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1. BACKGROUND

The Port of Port Hedland, as part of the Pilbara Ports Authority, is the largest single bulk export port servicing the Iron Ore, Salt and other smaller mineral exports. The Port also handles significant volumes of general cargo imports servicing the mining and pastoral industries. A varying range of vessels service these trades with vessel sizes ranging from 5,000 tonnes deadweight to Very Large Ore Carriers.

The Port of Port Hedland is currently in a phase of high growth with the expansion and upgrading of existing infrastructure as well as developing new infrastructure within the harbour.

Consequently there are a large number of small commercial vessels engaged in development works within the harbour which require a mooring location both in fair weather as well as during cyclones. Additionally, smaller vessels involved in commercial fishing also frequent the Port from time to time. These vessels often list Port Hedland as a port of refuge or a haven in the event of a cyclone forming off the coast and threatening the port area. Such vessels also seek a mooring within the port to unload catches, effect necessary repairs, perform crew changes or to provide rest and recreation for crew members. There are also locally based harbour work boats and vessels involved in the tourism industry which need regular moorings and other services.

Pilbara Ports Authority (PPA) acknowledges these legitimate requirements however due to the limitations faced with regards to the very limited space available within the sheltered areas of the port; it may not always be possible to afford all such vessels a safe mooring in fair or cyclonic weather conditions.

Each and every commercial vessel (including barges) remaining within Port Hedland Harbour throughout a declared Cyclone season must have an approved designed and installed Cyclone Mooring along with an approved Cyclone Management Plan.
2. OBJECTIVE

In line with standard port protection philosophy for the management of marine activities through the Prevention, Preparation, Response and Recovery from specific risks, the objective of these procedures is to eliminate the risk associated with inadequately designed and/or inadequately maintained moorings, as well as ensuring that well found moorings or vessels on such moorings do not pose or create an unacceptable risk or hazard within the port.

This document outlines the policy and procedures required to effectively eliminate the risk to people, vessels and port infrastructure and also to meet the information needs of the owners, designers and installers of moorings within the Port of Port Hedland by providing information with regard to mooring design, installation and maintenance.

The Port of Port Hedland must remain as safe as practicable during normal day-to-day operations and during times of cyclonic threat from the risks posed by vessels and/or moorings adrift in the harbour. PPA will enforce this Mooring Policy in line with its Duty of Care obligations to all mariners, vessels and other port users as well as protecting the port’s infrastructure.

The purpose of these procedures is to establish an equitable and transparent system of mooring approvals and management so that the port users, including owners of visiting vessels, understand the requirements of PPA in relation to moorings whether they are cyclone or day moorings.

3. SCOPE

These procedures have been developed and are administered by PPA in accordance with its responsibilities under the Port Authorities Act 1999 (the Act).

PPA has the statutory authority to give effect to these procedures within the gazetted port boundaries and within the declared piloting area extending twenty (20) miles from the Hunt Point beacon, including (but not limited to):

- Be responsible for the safe and efficient operation of the port
- Protect the environment of the port, and
- Minimise the impact of the port activities on the environment.

This policy is over-arched by the Port Marine Safety Plan and forms an Annex to the PPA Cyclone Procedures which should be read and understood in conjunction with this document.

In applying these procedures, the safety of personnel at all times remains paramount.
4. DEFINITIONS

In this document:

- “Mooring” means a structure or apparatus used or proposed to be used to secure a vessel in the port. A mooring includes a vessel’s anchor, but does not include a wharf, jetty or pylon attached to the sea bed.

- “Mooring Owner” means a person authorised to install or to use a mooring by the Harbour Master under the provisions of these procedures.

5. CONTROL OF MOORINGS

Unless authorised by the Harbour Master or delegate under these procedures a person must not install or use a mooring within port waters.

6. RESPONSIBILITIES OF A MOORING OWNER

Mooring owners must comply with PPA mooring standards by virtue of Port Authorities Regulations 2001 (WA) and to ensure the safety of all vessels and infrastructure within port waters.

- A mooring permit or location once granted may not be sold, transferred, rented, swapped, assigned, relocated or bartered except by prior approval of the Harbour Master.

- The owner of a mooring within the harbour undertakes that he/she has the capability to have the mooring relocated at short notice to another location within the harbour as defined by, and on request of, the Harbour Master should the need arise.

- A mooring owner must ensure that the mooring is maintained in good condition.

- In addition to the above, owners to comply with the notes listed in the addendum to the Mooring Application Form (Appendix 1).

7. APPLICATION FOR APPROVAL

- A person must apply to the Port Authority for authorisation to install or use a day or cyclone mooring.
An application is to be made on the Mooring Application Form approved by the Port Authority. Applications may be emailed to the Port Authority, attention to the Harbour Master or delegate at: cyclonemoorings@pilbaraports.com.au

8. STANDARDS FOR MOORING DESIGN

The design criteria for a day or cyclone mooring will vary according to the location of the mooring and the available water depth. Appendix 2 provides the minimum design criteria to be applied for cyclone, wind and sea state for various locations in the port.

Before placing a permitted mooring in the water the mooring tackle design and construction must be in accordance with mooring consultant/designer specifications and a copy of this report forwarded to the Harbour Master. Mooring design and specifications should take into account and be sufficient to overcome the forces likely to be experienced in the harbour as outlined in Appendix 2.

Upon installation the mooring must be inspected by an approved mooring inspector for structural integrity, disposition on the seabed and compliance with these standards. This report must include a written report containing photographs from diver inspection of the below water tackle and specified configuration.

Inspection reports are to be accompanied with evidence of engineering recertification and any maintenance work by the mooring consultant/designer.

9. AUTHORISATION OF MOORING

On receipt of an application, the Harbour Master may authorise the installation or use of a mooring, if satisfied that:

- The location or proposed location of the mooring is appropriate;
- The mooring is suitable for the vessel that is to be moored at the mooring;
- The mooring is designed and constructed, or proposed to be constructed, so that the vessel to be moored at the mooring would be securely moored during day or cyclone conditions as appropriate; and
- The vessel to be moored at the mooring would not constitute a danger to, or interfere with, the navigation of other vessels in the port.
- The Harbour Master will provide an applicant with written notice of authorisation or otherwise after having taken into account the requirements contained in this procedure.
10. REVOCATION OF AUTHORISATION

The Harbour Master may revoke a mooring authorisation issued under Clause 9 if:

- The mooring owner does not provide an inspection report as detailed in the appendixes of these procedures
- The Harbour Master is satisfied that it is in the interests of marine safety at the port to do so.

11. MOORING INSPECTION

A mooring owner authorised to install a mooring, or to use a mooring under these procedures, is to obtain a written report on the condition of the mooring:

- Immediately after it is installed or shifted; and
- Prior to the start of the cyclone season each year for a cyclone mooring.
- Every two (2) years for a day mooring.
- The reports are to be prepared by an approved mooring inspector. Further, a letter needs to be provided from the original mooring designer or a naval architect confirming that the mooring is compliant with PPA requirements.
- The mooring owner is to provide to the PPA a copy of the mooring inspection report within seven (7) working days of the inspection and in the case of an annual report pertaining to a cyclone mooring, not later than 31st October of the relevant year.
- If excessive deterioration is observed by the mooring inspection, the mooring is not to be used until all worn components are replaced and re-endorsed by the mooring consultant. Maintenance details are to be forwarded to the Harbour Master.
- For cyclone moorings, if 15% wear from original specifications is observed, the mooring is not to be used until all worn components are replaced and details of maintenance forwarded to the Harbour Master.
- In assessing the standards and specifications of a particular mooring, the following minimum Annual Return Intervals (ARI) are to be adhered to as per information detailed in Appendix 2:
  - For day moorings, an ARI of 20 is to be used.
  - For cyclone moorings, an ARI of 100 is to be used.
- The mooring owner is liable for the costs of an inspection and the cost of any remedial work that may be required following the inspection.
12. APPROVAL OF MOORING INSPECTORS AND MOORING DESIGNERS

A mooring owner applying to have a mooring installed within the port or undertaking an inspection of an existing mooring within the port, must employ the services of a mooring designer or inspector approved by the Port Authority.

Organisations wishing to be licenced and therefore listed as Mooring Inspectors and Mooring Designers with the port should apply to the Harbour Master in writing listing their qualification. In addition to other details, the application should be accompanied with the applicants:

- Registered Company Name
- Proof of Professional Indemnity Insurance and other related Insurance Policies
- A Safety Management Plan
- Qualifications, Experience, Confirmation Audits and proof of compliance with relevant Australian Standards and ISO Certification.

13. MOORING FLOATS AND MARKINGS

A mooring owner must ensure that there is at all times connected to the mooring a float or buoy (mooring buoy) that:

- Has sufficient size to provide buoyancy when supporting the rope or chain riser between the mooring array and the surface float, so that at least half of the mooring buoy projects above the water surface.
- Is bright yellow or orange in colour and additionally is fitted with retro reflective plates or tape and/or a flashing light.
- Has a diameter of not less than 300 mm.
- Is legibly marked with PPA allocated mooring number and 24 hour contact number of the owner as approved by the Harbour Master.
- A photograph of the buoy in the water depicting its markings to be provided to the Harbour Master at the time of submitting the initial inspection report as well as every year with the annual inspection report.

14. DISPOSAL OF MOORINGS

A mooring owner must notify the Port Authority if the mooring is sold or otherwise disposed of.
The Harbour Master may remove a mooring from the waters of the port if after reasonable enquiries is unable to identify or find the owner of that mooring or if the owner of that mooring fails to provide an annual report.

In the event of the loss of a mooring PPA is to be notified of the loss as soon as possible after the discovery of the loss.

15. CYCLONE MOORINGS

In the event of the approach of a cyclone to the port, vessel and mooring owners will comply with the Port’s Cyclone Procedures.

Small craft will be secured to moorings or removed from the water as per the owner’s annual cyclone management plan.

Generally the port will be closed to all small craft movements 6 – 12 hours before the onset of gale force winds associated with the cyclone.

At that time all craft are to be secured to their moorings and all personnel are to vacate the craft and return to the shore.

Under no circumstances will small craft remain manned within the port during a cyclone event either free running or on a mooring.

16. REFERENCES

- Port Authorities Regulations, 2001 (WA) Part 9 ‘Control of Moorings’
- Cardno Lawson Treloar – Wave Climate Study and Assessment of Vessel Cyclone Moorings and Ship Interaction Study Within the Port of Port Hedland
- Port of Dampier Mooring Standards

17. PROCESS OWNER

The Deputy Harbour Master has overall responsibility for this procedure.
APPENDIX 1 - RESPONSIBILITIES OF MOORING OWNERS

In accordance with Port Authorities Regulations 2001 and to ensure the safe navigation of all vessels within Port waters, the Pilbara Ports Authority (PPA) requires mooring owners (not the Approved Inspector) to comply with the following standards.

- Owners wanting to place a mooring for a vessel within Port Hedland Port Limits or 20NM offshore from Hunt Point must submit an application by email to cyclonemoorings@pilbaraports.com.au in the designated format. All Day / Cyclone Mooring applications must be accompanied by a mooring analysis from a PPA approved Mooring Designer as detailed in Appendix 3.

- Supply the Latitude and Longitude of the preferred location and a description of the vessel to PPA.

- Once the original application is approved the mooring can be set and must be checked by an approved mooring inspector, which includes a divers inspection of the below water tackle and specified configuration. Please refer to Appendix 4 for a list of PPA approved Mooring Inspectors.

- Final confirmation that the mooring is set in the designated location, along with a photograph of the buoy and top mark, must be forwarded to the Harbour Master.

- The mooring may then be approved/not approved for use by the Harbour Master.

- Ensure cyclone moorings are inspected annually and day moorings 2 yearly by a PPA approved Mooring Inspector prior to 01 October each year.

- Inspection Mooring Report Forms can only be performed by an "Approved Mooring Inspector" to ensure all recommended maintenance work is completed; the report form together with evidence of the work carried out, including a photo of the top mark and evidence of a diver’s inspection must be forwarded to the PPA prior to 1 November each year.

- Ensure allocated mooring number and a 24 hours contact number is on the buoy, positioned where it will be clearly legible at all times and away from marine growth, bird droppings and tackle chaffing.

- Buoy to be not less than 300mm diameter and either bright yellow or orange in colour and fitted with retro reflective plates or tape and/or a flashing light.

- Advise PPA prior to a mooring being sold or of any change to owners contact details by submitting an application by email to cyclonemoorings@pilbaraports.com.au.
Cyclone Moorings are "design specific" for a particular vessel. If the mooring is to be utilised by another vessel during a cyclone event, written PPA approval must be obtained in advance.

Notify PPA if mooring is completely removed from Port waters.

Failure to comply with any of the above standards may result in the removal of the mooring or prosecutorial action.

"Port Authorities Regulations 2001", Section 17, Revoking authorisation of mooring:

The harbour master may revoke an authorisation under clause 16 if:

- A mooring owner does not provide an inspection report as required under clause 20(4); or
- The harbour master is satisfied that it is in the interests of marine safety at the port to do so.”

APPENDIX 2 – DESIGN CRITERIA FOR MOORINGS

This Appendix details a condensation of results of wind and sea forces present in the harbour.

Listed mooring designers and engineers involved in the design of a mooring within the port are to use the information provided in this appendix as a basis on which the mooring is designed so as not to greatly over compensate the forces for which the mooring is designed.

In designing day moorings, an ARI of 20 is to be used.

In designing cyclone moorings, an ARI of 100 is to be used.

It is to be borne in mind that the below figures are the result of studies, modelling and simulation on the forces present in the harbour and though considered accurate, is intended to assist a designer/engineer in the designing of a mooring. PPA bears no responsibility with regards to the failure, loss or damage to a mooring as a result of compliance with this annex.

The synopsis of forces present in the harbour is as outlined below:

- Main Flood and Ebb Directions
- The main flood and ebb directions of the current at the northern and southern locations (Figure 1) are the following:

PHN:
- Ebb current direction is north-east: between 335° and 155°.
- Flood current direction is south-west: between 155° and 335°.

PHS:
- Ebb current direction is north-west: between 225° and 45°.
- Flood current direction is south-east: between 45° and 225°.

The current speeds for flood and ebb tide at the North (PHN) and South (PHS) locations for selected ARI are presented in Tables 1 and 2.

The storm tide (astronomical tide + storm surge) at the North (PHN) and South (PHS) locations for selected ARI are presented in Table 3.

Table 1: Ebb Current Velocities at the North (PHN) and South (PHS) Locations for 5, 10, 20, 50, 100, 200 and 500-Years ARI Calculated Using Cyclone External Analysis and During an Equinoctial Spring Tide.

<table>
<thead>
<tr>
<th>EBB CURRENT</th>
<th>PHN</th>
<th></th>
<th>PHS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ARI</td>
<td>U (m/s)</td>
<td>95% Confidence</td>
<td>U (m/s)</td>
</tr>
<tr>
<td>5</td>
<td>0.68</td>
<td>0.62 - 0.73</td>
<td>0.46</td>
<td>0.42 - 0.49</td>
</tr>
<tr>
<td>10</td>
<td>0.78</td>
<td>0.68 - 0.88</td>
<td>0.53</td>
<td>0.47 - 0.59</td>
</tr>
<tr>
<td>20</td>
<td>0.92</td>
<td>0.76 - 1.08</td>
<td>0.62</td>
<td>0.53 - 0.71</td>
</tr>
<tr>
<td>50</td>
<td>1.02</td>
<td>0.81 - 1.23</td>
<td>0.68</td>
<td>0.56 - 0.79</td>
</tr>
<tr>
<td>100</td>
<td>1.12</td>
<td>0.86 - 1.38</td>
<td>0.73</td>
<td>0.60 - 0.87</td>
</tr>
<tr>
<td>200</td>
<td>1.22</td>
<td>0.91 - 1.54</td>
<td>0.79</td>
<td>0.63 - 0.96</td>
</tr>
<tr>
<td>500</td>
<td>1.36</td>
<td>0.97 - 1.75</td>
<td>0.86</td>
<td>0.66 - 1.07</td>
</tr>
<tr>
<td>Spring Tide (Equinox)</td>
<td>0.78</td>
<td>0.97 - 1.75</td>
<td>0.52</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Flood Current Velocities at the North (PHN) and South (PHS) Locations for 5, 10, 20, 50, 100, 200, and 500-Years ARI Calculated using Cyclone External Analysis and During an Equinoctial Spring Tide.

<table>
<thead>
<tr>
<th>FLOOD CURRENT</th>
<th>PHN</th>
<th></th>
<th>PHS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ARI</td>
<td>U (m/s)</td>
<td>95% Confidence</td>
<td>U (m/s)</td>
</tr>
</tbody>
</table>

This document is uncontrolled if printed or distributed electronically
Table 3: Storm Tide Level (m LAT) at the North (PHN) and South (PHS) Locations for 5, 10, 20, 50, 100, 200 and 500-Years ARI calculated using Cyclone External Analysis and During an Equinoctial Spring Tide.

<table>
<thead>
<tr>
<th>ARI</th>
<th>PHN</th>
<th>PHN (m LAT)</th>
<th>95% Confidence</th>
<th>PHN (m LAT)</th>
<th>95% Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>6.73</td>
<td>6.52 - 6.94</td>
<td>6.78</td>
<td>6.57 - 6.98</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>7.10</td>
<td>6.83 - 7.38</td>
<td>7.15</td>
<td>6.87 - 7.43</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>7.52</td>
<td>7.16 - 7.88</td>
<td>7.56</td>
<td>7.20 - 7.93</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>7.81</td>
<td>7.36 - 8.25</td>
<td>7.85</td>
<td>7.40 - 8.29</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>8.08</td>
<td>7.52 - 8.63</td>
<td>8.11</td>
<td>7.57 - 8.66</td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>8.34</td>
<td>7.66 - 9.02</td>
<td>8.37</td>
<td>7.71 - 9.02</td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>8.67</td>
<td>7.80 - 9.53</td>
<td>8.69</td>
<td>7.86 - 9.51</td>
<td></td>
</tr>
<tr>
<td>Spring Tide (Equinox)</td>
<td>7.38</td>
<td>7.43</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HAT</td>
<td>7.50</td>
<td>7.50</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Design Wind Speed and Wave Height

Design wind speeds at the North (PHN) and South (PHS) locations are presented in Table 4.

Table 4: Wind Speed at the North (PHN) and South (PHS) Locations for 5, 10, 20, 50, 100, 200 and 500-Years ARI.

<table>
<thead>
<tr>
<th>WIND</th>
<th>PHN</th>
<th>PHS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARI (years)</td>
<td>W (m/s)</td>
<td>95% Confidence</td>
</tr>
<tr>
<td>5</td>
<td>19.6</td>
<td>14.3 - 25.0</td>
</tr>
<tr>
<td>10</td>
<td>29.1</td>
<td>22.3 - 35.8</td>
</tr>
<tr>
<td>20</td>
<td>37.9</td>
<td>30.6 - 45.1</td>
</tr>
<tr>
<td>50</td>
<td>43.3</td>
<td>35.8 - 50.8</td>
</tr>
<tr>
<td>100</td>
<td>48.2</td>
<td>40.1 - 56.2</td>
</tr>
<tr>
<td>200</td>
<td>52.6</td>
<td>43.7 - 61.5</td>
</tr>
<tr>
<td>500</td>
<td>58.0</td>
<td>47.3 - 68.6</td>
</tr>
</tbody>
</table>

Note that these are 10-minute average wind speeds at an elevation of 10m. Furthermore, they are the jointly occurring wind speeds associated with the design wave, water level and current parameters described elsewhere. Note that all designs shall also consider design wind speeds set down in the Australian wind code.

Tables 5 and 6 present the design wave parameters in terms of significant wave height (Hs), peak period (Tp) and direction at the north (PHN) and south (PHS) locations within Port Hedland harbour. Events have been presented in different colours depending on the wave direction. Generally the waves at the northern location are from the north-east or from the south-south-west, and at the south location from the north-west, south and north-east.

The maximum modelled wave heights (Hs) were ~2.9m at PHN during cyclone Karen and ~1.7m at PHS during cyclone Orson, with a peak period Tp around 3 to 5 seconds.

Table 5: Peak Storm Wave Parameters at the North (PHN) Location for 5, 10, 20, 50, 100, 200 and 500-years ARI.
**PHN** | **DEPTH** | **HSIG** | **DIR** | **TP**  
--- | --- | --- | --- | ---  
Cyclone | [m] | [m] | [degr] | [sec]  
Karen | 21.3 | 2.87 | 59 | 4.9  
Joan | 21.8 | 2.81 | 57 | 5.2  
John | 21.4 | 1.51 | 58 | 4.3  
Dean | 22.0 | 1.41 | 48 | 5.2  
Jane | 21.0 | 1.41 | 57 | 4.8  
Sheila-Sophie | 20.8 | 1.34 | 51 | 4.5  
Kerry | 21.7 | 0.92 | 63 | 3.8  
Clare | 20.5 | 0.79 | 44 | 4.2  
Connie | 20.1 | 0.74 | 45 | 3.9  
Gwenda | 20.2 | 0.67 | 54 | 3.5  
Monty | 16.3 | 1.47 | 214 | 3.4  
Leo | 19.1 | 1.39 | 179 | 3.3  
Kirsty | 16.7 | 1.28 | 142 | 3.0  
Trixie | 18.2 | 0.91 | 222 | 3.0  
Orson | 20.1 | 0.85 | 216 | 2.9

*The events are sorted by the 2 main wave directions and by decreasing values. Main wave direction are represented by different colours: i.e. blue for NE wave direction and yellow from SW wave direction*

Table 6: Peak Storm Wave Parameters at the South (PHS) Location for 5, 10, 20, 50, 100, 200 and 500-Years ARI.
**SMALL VESSEL MOORING PROCEDEURE**
**PORT OF PORT HEDLAND**

![Logo](Pilbara_Ports_Authority_Logo.png)

<table>
<thead>
<tr>
<th>PHN</th>
<th>DEPTH</th>
<th>HS</th>
<th>DIR</th>
<th>TP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyclone</td>
<td>13.7</td>
<td>1.66</td>
<td>335</td>
<td>3.7</td>
</tr>
<tr>
<td>Orson</td>
<td>13.4</td>
<td>1.00</td>
<td>331</td>
<td>3.5</td>
</tr>
<tr>
<td>Monty</td>
<td>13.4</td>
<td>0.80</td>
<td>337</td>
<td>3.0</td>
</tr>
<tr>
<td>Trixie</td>
<td>13.7</td>
<td>0.54</td>
<td>345</td>
<td>2.2</td>
</tr>
<tr>
<td>Sheila-Sophie</td>
<td>13.7</td>
<td>0.54</td>
<td>345</td>
<td>2.2</td>
</tr>
<tr>
<td>Leo</td>
<td>12.7</td>
<td>0.45</td>
<td>327</td>
<td>2.6</td>
</tr>
<tr>
<td>Connie</td>
<td>16.4</td>
<td>1.49</td>
<td>73</td>
<td>3.3</td>
</tr>
<tr>
<td>Clare</td>
<td>16.9</td>
<td>0.33</td>
<td>64</td>
<td>2.1</td>
</tr>
<tr>
<td>Dean</td>
<td>13.8</td>
<td>0.23</td>
<td>79</td>
<td>1.5</td>
</tr>
<tr>
<td>John</td>
<td>14.2</td>
<td>1.25</td>
<td>130</td>
<td>3.3</td>
</tr>
<tr>
<td>Karen</td>
<td>11.8</td>
<td>0.98</td>
<td>132</td>
<td>2.8</td>
</tr>
<tr>
<td>Kirsty</td>
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<td>0.96</td>
<td>198</td>
<td>2.8</td>
</tr>
<tr>
<td>Joan</td>
<td>13.4</td>
<td>0.86</td>
<td>123</td>
<td>2.7</td>
</tr>
<tr>
<td>Kerry</td>
<td>13.4</td>
<td>0.60</td>
<td>172</td>
<td>2.5</td>
</tr>
<tr>
<td>Gwenda</td>
<td>13.4</td>
<td>0.60</td>
<td>100</td>
<td>2.5</td>
</tr>
<tr>
<td>Jane</td>
<td>14.6</td>
<td>0.28</td>
<td>121</td>
<td>1.9</td>
</tr>
</tbody>
</table>

*The events are sorted by the 3 main wave directions and by decreasing values. Main wave direction is represented by different colours: i.e. blue for NW wave direction, yellow from ENE wave direction and pink for S to SE wave direction.

Using the data presented Table 5 and 6, the design wave heights (irrespective of wave direction) at the North (PHN) and South (PHS) locations were calculated and are presented in Table 7.

**Table 7: Significant Wave Heights at the North (PHN) and South (PHS) Locations for 5, 10, 20, 50, 100, 200 and 500-Years ARI.**
The penetration of swell into the harbour has been investigated. Generally, it is found that due to the complex bathymetry near the entrance to Port Hedland harbour; that is, a deep shipping channel that passes through a shallow near shore area, the wave energy is refracted out of the channel and onto the shallow areas. Therefore the extreme significant wave heights that would occur in Port Hedland harbour are caused mainly from near shore wind generated sea rather than swell propagating from offshore into the harbour, though there is some swell as well. Most of the swell component of the waves is refracted away from the entrance before it reaches the entrance of the harbour.

Table 8: Swell Height at the North (PHN) Location for 5, 10, 20, 50, 100, 200 and 500-Years ARI.
The swell component of the waves (i.e. longer period) tends to be more refracted than the short period waves. The swell wave heights in the harbour are significantly smaller than the sea although the peak period within the harbour may remain characteristic of swell waves, being typically 10 to 12 seconds period (Tp) in the harbour.

Tidal Currents

Figures 3 and 4 show tidal currents during flood and ebb periods for a typical spring tide. The flood and ebb currents generally follow the shipping channel and peak speeds are approximately 1 to 2 knots within the channel, but only about 0.5 knots within the shallower bays on the harbour’s west side. Further into the harbour, near Anderson and Burgess Points, tidal currents reach speeds up to 2.5 to 3 knots in the shallow estuarine bed areas.

Maximum current velocities and directions extracted for selected locations within the harbour: in the shipping channel and near the berths (Figures 5 and 6). Maximum Flood and Ebb velocities and directions are presented in Table 9 for the Spring and Neap tide and in Table 10 for the Equinoctial Spring tide.

Table 9: Maximum Flood and Ebb Current Velocities and Associated Directions during a Typical Spring and Neap Tides at Selected Location within Port Hedland Harbour (Location presented in Figure 3 and Figure 4).
### Table 10: Maximum Flood and Ebb Current Velocities and Associated Directions during an Equinoctial Spring Tide at Selected Locations within Port Hedland Harbour.

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>SPRING TIDE</th>
<th>NEAP TIDE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Flood (m/s)</td>
<td>Ebb (m/s)</td>
</tr>
<tr>
<td></td>
<td>U (m/s)</td>
<td>Dir (deg)</td>
</tr>
<tr>
<td>1</td>
<td>1.10</td>
<td>229</td>
</tr>
<tr>
<td>2</td>
<td>0.99</td>
<td>224</td>
</tr>
<tr>
<td>3</td>
<td>0.95</td>
<td>217</td>
</tr>
<tr>
<td>4</td>
<td>0.96</td>
<td>194</td>
</tr>
<tr>
<td>5</td>
<td>0.96</td>
<td>168</td>
</tr>
<tr>
<td>6</td>
<td>0.57</td>
<td>144</td>
</tr>
<tr>
<td>7</td>
<td>0.18</td>
<td>105</td>
</tr>
<tr>
<td>B1</td>
<td>0.28</td>
<td>202</td>
</tr>
<tr>
<td>B2</td>
<td>0.49</td>
<td>201</td>
</tr>
<tr>
<td>B3</td>
<td>0.45</td>
<td>171</td>
</tr>
<tr>
<td>B4</td>
<td>0.11</td>
<td>120</td>
</tr>
<tr>
<td>B5</td>
<td>0.14</td>
<td>82</td>
</tr>
<tr>
<td>B6</td>
<td>0.18</td>
<td>138</td>
</tr>
<tr>
<td>PHN</td>
<td>0.41</td>
<td>251</td>
</tr>
<tr>
<td>PHS</td>
<td>0.43</td>
<td>115</td>
</tr>
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</table>
### Wave Climate

Figures 7 to 13 shows the wave height and peak period characteristics at each of the location for the 3 year of UKMO wave data.

Table 11 presents the 50, 10 and 1% probability of exceedance in terms of significant wave height and the 1 day per year significant wave height as well as the mean wave direction at each location. The range of peak period corresponding to each significant wave height is also shown. This is determined by using the complete data set of wave heights and peak periods at each location presented in Figure 7 to 13.
Table 11: The Probability of Exceedance (50%, 10%, 1% and 1 day per year) in Terms of Significant Wave Height at the Seven Locations within Port Hedland & the Associated Peak Period Range and Mean Wave Direction at Each Location for Each Hs.

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>PROBABILITY OF EXCEEDANCE</th>
<th>Mean Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50%</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>Hs (m)</td>
<td>Tp (s)</td>
</tr>
<tr>
<td>1</td>
<td>0.10</td>
<td>1 - 10</td>
</tr>
<tr>
<td>2</td>
<td>0.08</td>
<td>1 - 10</td>
</tr>
<tr>
<td>3</td>
<td>0.08</td>
<td>1 - 10</td>
</tr>
<tr>
<td>4</td>
<td>0.08</td>
<td>1 - 10</td>
</tr>
<tr>
<td>5</td>
<td>0.07</td>
<td>1 - 10</td>
</tr>
<tr>
<td>6</td>
<td>0.06</td>
<td>1 - 10</td>
</tr>
<tr>
<td>7</td>
<td>0.06</td>
<td>1 - 10</td>
</tr>
</tbody>
</table>
Figure 1: Cyclone Moorings – Output Locations
Figure 2: Port Hedland Bathymetry Surveys 2005-2006
Figure 3: Flood Currents – Spring Tides
Figure 4: EBB Currents – Spring Tides
Figure 5: Wave Current and Output Locations
Figure 6: Significant Wave Height Probability of Exceedance
Figure 7: Significant Wave Height vs. Peak Period: Location 1
Figure 8: Significant Wave Height vs. Peak Period: Location 2
Figure 9: Significant Wave Height vs. Peak Period: Location 3
Figure 10: Significant Wave Height vs. Peak Period: Location 4
Figure 11: Significant Wave Height vs. Peak Period: Location 5
Figure 12: Significant Wave Height vs. Peak Period: Location 6
Figure 13: Significant Wave Height vs. Peak Period: Location 7
APPENDIX 3 – PPA LISTED MOORING DESIGNERS

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Facsimile: (08) 9335 1995
Contact Person: Justin McPherson

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Maritime Engineers Pty Ltd
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Total AMS

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