, crabs and freshwater crayfish.

Population:

Estimated Minimum Population Estimates (Smith 1991 and Watkins 1993)	
Eastern Asian-Australasian Flyway:	21 000
Australia	19 000
NSW	2 400

Whimbrel (*Numenius phaeopus*)

Conservation Status: The Whimbrel is listed as a migratory species under the EPBC Act and is listed under the JAMBA and CAMBA agreements.

Distribution: The Whimbrel breeds in arctic Russia, Siberia, Alaska, Canada and Iceland. During the non-breeding season it occurs on the coasts of every continent. Whimbrels occur around the Australian coastline, but numbers are greatest on the northern coasts and there is a marked decline in numbers down the coast of NSW. Occasional inland records represent birds in passage.

Movements: Whimbrels arrive in Australia over an extended period from August to October. At this time the bird migrates southwards through Roebuck Bay in north-western Australia. On the east coast there are influxes in northern Queensland in August, and in southern Queensland and NSW in September and October, suggesting a movement down the coast. The birds then disperse along the coast. Flocking occurs again in March, prior to the northward migration. The birds appear to depart most sites at about the same time, from early to late April. Roebuck Bay is not used as a stopover during the northward migration. Some birds remain in Australia during the breeding season at most sites. The central Queensland coast appears to be a favoured area for Whimbrels at this time of the year. In NSW the species is present in every month but most numerous September-April.

Habitat: Whimbrels typically forage on intertidal mudflats near mangroves, or along the banks of tidal creeks and rivers. They also often forage on intertidal rock shelves. They roost in mangroves or other shoreline trees, or on beaches or rocky shores.

This species (about 50-60 species in Botany Bay in present times) presently feeds on exposed mudflats near and under mangrove trees at Towra Point Aquatic Reserve and roosts in mangrove trees at Woolooware, Weeney and Stinkpot Bays. This species may occasionally feed at Penrhyn Estuary.

Feeding: Their food is obtained by probing in wet mud or among rocks. Little is known of their diet in Australia, the only recorded item being crabs. In Britain they take a variety of invertebrates, including crustaceans, insects and worms, as well as some plant material.

Population:

Estimated Minimum Population Estimates (Smith 1991 and Watkins 1993)	
Eastern Asian-Australasian Flyway:	40 000
Australia	10 000
NSW	700

Grey-tailed Tattler (*Tringa brevipes*)

Conservation Status: The Grey-tailed Tattler is listed as a migratory species under the EPBC Act and is listed under JAMBA and CAMBA agreements.

Distribution: The Grey-tailed Tattler breeds on alpine tundra in the mountains of Siberia, migrating to South east Asia and Australasia. It occurs around the entire coastline of Australia, but is more abundant in northern Australia. Numbers at NSW decline from north to south, with the bulk of the population occurring between the Queensland border and Botany Bay. Inland records are few and there are none for NSW.

Movements: The Grey-tailed Tattler arrives in northern Australia in late August and early September. A subsequent movement down the east coast is indicated by influxes there between September and November. Some birds may migrate across the continent to the coast of South Australia. On northward migration, birds from south-eastern Australia move up the east coast, as well as directly across the continent to the north-west coast. Pre-migratory fattening occurs in north-west Australia, with birds having sufficient weight to reach the Philippines and China. Some non-breeding birds remain in Australia over winter. In NSW the species has been recorded in every month, but is most numerous September-April.

Habitat: The Grey-tailed Tattler is typically found in estuaries with extensive mangroves and intertidal mudflats, although it also inhabits rocky shores along the coast. It often roosts in mangroves at high tide, or on rocks in preference to beaches.

This species presently feeds on exposed mudflats on the southern parts of Botany Bay and has been recorded roosting at a number of locations including the groynes at Kurnell, the old rocky wharf at the mouth of Quibray Bay, in mature spreading mangroves and on platforms in mangroves at Quibray Bay. This species may occasionally feed in small numbers at Penrhyn Estuary. The numbers of the species in the Bay in present times is around 180-190 maximum and do not seem to have varied significantly since the 1950s. These numbers may as well be an underestimate due to the difficulty in detecting the species at their roost sites.

Feeding: The birds forage on intertidal mudflats typically amongst mangroves, exposed seagrass beds or debris. They also forage amongst rocks exposed at low tide, and often on oyster racks. Most of their food is obtained by probing. The diet includes molluscs, marine worms, insects, crustaceans and small fish.

Population:

Estimated Minimum Population Estimates (Smith 1991 and Watkins 1993)	
Eastern Asian-Australasian Flyway:	48 000
Australia	36 000
NSW	900

Common Sandpiper (*Actitis hypoleucos*)

Conservation Status: The Common Sandpiper is listed as a migratory species under the EPBC Act and is listed under the JAMBA and CAMBA agreements.

Distribution: The Common Sandpiper breeds throughout the sub-arctic regions of northern Asia and Europe in various habitats, although not in the high arctic. The species migrates to southern Europe, Africa, the Middle East through to South east Asia and Australasia. It occurs throughout Australia in both coastal and inland localities, with the greatest numbers in Queensland, the Northern Territory and north western Australia.

Movements: The Common Sandpiper breeds across northern Europe and Asia and migrates to wetlands ranging from Africa to Australia. In Australia it occurs singly or in small loose flocks on most types of coastal and inland wetlands. Some non-breeding birds remain over winter and the species has been recorded in every month. It is most numerous in NSW from September-April.

Habitat: In NSW the Common Sandpiper inhabits the steep-sided muddy or rocky margins of various waterbodies, whether saline, brackish or fresh. In coastal sites it is typically found on the margins of salt or brackish watercourses, tending to occur in the upper rather than the lower parts of estuaries. Inland, it occurs on the margins of lakes, rivers, reservoirs, farm dams and other waterbodies, large or small. In northern Australia it is typically found among mangroves, both on the open shore and along the margins of tidal creeks and rivers.

A total of two (2) individuals of this solitary species occur on the edge of mangrove-lined creek channels in the Parramatta River estuary at Bicentennial Park, Homebush Bay, roosting on broken barges. This species also occurs at Newington wetlands. This species occurs most years in very low numbers in Botany Bay (probably 1or 2) and presently roosts on a wooden jetty at Shell Point which illustrates the lack of suitable high tide roosts for shorebirds in the Bay. Whilst only 1 or 2 individuals probably use the Bay, the NSW estimated population for the species is 80 and thus the bay is considered important habitat for this shorebird species. Foraging habitat in the bay is unconfirmed. A single sighting of the species at Penrhyn Estuary was recorded by the NSW Wader Study group since 1994 and thus the site should not be discounted as a possibly important foraging and roosting site for the species in the Bay.

Feeding: The Common Sandpiper is an active feeder, running and stopping, chasing and catching its prey on the surface of mud, rocks or debris. It also probes in shallow water for prey. The diet includes various insects, crustaceans and molluscs.

Population:

Estimated Minimum Population Estimates (Smith 1991 and Watkins 1993)	
Eastern Asian-Australasian Flyway:	30 000
Australia	3 000
NSW	80

Greenshank (*Tringa nebularia*)

Conservation Status: The Greenshank is listed as a migratory species under the EPBC Act and is listed under the JAMBA and CAMBA agreements.

Distribution: The Greenshank breeds largely in the coniferous forest zone of sub-arctic Europe through to the Kamchatka Peninsula, eastern Siberia. It migrates to Europe, Africa, the Middle East, India, South east Asia and Australasia. It is widespread throughout Australia on both inland and coastal wetlands.

Movements: Adult Greenshanks arrive and increase in numbers in Australia during August and September. Numbers then build up from September through November. There seem to be no north/south or inland/coastal differences in the timing of arrival, but perhaps the birds arrive first in the western half of Australia and then move eastwards. Irregular influxes occur at some sites between December and February, indicating some movements during this period. At other sites, the numbers remain stable.

The northward migration consists of two waves. The first, in late February and early March, involves influxes in northern Australia as the birds pass through. During the second wave, in late March and particularly April, there are influxes at sites in southern Australia but few birds stop in northern Australia. A sharp decline in numbers occurs across Australia and most birds have gone by late April and early May. Some non-breeding birds remain in Australia over winter. The species has been recorded in NSW in every month but is most numerous September-April.

Habitat: Greenshanks occur on all types of wetlands across Australia. The species is usually found beside shallow waters generally, either saline, brackish or fresh, including intertidal sand and mudflats, saltmarsh, mangroves and freshwater wetlands.

This species has been recorded on the mangrove lined shores of Woolooware Bay and use to favour the pond site at H1 (Woolooware Shorebird Lagoon) although was not recorded there last season. The numbers of this species in the Bay at present is in the order of 7 or 8 although this may be an underestimate due the difficulty in gaining access to Woolooware Bay by land or boat (due the number of oyster leases in the area). This species may be an occasional visitor to Penrhyn Estuary.

Feeding: Greenshanks usually forage in shallow water or on wet mud. They feed by probing or by quick dashes to take prey. They often walk with the bill held against the substrate, or swept from side to side in shallow water. They have also been seen to break into an unusual high stepping dance, which is though to stir insects into movement. The diet is varied, even for individual birds at one site on one day. It includes aquatic and terrestrial insects, crustaceans, molluscs, frogs, small fish and seeds.

Population:

Estimated Minimum Population Estimates (Smith 1991 and Watkins 1993)	
Eastern Asian-Australasian Flyway:	40 000
Australia	20 000
NSW	2 000

Terek Sandpiper (*Xenus cinereus*)

Conservation Status: The Terek Sandpiper is listed as Vulnerable under the TSC Act and is listed as a migratory species under the EPBC Act. The species is listed under the JAMBA and CAMBA agreements.

Distribution: The Terek Sandpiper breeds along rivers and lakes across most of sub-arctic Russia. During the non-breeding season it occurs mainly on the coasts of Africa, the Middle East, India, South east Asia and Australasia. In Australia it occurs around the northern coasts, with small numbers at some sites on the southern coasts. In NSW it occurs south to Botany Bay, with single birds occasionally recorded south to the Shoalhaven estuary. The two main NSW sites are the Hunter estuary and the Richmond estuary. The species is very seldom recorded inland.

Movements: The Terek Sandpiper arrives in northern Australia in late August and early September. There appear to be two waves of migration down the east coast: one in September and one in November. On departure from north-west Australia in late April, birds have sufficient weight to fly non-stop to the Gulf of Thailand and, possibly, the Philippines and Taiwan. There is also an influx in north-western Australia at this time, with the birds leaving there in late April. Some non-breeding birds remain over winter. The species has been recorded in every month in NSW but is most numerous October-April.

Habitat: The Terek Sandpiper forages on intertidal sand mudflats, often near mangroves or in tidal creeks. It occasionally forages on sandy ocean beaches or rocky shores. It typically roosts on or among mangroves, but also on open beaches.

This species (9 individuals in Botany Bay based on recent counts) presently feeds on intertidal mudflats between Taren Point and Woolooware Bay on the southern shores of the Bay and roosts on a disused jetty at Shell Point. This species may occasionally forage at Penrhyn Estuary (although no recent records exist of this species on the northern shores of the Bay).

Feeding: The species typically feeds by moving rapidly and erratically over soft, wet mud, pecking or probing at the surface, sometimes chasing prey. It also takes prey from shallow pools. It has been recorded feeding in Victoria on amphipods, dipterans and some beetles.

Population:

Estimated Minimum Population Estimates (Smith 1991 and Watkins 1993)	
Eastern Asian-Australasian Flyway:	36 000
Australia	18 000
NSW	250

Bar-tailed Godwit (*Limosa lapponica*)

Conservation Status: The Bar-tailed Godwit is listed as a migratory species under the EPBC Act and is listed under the JAMBA and CAMBA agreements.

Distribution: The Bar-tailed Godwit breeds mainly on low land tundra from Scandinavia, across northern Russia to Alaska. Two races occur in Australia *L.l. baueri* in south eastern Australia and *L.l menzbieri* in the north west. Bar-tailed Godwits occur all around the Australian coastline. They are most abundant in the east and south east, and in the north west. The species is most commonly found on the coast, however there have been occasional inland records of birds in passage.

Movements: Bar-tailed Godwits arrive in Australia, both in the north-west and along the east coast, in August. Few appear to move on from the north-west. Along the east and south-east coasts, numbers increase more or less synchronously in September, followed by temporary influxes at some sites until early November, and later still in Tasmania, indicating the slow southward movement of some birds. Numbers at most sites are generally stable from October to February.

The northward migration takes place in March and early April. Some evidence suggests large influxes to sites in north-eastern Australia at this time, indicating that the bird’s stopover on their way northwards. Conversely, other authors indicate no evidence of this and suggest that the majority of birds fly directly out of Australia.

Large numbers of non-breeding birds remain in Australia over winter. July numbers in northern NSW, Queensland and around Darwin average about 55% of February numbers, whereas in southern NSW, Victoria and Tasmania, in July numbers are less than 10% of February numbers. This suggests a northwards movement of young Bar-tailed Godwits out of south-eastern Australia during winter. The species has been recorded in NSW in every month but is most numerous September-March.

During the breeding season, sites in coastal New South Wales have been found to increase in relative importance for Bar-tailed Godwits remaining in Australia.

Habitat: Bar-tailed Godwits in NSW forage mainly on intertidal sand and mudflats in estuaries. They also forage at times in saltmarsh, mangroves and ocean beaches. They usually roost at high tide on beaches and other open sites.

This species presently feeds on intertidal sandflats at Penrhyn Estuary and at Rocky Point in Botany Bay (prefers Rocky Point) and roosts on beaches at Penrhyn Estuary and Sandringham Bay. The numbers of this species in the Bay in recent times are in the order of 200-400 and have thus shown a moderate decline in numbers in the last 10 years (when numbers have been in the order of 600-800).

Feeding: Bar-tailed Godwit feed while wading in shallow water or walking over soft mud and sand near the water's edge. Seagrass beds are a favoured foraging site. When foraging, the birds repeatedly probe the substrate with their bills, making a sudden deep thrust of the entire bill when prey is encountered. The diet includes marine worms, insects and crustaceans.

Population:

Estimated Minimum Population Estimates (Smith 1991 and Watkins 1993)	
Eastern Asian-Australasian Flyway:	330 000
Australia	165 000
NSW	8 000

Red Knot (*Calidris canutus*)

Conservation Status: The Red Knot is listed as a migratory species under the EPBC Act and is listed under the JAMBA and CAMBA agreements.

Distribution: The Red Knot breeds throughout the high-arctic. During the non-breeding seasons it migrates to Africa, Europe, North and South America and Australasia. The entire population of the subspecies *C.c rogersi* appears to winter in Australia and New Zealand. It occurs all around the Australian coastline, with occasional inland records of birds in passage. Widespread along the NSW coastline during migration, it occurs during summer mainly from the Hunter estuary northwards.

Movement: Great numbers of Red Knots arrive in north-western Australia in late August and early September. Banding studies have shown that the birds are fattening rapidly at this time, getting ready for onward migration and by November more than half have moved on. Maximum numbers occur at Darwin in September and October. At the same time, tens of thousands pass through the Gulf of Carpentaria. These observations suggest that many migrate along the north coast of Australia, probably on their way to New Zealand, where they are far more abundant than in southern Australia.

The northward migration takes place from late February to May. Most birds depart southern Australia between late February and early April, with corresponding temporary influxes to sites in northern Australia between early March and mid-April. This is followed by a substantial influx in late April to sites in Victoria, Queensland and Darwin, probably involving birds from New Zealand. North-western Australia is not an important staging area during the northward migration. Some non-breeding birds remain in Australia over winter. The species has been recorded in NSW in every month but is most numerous September-May.

Habitat: Red Knots in NSW forage on intertidal sand and mudflats in estuaries. They usually roost at high tide on beaches and other open sites.

This species presently feeds on intertidal sand and mudflats (tactile probing) at Penrhyn Estuary and at Rocky Point and roosts at Penrhyn Estuary (typically in association with Godwits). Six individuals of the species have been recorded feeding on bivalve molluscsat Woolooware Shorebird Lagoon on the southern shores of Botany Bay (pers. com., Phil Straw). Up to about 200 individuals of the species may be present in the Bay in present times.

Feeding: A characteristic foraging technique of the Red Knot is a rapid probing up and down, sometimes with a sideways movement, in soft wet sand or mud on either side of the water's edge. It is a tactile rather than a visual feeder. In Victoria it has been recorded feeding on gastropod molluscs and amphipod crustacea.

Population:

Estimated Minimum Population Estimates (Smith 1991 and Watkins 1993)	
Eastern Asian-Australasian Flyway:	255 000
Australia	153 000
NSW	300

Great Knot (*Calidris tenuirostris*)

Conservation Status: The Great Knot is listed as Vulnerable under the TSC Act and is listed as migratory under the EPBC Act. The species is listed under the JAMBA and CAMBA agreements.

Distribution: The Great Knot breeds in the sub-arctic highlands of north eastern Siberia and migrates to the coasts of South east Asia and Australasia, with most of the world population apparently coming to Australia. Although it occurs all around the Australian coastline it is more abundant in northern Australia. Inland records are few and represent birds in passage. In NSW Great Knots occur most regularly and in greatest numbers at the Richmond and Clarence estuaries.

Movements: Large numbers arrive in north-western Australia in late August and early September. Some of these move on by November, when there is a temporary influx at Darwin. Maximum numbers in the Gulf of Carpentaria are not reached until December. These observations suggest that the birds arrive in the north-west first and then spread eastwards. Birds appear on the south-eastern coast of Queensland between September and November, and reach Victoria and South Australia usually in October and November.

The northward migration occurs between late February and April. There are temporary influxes at this time along the east coast of Queensland, but no indication of a large-scale movement to the north-west. Most birds appear to depart the north coast directly rather than returning via the north-west. Large numbers of non-breeding birds remain in northern Australia over winter. The species has been recorded in every month in NSW, although chiefly November-March.

Habitat: Great Knots in NSW forage on intertidal sand and mudflats in estuaries. They usually roost at high tide on beaches and other open sites.

This species is a mudflat feeder and is occasionally recorded roosting and feeding at Penrhyn Estuary, particularly since it was displaced from its preferred habitat at the former Pilots Embayment which was lost due the parallel runway construction. The species is now restricted to Penrhyn Estuary in the Botany Bay estuary. The numbers of this species using the Bay are low (probably less than 4 or 5) although they are significant given the small size of the population on the east coast.

Feeding: Great Knots typically feed by repeatedly jabbing their bills into soft, wet mud near the water's edge or in shallow water. Minute gastropod molluscs have been found in the stomach of two Western Australian specimens.

Population:

Estimated Minimum Population Estimates (Smith 1991 and Watkins 1993)	
Eastern Asian-Australasian Flyway:	319 000
Australia	319 000
NSW	50

Red-necked Stint (*Calidris ruficollis*)

Conservation Status: The Red-necked Stint is listed as a migratory species under the EPBC Act and is listed under the JAMBA and CAMBA agreements.

Distribution: The Red-necked Stint breeds on arctic tundra in central and eastern Russia. It also breeds sporadically in western Alaska. Although this species migrates to South east Asia and Australasia, it is thought that the majority of the population migrate to Australia. It is an abundant wader all around Australia where it is predominantly coastal, although it does occur on inland wetlands.

Movements: The Red-necked Stint arrives in substantial numbers throughout Australia in late August and early September. Numbers increase steadily in coastal and inland sites in the south-east from late August to November. Numbers decline in the north-west in October before a second influx in November. A corresponding second influx occurs on the south-east coast from mid-November to mid-December. Banding has shown that individual birds return to the same sites in coastal Victoria each year.

The northward migration occurs from late February to April. Birds departing Victoria do not carry sufficient fat reserves to fly directly out of Australia. Some birds move up the east coast, with influxes at NSW coastal sites and Lake Bathurst at this time. Most birds, however, appear to take a more westerly route, with influxes along the coasts and nearby inland wetlands of South Australia and Western Australia. Departing birds have mostly gone from the south-east by mid-April, but passage of birds though the south-west continues until late April. A constant turnover of birds occurs in March and April in north-western Australia, although the numbers passing through this area appear to be many less than during the southward migration.

Large numbers of non-breeding birds remain in Australia over winter. In fact, numbers in inland south-eastern Australia are sometimes higher in winter than in summer. It appears that many young birds move inland in winter, often in response to flooding some distance from the coast. There is also a movement of young birds from Tasmania to the mainland in winter. The species has been recorded in NSW in every month but is most numerous September-April.

Habitat: On the NSW coast, Red-necked Stints are most numerous on intertidal sand and mudflats in estuaries. They also frequent saltmarsh, ocean beaches and rocky shores. Inland, they are most numerous on the muddy margins of saline lakes, although they often occur at freshwater wetlands as well.

This species presently feeds and roosts at Penrhyn Estuary and occasionally at Boat Harbour and Spit Island. The species also roosts on barges at Shell Point, which demonstrates the general lack of adequate high tide roosts for shorebirds utilising the Bay. Straw (1996) notes that the birds roosting at Boat Harbour are likely a result of the displacement of these birds from Penrhyn Estuary due to disturbance in the area. The species used to roost on the end of the original runway but this habitat has since been removed. Numbers of this species in the Bay have markedly declined from several hundred (1940s – 1980s) to about 50-100 on average during the summer period based on recent counts.

Feeding: The birds forage in a variety of habitats. In estuaries they forage mostly on wet or drying mud or sand above the edge of the water. They usually feed for the entire period for which the intertidal flats are exposed, and in cold or windy weather continue feeding on near-coastal wetlands during high tide. They feed by moving over the surface making repeated probes, locating prey by tactile rather than visual means, but also pecking at items on the surface which are located visually.

The diet includes insects, crustaceans, spiders, marine worms, molluscs, nematodes and various seeds. At Werribee, Victoria, studies found that the Red-necked Stint, Sharp-tailed Sandpiper and curlew Sandpiper all fed on the polychaete worm *Ceratonereis erythraeensis,* but the Red-necked Stint generally took smaller worms that the other two species.

Population:

Estimated Minimum Population Estimates (Smith 1991 and Watkins 1993)	
Eastern Asian-Australasian Flyway:	471 000
Australia	353 000
NSW	4 500

Curlew Sandpiper (*Calidris ferruginea*)

Conservation Status: The Curlew Sandpiper is listed as a migratory species under the EPBC Act and is listed under the JAMBA and CAMBA agreements.

Distribution: The Curlew Sandpiper breeds on high-arctic coastal tundra in central Siberia with small numbers also nesting in Alaska. Wintering grounds include Africa, the Middle East, India, South east Asia and Australasia. It occurs throughout Australia in both coastal and, less often, inland localities. The largest numbers occur in south eastern Australia, and on the north west coast during migration. The species occurs throughout NSW, with the greatest numbers between the Hunter Estuary and Botany Bay. High numbers also occur at some inland sites in southern NSW.

Movements: The Curlew Sandpiper first arrives in most parts of Australia in late August. It migrates through north-western Australia between August and November. Birds colour-dyed there in this period have been sighted in South Australia and Victoria about five weeks later. Flocks appear on the southern and eastern coasts and in inland eastern Australia between September and November, and there is a steady build-up in numbers in the south-east. Banding has shown that individual birds return to the same sites in coastal Victoria each year. However, studies have shown that substantial fluctuations in numbers at many Victorian and Tasmanian sites between November and February, indicate that the birds move around, although possibly only locally.

The northward migration occurs between February and April. Many thousands of birds pass through north-western Australia at this time, but there appears to be little movement of birds through north-eastern Australia. Birds departing Victoria and Tasmania have sufficient fat reserves to fly directly to the north-west coast and, in many cases out of Australia. However, some influxes occur during the northward migration at coastal and inland sites in NSW and South Australia. Some non-breeding birds remain in Australia over winter. The species has been recorded in NSW in every month but is most numerous September-April.

Habitat: Curlew Sandpipers in NSW typically forage on intertidal sand and mudflats in estuaries. At high tide they roost on beaches or rock platforms, or continue to feed in saltmarshes and backwaters. Although they often roost on ocean beaches and rock platforms, they seldom forage in these habitats. They also frequent the muddy margins of shallow inland wetlands, either freshwater or saline.

This species presently feeds and roosts at Penrhyn Estuary largely on intertidal mudflats (feeding) and sandflats at the Estuary mouth and on the north side of the channel (roosts). This species also roosts on steel barges and a wooden jetty near Shell Point in Woolooware Bay (pers. comm., Phil Straw). Straw (1996) notes that this species was formerly relatively abundant in Botany Bay prior to 1986 (counts between 300 and 700 were regularly made) and that since then numbers have declined significantly down to around 100 (NSW Wader Study counts 1994-2001; NPWS Botany Bay estuary Shorebird Action Plan 2001/2002 counts; pers.obs.).

Only small numbers of this species have been recorded on the southern shores of the Bay during a 20 year count (Straw 1996) and are mostly used for roosting only. Penrhyn Estuary is thus a site of major significance for this species in Botany Bay estuary. The loss of foraging habitat at the northern end of Foreshore Beach as a result of the construction of the parallel runway is considered to be a contributing factor to this species decline in the estuary. Remaining areas of Foreshore Beach have not become significant feeding areas for the species (or for any other shorebirds) due to the steepness of the shoreline in this area and the volume of pedestrian traffic (dog walkers). The shoreline steepness has resulted from erosion due to the changes in wave energy as a result of the construction and operation of the parallel runway.

Feeding: On intertidal flats, Curlew Sandpipers typically feed while wading, often belly-deep in water, probing the underlying mud and often completely submerging their heads; however, at later stages of the ebb they feed more often on wet mud above the water's edge. Studies have shown that at a non-tidal wetland in Tasmania they always foraged in shallow water, whereas at a non-tidal wetland in Victoria they foraged mainly on wet mud, either probing deeply or pecking at the surface. The diet includes molluscs, crustaceans, polychaete and oligochaete worms, insects (chiefly larvae and pupae) and seeds.

Population:

Estimated Minimum Population Estimates (Smith 1991 and Watkins 1993)	
Eastern Asian-Australasian Flyway:	250 000
Australia	188 000
NSW	6 000

Sanderling (*Calidris alba*)

Conservation Status: The Sanderling is listed as Vulnerable under the TSC Act and is listed as a migratory species under the EPBC Act. The species is listed under the JAMBA and CAMBA agreements.

Distribution: The Sanderling breeds in a few scattered localities from northern North America to northern Russia and islands in the Arctic Ocean and Greenland. Despite its limited breeding range, the species is widespread during the non-breeding season, when it migrates to the coasts of North and South America, Africa, Europe, India, the Middle East, South east Asia, Australasia and the Pacific Islands. It occurs all around the Australian coastline, but is rare on the east coast. Inland records are very few and refer to birds in passage.

Movements: The Sanderling arrives in Australia in September. It passes through Roebuck Bay and Darwin in northern Australia, and Eyre in southern Australia, between September and November. Few occur on the east coast or in New Guinea, even during migration periods. The northward migration occurs in March and April, when birds pass through Eyre and Darwin again, but few pass through Roebuck Bay. Some non-breeding birds remain in Australia over winter. The species has been recorded in NSW from September to May, with one record in June.

Habitat: Sanderlings are characteristically associated with sandy ocean beaches, where they feed in the wave-washed zone at low tide. At high tide they roost on the beaches or on nearby rocky reefs. They favour beaches near estuaries rather than log stretches of uninterrupted beach. They sometimes roost or shelter in the estuaries but seldom feed there.

Single birds of this species are occasionally seen in Botany Bay estuary. This species typically feeds in the wave zone of ocean beaches at Boat Harbour and will generally flee to the northern shores of the Bay during rough weather for shelter and feeding (Penrhyn Estuary). Straw (1996) notes that in the 1940s and 1950s the species was regularly present in summer at Boat Harbour, in numbers of up to 15 or more, with counts post 1970 revealing no more than one or two individuals. Remaining areas of Foreshore Beach and the southern shores of the Bay (with the exception of Towra Spit Island) have not become significant feeding areas for the species given the level of human disturbance (fisherman, dog walking) on the beach and the erosion and associated increasing steepness of the shoreline in this area which is unsuitable habitat.

Feeding: Sanderlings typically feed in the ebb and flow of waves on flat beaches where the water is not too turbulent. They follow the receding waves, pecking and probing in the wet sand for prey. One specimen collected in South Australia contained the remains of hairy caterpillars, worms, a beetle, an ant and a spider. These prey items were probably obtained away from the intertidal zone.

Population:

Estimated Minimum Population Estimates (Smith 1991 and Watkins 1993)	
Eastern Asian-Australasian Flyway:	11 000
Australia	8 000
NSW	60

Broad-billed (*Limicola falcinellus*)

Conservation Status: The Broad-billed Sandpiper is listed as Vulnerable under the TSC Act and is listed as a migratory species under the EPBC Act. The species is listed under the JAMBA and CAMBA agreements.

Distribution: Of the two sub-species recognised, *L.f. sibirica* breeds in the north and north east of Russia, migrating to eastern India, South east Asia and Australasia. In Australia it mostly occurs in northern Australia, especially the north west. Only occasional birds are seen on the southern coasts, and very few inland. In NSW the species has been recorded along the coast south to the Shoalhaven estuary, with the main site being the Hunter Estuary.

Movements: The Broad-billed Sandpiper occurs at Darwin between August and May. In NSW it is present September to April, and is most numerous October to March. In north-western Australia most birds depart in the second and third weeks of April. Flight range calculations indicate that migrating birds are able to fly non-stop from north-west Australia to the Gulf of Thailand.

Habitat: Broad-billed Sandpipers in northern Australia favour intertidal mudflats along the coast, particularly areas of soft mud on the seaward side of mangroves. In NSW they favour intertidal sand mudflats in estuaries.

Mostly single individuals of this species have been recorded in Botany Bay on an occasional basis since the mid 1970s (northern shoreline) and up to 17 birds were recorded on the northern shores of the Bay in 1953 (Straw 1996). No recent records of the species in the Bay exist, nevertheless the species may occasionally feed and roost at Penrhyn Estuary.

Feeding: The birds typically feed by rapidly and repeatedly jabbing their bills into soft wet mud. They also feed while wading, often so deep that they have to submerge their heads and necks when probing the underlying mud. In Europe they feed on insects, crustaceans, worms, molluscs and seeds.

Population:

Estimated Minimum Population Estimates (Smith 1991 and Watkins 1993)	
Eastern Asian-Australasian Flyway:	16 000
Australia	8 000
NSW	10

Sharp-tailed Sandpiper Calidris acuminata

Conservation Status: The Sharp-tailed Sandpiper is listed as a migratory species under the EPBC Act and is listed under the JAMBA and CAMBA agreements.

Distribution: The Sharp-tailed Sandpiper breeds in damp sedge land in the high-arctic lowlands of north eastern Siberia. It migrates to Indonesia and Australasia, with most of the population coming to Australia. This species has a wide distribution throughout Australia and occurs in both coastal and inland sites. Large numbers pass through northern Australia on migration, but from December to February the majority of the population is found in the wetlands of NSW, Victoria and eastern South Australia. In NSW the largest numbers occur on inland wetlands, although the species is also common along the coast.

Movements: Sharp-tailed Sandpipers start arriving in Australia in mid-August with peak arrival in south eastern Australia occurring in January to early February. In north western Australia peak arrival occurs in September. Numbers of birds at most sites in Australia are unstable, with movements apparently responsive to wetland conditions. In late February, numbers of Sharp-tailed Sandpipers decrease in the south east of Australia, corresponding with an increase at sites in northern Australia. The Gulf of Carpentaria has been proposed as a major staging area before northward migration. Most first-year birds are thought to leave Australia during the non-breeding season.

Habitat: This species typically feeds and roosts in saltmarsh at the Barton Park (Eve Street) wetland and may occasionally forage and roost in the upper reaches of Penrhyn Estuary in mudflats and saltmarsh. The species has been recorded at Penrhyn Estuary in 1995, 1996 (68 individuals) and 1997 (32 individuals). This species is regularly recorded in the low thousands in the Hunter estuary (Kooragang) and is abundant inland west of Bourke.

Feeding: Sharp-tailed Sandpipers forage on mud or in shallow water. On intertidal mudflats at Werribee, Victoria, it has been reported that they typically feed right at the water’s edge. Their main food here was small polychaete worms, which are particularly abundant at this site. Other dietary items recorded in Australia are aquatic and terrestrial insects (both larvae and adults), crustacea, molluscs and a variety of seeds.

Population:

Estimated Minimum Population Estimates (Smith 1991 and Watkins 1993, 2002)	
Eastern Asian-Australasian Flyway:	160 000
Australia	155 000
NSW	40 000

Black-tailed Godwit Limosa limosa

Conservation Status: The Black-tailed Godwit is listed as a migratory species under the EPBC Act and is listed under the JAMBA and CAMBA agreements.

Distribution: The Black-tailed Godwit breeds in northern Europe, Siberia and northern Mongolia. It migrates to southern Europe and Africa through to South east Asia and Australasia. Black-tailed Godwits occur at sites throughout Australia, chiefly on the coast and most abundantly in northern Australia. Only small numbers visit the southern coasts. Single birds or small flocks occur regularly at inland sites, where they may remain all summer. The species occurs sporadically at both coastal and inland sites throughout NSW.

Movements: In Australia Black-tailed Godwits are concentrated on the northern coast between Darwin and Weipa. The most important site is in the Gulf of Carpentaria in the mudflats north and west of Karumba. Small numbers occur at other coastal and inland wetlands across Australia.

Habitat: This species feeds on intertidal mudflats and on muddy margins of wetlands. The species occurs in very small numbers (1 or 2 individuals) in the Parramatta River estuary at Homebush Bay and may occasionally forage and roost at Penrhyn Estuary although no recent sightings of this species have been recorded at Botany in recent years. The species is regularly recorded in the hundreds in the Hunter and north coast estuaries (eg, Clarence).

Feeding: The birds typically feed along the water’s edge, either on shallow water or on soft, wet mud. Occasionally they wade out into deeper water. Prey is obtained by probing in the mud with their long bills. Their diet includes molluscs, insects and seeds.

Population:

Estimated Minimum Population Estimates (Smith 1991 and Watkins 1993, 2002)	
Eastern Asian-Australasian Flyway:	160 000
Australia	82 000
NSW	650

Marsh Sandpiper Tringa stagnatilis

Conservation Status: The Marsh Sandpiper is listed as a migratory species under the EPBC Act and is listed under the JAMBA and CAMBA agreements.

Distribution: The Marsh Sandpiper breeds in marshland in eastern Europe, south eastern Siberia, Mongolia and Northern China. After the breeding season it migrates to Africa, the Middle East, India, South east Asia and Australasia. It is a common species in the African and Indian parts of its range, it is less numerous in South east Asia and Australasia. The species occurs widely in Australia, in both coastal and inland districts, but is more common in northern and eastern Australia, and is only a vagrant to Tasmania.

Movements: The Marsh Sandpiper migrates to coastal and inland wetlands throughout Australia. Birds arrive in the north of Australia during September with numbers peaking at southern sites in December. Few birds are thought to remain in Australia during the non-breeding season.

Habitat: This species presently feeds and roosts in the Hawkesbury Swamps and at the waterbird refuge at Homebush and Newington Wetlands in the Parramatta River estuary in relatively low numbers (up to 17 birds have been recorded in the Hawkesbury Swamps). No recent records exist for this species in Botany Bay. One historical record for this species in the Bay was identified (in 1983 at the old mouth of the Cooks River). This species may feed on estuarine mudflats at Penrhyn Estuary on an occasional basis.

Feeding: The Marsh Sandpiper usually feeds while wading through shallow water, pecking rapidly, probing in wet mud or actively pursuing prey. It also swims occasionally. Their diet includes insects, molluscs and plant material.

Population:

Estimated Minimum Population Estimates (Smith 1991 and Watkins 1993, 2002)	
Eastern Asian-Australasian Flyway:	90 000
Australia	9 000
NSW	2 000

Little Tern Sterna albifrons

Conservation Status: The Little Tern is listed as Endangered under the TSC Act and is listed as a migratory species under the EPBC Act. The species is listed under the JAMBA and CAMBA agreements. A Little Tern Recovery Plan has been prepared by NSW NPWS.

Distribution: The Little Tern subspecies *sinensis* has a breeding range from Sri Lanka and southern India east to China and Japan, and south through the Philippines and Indonesia to New Guinea and Australia. It is a non-breeding visitor to New Zealand. Within Australia, the breeding distribution extends from Grove Peninsula, around to the Gulf of Carpentaria and down the east coast to Corner Inlet, Victoria, and north eastern Tasmania, with occasional breeding records from South Australia and Western Australia.

Movements: The migratory patterns of the Little Terns are complex and poorly known. Some populations in Asia are believed to be sedentary whereas others in Northern Asia are wholly migratory. The south eastern Australian population is believed to migrate down the east coast of Australia during spring-summer to nest. The great majority breeding in eastern Victoria and NSW and returning to NSW in September to November. The birds leave on migration from March to May.

Habitat: This species forages at the mouth of Penrhyn Estuary for small fish and also roosts at the Estuary. This species has successfully nested in recent years on Towra Spit Island but was unsuccessful last season to due predators (pers.comm., Geoff Ross). The species aborted nesting on Towra Spit Island last season and fled to Molineux Point to nest where roughly 30 chicks fledged, although no data on numbers of nesting pairs were recorded (pers. comm., Geoff Ross). NPWS note that upwards of 60 pairs of the bird nested on Towra Spit Island during the past 10 years (pers. comm., Geoff Ross). Enhancement of habitat at Penrhyn Estuary coupled with public access restrictions associated with the proposal may attract the species to nest in the area. Fox baiting is reportedly underway throughout all areas at Towra Point Nature/Aquatic reserve in an attempt to minimise the chances of foxes predating on future Little Tern nesting sites on Towra Spit Island (a concern given that the island is moving south and the foxes may be able to access the island via mangroves at Towra).

Feeding: Only limited information is available on the feeding ecology of Little Terns in Australia. Gut contents of five breeding specimens from Mallacoota disclosed only fish remains, including two whole Hardyheads. More comprehensive data on European birds suggests that invertebrates are also important in their diet, especially crustaceans and insects. The birds generally work back and forth over the water with quick wing-beats and their head directed downward. They often hover before making a rapid vertical dive into or under the water, or drop or dip more slowly to the surface.

Population:

Census data of Little Terns in NSW are described in the Draft Little Tern (*Sterna albifrons*) Recovery Plan (NSW NPWS 2000). This census data is described below:

Census	**No. Sites Surveyed**	**Breeding Population**	**Non-breeding Population**
1976/77	30	114-124	-
1977/78	30	174	-
1978/79	26	64	-
Dec 1984	40	204	1121
Dec 1989	52	247	1302
Dec 1993	30	292	723
Dec 1994	43	327	1411

Appendix G

Port Botany Expansion Penrhyn Estuary Shorebird Habitat Enhancement (Avifauna Research Services 2003)

Port Botany Expansion
Penrhyn Estuary Shorebird Habitat Enhancement

March 2003

FINAL

Report prepared by:

Avifauna Research Services

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Executive Summary

A small area of intertidal mudflats at Penrhyn Estuary, adjacent to Port Botany, is the only viable shorebird habitat remaining on the north side of Botany Bay. Without appropriate planning the proposed expansion of Port Botany could lead to the loss of the site as a shorebird habitat. The retention of Penrhyn Estuary as a shorebird habitat will therefore be a critical component of the proposed expansion of Port Botany.

Essential design elements for the proposed site include the minimum size of viable habitat within a developed port environment and disturbance factors relating to traffic, port operation, lighting, public access, dogs and watercraft. Concerns over whether shorebirds will fly between the enclosed site and Botany Bay have been considered in this report through comparison with overseas sites.

Key issues

* The retention of the existing mudflats at Penrhyn Estuary is essential to the long-term survival of shorebirds currently using the site.

* The area should remain free from disturbance from Port operations and from the general public

* Habitat enhancement, as outlined in this report, should be commenced as soon as possible in order to provide viable shorebird habitat (may take 3 to 5 years to fully establish). Works could be staged to ensure some areas of habitat are not unduly disturbed.

* Monitoring of the site and any adjustments to landscaping of topography will be essential to ensure long-term viability.

* People and dogs should be excluded east of the proposed rail bridge over the channel into Penrhyn Estuary. Dogs should also be excluded from the constructed boardwalks and viewing platforms.

* Works associated with the restoration of Penrhyn Estuary shorebird habitat should wherever possible be timed to coincide with periods when most migratory species are absent (mid April to late July). The smaller number of shorebirds present during winter (non-breeding juveniles and Double-banded Plovers visiting from New Zealand) are less likely to be disturbed, given the size of the area available to them.

* Retaining the open nature of tidal flats for feeding and saltmarsh for feeding and roosting will be essential including the management of mangroves. (A former roost site is now overgrown with mangroves).

1. Introduction

Until the 1940s much of Botany Bay consisted of extensive areas of intertidal mud and sand flats providing important feeding habitat for many species of shorebirds (waders). These areas included the estuary at the mouth of the Cooks River and Mill Stream and extensive tidal flats at the former Botany Beach where 'several thousand" shorebirds of "ten or eleven" species occurred. (Hindwood *et al* 1954). The former habitat is illustrated in Figure 1.

Each species of shorebird fill a different niche in the variety of habitats available. Some, especially the short-billed species, such as plovers, stints and sandpipers, feed in relatively firm muddy-sand substrate (typical of the former habitat of the north and north-western parts of the Bay) taking animals that are on or close to the surface, often feeding visually rather than tactilely. Other species, especially long-billed species such as the Eastern Curlew and Whimbrel feed in the softer, muddy, substrates of the southern part of the Bay. These birds usually probe deep into the substrate, relying on the tactile senses to detect prey.

During the expansion of Sydney Airport in the early 1950s the lower reaches of the Cooks River was diverted and a large proportion of the most important feeding habitat destroyed. Further losses of feeding habitat resulted during the infilling of the shoreline along the former Botany Beach and construction of the North-South Runway. The most recent losses occurred when Runway Beach, the northern end of Foreshore Beach, and the Pilots Embayment were filled in during the construction of the Parallel Runway (See Figure 2).

The area now known as Penrhyn Estuary was of relatively minor importance for shorebirds until the Maritime Services Board created the estuary, during the construction of Port Botany in the late 1970s.

Some species that occurred at Penrhyn Estuary and Foreshore Beach in flocks of several hundred during the 1970s to 1990s are now only observed in small groups of a few individuals while other species are now locally extinct. This may be due to:

* increased disturbance by people and dogs using Foreshore Beach and entering Penrhyn Estuary (formerly fenced off at the remains of the old Government Jetty) and;

* habitat deterioration due to the steepening of Foreshore Beach due to wave erosion and the recent invasion of mangroves over former saltmarsh roost sites and intertidal feeding areas at Penrhyn Estuary

Penrhyn Estuary is essentially the only habitat remaining for shorebirds formerly abundant in the north-western part of the Bay except for the highly disturbed narrow strip of sandflat at Foreshore Beach during very low tides. The proposed extension of Port Botany will partially enclose the remaining habitat at Penrhyn Estuary and modify some of Foreshore Beach. The 'closeting' effect on Penrhyn Estuary as a result of Port structures has the potential to exclude most shorebirds, because of their need for habitat with an open aspect, if not appropriately managed. Without appropriate planning this could result in the species dependent on the habitat not using the site. Sydney Ports Corporation have commissioned a study by Avifauna Research & Services, and URS, to look at measures that would retain sufficient habitat for shorebirds currently using Penrhyn Estuary and enhance Penrhyn Estuary to provide habitat for larger numbers of shorebirds.

Figure 1
Cooks River
1942

Figure 2
feeding sites prior to parallel runway construction

2. Existing Habitat

Botany Bay has long been identified as an important estuary for shorebirds, for example; Hindwood & Hoskin 1954, Smith 1991, Watkins 1993, as an 'over wintering' site for migratory shorebirds nesting in the Arctic tundra, and as a staging area for birds flying south to southeast Australia and New Zealand.

The shores of the Bay have been subject to an extensive loss of shorebird habitat as a result of industrial development (east and northern shores), and the construction of the existing port and Sydney Airport (northern shores). Recreational activities such as fishing, swimming, boating and picnicking have resulted in disturbances to shorebirds and their habitats. Shorebird feeding habitat on the north shore of Botany Bay is a fraction of that previously available and is restricted to Penrhyn Estuary, Foreshore Beach and a small section of beach between Penrhyn Estuary and Port Botany.

Although Botany Bay still has extensive shorebird habitat these are mangrove-fringed soft mudflats on the southern shores of the Bay between Taren Point and Bonna Point at Kurnell (see Figure 3). These mudflats provide suitable habitat for Grey-tailed Tattlers, Whimbrel, Eastern Curlew and a few Terek Sandpipers and their numbers have remained relatively stable. One species, the Bar-tailed Godwit has been able to adapt to changes in conditions in the Bay and has also remained relatively stable in numbers.

Species such as most sandpipers and plovers that cannot utilise most of the habitats in the southern parts of the Bay are now virtually absent except for small populations at Penrhyn Estuary.

2.1 Penrhyn Estuary

Important feeding habitat at Penrhyn Estuary is restricted to the exposed mudflats that extend from the mouths of Floodvale and Springvale drains to a narrow neck in the Estuary (about 1.5ha) also an area of sand flats along the southern shore of the Estuary and narrow margins of the beaches to the south and north of the Estuary as marked in Figure 4. Penrhyn Estuary is now the most important site in Botany Bay for shorebird species such as Red-necked Stint, Curlew Sandpiper, Red Knot, Pacific Golden Plover and Sharp-tailed Sandpiper that are now sparse or absent from other parts of the Bay.

2.2 Foreshore Beach

Foreshore Beach was created during dredging works by the Maritime Services Board and the creation of Foreshore Road replacing the former Botany Beach. This resulted in a loss of a large proportion of the intertidal flats that remained at the time. Wave action has eroded Foreshore Beach, steepening the profile deepening the immediate foreshore. This has further reduced the available habitat for shorebirds.

The main threats to any shorebirds using the beach is from frequent disturbance from people and unleashed dogs. Roost sites that previously existed along this beach have been lost to erosion.

2.3 Botany Wetlands

Botany Wetlands extend from Gardeners Road in the north to the eastern side of Sydney Airport. They are comprised of a series of lakes and ponds, many artificially created as a result of weirs having been constructed along the watercourse of Mill Stream during the early days of Sydney town. Due to the rank vegetation round many of the wetlands few areas of habitat for shorebirds exist around its shores. However the wetlands do provide roosting and feeding habitat for small numbers of Sharp-tailed Sandpiper and larger numbers of Latham's Snipe.

2.4 Barton Park Wetlands

A series of remnant wetlands situated approximately 1.5 km from the shores of Botany Bay, to the south of Cooks River, provide habitat for significant numbers of migratory shorebirds including Sharp-tailed Sandpiper, Curlew Sandpiper and non-migratory species such as Black-winged Stilt and Black-fronted Plover.

Eve Street Wetland was restored by Sydney Water Corporation with the goal of providing intertidal habitat for shorebirds. This small (ca 1.2 ha) wetland often accommodated relatively large numbers of Sharp-tailed Sandpiper and Curlew Sandpiper until 1998 when management of the site resulted in a marked decline in the numbers of shorebirds found there. The main threats to shorebirds are from disturbance from dogs and people at low tide and difficulties of management maintaining flows through a mangrove-lined channel from Cooks River. A combination of lack of tidal flows and boxing-in the area by the M5 East Motorway has resulted in migratory shorebirds abandoning the site.

Spring Creek Wetland was previously an open wetland, about 1.5 ha in size, providing feeding habitat for Sharp-tailed Sandpiper, Curlew Sandpiper and nesting Black-winged Stilts. However the extensive planting of trees around this wetland has resulted in the wetland being totally closed in resulting in all shorebirds and waterfowl to abandon the site.

Riverine Park Wetland is about 1.8 ha in size providing about 1.5 ha of feeding habitat in the form of semi-tidal mudflats and shallows and a similar sized area of saltmarsh. Species observed at the site on a regular basis include Curlew Sandpiper, Sharp-tailed Sandpiper, Black-winged Stilt and Masked Lapwing.

Figure 4 Existing shorebird feeding habitat (shown in orange) at Penrhyn Estuary (2002)

2.5 Cooks River

Little shorebird habitat remains in the Cooks River. Some habitat exists adjacent to Tempe Recreation Reserve and between the Princes Highway bridge and the nearby rail bridge and is used by shorebirds such as the Bar-tailed Godwit. However very few shorebirds have been seen in these areas in recent years.

2.6 Cooks River mouth to Rocky Point

Apart from a small area of sand flats close to the mouth of the Cooks River, that attracts small numbers of Bar-tailed Godwits, the only area of shorebird feeding habitat between Cooks River and Rocky Point is an area of muddy sand flats extending for about 1km east from Captain Cooks Bridge. These tidal flats attract moderate numbers of Bar-tailed Godwits and occasionally one or two Eastern Curlew and Red Knot. The main threats to shorebirds here are extensive disturbance from people and dogs and large numbers of bait collectors that cause disturbance of the substrate and damage to invertebrates hunted by shorebirds.

A major roost site previously existed at sand spit at Sandringham Bay but was dredged for local beach nourishment. Shorebirds such as Bar-tailed Godwit, Pied Oystercatcher and Red Knot still roost on the beach in Sandringham Bay but are subject to frequent disturbance by people and dogs.

2.7 Georges River

Georges River previously provided extensive tidal mudflats that attracted large numbers of shorebirds. Much of this habitat has now been filled in to provide sports fields, housing and other commercial development. Fringing mudflats remain in some of the embayments of the lower reaches of the River and its tributaries, such as the Woronora River, providing habitat for long-billed shorebirds such as Eastern Curlew and Bar-tailed Godwit.

2.8 Taren Point to Shell Point

The shorebird community occurring in much of the area from Taren Point to Shell Point has been listed as an Endangered Ecological Community on Part 3 of Schedule 1 of the Species Conservation Act 1995. Some of the species that occur at Penrhyn Estuary also occur within this community but only in very small numbers. This area of muddy tidal flats and patches of mangroves is of most significance for the Grey-tailed Tattler, Terek Sandpiper, Whimbrel, Eastern Curlew, Bar-tailed Godwit and Pied Oystercatcher.

Roost sites near Shell Point are important for large numbers of birds that feed in the immediate area as well as Woolooware Bay and other parts of Botany Bay. The roost sites are especially important to Grey-tailed Tattler, Bar-tailed Godwit and Pied Oystercatcher, as well as small numbers of Terek Sandpiper, Pacific Golden Plover, Red-necked Stint, Curlew Sandpiper, Red Knot, Ruddy Turnstone and Common Sandpiper. The main roost sites used are a private wooden jetty and derelict barges, illustrating the shortage of suitable roost sites remaining in this region of the Bay.

The intertidal area in front of a small beach east of Woodlands Road provides important feeding habitat for Bar-tailed Godwit and small numbers of Grey-tailed Tattlers, Red Knot and Pied Oystercatcher. At high tide these birds, with the exception of the tattlers, roost on a narrow strip of beach remaining. The main threats to shorebirds is disturbance, especially by unleashed dogs.

2.9 Woolooware Bay

Until recently Woolooware Bay was widely used for oyster farming and still has extensive areas of oyster racks over a large proportion of the tidal mudflats. The Bay is composed of seagrass beds, muddy and mud/sand substrate, and mangrove woodland. Woolooware Bay is used by long-billed shorebird species such as Eastern Curlew , Whimbrel, Bar-tailed Godwits and Common Greenshank as well as Grey-tailed Tattler and occasionally Marsh Sandpiper that prefer this type of habitat.

2.10 Woolooware Shorebird Lagoon

The Woolooware Shorebird Lagoon on Woolooware Bay is a former sand quarry that has been partially enhanced by the Roads and Traffic Authority for shorebird habitat (tidal mudflats). This was in compensation for the disturbance to the Eve Street Wetland at Arncliffe during the construction of the M5 East Motorway.

About 3 ha of intertidal mudflats have been created to provide feeding habitat for migratory species that may be displaced from Eve Street Wetlands. Species recorded at the site since construction include Bar-tailed Godwit, Red Knot, Ruddy Turnstone, Red-necked Stint, Sharp-tailed Sandpiper and Terek Sandpiper which feed at the site, Eastern Curlew that roost on the islands in the lagoon and Pied Oystercatcher, Black-winged Stilt, Black-fronted Plover and Masked Lapwing that nest on the islands in the lagoon.

2.11 Sand-flats at Pelican Point

The intertidal sand shoal and shallow seagrass beds near Pelican Point is a heavily used feeding area by long-billed shorebirds such as Bar-tailed Godwit and Eastern Curlew as well as a few Pied Oystercatchers. The area is particularly important as it is relatively stable with little movement of sands since the 1970s (unlike the beaches of Towra Point that have been unstable over the same period).

2.12 Towra Point/Spit Island

Towra Spit Island is the most important roost site in Botany Bay for many shorebird species despite the fact the island is unstable and moving in a westerly direction due to wave and wind erosion. The island formed the tip of the "Elephants Trunk" at Towra Point until 1991 when it was formed into an island during large tides and heavy seas.

The island is protected to a large extent from disturbance by people due to the fact that Little Terns that nest on the island are protected by the NPWS who have erected signs prohibiting landing and patrol the area during summer months.

2.13 Towra Point Nature Reserve

The saltmarshes at Towra Point Nature Reserve provide feeding habitat for some migratory shorebirds such as Sharp-tailed Sandpiper and roosting habitat for Pacific Golden Plover. The tidal mudflats at Weeney Bay, which is inside the nature reserve, provide feeding habitat for Whimbrel and Grey-tailed Tattler, which roost in mangroves in the area.

Tidal flats fringing the nature reserve, previously exposed on neap tides, are now only exposed on the lowest spring tides due to erosion by wave action. Wave action has also eroded beaches around the nature reserve making them too steep and unstable to support invertebrate prey that shorebirds feed on.

There are plans to annex the Spit Island roost site and the Woolooware Wader Lagoon to the nature reserve.

2.14 Quibray Bay

Quibray Bay provides important feeding areas, such as mud and sand flats, beaches and mangroves. Roosting sites in the area include oyster racks, large wooden posts, and a sandy beach. The area is use by large numbers of shorebirds including Bar-tailed Godwit, Grey Tailed Tattler, Eastern Curlew, Whimbrel and occasional small numbers of Red Knot.

The main threat to shorebirds in the Bay include disturbance by illegal use of the beach by horse riders and vehicles and the doubt about the long-term viability of roost sites if all oyster lease structures are removed in the wake of the collapse of the oyster industry.

2.15 Boat Harbour

The rock platform at Boat Harbour provides an important roost site for large numbers of migratory shorebirds including Red-necked Stint, Ruddy Turnstone, Lesser Sand Plover, and Pacific Golden Plover during the summer months and Double-banded Plover during the winter months. Many of these birds may feed in Botany Bay but take refuge at Boat Harbour due to disturbances in the Bay. The area is exposed to disturbance from 4WD vehicles and dogs as well as anglers and tenants of week end cabins.

3. Project Description

Sydney Ports Corporation is proposing to expand the port facilities at Port Botany through the construction of a new container terminal on the western side of the existing Patrick container terminal, extending northwards towards Foreshore Road. This will require reclamation of about 60ha of the Bay. This work will involve the construction of containment walls of rocks and infilling between these with material dredged from the immediate vicinity, at the same time deepening the berthing area to allow large ships to enter (see Figure 5).

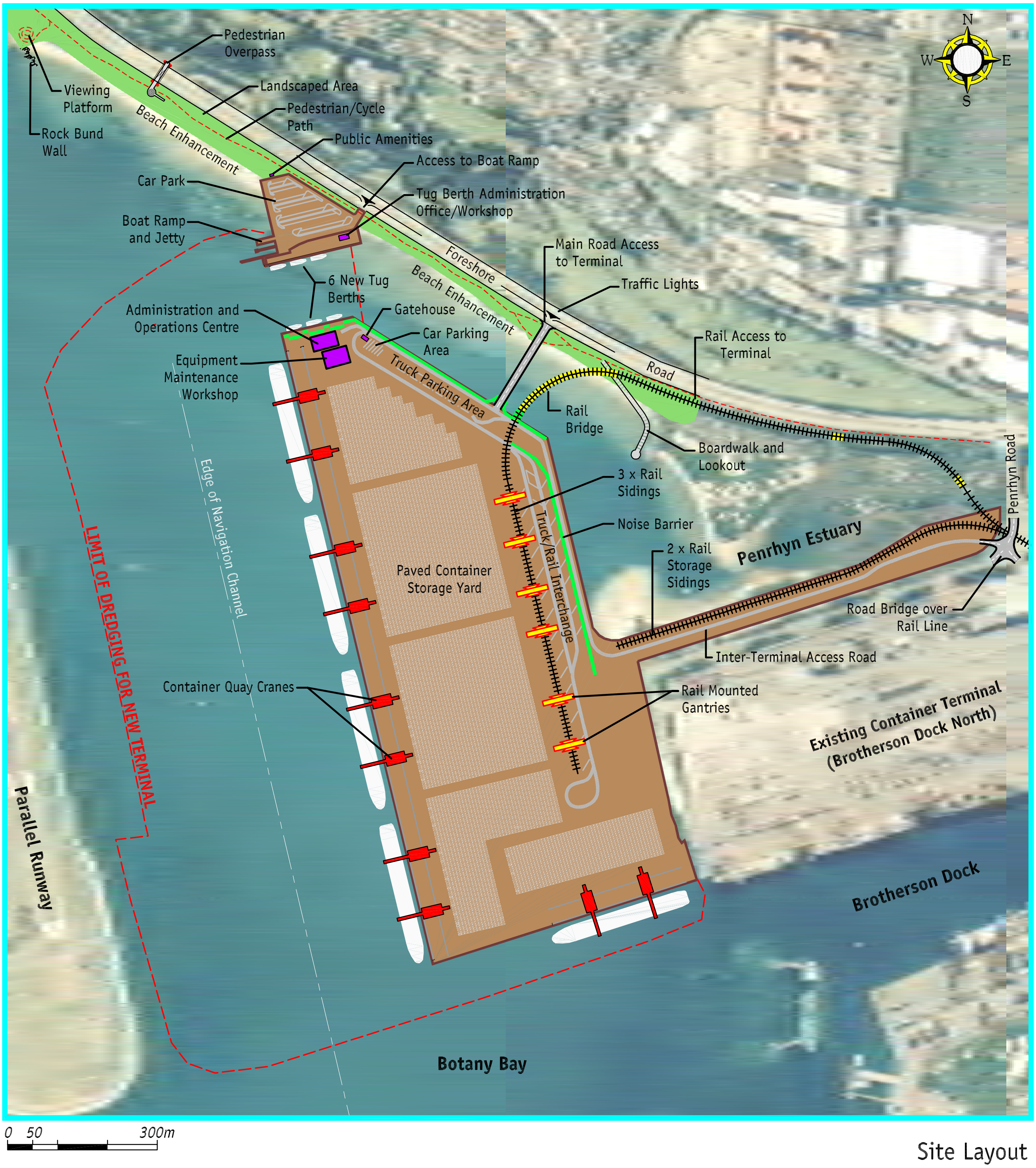
Trucks would access and egress the new terminal via Foreshore Road across a bridge constructed between the terminal and Foreshore Road. Traffic at the terminal would reach an estimated daily two-way movement of about 941 trucks by 2021 (Maunsell 2002).

A new rail link will be constructed to enter the site from the north. This will be achieved by a rail line, which approaches from the existing lines to the northeast of the existing Patrick container terminal, then loops around Penrhyn Estuary to the north and on to the proposed expansion, as shown in Figure 5. The line will be constructed on an embankment adjacent to Foreshore Road. The new terminal is estimated to generate 18 trains per day (Maunsell 2002).

It has been estimated that the expansion of Port Botany will include ten new quay cranes, 8 cranes on the western side of the site and 2 on the southern side of the site. Seven new rail mounted gantries will be situated on the eastern side of the site adjacent to the proposed rail siding. These cranes and gantries will be serviced by up to forty new straddle carriers that will operate between them (Wilkinson Murray 2002).

The result of these works will be the loss of some shorebird habitat, seagrass beds and saltmarsh and will partially enclose important shorebird habitat at Penrhyn Estuary.

To compensate for potential impacts on migratory shorebird habitat at Penrhyn Estuary it is planned to greatly expand the existing habitat to provide a larger, more open, area of habitat. The potential impacts of noise, lights and the movements of vehicles, people and dogs also need to be addressed.


Pedestrian Overpass
Viewing Platform
Rock Bund Wall
Landscaped Area
Pedestrian/Cycle Path
Public Amenities
Beach Enhancement
Access to Boat Ramp
Car Park
Tug Berth Administration Office/Workshop
Boat Ramp and Jetty
Foreshore
Main Road Access to Terminal
6 New Tug Berths
Beach Enhancement
Traffic Lights
Administration and Operations Centre
Gatehouse
Car Parking Area
Rail Access to Terminal
Road
Equipment Maintenance Workshop
Truck Parking Area
Rail Bridge
Boardwalk and Lookout
3 x Rail Sidings
Edge of Navigation Channel
Noise Barrier
Penrhyn Road
Penrhyn Estuary
2 x Rail Storage Sidings
Paved Container Storage Yard
Truck/Rail Interchange
Road Bridge over Rail Line
Inter-Terminal Access Road
LIMIT OF DREDGING FOR NEW TERMINAL
Container Quay Cranes
Rail Mounted Gantries
Existing Container Terminal (Brotherson Dock North)
Parallel Runway
Brotherson Dock
Botany Bay
N
S
E
W
0 50 300m

Site Layout

4. Potential Impacts

4.1 Operational Impacts

4.1.1 Size of habitat area

Shorebirds feed in a variety of wetlands varying in size from a few hectares to estuaries of many square kilometres in size. Generally speaking, the larger the wetland area the more shorebirds there are likely to be there. In the case of constructed wetlands it is often necessary to consider the minimum size required to make a site functional, then work upwards from this to consider how many shorebirds, and which species need to be catered for. Minimum size depends on the amount of feeding area available and the need for buffer zones to compensate for disturbances and the psychological 'openness' of a site required by shorebirds.

Areas that are 'boxed in' by tall trees and or buildings tend to be avoided by shorebirds (Straw 2002). It is therefore important to provide a large enough area to provide sufficient habitat and food resources for the shorebirds plus a clear line of view around this habitat (see Figure 6). In part the minimum size of habitat will depend on the number of shorebirds, and the species involved, that must be sustained by the habitat area and in part the need for an open line-of-site around the feeding habitat and roost sites.

The expansion of Port Botany will result in partially enclosing Penrhyn Estuary. The enclosing of a small area such as the existing intertidal flats at Penrhyn Estuary would result in a closely boxed-in area where shorebirds would be reluctant to enter. Shorebirds prefer an open aspect to allow a clear view of potential predators.

The minimum size of habitat to maintain existing species at Penrhyn Estuary will depend on the nature of the development proposed for the site and the number of shorebirds that need to be accommodated at the site. The proposed expansion will provide an open Estuary area of about 27 ha. Research carried out at shorebird sites in Japan, in highly developed areas, have shown that large numbers of shorebirds (4,000) do use sites of over 30 ha of intertidal mudflats (Yatsu-higata) and smaller areas if not boxed in by tall structures (Tokyo Port Wild Bird Park). (see Section 5)

In recent years about 1,200 shorebirds have been counted at Penrhyn Estuary and up to about 3,000 shorebirds have potentially used the site at any one time over the past 10 to 20 years, taking into consideration the maximum counts of each species (not necessarily there at the same time).

To mitigate the box-in effect, structures on the terminal should be set back from the edge of the Estuary.

4.1.2 Impact of physical structures

The expansion of Port Botany will result in partially enclosing Penrhyn Estuary with wharf structures, a rail line, stacked shipping containers and large cranes.

Birds, and particularly shorebirds that are used to long-distant migration, are capable of flying over any of the structures at the expanded port. However as discussed above they would be reluctant to enter a closely boxed in area and prefer an open aspect to allow a clear view of potential predators.

Structures at the proposed terminal will include quay cranes, rail mounted gantries, container stacks, and buildings. Quay cranes are approximately 47m high and rail mounted gantries 25-30m high. Whilst they are tall, they are not solid structures and they move along rails.

The proposed buildings would be a maximum of 3 storeys and are located on the north western corner of the terminal so would be less of a flyway barrier to the shorebirds than if located elsewhere on the terminal. Container stacks would be a maximum of 6 high (approximately 17m) but would typically be 3 high (approximately 8m).

To mitigate the boxing-in effect structures should be set back from the edge of the terminal where it adjoins the Estuary.

It is also worth noting that the construction and operation of the terminal will occur over a number of years. Initially the dredging and reclamation process would occur. This would create a land area of approximately 60ha with no structures on it. Operator works are unlikely to commence on the reclamation until 3 years after the commencement of dredging and there would be a gradual increase in the level of operation and equipment on the site over the next 10 years. Structures such as container stacks and cranes are not likely to be on the site until at least 4 years after the commencement of the habitat enhancement works.

4.1.3 Disturbance

The specific disturbance buffer for shorebirds will vary from species to species depending on the nature and extent of the disturbance. At least 20 m will need to be factored into the design of the habitat enhancement, although shorebirds will obviously determine their own preferred feeding/roosting sites. In general, it should be noted that most species prefer large open spaces.

4.1.3.1 Disturbance by people

The shorebird habitat at Penrhyn Estuary should be appropriately fenced to control public access and prevent dogs from entering the site. Disturbance of birds at the site would greatly reduce the value of the habitat for shorebirds. However it is advantageous to have viewing platforms and interpretative facilities for the general public and for schools to educate people about the importance of undisturbed feeding and roosting sites for migratory shorebirds. Any boardwalks or observation platforms should be constructed in accordance with plans provided to SPC by an appropriate ecologist in order to minimise disturbance.

Access to the Estuary via Foreshore Beach (except via a boardwalk) should be barred using an appropriate barrier, as well as signage to inform the public of the sensitive nature of the shorebird habitat. The design of the barrier needs special consideration bearing in mind the determination of fishers and some dog owners to bypass any structure to access an open area of foreshore or alternative fishing spot. A suitable barrier suspended from the bridge may also be necessary to prevent boats and swimmers from entering the Estuary. The placement of the oil boom at this location may help to deter entry into the Estuary.

Provided a safety fence is constructed around the perimeter of the rail loop access to the Estuary may not be an issue.

4.1.3.2 Disturbance from the railway

Although rail traffic will be slow moving it will cause disturbance to birds close to the rail line and allowances should be made for this when calculating area available as shorebird habitat. Disturbance would be intensified by sudden loud noises such as train whistles/horns. Bright lights will generally be directed away from mudflats within the Estuary due to the configuration of the railway (see also Section 4.2.5). The use of whistles/horns by trains when on the rail line adjacent to the Estuary, should be prevented or minimised.

4.1.3.3 Disturbance from port traffic (trucks & cars)

The effect of disturbance from port truck and car traffic will depend on how close the traffic will be to shorebird habitat, noise, lights (see lights from traffic) and activities of drivers. These impacts should be screened where possible.

4.1.4 Impact of artificial illumination

The report on Lighting Environmental Effects (Bassett 2002) has indicated that the proposed development will result in an increase in the amount of light spill over Penrhyn Estuary. Light sources include building mounted lighting, quay cranes, straddles, rail and/or rubber tyred gantrys, vehicles, road lighting and navigation lighting.

The Estuary currently experiences light from Port Botany and the existing Brotherson Dock North operation.

It is important to avoid the use of high mast lighting immediately adjacent to the Estuary as it will be virtually impossible to shield light from such installations (Bassett 2002).

Ensuring that road based activities occur around the edge of the terminal, rather than operational areas with high mast lighting, as indicated by Bassett (2002), can help to provide a buffer zone to the high mast lighting. Lower poles with cut-off type road lighting luminaires and back-light spill shields are required. Low mounting heights only require low wattage light sources, however, the number required is increased. The effect will be to provide greater control over light spill.

Headlights from trains should be pointing along the railway line and at no time be shining across the shorebird habitats within the amelioration site.

Headlights from vehicular traffic are especially disturbing to birds if vehicle headlights are allowed to shine across the Estuary habitat. Moving lights such as spotlights, strobes and vehicle headlights (especially of vehicles shining headlights over the Estuary while turning) should be screened. It is therefore important to have solid barriers along the edges of the port adjacent to the Estuary of sufficient height to obscure vehicle headlights, where the headlights are likely to be pointing into the Estuary, (see also Figure 8) but not too tall to minimise a boxing-in effect. Where appropriate the barriers could be obscured with vegetation.

Headlights from trucks turning onto the bridge between Foreshore Road and the expanded port are likely to have some disturbance effect on birds in the vicinity of the bridge. Suitable barriers at either end of the bridge would reduce this impact. Barriers on the Foreshore Road end could be in the form of tall/dense vegetation rather than constructed barriers to improve the aesthetics of the landscaped area.

Figure 6: Buffer zone requirements (from Straw 2002)

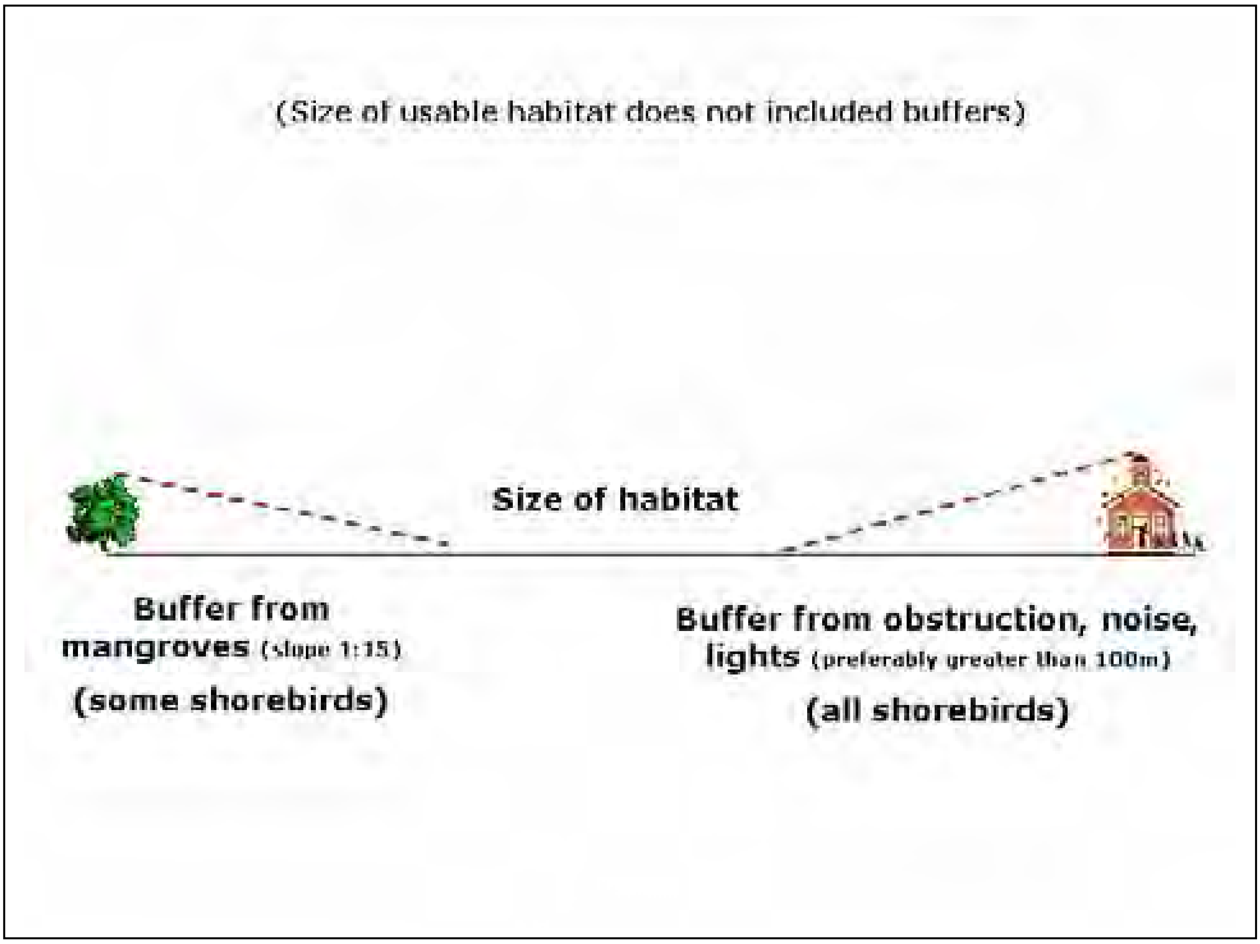


Figure 7: Minimising 'boxing' effect of the proposed port expansion

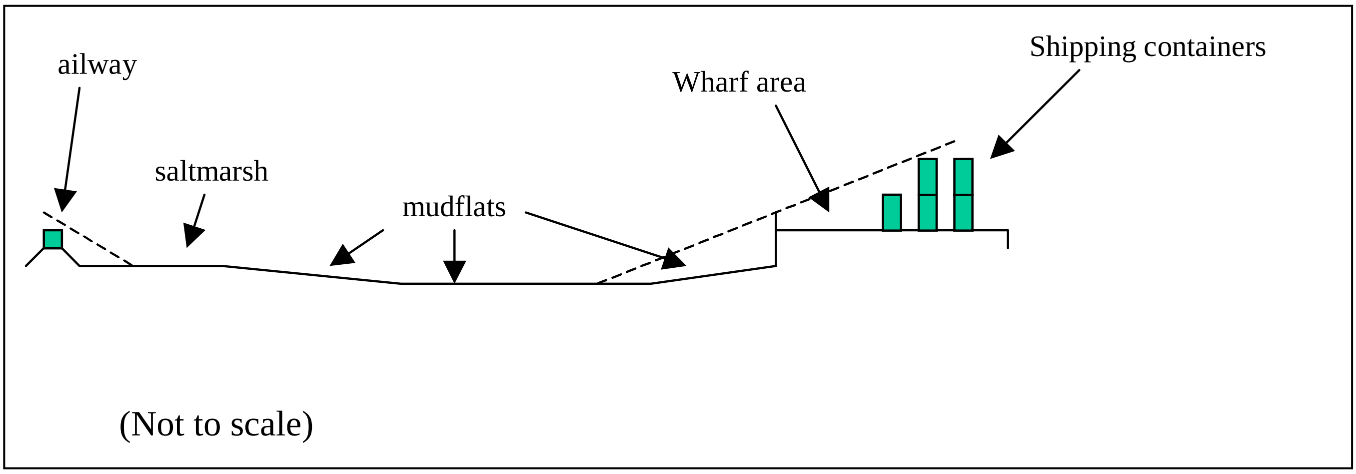
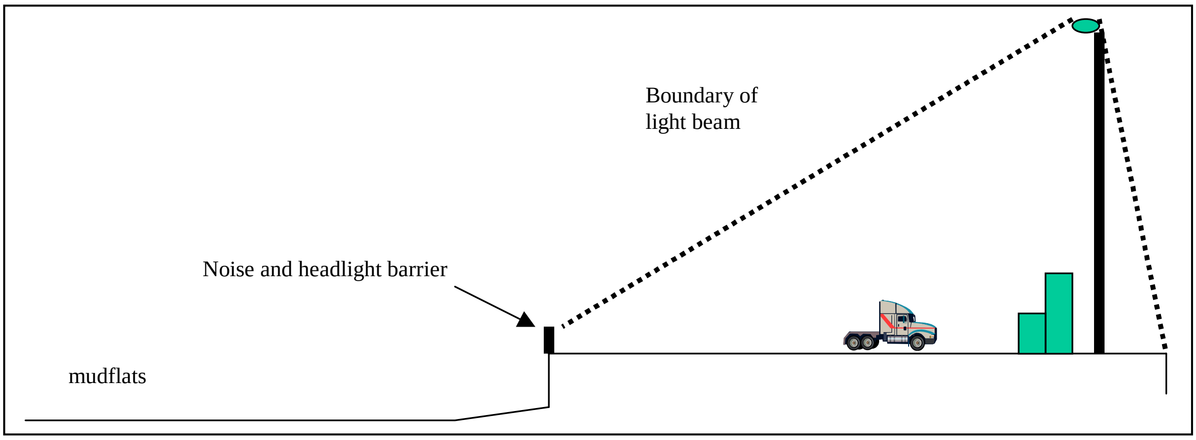


Figure 8: Reducing light spill from the proposed port expansion on wetlands habitats



4.1.5 Noise

Noise may have a significant impact on birds, especially sudden loud noises. To a certain extent birds appear to tolerate steady 'background' or regularly emitted noise more than sudden loud noises. To a large extent sound barriers, in the form of solid walls, may be constructed to deflect noise (eg. sound barriers bordering motorways) (see Figure 8).

Noise associated with the operations of the expanded port will come from a variety of sources and include those made by straddle carriers, rail locomotives, truck processing area, truck exchange area and auxiliary powers units (Wilkinson Murray 2002). The most effective way to reduce noise at Penrhyn Estuary would be to construct a noise barrier along the eastern and northern edge of the new terminal as recommended by Wilkinson Murray (2002). This would also act as a barrier against lights from moving vehicles at the new terminal from disturbing shorebirds at Penrhyn Estuary.

The proposed 4m high noise barrier recommended by Wilkinson Murray would increase the boxing-in effect of the port construction if it were opaque and constructed adjacent to the Estuary. A solid barrier of a height of 2m would have less of an impact but may not meet the noise reduction objectives by SPC for neighbouring public. In which case the upper 2m could be constructed from a translucent material to reduce the boxing-in effect, provided some form of pattern was printed onto the surface to make it visible to birds in flight and reduce the likelihood of birds flying into the barrier. This wall could therefore be used for both noise reduction and blocking of headlights from shining into the Estuary from truck loading and marshalling areas.

The wall should also be set back as far as possible from the edge of the Estuary to minimise the boxing-in effect.

4.1.6 Closure of tidal channel to watercraft and people

The tidal channel between the expanded port and Foreshore Road will provide an attractive sheltered place for anglers and boat drivers. It is essential that the channel be closed to all boat traffic and that the shores be closed to anglers and dogs east of the rail bridge. Pedestrian access is to be controlled as noted in Section 4.1.3.1.

4.2 Construction Impacts

Impacts during port operations will be mitigated to a large degree with the installation of noise barriers and management of light spill and other strategies discussed in the above Section 4.1. During construction such safeguards are not likely to be in place. It is therefore important that site managers and contractors are fully aware of the need to reduce any potential impacts on the Estuary during the construction of the Port Expansion as well as during habitat enhancement works.

4.2.1 Disturbance during construction of port facilities

During the construction of port facilities potential impacts could result from:

* dredging operations (lights, noise, movement of people and machinery);

* construction of wharf/quay structures, involving pile driving, transport and placement of materials to form a hard rock berm, the construction of retaining walls, infilling and surfacing to form quayside surfaces and facilities,

As well as disturbance of birds while feeding or roosting as a result of:

* unnecessary entry onto the site by people (contractors or members of the public);

* entry to the site by machinery;

* excessive lighting (especially moving light beams, floodlights etc); and

* excessive noise from heavy machinery, trucks etc

To minimise disturbances the site should be fenced prior to the commencement of construction (desirable from a public safety perspective as well as minimising the disturbance of birds). Apart from machinery used for the preparation of habitat enhancement Penrhyn Estuary should be closed to traffic and machinery and the Estuary area should not be used for storage of materials or parking of machinery.

4.2.2 Disturbance during habitat enhancement works

While it is necessary to use heavy machinery to level sand dunes, grade tidal flat surfaces and to infill deep areas of water these operations can cause major disturbance to birds using the existing Penrhyn Estuary mudflats (which will be left untouched). To minimise these disturbances works carried out during the construction of shorebird habitat should be carried out where possible during winter months, when the majority of shorebirds are in their breeding grounds or on migration, where this involves work immediately adjacent to the existing habitat. Screening and/or temporary sand embankments may also be used to minimise noise and visual disturbance by machines.

Work close to the existing feeding and roosting sites, such as levelling of sand dunes adjacent to the Estuary, saltmarsh creation and surface grading, should be staged so that disturbance is only from one side of the Estuary at any one time.

The construction of the proposed preferential flow channel adjacent to and through the existing mudflats should be carried out during the winter months.

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5. International Experience

Overseas research of shorebird habitat at developed sites

Due to the possible impacts of the proposed port extension on shorebirds using Penrhyn Estuary investigations were carried out by Phil Straw at similar sites overseas. Two wetlands; Yatsu-higata (40 ha in size) and Tokyo Bay Wild Bird Park (24 ha in size) were looked at specifically to assess the feasibility of creating a shorebird feeding habitat at Penrhyn Estuary (see Figure 9 and Figure 10). The sites were also visited to determine potential impacts of the construction of port facilities on the flight paths of shorebirds that use Penrhyn Estuary. From these investigations it is apparent that shorebirds will fly over port facilities similar to those proposed at Port Botany provided that the estuary area is extensive enough to provide a large open aspect or where the open space around the wetlands provides a sufficient buffer zone. The comparative size of Yatsu-higata is shown as an overlay in Figure 11.

The proposed shorebird habitat at Penrhyn Estuary will provide approximately 27ha of estuarine habitat, about half of which will be intertidal mudflats and half saltmarsh and seagrass habitat. This would represent the largest area of suitable habitat for some species of shorebirds in Botany Bay and may have a major influence on the numbers of shorebird species in the Bay. This compares with about 35ha of open habitat and wetland vegetation at Yatsu-higata in Japan. The 130m wide channel will provide a flyway for waders entering the estuary and compares favourably with access to Yatsu-higata that has two narrow channels connecting the wetland to Tokyo Bay 20m and 50m wide respectively. Although the species composition is somewhat different in the wetlands in Japan to those occurring in Australia 21 species are found at both locations (Table 1)

Yatsu-higata is a landlocked wetland adjacent to the Port in Tokyo Bay (surrounded by industrial development) at Narashino City in Japan that was recently listed as a Ramsar wetland of international importance for waterbirds. This wetland is used by large numbers of migratory shorebirds for part of their life cycle requirements. The shorebirds feed and roost at the site during flood tides (that is, when the tide is coming in) when their primary feeding habitat (exposed mudflats elsewhere in the Bay) is flooded.

Although the basic concept of the Yatsu-higata and Penrhyn Estuary are similar there are some fundamental differences in the size of shorebird populations and pressures on the birds at both sites. Yatsu-higata is located adjacent to Tokyo Bay which has more extensive mudflats and larger shorebird populations than Botany Bay. The number of shorebirds potentially using Yatsu-higata is greater, especially when feeding habitat in much of the Bay is covered during high tide. On the other hand the habitat at Penrhyn Estuary will virtually be the only available habitat suitable for some species of shorebirds in Botany Bay where most of the population will depend on the enhanced site.

Observations by staff and volunteers at Yatsu-higata indicated that the shorebirds fly over industrialised land, including a freeway viaduct of approximately 10 to 20 m in height, to access the wetlands (see Figure 9). However, at the proposed terminal it is recommended that the height of solid structures such as walls should be kept to a minimum and that stacks of containers be kept at least 50 metres from the edges of the reclamation adjacent to Penrhyn Estuary were possible to minimise the closeting effect (see Figure 6). The construction of noise barriers will add to the height of the profile of the wharf area close to the estuary. Using translucent materials to allow the passage of light through the barriers and setting barriers back as far as possible from the edge of the estuary may reduce this impact.

Due to the increased size of Penrhyn Estuary, shorebirds would be more likely to fly into the estuary over the operational docks or negotiate the 130 metre wide channel parallel to Foreshore Beach. The shorebirds would not be expected to have any difficulty in negotiating over the proposed road and rail bridges. Tall structures such as cranes are not likely to present substantial barriers provided lights are managed as recommended in Section 4.1.4

Table 1: Comparative abundance of similar species of shorebirds at sites in Japan and Penrhyn Estuary.

Species	Yatsu-higata 1999-2000	Tokyo Bay Wild Bird Park	Penrhyn Estuary 1977 - 2002
Black-winged Stilt	27	no data	16
Curlew Sandpiper/Dunlin#	1870	141	700
Common Sandpiper	4	13	1
Great Knot	20	1	15
Common Greenshank	15	66	1
Grey-tailed Tattler	213	76	2
Bar-tailed Godwit	232	25	500
Black-tailed Godwit	0	32	3
Eastern Curlew	2	0	3
Marsh Sandpiper	2	5	1
Red Knot (rare in Japan)	1	0	220
Red-necked Stint	409	157	400
Ruddy Turnstone	107	85	16
Terek Sandpiper	34	34	1
Sanderling	6	0	1
Whimbrel	575	20	1
Greater Sand Plover	1	1	1
Grey Plover+	144	6	2
Lesser Sand Plover	109	140	16
Pacific Golden Plover	1	47	158

Curlew Sandpiper and Dunlin numbers are used due to the similarity in habitat requirements although they are rare in Japan and Australia respectively.

\+ rare in south-east Australia but illustrates the numbers supported with other plover species

Note: Golden Plover were previously associated with saltmarsh habitat that is now overgrown with mangroves and no longer roost at Penrhyn Estuary.

Figure 9: Aerial photo of Yatsu-higata (curtesy Koji Iura, Yatsu-hagata Nature Observation Centre)

Figure 10: part of Tokyo Bay Wild Bird Nature Park

Yatsu-higata is approximately 40 ha in size. However a 5 ha portion is isolated by an 8 to 10 lane freeway viaduct (see Figure 9) reducing the open area of wetlands to about 35 ha (the boxing effect of the 5 ha portion renders it useless as shorebird habitat). The open area at Yatsu-higata wetland is similar in size to the proposed configuration of Penrhyn Estuary. The open area at Yatsu is mainly mudflats (feeding habitat) whereas the open area at Penrhyn Estuary is approximately half mudflats, the other half comprising saltmarsh and seagrass).

Yatsu is surrounded by development on all sides including tall apartment blocks and a freeway viaduct and is situated approximately 1 km from the nearest open water.

Figure 11: Relative size of Yatsu-higata

6. Habitat Enhancement Criteria

The proposed mitigation measures for shorebirds at Penrhyn Estuary should be carried out incorporating the following:

* habitat enhancement involving the removal/excision of the sand dunes on the western side of Floodvale Drain as shown in Figures 12 and 13;

* placement of this sand in the mouth of Penrhyn Estuary to create additional intertidal flats and saltmarsh (as much of the remaining available area as possible) for shorebird feeding/roosting with preference for intertidal flats over saltmarsh;

* the intertidal flats should be designed such that they are inundated twice daily at high tide. The flats should have at least 50 mm of suitable material to encourage benthic food sources for shorebirds;

* the saltmarsh should be used as a buffer to activities around the estuary as shown in the proposed habitat enhancement plan (Figures 12 and 13);

* mangroves in the Estuary should be removed to prevent them from out-competing the saltmarsh and colonising the tidal flats;

* the public should be excluded from the Estuary to prevent disturbance to the birds however, a boardwalk and observation structure should be provided to allow easy and safe access to a vantage point allowing viewing of the Estuary and migratory shorebirds, this should include interpretative signage, litter control, security patrols etc;

* disabled access should be provided between public facilities near the boat ramp (car park and toilets) and the boardwalk and along the boardwalk and observation structure (width of boardwalk should enable pedestrians/wheelchairs to pass or by providing "passing bays");

* dogs should be excluded from the boardwalk

* a purpose built observation structure should be constructed providing a comfortable venue from which to observe birds in all weather conditions. This should include a roof and walls (with observation windows), bench seating and space for at least one wheelchair with viewing window;

* the Estuary should be screened from direct spill from lighting on the wharf area, from cranes and from vehicle headlights driving on the wharf area as well as entering and exiting the port;

* the Estuary should be screened from noise from within the port and access roads where necessary. Rail noise should be minimised;

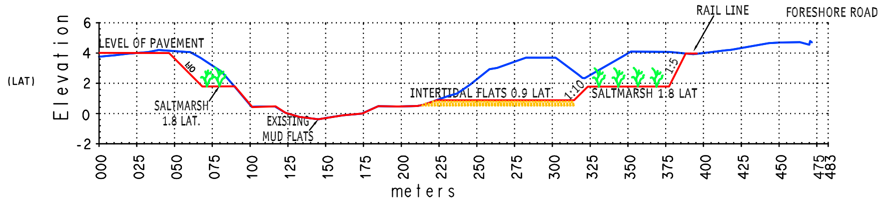
* bridges over the channel should be kept as low as possible to reduce the box-in effect of the site (shorebirds will fly over, not under, the bridge. Therefore clearance is not an issue);

* the construction phase of the port development should be managed to minimise disturbance to shorebirds; and

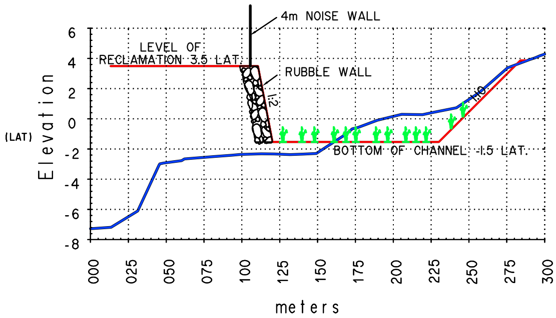
* the runoff from the port, roads and rail should be via an effective drainage system with appropriate pollution controls (oils, gross pollutants etc), especially in the case of chemical or oil spills.

Penrhyn Estuary Proposed Habitat Enhancement Plan

- Proposed Intertidal Sand/Mud Flats (area 11.0ha)
- Existing Mudflats To Be Retained (area 1.5ha)
- Proposed Saltmarsh Habitat (area 5.2ha including 0.6ha of existing mangroves to be removed)
- Existing Saltmarsh To Be Transplanted into Proposed Saltmarsh Habitat (area 0.35ha)
- Existing Saltmarsh To Be Retained (area 1.0ha)
- Existing Mangroves To Be Removed & Replaced With Saltmarsh Habitat
- Proposed Seagrass Habitat (area 8.1ha)
- Potential Opportunity For Sediment/litter Traps (subject to detailed assessment on drain hydraulics)
- Proposed Preferential Flow Channel
- Proposed Preferred Noise Wall Location (approx. 4m High)



LINE 1



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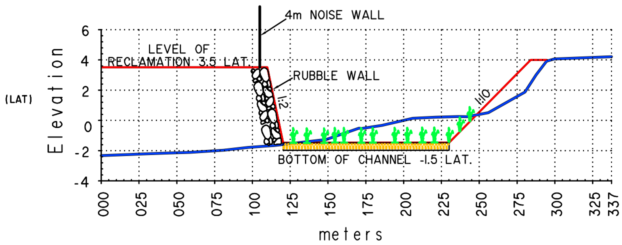

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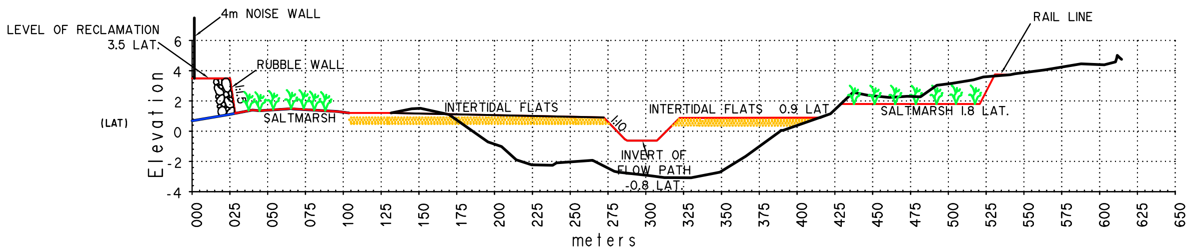

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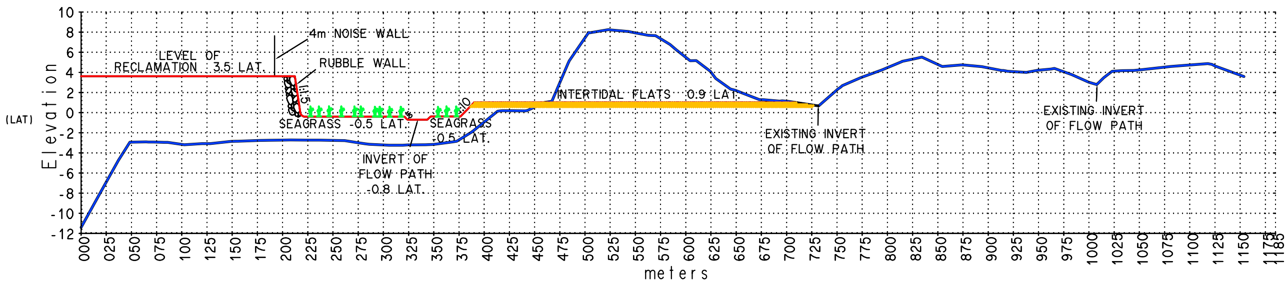

LINE 5

Vertical Exaggeration = 10x

All areas and measurements are approximations

Natural Surface

Proposed Development

Penrhyn Estuary Proposed Habitat Enhancement Cross Sections

7. Habitat Enhancement Description

The existing intertidal feeding habitat and roost sites used by migratory shorebirds at Penrhyn Estuary are proposed to be enhanced as part of the expansion of Port Botany. The key objective of this enhancement is to create a large open area with tidal flats for feeding & saltmarsh for roosting that will attract as many, and potentially a greater number of, migratory shorebirds than use the Estuary at present.

The proposed habitat enhancement incorporates the following elements:

* Provision of an Estuary of approximately 27 hectares (not including the area of the tidal channel).

* Retention of the existing 1.5 hectares of mudflats currently used by the migratory wader birds for feeding as shown in Figure 12.

* Removal / excision of sand dune on the western side of Floodvale Drain and placement of sand in the Estuary to create approximately 11 hectares of additional intertidal flats (ie. total intertidal flats of about 12.5 hectares) as shown in Figure 12.

* Retention and/or transplanting of existing saltmarsh and increase in area of saltmarsh to approximately 6 hectares for shorebird feeding/roosting. Saltmarsh is proposed to be located around the perimeter of the Estuary to form a buffer zone to the surrounding activities.

* Removal of mangroves currently present in the Estuary to prevent them from out-competing the saltmarsh and colonising the tidal flats.

* Access to be restricted to a pedestrian boardwalk and viewing platform extending a short distance into the Estuary. This will minimise disturbance of the migratory birds and damage to seagrass/saltmarsh.

* Opportunity to install coarse sediment and litter removal device at the inflow point of Floodvale and Springvale Drains to Penrhyn Estuary, subject to detail design.

* Creation of preferential flow path through the Estuary to minimise scouring and mobilisation of sediments during storm events (approximate location is shown in Figure 12).

This proposal is in accordance with the habitat enhancement criteria outlined in Section 6.

In addition to the above, it is also proposed to create up to 8 ha of seagrass habitat within the tidal channel and parts of the Estuary. The purpose of this is to provide sufficient seagrass habitat to compensate for the amount of seagrass being lost as a result of the proposed reclamation and to provide habitat for the colonisation of additional seagrass. There may be an opportunity to increase shorebird feeding habitat during low tides as part of the seagrass habitat creation.

The proposed noise barrier would be set back from the edge of the Estuary to minimise the boxing in effect but would still shield headlights from vehicles in the rail loading area.

In addition to the above components of the habitat enhancement, the substrate conditions and construction process need to be considered carefully as discussed below in section 7.1.

7.1 Substrate

7.1.1 Soils

To be successful the nature of the substrate of an enhanced estuary habitat should be similar to that of a functional wetland of the same or a similar nature at or near the site of the proposed constructed wetland. Considerations to be taken into account are particle sizes and composition of the soils, organic content and general chemistry. With an understanding of functions of shorebird habitat it is possible to recreate a wetland of similar function to a 'natural' wetland or even improve on it, especially if the existing site is degraded, as is the case with Penrhyn Estuary.

Substrate conditions directly affect plant growth, invertebrate colonization, and other factors. However many restoration projects are constructed using coarse-textured dredge spoil, beach sands or terrestrial soils, that may be very different from natural wetland soils and sediments. Created wetlands may have a series of soil deficiencies relating to coarse soil texture, low organic matter, and occasionally high acidity. This is likely to result in failure to achieve a comparable wetland to a natural site or a prolonged lead period before the wetland approaches the condition of a natural system. Soils from former wetlands will be more likely to be suitable for native species than soils at newly created sites. An alternative is to fabricate substrate soils using fine-grained material and add suitable organic material.

An analysis of existing soil conditions is needed before restoration begins, such as particle sizes and composition to help in designing the extended tidal mudflats. (see also invertebrate sampling). Penrhyn Estuary, despite levels of contamination in the substrate, provides a rich food source. The nature of the substrate at the existing site should be duplicated as close as possible in order to extend the area of feeding habitat. This will require a 'top dressing' of appropriate soils, as discussed above.

7.1.2 Organic content

One of the major compounding problems of coarse soils is that they do not accumulate organic matter rapidly compared with natural wetland soils. Coarse soils tend to be well drained and relatively aerobic. Under aerobic conditions decomposition rates are high and organic matter does not accumulate within the soil, even if organic matter production rates are similar.

An option at a constructed wetland site is to import fine material (top soil). A potential source of fine soil is a marsh that is being lost to development where soil would also incorporate roots, seeds, and invertebrates into the restoration site. At the Woolooware Shorebird Lagoon potential fines contained in terrestrial topsoils were stockpiled. The site was then over excavated and the topsoils used to back fill the site (Straw pers obs). If such soils were not available at Penrhyn Estuary they would need to be imported.

Choice of imported soils would be those excavated from a suitable wetland site elsewhere or dredge spoil if sufficient fines were present, and provided contaminants were minimal. If these sources are not available 'fabricated' topsoils may have to be investigated to which an appropriate source of organic material would have to be added.

Given the problems with coarse soil, clay and silt are obvious potential additives.

Sewage sludge is a possible additive. Many prime shorebird sites have been based on sewage sludge at sewage treatment facilities.

7.1.3 Invertebrate prey

Shorebirds at Penrhyn Estuary appear to rely heavily on bivalves and polychaete worms as a source of food. It is important to provide conditions to enable colonisation of the site by these animals. Providing the right substrate should enable eventual colonisation of the site by similar species to those already at the site. It may also be possible to speed up this process by introducing animals from other sites either by transporting soils containing invertebrates or by collecting invertebrates and releasing them into the compensatory habitat.

7.2. Construction Sequencing

The construction of shorebird habitat at Penrhyn Estuary will be achieved by excavating an area of sand dune adjacent to the estuary and partially filling an area of deep water to provide intertidal mudflats, saltmarsh habitat and seagrass beds, as shown in Figure 12.

Prior to works commencing the site should be secured to prevent access and for public safety. Construction should be commenced as soon as practicable to allow time for the site to become established and stabilised as early as possible.

The construction of the enhanced shorebird habitats may need to be carried out in stages and will depend on the time of the year construction is carried out. The first stage would most likely be the removal/excision of the sand dunes to the north of the Estuary and the filling of the deep areas behind the proposed development. Works should be carried out between late March and early August to correspond with the period when most migratory shorebirds are on migration or at their northern hemisphere breeding grounds. The upper reaches of the Estuary, including the existing mudflats, will be left relatively undisturbed to provide an area for shorebirds while the additional habitat is being prepared and stabilised.

The next stage should include the application of a layer of fine particulate and organic material to enable the rapid colonisation of invertebrates at the site. Dredged material from the Bay that may be unsuitable for terminal reclamation may suit benthic organisms. Otherwise soils may have to be manufactured to suit or sourced from other sites.

8. Management and Monitoring

The enhancement of shorebird habitat is a critical part of the long-term survival of a unique population of shorebirds in the Sydney region. The success of the project will depend on the skills of those involved in creating an area never attempted on such a scale in Australia, although there is a high level of confidence based on work done overseas, and smaller projects in Australia. Ongoing management and monitoring will be essential to the long-term success of the project.

The construction phase may take one or two years to complete in order to obtain the precise levels required to suit benthic fauna in tidal mudflats and the establishment of saltmarsh communities. Once excavation and levelling has been completed it will take several months for soils to settle and compact (Straw pers obs) but this depends on the nature of materials used to create the substrate. Only after this time will invertebrate populations start to colonise that suit the newly created substrate. The time it will take for invertebrate populations in the new substrate to approach the density and diversity levels of existing substrate at Penrhyn Estuary is hard to predict. However it has been found that three years is the minimum period for invertebrates to become established and that five years is more realistic as a minimum time period. Wetlands experts in overseas studies of restored wetlands suggest a monitoring period over a ten or twenty year period (Zedler 2001) although the frequency of monitoring (i.e. site visits) can be reduced over time.

Part of the management strategy for the site will be establishing a monitoring program that must take into consideration colonisation by benthic organisms, soil profiles, and the behaviour and population trends of migratory waders. These will indicate the success of the enhancement program. Site management can then be scheduled in order to make any adjustments necessary (i.e. organic content and composition of soils, final level profiling etc).

Management authority

The construction and establishment phase of the enhanced habitats will be the responsibility of Sydney Ports Corporation but as the site becomes established it will be necessary for one or more authorities to take on the long-term management of the site with the commitment of the necessary resources. Responsibilities include securing the site from disturbance or damage, weed management of invasive species (i.e. mangrove invasion), pest control including potential bird hazard species, predators such as foxes and dogs and public education.

Management of the site will be a specialised activity that is outside the normal management programs of the authorities involved. For this reason a management committee may be required involving various management authorities as well as specialists in marine and avian fields. This may include NSW NPWS, NSW Fisheries and various neighbours and stakeholders such as Botany Council, Sydney Coastal Councils, bird interest groups and appointed marine and avian specialists.

It is essential that ecologists, engineers, management and site owners should remain in contact over the construction and establishment phase of the project. Management issues should be reported and addressed early to maximise the effectiveness of the site as shorebird habitat.

9. Conclusions and Recommendations

In order to compensate for potential impacts to migratory shorebirds listed as Threatened under the TSC Act and/or international agreements as a result of the proposed expansion of Port Botany facilities, Sydney Ports Corporation plan to carry out ameliorative measures to protect and enhance shorebirds and their habitat at Penrhyn Estuary by substantially enlarging the existing area of feeding and roosting habitat as well as securing the site from disturbance from people, dogs and vehicles and shielding the estuary as far as practicable from the impact of port operations.

Studies have shown that in similar situations overseas viable shorebird habitat can be maintained within an enclosed, artificially maintained site.

Recommendations

In order to ensure the long-term viability of the shorebird populations at Penrhyn Estuary it is recommended that:

* Work should be carried out as soon as possible to create the expanded shorebird habitat to allow the newly created tidal flats and saltmarsh time to evolve well before the operation phase of the expanded port;
* the area of estuarine habitat should be enhanced and extended as far as possible;
* appropriate substrate should be imported or manufactured to provide optimal feeding habitat for migratory shorebirds;
* construction of the enhanced shorebird habitat should be carried out in a way to minimise the impact on shorebirds currently using the Estuary eg construction during winter and not impacting existing mudflat areas;
* a boardwalk and all-weather observation structure should be provided to enable people to observe migratory shorebirds without disturbing the birds;
* the area is secured with an exclusion fence to prevent disturbance of the estuary by people and dogs with the exception of public facilities, such as a boardwalk, viewing area, interpretative signage;
* dogs should be excluded from the boardwalk and observation areas;
* noise at the Estuary should be minimised, for example trains should not use whistles/horns while near the Estuary;
* opaque barriers 2m high should be constructed to prevent headlights from shining into the estuary at night;
* barriers to headlights of trucks entering the proposed road bridge

should be constructed;

* a plan of management be prepared to ensure the long-term protection and viability of the shorebirds and their habitat at Penrhyn Estuary;

* authorities responsible for the long-term management of the site should be identified at an early stage to allow for a plan of management, including the need for ongoing resources to be identified prior to the completion of the site construction or immediately after; and

* the measures outlined in Bassett (2002) to mitigate light spill should be implemented.

References

Anon (undated). "Welcome to Yatsuhigata (tidal flat)" Information booklet provided by Yatsuhigata Nature Observation Center.

Bassett Consulting Engineers (2002). Proposed Port Botany Expansion Third Container Terminal Lighting Environmental Effects. Report to Sydney Ports Corporation.

Evans, P.R., Ward, R.M., Bone, M. & Leakey, M. (1999). The Creation of Temperate-Climate Intertidal Mudflats: Factors Affecting Colonisation and Use of Benthic Invertebrates and their Bird Predators. *Marine Pollution Bulletin.*

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Maunsell Australia Pty Ltd (2002) Traffic and Landside Transport Study for Proposed Port Botany Expansion. Prepared for Sydney Ports Corporation.

Straw, P. (2002) (in press). Habitat Restoration - Trials, Tribulations and Successes. In: *Status and Management of Migratory Shorebirds in Sydney*. Sydney Olympic Park Authority & NSW Wader Study Group (special publication)

Smith, P. (1991). The Biology and Management of Waders (Suborder Charadrii) in NSW. National Parks and Wildlife Service.

Watkins, D. (1993). A National Plan for Shorebird Conservation in Australia. Australasian Wader Studies Group, Royal Australasian Ornithologists Union and World Wide Fund for Nature.

Wilkinson Murray Pty Ltd (2002). Port Botany Container Terminal Expansion Noise Assessment. Report to Sydney Ports Corporation

Zedler, J.B. (Ed.) (2001). Handbook for Restoring Tidal Wetlands, CRC Press, Florida.

APPENDIX A

Curriculum Vitae

PHILIP STRAW

Consultant Avian Ecologist
Avifauna Research & Services

ABN 13 004 890 690
P.O. Box 2006, Rockdale Delivery Centre
ROCKDALE NSW 2216

NAME: Philip John Straw

QUALIFICATIONS

Bachelor of Applied Science (Charles Sturt University)

PROFESSIONAL AFFILIATIONS

- Royal Australasian Ornithologists Union
- European Ornithologists' Union
- British Ornithologists Union
- Australian Bird Studies Association
- Australian Wildlife Management Society
- Australasian Wader Studies Group (Vice Chair)
- Australian Seabird Group
- Birds Australia Parrot Association
- Coast and Wetlands Society
- Ecological Consultants Association of NSW
- British Trust for Ornithology
- Duck Specialist Group of IUCN
- Swan Specialist Group of IUCN
- Waterbirds Society
- International Wader Study Group

FIELDS OF EXPERTISE

- Avian Ecology
- Wetlands Habitat Restoration
- Wetlands Habitat Design and Construction
- Environmental Impact Assessment
- Fauna Habitat Assessment
- Bird Hazard Management
- Coordination of community based bird studies

PROFESSIONAL EXPERIENCE

1992-2003	Principal - Avifauna Research Services Environmental management assessment, specialising in wetlands and waterbird habitat restoration, design and construction.
1991	Sydney Water Board - Natural Resource Projects Coordinator. Coordination of bushland and wetlands restoration projects.

1988-91	National Parks and Wildlife Service - Senior Technical Officer. Wildlife management issues including population dynamics and environmental concerns relating to the Silver Gull (contract for Waste Service NSW and Sydney Water)
1978-87	Director, Co-ordinated Sports and Adventure Pty Ltd. Underwater instruction of sport and research divers. Underwater survey and equipment design.
1971-77	NSW Fisheries - Senior Technical Officer. Assessment of marine areas for the establishment of marine parks and artificial reefs sites
1967-70	Queensland University – Field Officer Marine surveys, including Crown-of-Thorns starfish. Collection and preparation of marine animals for university students and researchers.
1965-66	Royal Society for the Protection of Birds – Field Officer. Wetlands Management including the construction of shorebird nesting and feeding habitat and maintenance of visitor facilities at Minsmere Nature Reserve.
1964-65	Edward Grey Institute of Field Ornithology, University of Oxford – Field Ornithologist. Field studies of the breeding biology of woodland birds.
1960-64	Ornithological Research Laboratory, Station Biologique de la Tour du Valat, France – Manager. Trapping and banding of migratory birds, wildfowl studies. Conservation of the Greater Flamingo including predator control and nest site restoration.
1963	Trinity College East Greenland Expedition – Ornithologist. Studies of Arctic breeding birds including shorebirds, seabirds and waterbirds.
1960	Bardsey Island Field Station and Bird Observatory, Wales. – Warden. Studies of migratory birds and breeding seabirds. Maintenance of facilities for visitors.
1959	Gibraltar Point Bird Observatory and Field Centre, England – Assistant Warden. Assisting with the trapping and banding of migratory birds and maintenance of the facilities for visitors and researchers.

FAUNA ASSESSMENT AND MANAGEMENT PROJECTS

Habitat construction, restoration and management

Flora and Fauna Assessment (eight part test) for Stages 1 & 2 of the Multi-Use Recreational Pathway, Woolooware Bay
Sutherland Shire Council

Assessment of shorebird habitat in a developed environment in Japan. Shorebird habitat usage assessment and impacts of development in Tokyo Bay, Nagoya, Tokushima, Fukuoka, Okinawa and Hokkaido. Reports to Sydney Ports Corporation and the Japan Alliance for Wetlands Action Network.

Migratory Waders Study at Sydney Olympic Park and the Parramatta River Estuary
Sydney Olympic Park Authority

Investigation of options for the construction of compensatory habitat to compensate for the loss of habitat for migratory waders at Eve Street Wetlands, Arncliffe, as a result of the construction of the M5 East Motorway.
Roads and Traffic Authority.

Investigation of migratory and non-migratory wader habitat in the Hunter River estuary and recommendations for the construction of compensatory habitat.
NSW National Parks and Wildlife Service

Plan of Management Assessment and Recommendations (Avifauna) for Pourmalong

(wetlands) Nature Reserve.

NSW National Parks and Wildlife Service.

Projects coordinator Homebush Bay Olympic Parklands.
Assessment of the impacts of the construction and remediation of wetland habitats at Homebush Bay.
Recommendations for design of aquatic habitats and establishment of wetland vegetation communities.
Olympic Co-ordination Authority (1992-1999)

Eve Street Wetland relocation and remediation design and 8 part test for Eve Street Wetlands. Potential impacts of the construction of the M5 East Motorway
Roads and Transport Authority

Avifauna study for Plan of Management for Mason Park Wetland.
Urban Bushland Management

Report to the Federal Airports Corporation. Relocation of Little Terns, A Feasibility Study and Management Options.

NSW National Parks and Wildlife Service.

Relocation of shorebirds, feasibility study. Field Assessment and Report to the Federal Airports Corporation
Royal Australasian Ornithologists Union

Field Study and Report on the options for management of avifauna at Botany Wetlands.
Sydney Water Board.

Field Study and Report on the management options for avifauna at Eve Street Wetland, Arncliffe.
Sydney Water Board.

Bird Hazard Management

Proposed Port Botany Expansion Bird Hazards to Aircraft Assessment.
Sydney Ports Corporation

Bird Assessment for the Proposed Foreshore Beach boat ramp. Identification of mitigative measures (if required) to minimise potential impacts of birds at Sydney Airport.
Sydney Ports Corporation

Bird Hazard Management. Review of current practices and recommendations for future management strategies at Sydney Airport.
Federal Airports Corporation

Management of Waterbirds at the Engine Ponds, Sydney Airport. Assessment of waterbird populations and recommended aquatic vegetation management.
Federal Airports Corporation

The Silver Gull. Populations dynamics in relation to impacts of Silver Gull Populations at Prospect Reservoir and waste disposal sites in New South Wales. Three year study.
National Parks and Wildlife Service, for NSW Waster Services and Sydney Water.

Landscape management for avifauna

Land management development recommendations including landscaping for native bird species
Royal Sydney Golf Club

Land management development recommendations including landscaping
for native bird species
The Australian Golf Club

Fauna and Flora Assessment

Bird Hazard Assessment for EIS for Proposed Port Botany Expansion
Sydney Ports Corporation

Peer Review of Port Botany Expansion EIS - Terrestrial Ecology (avifauna)
Sydney Ports Corporation/URS

Species Impact Statement for proposed recreational development at Picnic Point, The Entrance.
Wyong Shire Council

Terrace Tower Holdings vs Sutherland Shire Council. Development application, Bulky Goods Retail Application, Taren Point. Statement in Evidence, Statements in Reply and Court appearances as expert witness, environmental issues.
Sutherland Shire Council

Silverwater Estate v. Department of Land and Water Conservation. Development application, Duck River, Silverwater. Impact Assessment on the Avifauna and recommendations evidence prepared for the Land and Environment Court.
Department of Land and Water Conservation

Fauna and Flora Assessment Wolli Creek
Roads and Traffic Authority

Fauna and Flora Assessment H1 Lands, Kurnell
Roads and Traffic Authority

Species Impact Assessment (Avifauna), Hunter Lakes Resort, Richmondvale
Conacher Travers

Eight-part test for siting of ferry wharf, Kissing Point, Parramatta River.
NSW Department of Transport

Eight-part test for maintenance dredging of boat access channel, Shell Point, Botany Bay.
St George and Sutherland Anglers Club

Impact assessment of maintenance dredging of Sylvania Waters Canal Estate.
Fielders Engineers

Species impact study and 8-part test for Saltpan Creek M5 bridge.

Roads and Transport Authority

Avifauna study, Cabramatta Creek remediation project.
Cabramatta Council/ Sainty and Associates

Avifauna survey and population assessment Penrith Wetlands.
Sainty and Associates/Penrith Council

Assessment of the potential impact of possible bridge construction on avifauna habitat at various sites at Duck River, Camelia.
Manidis Roberts P/L

Fauna survey and impact assessment Saltpan Creek M5 East Motorway crossing.
Sainty and Associates

Avifauna survey and environmental threats assessment Hawkesbury Wetlands.
NSW National Parks and Wildlife Service

Avifauna assessment and impact study Brays Bay Mangrove Walk
Concord Council

Study of potential impact of proposed water releases via the Wingecarribee River on waterbird populations.
Sydney Water Board.

Filming sequence - potential impact on nesting birds; study and report.
NSW National Parks and Wildlife Service.

Potential Impact Study of Curl Curl Lagoon and Greendale Creek Rehabilitation Program on Bird Populations.
Antcliff Ecological Surveys/Warringah Shire Council.

Effect of minor flooding on the waterbird population of the Warrego/Cuttaburra Catchments, Bourke.
Warrego River System Water Users Association.

Initial study of the impact of upstream water allocation on waterbird habitat.
Warrego River System Water Users Association.

Assessment of habitat construction for waders and Little Terns, Botany Bay, for Environment Impact Statement.
Dames and Moore

Plan of management of Botany Wetlands, aquatic avifauna study.
GHD Pty Ltd/Sydney Water Board.

Wading Birds of Hen and Chicken Bay, Potential Impact of Constructions on the Intertidal Foreshore
Concord Council.

Assessment of seabird populations of Botany Bay for Bulk Liquids Berth,

Environmental Impact Study.
Mitchell McCotter.

Special Report. The potential impact of varying water levels on avifauna in the Glenquarry Cut catchment.
Sydney Water Board.

Study and Special Report. The effect of trial water releases on waterbirds in the Wingecarribee catchment.
Sydney Water Board.

Wader monitoring study to determine impact of the parallel runway construction on waders in Botany Bay.
Federal Airports Corporation/Royal Australasian Ornithologists Union

Avifauna species or population studies

Migratory wader population assessment of the Parramatta estuary, data collection and GIS mapping of feeding and roosting habitat.
Sydney Olympic Park Authority

Oil Spill Response Atlas, GIS mapping and database update of seabirds and waterbirds feeding, roosting and nesting habitat.
NSW National Parks and Wildlife Service for Department of Transport

Waterbird survey of the Warrego/Cuttaburra floodplain, involving ground and aerial surveys.
Warrego River Water Users Association

Botany Bay Wader Monitoring and Habitat Remediation Project
Federal Airports Corporation/RAOU (1992-1995)

Bird survey of estuaries, coastal wetlands, beaches and headlands of north-eastern NSW.
NSW National Parks and Wildlife Service (Environmental Audit).

Silver Gull population study - cannon-netting and banding project. Forster/Seal Rocks.
NSW National Parks and Wildlife Service, Hurstville.

Avifauna study (part 2, woodland birds) of Homebush Bay and habitat assessment for Homebush Bay Renewal Program. Twelve month Study.
Property Services Group.

Waterbird study of Homebush Bay and habitat assessment for the Homebush Bay Renewal Program.
Property Services Group/Royal Australasian Ornithologists Union

Appendix H

Field Proforma Data Sheets

URS Proforma Field Data Sheet (Vegetation Surveys – Random Meander)

Page 1

LOCATION

Site/Plot No. : 1

Mapsheet: Syd

AMG reference: 334312 ; 6240727

Date of survey: 27.7.02

Assessor: IKM

Air photo run: BOTANY BAY.

BIOPHYSICAL INFORMATION:

Size of stand (ha): 400 m² plot

Soils: clay loam sand silt laterite dredged marine sand

Geology:

Landform: flat undulating hilly steep

Slope position: ridgetop upper mid lower level

Aspect: N S E W

Vegetative Structure(after Specht): shrubland

Dominant Tree height: 7m

Projective Foliage Cover: 10%

Diameter Dominant Trees (cm): 40

No. age classes: 2

Tree density: sparse moderate dense

Shrub layer density: sparse moderate dense

Shrub height (m): 4

Groundcover density: sparse

Groundcover height (m): 10cm

MANAGEMENT INFORMATION

Catchment: upper mid lower floodplain

Surrounding landuses: residential rural bushland pasture Port Botany; Airport; Bay

Corridors:

Distance to other remnants: Sir Joseph Banks Park northern side Foreshore Rd.

Soil erosion: minor moderate severe steep drop off from beach

Roads and tracks: none minimal <u>moderate</u> extensive some tracks

Page 2

Watercourses/ponds:

Weeds: none minor <u>moderate</u> → <u>infested</u>

Fire history: Nil.

Health of vegetation: no issues.

Vegetation disturbance level: undisturbed partially cleared understorey disturbed canopy and understorey disturbed weed infestation in patches.

Extent of natural regeneration: <u>low</u> → <u>moderate</u> high

Other comments:

Planted shrubland by Waterways Authority for beach stabilisation in 1970s.
Most taxa indigenous to represent remnant Coastal Dune <u>Heath</u>.

Floristic List (page 3)

Growth Form Key:

T=tree	Small tree= ST
S=shrub	Climber=C
L=low shrub	Fern=F
G=grass	Aquatic=Aq
Se=sedge/rush	
H=herb	

Species	Growth Form	Comments
Banksia integrifolia		
Leptospermum laevigatum		
Acacia longifolia		
Melaleuca ericifolia		
Bitou Bush		
Banksia serrata		
Lantana		
Melinus repens		
Acacia saligna		
Hydrocotyle bonariensis		
Dodonea triquetra		
Plantago lanceolata		

URS Proforma Field Data Sheet (Vegetation Surveys – Random Meander)

Page 1

LOCATION

Site/Plot No. : 2

Mapsheet: syd

AMG reference: 333514 ; 6241213

Date of survey: 27.7.02

Assessor: 14M

Air photo run: BOTANY BAY

BIOPHYSICAL INFORMATION:

Size of stand (ha): 400 m² plot

Soils: clay loam sand silt laterite dredged marine sand

Geology:

Landform: flat undulating hilly steep

Slope position: ridgetop upper mid lower level

Aspect: N S E W

Vegetative Structure(after Specht): shrubland

Dominant Tree height: 6m

Projective Foliage Cover: 10 - 15 %

Diameter Dominant Trees (cm): 30 - 40

No. age classes: 2

Tree density: sparse moderate dense

Shrub layer density: sparse moderate dense

Shrub height (m): 3 - 4

Groundcover density: sparse

Groundcover height (m): 10 cm

MANAGEMENT INFORMATION

Catchment: upper mid lower floodplain

Surrounding landuses: residential rural bushland pasture Port Botany; Airport; E

Corridors:

Distance to other remnants: Sir Joseph Banks Park, northern end Foreshore Rd.

Soil erosion: minor moderate severe steep drop off from end of beach.

Roads and tracks: none minimal moderate extensive some tracks

Page 2

Watercourses/ponds:

Weeds: none minor moderate → infested

Fire history: –

Health of vegetation: no issues

Vegetation disturbance level: undisturbed partially cleared understorey disturbed canopy and understorey disturbed some weed infestation

Extent of natural regeneration: low moderate high

Other comments:

Planted shrubland

Some indigenous trees representing Coastal Dune Heath

Floristic List (page 3)

Growth Form Key:

T=tree
S=shrub
L=low shrub
G=grass
Se=sedge/rush
H=herb

Small tree= ST
Climber=C
Fern=F
Aquatic=Aq

Species	Growth Form	Comments
Leptospermum laevigatum		
Banksia integrifolia		
Banksia serrata		
Dodonea triquetra		
Bitou Bush		
Lantana		
Melaleuca armillaris		
" ericifolia		
Acacia longifolia var. longifolia		
" " " sophorae		
Allocasuarina littoralis		
Spinifex sericeus		
Cakile edentula		
" maritima		
Atriplex sp.		
Hydrocotyle bonariensis		
Acetosa sagittata		

URS Proforma Field Data Sheet (Vegetation Surveys – Random Meander)

Page 1

LOCATION

Site/Plot No. : 3

Mapsheet: syd

AMG reference: 334815 ; 6240400

Date of survey: 334738 ; 6240466 27.7.02

Assessor: IKM

Air photo run: BOTANY BAY.

BIOPHYSICAL INFORMATION:

Size of stand (ha): ~ 110 m line

Soils: clay loam sand silt laterite sand ; muddy sand ; mud

Geology:

Landform: flat → undulating → hilly steep

Slope position: ridgetop upper mid lower level

Aspect: N S E W

Vegetative Structure(after Specht): Herbland \ Low shrubland (subshrubs)

Dominant Tree height:

Projective Foliage Cover:

Diameter Dominant Trees (cm):

No. age classes:

Tree density: sparse moderate dense

Shrub layer density: sparse moderate dense

Shrub height (m): 100 cm

Groundcover density: sparse → dense patchy

Groundcover height (m): 30 cm.

MANAGEMENT INFORMATION

Catchment: upper mid lower floodplain

Surrounding landuses: residential rural bushland pasture

Corridors:

Distance to other remnants: Planted shrubland along Foreshore Beach

Soil erosion: minor moderate severe

Roads and tracks: none minimal moderate extensive

Watercourses/ponds: ✓ estuary – 2 deltas from Springvale / Floodvale.

Weeds: none minor moderate infested

Fire history: –

Health of vegetation:

Vegetation disturbance level: undisturbed partially cleared understorey disturbed canopy and understorey disturbed

Extent of natural regeneration: low moderate high

Other comments:

mangrove encroachment into mid – upper intertidal

Floristic List (page 3)

Growth Form Key:

T=tree	Small tree= ST
S=shrub	Climber=C
L=low shrub	Fern=F
G=grass	Aquatic=Aq
Se=sedge/rush	
H=herb	

Species	Growth Form	Comments
Sarcocornia sp.		
Suaeda sp.		
Sporobolus virginicus		
Avicennia marina		
Wilsonia sp.		
Juncus kraussii		
Isolepis nodosa		

URS Proforma Field Data Sheet (Vegetation Surveys – Random Meander)

Page 1

LOCATION

Site/Plot No. : 4

Mapsheet: 57 d

AMG reference: 334825 ; 6240405

Date of survey: 334954 ; 6240526 27.7.02

Assessor: I+M

Air photo run: BOTANY BAY.

BIOPHYSICAL INFORMATION:

Size of stand (ha): ~ 100m line

Soils: clay loam sand silt laterite sand; muddy sand

Geology:

Landform: flat undulating hilly steep

Slope position: ridgetop upper mid lower level

Aspect: N S E W

Vegetative Structure(after Specht): heathland / rushland

Dominant Tree height:

Projective Foliage Cover:

Diameter Dominant Trees (cm):

No. age classes:

Tree density: sparse moderate dense

Shrub layer density: sparse moderate dense subshrub

Shrub height (m): 80 cm

Groundcover density: sparse → dense

Groundcover height (m): 50 cm.

MANAGEMENT INFORMATION

Catchment: upper mid lower floodplain

Surrounding landuses: residential rural bushland pasture

Corridors:

Distance to other remnants: Foreshore Beach shrubland.

Soil erosion: minor moderate severe

Roads and tracks: none minimal moderate extensive

Page 2

Watercourses/ponds: estuary deltas. (inner)

Weeds: none minor moderate infested

Fire history:

Health of vegetation:

Vegetation disturbance level: undisturbed partially cleared understorey disturbed canopy and understorey disturbed

Extent of natural regeneration: low ⇒ moderate high

Other comments:

mangrove encroachment into mid-upper intertidal.

Floristic List (page 3)

Growth Form Key:

T=tree
S=shrub
L=low shrub
G=grass
Se=sedge/rush
H=herb

Small tree= ST
Climber=C
Fern=F
Aquatic=Aq

Species	Growth Form	Comments
Sarcocornia sp.		
Suaeda sp.		
Sporobolus virginicus		
Isolepis nodosa		
Juncus kraussii		
Wilsonia backhousei *		
Avicennia marina		

Appendix I
Curricula Vitae

Isaac Mamott

Senior Ecologist

CURRICULUM VITAE

Areas of Expertise

- Flora and Fauna Survey and Assessment
- Flora and Fauna Management Plans
- Site Rehabilitation

Education

York University, Toronto, Canada, Bachelor of Science (Earth and Biological Science) 1989

York University, Toronto, Canada, Bachelor of Arts (Economics) 1994

Career Summary

Isaac Mamott has 7 years ecological consulting experience in Australia, with an emphasis on the planning, management and conduct of terrestrial flora and fauna survey and assessments (general and targeted) as part of Biodiversity Surveys (National Parks Estate), Environmental Impact Statements (EISs), Species Impact Statements (SISs) and other Environmental Impact Assessments (EIA) documentation.

Isaac has 5 years (part time) public sector ecological experience in Ontario Canada where he assisted in the conduct of baseline vegetation surveys and the implementation of a pilot recycling program within Ontario's Provincial Park estate as a part time Natural Resource Officer for the Ontario Ministry of Natural Resources. Isaac undertook this position during his undergraduate university years.

Isaac has gained extensive experience in designing, planning and directing site rehabilitation programs in a variety of ecosystems, including wet and dry coastal forest, wet and dry heath, wetlands, and mallee. Experience in this area includes development of site specific rehabilitation methods and plans, site preparation and species selection, supervision of earthmoving operations, local provenance seed collection programs, site stabilisation and seedling establishment, weed management programs and completion criteria design, assessment and reporting.

Career Detail

- Vegetation assesement of plant communities within 860 km^2 Kangaroo River Valley Catchment as part the preparation of Kangaroo River Valley Wastewater Survey. Report prepared for the Sydney Catchment Authority, November 2002.
- Preparation of Draft Species Impact Statement (to date) for proposed Port Botany Expansion EIS for Sydney Ports Corporation. SIS involved baseline vegetation surveys and mapping of coastal dune heath and saltmarsh and focused on reconfiguration of Penrhyn estuary to enhance existing shorebird habitat as a mitigative measure. The Draft SIS was prepared in close consultation with shorebird expert, Phi Straw (Avifauna Reasearch) (in prog.).
- Preliminary flora and fauna survey and assessment of Shanes Park Airservices Australia Radiotransmitter Station, Llandilo, (c. 560 hectares) as part of preparation of an updated Environmental Management Plan. Threatened Castlereagh Woodland complex and plant taxa were addressed in preliminary study.
- Baseline and targeted vegetation survey and mapping and fauna habitat assessment of Coastal Dune Heath (wet and dry), Sydney Sandstone Ridgetop Woodland, and Mallee, for proposed expansion of the Kimbriki Tip site, Terrey Hills, NSW. Report prepared as part of an Opportunities and Constraints Study for SHOROC, November 2002.
- Baseline and targeted vegetation survey and mapping and assessment of 400 hectares of Moorebank Defence Lands for possible site redevelopment. Report prepared for Department of Defence and GHD Group (formerly Egis Consulting), August 2002. Several Threatened taxa and plant communities addressed.

- Provision of advice in relation to ecological constraints for possible site redevelopment of the 416 hectare Thrumster Council lands, Port Macquarie, NSW. Report prepared for Hastings Council, October 2002
- Baseline flora and fauna survey and assessment and mapping of a proposed 26 km transmission line easement proposed by Transgrid, Molong – Manildra, NSW, October 2001. Threatened plant communities (White Box – Yellow Box – Blakely's Red Gum Woodlands) and regionally significant woodland birds were addressed. Project also involved the preparation of a Flora and Fauna Management Plan (FFMP) detailing site rehabilitation measures proposed. FFMP for
Stage 1 prepared in October 2002.
- Baseline flora and fauna survey and assessment of the 300 hectare former Ingleburn Army Camp site at Ingleburn, NSW, as part of Opportunities and Constraints study for the site. Report prepared for Department of Defence and GHD Group, August 2002. Threatened plant communities addressed included one of the largest tracts of Cumberland Plain Woodland and Sydney Coastal River Flat Forest.
- Baseline and targeted vegetation survey, mapping and assessment of the southern-most extent of Duffys Forest at North Seaforth, as part of an Opportunities and Constraints study for site redevelopment. Report also addressed other Threatened and rare plant taxa recorded on the site. Report prepared for LesryK Environmental Consultants and GHD Group (formerly Egis) on behalf of RTA, planningNSW, March 2002.
- Flora survey, vegetation mapping and impact assessment of Threatened Shale/Sandstone Transition Forest on the Upper Nepean River, Maldon, NSW, for proposed optical fibre cable works. Preliminary report prepared for Telstra, May 2002.
- Vegetation Survey and Mapping of sections of Lane Cove River National Park (Blackbutt Creek, West Killara and Kissing Point Rd aqueduct, South Turramurra), for proposed aqueduct and access track maintenance. Report prepared for NSW NPWS and LesryK Environmental Consultants, March 2001. Numerous Threatened taxa addressed. Post construction site rehabilitation issues were also addressed.
- Vegetation Survey and Mapping of sections of Ku-ring-gai Chase National Park at Kilkari, for proposed sewage scheme. Report prepared for NSW NPWS and LesryK Environmental Consultants, July 2001. Numerous Threatened taxa addressed. Post construction site rehabilitation issues were also addressed.
- Baseline and targeted flora and fauna survey, mapping and assessment of freehold lands at Wingham, NSW, for a proposed Senior Citizens Village Estate, July 2001, Wingham, NSW. Report prepared for Manning Valley Senior Citizens Homes. Studies addressed numerous dry and wet plant communities and a local Koala corridor.
- Technical Peer Review of ecological reports prepared by Dr Stephen Ambrose (Ambecol) for Parramatta-Chatswood Rail Link EIS, Oct 2001. Report prepared for Blake Dawson Waldron.
- Preparation of on-site Constructed (artificial) Wetland Management Plan detailing design, species selection, planting and monitoring protocol, Botany, NSW for a groundwater treatment scheme. Report prepared for Orica, January 2001;
- Flora survey, mapping and assessment of remnant Callitris and White Box Grassy Woodlands and River Red Gum Forest (c.300 ha.) surrounding Western Plains Zoo, Dubbo, NSW, as part of an Opportunities and Constraints study for possible zoo expansion. Report prepared for Lesryk Environmental Consultants on behalf of the Zoological parks Board of NSW, January 2001.

- Baseline and targeted flora and fauna survey and assessment and mapping of roadside vegetation of 40 km segment of Lachlan Valley Way between Yass and Boorowa, for proposed pavement rehabilitation and widening works. Baseline surveys were subsequently augmented with targeted searches for a number of Threatened bats and a Threatened Moth. The assessment report addressed large tracts of the Threatened Yellow Box – Blakely's Red Gum plant community. Report prepared for the RTA, January 2001.
- Flora survey, mapping and assessment and fauna habitat assessment of roadside vegetation along c. 100 km of roads within Kosciusko National Park (Elliott Way, unnamed road to Guthega, Olson's Lookout Road, Cabramurra Road) as part of a park-wide Engineering (Geotechnical) Risk Assessment program. Plant communities addressed included Wet Montane Forest, Dry Sclerophyll Forest, Subalpine and Savannah Woodland. Report prepared for NSW NPWS, June 2001. Numerous Threatened flora and fauna species were addressed in the report.
- Flora and fauna survey and assessment of riparian vegetation along lower Hunter River between Raymond Terrace and Maitland for Department of Public Works and Services, Feb. 2000 as part of levee bank restoration program. Site rehabilitation advice including noxious weed control, site stabilisation, species selection and planting protocols were also addressed in the report.
- Baseline flora and fauna survey and assessment of Brigalow woodland on former mining lease lands as part of an EIS for proposed charcoal processing plant facility. Report prepared for Rio Tinto, April 2000.
- Baseline and targeted flora and fauna surveys and vegetation mapping of old growth wet montane forest in sections of the upper Geehi River Valley in Kosciusko National Park for proposed aqueduct stabilisation works. Report prepare for NSW NPWS and Snowy Mountains Authority, August 2000. Preparation of a Vegetation Management Plan detailing site rehabilitation and monitoring measures post engineering works was also prepared.
- Flora and Fauna survey and assessment of Dry Tallowood Forest for proposed water treatment plant, prepared for Department of Public Works and Services, Wauchope, NSW, 1999. Several Threatened species addressed in project.
- Baseline and targeted species survey and assessment of Dry Sclerophyll Forest and Swamp Sclerophyll Forest of lands off Violet Town Road, Tingira Heights, Lake Macquarie, for proposed residential subdivision.. Report prepared for County Property Group, 1999. Study addressed numerous Threatened species including *Diuris praecox, Tetratheca juncea,* Brush-tailed phascogale and Squirrel Glider.
- Technical Peer Review of terrestrial ecology studies undertaken by Biosis as part of EIS investigations for proposed Naval Ammunitions Depot, Two-fold Bay. Eden, NSW, October 1999.
- Species Impact Statement (SIS) for Yelgun-Chinderah Pacific Highway Bypass prepared for Sinclair Knight Merz and RTA. Baseline flora and fauna studies addressed a number of SEPP 14 wetlands and Threatened species, July 1998. Study also addressed post construction site rehabilitation measures along the route alignment.
- Baseline flora and fauna survey and assessment of Dry Sclerophyll Forest and Hanging Swamps on the Newnes plateau, for proposed dewatering program. Report assessed the effects of a changing hydrological regime on downstream forest and swamp habitats. Report prepared for Springvale Coal Pty Ltd, Newnes Plateau, Lithgow, NSW 1997
- Technical Peer Review of terrestrial ecology studies of the ADI site at St Marys undertaken as part of a Due Diligence program for site redevelopment. Report prepared for Blake Dawson Waldron and Baring Brothers Burrows, June 1997.

- Baseline and targeted flora and fauna survey and assessment of roadside sclerophyll woodland for a proposed 20 km Transmission Line Easement from Orange to Cadia mine site. Report prepared for Advance Energy, Orange, NSW 1996. Site rehabilitation including compensatory planting programs were also addressed in the report.
- Technical Peer review for a range of environmental studies undertaken as part of EIS investigations for a proposed boat harbour/marina and residential development, prepared for Walker Engineering Pty Ltd, Shellharbour, NSW 1995. Project included a peer review of terrestrial ecology studies of a SEPP 14 wetland and establishment of compensatory wetlands at Shadforth.

Professional History

URS Australia Pty Ltd (formerly AGC Woodward-Clyde Pty Limited), Senior Ecologist, 1995–Present
Mitchell McCotter & Associates, Contract Environmental Scientist, 1991
Ontario Ministry of Natural Resources – Provincial Parks Branch, Natural Resource Officer (permanent part-time during Uni), 1986-1990

Training

Several professional and amateur workshops and courses (in house and external) for plant identification, bush regeneration, shorebird identification, Ultrasonic (Anabat) Bat detection, GIS mapping, multi-variate statistical analysis (PATN)

Sophy Townsend

Environmental Scientist

CURRICULUM VITAE

Areas of Expertise

- Marine and terrestrial ecology.
- Flora survey and assessment.
- Environmental Planning/ Assessment

Education

University of Wollongong, Bachelor of Environmental Science, Honours Class II Division I, 1997-2000

Career Summary

Sophy has had 2 years experience as a consultant with URS with experience in environmental impact assessment and flora and fauna assessment. Projects have included Statement of Environmental Effects, Review of Environmental Factors, Fatal Flaw Analysis, Environmental Impact Statements and flora and fauna survey and assessment. She has co-written several Environmental Impacts Statements such as the Modernisation of the Mulwala Facility for ADI and the Smeaton Grange Aluminium Extrusion Plant for Capral. Flora and fauna work has involved small and large scale vegetation mapping and the consideration of conservation values of plant alliances recorded as well as Threatened species, chiefly through the preparation of either 8 Part Tests (Section 5A Assessment) and Species Impact Statements (SIS) under the TSC Act 1995.

Career Detail

Environmental Planning and Assessment

Work in this field has included:

- Wyrallah Road Waste Facility Environmental Fatal Flaw Analysis. Report prepared for Lismore City Council (2003).
- Edmonson Park Social Plan. Report prepared for Liverpool City Council (2002).
- Styx Creek Rail Underbridge Main North Line 164.475 km Statement of Environmental Effects. Report prepared for Rail Infrastructure Corporation (2002).
- Smeaton Grange Aluminium Extrusion Plant Environmental Impact Statement. Report prepared for Capral (2002).
- Modernisation of Mulwala Facility Environmental Impact Statement. Report prepared for ADI Limited (2002).
- Relocation of Battery Assembly Production Environmental Impact Statement. Report prepared for SAFT (2002).
- Jervis Bay Court Case. This job involved obtaining documents and information from various agencies to extract evidence to be used for a court case in Jervis Bay. This has included collecting the information, summarising the documents and reports and collating the information. Work for this project was carried out on behalf on NSW National Parks and Wildlife Service.

Ecological Studies and Site Assessment

Work in this field has covered aquatic and terrestrial flora and fauna investigations and habitat rehabilitation:

- Flora survey and assessment of roadside strip of remnant vegetation at Seaforth. Report prepared for Egis Consulting (2002).
- Opportunities and constraints flora survey and assessment of various defense sites at Holsworthy, Ingleburn and Moorebank. Report prepared for Egis Consulting (2001, 2002).
- Flora survey and assessment and Threatened Community assessment of Kirrawee Brickpit site. Report prepared for planning NSW (2001).

- Description of community structure, habitat requirements and the extent of spatial and temporal variation of micro-molluscan assemblages in turfing algae on rocky intertidal shores in NSW (2000).
- Coastal wetland flora and avifauna assessment and management, Spring Creek Wetland. Report prepared for Kiama Council (1999)
- Determination of acid sulfate soils in Greenwell Point, Nowra (1999).
- Marine biodiversity assessment at Jervis Bay National Park (1999)
- Leaf litter invertebrate biodiversity survey in rainforest and dry sclerophyll forest on Mount Kiera, Wollongong (1999).
- Vegetation mapping from air photo interpretation and ground truthing.
- Rainforest vegetation assessment and management.
- Field sampling analysis of:
  - Soil (moisture content, acid sulfate soils and salinity);
  - Water (as pH, electrical conductivity, DO, turbidity, colour analysis and total dissolved solids);
  - terrestrial and aquatic vegetation and
  - terrestrial and aquatic vertebrate and invertebrate fauna.
- Coastal and inland vegetation and fauna assessment and management.
- Mineral and rock identification.
- Geographical land use mapping.
- Construction of geological cross sections.
- Genetic studies including allozyme electrophoresis, isolation of DNA, chromatography of amino acids, electrophoresis of proteins and determination of enzyme activity.

Professional History URS Australia Pty Ltd, Environmental Scientist, 2001-Present

Training 24 hour Occupational Health and Safety Training

Publications

"Rocky Reef Biodiversity: Micro-mollusc Assemblages in Turfing Algae" Molluscs 2000. Understanding Molluscan Biodiversity in our Region into the 21st Century. Malacological Society of Australasia Conference Abstracts pg 83.

BEnvSci Thesis*: "Rocky Reef Biodiversity: Micro-mollusc Assemblages in Turfing Algae"* (2000).

Molluscs 2000 (4-8 December) Sydney, Australia - Poster paper presentation.