EIA Services for New Rapid Bay Jetty

ENVIRONMENTAL ASSESSMENT

- Final Report
- 30 March 2007

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1 Executive Summary

Rapid Bay jetty is located approximately one hundred kilometres south of Adelaide, South Australia. The jetty was originally associated with a quarry, but ceased commercial activity in 1990, and has since been a popular recreational area. The site supports some of the most diverse marine flora and fauna on the Fleurieu coast and is regarded as one of the best jetty diving locations in Australia and is frequented by anglers. However, because of age related decay of the jetty and recent storm damage, the structure has become a safety hazard, and was closed in 2004.

This report comprises an environmental impact assessment for the development of a new jetty parallel to the original structure and considers the potential impacts of the pile testing and construction activities. The area hosts a significant biodiversity and a number of species listed under the Environmental Protection and Biodiversity Conservation Act (1999) may occur in the area. Of particular interest is the EPBC listed Leafy Seadragon (*Phycodurus eques*) which is known to frequent the area.

Surveys conducted as part of this study indicate that the footprint of the proposed development lies mostly over bare sand, with seagrass and algal areas only at the distal and proximal ends of the alignment. Impacts on the flora at the site should thus be minimal. The majority of the faunal biodiversity at the site occurs beneath the existing jetty, and should not be significantly impacted by the construction of a new jetty. Mitigation measures should be employed however, to ensure that construction activities cause the minimum possible disturbance, particularly with respect to the impacts of noise, turbidity and vibration, particularly from blasting (if used). Construction methods which aim to minimise adverse impacts on the environment will be optimised via a test piling procedure before the main construction commences. It is recommended that pre and post construction monitoring of the flora and fauna communities be performed, and follow-up monitoring schedules be established to ensure recovery of damaged areas and assess any on going impacts of the development.

The construction of a new jetty is preferable to rebuilding of the existing jetty, as environmental impacts of the latter are likely to exceed those of the former.

2 Introduction

2.1 Background

Rapid Bay is located approximately 100 km south of Adelaide near Cape Jervis and consists of a small town, limestone and dolomite quarry and a long jetty formerly used for shipment of limestone and dolomite to various locations. The jetty is an important recreational resource and is popular with anglers and divers as it provides for deep water fishing and is rated as one of the top ten jetty dives in Australia. The area is also significant in terms of marine biodiversity.

The South Australian Department for Transport, Energy and Infrastructure (DTEI) has proposed to construct a new jetty to replace the existing jetty which has fallen into a state of disrepair and is no longer safe. This report comprises an assessment of marine flora and fauna at the site focussing on the new jetty alignment and discusses possible impacts of the development. Mitigation measures to manage environmental impact during construction are also discussed.

2.1.1 Rapid Bay Jetty

Rapid Bay Jetty was built in 1941 by Broken Hill Proprietary as part of the development of a dolomite and limestone quarry at the site. It is 488 metres long, with a 200 metre wide T-section at its distal terminus, and is oriented primarily north–south. While originally constructed of steel and timber piles, reconstruction work in the 1950s and 1960s replaced much of the original timber piles with steel.

Ownership of the jetty was transferred to the South Australian Government in 1981 and it was subsequently leased to Adelaide Brighton Cement Ltd (who had taken over operation of the quarry). The jetty was last used commercially in 1990 and subsequent limestone shipments have been conveyed by truck. All but the shoreward 130 metres of the jetty was closed in 2004, as the structure was deemed unsafe.

2.1.2 Flora and fauna at the site

The Rapid Bay Jetty provides considerable substrate for marine flora and sessile invertebrates which in turn attract mobile invertebrate and vertebrate species. The length of the Jetty provides a large area of habitat and also spans shallow and deep water (up to ~10 m), thus providing a range of environments for marine organisms. In comparison with other sites in the lower Gulf St Vincent and Investigator Straight, the Rapid Bay Jetty area hosts approximately double the number of fish species and supports a high abundance of many species (Shepherd 2005).

Species of interest include the protected Leafy Seadragon (*Phycodurus eques*), and deeper water species rarely seen inshore including Silverbelly, Black-spotted wrasse, Rough leatherjacket, Western Cleaner clingfish, Bullseyes and Black-throated threefin (Shepherd 2005). The site also provides a nursery haven for several species and includes fish cleaning stations near some piles which are biologically important for fish health.

Rapid Bay Jetty lies within the proposed Encounter Marine Park – the first of South Australia's proposed marine protected areas. As a "Habitat Protection Zone" within this park, the area is intended to "provide protection for species and habitats … whilst allowing activities and uses that do not harm habitats or the functioning of ecosystems," (see www.environment.sa.gov.au).

2.1.2.1 Leafy Seadragon (*Phycodurus eques*)

Leafy Seadragons are found in the southern waters of Western Australia and in South Australia, and extend into Victoria. This species is protected within South Australia (*Fisheries Act 1982*; though DTEI is not bound by this Act) and listed under the *Environment Protection and Biodiversity Conservation Act (1999*). It is a slow moving animal that relies on its camouflage for defence, and lives among protected sites including seaweed beds and seagrass meadows where it feeds on small invertebrates. There are only two species of seadragons globally, and the Leafy Seadragon is South Australia's marine emblem. It is a significant attraction for divers to the site.

2.1.3 The New Jetty

The proposed new jetty will be constructed parallel to the original structure, a minimum of 10 m to the east at the beach end and approximately 30 m at the seaward end. The structure is proposed to be approximately 300 m long, with no T-section at the seaward terminus. This construction has the potential to impact on benthic flora along the alignment and cause disturbance of other flora and fauna communities. As part of the management program, the superstructure at the landward end of the existing jetty will be removed thus preventing easy access to the remaining structure.

The new jetty will consist of approximately 25 twin pile bents, supporting a pre-cast concrete deck. The nominated piles are steel tubes 610mm in diameter with 12.7mm wall thickness, with a rake of 1 to 5. The exact number of piles required will depend on the results of a series of test piles that are to be installed prior to the final design.

Piles will be driven in with a hammer weight of up to 8 tonnes. The driving of the piles and possible need for blasting of the founding rock will result in transient vibrations throughout the soil and rock strata, as well as through the surrounding seawater, which may have the potential to affect local sea grasses and the substrate they are growing on. There is a possibility that the seabed sediment may move under this vibration. It is therefore necessary to understand how these vibrations are attenuated to assess the extent of this movement.

2.2 Flora and Fauna Survey

The original EIA for the Rapid Bay Jetty (KBR 2005) identified 26 marine fauna species as nationally threatened or listed under the *Environment Protection and Biodiversity Conservation Act*, *1999* and a moderate diversity of marine flora. The report concentrated on the flora and fauna beneath and on the existing jetty and did not include the surrounding area. Since this survey was undertaken, the scope of the development has changed to the construction of a new jetty approximately parallel to and eastwards of the existing jetty. Therefore a new environmental impact assessment is required. This report thus includes and expands upon the scope of the original report, and covers all of the species listed in the original report.

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3 Methods

The site survey was conducted on the 21 and 22 of February 2007. Conditions at the time of the sampling were good with generally light winds from the ENE with a flat sea and no swell. No significant current was noted, except during the morning of the 22 February. Geographical coordinates for all survey sites were recorded using a hand held Garmin GPS76 in WGS84 datum.

There were three main components of the survey undertaken.

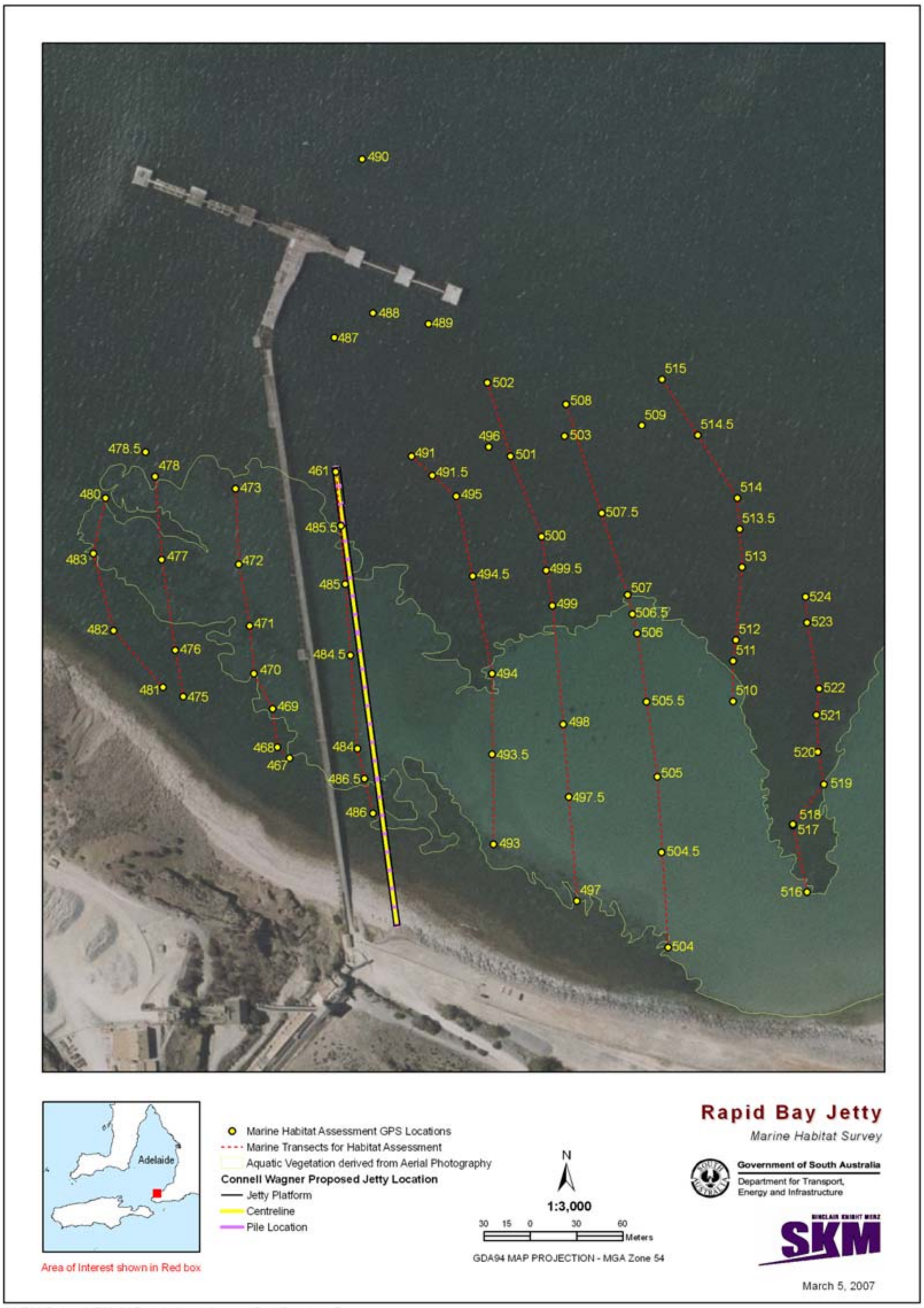
- Surface transects and ground truthing to map the distribution of seagrass at the site.
- Description of habitats along the proposed new jetty alignment.
- Underwater survey work incorporating video transects, photography and identification of species present along the existing Rapid Bay Jetty and surrounding seabed.

3.1 Habitat Mapping

Initial aquatic vegetation was captured in ArcGIS by digitizing the outline of aquatic vegetation visible on 2005 digital aerial photography provided by DTEI (Image resolution 0.5 m). In preparation for the marine survey, an ArcGIS layer was created to display the location of eight potential field transects. Proposed transects were located parallel to the proposed alignment of the new jetty at intervals of 50 m. Four transects were located on the eastern side and four on the western side of the proposed structure. A map was then created displaying the distribution of aquatic vegetation, the existing jetty location, and proposed location of the future jetty along with proposed transect locations and reference GPS points (for quality control purposes).

After initially examining the project area, it was decided to establish a total of nine transects which ran approximately parallel to the existing jetty. This was deemed the most effective means for mapping of the habitats and to ground-truth areas identified on the aerial photograph. Three transects were located to the west of the existing jetty while five were established to the east. One transect was established along the alignment of the proposed jetty. Survey points were then established on each of the transects. In all a total of 56 survey points were established along the nine transects (see Figure 1).

The survey was conducted by boat commencing from the shoreward end of each transect (see Figure 1) and extended approximately 350 m from shore. An underwater viewer was used to identify habitats and/or species from the boat, combined with spot snorkelling where species could not be confirmed from the surface. In this manner, linear composition of the benthic flora in the project area could be determined and mapped as indicated on Figure 2. Detailed habitat descriptions and GPS locations were recorded for each of the survey points. These are provided in Appendix D.



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- **Figure 1 Map of Rapid Bay Jetty area and transect locations**

GPS locations and associated detailed habitat descriptions were imported into GIS and used to generate a data layer. The habitat description was then reviewed and grouped into the following generalised habitat types:

- *Amphibolis sp.* seagrass
- Macroalgae
- *Posidonia* sp. seagrass
- Mixed Seagrass
- Mixed Seagrass/Macroalgae
- Sediment/Bare Sand

Generalised habitat points and detailed habitat points were then overlayed with aquatic vegetation and aerial photography. A polygon layer representing generalised marine habitat was then created by tracing isoclines of similar habitat description. To simplify the interpretation of the habitat types within the study area, a total of four habitats were mapped according to the dominant habitat type. These were:

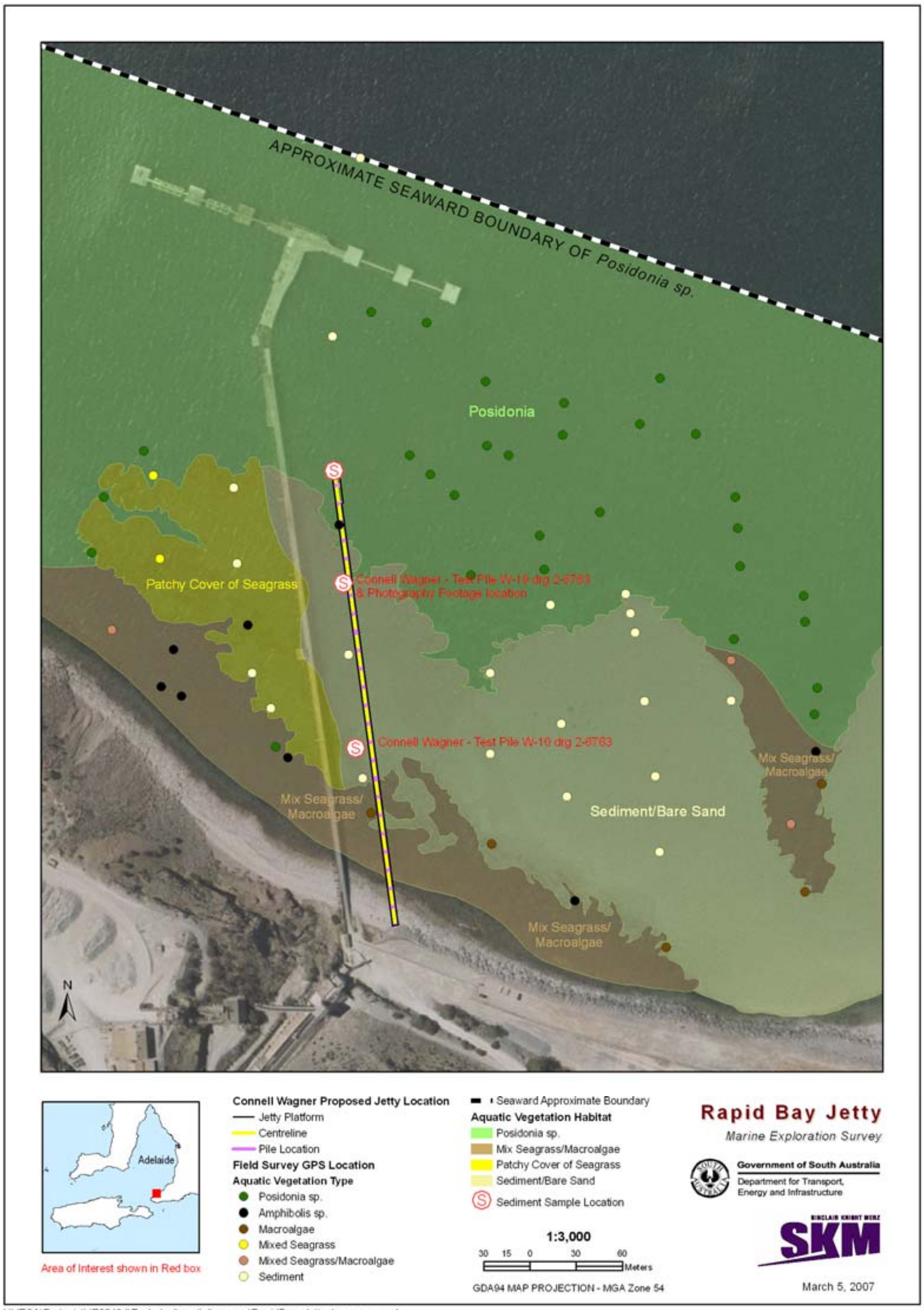
- *Posidonia sinuosa*
- Mixed Seagrass/Macroalgae
- Patchy Cover of Seagrass
- Sediment/Bare Sand

3.1.1 Proposed Jetty Alignment

Divers conducted several transect dives along the proposed jetty alignment to document the flora and fauna present. Samples were collected and photographed underwater to ensure accurate identification. A video transect was taken along the alignment of the proposed development to document species present and changes in species composition over the length of the proposed jetty. This ground truthing was combined with satellite imaging data to reconstruct a map of the benthic flora at the site (Figure 2). A complete list of the fauna species observed is included in Appendix A.

3.1.2 Existing Rapid Bay Jetty

Several dives were also conducted at various locations around the existing jetty to document the dominant flora and fauna present and to identify any significant species present.



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- **Figure 2 Composition of benthic flora in project area.**

4 Existing Conditions

4.1 New Jetty Alignment

The proposed new jetty alignment intersects a large area of bare seabed and proportionally smaller areas of seagrass and macroalgae. The dominant seagrass (based on area covered) along the proposed alignment was *Posidonia sinuosa*; however, its distribution was generally limited to the seaward end of the proposed jetty. Some *P. sinuosa* was also present as discrete patches closer inshore; however, the seagrass *Amphibolis griffithii* was much more common in the shallow inshore area. The shallow subtidal zone close to the shoreline consisted of a mixture of brown macroalgal species namely, *Caulocystis* sp., *Sargassum* sp., *Cystophora* sp. and the alga *Scaberia agardhii.*

Common epifaunal species noted along the proposed alignment were the queen scallop, *Equichlamys bifrons,* the stalked ascidian, *Pyura australis* and the eleven armed starfish, *Coscinasterias muricata*. Fish present along the seabed alignment included Silverbelly, *Parequula melbournensis,* Goatfish (Southern red mullet), *Upeneichthys vlamingii*, Magpie perch *Cheilodactylus nigripes* and the Western shovelnose stingaree, *Trygonoptera mucosa.*

A full species list of recorded flora and fauna is provided in Appendix A and images of some species are provided in Appendix B.

4.1.1 End of Proposed Jetty

Depth at the end of the proposed alignment was ~7.2 m (~1000 CDST, 22/02/07). Sediments were composed of coarse sand and gravel with some silt. Areas of bare seabed 'blowouts' were surrounded by dense beds of *Posidonia sinuosa* and *Amphibolis griffithii*. Some smaller areas of seabed were covered by a sparse cover of *Heterozostera tasmanica* and *Halophila* sp.

Simple probing of the seabed with a steel rod found that there was significant resistance and that the gravel was quite dense. Some additional probing within a couple of metres of the initial probe found that the sediment was much softer and that penetration was possible to about 0.7 m.

4.1.2 Outer Test Site (CW – W19)

Depth at the Outer Test Site was ~6.0 m (~1000 CDST, 22/02/07). Sediments were predominantly gravel and coarse sand. The seabed was generally devoid of seagrass apart from a patchy, sparse cover of *Zoster Sp*. Epibenthic species noted in the immediate vicinity were the razor shell, *Pinna bicolour* and the scallop, *Equichlamys bifrons.* Probing of the seabed found significant resistance with the probe only able to penetrate to less than 0.2 m.

4.1.3 Inner Test Site (CW – W10)

Depth at the Inner Test Site was ~4.0 m (~1000 CDST, 22/02/07). This site was close to the edge of a large, barren sand area that extended northward toward the Outer Test Site. Shoreward of this point, the seabed was covered by an extensive meadow of *A. griffithii* interspersed with patches of *Caulocystis sp*., *S. agardhii* and *Zostera sp*. The seabed also graded from flat and featureless into a field of boulders. Similar to the Outer Test Site, probing of the seabed found significant resistance with the probe only able to penetrate to less than 0.2 m.

4.2 Habitat Mapping

The habitat map of the study area including the proposed new jetty alignment is shown in Figure 2. Much of the inshore area was composed of a complex mixture of seagrass and macroalgae. This complexity made mapping problematic, and thus regions were mapped according to the dominant flora types into four categories (see Section 3.1).

4.2.1 Posidonia sinuosa

The seagrass, *P. sinuosa* (Figure 3) was the dominant seagrass species near Rapid Bay Jetty, particularly between six and nine metres in depth. Although it was also common in the shallower inshore areas it did not occur as an extensive meadow as in the deeper water. *Posidonia* species are the dominant seagrass in South Australian waters, particularly in Gulf St Vincent and Spencer Gulf where they occupy more than 5,000 km^2 (Kirkman 1997).

- **Figure 3 The seagrass, *Posidonia sinuosa***

Blowouts (Figure 4) in the *Posidonia* meadow were noted at several locations, including around the end of the proposed jetty. These can occur naturally due to severe storm damage and may explain the total absence of *Posidonia* between three and six metres in depth to the east (and west) of the existing jetty.

- **Figure 4 Blowout in Seagrass Meadow**

4.2.2 Mixed Seagrass/Macroalgae

Much of the inshore areas were covered by dense seagrass and macroalgae. Figure 5 shows a variable cover of *Amphibolis griffithii* interspersed with patches of *Caulocystis* and *Scaberia*.

- **Figure 5 Typical Mixed Seagrass/Macroalgae Habitat**

4.2.3 Patchy Seagrass

Much of the area to the west of the existing jetty consisted of patchy areas of seagrass (both *Posidonia* and *Amphibolis*) interspersed with large areas of sand and gravel. Many of the patches were relatively small (Figure 6) and could not be mapped at the appropriate scale.

- **Figure 6 Patchy cover of *P. sinuosa***

4.2.4 Sediment/Bare Sand

Much of the proposed jetty alignment overlies areas of bare sediment. The sediments consist of coarse gravel and sand but smaller areas of fine sand were noted to the east of the existing Jetty. Figure 7 shows typical seabed conditions in the immediate vicinity of the proposed jetty alignment. The seabed was contoured by sand waves, indicating the area is probably exposed to significant wave energy.

■ **Figure 7 Typical Seabed along Proposed Jetty Alignment**

4.3 Marine Communities

The marine communities in the vicinity of the Rapid Bay jetty can be broadly classified into two distinct groupings.

- Flora and fauna associated with the piles and jetty.
- Flora and fauna associated with the seagrass habitat and general seabed.

4.3.1 Rapid Bay Jetty

The ecological significance of Rapid Bay has been described previously by KBR (2005) and by other specialists (Shepherd 2005). The fish fauna in particular are numerous and diverse and represent a diversity hotspot for the region (Shepherd 2005). The invertebrate fauna is also comparatively rich and consists of a diversity of hydroids, sponges, ascidians and seastars. The flora and fauna associated with the existing jetty are summarised in list form in Appendix A, and images are provided in Appendix B.

It was also noted during the survey that diversity of invertebrates and fish appeared to be much higher at the T section of the existing jetty than along the length of the main section of jetty. It has been shown in previous studies (Storrie et al. 2003) that the wider the jetty the more diverse the marine life beneath. This is largely a function of shading which reduces algal competition for encrusting fauna. Over time, it is likely that the new jetty will become colonised by a similar suite of species to that of the existing jetty, however species diversity may be lower due to the configuration of the proposed jetty.

4.4 Seabirds

Several species of bird use the seaward end of the existing jetty as a roosting site. Noted species included a large number of Crested terns (*Sterna bergii*) and several Black-faced cormorants (*Phalacrocorax fuscescens*) and Pacific gulls (*Larus pacificus*). All are listed marine species under the EPBC Act (1999).

4.5 Other species

Appendix C comprises a tabular listing of all EPBC listed species likely to occur in the area, based on a desktop search using the Department of Environment and Heritage's online environmental reporting tool. Species of note include the endangered terrestrial Osborne's Eyebright (*Euphrasia collina* subsp. *osbornii*), which may occur in the area but will not be impacted by the development.

5 Geotechnical Assessment

5.1 Site Conditions

5.1.1 General

The seabed has a gentle 2% slope, reaching a depth of approximately 7m below sea level at the end of the jetty. The shoreline is characterised by a number of medium to large cobbles and boulders, which also exist in the surf zone in the vicinity of the site. The bedrock is overlain by silty and clayey gravels, which appear to be medium-dense, thus having a likely relative density of 35% to 65%. The seabed soils have a rippled appearance, suggesting that the entire site is subject to reworking by currents and wave action.

In order to confirm the suitability of the proposed piles, at least four raked test piles will be constructed along the length of the proposed jetty, at approximate distances of 10.5m, 12.9m, 15.7m and 18.2m from the shoreline. Depending on the results of the test installation, other test piles may also be installed.

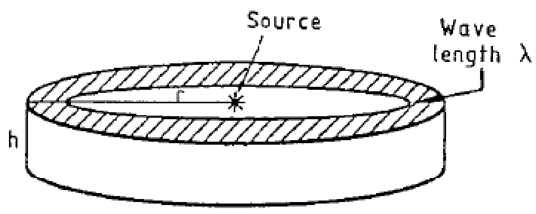
5.1.2 Geotechnical Information

Geotechnical information was obtained from a borehole survey performed in 1938 for the existing jetty, summarised in the Preliminary Design report provided by Connell Wagner (2007). Inferences have also been made from observations and sampling of seabed conditions. The Connell Wagner report indicates that limestone bedrock is expected to be encountered approximately 150mm below the seabed for the first 200m of the jetty, and thereafter at a depth of 1 to 2m. The Connell Wagner report also notes that drilling and blasting was required in some instances for the installation of timber piles for the construction of the existing jetty. It is anticipated that piles for the new jetty will be driven at least 4m into the limestone.

5.2 Vibrations caused by Construction

5.2.1 Source of Vibrations

Driving of piles or blasting of bedrock has the potential to cause vibrations throughout the rock, soil and overlying seawater. Of most concern in this regard is the effect of Rayleigh surface waves (R-Waves) which, as their name suggests, travel along the surface of the seabed. These waves contain up to 2/3 of the energy of a point source blast, and thus have the potential to uproot sea grass, or to roll boulders or cobbles. Figure 8 shows schematically how an idealised surface wave propagates.



- **Figure 8: Surface wave schematic (Hart and Plesiotis, 1993)**

Vibrations can also leave the surface of the seabed and propagate through the overlying seawater as a compressional 'p'-wave and, where the depth of the water is insufficient to adequately attenuate the wave, through the air above. The interaction of the water and air as the vibration propagates across the boundary of the two transient media causes a partial reflection (inversion) of the wave through the water, propagating the wave further.

Vibrations through the water behave in a similar manner to blast waves in air, and attenuate rapidly, as the surface area of the blast face is proportional to the square of the radial distance, r.

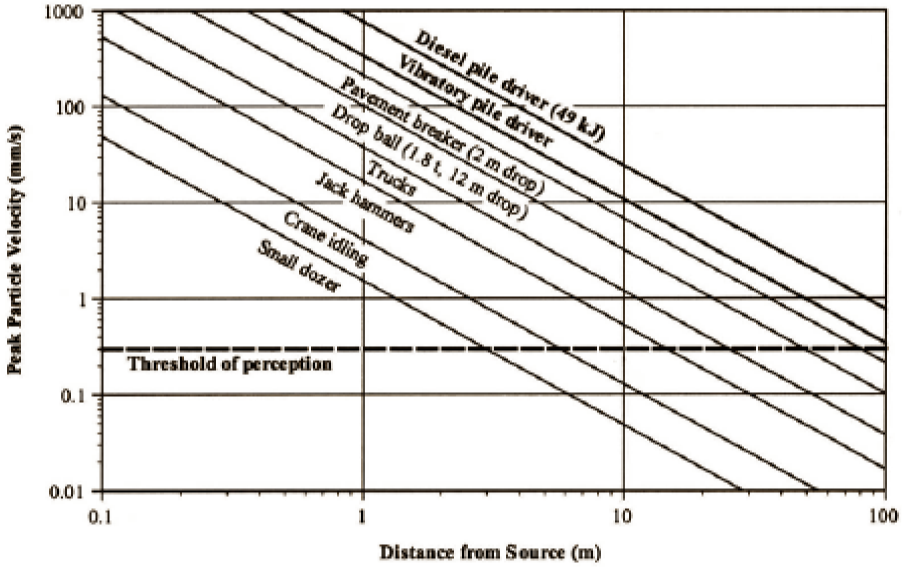
5.2.2 Geotechnical Concerns

Surface vibrations which arise from driving or blasting have the potential to cause liquefaction of loose soils, or induce higher settlements than may be desirable. However, it is considered unlikely that liquefaction will occur, given that the soil is relatively well-graded, and does not appear to be in a loose state. Whilst some settlement may occur in the vicinity of the pile driving or blast, the use of blast mats will minimise the energy at the surface and thus the amount of settlement induced.

No Australian code provides guidance on this issue, however German code DIN4150, recommends that a maximum peak particle velocity (PPV) of 6mm/s at the surface should be adopted as the target threshold to avoid settlement of the sediments near the surface. Further to this, the code recommends a threshold PPV for structural damage in the order of 100mm/s. It can be assumed that this PPV would also apply to low to medium strength rocks, which have similar strength characteristics to concrete.

5.2.3 Vibrations due to Pile Driving

Figure 9 shows an attenuation curve, published by Jaksa and Grounds (2002), showing how PPV relates to the distance from the source. This can be used to estimate how much attenuation occurs as vibrations arising from pile driving move through the ground.



- **Figure 9: Attenuation curve for vibrations through soil/rock**

The Connell Wagner report indicates that the piles will be driven by a hammer up to 8 tonnes in weight. Assuming a drop height of 1m is used, each blow will impart energy of up to 78kJ. According to Figure 9, this would result in a PPV greater than the 100mm/s required to break up the rock within approximately 2 to 3m.

As previously indicated, settlement of near surface, non-cohesive sediments is unlikely where the PPV is less than 6mm/sec. Thus, wherever the PPV resulting from each blow is below this upper limit, the seabed sediments and thus the sea grasses rooted in them should remain undisturbed by the vibrations. Following the example given above, and assuming energy per blow of up to 78kJ, a PPV of less than 6mm/s will be reached at approximately 20 to 30m from the pile.

It is important to note that the driving methodology is yet to be finalised, and these calculations are only indicative of the likely magnitudes which can be expected based on the information available.

5.2.4 Blasting

In order for blasting to be an efficient means of installing the piles, vibrations which result from the blast must be sufficient to break up the rock in the zone of influence while minimising the impact of the blast on the surrounding environment. Thus, the contractor should aim to use an amount of explosive sufficient to generate sufficient blast energy in the required zone of influence, whilst at the same time aiming to minimise the blast radius at which a PPV of 6mm/s is felt at the surface, in order to restrict any adverse affects to the seagrasses in the immediate vicinity of construction.

It is known that a surface explosion in open air transmits more than 90% of its blast energy to the surrounding air, and very little into the ground. Similarly in this case, any blast close to the surface of the seabed will transmit most of its energy into the surrounding water. Not only will this have undesirable affects on marine flora and fauna and produce strong surface ‘R’-waves and cratering, but is an inefficient use of the energy of the blast. Thus, any blasting which occurs should be stemmed deep enough beneath the seabed to minimise PPVs at the surface, whilst still achieving the necessary blasting of surrounding rock. Jaeger and Cook (1979) present an equation for peak particle velocities in rock due to blasting:

$$V = H\left(\frac{W^{1/2}}{r}\right)^{n}$$

Where H = 121.1 & n = 1.67, W is the mass of the charge and V is the PPV (‘H’ and ‘n’ are constants; all values are in imperial measurements).

This differs slightly from the equation of the attenuation curve given in Figure 9, used for measuring vibrations from driving processes. For example, in order to reach a PPV of 100mm/s in a 2m radius around the charge, the blast would need approximately 400g of ANFO (Ammonium Nitrate Fuel Oil). A blast of this magnitude will create a PPV in excess of 6mm/s (limit of soil disturbance) to a radius of approximately 11m.

It is important to note however that these calculations are only indicative of the magnitude of the blast and its zone of influence which can be expected for this purpose. Actual determination of quantities and types of explosives (and their specific characteristics) is the responsibility of the relevant contractor.

5.2.5 Potential affect of vibrations on Flora

Observations of the seafloor suggest that disturbance of the macroalgae and sea grass populations occur naturally from storms. Disturbance of the macroalgae can occur when the rocks on which they grow are rolled by strong waves. In a similar manner, seagrass, which is abundant only at water depths greater than 5m, can be damaged or uprooted by storm surges creating waves which are large enough to scour the seabed. The Bureau of Meteorology defines this sea state (waves in excess of 5m) as ‘Very Rough’. A number of bare erosion zones which exist within the sea grass beds at water depths of 5-7m suggest that may occur on occasions, however the influence of the strong currents that prevail in this area are unknown. Other studies suggest that seagrass is unlikely to grow back where the root mat is damaged, or where troughs or craters form.

Vibrations arising from the construction process will adversely affect the local flora, in particular the seagrass, in the immediate vicinity of the installed piles. Whilst 6mm/s peak particle velocity should be adopted as the recommended target threshold to ensure no damage occurs, it is likely that the seagrass will be able to tolerate vibrations of higher magnitudes, approaching the energy carried by naturally occurring destructive waves. This is because the grass appears to be well-rooted, and thus should not be affected by minor soil movements. The formation of troughs or craters due to any blasting may also have an adverse affect on seagrass, particularly with respect to regrowth of damaged (but not removed) plants.

Test pile results will give a better indication of the threshold energy for damage to the local seagrasses. There is currently no test piles planned for deeper water, so it is recommended that one test pile be constructed within the seagrass habitat. Monitoring of both PPVs resulting from these tests, and subsequent seagrass damage will provide a much better indication of the potential damage which may result, allowing for a more robust review of the construction methodology. Finally, drilling and grouting should be considered as a potential alternative construction method for piles in place of driving or blasting, as this will reduce the need for vibration mitigation.

6 Impact Assessment

An assessment of marine impacts from construction of a new jetty at Rapid Bay can be broadly divided between construction and operational impacts. The significant impact generating processes from construction are primarily due to the construction of the jetty (from piling), while the main operational impact is likely to be due to the physical presence of the proposed structure. As the jetty will be used primarily for access by divers, anglers and tourists, impacts usually associated with shipping and accidents (from spillages) will be limited to, and depend on the scope of, construction activities.

6.1 Mooring

Installation of a mooring buoy has been proposed to provide safe anchorage for boats. Moorings and anchors have the potential to disturb benthic habitat such as seagrass meadows by uprooting seagrass plants resulting in significant scour. It is important that mooring buoys be placed over bare substrate where possible, to minimise disturbance to seagrass meadows. Risks associated with mooring activity in the area, including spillages and boat noise are a further reason for locating mooring activity away from seagrass meadows. Although the T-section of the jetty is of most interest to divers, and thus mooring for diving activities, location of a mooring buoy in close proximity will be detrimental to the area and thus should be avoided. However, relative impacts of a permanent buoy and repeated anchoring need to be weighed against each other.

6.2 Jetty Structure

The proposal is for construction of a 300 m long trestle jetty. It will consist of evenly spaced twin pile bents (approximately 25), supporting a typically 3.6 m wide deck (4.8 m wide at the last two seaward spans) that covers a total area of 1110 m^2. The preliminary design is based on a precast concrete bridge deck system supported by 610 mm diameter steel piles driven into the seabed. The preferred method of construction is to pile from a floating plant that is anchored to the seabed. A preliminary feasibility of alternative construction methods are discussed by Connell Wagner (January, 2007).

6.2.1 Jetty Construction

The major impacts from jetty construction are likely to be noise and disturbance from pile driving and associated activity e.g. anchoring of floating plant. Some habitats may also be affected by shading although this is unlikely if the proposed jetty is constructed at the same height as the existing jetty. There would also be localised short term turbidity from pile driving and boat movements (including anchoring).

6.2.2 Loss of Habitat

The total area of seabed that will be impacted by construction of the jetty is 1,110 m^2 (0.11 ha). Areas of habitat that may be impacted by the structure are summarised in Table 1.

- **Table 1 Areas of Habitat beneath Proposed Jetty**

Habitat Type	Area (m^2)	Relative Area (%)
Posidonia seagrass	225	20
Mixed seagrass/macroalgae	189	17
Bare sediment	582	53
Terrestrial (above high water)	110	10
Total	1106	

Piling will remove a relatively small area of seagrass (<5 m^2 in total) given that most of the piles will be driven into sandy seabed and that most of the *Posidonia* seagrass is near the head of the jetty. The length of the jetty could be shortened to avoid the dense bed of *Posidonia*, however the layout as detailed by Connell Wagner Pty Ltd (January 2007) intends that the end of the jetty be placed over seagrass for angling and diving purposes.

Removal of native vegetation including seagrass removal comes under the Native Vegetation Act (1991), and is regulated by DTEI's Vegetation Removal Policy (DTEI 2005). Under this legislation, the removal of seagrass associated with the proposed development is a level 1 (minor) impact, as it covers an area less then 0.5 Ha, and thus does not require referral to the Native Vegetation Council Secretariat. Although it could be argued that the removal is 'significantly at odds' with the Principals of Clearance (DTEI 2005) in that the seagrass 'has significance as a habitat for wildlife', given the extent of the seagrass and the limited nature of the impact into the seagrass community, the impact is not deemed to be 'significantly at odds' under this legislation.

Inspection of the existing Rapid Bay Jetty revealed that seagrass does occur beneath the existing structure but cover is patchy and generally sparse. The seagrass also tends to grow up to the jetty structure indicating that loss of seagrass through reduced light, caused by shading is highly unlikely. The greatest potential for seagrass loss is from anchoring associated with construction activities. As previously mentioned, impacts from anchoring in seagrass meadows (during construction) could be significant if not properly managed and could result in significant scouring. Scour holes are likely to persist as recovery of *Posidonia* meadows can be very slow (in the order of decades), (Kirkman 1997).

DTEI is currently planning to remove a section of superstructure from the beach end of the existing jetty to reduce the likelihood of people accessing the jetty. Piles are to remain intact and will not be removed unless considered a hazard. The loss of habitat resulting from partial demolition of the existing jetty is considered negligible.

6.2.3 Impacts from Turbidity and Sedimentation

Jetty construction has the potential to generate increased turbidity and sedimentation, but these increases will be extremely localised and transitory in nature. The main source of turbidity generation will be from the pile driving. Surface probing of sediments confirmed the presence of silt within the seabed which will be readily disturbed and mobilised by pile driving. Water movement around the jetty from currents and wind are significant and any plume generated is unlikely to persist. The actual impact from turbidity is difficult to ascertain prior to test piling, but the potential exists for impact extending to and beyond the existing structure depending on the level of silt in the seabed and the current and weather conditions during construction. As the T-section at the end of the existing jetty is most distal from the proposed alignment, there is a low likelihood of impact here. Nonetheless, activities that generate turbidity should be restricted to calm weather and times of low current regardless to minimise impacts.

6.2.4 Impacts from Noise

Pile driving is proposed over an unspecified time period, subject to the outcomes of the test piling works. Noise associated with jetty construction is usually dominated by intermittent high levels of impulsive sound generated by piling which is caused by ramming of the hammer onto the pile (CoA 1996). This level of noise is readily transmitted underwater and impacts will need to be further assessed once the construction schedule is available. Noise has the potential to impact significantly on marine fauna in particular, and may disturb residents and visitors to Rapid Bay.

6.2.5 Impacts from Pile Driving and Blasting

Underwater blasting to assist piling is not currently proposed but may be required subject to the outcome of the pile testing program. If blasting is required, safe distances and effects levels for marine organisms will need to be determined. As an example, a study by Teleki and Chamberlain (1978) found that the fatality radii caused by a 22.7 kg buried blast, varied between 15 and 50 metres. The estimated pressure at the perimeter of the fatality radii were 117 kPa and 30 kPa respectively and caused mortality in a number of post-larval and adult fish (Maunsell 1993).

Even though methodology for pile construction is dependant on results from the proposed test piling, it is recommended that blasting be considered only as a last resort, due to its relative inefficiency and potential for a greater environmental impact than driving. Pile driving is considered a less invasive procedure, and should be used where possible.

Given that the existing jetty is founded in the underlying bedrock, and given that the jetty is to be decommissioned and the superstructure removed, installation of the piles for the proposed jetty is

SKM

unlikely to have any noticeable affect on the existing structure. Further to this, any mitigation methods adopted to minimise environmental impact of the jetty construction will further minimise the affect of construction on the existing structure.

6.3 Mitigation measures

Mitigation measures should be employed during construction that address the concerns raised above, specifically the impacts of noise, sedimentation and turbidity, blasting and removal of habitat. The latter of these is an unalterable consequence of the development and cannot be mitigated *per se*, but may be addressed by monitoring procedures (see Section 6.4 below). Several mitigation measures that should be considered are listed in Table 2.

- **Table 2 Threats and mitigation measures**

Threatening process	Impacted flora and/or fauna	Mitigation measures
Blasting	Marine Vertebrates	Use of blast mats or bubble curtain to limit radiation of shock waves from blasting. Use of minimal amounts of explosive to achieve desired results as determined by test-piling. Burying charges can reduce the zone of lethality.
Anchoring (During Construction)	Seagrass and Benthic Communities	Minimise the number of anchor points and the frequency of moving anchor. Use of anchors such as Stingrays that self bury and are easy to remove without stripping seagrass cover.
Piling	Seagrass	A test pile in the seagrass habitat is recommended to assess impact resulting from the driving method.
Turbidity	Marine Benthic Primary Producers	Minimise the suspension of sediment from the seabed as much as practicable and where possible use silt curtains to contain turbid plumes.
Noise	Marine Mammals	Visual scanning for the presence of marine mammals within 3 km prior to commencement of works by construction personnel. A soft start process should be adopted for pile driving to allow fauna that are sensitive to noise to depart without risk of harm.

6.4 Future monitoring and mitigation

Further assessments of flora and fauna should be made subsequent to driving of test piles to verify predicted impacts and suitability of the methodology for minimizing damage to the surrounding ecology. In addition, post-construction and ongoing monitoring surveys will be required to assess the impact of the construction and the subsequent recovery of ecological communities.

Full follow-up surveys of flora and fauna, employing similar methods to this report, should be undertaken immediately after construction activities have been completed, and again at suitable periods to assess recovery of flora and fauna communities. The post-construction survey will provide a record of damage resulting from the construction relative to the information provided in this report, and provide a baseline for pursuant monitoring surveys. The appropriate timescale for monitoring surveys will be influenced by the results of prior surveys as more information becomes available, but an initial monitoring survey should be undertaken within 3-6 months of the post-construction survey. Due to the long recovery time for sea grasses, it is likely that monitoring surveys will have to be conducted, at increasing intervals, for several years.

The results of monitoring can be used to ensure that management of flora and fauna at the site is adaptive. This will permit the alteration of management procedures or adoption of new measures depending on the results of measures initially in place. Adaptive management maximises the chance of a successful recovery of impacted flora and fauna communities and will permit the rapid introduction of mitigation procedures should unforseen negative impacts develop as a result of the project.

7 Comparative Assessment of Construction Options

7.1 Key issues

Under consideration is the construction of a new jetty or possible the rebuilding of the existing structure. The positive and negative environmental and social issues of each are considered in Table 3.

▪ **Table 3 Comparative issues of constructing new jetty or rebuilding old jetty**

Rebuilding existing jetty		**Constructing new jetty**	
Positives	Negatives	Positives	Negatives
Flora			
Minimal impact on other seagrass	Damage to vegetation under existing jetty	Minimal impact to flora near or under existing structure	Impact of construction on seagrass from piling and mooring
Fauna			
	Impacts of construction activities (noise, blasting, turbidity etc) on existing fauna in area	New substrate for sessile animals and refuge for motile fauna	Impacts of construction activities (noise, blasting, turbidity etc) on existing fauna in area
	Higher impact on motile animals that use jetty as a refuge	Existing structure will provide large area for bird roosting	
	Damage to existing sessile fauna through replacing piles	Retaining old jetty means local communities exist to rapidly populate the new structure	
Social			
Aesthetic value of single jetty as opposed to two structures	Lag for redevelopment of flora/and fauna associated with jetty will impact scuba diving	New jetty can be designed with recreational use in mind	Possible negative visual impact of retaining old jetty
No interference with second structure for anglers		Retaining old jetty will add to diving and angling value of the site	Potential for existing structure to interfere with fishing activity on western side of new jetty
Bird communities unlikely to expand			Smell of bird faeces from bird roosting on existing structure likely to have negative impact on users of new jetty

7.1.1 Impacts on flora and fauna

The existing jetty provides a habitat for a high diversity of marine flora and sessile fauna, as well as a refuge for a variety of motile animals (mostly fish). Any rebuilding of this structure would destroy most of the sessile communities and impact motile species considerably. Destruction of sessile communities may result in a significant hiatus before the area is re-inhabited. Construction of a new jetty will have a lower impact on flora and fauna associated with the existing structure, but will impact some seagrass communities at the seaward end of the alignment.

7.1.2 Seabird roosting on existing jetty

The potential for increased bird activity on the existing jetty should be considered if a new jetty is constructed and people are excluded from the old structure. Although the jetty is officially closed now, many anglers continue to use a significant portion of the jetty which limits bird roosting. Cormorants and teals already nest on the seaward end of the jetty, and increased roosted should be expected if the jetty is totally closed. Although this could be considered a positive aspect for bird life, it is unlikely that the site will be used by species of conservation significance and, moreover, there are potentially negative impacts of such an outcome. Increased use as a roosting site will result in build up of bird faeces on the structure which produces a considerable odour. Other examples of isolated infrastructure becoming heavily populated with birds include the Tipirra Light at Cape Elizabeth and the northern Outer harbour breakwater, both of which produce a strong odour that impacts a considerable area (D. Simpson pers. com.). Given the proximity of the proposed new structure, it is likely that odour from bird faeces will negatively impact users of the new jetty during westerly winds. Depending on the extent of use by birds, the odour could also impact users of beach camping facilities and possibly residents of Rapid Bay. Birds themselves could also interrupt fishing activities and possibly be injured by the close association (e.g. through swallowing tackle).

7.1.3 Fishing amenity

Angling is a primary function of the jetty in either form, and amenity for fishermen should be considered. As mentioned above, construction of a new jetty leads to the potential for odour from bird roosting at the existing jetty and entanglement of fishing tackle in the structure of the existing jetty given its proposed close proximity.

7.1.4 Potential for demolition of old jetty

If a new jetty is constructed, the removal of the old jetty would ameliorate problems associated with angling in close proximity to the old structure and bird roosting. Ideally, the existing structure would remain on the sea floor to form an artificial reef. As legislation dictates that if the structure is demolished it must be removed, the only practical means of achieving this goal is to allow the jetty to decay by natural means, and given the already much degraded status of the structure this should not take too long. While this will obviously result in the destruction of most of the existing sessile marine fauna and flora using the piles as a substrate, it will have the benefit of mitigating other negative impacts of leaving the jetty, including bird roosting, safety issues relating to public use of the jetty, and potential problems of the jetty interfering with angling on the western side of the jetty. Furthermore the degradation will take time, and slow natural decay is preferred to demolition from a conservation perspective as not all the available habitat will be removed at once. The contemporary presence of both jetties will permit flora and fauna to populate the new structure before all of the old structure collapses, facilitating rapid colonisation of the new structure and conserving biodiversity from the old structure. The creation of an artificial reef will result in eventual improvement of the biodiversity of the area and will benefit fishing.

Importantly, maintaining the distal end of the existing jetty is of considerable interest to divers, and works to stabilise and preserve the T-section at the end of the jetty, and separating this physically from the remaining jetty should be considered. Furthermore, allowing the jetty to decay raises safety issues which need to be addressed including the risk of vessels striking debris or jetty components falling onto divers.

7.2 Overall environmental impacts of each proposal

As the construction of the new jetty will take place primarily in an area that does not contain seagrass, its impact on benthic vegetation communities should be minimal. This will also depend on the location of mooring buoy(s) during construction, which should be placed over sand if possible. Impacts of construction activities including pile driving and blasting will not be clear until test piling has been done, however, and the impact will need to be reassessed in the light of information in this regard. There are, however, several issues regarding the presence of the existing jetty in close proximity to the new jetty that are of some concern, including bird roosting, possible interference with fishing activities, and visual amenity. Positive aspect of the construction include limited disturbance to sessile flora and fauna on the existing jetty.

Rebuilding the existing jetty will result in destruction of sessile fauna and flora currently using the piles as a substrate and a higher impact on motile fauna that use the jetty as a refuge. On the positive side, visual amenity of a single jetty is retained, angling is unaffected, bird roosting is not increased, and there are no additional impacts on benthic floral communities from construction or shading relating to a new jetty.

As both options will require piling and jetty construction, it is likely that impacts relating to noise, turbidity etc will be similar, the primary difference being the location of the footprint. For the existing jetty, this encompasses a zone of high biodiversity whereas the alignment of the new jetty lies mostly over bare sand as currently proposed. No threatened or listed flora/fauna were found during this survey except the Leafy Seadragon, and this species will probably suffer a similar, and limited, impact for either project. In the short term, the construction of a new jetty will have less impact on the existing biodiversity at the site because of the reduced impact on the inhabitants of the flora and fauna living on current structure. In the long term, construction of a new jetty will provide increased habitat and refuge for marine animals, but will suffer from the concerns raised regarding the proximity of the existing structure. Overall, construction of the new jetty is likely to have the least negative environmental impact, though this must be weighed against practical and amenity issues of two coexisting jetties. Allowing the existing jetty to decay will ameliorate these concerns and benefit marine flora and fauna in the long term.

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Appendix A Species Lists

Plants	Scientific name	EPBC Status	Habitat Type
Green Algae	*Caulerpa trifaria*		Pile
Brown Algae	*Dictyopteris muelleri*		Pile
	Cystophora spp.		Rubble Seabed
	Ecklonia radiata		Pile
	Sargassum sp.		Pile and Seabed
	Scaberia agardhii		Seabed
	Zonaria sp.		Pile
	Padina sp.		Pile
	Caulocystis spp.		Rubble Seabed
Red Algae	*?Mychodea sp.*		Epiphytic
	Halosaccion sp.		Pile
Seagrasses	*Posidonia sinuosa*		Seabed
	Amphibolis griffithii		Seabed
	Halophila australis		Seabed
	Zostera muelleri		Seabed
Invertebrates			
Sponges (Porifera)	*Darwinella sp.*		Pile
	Dendrilla rosea		Pile
Hydroids (Hydrozoa)	*Pennaria disticha*		Pile
Anthozoa (Soft Coral)	*Carijoa sp. (Alcyonacea)*		Pile
Anthozoa (Stony Coral)	*Culicia sp.*		Pile
Polychaetes (Worms)	*Sabellastarte sp.*		Pile
Bryozoans	*Celleporaria sp.*		Pile
Crustaceans	*Plagusia chabrus*		Pile
Molluscs	*Equichlamys bifrons*		Seabed
	Astralium aureum		Rubble
	Pinna bicolor		Seabed
Nudibranch	*Ceratosoma brevicaudatum*		Pile
Cuttlefish	*Sepia apama*		Pile

Seastars	*Anthenea australiae*	Pile
	Tosia australis	Pile
	Coscinasterias muricata	Seabed
	Pentagonaster dubeni	Seabed
Sea Cucumber	*Stichopus ludwigi*	Seabed
Sea Squirts (Ascidians)	*Clavelina molluccensis*	Pile
	Polycarpa clavata	Pile
	Pyura australis	Seabed/Seagrass
	Phallusia obesa	Pile
	Ascidia thompsoni	Pile
	Botrylloides sp.	Pile
Fish		
Eagle Ray	*Myliobatis australis*	Under Jetty
Stingaree	*Trygonoptera mucosa*	Seabed
Long-finned Pike	*Dinolestes lewini*	Under Jetty
Barracouta (Snook)	*Thyrsites atun*	Under Jetty
Yellowtail	*Trachurus novaezelandiae*	Under Jetty
Old Wife	*Enoplosus armatus*	Under Jetty
Trevally	*Pseudocaranx sp.*	Under Jetty
Rough Bullseye	*Pempheris klunzingeri*	Under Jetty
Magpie Perch	*Cheilodactylus nigripes*	Seabed
Ringed Toadfish	*Omegophora armilla*	Under Jetty
Dusky Morwong	*Dactylophora nigricans*	Under Jetty
Pygmy Leatherjacket	*Brachaluteres jacksonianus*	Under Jetty
Long Snouted Boarfish	*Pentaceropsis recurvirostris*	Under Jetty
Silverbelly	*Parequula melbournensis*	Seabed
Bluethroat Wrasse	*Notolabrus tetricus*	Under Jetty
Castelnau's Wrasse	*Dotalabrus aurantiacus*	Under Jetty
Black Spotted Wrasse	*Austrolabrus maculatus*	Under Jetty
Zebra fish	*Girella zebra*	Under Jetty
Southern Goatfish	*Upeneichthys vlamingii*	Under Jetty
Moonlighter	*Tilodon sexfasciatum*	Under Jetty

Squareback Butterflyfish	*Chelmonops curiosus*		Under Jetty
Scalyfin	*Parma victoriae*		Under Jetty
Western smooth boxfish	*Anoplocapros robustus*		Under Jetty
Leafy Seadragon	*Phycodurus eques*	Listed marine	Under Jetty

Appendix B Photographs

A. Original Jetty

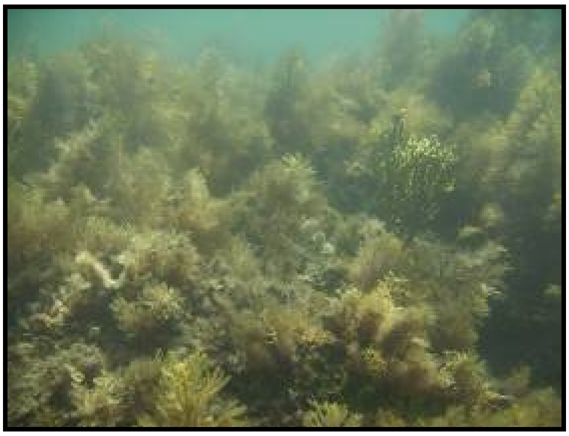
Decay of piles at seaward end of Jetty

Nesting terns at seaward end of Jetty

The extensive original Jetty

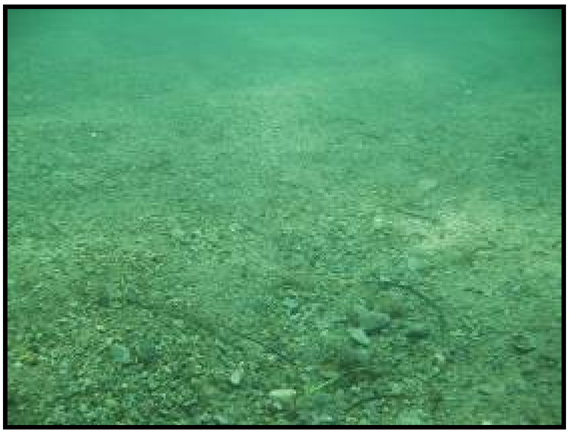
Restriction to public access, often ignored by anglers

B. Flora in new Jetty alignment



Inshore areas of rock and gravel dominated by macroalgal species e.g. *Caulocystis, Cystophora, Sargassum and Scaberia*

Amphibolis



Seabed along proposed jetty alignment near Offshore Test Pile Site

Halophila

Mixed community off *Amphibolis/Posidonia*

Seabed along proposed jetty alignment near Inshore Test Pile Site (Site 484)

Dense bed of *Posidonia sinuosa*

Heterozostera

Blowout

C. Common fauna in alignment

Magpie perch, *Cheilodactylus nigripes*

Stingaree, *Trygonoptera mucosa*

Eleven-armed seastar, *Coscinasterias muricata*

Queen scallop, *Equichlamys bifrons*

D. Flora and fauna associated with existing Jetty

Hydroid (*Pennaria disticha*)

Colonial Ascidian, *Clavelina molluccensis*

Seastar, *Anthenea sp*.

Ecklonia radiata, Sabellastarte sp. (fan worm)

Stony coral anemone, *Culicia sp*.

Seastar, *Tosia australis*

Yellow encrusting sponge, *Darwinella sp*.

Ascidian, (*Polycarpa* sp.)

Caulerpa trifaria

Alcyonacean, *Carijoa sp.*

Leafy Seadragon, *Phycodurus eques*

School of rough bullseye, *Pempheris klunzingeri*

School of old wives, *Enoplosus armatus*

School of yellowtail, *Trachurus novaezelandiae*

Southern goatfish, *Upeneichthys vlamingii*

Appendix C Listed species that may occur in the area

Scientific name	Common name	EPBC Status	Comment
Birds			
Diomedea gibsoni	Gibson's Albatross	Vulnerable	Species or species habitat may occur within area
Macronectes giganteus	Southern Giant-Petrel	Endangered	Species or species habitat may occur within area
Macronectes halli	Northern Giant-Petrel	Vulnerable	Species or species habitat may occur within area
Thalassarche bulleri	Buller's Albatross	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta	Shy Albatross	Vulnerable	Species or species habitat may occur within area
Thalassarche impavida	Campbell Albatross	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini	Salvin's Albatross	Vulnerable	Species or species habitat may occur within area
Rostratula australis	Australian Painted Snipe	Vulnerable	Species or species habitat may occur within area
Stipiturus malachurus intermedius	Southern Emu-wren	Endangered	Species or species habitat likely to occur within area
Gallinago hardwickii	Latham's Snipe	Migratory	Species or species habitat may occur within area
Haliaeetus leucogaster	White-bellied Sea-Eagle	Migratory	Species or species habitat likely to occur within area
Hirundapus caudacutus	White-throated Needletail	Migratory	Species or species habitat may occur within area
Merops ornatus	Rainbow Bee-eater	Migratory	Species or species habitat may occur within area
Rostratula benghalensis s. lat.	Painted Snipe	Migratory	Species or species habitat may occur within area
Apus pacificus	Fork-tailed Swift	Listed - overfly marine area	Species or species habitat may occur within area
Ardea alba	Great Egret, White Egret	Listed - overfly marine area	Species or species habitat may occur within area
Ardea ibis	Cattle Egret	Listed - overfly marine	Species or species habitat may occur within area

		area	
Thinornis rubricollis rubricollis	Hooded Plover (eastern	Listed - overfly marine area	Species or species habitat likely to occur within area
Sterna albifrons	Little Tern	Listed	Species or species habitat may occur within area
Mammals			
Eubalaena australis	Southern Right Whale	Endangered	Species or species habitat known to occur within area
Isoodon obesulus obesulus	Southern Brown Bandicoot	Endangered	Species or species habitat likely to occur within area
Megaptera novaeangliae	Humpback Whale	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera edeni	Bryde's Whale	Migratory	Species or species habitat may occur within area
Caperea marginata	Pygmy Right Whale	Migratory	Species or species habitat may occur within area
Eubalaena australis	Southern Right Whale	Migratory	Species or species habitat known to occur within area
Lagenorhynchus obscurus	Dusky Dolphin	Migratory	Species or species habitat may occur within area
Megaptera novaeangliae	Humpback Whale	Migratory	Species or species habitat likely to occur within area
Orcinus orca	Killer Whale, Orca	Migratory	Species or species habitat may occur within area
Arctocephalus forsteri	New Zealand Fur-seal	Listed	Species or species habitat may occur within area
Arctocephalus pusillus	Australian Fur-seal	Listed	Species or species habitat may occur within area
Neophoca cinerea	Australian Sea-lion	Vulnerable	Species or species habitat likely to occur within area
Sharks			
Carcharodon carcharias	Great White Shark	Vulnerable	Species or species habitat likely to occur within area
Plants			
Euphrasia collina subsp. *osbornii*	Osborn's Eyebright	Endangered	Species or species habitat likely to occur within area
Ray-finned fishes			
Acentronura australe	Southern Pygmy Pipehorse	Listed	Species or species habitat may occur within area

Campichthys tryoni	Tryon's Pipefish	Listed	Species or species habitat may occur within area
Filicampus tigris	Tiger Pipefish	Listed	Species or species habitat may occur within area
Heraldia nocturna	Upside-down Pipefish	Listed	Species or species habitat may occur within area
Hippocampus abdominalis	Eastern Potbelly Seahorse	Listed	Species or species habitat may occur within area
Hippocampus breviceps	Short-head Seahorse	Listed	Species or species habitat may occur within area
Histiogamphelus cristatus	Rhino Pipefish	Listed	Species or species habitat may occur within area
Hypselognathus rostratus	Knife-snouted Pipefish	Listed	Species or species habitat may occur within area
Kaupus costatus	Deep-bodied Pipefish	Listed	Species or species habitat may occur within area
Leptoichthys fistularius	Brushtail Pipefish	Listed	Species or species habitat may occur within area
Lissocampus caudalis	Australian Smooth Pipefish	Listed	Species or species habitat may occur within area
Lissocampus runa	Javelin Pipefish	Listed	Species or species habitat may occur within area
Maroubra perserrata	Sawtooth Pipefish	Listed	Species or species habitat may occur within area
Notiocampus ruber	Red Pipefish	Listed	Species or species habitat may occur within area
Phycodurus eques	Leafy Seadragon	Listed	Species or species habitat may occur within area
Phyllopteryx taeniolatus	Weedy Seadragon	Listed	Species or species habitat may occur within area
Pugnaso curtirostris	Pug-nosed Pipefish	Listed	Species or species habitat may occur within area
Solegnathus robustus	Robust Spiny Pipehorse	Listed	Species or species habitat may occur within area
Stigmatopora argus	Spotted Pipefish	Listed	Species or species habitat may occur within area
Stigmatopora nigra ,	Wide-bodied Pipefish	Listed	Species or species habitat may occur within area
Stipecampus cristatus	Ring-backed Pipefish	Listed	Species or species habitat may occur within area

Urocampus carinirostris	Hairy Pipefish	Listed	Species or species habitat may occur within area
Vanacampus margaritifer	Mother-of-pearl Pipefish	Listed	Species or species habitat may occur within area
Vanacampus phillipi	Port Phillip Pipefish	Listed	Species or species habitat may occur within area
Vanacampus poecilolaemus	Australian Long-snout Pipefish	Listed	Species or species habitat may occur within area
Vanacampus vercoi	Verco's Pipefish	Listed	Species or species habitat may occur within area

SKM

Appendix D Ground Truthing Data

Location	Depth (ft)	Wpt	Northing	Easting	Detailed Habitat
T1 West	9.5	467	6065374	244730	Macroalgae, dense Amph
21-Feb	10.5	468	6065381	244722	Posidonia, some Amph
~3pm	12.5	469	6065406	244719	Macroalgae, mainly sand
	14.8	470	6065429	244707	some Amph, sand
	16	471	6065460	244704	dense Amph, patch of sand
	19	472	6065500	244697	Mainly sand, some Amph (all sand b/n 472-473)
	22	473	6065549	244695	Sand
T2 West	12.5	475	6065414	244661	Dense Amph, patchy Pos, some algae
21-Feb	14	476	6065444	244656	patchy Amph, sand, algae
	19	477	6065503	244647	patchy Pos, Amph, sand
	22.5	478	6065557	244643	Pos and Amph, sand
					Seaward of 478, large dense area of Posidonia
T3 West	13	481	6065420	244648	dense Amph, some Pos
21-Feb	16	482	6065457	244616	dense Amph, variable cover of algae and Pos
		483	6065507	244603	Pos more dominant, continuous bed some sand
	21	480	6065543	244611	more Pos, some sand
	Depth (m)				
T0	1.9	486	6065338	244784	brown algae, rock and gravel
					some Amph (patchy), algae mainly sand
	3.5	484	6065380	244774	Sand. Connell Test Pile W-10 drg 2-6763
					Sand.
	5	485	6065487	244766	Sand. Connell Test Pile W-19 drg 2-6763
	6				Patches of Amph
End of New Pier	6.5	461	6065560	244760	Patch of Amph into dense bed of Posidonia
	7.5	487	6065647	244759	patches of Pos and Amph
Beyond Old Pier	9.6	490	6065763	244777	Gravel, sparse patchy areas of Pos
		488	6065663	244784	All Pos between 488 and 489
		489	6065656	244820	
T1 East					
22-Feb	2.3	493	6065318	244862	Brown macroalgae, edge between algae and sand
					Sand, gravel
	3.8	494	6065429	244861	Pos. continuous bed.
	5.5				patches of Amph, dense Pos
	6.7	495	6065544	244838	dense Pos
	7	491	6065570	244809	end of Gen's transect, Pos. some patches of sand
	7.4				limit of vis. Dense Pos
T2 East	1.4	497	6065281	244916	Amph patch, some macroalgae. Point starts close to sand/algae boundary
					sand
	3.5	498	6065396	244907	sand
	5.3	499	6065473	244900	sand into bed of Pos

					continuous beds of Pos with some sand blowouts
	6.1	500	6065518	244893	continuous beds of Pos with some sand blowouts
	7	501	6065570	244873	Posidonia near end of Gen's transect
		496	6065576	244859	End of transect
	7.5	502	6065618	244858	limit of vis. Dense Pos.
T3 East	1.3	504	6065251	244975	sand, inshore fromm here macroalgae
					sand
	2.7	505	6065362	244968	sand
					sand
	4.8	506	6065455	244955	sand
					sand
	5.5	507	6065480	244949	start of Pos, some blowouts but Pos predominant
					dense Pos
	7	503	6065583	244908	dense Pos
	7.2	508	6065604	244909	limit of vis - dense Pos
T4 East	3.6	510	6065411	245017	Sand, all sand inshore from this point
		511	6065437	245017	Patches of Amph, Pos and macro
	4.2	512	6065451	245019	Posidonia, medium cover
	5	513	6065498	245023	dense Pos
					dense Pos
	5.7	514	6065543	245020	dense Pos
					dense Pos
	6.8	509	6065590	244958	end of gen transect, Posidonia some patches of rock
	7	515	6065620	244971	Limit of vis - Pos
T5 East	2	516	6065287	245065	Macroalgae
	2.2	517	6065330	245056	predominantly macro with some Amph and Pos
		518	6065331	245056	predominantly macro with some Amph and Pos
	2.6	519	6065357	245076	On edge, mostly macroalgae in shaded area
	3.4	520	6065378	245072	Amph starts to dominate and then grades into Amph/Pos
	3.6	521	6065402	245071	Mostly Pos. and some Amph/macro
		522	6065419	245073	Mostly Pos. with some Amph
	4.3	523	6065462	245065	Mostly Pos with some Amph
	4.9	524	6065479	245064	Posidonia