Section 9.2 Impacts of Dredging and Reclamation to Benthic Primary Producer Habitat (BPPH)

Section 9.2.1 Management Goals for BPPH

The management goals for BPPH are to:

- Maintain the abundance, diversity, geographic distribution and productivity of marine biota at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.
- Minimise direct loss and disturbance to marine habitat during dredging and dredge material disposal activities.
- Minimise indirect impacts to marine habitat through turbidity and increased vessel traffic.

Section 9.2.2 Standards and Guidelines Applicable to BPPH

Applicable standards and guidelines include:

- Guidance Statement No 29: Benthic Primary Producer Habitat Protection for WA’s Marine Environment (EPA, 2004); and
- Australian New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000).

Section 9.2.3 Calculation of Potential Impacts to BPPH

EPA Requirements

The EPA ‘Benthic Primary Producer Habitat Protection for WA’s Marine Environment’ Guidance Statement No. 29 (EPA, 2004) defines BPPH as communities of marine plants and scleractinian corals along with the substrate that support these communities. An ecosystem’s approach is applied to the management of BPPH, which takes into account the relationships of the biological, physical, and chemical components of aquatic ecosystems over temporal and spatial scales.

Guidance Statement No. 29 sets out a framework using management units and the determination of cumulative impacts for evaluating potential damage to BPPH, and cumulative losses associated with the Albany Port Expansion Proposal.

Management Units: Management unit(s) must be defined with appropriate categories of ecological protection assigned. The six categories of ecological protection have differing cumulative loss thresholds against which the proposal’s potential impacts on BPPH are assessed. These are outlined in Table 9.5.

Cumulative Impacts: Both the current extent and an estimate of the pre-European extent of each type of BPPH in the management unit(s) must be determined for each management unit to establish the baseline for cumulative impact assessment.
9. POTENTIAL IMPACTS ASSOCIATED WITH DREDGING AND LAND RECLAMATION

Table 9.5  EPA Categories of Ecological Protection and Cumulative Loss Thresholds.

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Cumulative Loss Threshold (percentage of original BPPH within a defined management unit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Extremely special areas</td>
<td>0%</td>
</tr>
<tr>
<td>B</td>
<td>High protection areas other than above</td>
<td>1%</td>
</tr>
<tr>
<td>C</td>
<td>Other designated areas</td>
<td>2%</td>
</tr>
<tr>
<td>D</td>
<td>Non-designated areas</td>
<td>5%</td>
</tr>
<tr>
<td>E</td>
<td>Development areas</td>
<td>10%</td>
</tr>
<tr>
<td>F</td>
<td>Areas where cumulative loss thresholds have been significantly exceeded</td>
<td>0% net damage/loss (+ Offsets)</td>
</tr>
</tbody>
</table>

Management Units

For the purposes of considering the impact of habitat loss on ecological integrity for this Project three management units have been chosen as follows:

- Management Unit 1: Princess Royal Harbour (28.9 km² or 2,889.2 ha);
- Management Unit 2: Inner King George Sound encompassing the proposed channel and habitat that could potentially be affected by dredging (65.4 km² or 6,540.9 ha); and
- Management Unit 3: Outer King George Sound encompassing the offshore islands and shoreline areas potentially affected by disposal of dredge material (54.8 km² or 5,478.8 ha).

Both Management Units 2 and 3 are greater than 50 km² in order to encompass the area of potential effects on seagrasses as a result of dredging and disposal.

The categories for marine ecosystem protection and the allowable cumulative loss threshold of Benthic Primary Producer Habitat within the three management Units are as follows:

- Management Unit 1: Category F (Area where cumulative loss threshold has been significantly exceeded) thus a 0% net damage/loss (+ offsets); 0% net damage/loss (+ Offsets).
- Management Unit 2: Category D (Non-designated Area); 5% cumulative loss threshold.
- Management Unit 3: Category C (Other designated Area); 2% cumulative loss threshold.

The methods used to determine the extent of BPPH present in each management unit is outlined in Section 6.5.1.

Cumulative Impacts

Human-induced BPPH loss has been divided into historical loss and potential loss associated with the project for both Princess Royal Harbour and King George Sound, as follows, for calculation purposes:

Historical Loss: The condition of BPP prior to European colonisation is difficult to accurately determine as historically, records were rarely kept. Certain assumptions are therefore required. As a precautionary principle, unless data is available or reasonable doubt exists, areas without seagrass were assumed to have been vegetated prior to European colonisation.
Princess Royal Harbour: It is assumed that prior to European colonisation Princess Royal Harbour was completely vegetated by seagrass below the low tide mark. The historical loss of BPPH in Princess Royal Harbour has most likely been as a result of the following:

- **Foreshore and Port Development**: It is assumed that dredging and reclamation for the Port and other foreshore facilities resulted in either the loss of seagrass or of area highly suitable for seagrass colonisation. Reclamation of sub-tidal area once occupied by seagrass has been estimated at approximately 50 ha. Dredging of the Port area has resulted in the loss of an additional 155.7 ha of seagrass.

- **Water Quality Impacts**: Although it is likely that Princess Royal Harbour was historically completely vegetated by seagrass below the low tide mark, there is presently no seagrass in water depths greater than 5 m. It is assumed that the loss of the seagrass meadows in water depths greater than 5 m is as a result of human-induced effects such as nutrient discharges into the Harbour or elevated turbidity. This loss is equivalent to approximately 286.8 ha. In addition, there are large areas of bare sand or macroalgal cover that were presumably once covered with seagrass. It is estimated that an additional 1,011.6 ha of seagrass has been lost in the Harbour since the time of European colonisation.

King George Sound: The historical anthropogenic loss of BPPH in King George Sound has been determined to be negligible. Whilst there have been human activities in King George Sound, none have resulted in significant loss of BPP, in particular seagrasses. Evidence for this is limited and is provided as follows:

- **Channel Dredging**: The existing entry channel to the Port shows no signs of seagrass on either side apart from that at Possession Point. The seagrass at Possession Point is in good health and appears to be limited by the strong tidal currents and depth to the same extent as seagrass in areas further from the Port. It is highly unlikely that the limited dredging of the existing channel could have extinguished seagrass for such a great distance, making it reasonable to assume that seagrass did not exist in this area at the time of European settlement.

- **Aquaculture Leases**: Marine farms are located north and south of Mistaken Island and along the north shore of Flinders Peninsula. Mussel lines can shade the seabed potentially reducing the seagrass cover. No studies have documented a loss of seagrass as a result of the activities on the aquaculture leases. There is no sign of any reduction in seagrass cover in these areas and, as such, it is assumed there is no historical loss of BPPH.

- **Historical Whaling Activities**: The only potential human-induced loss of seagrass resulting from historical whaling activities would be the footprint of the groyne at the whaling station near Frenchman Bay. The furthest offshore section of this groyne is likely to have been built over seagrass. This area is estimated to be approximately 50 m². While this is clearly a loss of seagrass, it is 0.006% of the seagrass in King George Sound and is therefore considered negligible. All other shore activities were on bare sand, inter- and sub-tidal areas.

### Table 9.6 Historical Changes to Seagrasses.

<table>
<thead>
<tr>
<th>Management Unit</th>
<th>Location</th>
<th>Cause</th>
<th>Loss of Seagrass Area (ha)</th>
<th>Change (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Port area and channel</td>
<td>Dredging and reclamation</td>
<td>205.70</td>
<td>7.12</td>
</tr>
<tr>
<td></td>
<td>Princess Royal Harbour</td>
<td>Other human-induced impacts</td>
<td>1298.4</td>
<td>44.94</td>
</tr>
<tr>
<td>2</td>
<td>Inner region of King George Sound</td>
<td>Other human-induced impacts</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>3</td>
<td>Outer region of King George Sound</td>
<td>Other human-induced impacts</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>
9. POTENTIAL IMPACTS ASSOCIATED WITH DREDGING AND LAND RECLAMATION

This Project: The loss of BPPH associated with the Albany Port Expansion Proposal is related to permanent and temporary losses as follows:

- **Permanent Loss**: This is direct loss as a consequence of the dredging and is the total physical removal of all seagrass in the channel alignment making it unsuitable for recovery as well as indirect loss adjacent to the dredging and disposal as a result of light climate reduction.

- **Temporary Loss Damage**: This would be as a result of diminished light levels caused by dredging which would reduce the density or health of the BPP. Recovery would be expected but the timescale is dependent upon the reduction in density and could be several growing seasons.

**Calculation of Threshold Values for Potential Impacts to BPPH**

Threshold levels are values used to determine the zones of effect on BPPH. These values are applied to numerical modelling of turbidity effects of dredging and disposal to generate three zones. These zones can be best visualised as concentric circles one nested within another as shown in the conceptual model in (Figure 9.21) with the boundaries being delineated by threshold values.
9. POTENTIAL IMPACTS ASSOCIATED WITH DREDGING AND LAND RECLAMATION

The zones of impact have been defined as follows:

**Zone of Permanent Loss**: is generally predicted as both:

- the area directly affected (e.g. the channel and disposal site); and
- an area immediately about/surrounding the proposed dredging and disposal areas, which is indirectly affected (e.g. by smothering or light limitation) with a severity and duration such that impacts to biota and their habitats will be severe.

This zone defines the area where mortality of, and long term (i.e. months to years) damage to, biota and their habitats would be predicted.

**Zone of Temporary Loss Damage**: this zone abuts and lies immediately outside of the Zone of Permanent Loss. Within this zone sub-lethal effects on key benthic biota would be predicted, but there should be no mortality of benthic biota and no long-term damage to, or modification of, the communities they form or the substrates on which they grow. The outer boundary of this zone is coincident with the inner boundary of the next zone – the ‘Zone of influence’.

**Zone of Influence**: this zone is the area where, at some time during the proposed dredging activities, changes in sediment-related environmental quality levels which are outside natural ranges (e.g. median value beyond 80th percentiles of un-impacted reference distribution) might be expected; however, their intensity and duration is such that no detectible effects on benthic biota or their habitats are predicted.

The threshold values delineate the boundaries of the three zones. For this project the primary BPPH that will be impacted, based on the footprint of dredging, disposal and numerical modelling of TSS levels, is seagrass. The calculation of the threshold values is, therefore, based upon light attenuation effects on seagrass correlated to TSS values used in the numerical modelling.

**Seagrass Minimum Light Requirements**

The minimum light requirement for seagrass is the percentage of available sub-surface light irradiance required to sustain seagrasses at a given water depth. The minimum light requirement is based on the physiology of a given seagrass so that each species has its own characteristic level. The compensation depth is the water depth beyond which the seagrass cannot receive sufficient light over the course of an average year to sustain itself. Also of importance is the length of time that different species can survive at light intensities below their minimum light requirement.

The variation in minimum light requirements reported in the literature is in part caused by differences in the methods used to derive these values. Methods range from physiological studies of photosynthesis/irradiance relationships, field observations of maximum depth of seagrass colonisation, and experimental manipulation of light levels during growth studies, to statistical models (Batiuk et al. 2000).

The minimum light requirement for the dominant seagrass species found in the project area have been derived from the literature and where possible, in a similar environment. These values are presented in (Table 9.7). Given that the minimum light requirement for *Posidonia coriacea* is at or below that of *Posidonia sinuosa* the higher requirement for light of *Posidonia sinuosa* has been used for the calculation of threshold levels.
9. POTENTIAL IMPACTS ASSOCIATED WITH DREDGING AND LAND RECLAMATION

Table 9.7  Minimum Light Requirements for Seagrasses in the Project Area.

<table>
<thead>
<tr>
<th>Seagrass Species</th>
<th>Minimum Light Requirement</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Posidonia australis</em></td>
<td>10%</td>
<td>Fitzpatrick and Kirkman (1995); Gordon <em>et al.</em> 1994</td>
</tr>
<tr>
<td><em>Posidonia sinuosa</em></td>
<td>8.5%</td>
<td>C.J. Collier (2006)</td>
</tr>
<tr>
<td><em>Posidonia coriacea</em></td>
<td>8.0%</td>
<td>Westphalen <em>et al.</em> (2004)</td>
</tr>
</tbody>
</table>

Light Attenuation and Turbidity

The amount of light available to seagrasses is attenuated and decreases with water clarity and increasing water depth. Attenuation is increased by turbidity resulting in a further reduction in light reaching the seabed. The relationship between light extinction and water depth is defined by the Beer-Lambert Law for water which is shown below.

\[ K_d(PAR) = \frac{1}{z} \ln\left(\frac{I_z}{I_0}\right) \]

where:  
\( I_0 \) is the incident light  
\( I_z \) is the light at depth \( z \)  
\( z \) is the water depth or vertical distance between \( I_0 \) and \( I_z \)

The light extinction coefficient \( (K_d) \) was then expressed as a \( \log_{10} \) relationship to represent the light attenuation coefficient \( (AC) \) thus the equation becomes:

\[ AC(PAR) = \frac{1}{z} \log_{10}\left(\frac{I_z}{I_0}\right) \]

The minimum light requirement for a given species is therefore dependent upon the water depth.

Calculation of Threshold Levels

The calculation of threshold values involved the determination of light attenuation to reduce the incident light to the minimum light requirement of each seagrass species at one metre water depth intervals. The depth interval range was required to account for the fact that seagrass grows in coastal sub-tidal waters of Albany down to approximately 16 metres. The light attenuation values were then represented by turbidity levels in mg/L of TSS to be applied to the modelled data.

Following is a summary of the method used to calculate these threshold levels. A full discussion is provided in Technical Appendix 16.2:

1) **Threshold level 2**, the zone of temporary loss damage was based on 30% of the minimum light requirement during the dredging programme. Research (*Gordon et al.*, 1994) found that shading to 20% of the minimum light requirement available to seagrasses in 3-4 m of water for approximately 5 months during the seagrass growing season resulted in significant recovery in shoot density to pre-shading levels after approximately 8 months. The minimum light requirement value of 30% was chosen to add greater incident light for the seagrasses as a precautionary measure.

2) **Threshold level 1**, zone of permanent loss was based on no available light during the dredging programme.
9. POTENTIAL IMPACTS ASSOCIATED WITH DREDGING AND LAND RECLAMATION

3) The DREDGE3D dredge model used to predict turbidity plumes deals with the distribution and concentration of particles within the water column. The light attenuation values for each seagrass species for each threshold level must, therefore, be converted to total suspended solids (TSS) levels in mg/L to link the predicted water quality to levels that will impact on seagrasses. The relationship between light attenuation and TSS was based on laboratory results using sediment from the proposed dredging area as discussed in Section 9.1.2. The following relationship was used:

\[ TSS = \frac{AC}{0.0217} \quad (R^2 = 0.970, P < 0.0001) \]

where: \( AC \) is the light attenuation coefficient

4) The DREDGE3D dredge modelling overlays added turbidity to the system. As it does not take into account ambient (background) conditions, the same light attenuation to TSS relationship was used to calculate background levels. A value of 0.098 for natural light attenuation (Smith et al. 1989) was applied which gave an ambient TSS level of 4.52 mg/L.

The contribution of background to overall turbidity resulting from dredging would have a minimal effect on the modelled output due to the low background level. For this reason, the background turbidity (TSS) was factored into the threshold levels used to predict the zones of permanent loss and temporary loss damage.
9. POTENTIAL IMPACTS ASSOCIATED WITH DREDGING AND LAND RECLAMATION

Section 9.2.4 Potential Impacts to BPPH

Potential impacts to BPPH associated with dredging, offshore disposal and increased vessel traffic into the Port are:

- Direct removal or burial of marine and near shore habitats.
- Indirect loss of benthic primary producers (BPP) as a result of increased suspended solids and smothering.
- Introduction of and/or spread of exotic species due to ballast water and hull fouling quarantine practices.

The habitat present in each of the three management units has been calculated based on the results of habitat mapping presented in Section 6.5.1 and historical losses as described and calculated in Section 9.2.3. The total area of each BPPH is presented in Table 9.8.

### Table 9.8 Benthic Primary Producer Habitat Area.

<table>
<thead>
<tr>
<th>Management Unit</th>
<th>Bare Sand (ha)</th>
<th>Seagrass (ha)</th>
<th>Macroalgae (ha)</th>
<th>Total (Historic)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Historical</td>
<td>Present</td>
<td>Historical</td>
<td>Present</td>
</tr>
<tr>
<td>1 Princess Royal Harbour</td>
<td>0.0</td>
<td>1,453.9</td>
<td>2889.0</td>
<td>1,385.0</td>
</tr>
<tr>
<td>2 Inner King George Sound</td>
<td>5,702.4</td>
<td>5,702.4</td>
<td>817.5</td>
<td>817.5</td>
</tr>
<tr>
<td>3 Outer King George Sound</td>
<td>5,243.5</td>
<td>5,243.5</td>
<td>3.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Corals are not included in the table as the two reefs Gio Batta Patch and Michaelmas Reef comprise less than 1% of BPPH.

Direct Removal of Habitats

A small sub-tidal granite rock pile (approximately 10 m in diameter) lies in the north east corner of the proposed land reclamation area and would be buried during reclamation. The ecological significance of the rock pile is minimal given its size and its loss would have negligible impact on benthic primary producer habitat. The macroalgae present on the rock pile is similar to that which would colonise the seawall of the reclamation area and on this basis the macroalgal benthic primary producer habitat would increase and thus could be considered an offset for the loss of the rock community. Colonisation by macroalgae can be rapid with *Ecklonia radiata*, particularly with adjacent stands providing propagules, and establishment could be as short as a single growing season. Equally, the seawall will attract fish in greater numbers due to the greater physical size and quantity of habitat for colonisation than the rock, providing similar opportunities for the fishers who frequent the area.

The Albany Port Expansion Proposal will result in the direct disturbance of approximately 473 ha of seabed of which 12.15 ha is BPPH. This is comprised of 11.79 ha in the channel alignment through King George Sound and 0.36 ha in the new berth area and on the south side of the channel (Figure 6.18) for the swing basin in Princess Royal Harbour. This represents a permanent loss of BPP as dredging will remove both the BPP and the habitat. Ground truthing by divers of the proposed channel revealed that most of the channel to the bend (Dredge Areas 1 and 2, Figure 6.6, Figure 6.18), is bare sand (Figure 6.17) with some sea pens recorded at several sites. Seagrass (*P. coriacea*) was recorded at densities varying from trace to 20% cover along approximately half of Dredge Area 3 (Figure 6.6, Figure 6.18) in the north-eastern portion of the inner region of King George Sound. It is unlikely that the seagrass will return to this area. The areas that have been ground truthed historically and during the current investigations are shown in (Figure 6.19).
The new berth area at the entrance to Princess Royal Harbour also contains small areas of macroalgae and rock habitat which will be removed during the construction of the seawall and land reclamation area. However, the proposed seawall surrounding the reclamation area will provide a far greater surface for macroalgae and other marine life to colonise. A seagrass re-establishment programme will be developed in consultation with the DEC and local experts as part of the APA commitment to offset permanent losses of seagrass within Princess Royal Harbour associated with the Albany Port Expansion Proposal.

**Cumulative Impacts to BPPH**

A loss of BPPH is equal to a loss of the BPP but this does not necessarily mean that it is a permanent situation. If the BPP existed prior to the dredging and disposal process and the conditions return to normal afterwards, then the BPP may recover or recolonise the area; however, this may take some time (several years).

**Corals:** Dredging and associated turbidity are not anticipated to impact Gio Batta Patch or Michaelmas Reef (Figure 6.20). Michaelmas Reef is not within the zone of predicted turbidity (Figure 9.18, Figure 9.19 and Figure 9.20) or sedimentation (Figure 10.9, Figure 10.11 and Figure 10.13) for any of the dredge scenarios. Gio Batta Patch, however, is located closer to the dredge channel. The sedimentation plots indicate that the reef may be exposed to bottom sediment loads of up to 1000 gm/m² during the March to June (Figure 10.9) and July to October (Figure 10.11) dredging scenarios. No environmental impacts are anticipated from the turbidity as the limestone reefs experience significant wave energy such that any sedimentation will be prevented. This is supported by observations (Section 6.5.5) that the seabed in the vicinity of the reef is a flattened limestone pavement free of fine sediment and generally devoid of flora and encrusting fauna.

As outlined in Section 6.5.5, Gio Batta Patch experiences significant wave energy which will prevent any sedimentation in the unlikely event of an influence.

**Seagrasses:** Historical losses of seagrass are described in Section 9.2.3 and Table 9.6, while the predicted loss for this Project was based on overlaying the modelled outputs using the threshold boundaries onto the habitat map (see Figure 9.22, Figure 9.23 and Figure 9.24). The estimates of BPPH permanent loss and temporary loss damage are summarised in Table 9.9 by dredging scenario for each management unit.

The modelled impacts of the Albany Port Expansion Proposal on seagrasses in King George Sound and Princess Royal Harbour for the three dredge scenarios modelled are presented in Figure 9.22, Figure 9.23 and Figure 9.24. The Figures delineate the ‘Zone of Permanent Loss’, the ‘Zone of Temporary Loss Damage’ and the ‘Zone of Influence’ for each dredge scenario. The Zone of Influence covers a much larger region than the zones of impact, however the Zone of Influence represents a dredging induced TSS of 1 mg/L and is only an indication of where turbid plumes may be seen at some time during the dredging but, by definition, do not cause any impacts to seagrasses.
## Table 9.9  Predicted Changes to Benthic Primary Producer Habitat.

<table>
<thead>
<tr>
<th>Management Unit</th>
<th>Location</th>
<th>Cause</th>
<th>July–October</th>
<th>November–February</th>
<th>March–June</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Area (ha)</td>
<td>Area (ha)</td>
<td>Area (ha)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Change (%)</td>
<td>Change (%)</td>
<td>Change (%)</td>
</tr>
<tr>
<td>1</td>
<td>Permanent loss</td>
<td>Dredging / light climate</td>
<td>0.38</td>
<td>0.40</td>
<td>0.38</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Light climate</td>
<td>0.79</td>
<td>0.98</td>
<td>0.84</td>
</tr>
<tr>
<td></td>
<td>Temporary loss/damage</td>
<td>Light climate</td>
<td>0.79</td>
<td>0.31</td>
<td>0.03</td>
</tr>
<tr>
<td>2</td>
<td>Permanent loss</td>
<td>Dredging / light climate</td>
<td>21.44</td>
<td>25.11</td>
<td>25.77</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Light climate</td>
<td>8.75</td>
<td>30.20</td>
<td>11.23</td>
</tr>
<tr>
<td></td>
<td>Temporary loss/damage</td>
<td>Light climate</td>
<td>8.75</td>
<td>0.31</td>
<td>1.37</td>
</tr>
<tr>
<td>3</td>
<td>Permanent loss</td>
<td>Dredging / light climate</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Light climate</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>
9. POTENTIAL IMPACTS ASSOCIATED WITH DREDGING AND LAND RECLAMATION

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Impact on Benthic Primary Producer Habitat of Princess Royal Harbour and King George Sound study area March to July
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Impact on Benthic Primary Producer Habitat of Princess Royal Harbour and King George Sound study area July to November
This page has been left intentionally blank.
Impact on Benthic Primary Producer Habitat of Princess Royal Harbour and King George Sound study area November to February
This page has been left intentionally blank.
Predictions of loss of BPPH have been further classified into the following cases with the results presented in Table 9.10.

**Best Case:** This is the direct loss in the footprint of dredging and reclamation.

**Most Probable Case:** This is the area predicted for the zones for Permanent Loss.

**Worst Case:** This is a combination of the area predicted for the zones for Permanent Loss and Temporary Loss Damage.

<table>
<thead>
<tr>
<th>Dredging Scenarios</th>
<th>Case</th>
<th>Management Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>July–October</td>
<td>Best case</td>
<td>0.01%</td>
</tr>
<tr>
<td></td>
<td>Most probable case</td>
<td>0.01%</td>
</tr>
<tr>
<td></td>
<td>Worst case</td>
<td>0.04%</td>
</tr>
<tr>
<td>November–February</td>
<td>Best case</td>
<td>0.01%</td>
</tr>
<tr>
<td></td>
<td>Most probable case</td>
<td>0.01%</td>
</tr>
<tr>
<td></td>
<td>Worst case</td>
<td>0.32%</td>
</tr>
<tr>
<td>March–June</td>
<td>Best case</td>
<td>0.01%</td>
</tr>
<tr>
<td></td>
<td>Most probable case</td>
<td>0.01%</td>
</tr>
<tr>
<td></td>
<td>Worst case</td>
<td>0.04%</td>
</tr>
</tbody>
</table>

Percentages based on Historical areas of BPPH.

**Management Unit 1**

Management Unit 1 has been designated as Category F, representing areas where cumulative loss thresholds have been significantly exceeded and a 0% net damage/loss (+ Offsets) is allowable. Historically there has been a 52.06% loss of BPPH in Princess Royal Harbour as a result of anthropogenic effects such as nutrient discharges and elevated turbidity and Port development (dredging and reclamation). Substantial recovery has taken place since the impact that resulted in this loss thus the present day loss value is less than that calculated shortly after the impact.

In addition to historical losses, dredging at the entrance to Princess Royal Harbour will result in a loss of 0.01% seagrass. Seagrass losses in Management Unit 1 is associated with permanent removal of seagrass through dredging and land reclamation, sedimentation and light limitation.

As the allowable level of loss (0%) has been exceeded, the APA will offset seagrass loss in Princess Royal Harbour associated with the Project through planting and other programmes to ensure no additional loss of seagrass in Princess Royal Harbour.
Management Unit 2

A Category D, 5% cumulative loss threshold has been applied to Management Unit 2. There has been no historical loss of BPPH in King George Sound that can be attributed to human-induced effects apart from approximately 50 m² at the old whaling station which is considered to be negligible for calculation purposes.

Dredging of the channel within King George Sound will result in a minimum permanent loss of 1.44% (11.79 ha). Dependant on the timing of the dredge programme and the associated prevailing winds, it is anticipated that there will be a 2.62% to 3.15% permanent loss of BPPH in the inner region of King George Sound resulting from the establishment of the channel by dredging. This loss is predicted to be permanent in the channel area and its batter walls; however, outside of this area the seabed will still be suitable for re-colonisation by seagrasses and thus BPPH. The predicted permanent loss for each dredge scenario is as follows:

- July–October = 2.62%
- November–February = 3.07%
- March–June = 3.15%

It is not anticipated that permanent losses of seagrass associated with the dredge project will exceed the 5% threshold as measures will be implemented to minimise turbidity throughout the dredge programme (Section 9.1.4.2).

The BPP monitoring programme (as outlined in Section 9.2.5, Figure 9.16) will monitor temporary impacts for approximately two to three years after dredging to determine the total loss of seagrasses. Results will be forwarded to the DEC with an appropriate offset package discussed for any loss of seagrasses greater than 5%.

Management Unit 3

A Category C, 2% cumulative loss threshold has been applied to Management Unit 3. There has been no historical loss of BPPH in this unit. The Project will not impact seagrass in Management Unit 3.

Section 9.2.5 Management of BPPH

Management procedures for dredging and land reclamation will focus on minimising the impact footprint and restricting additional impacts to a practical minimum. During the dredging operation, BPPH will also be managed through maintaining, at a minimum, marine water and sediment quality as described in Section 9.1.

Dredging will be conducted such that additional maintenance dredging will be minimised, allowing seagrass densities, where temporarily impacted, to recover. Based on previous experience at the Port, the occurrence of maintenance dredging is infrequent with the last maintenance dredging event occurring in 1985 following a large storm event.

As seagrasses are vulnerable to light climate disturbances (which lower the photosynthetic capacity of individual plants), the duration and the quantity of the TSS associated with dredging will be minimised where possible. Strategies for minimising turbidity associated with dredging are outlined in Section 9.1.4.2.

A BPP monitoring programme will be included in the Dredge and Land Reclamation Management Plan submitted prior to dredging operations. The monitoring programme will involve collection of
9. POTENTIAL IMPACTS ASSOCIATED WITH DREDGING AND LAND RECLAMATION

baseline data and establishment of trigger values for reactive monitoring of seagrass health and shoot density throughout the dredge programme. Monitoring will be continued after completion of the dredge programme to monitor seagrass recovery and provide final data on the Project’s impacts to seagrasses.

Dredging in the entrance to Princess Royal Harbour is likely to disturb sediment containing nutrients from historical land uses within the catchment. Large quantities of nutrients introduced into the marine environment have the potential to impact BPPH health through the proliferation of algal blooms which can limit the available light to seagrasses. Dredge management strategies will be implemented to ensure significant concentrations of nutrients are not introduced into the marine environment.

Vessels will comply with the Australian Quarantine and Inspection Service Australian Ballast Water Management Requirements, 2001, and the Australian Quarantine Regulations 2000. These requirements include no discharge of high-risk ballast water, or sediments from ballast tanks in Australian Ports or waters, and strict reporting requirements for vessels arriving in Australia from international waters. APA will also consult with Department of Fisheries WA (DoF) Biosecurity Unit regarding vessel mobilisation and hygiene requirements prior to entry into the port.

Section 9.2.6 Predicted Outcome for BPPH

Management Unit 1: Princess Royal Harbour

In Princess Royal Harbour there will be a loss of 0.01% of BPPH in the land reclamation area and on the south side of the channel associated with dredging and land reclamation activities. The small area of low density seagrass in the land reclamation area is dominated by Posidonia australis with a little P. sinuosa, whereas the seagrass on the south side of the channel is a dense meadow of mixed seagrass dominated by P. sinuosa and P. australis. This represents a loss of 0.01% of BPPH from Management Unit 1, which exceeds the cumulative loss threshold of BPPH allowable for Category F; of 0% net damage/loss.

Loss of seagrasses from Princess Royal Harbour will be offset through maximising the re-planting or seed stock from seagrass that will be lost to achieve the greatest areal extent possible from the donor material in an appropriate location as outlined in the Seagrass Rehabilitation Management Plan, developed in consultation with the DEC.
9. POTENTIAL IMPACTS ASSOCIATED WITH DREDGING AND LAND RECLAMATION

Management Unit 2: Inner King George Sound

The most probable level of impact in Management Unit 2 associated with the dredging will be a 2.62% to 3.15% permanent loss of BPPH in the inner region of King George Sound resulting from the establishment of the channel by dredging. This loss is predicted to be permanent in the channel area and its baffle walls; however, outside of this area the seabed will still be suitable for recovery and re-colonisation by seagrasses and thus BPPH.

Dredging when the meteorology is dominated by westerly winds (winter-spring: July to October) is the best case scenario for BPPH as the turbid plumes are the most spatially confined (Figure 9.23). South easterly prevailing winds (March to June) allow plumes to persist in King George Sound for a longer period of time relative to the winter-spring scenario. The ‘mixed season’ (November to February) scenario is also influenced by easterly winds, resulting in turbidity levels more pronounced than the other two dredge scenarios (Figure 9.22, Figure 9.24).

Management Unit 3: Outer King George Sound

No permanent loss of BPPH is predicted in the outer region of King George Sound (Management Unit 3).

BPPH will not be impacted by algal blooms or introduced species due to the implementation of appropriate dredge strategies and quarantine measures.

Section 9.2.7 Environmental Management Commitments for BPPH

Commitment 7: Prior to activities that may impact on the marine environment, a Dredge and Land Reclamation Management Plan will be developed. This will include Benthic Primary Producer management actions for a reactive monitoring programme to detect potential BPP loss beyond that predicted. In addition an effects monitoring programme will be implemented to ascertain actual impacts and the degree of recovery over time.

Commitment 8: The Dredge and Land Reclamation Management Plan will be implemented throughout dredge and land reclamation activities.