Fremantle Ports Outer Harbour Project

Fremantle Ports/Department for Planning and Infrastructure

Advice to the Minister for the Environment from the Environmental Protection Authority (EPA) under Section 16(e) of the *Environmental Protection Act 1986*

(This is not an assessment of the Environmental Protection Authority under Part IV of the Environmental Protection Act 1986)

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1. Introduction and background

This report provides the Environmental Protection Authority's (EPA's) advice to the Minister for the Environment under section 16(e) of the *Environmental Protection Act 1986* and the Western Australian Planning Commission (WAPC) on the proposal by Fremantle Ports and the Department for Planning and Infrastructure (FP/DPI) to develop a new port facility and related transport infrastructure for container trade and general cargo in Cockburn Sound.

The project is intended to provide a substantial container and general cargo port facility which would accommodate growth of shipping trade beyond 2017, when the existing Inner Harbour facilities are predicted to reach capacity. The preferred site is located at Naval Base/ Kwinana, north of James Point. Four development concepts have been considered by the proponents. Three options are for an offshore facility while the fourth is a combined land backed and offshore design. The offshore designs would be approximately 2.6 km long and 0.7 km wide, and linked to new rail and road infrastructure by a bridge. Following consideration of these alternative concepts, a preferred development option has been recommended by the proponents.

Fremantle Ports and the Department for Planning and Infrastructure, as joint proponents, have commenced a process to obtain environmental, planning and other approvals for a future port facility in Cockburn Sound and associated road/rail links. In view of the scale and complexity of the proposal and issues arising from the options, FP/DPI are proceeding through a two-stage strategic assessment and statutory approval process.

The first stage strategic assessment involves the EPA providing section 16e advice to the Minister for the Environment and the WAPC providing integrated strategic advice to the Minister for Planning and Infrastructure, following consideration of significant environmental, social and economic issues related to the four concepts and a preferred development proposal.

Once the integrated strategic advice is received from the WAPC, the Western Australian Government would then make a decision on proceeding to the next stage of obtaining statutory environmental and planning approvals on a specific proposal. This second stage environmental assessment is expected to be undertaken under section 38 of the *Environmental Protection Act 1986* rather than section 48A, even though an amendment to the Metropolitan Region Scheme (MRS) will be required. There are likely to be limitations in the ability of the MRS, as a planning instrument, to impose detailed environmental conditions on aspects of the project, such as dredging, which would occur beyond the amendment area.

2. The proposal

The Strategic Assessment Report (FP/DPI 2006a) provides the following description of the details of the proposal requirements and port development options.

The proposed port facility is intended to provide a world-class container and general cargo port facility capable of accommodating future generations of container ships to service the growing trade needs of Perth and wider Western Australia.

The proponents state (FP/DPI 2006a, p3) that it is therefore necessary to have a port facility with sufficient land for the handling and storage of cargo; ship berthing facilities with adequate shelter from waves and swell; shipping channels and harbour basins with adequate width and depth to handle future generations of ships; efficient cargo handling facilities to enable the efficient movement of cargo from ship to shore and to road and rail transport links and vice versa and efficient road and rail linkages to enable the efficient transport of freight between the port and importers and exporters.

Four project options for a port facility at the Naval Base/Kwinana location have been evaluated, together with associated road and rail links. The main components of the overall project are:

- three two-berth container terminals;
- one two-berth general cargo terminal;
- bridge to shore (Option 1, 2 and 3) or bridge to land backed facility (Option 4);
- road and rail access across the bridge;
- upgrade of existing shipping channels or/and new shipping channel;
- ship berthing and turning areas;
- land reclamation;
- primary road access (west of Kwinana Freeway to the port); and
- freight rail access (west of the Kwinana-Kewdale Freight Line).

Secondary components could include improved road access within the Kwinana Industrial Area and facilities to replace the recreational boat ramp at Sutton Road, in the event it is impacted by the port.

The four port facility options are shown in Figure 1. Each of the options, when fully developed, would have the same port capacity. They would each provide three two-berth container terminals and one two-berth general cargo terminal. Each of the options would be able to be developed in stages to progressively meet growing trade needs.

In each of the four options, the need for continued shipping access to Alcoa and the Australian Marine Complex (AMC) has been taken into account.

Following consideration of all of the port and transport infrastructure options, the proponents have selected a refined Option 1 as their preferred outer harbour development (FP/DPI 2006b). Some modifications to the proposal illustrated in Figure 1 have been made. These include:

- Raising of the road and railway to reduce the depth and width of the transport corridor cutting and removing the need for reclamation for the rail spur and Sutton Road realignment.
- Shifting the corridor southwards to reduce clearing of native vegetation north of the corridor by 9.4 Ha and providing better delineation between the industrial zoned land and Beeliar Regional Park.
- Retention of the high, wide load access along Cockburn Road and access to Sutton Road, Challenger Beach, Naval Base Holiday Park and Beeliar Regional Park (FP/DPI 2006b, p31).

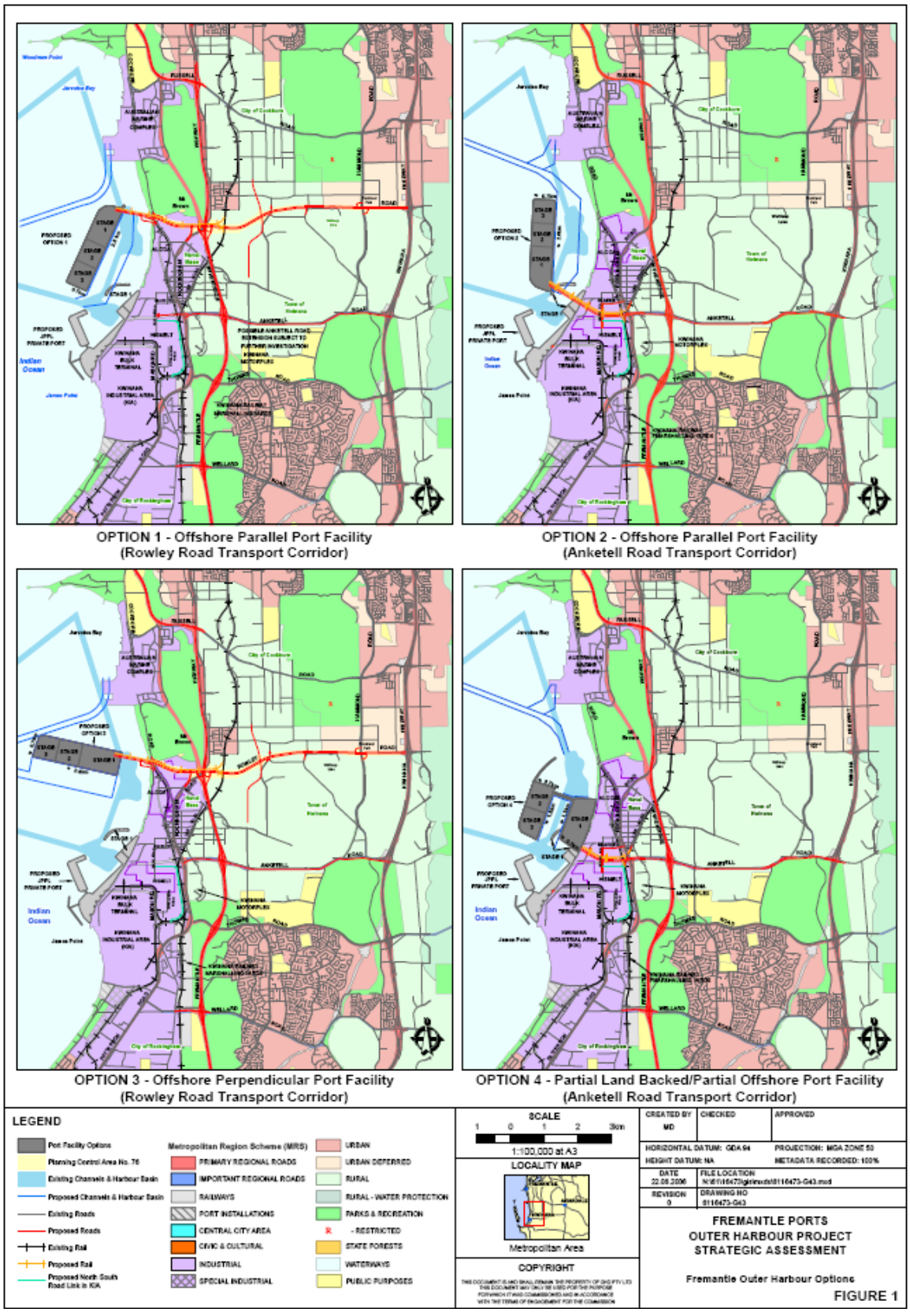

Figure 1: Port Development and Infrastructure Options (from FP/DPI 2006a)

3. Consultation

There has been extensive stakeholder consultation by Fremantle Ports and Department for Planning and Infrastructure over the whole of this strategic assessment phase.

The Draft Recommendation Report on Preferred Option (FP/DPI 2006b) and the key documents supporting the strategic assessment process were released for a 4 week public comment period from 26 July until 23 August 2006. A total of 36 submissions were received from individuals, community organisations, Government Departments and local businesses. The EPA has been provided with a copy of the proponents' summary, analysis and response to all submissions.

Key views on environmental issues expressed in submissions on the preferred option report included:

Marine environment

- The majority of comments received by the proponents on the Strategic Assessment Report and Report on the Preferred Option were in relation to concerns over the choice of site location within Cockburn Sound rather than the preferred option itself. Some submitters also expressed concerns that the preferred option would negatively impact on the marine environment of Cockburn Sound.
- Several submitters indicated that Cockburn Sound was overburdened with industry, nutrient loading and contaminants and that an alternative site should be considered.
- Concerns over the cumulative impacts of development in Cockburn Sound were also raised. The necessity of a public and private port (James Point Private Port) in the same vicinity and concerns in relation to the combined impacts of the desalinisation plant, New Gen power plant and other discharges were raised in the context of cumulative impacts.
- The potential for the construction and operation of the port to impact on local industry such as the Water Corporation desalination plant, BP refinery and also on local professional fisherman was also raised.
- The Cockburn Sound Management Council (CSMC), in its submission to Fremantle Ports, highlighted the concern that the nature and scale of the development pose a potential for significant and possibly irreversible effects impacts upon the marine environment of Cockburn Sound.

Terrestrial environment

- In terms of potential impacts on the terrestrial environment associated with the northern access (Rowley Road) of the preferred option, submitters raised concerns in relation to impacts on Lake Wattleup, wetlands and flora and fauna in Beeliar Regional Park and Mt Brown. Risks from spillages, increased traffic and visual amenity were also raised in this context.
- Other issues raised in the submissions include impacts on land use, impacts on industry and local business, community values and access to Cockburn Sound and traffic and emergency access.

4. Strategic Advice on Outer Harbour Project

4.1 Site Selection

This strategic assessment follows from investigations finalised in the 1990's that identified a preferred port site in the Kwinana/Naval Base area. This strategic assessment only examines port and transport corridor options related to a facility in Cockburn Sound in the Kwinana/Naval Base area.

The EPA notes that the majority of comments received by the proponents on the Strategic Assessment Report on the Preferred Option were in relation to concerns over the choice of site location within Cockburn Sound rather than the preferred option itself.

One issue of concern to the EPA is that the James Point proposal as an alternative facility has not been addressed, except in terms of its physical compatibility with the port and infrastructure options. James Point Stage 1 has received environmental approval subject to conditions and James Point has now referred its Stage 2 proposal, which will be formally assessed by the EPA at the level of Environmental Review and Management Programme (ERMP). In making this comment, the EPA is not advocating for one or other proponent or proposal, but is concerned about increasing complexity and how cumulative environmental impacts as well as social and economic matters can be adequately evaluated and addressed.

4.2 Current Condition of Cockburn Sound

The ecological condition of Cockburn Sound was at its lowest in the 1970s, with poor water quality, high chlorophyll-a levels and the loss of extensive areas of meadow forming seagrass from the eastern margin of Cockburn Sound. A substantial amount of time and resources has been invested by the Government, industry and the community to improve the environmental quality in Cockburn Sound since the late 1970's. During the mid to late 1980s and early 1990s chlorophyll-a concentrations and water clarity improved, and have generally stabilised since then.

The *State Environmental (Cockburn Sound) Policy 2005* (Cockburn Sound SEP) provides for an environmental quality monitoring program to be implemented in Cockburn Sound to determine if the established Environmental Quality Objectives[1] set for the Sound are being achieved, and therefore whether the Environmental Values[2] are being protected. Under the Cockburn Sound SEP, the Cockburn Sound Management Council (CSMC) has responsibility to oversee the environmental quality monitoring program and publicly reports the findings each year. In 2005, the council prepared a *State of Cockburn Sound Report 2005* (in addition to the public reporting program), which was tabled in Parliament (Cockburn Sound Management Council, 2005).

[1] Environmental Quality Objectives (EQOs) have been established by the Cockburn Sound SEP for each Environmental Value. EQOs are specific management goals for a part of the environment and are either ecologically based by describing the desired level of health of the ecosystem or socially based by describing the environmental quality required to maintain specific human uses.

[2] Under the Cockburn Sound SEP, Environmental Value means a particular value or use of the marine environment that is important for a healthy ecosystem or for public benefit, welfare, safety or health and which requires protection from the effects of pollution, environmental harm, waste discharges and deposits. The Environmental Values that apply to the Cockburn Sound policy area are listed in Clause 6 of the Cockburn Sound SEP.

Overall (based on the best available information and expert advice) there appears to have been no significant change in the overall health of Cockburn Sound since monitoring programs began in 2000. Data collected under the monitoring program was assessed against the Environmental Quality Criteria for Cockburn Sound and a series of Report Cards were developed to inform stakeholders and the community on the health of the Cockburn Sound marine environment.

The Cockburn Sound Report Cards for 2005, produced from data collected during 2004-2005, indicate that investigation and/or action is required in relation to a number of parameters monitored for ecosystem health (seagrass shoot density in Mangles Bay; chlorophyll-a, light attenuation and tributyltin in Jervoise Bay).

The 2005 Report Cards highlighted that in the area of *High Ecological Protection*[3]:

- chlorophyll-a concentrations met the relevant guidelines, but were elevated in Jervoise and Mangles Bays;
- water clarity met the guideline, but was poorest in northern sites and Jervoise Bay; and
- seagrass health met the standard in all sites except Mangles Bay. Overall there has been no significant region-wide change in the status of seagrass meadows at sites surveyed between 1998 and 2005.

In the areas of *Moderate Ecological Protection*[4], environmental quality met the guidelines except in the Jervoise Bay Harbours where:

- the guidelines for chlorophyll-a and light attenuation, in addition to the guideline and standard for phytoplankton biomass, were not met at any of the sites in Northern Harbour, and
- the guideline for tributyltin was not met at any of the sites within Jervoise Bay Harbours (Northern and Southern harbours).

More recent monitoring for 2005-06 together with the 2006 Report Cards highlighted that some of the environmental quality indicators monitored in Cockburn Sound were at levels that required action to be taken. These indicators include bacteria levels at the Rockingham foreshore waters, chlorophyll-a at Jervoise Bay Northern Harbour and tributyltin at James Point, Careening Bay, Woodman Point and both harbours in Jervoise Bay.

In summary, water quality improvement in Cockburn Sound seems to have reached a plateau which is significantly better than several decades ago but where improvement is getting more difficult to achieve.

[3] For the EQO–'Maintenance of Ecosystem Integrity', there are 3 levels of ecological protection that apply. A High level of ecological protection allows for small changes in the quality of water, sediments and biota. The extent and boundary of the High Ecological Protection area within the policy area is shown in Schedule 2 of the Cockburn Sound SEP.

[4] Moderate level of ecological protection allows for moderate changes in the quality of water, sediments and biota. The extent and boundary of the Moderate Ecological Protection area is shown in Schedule 2 of the Cockburn Sound SEP.

4.3 Pressures on Cockburn Sound

As indicated above, while nutrient related water quality parameters improved during the mid to late 1980s and early 1990s, and have generally stabilised since then, overall, Cockburn Sound remains under significant pressure from existing activities. Further pressures are likely from approved projects which are yet to operate.

In 1998, the EPA provided Strategic Environmental Advice on the Marine Environment of Cockburn Sound in Bulletin 907 (EPA 1998a). This advice was prepared as part of the environmental assessment of the proposed Industrial Infrastructure and Harbour Development in Jervoise Bay.

In Bulletin 907, the EPA attempted to deal with some of the future developments that were likely to arise in Cockburn Sound, and address environmental implications that could result from these proposals.

Forecast developments identified in Bulletin 907 included the following:

- proposed Industrial Infrastructure and Harbour Development in Jervoise Bay (received environmental approval in 1998 (Ministerial Statement 490), now constructed as the Marine Support Facility);
- a Fremantle Port Authority harbour at Naval Base (now called the Fremantle Ports Outer Harbour Project;
- a residential marina in Mangles Bay (currently the subject of section 16 advice by the EPA);
- expressions of interest to construct and manage a private port in Cockburn Sound (now called James Point Port); and
- proposed additional berth at the FPA bulk cargo jetty (not yet constructed).

Since Bulletin 907 was published, the James Point Port Stage 1 proposal has received environmental approval subject to conditions (Ministerial Statement No. 669), while the larger James Point Stage 2 has commenced its environmental assessment at the level of Environmental Review and Management Programme. The EPA is also assessing a proposal by Fremantle Ports to significantly upgrade the capacity of the Kwinana Bulk Terminal Berth No. 1 (at Public Environmental Review level of assessment). Recent industrial developments along the Cockburn Sound foreshore, using Cockburn Sound for water supply and water discharge, include the Perth Seawater Desalination Plant, Verve Energy's Cockburn 1 and 2 gas turbine power stations and NewGen Power's Kwinana Gas-Fired Power Station. Some of these projects are in operation or under construction, and all have environmental approval.

Apart from the Marine Support Facility (MSF), the proposed Mangles Bay residential marina and the proposed bulk cargo jetty expansion, all of these proposals and projects are located between James Point and Challenger Beach. There are already marine activities associated with Alcoa's Kwinana Refinery and Verve Energy's Kwinana Power Station in this section of Cockburn Sound.

Bulletin 907 included a Statement of Advice entitled: An Appraisal of Potential Environmental Consequences for Cockburn Sound of Future Harbour Developments. This Statement of Advice was prepared for the EPA through a series of technical workshops comprising a group of experienced marine scientists. The Statement pointed out that

environmental changes resulting from potential harbour developments need to be considered at three spatial scales:

- within harbours;
- between harbours (along the eastern margin of Cockburn Sound); and
- broader Cockburn Sound.

The EPA considers that the Statement of Advice remains relevant to consideration of cumulative environmental impacts arising from existing and proposed marine-related developments for Cockburn Sound, including the Outer Harbour Project. Matters raised as potential implications from harbours include effects on ecological processes, loss or alteration of habitat, changes to nutrient cycling and increased biota stimulation, disturbance of sediments and contaminants, reduction in light, introduction of pest species, and changed water circulation.

The executive summary of the Statement of Advice is provided in Appendix 2 of this report.

4.4 Environmental Issues Related to Port Options and Transport Infrastructure

While some of the terrestrial impacts arising from the preferred option may be reduced through actions such as those mentioned above (in Section 2), there are few opportunities to reduce marine impacts arising from the port options, including Option 1.

Each port option would lead to significant adverse environmental change in Cockburn Sound through a combination of marine habitat loss (seabed and water) arising from dredging and reclamation and potential environmental quality impacts arising from changed water flow patterns (hydrodynamics) and contaminants.

In large part because of the scale of the dredging and reclamation requirements of any of the options, the Outer Harbour Project has the potential to adversely affect a substantial portion of the eastern-shelf of Cockburn Sound. Based on current information, it is not yet possible to form the view that construction and operational impacts for any of the options within Cockburn Sound are likely to be acceptable.

Terrestrial

Two main infrastructure access corridors were considered for the port options, a realigned and extended Rowley Road and an extended Anketell Road. The recommended preferred route from the Kwinana Freeway to port Option 1 is Rowley Road.

Although the Rowley Road and Anketell Road corridors would be close to Wattleup Lake and The Spectacles respectively, detailed design would be required to ensure that the wetlands can be avoided and adequate buffers maintained. Likewise, the Threatened Ecological Community located within the Anketell Road corridor should be avoidable and could be protected through detailed design.

Impacts on fauna will result from clearing for each of the transport corridors, with loss of habitat. The corridors will also lead to larger breaks in planned linkages between protected areas and the roads will act as a barrier which would be likely to increase the loss of fauna. In this regard, the Hope Valley-Wattleup redevelopment could be expected to have a greater

effect than the other options. The Mt Brown regional open space area is outside of the redevelopment area.

There are four Bush Forever sites that would be affected by the Rowley Road and Anketell Road corridor options:

- Bush Forever Site 346 (Brownman Swamp, Mt Brown Lake and Adjacent Bushland). Most of Bush Forever Site 346 is reserved as part of the Beeliar Regional Park, with the southern portion (Part B of Site 346) listed in the Bush Forever Site Implementation Recommendations as 'Proposed Parks and Recreation'. The western part of the Rowley Road transport corridor for port Options 1 and 3 affects the southern portion of Bush Forever Site 346. The initial proposed concept for a road and rail reserve would result in the clearing of 28 ha of vegetation within Bush Forever Site 346 and an additional 16.5 ha of Site 346 would be separated to the south of the road and rail reserve, leading to a total of 44.5 ha (or 7.5% of Bush Forever Site 346) being affected by the Rowley Road corridor. The revised alignment reduces clearing by 9.4 ha and also reduces the size of the separated land to the south of the corridor.
- Bush Forever Site 393 (Wattleup Lake and Adjacent Bushland). The Rowley Road transport corridor for port options 1 and 3 affects this site. The corridor passes through a narrow linking corridor between Wattleup Lake and the Harry Waring Marsupial Reserve.
- Bush Forever Sites 268 (Mandogalup Road Bushland) and 269 (The Spectacles). The Anketell Road transport corridor for port options 2 and 4 would affect both these sites. Anketell Road would remain largely within its existing reserve, with only a small loss from these sites.

While the refinement of the corridor has reduced the physical impact on Bush Forever Site 346 associated with Mt Brown, the impacts on the area are still considered to be significant. Construction of the road/rail corridor and associated link roads between Rockingham Road and Cockburn Sound would clearly have substantial effects, through the loss or dislocation of vegetation and habitat values, as well as by creating a visible scar on a prominent landscape feature.

Although the proponents have modified the alignment in the vicinity of Mt Brown to reduce ecological impacts, the EPA would prefer transport corridors that avoid the Mt Brown area. The EPA has previously highlighted the importance of Bush Forever Site 346 through its System 6 review report into conservation reserves on the Swan Coastal plain (DCE, 1983) and also in Bulletin 908, related to the assessment of the proposed Industrial Infrastructure and Harbour Development, where loss of reserved land was part of the proposal (EPA 1998).

The EPA notes that some modifications to the alignment affecting Mt Brown have been indicated in the Draft Recommendation Report on Preferred Option (FP/DPI 2006b, p 31). While the modifications to the Rowley Road road/rail alignment may reduce the impacts associated with this access infrastructure, this will need to be demonstrated in the statutory assessment phase along with the provision of detailed information on the proponent's further mitigation of impacts on the Bush Forever site.

Marine

Each of the port options would have impacts on benthic habitat and environmental quality during the construction and operations phases. The extent of loss and degradation of marine habitat and biodiversity through dredging and reclamation, water quality impacts from reduced flushing times and changed circulation patterns, and potential cumulative effects from existing and approved infrastructure and discharges on the eastern shore of Cockburn Sound, remain significant issues needing to be addressed.

Circulation and flushing issues

Each of the port options will affect water circulation patterns at a range of scales, from the harbour-scale to Cockburn Sound-scale. While water circulation within the harbour (or at the local-scale) is likely to be improved to some extent with the removal of the access spur on Challenger Beach compared with a situation where an access spur is present, it will still be affected by the overall size, shape and angle of the port configuration. This would also be the case at a Cockburn Sound-scale. The modelling of water circulation based on conceptual layouts of the reclamation, channel and basin configurations (which includes the spur but does not include James Point Stage 1,) suggests that Option 4 is likely to have the least effect at the Cockburn Sound-scale and harbour-scale, and that Options 3 and 2 would have greater effects than Option 1 (Oceanica, 2006). For Option 1, modelling indicates that at the harbour-scale water currents are expected to be weak and variable in the deepened harbour basin with stronger currents expected through the northern causeway.

Based on the results of flushing studies presented in Oceanica (2006), the proponent predicts that longer residence times for waters within the harbour are likely for Options 1 and 2, with the latter Option increasing residence times of surface waters by between 4 and 8 fold relative to the current situation. For deeper waters, Option 2 is predicted to increase residence times by up to 6 days. The report states, "the flushing characteristics of (Option 2) are poor" (GHD 2006, p131).

For Option 1 it is predicted that the local water residence times are expected to be up to 24 hours longer than the existing situation. Modelling the effects of Option 1 on adjacent waters also indicates that water residence times near the MSF in the Jervoise Bay region, and between Option 1 and the MSF, are predicted to increase.

Water residency time is a measure of the time it takes for a body of water to flush from an area of the ocean. The environmental consequences of longer water residency times in Cockburn Sound are discussed in greater detail in EPA Bulletin 907 but include potential for greater biomass of phytoplankton and changes in the cycling of nutrients in Cockburn Sound's waters and marine sediments.

The potential impacts of the Outer Harbour options on industrial discharges may have environmental and policy implications. From results of flushing studies, the proponent predicts that Options 1, 2 and 4 are likely to lead to changes in the flushing times of waters between Alcoa's Kwinana Refinery and James Point, where there are a range of existing and proposed outfalls and other industrial facilities. However, the effect of these options on discharge plume behaviour from these sites has not been examined in detail. Development of Options 1, 2 or 4 is likely to adversely impact intake water quality for the Perth Desalination Plant and possibly other seawater intakes in the area (Industrial water supply is an Environmental Value in the Cockburn Sound SEP), while the predicted longer water residence

time caused by the port structure and harbour deepening may lead to some changes in the behaviour (and possibly reduced performance) of the existing and approved industrial outfalls.

From a policy perspective, the effect of the Outer Harbour Project options on existing and approved Low Ecological Protection Areas, as shown in Schedule 3 of the Cockburn Sound SEP, will require detailed investigations.

The results of modelling undertaken to date are best considered as indicative only. Of concern is the fact that the flushing studies did not include consideration of James Point Stage 1, which has been granted environmental approval subject to conditions. The hydrodynamic implications of all existing and approved developments, including the James Point Stage 1 Port, on the Fremantle Ports proposal need to be examined and considered in more detail.

Based on the hydrodynamic modelling information in the Strategic Assessment Report, it is not possible, with any degree of certainty, to make a judgement on implications of the port options on water circulation patterns and flushing times. For example, while the document provides basic information on circulation pattern changes for one season (summer), this is too limited to properly address the potential consequences of any option on the different seasonal water movement patterns which occur in Cockburn Sound. This is acknowledged in the Strategic Assessment Report (FP/DPI 2006a).

Furthermore, hydrodynamic information alone will not answer questions about the effect of an Outer Harbour on the overall 'Ecosystem Health' of the Sound. Ecosystem Health is a fundamental ecological value identified in the Cockburn Sound SEP, and a significant further effort would be necessary to predict impacts of the presence of an outer harbour on overall Ecosystem Health, including water and sediment quality, and seagrass health. Such predictions would need to be presented in the context of the Cockburn Sound SEP, as the EPA will use the SEP as the basis on which to assess environmental quality implications of a proposal should Government decide to progress an environmental impact assessment of a preferred option.

Dredging and reclamation

Construction of any one option would involve significant reclamation and dredging in Cockburn Sound to develop new or deeper shipping channels and a harbour basin. Protection of the biota and their supporting systems is a primary goal of the EPA for Cockburn Sound. Benthic and other flora and fauna in Cockburn Sound could be significantly affected during and following construction of any of the port options. Construction would cause direct permanent loss of benthic habitat through excavation and overtopping, and also has potential to indirectly impact benthic habitats and environmental quality through the liberation of fine sediments to the water column during dredging and reclamation.

The extent of loss of shallow habitat along the eastern margin of Cockburn Sound from dredging and reclamation is determined by the design capacity of the port. The scale of the direct impacts varies between the port options, but is substantial in all cases. For example, the combination of dredging and reclamation will lead to the permanent loss of between 338 ha (Option 1) and 398 ha (ha) of benthic primary producer habitat found in waters less than 10 m depth. These losses include areas of extant seagrass but are predominantly unconsolidated marine sediment, where seagrass once grew.

Impacts on benthic primary producer habitats

Cumulative permanent losses of benthic primary producer habitats (BPPH) are considered by the EPA in the context of Guidance Statement No.29 Benthic Primary Producer Habitat Protection (EPA, 2004). The EPA defines BPPH as both the benthic primary producer communities as well as the substrata that can or do support these communities (EPA, 2004). In the Cockburn Sound context, the key benthic primary producer habitats are areas of extant seagrass and unconsolidated sediments where seagrass once grew and could recolonise if ambient environmental conditions were suitable. The EPA will expect that the proponent addresses the cumulative loss of each different BPPH in the context of Guidance Statement No. 29, if a preferred Option is presented to the EPA for formal environmental impact assessment.

Concern about seagrass loss in Cockburn Sound is not new. Approximately 80% of the seagrass present in Cockburn Sound prior to development commencing in the area has been lost since the 1950's. The EPA has a stated objective to protect the remaining seagrass meadows in Cockburn Sound (EPA, 1998). The EPA is concerned about the incremental loss of further *Posidonia* seagrass in Cockburn Sound. In previous assessments of proposals in Cockburn Sound where loss has been a predicted outcome, the EPA expressed significant concern about the loss of any further seagrass in Cockburn Sound in the context of historical losses (eg. Jervoise Bay Southern Harbour and Mangles Bay Marina). The EPA remains of the view that the remaining seagrass in Cockburn Sound should be protected and that activities and developments should be planned and implemented with an environmental objective for *Posidonia* seagrass of no net loss and preferably a net environmental gain.

Further loss of BPPH that is potentially suitable for seagrass recolonisation (i.e. unconsolidated sediment generally in less than 10 m water depth where seagrass once grew) is also of significant concern. The importance of protecting sandy banks and margins where seagrass meadows once grew in the Sound has been highlighted by the EPA (1998) and this issue is also reflected in the Cockburn Sound Management Plan (CSMC, 2005), which includes a recommendation related to the promotion of the recolonisation and re-establishment of seagrass in areas of Cockburn Sound where it once occurred (recommendation 1.3-16). Excluding the areas of reef habitat shown in Table 5 of the Strategic Assessment Report (FP/DPI, 2006a), the sum of the areas of other benthic primary producer habitat directly disturbed by each Option provides an indication of the potential total direct loss of "seagrass" habitat for those Options. For example, Option 4 would cause greatest loss (378 ha) while Option 1 the least (326 ha), followed by Option 2 (376 ha). The potential losses of each BPPH associated with any port option would need to be considered in the context of all other historical and approved losses.

From the available information, each of the port options will cause the cumulative loss thresholds set out in the EPA's in Guidance Statement No. 29 to be exceeded for both seagrass and sandy habitat that once supported seagrass. Considering historical and approved losses, the proponents have predicted that this project, if approved, could see the cumulative loss since European habitation of sandy habitat that once supported seagrass reach 17%. This figure is well above the 10% cumulative loss threshold in the EPA Guidance Statement for Category E: Development Areas. There needs to be further discussion of the predicted cumulative loss from this project against the EPA cumulative loss threshold.

In relation to implications for each of the different marine BPPHs, Table 1 below shows the calculated areas of direct loss of each type of BPPH for each (Oceanica 2006, p 27).

The mechanisms and the extent to which the loss of these habitats, especially the seagrass components, could be offset has not been addressed by the proponent and requires significantly more discussion. In particular, the Strategic Assessment Report assumes "that any requirement for a direct offset for the loss of *Posidonia sp*. is more important than the need to offset the loss of other habitat types" (FP/DPI 2006a, p. 61). With respect to seagrass-related off-sets, the EPA notes that planting of seagrass sprigs in Oyster Harbour, Albany has been very successful. Trials using similar techniques in Cockburn Sound are, however, not showing anywhere near the same degree of success.

Table 1: Calculated areas of direct loss of each benthic primary producer habitat type for each option from Oceanica (2006), as modified.

	Option 1 (Ha)	**Option 2 (Ha)**	**Option 3 (Ha)**	**Option 4 (Ha)**
Direct loss of BPPH currently supporting *Posidonia* sp.	0.14	0.02	11.07	0.11
Direct loss of BPPH currently supporting *Halophila* sp.	28.65	35.80	36.02	2.44
Direct loss of BPPH: soft sediment habitat	297.06	340.85	311.89	357.17
Direct loss of BPPH: reef habitat	11.57	21.18	27.80	4.48
Total area in hectares	**337.42**	**397.85**	**386.78**	**364.20**

In addition to the direct losses of benthic habitat associated with dredging and reclamation, these activities will have indirect effects. The dredging associated with the proposal is expected to take between 83 weeks (1.6 years) and 113 weeks (2.2 years), although this may be in two stages. While it may be possible to reduce the duration of these periods, the dredging programme for the Outer Harbour basin and channel would still extend beyond well 1 year. Even with best management endeavours, the elevated turbidity associated with dredging and dumping activities is likely to be significant. Elevated turbidity from dredging and reclamation over such a long period of time is likely to have adverse ecological effects though light deprivation, smothering, toxicity effects (if sediment bound toxicants are mobilised in significant amounts) and behaviour changes (e.g. avoidance) in some mobile marine species. Experience elsewhere along the WA coast, and also in Cockburn Sound, is that elevated turbidity over extensive areas and extended periods of time is likely to significantly affect marine biota and communities and the recovery of these from dredging-related stress is relatively poorly understood at present.

Impacts of dredging on aesthetics and seawater use by industry

Elevated turbidity will also be a significant aesthetic issue and may have implications for the quality of seawater utilised by industry for the duration of, and beyond, the dredging process. These aspects have not been considered in the Strategic Assessment Report, except in general terms.

Marine Fauna

The implications of the construction and operation of any of the options on marine fauna habitat and nursery areas will also be important, but the significance is difficult to determine at this stage. It is known that dolphins forage in the shallower eastern margin in the area of the port options and that Cockburn Sound is a primary spawning area for snapper in the metropolitan region. How these two important ecosystem attributes and functions will be

protected acceptably is unclear from the current information. The soft substrate benthic community of the deep basin is unique and found nowhere else in WA and as such has a very high conservation value. Cockburn Sound is also important for other marine species, including some that have significance for the recreational and professional fishing communities (e.g. blue swimmer crabs). The potential impact of a preferred Option on these values requires further, more detailed, investigation.

Impacts on social uses
Recreational fishing may be adversely affected by the loss of benthic habitat and also reclamation associated with each option. Although boat access to Cockburn Sound from Challenger Beach boat ramp is likely to be retained, the removal of shallow areas through dredging and the reclamation of the island structure will lead to a substantial loss of existing habitat supporting marine species. How these effects could be mitigated and offset is not clear.

4.5 Future Issues to Address

A number of comments made above point to matters which will need to be addressed during the assessment of a specific development proposal. These include cumulative marine impacts arising from multiple developments and proposals in the same portion of Cockburn Sound, as well as marine and terrestrial issues.

Some additional matters are identified below for Fremantle Ports and the Department for Planning and Infrastructure to consider.

The current timetable would see construction of an approved proposal commencing within the next five years. Should construction of the port be significantly delayed beyond 2010, the rapidly changing circumstances in Cockburn Sound may require further consideration of the proposal in the context of cumulative environmental impacts.

The Cockburn Sound SEP
The Government's SEP for Cockburn Sound reflects the community's aspirations for the environmental quality of Cockburn Sound. It also contains benchmarks against which to determine if those aspirations are being met. The EPA has also prepared Guidance Statement No. 29 which addresses cumulative loss of benthic primary producer habitat. Accordingly, it is expected that if a decision is taken to progress an assessment of a preferred option under Part IV of the *Environmental Protection Act 1986*, information on marine environmental quality and habitat impacts prepared to inform that assessment should be considered and presented in the context of the Cockburn Sound SEP and Guidance Statement No. 29.

The EPA considers that regardless of the port configuration, the ramifications of any Outer Harbour Project option of this scale are significant. These issues are flagged in the footnotes on Page 11 of the Cockburn Sound SEP.

Cumulative impacts
As indicated in section 4.4 of this report, the EPA considers that should Government decide to progress detailed assessment of a preferred option, detailed environmental impact assessment studies will need to take into account the cumulative effects of an Outer Harbour Project combined with the effects of all other existing, approved and proposed developments in Cockburn Sound. The Strategic Assessment Report's consideration of the port options in

isolation from projects which have received environmental approval, such as the James Point Private Port Stage 1, ignores the important issue of cumulative impacts; an issue central to the evaluation of environmental impacts of developments in Cockburn Sound. The EPA's view (as expressed in EPA Bulletin 907) that the marine environmental effects of potential developments should not be considered in isolation, either from each other, or from already existing activities and environmental concerns in Cockburn Sound, remains relevant to the Outer Harbour Project.

Accordingly, the EPA will require detailed cumulative impact modelling and assessment of the Outer Harbour Project combined with existing developments and discharges, developments and industrial discharges which have received environmental approvals but have yet to be implemented, such as the James Point Private Port Stage 1 and the Perth Seawater Desalination Plant (Kwinana), and also proposals which have been referred to the EPA for assessment such as the James Point Private Port Stage 2 and the proposed upgrade of the Kwinana Bulk Berth Terminal project.

As the construction of the Outer Harbour Project will be staged, the EPA will also need to have an understanding of how the staging of the development will be taken into account in cumulative effects assessment and modelling.

As mentioned, the information in relation to cumulative impacts to be presented as part of progressing a detailed assessment of the project, should be considered in the proponent's environmental impact assessment documentation in the context of the Cockburn Sound SEP and other policy statements of the EPA, such as Guidance Statement No. 29.

Impacts of dredging and reclamation
The long duration and extent of any dredging campaign would have major short term and long term impacts on ecological values and also amenity across much of Cockburn Sound, and possibly beyond the Sound. These issues are likely to prove difficult to manage. Nevertheless, if a decision is taken to seek approval for a preferred option, the implications of these impacts will need to be fully considered, and matters such as fauna avoidance, effect on marine fauna and flora life-cycles, and also existing users of the Sound will need to be addressed in considerable detail.

Marine fauna
Studies into the marine fauna of Cockburn Sound continue to highlight its importance for some species, such as snapper spawning and recruitment. Future assessment of any port option will need to consider the implications to marine species and determine the significance of impacts at local and regional scales. There is limited relevant information about population dynamics, which points to potential difficulties in satisfactorily addressing this issue without a substantial increase in available knowledge.

Environmental Offsets
It is clear at this stage that the decision to progress the environmental approval process for any of the port and transport infrastructure options will require the proponents to clearly demonstrate that they have fully considered and addressed the impact mitigation sequence, including the identification of offset projects, consistent with the principles in the EPA's Environmental Offsets Position Statement No. 9. Consideration of offsets in relation to key marine and terrestrial values will be an important component of the next stage.

Technical issues and investigations
Should Government decide to progress detailed assessment of a preferred option, the EPA expects that further detailed investigations, as part of the statutory environmental impact assessment process, include the following technical elements:

- high quality benthic habitat mapping and analysis;
- well validated hydrodynamic modelling;
- sediment transport modelling, to predict the behaviour of particles liberated to the water column due to dredging and reclamation, as well as any other particles such as phytoplankton or particulates in discharges that may be affected by the presence of an outer harbour;
- detailed geotechnical studies to inform the dredging design and associated impact predictions;
- studies of the ambient environmental conditions in Cockburn Sound, including for periods outside of the annual summer monitoring coordinated by CSMC; and
- studies to inform predictions of the ecological consequences of construction and operation of an outer harbour, including predictions of flow-on effects that may be associated with primary impacts (e.g. consequences of habitat loss for important flora and fauna).

Requirement for construction materials
The proposal would require substantial volumes of fill and armour material for the transport corridors and especially the port development. The port will require between 0.58 million cubic metres (Mm^3) and 0.72 Mm^3 of armour and between 4.6 Mm^3 and 13.4 Mm^3 of imported fill and core, in addition to the dredged reclamation volumes of between 10.1 Mm3 and 13.8 Mm^3 (FP/DPI 2006a). Obtaining these substantial quantities of material could have flow-on environmental consequences. It is understood that there are limited supplies of sand and limestone fill materials available in the Perth metropolitan region. The requirement for large volumes of materials for all options will impact on the availability of local materials and may bring forward the need to identify and develop new extraction areas. Many sites that contain undeveloped limestone and sand resources in the metropolitan region occur in locations where planning and environmental constraints, such as Bush Forever sites and noise and dust amenity issues, may preclude or severely constrain extraction.

Moving this material would also increase heavy truck traffic along transport routes. These are matters that would need to be fully considered during detailed assessment stage.

The assessment of the preferred option, should Government agree to proceeding to obtaining approvals, will need to comprehensively address the issues identified in this section and elsewhere in this report.

5. Conclusions

Development of an island port in Cockburn Sound like that proposed by the Fremantle Ports and Department for Planning and Infrastructure would be a substantial undertaking. Although the detail of impacts arising from each of the port options outlined in the Strategic Assessment Report would be different, it also clear that all options would have significant adverse impacts that go well beyond the local scale, primarily because of the substantial size of the port.

In providing this advice, the EPA is most concerned that there remains limited information available on some critical environmental issues. These include effects on marine impacts in general, fish fauna and habitat in particular, and the definition of potential offsets. There is also increasing complexity in relation to the potential cumulative impacts of the number and nature of developments in the portion of Cockburn Sound between Challenger Beach and James Point, which have yet to be addressed in detail. Both of these points are particularly relevant at a time when the proponents are seeking government support to proceed to obtaining statutory environmental and planning approvals for a specific port and transport infrastructure proposal.

The EPA is of the view that the effects of infrastructure development on the terrestrial environment are more easily definable and quantifiable than those related to Cockburn Sound. The information currently available in relation to impacts in Cockburn Sound does not allow any judgement to be made about the likely environmental acceptability of any of the port options. Considerable investigation and the provision of detailed and appropriate information will need to occur to change this view. The key issues and detailed further work which will need to be addressed and undertaken as part of the next stage have been identified in this report and relate to the following areas:

- cumulative impact assessment;
- the Cockburn Sound SEP;
- impacts of dredging and reclamation;
- impacts on BPPHs;
- marine fauna;
- environmental offsets; and
- impacts on the ecological values of Bush Forever sites.

As mentioned in Section 4 of this report, such information would need to be presented in the context of the Cockburn Sound SEP, as the EPA will use the SEP as the basis on which to assess environmental quality implications of a proposal should Government decide to progress detailed assessment of a preferred option.

On the basis of the information currently available, the EPA does not express a preference for any particular port option. It appears all options would have significant adverse impacts. Detailed assessment will be required, in the formal environmental impact assessment stage, to determine the full extent of impacts from any selected option. Such assessment will also need to evaluate the effectiveness of any management, mitigation and offset measures proposed. Only then will it be possible to determine the environmental acceptability or otherwise of a port proposal of this scale.

The EPA is also concerned that cumulative pressures along the eastern margin of Cockburn Sound will increase the threat to the improvements in the condition of Cockburn Sound which have been achieved through strong action by Government, industry and the community in recent decades. The increasing pressures from this and other proposals and developments on Cockburn Sound have, in combination, the potential to either delay or even reverse further improvement in the environmental quality of the Sound.

6. Recommendations

The EPA submits the following recommendations to the Minister for the Environment:

1. That the Minister notes that the EPA does not express a preference for any particular port option. It appears all options would have significant environmental impacts, especially within Cockburn Sound.
2. That the Minister notes that cumulative pressures along the eastern margin of Cockburn Sound will increase the threat to the improvements in the condition of Cockburn Sound which have been achieved through strong action by Government, industry and the community in recent decades.
3. That the Western Australian Planning Commission notes the advice in this report.

Appendix 1

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Appendix 2

Executive Summary from
Statement of Advice: An Appraisal of Potential Environmental Consequences for Cockburn Sound of Future Harbour Developments.
EPA Bulletin 907

STATEMENT OF ADVICE

AN APPRAISAL OF POTENTIAL ENVIRONMENTAL CONSEQUENCES FOR COCKBURN SOUND OF FUTURE HARBOUR DEVELOPMENTS

Report to the Environmental Protection Authority

August 1998

Executive Summary

Background

The sheltered waters of Cockburn Sound are used for recreation, tourism, commercial fishing (including aquaculture), shipping and industry. Major losses of seagrass habitat and contamination of marine life, sediments and waters had occurred by the late 1960's and early 1970's. In response to these problems, industry and Government have achieved significant reductions in the quantities of toxicants and nutrients discharged from point sources directly to the Sound, and further reductions in these loads are projected. Diffuse sources (e.g. nutrients in groundwater outflows) and ship-related sources (e.g. release of tributyltin in antifouling paints) are also a major concern. Other pressures on the Sound include the disturbance to marine habitats through anchor damage from recreational boats, the dredging of shipping channels and the construction of berths and harbours. As a result of these combined pressures the Sound remains in a delicate state of ecological balance.

During the last two years the State Government announced infrastructure development plans for several commercial harbours on the eastern margin of Cockburn Sound and a residential marina in Mangles Bay, at the southern end of the Sound.

Strategic Environmental Assessment

The Environmental Protection Authority (EPA) is of the view that the marine environmental effects of these potential developments should not be considered in isolation, either from each other, or from already existing activities and environmental concerns in Cockburn Sound. The EPA therefore decided to prepare a strategic environmental assessment of the cumulative effects of anticipated harbour developments in Cockburn Sound over the next 20-30 years. The strategic environmental assessment was to be based on currently available plans and proposals. The EPA requested that a series of technical workshops be convened, culminating in the preparation of a Statement of Advice from a group of experienced marine scientists. This will be part of the EPA's Strategic Environmental Assessment which will take the form of a public report to the Minister for the Environment.

Purpose and Scope of the Statement of Advice

The focus of the Statement of Advice is on the response of the marine environment of Cockburn Sound to potential long-term harbour development scenarios, taking into account existing pressures on the marine environment from waste inputs and other activities. Given the short time frame that was made available to prepare the Statement, it must be considered as initial advice in relation to the issues considered. In particular, it is stressed that the workshop participants were considering the possible consequences of a long-term 'major developments' scenario. Further, it must be emphasised that, while this Statement advises on the qualitative nature and direction of ecological changes likely to occur, further scientific investigations would be required to determine, with reasonable certainty, the magnitude of these changes. Nonetheless, it is intended that this Statement should highlight key environmental issues that need to be resolved through sound planning, management and decision making, supported where necessary by continuing research.

The anticipated effects of a 'major developments' scenario were referenced against a 'baseline' scenario (existing situation). The baseline scenario includes the existing Northern Precinct harbour and the adjoining Marine Support Facility, Jervoise Bay, in the northeast corner of Cockburn Sound. In addition to existing structures, the major developments scenario also includes the proposed Industrial Infrastructure and Harbour Development (Jervoise Bay), a concept for a significant harbour development located off the Kwinana industrial area (between James Point and the Alcoa Jetty), and a proposed recreational marina off Mangles Bay (near Rockingham).

The Statement of Advice addresses the environmental issues which could be expected to arise as a result of prolonged periods (several years per project) of construction, involving the building of breakwaters and reclaimed areas, as well as the dredging of shipping channels and ship turning basins. It also deals with post-construction issues associated with increased shipping and the combined effects of the harbours on water movement, sedimentation, the dispersion and fate of nutrients and contaminants, and the consequences of these changes for water quality and the marine plant and animal communities.

The potential for these environmental changes to occur has been considered at three spatial scales:

- within harbours
- between harbours (eastern margin of Cockburn Sound)
- broader Cockburn Sound.

Summary of the Statement of Advice

(a) Within harbours

Existing breakwaters enclose an area of approximately 50 ha of sea bed. Under the major developments scenario there would be a total of approximately 550 ha of sea bed either enclosed by breakwaters or covered by 'reclaimed' land. These areas represent approximately 2 % (existing development) and 20 % (major developments scenario) of the total area of the broad, relatively shallow eastern margin of Cockburn Sound between Woodman Point and James Point. There will be significant changes to ecological processes and major environmental alteration to these areas.

During prolonged construction periods (up to several years), breakwater placement and dredging will smother or remove marine life on the sea bed, and sediments will be disturbed, and may result in the release of nutrients, the mobilisation of toxicants and reduction in light regimes. Depending on the configuration, sequence and method of breakwater construction, water exchange between the harbour site and surrounding areas may be significantly inhibited during this period.

After construction, water currents along the eastern margin will be obstructed by harbour developments of the type examined and the length of time required to flush these sites will be increased.

The deeper, calmer waters inside developments will encourage accumulation of fine particle deposits and episodes of increased turbidity due to shipping movements. Under certain conditions, these areas will experience periods of reduced mixing between bottom and surface waters.

Lengthened flushing times will magnify the impacts of local (within harbour) nutrient sources, resulting in accumulation of total nutrients, greater nutrient assimilation and more algal biomass within the breakwaters.

There will be an increase in the deposition of dead algae to the sediments.

Increased deposition of fine organic particles and decreased bottom light levels, due to greater depth and turbidity, will increase sediment respiration and the likelihood of oxygen depletion in bottom waters and sediments. Reduced mixing would reduce the likelihood of oxygen replenishment of bottom waters and marine sediments.

Under these conditions there is likely to be a shift in the processes of nitrogen recycling from the sediments, with a reduced ability for the sediments to denitrify (and export biologically unavailable nitrogen gas to the atmosphere) and an increased tendency for the release of

ammonia and the build-up of dissolved inorganic nitrogen, which is readily available for biological uptake and algal growth.

Density-stratified, turbid, nutrient-enriched waters tend to favour development of dinoflagellate blooms. It is possible for dinoflagellate cysts to accumulate in high concentrations in bottom sediments and to act as seed populations for more widespread blooms.

Changes in bottom sediment type and oxygen depletion in bottom waters could lead to loss of filter-feeding animal communities, reducing phytoplankton loss rates and thus resulting in higher concentrations of phytoplankton in the water.

Decreases in light levels at the sea bed, due to increased depth and enhanced water turbidity, will lead to decreases in microscopic plant communities that dwell on the sea bed (microphytobenthos). Microphytobenthic production is presently likely to be high on the eastern margin, and so reduction or loss of these communities may significantly affect sediment oxygenation, nutrient cycling and ecosystem function within the harbours.

With the projected growth in shipping there is an increased risk of toxic species introductions (for example from ballast water discharge). The risk that abundances of toxic species could build up to unacceptable levels would be exacerbated by an increase in the area of poorly flushed, turbid waters which could result from the projected developments.

Other pest species, such as the fan worm *Sabella cf. spallanzanii* or the algae *Caulerpa taxifolia* and *Codium fragile tomentosoides* are more likely to become established in disturbed areas. The projected harbours may therefore act as additional sites of introduction, both because of disturbed habitat and because of the frequent movement and servicing of ships that may carry these organisms in their hull fouling.

Much of the seagrass meadows that once covered the eastern margin have been lost. Construction of the harbours would result in further loss of remaining seagrass habitats and would also sacrifice the potential opportunity for re-establishment of seagrasses in these areas. Re-establishment of seagrasses across the eastern margin will require sustained reductions in nutrient inputs to achieve and maintain water quality and light climate conditions which would allow seagrass survival and growth. The availability of appropriate seagrass establishment technologies would also be required, and these are currently being researched.

The major toxicant of concern will continue to be tributyltin (TBT), which is leached into the water from antifouling paints on the hulls of vessels. An increase in the total number of ship-days in the harbours will increase this input. If hull cleaning and repainting of hulls is permitted in these harbours, the release of TBT will be further increased. TBT concentrations in waters and sediments are likely to have significant impacts on sensitive marine biota, particularly shellfish.

Concentrations of contaminants such as petroleum hydrocarbons and trace metals in biota which frequent or are resident in the harbours are likely to be elevated, compared to species in the broader Sound. These contaminants occur in industrial discharges and in runoff and inputs associated with harbour development infrastructure. Oils, greases and other hydrocarbons may lead to tainting of fish.

There is potential for chronic and accidental spills of nutrients and contaminants during loading and unloading of ships.

(b) Between harbours (on the eastern margin of Cockburn Sound)

The placement of several large-scale developments along the eastern margin will leave marine areas between the developments (or between developments and the coast) which are of similar size to the developments themselves. For the major developments scenario, the size of these

inter-harbour areas is estimated to be 380 ha, i.e. about 15 % of the eastern margin between James Point and Woodman Point. Environmental alterations and changes to ecological processes are likely to occur in these areas.

During construction, dredging of access channels will result in the removal of bottom-dwelling marine life from portions of the inter-harbour areas. There is potential for release of nutrients in sediment pore waters, toxicant mobilisation, siltation and light reduction arising from dredging these channels and from dispersion of waters while dredging within harbour confines. Both suspension feeders and photosynthetic organisms may be affected and there may be changes in species composition. The magnitude of these effects would depend upon the configuration of the inter-harbour areas, their flushing times and the length of the construction period.

Post-construction, the flushing times of these inter-harbour marine areas are likely to be significantly lengthened because of obstruction of flow by adjacent breakwaters.

The cumulative effect of a number of large-scale developments along the eastern margin is likely to be a reduction in the rate of exchange of water between the inner eastern margin and the remainder of the Sound.

Vertical mixing and bottom stress (from the action of wave-induced currents near the sea bed) will be reduced in regions between or adjacent to harbours.

Lengthened flushing times, reduced mixing and reduced bottom stress in conjunction with nutrient loads will lead to changes in water quality, nutrient cycling and biological effects which are qualitatively similar to those predicted within harbours. There is also potential for exchange of water containing high nutrients, phytoplankton biomass, turbidity and depleted oxygen between harbours and adjacent regions.

To the extent that multiple harbours lead to low flushing over an extended region along the eastern shore, there is potential for trapping of nutrients originating outside this region, e.g. the groundwater and industry nitrogen loads south of James Point.

If zones between harbours contain sufficient shallow habitat, there is potential for development of a high biomass of drift and attached macroalgae.

Increased inputs or delayed flushing of contaminants, including TBT, may affect sensitive marine biota, particularly shellfish, and prejudice their suitability for commercial use.

(c) Broader Cockburn Sound - beyond the harbour and inter-harbour areas.

During prolonged construction, there is likely to be movement of nutrients, toxicants and turbid waters from the vicinity of the harbour developments into areas of the broader Sound.

The short model runs and limited analyses conducted in the period between the technical workshops do not permit comment at this stage on the effects of several major harbour developments on the flushing time of the broader Sound, or on the water residence times in regions of the Sound well away from the developments.

It is likely that, under a range of meteorological conditions, water will be transported from the eastern margin into the broader Cockburn Sound. The eastern margin harbour developments may therefore represent sources of lower quality water to parts of the Sound which have long residence times.

It is possible that the developments could increase the proportion of the nitrogen load from the eastern margin of the Sound which is transferred to the deeper central basin. This could occur through a reduction in denitrification efficiency of the sediments on the eastern margin and an increase in the dissolved inorganic nitrogen released to the water column.

Nutrient and chlorophyll levels in some parts of Cockburn Sound may favour development of harmful or nuisance blooms. If harbours or adjacent areas act as a seed area for dinoflagellates, there is potential for these to spread to other nutrient-enriched parts of the Sound. This may impact commercial exploitation of filter-feeders (e.g. mussels). Similarly, pest species such as macroalgae or worms, initially established in the harbours, may spread, with potential to alter the functioning of ecosystems in the Sound.

The proposed and projected harbour sites cover a substantial proportion of the seafloor within the Sound where light levels were once sufficient to support the growth and survival of perennial seagrass meadows. Harbour construction would permanently deepen these sites, thus significantly reducing the total area available for benthic photosynthesis.

Information Requirements

It was the EPA's intention that this Statement of Advice should be provided within tight time constraints, based on available information and the marine scientific experience of the workshop participants. The workshops were expected to identify a number of areas where improved knowledge and understanding would be needed if the Government and the EPA were to seek more detailed and quantitative advice on the ecological response of Cockburn Sound to harbour development scenarios. While acknowledging that much environmental data exists for this region, the workshops nonetheless identified a number of critical areas where further information would definitely be required. These critical information requirements are detailed in section 7.3. It is strongly recommended that a programme to carry out the necessary investigations be prepared and supported.