Port Hedland Spoilbank Marina Project

Operational Environmental Management Plan

CLIENT: Department of Transport

STATUS: Rev 1

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In the spirit of reconciliation, the Department of Transport and O2 Marine Pty Ltd acknowledge that this project is implemented on the lands of the Kariyarra, Ngarla, and Nyamal People. We pay our respects to Elders past, present and emerging and recognise their continuing connection to land, sea, culture and community.

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Version Register

Version	Status	Author	Reviewer	Comment	Authorised for Release (signed and dated)
Rev A	Draft	M Spence (DoT)	-	-	-
Rev B	Draft	J Bradford (DoT)	-	Submitted to EPA as draft management Plan to support project referral.	-
Rev C	Draft	P Bouvais (O2M)	R Stevens (O2M)	Internal O2M review	-
Rev D	Draft	P Bouvais (O2M)	T Harken (DoT) J Bradford (DoT)	Issued for Client review	R Stevens 18/01/2024
Rev E	Draft	P Bouvais (O2M)	Derek Walker (PPA)	Client (DoT) review addressed into final draft for issue to regulator	R Stevens 7/02/2024
Rev F	Draft	P Bouvais (O2M)	DCCEEW	PPA review addressed into final draft for issue to regulator	R Stevens 20/02/2024
Ref G	Draft	P Bouvais (O2M)	DCCEEW	DCCEEW pre-comment comments addressed in this version for resubmission	R Stevens 14/05/2024
Rev 0	Final	P Bouvais (O2M)	DCCEEW	Comments from DCCEEW assessment addressed in updated version	R Stevens 18/07/2024
Rev 1	Final	P Bouvais (O2M)	DoT	Updates to Appendix plans	R Stevens 13/08/2024

		S Billinghurst (O2M)			

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I declare that to the best of my knowledge, all the information contained in, or accompanying this document is complete, current, and correct. I am duly authorised to sign this declaration on behalf of the approval holder. I am aware that:

a. section 490 of the Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth) (EPBC Act) makes it an offence for an approval holder to provide information in response to an approval condition where the person is reckless as to whether the information is false or misleading.

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c. the above offences are punishable on conviction by imprisonment, a fine or both.

Signed: ___________________________

Full name: Shelley Grice

Document will be signed when issued as final

Organisation: Department of Transport (DoT)

DoT ABN: 27 285 643 255

EPBC Referral Number: 2019/8520

Name of Action Management Plan this document and declaration refers to: Spoilbank Marina: Operational Environmental Management Plan.

Date: 16 August 2024

Acronyms and Abbreviations

Term	Full term
AHD	Australian Height Datum
ALMP	Spoilbank Marina Artificial Light Management Plan
BCH	Benthic Communities and Habitat
DAWE	Department of Agriculture, Water and the Environment
DBCA	Department of Biodiversity, Conservation and Attractions
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DoT	Department of Transport
DoE	Department of the Environment
DoEE	Department of the Environment and Energy
DEMP	Dredging Environmental Management Plan
DPIRD	Department of Primary Industries and Regional Development
DWER	Department of Water and Environmental Regulation
EMP	Environmental Management Plan
EPA	Environmental Protection Authority
EPO	Environmental Protection Outcome
EV	Environmental Value
HSE	Health Safety Environment
LAU	Local Assessment Unit
MEQMP	Marine Environment Quality Management Plan
MEER	Maritime Environmental Emergency Response
MNES	Matters of National Environmental Significance
MT	Management Target
PPA	Pilbara Ports Authority
OEMP	Operational Environmental Management Plan
RAMP	Revised Action Management Plan
RSI	Referral Supplementary Information
SMP	Sediment Management Plan

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Summary

Project detail	Description	
Title of Project	Port Hedland Spoilbank Marina Project: Operational Environmental Management Plan (OEMP)	
Proponent	Department of Transport	
Approval	• State environmental approval was granted by the Environmental Protection Authority (EPA) under the Environmental Protection Act 1986 on 14 April 2020 as 'Referral Examined, preliminary investigations and inquiries conducted. Proposal not to be assessed under Part IV of the EP Act – Advice given' • Federal environmental approval was granted by the Department of Climate Change, Energy, the Environment and Water (DCCEEW) under the Environmental Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) on 19 February 2021 via EPBC 2019/8520.	
Purpose of the Operational Environmental Management Plan (OEMP)	This OEMP has been prepared to outline how environmental aspects and impacts will be managed during the operational phase of the marina complex.	
Approval conditions (EPBC 2019/8520)	5.	The approval holder must submit an Operational Environment Management Plan (OEMP), at least three months prior to the anticipated commencement of the operation of the marina, for the Minister's approval to ensure that the operation of the marina does not significantly impact protected matters. The OEMP must: a) include an Artificial Lighting Management Plan (ALMP) that ensures artificial lighting associated with the operation of the marina does not impact upon Flatback Turtle nesting on Cemetery Beach. The ALMP must be consistent with the Department's National Light Pollution Guidelines for Wildlife including Marine Turtles, Seabirds and Migratory Shorebirds (2020) and include: i. the finalised artificial lighting design of the marina; ii. justification of how the proposed design will prevent impacts to Flatback Turtle hatchlings on Cemetery Beach; iii. a monitoring and reporting program, which includes baseline data that monitoring and reporting will be evaluated against, to be undertaken for a minimum length of two years post commencement of operation of

		the marina to provide certainty that the artificial lighting of the marina is not impacting Flatback Turtle hatchlings or nesting on Cemetery Beach; and iv. management measures and corrective actions to be implemented should monitoring indicate that the marina's artificial lighting is likely to impact Flatback Turtle hatchlings on Cemetery Beach. b) include a Sediment Management Plan (SMP) that ensures anthropogenic activities of the action do not result in, or contribute to, the denuding of Cemetery Beach. The SMP must include measures to monitor for denuding of Cemetery Beach and specify intervention measures to be implemented should denuding of Cemetery Beach be predicted or detected as a result of: i. anthropogenic activities; and/or ii. environmental factors in combination with anthropogenic activities. c) include a Marine Environment and Water Quality Management Plan (MEQMP) that addresses how marine water quality, sediment quality and accumulation of marine debris will be monitored and managed to prevent impacts to protected matters from the operation of the marina. The MEQWMP must specify and justify the quality indicators to be monitored and timing of monitoring to prevent impacts to protected matters, including specific trigger criteria and limits, and clear, detailed corrective actions that will be implemented to prevent impacts to protected matters should trigger criteria and limits be reached.
	6.	The approval holder must not commence operation of the marina unless the Federal Minister for the Environment and Water has approved the OEMP in writing. If the Minister approves the OEMP then the approved OEMP must be implemented.
	7.	All plans required under these conditions must be consistent with the DCCEEW's Environmental Management Plan Guidelines, and must include: a) The environmental objectives, relevant to protected matters and a reference to EPBA Act approval conditions to which the plan refers; b) A table of commitments made in the plan to achieve the objectives; and a reference to where the commitments are detailed in the plan; c) Reporting and review mechanisms, and documentation standards to demonstrate compliance with the commitments made in the plan; d) An assessment of risks to achieving the environmental objectives and risk management strategies that will be applied; e) Impact avoidance, mitigation and/or repair measures, and their timing; and

		f) A monitoring program, which must include: i. measurable performance indicators; ii. trigger values for corrective actions; iii. the timing and frequency of monitoring to detect trigger values and changes in the performance indicators; and iv. proposed corrective actions, if trigger values are reached.
Key Environmental Factors	The following EPA Environmental Objectives guide and inform the OEMP and the attached management plans, which have been developed in accordance with the EPA's Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans and align with the EPAs Environmental Factor Guidelines: • Marine Fauna (EPA 2016a) – The EPA's Environmental Objective for this Factor is 'to protect marine fauna so that biological diversity and ecological integrity are maintained'. • Marine Environmental Quality (EPA 2016b) – The EPA's Environmental Objective for this Factor is 'to maintain the quality of water, sediment and biota so that environmental values are protected'. • Coastal Processes (EPA 2016c) – The EPA's Environmental Objective for this Factor is 'To maintain the geophysical processes that shape coastal morphology so that the environmental values of the coast are protected'.	

1. Introduction

1.1. Background

The construction of the Spoilbank Marina (the Marina) is currently underway on the western side of the Spoilbank. The Marina consists of an enclosed basin protected by an outer rock wall and a ~1 km channel to provide access to the open sea. The Marina design includes a four-lane boat ramp, public fishing jetty and allows for up to 80 boat pens, with 22 initial pens to be constructed and the remainder to be constructed following a staged approach after the Marina is operational.

PPA were nominated as the developer of the Port Hedland Spoilbank Marina, a government initiative originally led by the Department of Transport (DoT) in partnership with the Town of Port Hedland (ToPH). The Marina is located on the western side of the spoil bank sand formation, a man-made coastal landform created in the late-1960s and early-1970s from the disposal of material dredged from Port Hedland's inner harbour and shipping channel. Subsequently, DoT has replaced PPA as the proponent and approval holder for the maritime facilities and will be responsible for the operations including management, monitoring, and maintenance of the Marina's water body. The Town of Port Hedland will ensure the maintenance of landside facilities.

The Marina will replace the existing Richardson Street boat ramp (which will be closed to the public) and redirect recreational boating activities away from the commercial operations of Port Hedland's inner harbour and navigation channel (Town of Port Hedland 2019). The Marina includes a four-lane boat ramp, 22 boat pens, car and trailer parking bays, amenities, public open space, recreational boating activities, and event space (Figure 1).

The proposed marina project was initially referred to the Western Australian Environmental Protection Authority (EPA) and the Department of Climate Change, Energy, the Environment and Water (DCCEEW) for formal assessment. The EPA considered the Project did not require formal assessment and provided 'Referral examined, preliminary investigations and inquiries conducted. Proposal not to be assessed under Part IV of the EP Act. Advice given (Appealable)' decision on 14 April 2020. Federal environmental approval was granted by the Department of Climate Change, Energy, the Environment and Water (DCCEEW) under the Environmental Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) on 19 February 2021 via EPBC 2019/8520.

As required by Condition 5 of EPBC 2019/8520 this Operational Environmental Management Plan (OEMP) has been developed to ensure that the operational activities associated with the marina to not result in adverse or unacceptable marina environmental impacts.

1.2. Approval Holder Details

In May 2021, application was made under Section 145B of the EPBC Act for the Transfer of approval holder from DoT to PPA with the transfer formalised on 18 May 2021. DoT will be the operator of the Marina and therefore the approval is to be made under Section 145B of the EPBC Act to transfer back from PPA to DoT. The DoT operators details are presented in Table 1.

Table 1: Approval holder details

Company Name:	Department of Transport
Australian Business Number (ABN):	27 285 643 255
Address:	5 Newman Court, FREMANTLE WA 6160
Key Contact (Role):	Shelley Grice A/Director Coastal Facilities Management
Key Contact Details:	Phone: 0427 934 814 Email: Shelley.Grice@transport.wa.gov.au

1.3. Spoilbank Marina Short Summary

A short summary of the approved proposal and the associated physical elements for the Marina are detailed and summarised below and in Table 2 and Table 3:

- Marina basin, berth facilities (up to 80 pens), boat launching area and entrance channel
- Marina's breakwaters, revetments, and silt trap
- Parking facility, amenities (public and pen holders), public open space and upgrading of road infrastructure.

Table 2: Summary of the Spoilbank Marina

Title	**Port Hedland Spoilbank Marina**
Proponent name	Department of Transport
Short description	The Spoilbank Marina is a recreational boating and waterfront precinct that is being constructed on the western shoreline of the Spoilbank, located within the Town of Port Hedland, Pilbara. The Marina has been through a detailed design and environmental approval process and is currently set for all required construction to be completed by end 2024. Currently the marina and marine facilities (entrance channel, breakwaters, navigational markers etc.) are all completed with landside construction ongoing (car parking, landscaping, and associated facilities buildings). The Marina is anticipated to be fully operational by 1 May 2024. The Operational Environment Management Plan (OEMP) has been prepared to outline the monitoring and management requirements during ongoing operational activities and maintenance of the marina water body and infrastructure.

Table 3: Physical elements of the Spoilbank Marina

Element	Location	Extent (as constructed)
Physical Marine Element		
Marina basin and entrance channel	Figure 1	Ground disturbance and clearing of up to 12 ha
Breakwater and revetment wall	Figure 1	Ground disturbance and clearing of up to 6 ha
Silt trap	Figure 1	Ground disturbance and clearing of up to 8.5 ha
Physical Terrestrial Element		
Parking and trailer bays	Figure 1	Ground disturbance and clearing of up to 5 ha
Public open space	Figure 1	Ground disturbance and clearing of up to 5 ha
Road infrastructure	Figure 1	Ground disturbance and clearing of up to 3 ha

Figure 1: Port Hedland Spoilbank Marina Project Development Envelope

2. Project Approvals

2.1. State Determination

DoT referred the Project to the State Environmental Protection Authority (EPA) under the *Environmental Protection Act 1986* (EP Act) on 14 April 2020. The Chairman of the EPA identified the Project 'Referral Examined, preliminary investigations and inquiries conducted. Proposal not to be assessed under Part IV of the EP Act – Advice given'.

2.2. Commonwealth Determination

DoT referred the Project to the Commonwealth's Department of Environment and Energy (DoEE)[1] under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) on 22 August 2019. The Project was determined to be a 'Controlled Action' by a Delegate of the Commonwealth Minister for the EPBC Act on 21 January 2020 as it will, or is likely to have, a significant impact on the following Matters of National Environmental Significance (MNES):

- Listed threatened species and communities (section 18 and 18A); and
- Listed migratory species (sections 20 & 20A).

2.3. Approval Conditions

The requirements of Conditions 5, 6 and 7 of EPBC 2019/8520 and the commitments outlined within this OEMP are presented in Table 4.

[1] Now the Department of Climate Change, Energy, the Environment and Water

Table 4: Approved Conditions as applicable to this OEMP

Condition	Requirement	Reference	Commitments
EPBC 2019/8520[2]			
5	1. The approval holder must submit an Operational Environment Management Plan (OEMP), at least three months prior to the anticipated commencement of the operation of the marina, for the Minister's approval to ensure that the operation of the marina does not significantly impact protected matters. The OEMP must: a. include an Artificial Lighting Management Plan (ALMP) that ensures artificial lighting associated with the operation of the marina does not impact upon Flatback Turtle nesting on Cemetery Beach. The ALMP must be consistent with the Department's National Light Pollution Guidelines for Wildlife including Marine Turtles, Seabirds and Migratory Shorebirds (2020) and include: i. the finalised artificial lighting design of the marina; ii. justification of how the proposed design will prevent impacts to Flatback Turtle hatchlings on Cemetery Beach; iii. a monitoring and reporting program, which includes baseline data that monitoring and reporting will be evaluated against, to be undertaken for a minimum length of two years post commencement of operation of the marina to provide certainty that the artificial lighting of the marina is not impacting Flatback Turtle hatchlings or nesting on Cemetery Beach; and	This document forms the OEMP framework. The following supporting plans satisfy parts a)-c) Part a) Appendix A – MEQMP Part b) Appendix B – ALMP Part c) Appendix C - SMP	The proponent has developed and commits to the implementation of the OEMP and supporting management plans.

Condition	Requirement	Reference	Commitments
	iv. management measures and corrective actions to be implemented should monitoring indicate that the marina's artificial lighting is likely to impact Flatback Turtle hatchlings on Cemetery Beach. b. include a Sediment Management Plan (SMP) that ensures anthropogenic activities of the action do not result in, or contribute to, the denuding of Cemetery Beach. The SMP must include measures to monitor for denuding of Cemetery Beach and specify intervention measures to be implemented should denuding of Cemetery Beach be predicted or detected as a result of: i. anthropogenic activities; and/or ii. environmental factors in combination with anthropogenic activities. c. include a Marine Environment and Water Quality Management Plan (MEQMP) that addresses how marine water quality, sediment quality and accumulation of marine debris will be monitored and managed to prevent impacts to protected matters from the operation of the marina. The MEQWMP must specify and justify the quality indicators to be monitored and timing of monitoring to prevent impacts to protected matters, including specific trigger criteria and limits, and clear, detailed corrective actions that will be implemented to prevent impacts to protected matters should trigger criteria and limits be reached.		
6	The approval holder must not commence operation of the marina unless the Federal Minister for the Environment and Water has approved the OEMP in writing. If the Minister approves the OEMP then the approved OEMP must be implemented.	The final version of this Plan with DCCEEW endorsement and DoT signature of declaration of accuracy	The proponent has developed and commits to the implementation of the OEMP and supporting management plans prior to operations within the Marina

Condition	Requirement	Reference	Commitments
7	2. All plans required under these conditions must be consistent with the DCCEEW's Environmental Management Plan Guidelines, and must include: a. The environmental objectives, relevant protected matters and a reference to EPBC Act approval conditions to which the plan refers; b. A table of commitments made in the plan to achieve the objectives, and a reference to where the commitments are detailed in the plan; c. Reporting and review mechanisms, and documentation standards to demonstrate compliance with the commitments made in the plan; d. An assessment of risks to achieving the environmental objectives and risk management strategies that will be applied; e. Impact avoidance, mitigation and/or repair measures, and their timing; and f. A monitoring program, which must include: i. measurable performance indicators; ii. trigger values for corrective actions; iii. the timing and frequency of monitoring to detect trigger values and changes in the performance indicators; and iv. proposed corrective actions, if trigger values are reached.	This OEMP, including the supporting plans (ALMP, SMP and MEQMP) is consistent with EMP Guidelines: a. Section 3.2 b. Table 5 and Section 8 c. Section 6 d. Section 7 e. Section 9.2 f. Section 8 and Table 8	The proponent has developed and commits to the implementation of the OEMP and supporting management plans.

3. Scope and Objectives of this Plan

3.1. Scope

The scope of this OEMP and adjoining management plans are to manage impacts from the operational activities associated with the Marina. Construction impacts are not within the scope of this plan and are managed in accordance with specific management plans developed to manage dredging and construction. The OEMP is comprised of an overall environmental management framework and specific management sections to address relevant environmental factors and mitigate potential impacts from operational activities.

3.2. Objectives

The broad objective of this OEMP is to ensure that the ongoing operational use of the Marina does not result in unacceptable environmental impacts to the marine environment within, or surrounding the marina through operational activities, or from the physical elements of the as constructed Marina.

The specific objectives have been aligned with the EPA Environmental Factor Guidelines and include:

- Marine Environmental Quality (EPA 2016a) – The EPA's Environmental Objective for this Factor is 'to maintain the quality of water, sediment and biota so that environmental values are protected'.
- Marine Fauna (EPA 2016b) – The EPA's Environmental Objective for this Factor is 'to protect marine fauna so that biological diversity and ecological integrity are maintained'.
- Coastal Processes (EPA 2016c) – The EPA's Environmental Objective for this Factor is 'to maintain the geophysical processes that shape coastal morphology so that the environmental values of the coast are protected.

As this Proposal is a Controlled Action under the EPBC Act, DoT is committed to ensuring management for MNES are guided by clear environment objectives defined to achieve the following outcomes, including:

- Listed Threatened Species and Communities Environmental Outcome: Significant residual impacts do not occur from the Project as constructed and therefore the biological diversity and ecological integrity of Listed Threatened Species and Communities will be maintained.
- Listed Migratory Species Environmental Outcome: Significant residual impacts will not occur from the Project as constructed and therefore the biological diversity and ecological integrity of Listed Migratory Species will be maintained.

The key environmental factors and objectives to be managed under this OEMP have been derived from the Statement of Environmental Principles, Factors and Objectives (EPA 2016), which outlines objectives aimed at protecting all environments (Themes) including: Sea, Land, Water, Air and People. In consideration of potential environmental impact pathways associated with Marina activities, subsequent project specific Environmental Protection Outcomes (EPOs) and Management Targets (MTs) were derived for each of these factors and are outlined in Table 5.

Table 5: Environmental Objectives and Management Provisions

Environmental Factor	EPA Objective	Potential Environmental Impacts	Environmental Protection Outcomes	Management Targets	Management Measures
Marine Environmental Quality	To maintain the water, sediment and biota quality so that the environmental values are protected.	Water quality decline during the on-going operational phase.	No reported negative impacts on marine water quality attributable to the facility operation.	Manage water quality to maintain a Moderate Level of Ecological Protection within the marina waterbody and a High Level of Ecological Protection in all marine areas outside of the development envelope.	Outlined in Marine Environment Quality Management Plan (Appendix A). Maintenance dredging undertaken in accordance with Department of Transport's Maintenance Dredging Environmental Management Framework.
		Hydrocarbon spills.		Manage vessel bunkering, chemical storage and spill response to ensure no adverse impacts to the marine environment.	
		Short duration declines in water quality (turbidity) during necessary maintenance dredging operations		Manage turbidity generated by maintenance dredging to maintain a Moderate Level of Ecological Protection within the marina waterbody and a High Level of Ecological Protection in all marine areas outside of the development envelope.	
Marine Fauna	To ensure the biological diversity and ecological integrity are maintained.	Operational light spill/pollution impacts to Flatback Turtle (N. depressus) community on Cemetery Beach.	No reported negative impacts on marine fauna attributable to the operational lighting requirements of the marina.	Minimise the residual risk to hatchling disorientation towards the west of Cemetery Beach from the implementation of the marina development; and The lighting design for the constructed marina development is meeting legislative and regulatory requirements for human safety whilst maintaining the biological diversity and ecological integrity of flatback turtles.	Outlined in the Artificial Light Management Plan (Appendix B) and Section 0.

Coastal Processes	To maintain the geophysical processes that shape coastal morphology so that the environmental values of the coast are protected.	Operation of the Spoilbank Marina resulting in, or contributing to, the denuding of sediment from Cemetery Beach	No reported negative impacts on coastal process and sediment transport attributable to the facility operation.	Coastal Processes Monitoring to determine; (i) if denuding of Cemetery Beach occurs; (ii) if the denuding is attributable to the construction or operation of the Spoilbank Marina; and (iii) inform the implementation of management strategies.	Outlined I the Cemetery Beach Sediment Management Plan (Appendix C).
				Implementation of Shoreline Management Strategies to mitigate impacts if required – i.e. sand bypassing/back passing and/or sand nourishment.	

3.3. Matters of National Environmental Significance

The EPBC Act (1999) establishes a process for the assessment and approval of proposed actions that are likely to have a significant impact on matters of national environmental significance or on Commonwealth land.

The Spoilbank Marina Project was initially referred by DoT to the Commonwealth Department of Agriculture, Water, and the Environment[3] (DAWE) under the EPBC Act on 22 August 2019. The Proposal was determined to be a 'Controlled Action' by a Delegate of the Commonwealth's Minister for the EPBC Act on 21 January 2020 as it will, or is likely to have, a significant impact on the following Matters of National Environmental Significance:

- Listed threatened species and communities (section 18 and 18A):
  - Flatback turtle (*Natator depressus*) – vulnerable and migratory
  - Green turtle (*Chelonia mydas*) – vulnerable and migratory
  - Green sawfish (*Pristis zijsron*) – vulnerable and migratory
  - Dwarf sawfish (*Pristis clavata*) – vulnerable and migratory.
- and listed migratory species (sections 20 & 20A):
  - Narrow sawfish (*Anoxypristis cuspidata*) – migratory.

On 19 February 2021, DAWE issued an approval under the EPBC Act (EPBC 2019/8520) for the Proposal.

3.4. Key Environmental Factors

In accordance with Conditions 5 and 7 of EPBC 2019/8520, it is noted that this OEMP address the following Key Environmental Factors for:

- Marine Fauna
- Marine Environmental Quality
- Coastal Processes

[3] Now the Department of Climate Change, Energy, the Environment and Water

4. Existing Environment

4.1.1. Existing Investigations

The Port Hedland region has historically been the subject of numerous large-scale infrastructure developments, including extensive and periodic capital and maintenance dredging campaigns. The environment has been extensively surveyed and is well-understood.

DoT's environmental consultants undertook survey work within the development envelope and surrounding environment to support the Referral documentation, including:

- Sediment Sampling and Analysis Plan Implementation Report (Teal et al, 2019a)
- Marine Environmental Quality Plan (Teal et al 2020b)
- Water Quality Modelling Report (Baird 2020a)
- Dredge Environmental Management Plan (Teal et al 2020c)
- Benthic Communities & Habitat Report (Teal et al 2019b)
- Cumulative Loss Assessment Report (Teal et al 2020d)
- Care for Hedland Environmental Association - Community Volunteer Turtle Monitoring Program (1 October 2019 to 31 March 2020)
- Port Hedland Spoilbank Marina Artificial Lighting Impact Assessment Report (RPS et al 2020)
- Technical Memo – Spoilbank Marina Proposal: Review of Potential Impacts to Green Sawfish (Morgan et al 2019)
- Technical Memo – Assessment of potential Impacts upon Migratory Waterbirds (Bamford 2019)
- Technical Memo – Spoilbank Marina Proposal: Review of Potential Impacts to Flatback Turtles (PENV 2019)
- Technical Report – Spoilbank Marine Sawfish Risk Assessment Workshop Report (Teal et al 2020a)
- Underwater Noise Modelling Report (Talis 2020).
- Port Hedland Spoilbank Marina Metocean Design Criteria and Coastal Process Studies (Baird 2020b)
- A morphological assessment of the Spoilbank to identify past and current sedimentation processes and support the numerical modelling.
- Sea Level Change in Western Australia – Application to Coastal Planning (DoT 2010).
- Suspended Sediment Analysis – Port Hedland Spoil Bank Marina (Cardno 2019).
- Port Hedland Spoilbank Marina: Spoil Bank Morphodynamics (Seashore Engineering 2019).

Development WA's (formally LandCorp) environmental studies for the original Spoilbank Marina Proposal as proposed in 2011, undertaken by RPS Environmental Consultant between 2011 and 2015 include:

- Geotechnical Studies (Golder 2009 ; Cardno 2011)
- Preliminary Site Investigation (RPS 2011)
- Detailed Site Investigation (RPS 2011)
- Sampling and Analysis Plan for a Contaminated Site Investigation (RPS 2013)
- Water Quality Report (RPS 2014c)

- Final Groundwater Monitoring Report (RPS 2015)
- Intertidal and Subtidal Benthic Habitat Mapping (RPS 2013)
- Water Quality Report (RPS 2014c)
- Environmental Constraints Summary Report (RPS 2011)
- Marine Fauna Review (RPS 2014a)
- Waterbird Technical Review (RPS 2014b)

Consideration for BHP Billiton Iron Ore's environmental studies for the BHP Outer Harbour Development, located approximately 5 km west from the Spoilbank Marina project area, including:

- Intertidal Benthic Primary Producer Habitat Summary (BHP 2009c)
- Baseline Coral Health Monitoring Report Periods 1-13 (BHP 2009d)
- Subtidal Marine Benthic Habitats Impact Assessment (BHP 2011)
- Port Hedland Migratory Shorebird Survey Report and Impact Assessment (Bennelongia 2011)
- Marine Turtle Usage Within the Port Hedland Region and Impacts Assessment (PENV 2009)
- Marine Turtle Towed Video Surveys 2009-10 (BHP 2009a)
- Marine Mammal Management Plan (BHP 2009b)
- Flatback Turtle Tagging Program at Cemetery Beach 2009/2010 (PENV 2010).

4.1.2. Current Understanding

Terrestrial flora and vegetation

DoT environmental consultants undertook a flora and vegetation desktop assessment and reconnaissance site survey work in February 2019, in accordance with EPA's guidelines. It was noted that the site is characterised by predominantly bare sediment with areas of sparsely covered patches of colonising coastal shrubs and grasses (dominant species Buffel grass). No Threatened or Priority Ecological Communities were recorded, and no species of conservation significance were found. The vegetation was generally in degraded condition, being dominated by Buffel grass, and was fragmented by many four-wheel-drive tracks (Strategen 2020b).

DoT's consultants concluded that the Spoilbank Reserve is characterised by a low diversity of vascular flora species and high densities of aggressive weeds. The vegetation does not meet criteria for conservation significance, and no Priority Flora species were identified at the site (Strategen 2020b).

Groundwater

Groundwater survey work included a 12-month groundwater monitoring program of the study area in 2015 (RPS 2015). The program consisted of salinity profiling to determine the presence and location of the saline interface, groundwater quality monitoring and an assessment of groundwater-tidal interactions. The study identified groundwater flowed in a northly direction and discharge into the ocean at the coast. However, due to the presence of the Spoilbank, a minor north to south aligned groundwater mound developed, acting as a groundwater divide between the east and west boundaries of the site, directing flows towards both sides of the Spoilbank.

The Project area experiences a very high tidal range, which at times exceeds six metres (RPS 2014). Tidal impact on groundwater elevations occurs in two main cycles – semi-diurnal cycles between high and low, and neap and spring tides occurring twice every lunar month. Salinity fluctuated during the 12-month period, most likely correlating to the temporal variations of rainfall recharge to the aquifer. Salinity ranged between saline and hypersaline (5000 mg/L and 40,000 mg/L TDS).

Groundwater quality investigations recorded exceedances in total iron and dissolved cadmium, copper, nickel and zinc (RPS 2014). These recordings were similar throughout the entire monitoring period with no spatial or temporal trend. The Detailed Site Investigation undertaken by RPS in 2014 concluded that metal concentrations in groundwater are considered reflective of natural conditions in the aquifer given the consistent concentrations across and up-hydraulic gradient of the site, and the fact that no contamination sources were identified.

Surface Water

The Project is located on a man-made feature with no discernible surface water flows. No surface water or surface expressions of groundwater are present at the site (RPS 2011).

Sediment Quality

Environmental investigations and survey work was undertaken across the Project's development envelope to characterise the physio-chemical composition of the marine sediment (subtidal and intertidal) (Teal et al 2019). Sampling was undertaken in accordance with the National Assessment Guidelines for Dredging (NAGD 2009) and the samples were analysed for particle size distribution, total organic carbon, pesticides, metals, organotins, acid sulfate soils, asbestos containing materials and hydrocarbons.

All analytes were below the available ANZG (2018) guideline values, NEPM (2013) Health Investigation Levels (HILS) and NAGD (2009) Screening Levels. At six locations, Aluminium and Iron exceeded locally derived background levels, however these exceedances were considered to be consistent with ambient concentrations in the area.

All samples were screened for acid sulfate soils and selected samples were subject to chromium suite acid sulfate analysis. The chromium reducible sulfur concentration of three samples were above the action criteria of 0.03% sulfur. The locations of two samples (B12 and S29-B) were in the nearshore environment and one (C02) at the start of the navigation channel. However, consideration of the acid neutralising capacity presented a positive Net Acidity, which indicated sufficient in-situ buffering capacity for any acid generated during handling. The analysis concluded that sediments were considered suitable for onshore disposal.

Marine Fauna

The Port Hedland area is known to support a number of conservation significant marine fauna species, including marine reptiles, cetaceans, fish species and migratory shorebirds. Cemetery Beach, located approximately 2 km east of the development envelope, has been identified as a biologically important area for inter- nesting flatback turtles (Natator depressus). It is understood that Cemetery Beach supports a mid-sized community (approx. 200 – 500 individuals) that nest on the beach between late November and March, with key hatchling periods between January to March (PENV, 2020).

The EPBC Act Protected Matters Search Tool (PMST) report (5 km buffer radius) identified a number of threatened and migratory marine fauna species that may frequent the area, including the blue whale, southern right whale, humpback whale, great white shark, whale shark, as well as dwarf, narrow and green sawfish.

Green turtles have also been observed within the Port Hedland Harbour and surrounding mangrove creeks (PENV 2009). Although juvenile and adult turtles utilise habitat within the Port Hedland area for foraging and breeding, regionally significant foraging sites are known to occur beyond the Port Hedland Inner Harbour (RPS et al 2020).

The green sawfish has been historically recorded in inshore marine waters and inhabits muddy bottom habitats and estuaries (Thorburn et al 2007). The green sawfish is the most commonly distributed species of sawfish in Western Australian waters, occurring in areas with a muddy substrate and frequently found in shallow water. It commonly inhabits marine inshore waters, estuaries and lagoons. Most sawfish move into marine waters during or after the wet season and re-enter estuarine or fresher waters to breed (Morgan et al 2011).

A large number of seabird and shorebird species (or species habitat) may occur within the vicinity of the Project area; this includes species classified as threatened and migratory under the EPBC Act or specially protected under the WA Biodiversity Conservation Act 2016.

Benthic Communities and Habitat

DoT's environmental consultants undertook ground truthing surveys and targeted survey work in 2019 in accordance with Technical Guidance, Protection of Benthic Communities and Habitats (EPA 2016e).

The Project subtidal BCH assessment mapped three broad BCH classes within the Detailed Mapping Zone and LAU, including:

- Bare Sand
- Mixed assemblage (Corals, Sponges, Macroalgae, and Hydrozoan)
- Mixed assemblage with seagrass (sparse Seagrass, Sponges, Macroalgae, and Hydrozoan)

The benthic cover was found to be generally sparse to low across more than 95 per cent of the study area. Small areas of low to medium-density mixed assemblage habitat were typically found on consolidated or semi-consolidated substrate generally in shallow water and/or in the intertidal zone and mostly along the shoreline. Areas of mixed assemblage with seagrass were found in slightly deeper water (>3 m) generally in areas with coarse sediment substrate. All habitats identified within LAUs are widespread across the turbid nearshore environments of the Pilbara region and did not represent conservation significant habitat (Teal et al 2019b).

Near the development envelope mixed assemblage habitat were present on low profile reefs and patches of very sparse ephemeral seagrass on sand were also observed. Sparse seagrass communities were observed in the vicinity of the Project area, and in the coastal LAU to the west. Survey work also observed corals occurring in proximity of the Project's development envelope.

In mid-2023 PPA completed the dredging and marina construction works associated with the Port Hedland Spoilbank Marina development. Dredging was conducted by Hall Dredging Contractors. To ensure that potential project impacts were adequately managed, a project specific Dredging Environmental Management Plan (DEMP) (O2 Marine 2021) was developed and implemented throughout the dredging campaign. One of the requirements of the DEMP was to implement a Benthic

Communities and Habitat (BCH) Monitoring Program which comprised pre- and post-dredging surveys to assess potential impacts associated with light reduction and sediment smothering to validate marine environmental impact predictions presented within the DEMP. The findings from this study indicate that there was no impact on BCH presence attributable to dredging activities, and in fact there has been an overall increase in BCH cover. Indeed, during the 2023 post dredge survey, bare substrate had decreased by 35.2 ha to represent 45% of the study area, while mixed assemblage had increased by 9.1 ha and mixed assemblage with sparse seagrass had increased by 26.1 ha comprising of 25.9% and 29.0%, respectively. However, the variability between the pre- and post-dredge survey is likely due to the four-year gap between surveys, therefore, differences are likely attributed to natural variation of the region.

Coastal Processes

The Spoilbank is an artificial landform created from the disposal of dredge material during capital dredging of the Port Hedland and the Goldsworthy shipping channel in the late-1960s and early 1970s. Over the past 50 years, this artificially constructed area of land has migrated south and evolved from an offshore island to a shore-connected sandspit peninsula.

Multiple regional scale geomorphology and coastal engineering assessments confirmed that the Spoilbank is highly vulnerable to hydrodynamic forces. This man-made land feature was initially accreting sediment onshore but has now stepped into a shrinking / eroding phase. Substantial erosion is anticipated to occur over forthcoming decades. Morphological changes are particularly pronounced during severe tropical cyclone storms, including the recent Tropical Cyclone Veronica event in March 2019.

Since 2003, the land feature has been experiencing a clear erosional trend and with the absence of a sediment source to replenish the Spoilbank, the mechanisms for continued rotation of the northern shoreline and loss of the Spoilbank landmass continues unmitigated (Baird 2020b). The Spoilbank evolution over the next 50-year period predicts a loss of over 50 per cent of its footprint as the erosional trend continues.

Coastal environmental values located on, and adjacent to the Spoilbank land formation include conservation significant marine fauna habitat (including nesting, breeding or foraging habitat) intertidal and sub-tidal benthic communities, including a stand of open canopy arid zone mangrove (Avicennia marina) population that occupies the seaward margin of the foreshore located approximately 1 km to the south-west of the project area. The Spoilbank also provides the community of Port Hedland with a site for active and passive recreational activities, including fishing and 4WD activities. No unique landforms, significant cultural and aesthetic values, conservation significant flora and vegetation species occur on Spoilbank (Strategen 2020a).

5. Roles, Responsibilities and Training

5.1. Environmental Management Roles and Responsibilities

DoT and their Contractors will assign suitable resources to oversee the management and implementation of the OEMP. Key roles and responsibilities are summarised in Table 6.

Table 6: Roles and responsibilities of key personnel for implementing the OEMP

Role	Key Responsibility
Department of Transport Environment & Approvals	• Liaise with regulatory authorities as required. • Manage the review this OEMP and associated management plans as necessary and manage change requests. • Approve proposed responsive or contingency management actions to be implemented in the event of an exceedance. • Monitor and close out corrective actions identified during environmental monitoring or audits. • Ensure compliance with all conditions of EPBC 2019/8520 and all commitments within this Plan and associated management plans • Ensure all monitoring requirements of all management plans are implemented and reported within the Annual Reporting Period • Ensure compliance with all reporting and review requirements • Oversee any contractors commissioned to undertake environmental monitoring and reporting requirements under this, or associated management plans
Spoilbank Marina Operator	• Comply with the requirements set out in this OEMP and other relevant plans • Liaise with contractors to ensure communication and understanding of environment requirements as outlined in this OEMP Ensure all site personnel are aware of their responsibilities set out in relevant management plans and procedures. • Oversee health, safety and environment (HSE) inspections, audits and investigations. • Review and approve the Contractor's HSE plans. • Review reporting on HSE non-compliances and incidents. • Verify relevant Environmental Approvals for the activities exist prior to commencing. • Assist with the review, investigation and reporting of environmental incidents. • Ensure environmental monitoring and inspections/audits are undertaken as per the requirements of this OEMP. • Liaise with relevant regulatory authorities as required. • Perform external reporting of any environmental incidents/events. • Monitor and close out corrective actions identified during environmental monitoring or audits. • Provide advice to relevant DoT personnel and Contractors to assist them to understand their environment responsibilities. • Oversee implementation of the in force OEMP in the field.
Contractors	• Comply with the requirements set out in this OEMP and other relevant plans.

Role	Key Responsibility
	• Manage the activity so it is undertaken as per the relevant standards and commitments in this OEMP. • Ensure all personnel are aware of their responsibilities through an induction program. • Investigate and propose effective responsive or contingency management actions for implementation, where required. • Implement responsive or contingency management action on direction from DoT. • Participate in HSE inspections, audits and investigations. • Report on HSE non-compliances and incidents. • Ensure personnel are competent to undertake the work they have been assigned. • Ensure equipment is appropriately maintained and operated to prevent risk of environmental incidents. • Establish and maintain clear communication with DoT.
Monitoring Contractor	• Implement the OEMP monitoring program as described in Section 5. • Ensure all Monitoring personnel are aware of their responsibilities through a induction program. • Develop HSE Plans for approval by DoT personnel. • Participate in HSE inspections, audits and investigations. • Report on HSE non-compliances and incidents. • Ensure equipment is appropriately maintained and operated to prevent risk of environmental incidents. • Establish and maintain clear communication with DoT.

5.2. Training and Competency

To ensure personnel understand their responsibilities and expectations in relation to environmental management, training and awareness will occur continuously throughout the life of the Project.

All project personnel attending site will be subject to a Company and Project Site Induction which includes relevant environmental information such as:

- Fauna management
- Incident notification and procedures
- Waste management
- Spill responses procedures; and
- Aboriginal heritage awareness

An induction and training register will be used to record and monitor induction attendance by all personnel. The Contractor(s) will be required to ensure that environmental issues and the requirements of the OEMP are adequately communicated to the work teams. Examples of methods/forum which could be used include but are not limited to:

- Project kick-off meetings

- Daily pre-start meetings
- Tool-box meetings
- Noticeboards, and
- Environment alerts

The Contractor(s) will be required to keep records of the above (as applicable) for review by DoT on request.

5.3. Stakeholder consultation

A community educational program will be developed to inform marine users and the wider general public about environmental issues relating to the site and how to minimise their impacts to the marine environment, including wildlife awareness information (targeting marine turtles and migratory birds) and strategies to reducing marine debris, rubbish and dust emissions.

6. Reporting

Reporting is the responsibility of the Department of Transport Maritime in accordance with the following sections.

6.1. Annual Environmental Reports

The data collected from monitoring programs will be compiled into a comprehensive and interpretive annual report to provide an overview perspective of the data collected. This may be included as a single report for all monitoring program or separate reports for each program, with an assessment against the defined project objectives, EPOs and MTs for determination on the influences of the Marina activities on the key factors and MNES.

Further specific reporting for each of the three specific management and monitoring programs are contained within each of the management plans included as Appendix A-C.

Annual monitoring reports will be provided to DCCEEW on an annual basis. Reporting is the responsibility of the Department of Transport Environment & Approvals Department.

6.2. Annual Compliance Reports

DoT will prepare a compliance report for each 12 month period following the date of commencement of the action, or otherwise in accordance with an annual date that has been agreed to in writing by the Minister. The approval holder will:

a. publish each compliance report on the website within 60 business days following the relevant 12 month period;

b. notify the Department by email that a compliance report has been published on the website and provide the weblink and documentary evidence providing proof of the date of publication for the compliance report within five business days of the date of publication;

c. keep all compliance reports publicly available on the website until this approval expires;

d. exclude or redact sensitive ecological data from compliance reports published on the website; and

e. where any sensitive ecological data has been excluded from the version published, submit the full compliance report to the Department within 5 business days of publication

6.3. Non-compliance Reporting

DoT will notify the Department in writing of any: incident; non-compliance with the conditions; or non-compliance with the commitments made in plans. The notification will be given as soon as practicable, and no later than two business days after becoming aware of the incident or non-compliance. The notification will specify:

a. any condition which is or may be in breach;

b. short description of the incident and/or non-compliance; and

c. the location (including co-ordinates), date, and time of the incident and/or non-compliance. In the event the exact information cannot be provided, provide the best information available.

DoT will provide to the Department the details of any incident or noncompliance with the conditions or commitments made in plans as soon as practicable and no later than 10 business days after becoming aware of the incident or non-compliance, specifying:

a. any corrective action or investigation which the approval holder has already taken or intends to take in the immediate future;

b. the potential impacts of the incident or non-compliance; and

c. the method and timing of any remedial action that will be undertaken by the approval holder

7. Potential Environmental Impacts and Risk

DoT has identified the key sensitive receptor requiring specific management to be the biologically important population of flatback turtles (*N. depressus*) located at Cemetery Beach, approximately 2 km east of the development envelope. The flatback turtle is considered a Matter of National Environmental Significance and is protected under the Commonwealth's Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act) and the State's Biodiversity Conservation Act 2016. Operational light spill / pollution and water quality changes have been identified the key impact pathways for the species requiring management.

Alterations to marine environmental quality within the marina have also been identified due to the operations within, and the altered physical processes of, the marina. This typically relates to the potential for litter/waste and altered chemical and physical parameters effecting water and sediment quality within the marina.

Altered, localised coastal processes were also identified as potentially resulting in coastal erosion. This was particularly highlighted due to the importance of Cemetery Beach for Turtle Nesting and socially within the region.

DoT has outlined a robust management approach as part of the OEMP and support management plans and is of the view that the impacts associated with the Project could be avoided entirely or minimised to an acceptable level.

The pressure analysis assessed present and potential pressures within the Marina potentially affecting Marine Environmental Quality, Marine Fauna and Coastal processes. For the purpose of the Plan, pressures are defined broadly as *'processes influenced by marina activities that can detrimentally affect key environmental factors.'*

The assessment enables the pressures to be categorised in terms of their relative importance and has informed the identification of environmental priorities for monitoring, management, and reporting. The assessment encompasses all known risks posed to the marine environment in the Marina and surrounding waters and informs the selection of the most appropriate management measures.

Table 7 includes a description and discussion of the pressures and risks in the context of the Marina.

Table 7: Summary of the pressure and risk for Spoilbank Marina

Pressure	Description of Pressure	Rationale	Risk
Toxicants	Loads, concentrations or bioavailability of pesticides, herbicides, organics, oils, hydrocarbons, metals, metalloids, organometallics, radiation, other toxic chemicals and contaminants.	Heavy metals and metalloids can enter the marine system through vessel maintenance activities, breakdown of anodes, degradation of antifoul coatings, and hydrocarbons from vessels or a potential spill incident within the marina pose a risk to EVs of the area	Moderate
Hydrocarbon spills	Loads, concentrations or bioavailability of hydrocarbons.	Hydrocarbons can enter the marine system through vessels or a potential spill incident within the marina pose a risk to key environmental factors.	Moderate
Aquatic sediment	Change to load, distribution / movement patterns, settlement / resuspension rates, grain size of suspended or settled sediments.	Dredging and alteration of hydrodynamics affect the distribution of sediments within the Marina, with a build-up of sediments likely to occur in low energy areas. The area is located adjacent to an anthropogenic in nature and the Marina constitutes no new threat to aquatic sediments. Sediment transport modelling was also conduced (Baird 2020) which identified the location displaying an erosional trend since ~2003 with the marina providing a stabilising benefit.	Low
Hydrodynamics	Changes to local patterns of waves, currents or changes to frequency and duration of tidal inundation above MSL. Ponding of marine water.	Physical modification of the Spoilbank, such as increases in depth of the Marina and access channel, and artificial structures such as breakwalls, can affect local current and tidal exchange patterns and contribute to the loss or degradation of habitat. Hydrodynamic modelling identified minor, highly localised shifts ion hydrodynamics from the approved design.	Low
Bacteria/ pathogens	Bacteria, viruses, protozoans or fungi which cause disease. Recreational vessels using the facility may include liveaboard vessels, such as houseboats or yachts.	Pathogens have the potential to enter the marine system through discharges of sewage from commercial and recreational vessels. Commercial vessel activity is managed by the federal government and locally by PPA.	Moderate

Pressure	Description of Pressure	Rationale	Risk
Biota (animal) removal or disturbance	Removal, loss or disturbance of individual organisms of a specific species, not areas of habitat.	Recreational vessel currently operate from the Richardson Street Jetty. As the Spoilbank Marina replaces this aged facility, there is not considered to be any additional threat over and above current recreational activities. The Marina is also adjacent to a major Port facility and is considered a far lower risk to biota.	Low
Nutrients	Change to load, bioavailability and/or concentrations of nutrients.	Waters of Port Hedland are typically nutrient poor and anthropogenic influences such as agriculture runoff and discharge from sewage treatment plants/ablution facilities are a very low risk.	Low
Altered physiochemistry	Changes to natural temperature, salinity, turbidity, dissolved oxygen or pH.	The enclosed embayment within the Marina has the potential to change locale physiochemistry of the water quality leading to potential biological impacts.	Moderate
Artificial lighting	<u>Adult turtles:</u> Artificial light can impact various aspects of adult female turtle nesting behaviours, such as the location of beach emergence, nest construction, nesting abandonment, egg deposition success, hatchling production, and adult return to the sea.	Some of the pole lighting in the marina being elevated above the line-of sight level from Cemetery Beach, which means that the lighting will be directly visible even with current mitigation measures in place. In addition to direct visibility of lights, there will also be some sky glow visible.	Low
	<u>Hatchling Turtles:</u> • misorientation and disorientation of hatchling turtles. • hatchling dispersal disruption, resulting in delayed movement, disorientation in the nearshore, and the exertion of energy.		Moderate
Changes to coastal process and sediment transport pathways	Operation of the Spoilbank Marina resulting in, or contributing to, the denuding of sediment from Cemetery Beach.	Changes to the local sediment transport pathways and subsequent movement of Cemetery Beach, including shoreline recession, have occurred in the past and are predicted to continue independent of the Spoilbank Marina.	Low
Marine Debris	Human made rubbish/debris. Marine debris may include solid	Litter entering the marine system from recreational vessel activities can detract from the visual amenity,	Moderate

Pressure	Description of Pressure	Rationale	Risk
	wastes, hazardous wastes and sewage and grey water.	can harm animals (entanglement, starvation, suffocation) and toxic substances can leach out of litter.	

8. Management Approach

The approach to development of the OEMP for the Spoilbank Marina was undertaken in a manner consistent with the EPAs Environmental Factor Guidelines (EPA 2016a; EPA 2016b; EPA 2016c), Technical Guidance (EPA 2016d), Environmental Assessment Guideline (EPA 2010), National Light Pollution Guidelines for Wildlife (DCCEEW 2023) and the Environmental Management Plan Guidelines (DoE 2014).

To ensure the operation of the marina does not significantly impact protected matters, the OEMP incorporates three specific management plans developed to manage impacts related to the three Key Environmental Factors and include:

1. The Marine Environmental Quality Plan (O2 Marine 2023) (Appendix A), that addresses how marine water quality, sediment quality and accumulation of marine debris will be monitored and managed to prevent impacts to protected matters from the operation of the marina. The focus of the undertaken approach is on maintaining existing environmental quality, identifying where management and/or remediation actions may be required and to measure the effectiveness of these actions.
2. The Artificial Light Management Plan (PENV 2023) (Appendix B), that ensures artificial lighting associated with the operation of the marina does not impact upon Flatback Turtle nesting on Cemetery Beach.
3. The Cemetery Beach Sediment Management Plan (Coasts and Ports 2023) (Appendix C), that ensures anthropogenic activities subsequent to marina's operations and maintenance activities do not result in, or contribute to, the denuding of Cemetery Beach.

An overview of each of these plans is presented in Sections 8.1-8.3 and a summary provided for in Table 8.

Additionally, provisions for marina management from operational pollution are included herein.

Management of future maintenance dredging requirements of the marina basin, navigational channel and silt trap will be undertaken in accordance with the DoT Maintenance Dredging Environmental Management Framework (BMT 2016). Depending on the operational requirements, dredge material will be managed onsite and re-used were possible. If required, alternative disposal options will be investigated, and appropriate approvals will be sought from State and Commonwealth departments.

8.1. Marine Environmental Quality Management Plan (MEQMP)

The purpose of this MEQMP is to manage the marine environmental quality within and adjacent to the Marina to ensure that the operation of the Marina does not adversely affect marine environmental quality. The MEQMP provides a framework to monitor, characterise and report long-term trends in marine water and sediment quality within the Marina and surrounding waters and the document forms part of the OEMP for the Marina.

8.1.1. Scope and Objectives

This Plan has been developed to achieve the following specific objectives:

- To ensure compliance with Condition 5c EPBC 2019/8520
- Briefly summarise the MEQMP for the Spoilbank Marina
- Outline the proposed changes to the Spatial Levels of Ecological Protection to account for the Marina design footprint
- Outline the water and sediment quality sampling and analysis procedures to:
  - Ensure collection, analysis and reporting of water and sediment quality data in a consistent and robust manner; and
  - Provides a suitable basis on which to inform future management strategies to maintain and/or improve water and sediment quality in the Marina and surrounding waters.

8.1.2. Legislation / Guidelines

This MEQMP was developed in accordance with the Environmental Protection Authority's (EPA) Technical Guidance for Protecting the Quality of Western Australia's Marine Environment (EPA 2016b). It is also written to address Condition 5.c of EPBC 2019/8520 issued under the EPBC Act.

8.1.3. Monitoring Approach

This monitoring program adopts a tiered approach consisting of:

- Routine monitoring
- Investigative monitoring
- Reactive monitoring.

The monitoring framework is described in Section 5.1 of the MEQMP.

8.1.4. Management Actions

Where an assessment of monitoring data identifies an exceedance of any Environmental Quality (EQ) Criteria, escalation of the monitoring program from an EQ Guideline exceedance to and EQ Standard assessment, implementing specific monitoring actions presented in Section 6.2 of the MEQMP as required.

8.2. Artificial Light Management Plan (ALMP)

The purpose of the Artificial Light Management Plan (ALMP) is to ensure that artificial lighting associated with the operation of the Marina does not impact flatback turtle nesting on Cemetery Beach. The ALMP has been developed to provide a monitoring program to inform an adaptive management framework to support continuous improvement in light management and the document forms part of the OEMP for the Marina.

8.2.1. Scope and Objectives

In accordance with the National Light Pollution Guidelines for Wildlife (DCCEEW 2023) including Marine Turtles, Seabirds and Migratory Shorebirds the objectives of the plan include:

- Ensuring compliance with Condition 5a of EPBC 2019/8520
- The finalised artificial lighting design of the Marina
- Justification of how the lighting design will prevent impacts to flatback turtle hatchlings on Cemetery Beach
- A monitoring and reporting program, which includes baseline data that monitoring and reporting will be evaluated against, to be undertaken for a minimum length of two years post commencement of operation of the Marina to provide certainty that the artificial lighting of the Marina is not impacting flatback turtle hatchlings or nesting on Cemetery Beach
- Management measures and corrective actions to be implemented should monitoring indicate that the Marina's artificial lighting is likely to impact flatback turtle hatchlings on Cemetery Beach.

8.2.2. Legislation / Guidelines

The ALMP was developed in accordance with DCCEEW 2023. It is also written to address Condition 5.a of EPBC 2019/8520 issued under the EPBC Act.

The initial artificial lighting impact assessment (RPS 2020) and lighting design (including procurement; was completed with reference to the National Light Pollution Guidelines for Wildlife including Marine Turtles, Seabirds and Migratory Shorebirds (Commonwealth of Australia 2020). This ALMP aligns with the National Light Pollution Guidelines for Wildlife (Version 2.0), which was released in May 2023 (Commonwealth of Australia 2023). The updates to the National Light Pollution Guidelines have no effect on the requirements of this ALMP.

8.2.3. Monitoring approach

Section 6 of the ALMP presents a comprehensive monitoring program developed to meet conditions 5(a)iii and 5(a)iv of EPBC 2019/8520.and typically includes:

- Hatchling orientation monitoring (spread and offset angle)
- Artificial Light monitoring
- Lighting audit
- ALMP review.

The full monitoring, auditing, and reporting schedule will be conducted post-commencement of operations, once all lighting in the Marina is fully operational. However, hatchling orientation monitoring must also be conducted post-commencement of any operations, such as limited operations (e.g., marine and carpark lighting only).

8.2.4. DBCA Stakeholder Consultation

The DBCA is recognised as a stakeholder for ongoing consultation regarding Marina construction and operations. This ongoing consultation is demonstrated through:

- Prior consultation on 13 September 2019 to confirm the ALMP lighting impact assessment methodology. DBCA were satisfied with the proposed approach and asked only that an additional survey location on the spoil bank be included.
- Submission of all reports and monitoring results to DBCA for review, with requirements for further monitoring and/or implementation of corrective measures to be determined in consultation with DBCA.
- DBCA endorsement of any future reviews of the ALMP that are triggered by monitoring results indicating that corrective actions are unsuccessful and/or following any major changes in project facilities or building lighting.

8.2.5. Management actions

A summary of the monitoring, auditing, and reporting schedule is presented in Table 14 of the ALMP . If hatchling orientation monitoring data exceeds the trigger/threshold values, indicating a significant change in hatchling behaviour, then the steps in the response plan outlined in Table 15 of the ALMP must be followed.

The management actions will be formalised in the Project's Operational Light Plan, which will be prepared in consultation with the Department of Biodiversity, Conservation and Attractions (DBCA) to confirm the timing and manner in which the management measures will be adequately implemented.

8.3. Cemetery Beach Sediment Management Plan

The purpose of this Sediment Management Plan (SMP) is to monitor the coastal processes associated with the Marina and surrounding beaches to ensure no impacts arise to the turtle nesting grounds at Cemetery Beach or from altered coastal processes associated with the facility. The monitoring plan will also inform management responses if denuding of the turtle nesting grounds at Cemetery Beach is identified as a result of the Marina.

8.3.1. Scope and Objectives

This Plan has been developed to achieve the following primary objective:

- To ensure compliance with Condition 5b of EPBC 2019/8520
- To minimise the impacts of the Port Hedland Spoilbank Marina Project on sediment transport pathways within the region surrounding the Spoilbank Marina and Cemetery Beach and associated impacts to relevant protected matters under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).

The secondary objectives of this SMP are as follows:

- To quantify the existing sediment transport pathways within the region surrounding the Spoilbank Marina and Cemetery Beach, including details of how these sediment transport pathways are expected to change in the future.
- To outline a coastal monitoring regime that can be used to assess changes in the sediment transport pathways and subsequent positions of the shoreline.
- To outline a methodology to investigate any changes observed during the coastal monitoring and to determine whether the changes were a result of the construction or operation of the Spoilbank Marina.
- To specify appropriate intervention measures to be implemented should the investigations show that any denuding of sediment from Cemetery Beach is a direct result of the construction or operation of the Spoilbank Marina.

8.3.2. Legislation / Guidelines

This SMP was developed in accordance with the Environmental Protection Authority's (EPA) Environmental Factor Guideline – Coastal Processes (EPA 2016c). It is also written to address Condition 5.b of EPBC 2019/8520 issued under the EPBC Act.

8.3.3. Monitoring approach

A coastal process monitoring program has been developed in consultation with the PPA to measure actual changes to the beach and inform the appropriate management actions.

This program will be completed to monitor and quantify changes to the shoreline in the vicinity of Cemetery Beach and to review whether the operation of the Spoilbank Marina have an impact on Cemetery Beach. The monitoring program includes:

- Baseline aerial topographic surveys
- Beach profiles
- Photographic monitoring
- Shoreline mapping.

Details of the monitoring program are described in Section 3 of the SMP.

8.3.4. Management actions

Where it is identified that the Spoilbank Marina facility has resulted in an impact on Cemetery Beach then management actions will be planned to rectify the issue. Where changes have occurred that are attributable to the Spoilbank Marina but have not directly impacted Cemetery Beach, then management actions will only be undertaken if there is the potential for these changes to have an impact on Cemetery Beach and, in turn, an impact on the relevant EPBC Act protected matters of Flatback Turtle nesting at Cemetery Beach.

An overview of the potential management actions are presented in Section 4.3 and Table 4.1 of the SMP.

Table 8: Overview of the MEQMP, ALMP, and SMP

Marine Environmental Quality Management Plan (MEQMP)				
EPA factor and objectives – Marine Environmental Quality: 'to maintain the quality of water, sediment and biota so that environmental values are protected' Environmental Protection Outcomes: No reported negative impacts on marine environmental quality attributable to the facility operation. Key impacts and risks (related to this MEQMP): – Water quality decline during the on-going operational phase. – Hydrocarbon spills. – Short duration declines in water quality (turbidity) during necessary maintenance dredging operations				
Element • Trigger Criteria/EQG • Trigger Thresholds/EQS	Response actions • Trigger level/EQG actions • Threshold/EQS contingency actions	Monitoring	Timing/frequency of actions	Reporting
<u>Recreation and aesthetics</u> EQG Not applicable EQS Refer to Table 12, Table 13, Table 14 of the MEQMP	EQG Exceedance Management Actions Not applicable EQS Exceedance Management Actions Refer Section 6.4, Table 18 and Figure 4 of the MEQMP	<u>Physical observations of operational areas:</u> • nuisance organisms • largescale deaths/disease • oil/film • odour • floating debris, rubbish, surface slicks <u>Water Sampling:</u> • nuisance organisms • pathogens	Quarterly routine or as identified by public or other notification	Refer to Section 7 for exceedance regulatory reporting

		• pH • toxic algae		
Physical and Chemical Stressors EQG Refer to Table 9 of the MEQMP EQS Refer to Table 9 of the MEQMP	EQG Exceedance Management Actions Refer to Section 6.3 and Figure 4 of the MEQMP EQS Exceedance Management Actions Refer to Section 6.4, Table 18 and Figure 4of the MEQMP	Water column profiling: • temperature • dissolved oxygen • pH • salinity • turbidity Water Sample Collection: • chlorophyll α	Quarterly	Refer to Section 7 for exceedance regulatory reporting
Toxicants in Water EQG Refer to Table 7 of the MEQMP EQS Refer to Table 7 of the MEQMP	EQG Exceedance Management Actions Refer to Section 6.3 and Figure 4 of the MEQMP EQS Exceedance Management Actions Refer to Section 6.4, Table 18 and Figure 4of the MEQMP	Water sample collection for: • dissolved metals • hydrocarbons	Quarterly	Refer to Section 7 for exceedance regulatory reporting
Toxicants in Sediments EQG Refer to Table 8 of the MEQMP EQS Refer to Table 8 of the MEQMP	EQG Exceedance Management Actions Refer to Section 6.3 and Figure 4 of the MEQMP EQS Exceedance Management Actions Refer to Section 6.4, Table 18 and Figure 4of the MEQMP	Sediment sample collection for: • total metals • hydrocarbons	Annual	Refer to Section 76 for exceedance regulatory reporting
Artificial Light Management Plan (ALMP)				
EPA factor and objectives – Marine Fauna: “to protect marine fauna so that biological diversity and ecological integrity are maintained”.				

Environmental Protection Outcomes: No reported negative impacts on marine fauna attributable to the operational lighting requirements of the marina. Key impacts and risks (related to this OEMP): Operational light spill/pollution impacts to Flatback Turtle (N. depressus) community on Cemetery Beach.				
Element • Trigger Criteria • Trigger Thresholds	Response actions • Trigger level actions • Threshold contingency actions	Monitoring	Timing/frequency of actions	Reporting
Hatchling Orientation: Spread angle Trigger criteria The mean spread angle exceeds 96° and the lower bound (95 % highest posterior density interval) is below 96°. Threshold The lower bound spread angle (95 % highest posterior density interval) exceeds 96°. **Hatchling Orientation: Offset angle** Trigger criteria The mean offset angle exceeds 32° and the lower bound (95 % highest posterior density interval) is below 32°. Threshold The lower bound offset angle (95 % highest posterior density interval) exceeds 32°.	Trigger level actions (for spread or offset angle) If a single season of monitoring reports an exceedance in trigger criteria: Hatchling orientation monitoring must continue for another season to determine if this is a trend. If two or more consecutive seasons of monitoring report an exceedance in trigger criteria: Undertake desktop review of artificial light monitoring, lighting audit and hatchling orientation data to determine cause. The assessment will rate the level of impact associated with this exceedance and recommend actions (as described in Section 6.6 of the ALMP). Threshold contingency actions (for spread or offset angle)	Indicators: Spread angle, offset angle Hatchling orientation monitoring will be conducted seasonally at Cemetery Beach during peak flatback turtle hatching period and to coincide with new moon conditions.	Hatchling orientation monitoring will be undertaken post commencement of operations (e.g., limited operation) and for a minimum of three years post commencement of full operations. If trigger/threshold criteria are exceeded, additional seasons of monitoring may be required pending the outcome of a desktop review. Additional monitoring surveys may be required in event adequate samples are not collected	One report annually (per monitoring season) describing the results of the monitoring survey, including comparison against trigger and threshold criteria. Refer to Section 6.4 of the ALMP for exceedance regulatory reporting

	If any season of monitoring reports an exceedance in threshold criteria: Undertake review of artificial light monitoring, lighting audit and hatchling orientation data to determine cause. The assessment will rate the level of impact associated with this exceedance and recommend actions (as described in Section 6.6 of the ALMP).		(minimum 30 nests with 5 or more tracks).	
Cemetery Beach Sediment Management Plan				
EPA factor and objectives – •Coastal Processes: 'to maintain the geophysical processes that shape coastal morphology so that the environmental values of the coast are protected.				
Environmental Protection Outcomes: No reported negative impacts, on the denuding of sediment from Cemetery Beach attributable to the operation of the marina.				
Key impacts and risks (related to this BCHMMP): Operation of the Spoilbank Marina resulting in, or contributing to, the denuding of sediment from Cemetery Beach				
Element • Trigger Criteria • Trigger Thresholds	Response actions • Trigger level actions • Threshold contingency actions	Monitoring	Timing/frequency of actions	Reporting
<u>Cemetery Beach</u> Trigger criteria Where the observed rate of recession of the shoreline or beach profile at Cemetery Beach is greater than 5 m plus the assessed rate of long term shoreline recession (approximately 0.7 m/yr) as measured from the baseline, or as assessed an experienced coastal engineer, further investigation will	<u>Cemetery Beach</u> If the changes to Cemetery Beach are considered likely to be attributable to the construction of the Spoilbank Marina then a plan will be developed to rectify / remediate the impacts. Rectification / remediations options may include the following: – Sand bypassing or back passing – Sand nourishment. <u>Other area within the Monitoring Area</u>	Monitoring will include the following. • Aerial Topographic Survey. • Profile Monitoring. • Photographic Monitoring. • Shoreline Mapping (annually).	Baseline monitoring completed in May/June 2023, and planned for September 2023. Monitoring will then be completed biannually (in May and September) each year,	Reporting of the monitoring described within the SMP will be completed annually following the collection of monitoring data in September. Refer to Section 6.2 of the SMP for

be required to ascertain the potential cause of the erosion **Other areas within the Monitoring Area** Trigger criteria Where the observed shoreline movement outside of Cemetery Beach is significantly different to the expected shoreline changes (approximately greater than 10 m plus the assessed rate of long term approximately 0.7 m/yr rate of shoreline recession as measured from the baseline, or as assessed by an experienced coastal engineer), further investigation will be required to ascertain the potential cause of the difference.	If changes are observed areas that are outside of Cemetery Beach, then these changes will be assessed to determine if they have the potential to impact Cemetery Beach in the short term. If there is the potential for Cemetery Beach to be impacted, then the following management actions may be completed: – Sand bypassing or back passing – Sand nourishment.	• Post Cyclone Monitoring.	until at least September 2025. Monitoring will then be annually (in September) each year, until at least September 2027	exceedance regulatory reporting

8.4. Other Impact Pathways and Management Approaches

The OEMP further outlines several operational related impact mechanisms that have the potentially to impact the EPA's Environmental Factors listed above, including:

- Hydrocarbon Spills
- Marine Debris (Pollution)
- Feral Animals.

8.4.1. Hydrocarbon Spills

8.4.1.1. Environmental Objectives

- To protect marine fauna so that biological diversity and ecological integrity are maintained.
- Significant residual impacts do not occur from the Project as constructed and therefore the biological diversity and ecological integrity of EPBC Act 'Listed Threatened Species and Ecological Communities' and 'List Migratory Species' will be maintained.

8.4.1.2. Legislation / Guidelines

- EPBC Act (Commonwealth)
- BC Act (WA)
- Environmental Factor Guideline – Marine Fauna (EPA 2016)

8.4.1.3. Management Measures

- Implement actions to avoid spills of liquids/chemicals into surface and groundwater, and if a spill occurs within the jetty project area, emergency spill procedures will be implemented as appropriate.
- Uncontained spills to be reported to the DWER via the Pollution Watch Hotline on 1300 784 782.
- Spill kits to be located on site and personnel trained in their use.

8.4.1.4. Monitoring

Response

- Hydrocarbon spills into the marine environment (in State waters) be immediately reported to Department of Transport's Maritime Environmental Emergency Response (MEER) unit (ph. 9480 9924).
- Implement MEER's oil spill response protocols.

8.4.2. Marine Debris (Pollution)

Marine debris may include solid wastes, hazardous wastes and sewage and grey water. DoT's environmental consultants have prepared the Project's Marine Environmental Quality Plan (MEQP) to monitor and manage water quality to maintain recreational and aesthetic environmental values of the marina basin. To achieve this objective the marina basin will be cleared of wastes and debris on a regular basis.

8.4.2.1. Environmental Objectives

- To protect marine fauna so that biological diversity and ecological integrity are maintained.
- Significant residual impacts do not occur from the Project as constructed and therefore the biological diversity and ecological integrity of EPBC Act 'Listed Threatened Species and Ecological Communities' and 'List Migratory Species' will be maintained.

8.4.2.2. Legislation / Guidelines

- EPBC Act (Commonwealth)
- BC Act (WA)
- Environmental Factor Guideline – Marine Fauna (EPA, 2016)

8.4.2.3. Management Measures

- Implement standard waste minimisation and reduction strategies, including providing facilities for waste disposal.
- Implement routine removal and off-site disposal of wastes in accordance with State and local policies and procedures.

8.4.2.4. Monitoring

Protocols and Procedures

- Daily visual checks

Frequency

- On-going

Location

- On-site and within the marine environment of the development envelope.

Responsibility

- Contractor

Response

- Hydrocarbon spills into the marine environment (in State waters) be immediately reported to Department of Transport's Maritime Environmental Emergency Response (MEER) unit (ph. 9480 9924).
- Implement MEER's oil spill response protocols.

8.4.3. Feral animals

8.4.3.1. Environmental Objectives

- To protect marine fauna so that biological diversity and ecological integrity are maintained.
- Significant residual impacts do not occur from the Project as constructed and therefore the biological diversity and ecological integrity of EPBC Act 'Listed Threatened Species and Ecological Communities' and 'List Migratory Species' will be maintained.

8.4.3.2. Legislation / Guidelines

- EPBC Act (Commonwealth)
- BC Act (WA)
- WA Department of Primary Industries and Regional Development (DPIRD) Biosecurity Procedures

8.4.3.3. Management Measures

- The Operator will be required to ensure all vessels are following the DPIRD biosecurity procedures and protocols.
- The completion of the DPIRD risk assessment tool for any vessels entering the marina from international or interstate waters will be a requirement. The recommendations from the tool will be implemented.

8.4.3.4. Monitoring

Protocols and Procedures

- On-going visual monitoring for invasive species establishing a presence within the marina complex.

Frequency

- On-going

Location

- Marina basin

Responsibility

- Contractor

Response

- Contact DBCA within 24 hours of finding feral animals within the marina complex.

9. Environmental Incidents and Response Framework

9.1. Environmental Inspections

The Facility Manager shall document and sign-off after checking off each monitoring aspect (where applicable). Further Environmental Inspections shall be conducted when the job requirements change.

9.2. General Incident Response

In the event that any unplanned or non-conforming environmental issues (i.e. targets are not met or management actions are not followed) are observed, they will be noted on an inspection sheet and an environmental incident form completed. The following points will be recorded in an environmental incident form:

1. Time and date of incident
2. Location and description of event
3. Incident category, as described in Table 9
4. Weather conditions
5. Involved parties
6. Person recording complaint and witness (if applicable)
7. Steps to make area safe
8. Steps to rectify problem
9. Steps to ensure incident will not occur again (e.g. process review of management plans)
10. Notification to relevant authority
11. Deadline to rectify incident
12. Sign off once clean-up is completed. Stop/prevent any activity in the area.

Any significant incident that occurs on or arises from this Site shall be reported with urgency commensurate with the incident. Table 9 provides guidance on the hierarchy of incidents and their reporting.

Table 9: Incident Category

Incident Category	Rank	Description	Reporting Level	Reporting Time
1	High	Incident with a significant risk of environmental impact, potential impact off-site (e.g. neighbouring occupants) and/or cause alarm to the community	Contractor, Facilities Manager, Responsible authorities (i.e. DWER, EPA)	All environmental incidents be reported to the Facilities Manager as soon as the immediate response to the incident is complete. It is also a requirement that all hydrocarbon spills into the marine environment (in State waters) be immediately reported to Department of Transport's Maritime Environmental Emergency Response (MEER) unit (ph. 9480 9924). MEER's protocols must then be followed. Refer also DoT website.
2	Intermediate	Incident with potential to cause minor environmental impact or cause concern to neighbouring occupants and/or the community.	Contractor, Facilities Manager & responsible authorities (i.e. DWER, Council, EPA)	All environmental incidents be reported to the Facilities Manager as soon as the immediate response to the incident is complete. 24 Hours
3	Low	Incident unlikely to cause immediate environmental impact but requires rectification	Contractor, Facilities Manager & responsible authorities (i.e. DWER)	All environmental incidents be reported to the Facilities Manager as soon as the immediate response to the incident is complete. 7 days

In addition, emergency response to protect public health and safety, and the environment requires the following actions:

- Assess the nature and scale of the problem
- Take appropriate actions to immediately contain/mitigate problem - if safe to do so
- Make the area safe
- Communicate with relevant personnel on/off-site to advise them of the situation
- Verbally report to Superintendent and relevant regulatory authorities based on the magnitude and seriousness of the event
- Deploy appropriate internal and/or external resources to rectify the situation, if necessary
- Record and report the incident and outcome in Site's OEMP Environmental Incident Forms
- Implement remedial/corrective action on facilities, procedures and/or practices
- Superintendent signs out the final check in OEMP Environmental Incident Forms
- Review and update the OEMP

9.3. Emergencies

An "emergency" is any situation arising in which an unplanned occurrence potentially results in an immediate or imminent hazard to public health and safety or to the environment. Certain "near miss" situations will also be treated as reportable emergency incidents.

Table 10 summarises some of the potential environmental emergency situations possible at this Site for which contingency plans are to be prepared by the Contractor.

Table 10: Environmental Emergency Contacts

Issue	Emergency Condition	Contact In Event of Emergency
Contamination of the ocean	• Spill of contaminant into the ocean (e.g. fuel). • Sediment runoff into ocean	• Facility Manager • DWER • DoT MEER
Dust, litter, waste or feral animals	• Visible particles, litter or waste resulting in aesthetic impact on neighbouring properties or environment. • Feral animals present on site.	• Facility Manager • DBCA
Fire	• Fire in equipment, facilities or fuel/chemical storage.	• Facility Manager • DFES • DWER

9.4. General Incident Response

In the event a complaint is received it shall be recorded appropriately. It is the responsibility of the Facility Manager to assess the collected complaint to allow formal judgement of the nature and severity of the complaint and to ensure that the person voicing the complaint could receive feedback if the person had requested it.

All information will be recorded, either from a phone call, written or verbal complaint made to a member onsite. The following information will be collected:

1. Time and date of complaint
2. Nature of complaint (e.g. location, description of events that led to complaint, etc.)
3. Weather conditions (e.g. windy period and potential for increased dust)
4. Involved parties
5. Name and contact details of person making complaint, if provided
6. Is a response required?
7. Person recording complaint
8. Project manager of appointed personnel following it up.

Every complaint relating to the environment shall be treated as an environmental incident and therefore recorded as an environmental incident.

10. Adaptive management and review

The overarching responsibility for the implementation of this OEMP lies with the Facility Manager.

An example for contact details and relevant summary information for the parties and project personnel having responsibilities for management of these issues is provided in Figure 2. At the time of implementation and activation of this OEMP

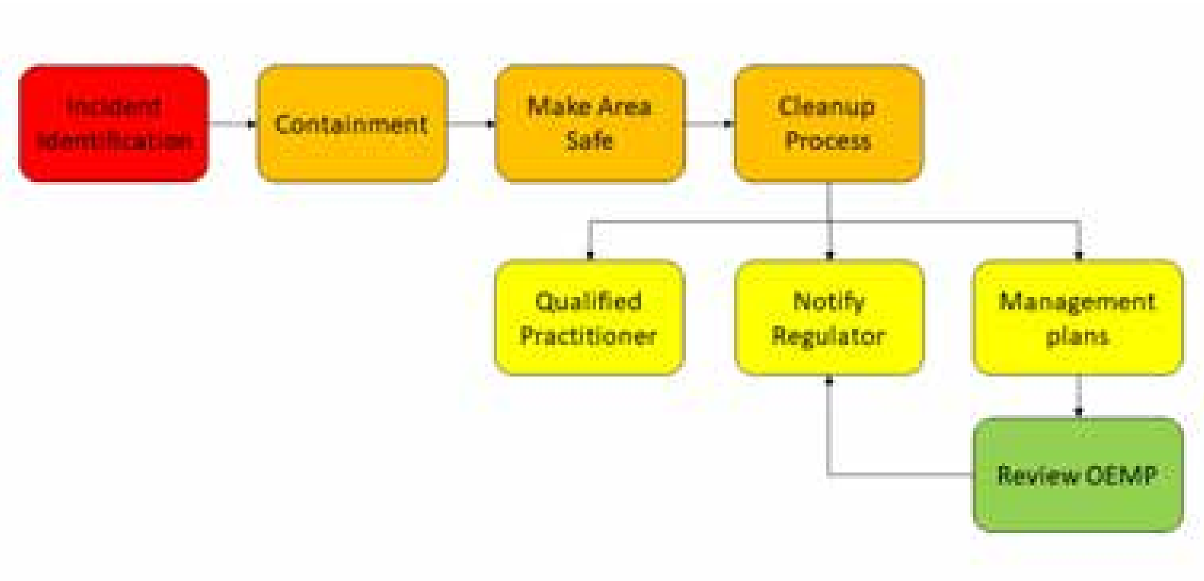

Figure 2: Overarching Management of Environmental Incident

10.1. Adaptive management

DoT is committed to improving environmental results and management practices throughout the implementation of the Project and therefore will use an adaptive management approach for this OEMP. Adaptive management practices will include:

- Quarterly review and comparison of monitoring data and information gathered against established baseline, ongoing monitoring and reference data.
- Annual evaluation of monitoring and management outcomes against management targets and the objectives of this OEMP.
- Review of management actions throughout the implementation of the Project, and identification of potential new management measures, methodologies, and technologies that may be more effective.
- Review of monitoring data, information, trigger and threshold criteria and management actions described in the in-force OEMP in response to an exceedance.

10.2. Review requirements

DoT is committed to conducting activities in an environmentally responsible manner and aims to implement reviews of its environmental management as part of a program of continual improvement.

This commitment to continual improvement means that the Plan will be reviewed annually or following any major environmental changes during operations.

The Plan will be updated based on review outcomes. The review will take into account whether best practice and management targets are being achieved or are likely to be achieved and will identify any updates required to realise the targets.

10.3. Approval requirements for revised OEMP

This OEMP has been developed to meet the approval conditions detailed within EPBC 2019/8520.

DoT may, at any time, apply to the Minister for a variation to an action management plan approved by the Minister under condition 5, by applying in accordance with the requirements of section 143A of the EPBC Act. If the Minister approves a revised action management plan (RAMP) then, from the date specified, the approval holder must implement the RAMP in place of the previous action management plan.

Provided a review of the Plan does not change the structure of the OEMP, DoT may choose to revise an action management plan approved by the Minister under conditions 5 or as subsequently revised in accordance with these conditions, without submitting it for approval under section 143A of the EPBC Act, if the taking of the action in accordance with the RAMP would not be likely to have a new or increased impact.

If DoT makes the choice under condition 21 to revise an action management plan without submitting it for approval, the approval holder must:

a) notify the Department in writing that the approved action management plan has been revised and provide the Department with:
    i. an electronic copy of the RAMP;
    ii. an electronic copy of the RAMP marked up with track changes to show the differences between the approved action management plan and the RAMP;
    iii. an explanation of the differences between the approved action management plan and the RAMP;
    iv. the reasons the approval holder considers that taking the action in accordance with the RAMP would not be likely to have a new or increased impact; and
    v. written notice of the date on which the approval holder will implement the RAMP (RAMP implementation date), being at least 20 business days after the date of providing notice of the revision of the action management plan, or a date agreed to in writing with the Department.
b) subject to condition 24 implement the RAMP from the RAMP implementation date.

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Appendix A. Marine Environmental Quality Management Plan

Marine Environmental Quality Management Plan

Port Hedland Spoilbank Marina

CLIENT: Department of Transport

STATUS: Rev 3

REPORT NUMBER: R190244

ISSUE DATE: 19 July 2024

Important Note

This report has been prepared for the sole use of the Spoilbank Operator, for a specific site (herein 'the site', the specific purpose specified in Section 1 of this report (herein 'the purpose'). This report is strictly limited for use by the client, to the purpose and site and may not be used for any other purposes.

Third parties, excluding regulatory agencies assessing an application in relation to the purpose, may not rely on this report. O2 Marine waives all liability to any third-party loss, damage, liability, or claim arising out of or incidental to a third-party publishing, using or relying on the facts, content, opinions or subject matter contained in this report.

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Maps are created in WGS 84 - Pseudo-Mercator (EPSG:3857) coordinate reference system and are not to be used for navigational purposes. Positional accuracy should be considered as approximate.

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Version Register

Version	Status	Author	Reviewer	Change from Previous Version	Authorized for Release (signed and dated)	
Rev 0	Final	R Stevens	B Hegge	Client review incorporated into final version	R Stevens	16/01/2023
Rev 1	Final	R Stevens	A Stanley M Logue	Updated to reflect transfer of project owner from DoT to PPA and to capture approved conditions from DCCEEW and then retransfer of owner back to DoT	R Stevens	14/09/2023
Rev 2	Final	R Stevens	DCCEEW	Initial comments from DCCEEW addressed with minor language variations made throughout	R Stevens	15/05/2024
Rev 3	Final	R Stevens	DCCEEW	Comments from DCCEEW assessment addressed in updated version	R Stevens	19/07/2024

Transmission Register

Controlled copies of this document are issued to the persons/companies listed below. Any copy of this report held by persons not listed in this register is deemed uncontrolled. Updated versions of this report if issued will be released to all parties listed below via the email address listed.

Name	Email Address
Tracy Harken	Tracy.Harken@transport.wa.gov.au

Declaration of Accuracy

I declare that to the best of my knowledge, all the information contained in, or accompanying this document is complete, current, and correct. I am duly authorised to sign this declaration on behalf of the approval holder. I am aware that:

a. section 490 of the Environment Protection and Biodiversity Conservation Act 1999 (Cwth) (EPBC Act) makes it an offence for an approval holder to provide information in response to an approval condition where the person is reckless as to whether the information is false or misleading.

b. section 491 of the EPBC Act makes it an offence for a person to provide information or documents to specified persons who are known by the person to be performing a duty or carrying out a function under the EPBC Act or the Environment Protection and Biodiversity Conservation Regulations 2000 (Cwth) where the person knows the information or document is false or misleading.

c. the above offences are punishable on conviction by imprisonment, a fine or both.

Signed: ______________________________

Full name: Shelley Grice

Organisation: Department of Transport

Document will be signed when issued as final

EPBC Referral Number: 2019/8520

Name of Action Management Plan this document and declaration refers to: Port Hedland Spoilbank Marina: Marine Environmental Quality Plan.

Date: 16 August 2024

Acronyms and Abbreviations

Acronyms/Abbreviation	Description
BCH	Benthic Communities and Habitat
DoH	Department of Health
DoT	Department of Transport
EQC	Environmental Quality Criteria
EQG	Environmental Quality Guidelines
EQI	Environmental Quality Indicators
EQO	Environmental Quality Objectives
EQMF	Environmental Quality Management Frameworks
EQS	Environmental Quality Standards
EPA	Environmental Protection Authority
EV	Environmental Value
HEPA	High Ecological Protection Area
LEP	Level of Environmental Protection
LEPA	Low Ecological Protection Area
MEPA	Moderate Ecological Protection Area
MEQMP	Marine Environment Quality Management Plan
PHMEQSAP	Port Hedland Marine Environmental Monitoring Quality Sampling and Analysis Plan
PPA	Pilbara Ports Authority
OEMP	Operational Environmental Management Plan
ToPH	Town of Port Hedland
XEPA	Maximum Ecological Protection Area

Contents

Figures

Tables

1. Introduction

1.1. Background

The Spoilbank Marina (the Marina) is currently being constructed by Pilbara Ports Authority (PPA) on the western side of the Spoilbank, adjacent to the Port Hedland Yacht Club. The Marina consists of an enclosed basin protected by an outer rock wall and a ~1 km channel to provide access to the Port Hedland Outer Channel. The Marina design includes a four-lane boat ramp, public fishing jetty and allows for up to 80 boat pens, with 22 initial pens to be constructed and the remainder to be constructed following a staged approach after the Marina is operational.

PPA were nominated as the developer of the Port Hedland Spoilbank Marina, a government initiative originally led by the Department of Transport (DoT) in partnership with the Town of Port Hedland (ToPH). The Marina is located on the western side of the spoil bank sand formation, a man-made coastal landform created in the late-1960s and early-1970s from the disposal of material dredged from Port Hedland's inner harbour and shipping channel. Subsequently, DoT has replaced PPA as the proponent for the facility and will be responsible for the operations including management, monitoring and maintenance of the facility.

The Marina will replace the existing Richardson Street boat ramp (which will be closed) and redirect boating activities away from the commercial operations of Port Hedland's inner harbour and navigation channel (Town of Port Hedland 2019). The Marina includes a four-lane boat ramp, ~80 boat pens, car and trailer parking bays, amenities, public open space, and recreation and event space (Figure 1).

1.2. Purpose of this Plan

The purpose of this Marine Environment Quality Management Plan (MEQMP) is to manage the marine environmental quality adjacent to the Marina to ensure that the operation of the Marina does not adversely affect marine water quality in the Port Hedland area. The MEQMP provides a framework to monitor, characterise and report long-term trends in marine water and sediment quality within the Marina and surrounding waters and the document forms part of the Operational Environmental Management Plan (OEMP) for the proposed Marina.

This MEQMP was developed in accordance with the Environmental Protection Authority's (EPA) Technical Guidance for Protecting the Quality of Western Australia's Marine Environment (EPA 2016). It is also written to address condition 5.c of the Commonwealth approval (EPBC 2019/8520) issued under the *Environmental Protection and Biodiversity Conservation Act (1999)* (EPBC Act).

1.3. Scope and Objectives

This Plan has been developed to achieve the following specific objectives:

- Briefly summarise the MEQMP for the Spoilbank Marina.
- Outline the proposed changes to the Spatial Levels of Ecological Protection to account for the Marina design footprint.
- Outline the water and sediment quality sampling and analysis procedures to:

- Ensure collection, analysis and reporting of water and sediment quality data in a consistent and robust manner; and
- Provides a suitable basis on which to inform future management strategies to maintain and/or improve water and sediment quality in the Marina and surrounding waters.

1.4. Approach

The approach to development of the MEQMP for the Spoilbank Marina was undertaken in a manner consistent with the EPAs technical guidance (EPA 2016). The approach includes the identification of Environmental Values (EVs), Environmental Quality Objectives (EQOs), Level of Environmental Protection (LEP) and Environmental Quality Criteria (EQC). This approach was based on the principles and guidelines of the National Water Quality Management Strategy (NWQMS, 2018), with particular regard to the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018). The focus of the approach is on maintaining existing environmental quality, identifying where management and/or remediation actions may be required and to measure the effectiveness of these actions.

The MEQMP is described in further detail in Section 3. The structure of this Plan is outlined in Table 1.

Table 1: Structure of the Plan

Section	Heading	Description
Section 1	Introduction	Background to the Plan, including the purpose and scope relevant to the Plan.
Section 2	Approval Conditions	Summary of the relevant approval conditions pertaining to the Marina and this Plan
Section 3	Environmental Quality Management Framework	Summary of the MEQMP and definition of the EVs, EQOs and LEPs.
Section 4	Environmental Quality Criteria	Defines the Environmental Quality Criteria as they relate to the EQOs.
Section 5	Monitoring	Identifies the monitoring and methodologies to be undertaken.
Section 6	Assessment of Monitoring Results	Describes how monitoring data will be assessed in the context of the MEQMP.
Section 7	Review	Describes requirements for review of the Plan.

Figure 1: Concept design for the Marina

2. Approval Conditions

A summary of the relevant approved condition detailed within EPBC 2019/8520 and as applicable to this document are summarised in Table 2.

Table 2: Approved Conditions as applicable to this MEQMP

Approved Condition	Summary	Reference	Commitment
5c	Include a Marine Environment and Water Quality Management Plan (MEWQMP) that addresses how marine water quality, sediment quality and accumulation of marine debris will be monitored and managed to prevent impacts to protected matters from the operation of the marina. The MEQWMP must specify and justify the quality indicators to be monitored and timing of monitoring to prevent impacts to protected matters, including specific trigger criteria and limits, and clear, detailed corrective actions that will be implemented to prevent impacts to protected matters should trigger criteria and limits be reached.	This Plan	This plan has been designed in accordance with the WA EPA Technical Guidance for Protecting the Quality of Western Australia's Marine Environment and to ensure this Condition is achieved.
7	All plans required under these conditions must be consistent with the Department's Environmental Management Plan Guidelines, and must include: a) The environmental objectives, relevant protected matters and a reference to EPBC Act approval conditions to which the plan refers; b) A table of commitments made in the plan to achieve the objectives, and a reference to where the commitments are detailed in the plan; c) Reporting and review mechanisms, and documentation standards to demonstrate compliance with the commitments made in the plan; d) An assessment of risks to achieving the environmental objectives and risk management strategies that will be applied; e) Impact avoidance, mitigation and/or repair measures, and their timing; and f) A monitoring program, which must include: i. measurable performance indicators; ii. trigger values for corrective actions; iii. the timing and frequency of monitoring to detect trigger values and changes in the performance indicators; and iv. proposed corrective actions, if trigger values are reached.	a) EPOs: Section 3.1 and Table 4 MNES: Section 2.1.1; Approval Conditions Table 2. b) This Table c) Section 7 d) Section 4.1 e) Section 6 f) Section 5	The proponent commits to implementing this plan, including all obligations included herein

2.1. Approval Holder Details

In May 2021, application was made under Section 145B of the EPBC Act for the Transfer of approval holder from DoT to PPA. This transfer was formalised on 18 May 2021 with the current approval holder details presented in Table 3.

Table 3: Approval holder details

Company Name:	Department of Transport
Australian Business Number (ABN):	27 285 643 255
Address:	5 Newman Court, Fremantle WA 6160
Key Contact (Role):	A/ Director Coastal Facilities Management
Key Contact Details:	Phone: 0427 934 814 Email: mailto: shelley.grice@transport.wa.gov.au

2.1.1. Matters of National Environmental Significance

The EPBC Act (1999) establishes a process for the assessment and approval of proposed actions that are likely to have a significant impact on matters of national environmental significance or on Commonwealth land.

The Spoilbank Marina Project was initially referred by DoT to the Commonwealth Department of Agriculture, Water, and the Environment under the EPBC Act on 22 August 2019. The Proposal was determined to be a 'Controlled Action' by a Delegate of the Commonwealth Minister for the EPBC Act on 21 January 2020 as it will, or is likely to have, a significant impact on the following Matters of National Environmental Significance:

- Listed threatened species and communities (section 18 and 18A):
  - Flatback turtle (*Natator depressus*) – vulnerable and migratory.
  - Green turtle (*Chelonia mydas*) – vulnerable and migratory.
  - Green sawfish (*Pristis zijsron*) – vulnerable and migratory; and
  - Dwarf sawfish (*Pristis clavata*) – vulnerable and migratory.
- and listed migratory species (sections 20 & 20A):
  - Narrow sawfish (*Anoxypristis cuspidata*) – migratory.

On 19 February 2021, DAWE issued an approval under the EPBC Act (EPBC 2019/8520) for the Proposal.

3. Environmental Quality Management Framework

Environmental Quality Management Frameworks (EQMF) are a mechanism to enable the National Water Quality Management Strategy Guidelines No. 4 and 7 (ANZECC/ARMCANZ 2000). In Western Australia, this approach has been incorporated into the State Water Quality Management Strategy No.6 (GWA 2004). The EPA offers further guidance on the development and application of this framework approach to ensure a consistent and standardised approach for measuring and reporting on marine environmental quality across Western Australia (EPA 2016).

EVs, EQOs and LEP areas were determined for all Pilbara coastal waters, including Port Hedland in 2006, by the Department of Water and Environmental Regulation (previously Department of Environment) (DoE 2006). Subsequently, this approach has been applied to specific development projects within the Port of Port Hedland and endorsed through the State Government's environmental approvals process.

The *Pilbara Coastal Water Quality - Consultation Outcomes Study* (DoE, 2006) undertook a comprehensive community and stakeholder consultation process in 2006 to seek public input on how the EQOs and their LEP areas should be allocated spatially throughout the region so as to protect EVs held by the community. During 2015 the Port Hedland Industry Council commissioned a review and revision of the framework to cover the 'whole of Port' operations and activities (O2 Marine 2016). Extensive stakeholder consultation was undertaken during this process to ensure the EVs, EQOs and boundaries of the LEP areas were aligned to meet the expectations of the community (O2 Marine 2016).

However, the boundaries of the LEP areas proposed in this Plan are slightly modified to accommodate the proposed Marina footprint. The approach to the development of the MEQMP is outlined below and summarised in Figure 2.

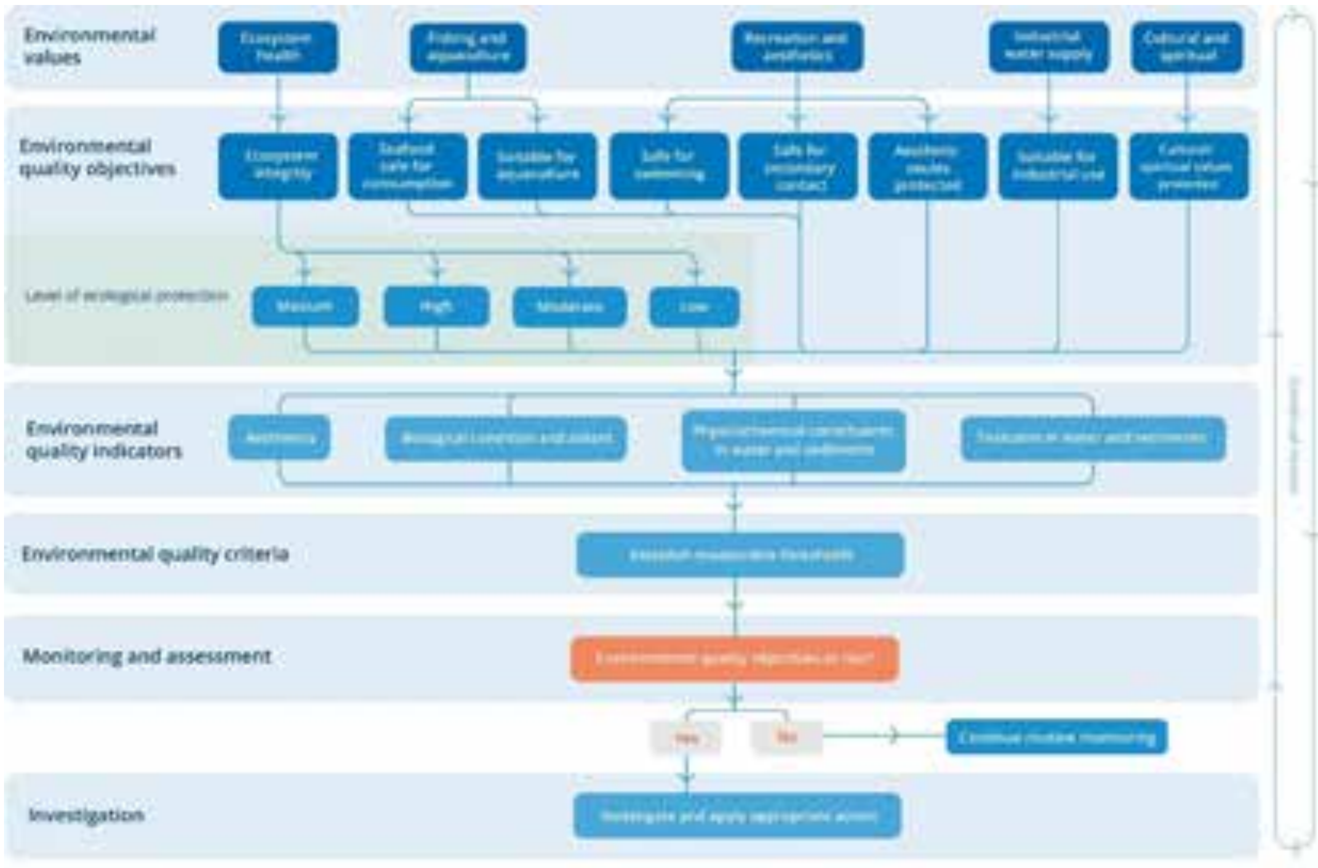

Figure 2: Overview of the Environmental Quality Management Framework applied within this Plan

3.1. Environmental Values and Environmental Quality Objectives

Environmental Values (EVs) are defined as particular values or uses of the environment that are important for a healthy ecosystem or for public benefit, welfare, safety or health and which require protection from the effects of pollution, waste discharges and deposits (ANZG 2018). The Environmental Quality Objectives (EQOs) are high-level management objectives that describe what must be achieved to protect each EV (EPA 2016).

The EVs and associated EQOs for Port Hedland have been defined by DoE (2006) and the EVs and associated EQOs relevant[1] to the Marina are presented in Table 4.

[1] Note that not all EVs and EQOs are considered to be at risk from Marina operations and have therefore been omitted from this Plan.

Table 4: Environmental Values and Environmental Quality Objectives applicable for the Marina and surrounding waters

Environmental Values	Environmental Quality Objectives
Ecosystem Health	EQO1: Maintenance of ecosystem integrity. EQO1 is split into four sub-objectives, being: Maximum, High, Moderate and Low Levels of Ecological Protection (LEPs) (Refer Section 3.2 below).
Fishing & Aquaculture	EQO2: Seafood (caught) is of a quality safe for human consumption.
Recreation & Aesthetics	EQO3: Water quality is safe for primary contact recreation (e.g. swimming and diving). EQO4: Water quality is safe for secondary contact recreation (e.g. fishing and boating). EQO5: Aesthetic values of the marine environment are protected.
Cultural & Spiritual	EQO6: Cultural and spiritual values of the marine environment are protected.

Fishing is a popular recreational activity within the waters surrounding the Marina. The marina provides a public fishing jetty, in which artificial reef balls have been placed underneath. The artificial reef was installed to provide a habitat for marine species and encourage fish to access the area and is expected that fishing will occur as a result. The EV 'Fishing and Aquaculture' and the corresponding EQO2: 'Seafood (caught) is of a quality safe for human consumption' are applicable to Marina waters.

The primary threats to human consumers of seafood are considered to relate to contamination of filter feeding shellfish by faecal pathogens (e.g. bacteria), the accumulation of biotoxins from toxic algae and/or the accumulation of toxic chemicals in the flesh of the shellfish (EPA 2015). Filter feeding shellfish filter large quantities of water to obtain their food which has the potential to result in the accumulation of significant quantities of pathogens and other contaminants that can cause serious illness in humans (EPA 2015). It is unlikely that harvesting of shellfish within the marina is to occur, as access to areas within the tidal range where they could grow will be restricted and prohibited for swimming.

For people that collect and eat wild shellfish the Department of Health (DoH) suggests that they may be putting their health at risk and recommends that the public only eat shellfish harvested commercially under strict quality assurance monitoring programs. It should be noted that EQC for toxic algae and bacteria do not protect the fish populations themselves. To protect the wild seafood populations from the effects of environmental contamination the environmental quality guidelines and standards for maintaining ecosystem integrity (EQO1) are recommended. These should aim to protect the harvested species as well as the food webs, habitats and other environmental processes that support them. For these reasons, under the scope of this Plan, the EQO for Fishing and Aquaculture (EQO2) is deemed to be met if the EQOs for Ecosystem Health (EQO1), and Recreation & Aesthetics (EQO, EQO4 and EQO5) are achieved.

The *Cultural & Spiritual* EV has been included in this MEQMP in recognition of the cultural and spiritual significance of the region to the indigenous people of the area. However, for the purpose of this MEQMP this EV is considered to be protected it the Environmental Quality Objectives for *Ecosystem Health* (EQO1) and *Recreation & Aesthetics* (EQO4, EQO5 and EQO6) are met. This approach is consistent with EPA (2016) and ANZG (2018).

3.2. Levels of Ecological Protection

The ‘Ecosystem Health’ EQO is divided into four Levels of Ecological Protection (LEP):

- Maximum (XEPA)
- High (HEPA)
- Moderate (MEPA) and
- Low (LEPA)

For this program there are no XEPAs or LEPAs, and for this plan has been herein omitted.

LEP areas have previously been defined for Port Hedland and surrounding waters in the Pilbara Coastal Water Quality Consultation Outcomes (DoE 2006). A consolidated LEP spatial dataset was also accessed through the EPA website on the 31st of July 2023, which includes the most recent LEP areas as approved by the EPA in accordance with Part IV of the EP Act.

The above datasets were incorporated into a revised MEPA specific to this program. The revised MEPA was established in accordance with EPA (2016) considering the revised infrastructure and includes the marina water body, as surrounded by the breakwater rock armour.

Figure 3: Spatial Levels of Ecological Protection for the Marina

4. Environmental Quality Indicators and Environmental Quality Criteria

Environmental Quality Indicators (EQI) are the analyte or parameters suites which are used to monitor the environmental quality whilst Environmental quality criteria (EQC) are quantitative benchmarks used to measure the performance of environmental management actions in achieving the EQOs, and thereby protecting the corresponding EVs. EQC are separated into:

Environmental Quality Guidelines (EQGs): Numerical values or narrative statements which, if not met, indicate some uncertainty that the associated Environmental Quality Objective has been achieved.

Environmental Quality Standards (EGSs): Numerical values or narrative statements which, if not met, indicate a high risk that the associated Environmental Quality Objective has not been achieved.

The EQC for the Marina were established via the following steps:

1. Identifying the pressures and threats to the quality of the marine environment in the Marina of Port Hedland and surrounding waters.
2. Selecting the relevant EQI.
3. Defining specific EQC to identify early warning and unacceptable changes to EQI specific for each EQO.

These steps are described below.

4.1. Identification of Pressures and Risk

The pressure analysis assessed present and potential pressures within the Marina potentially affecting the EVs. For the purpose of the Plan, pressures are defined broadly as *'processes influenced by marina activities that can detrimentally affect the Environmental Values'.*

A range of pressures described in Scheltinga *et al*., (2004) were considered in the pressure analysis. Note that the pressures outlined below are identified based upon the 'worst case' scenario and does not factor in future controls and management that are proposed by the Spoilbank Marina Operator (Section 6).

The risk assessment has been based on DoTs existing knowledge of operational marinas, with their ongoing management of marinas right across Western Australia. Based on the operational activities the marina will support, a simplified risk assessment has been applied as there is no justification for exhaustive risk assessment. By not applying controls to reduce the risk ratings, the risk assessment is also considered to be highly conservative, thus the selected EQIs are likely to be more than would actually be required based on controlled risk. The risk ratings are simply assigned "low, Moderate, High or Extreme.

The assessment enables the pressures to be categorised in terms of their relative importance and has informed the identification of environmental priorities for monitoring, management and reporting. The assessment encompasses all known risks posed to the marine environment in the Marina and surrounding waters and informs the selection of appropriate EQI to ensure monitoring addresses the risks that represent the highest potential of impacting on the EV. Note that only the pressures rated moderate or higher are assigned EQIs for routine monitoring under this program.

Table 5 includes a description and discussion of the pressures and risks in the context of the Marina.

Table 5: Summary of the pressure and risk for Spoilbank Marina

Pressure	Description of Pressure	Rationale	Risk
Toxicants	Loads, concentrations or bioavailability of pesticides, herbicides, organics, oils, hydrocarbons, metals, metalloids, organometallics, radiation, other toxic chemicals & contaminants.	Heavy metals and metalloids can enter the marine system through vessel maintenance activities, breakdown of anodes, degradation of antifoul coatings, and hydrocarbons from vessels or a potential spill incident within the marina pose a risk to EVs of the area.	Moderate
Aquatic sediment	Change to load, distribution / movement patterns, settlement / resuspension rates, grain size of suspended or settled sediments which can directly or indirectly impact biological communities or redistribute contamination	Dredging and alteration of hydrodynamics affect the physical distribution of sediments within the Marina and along the Spoilbank sand spit. Over time a build-up of sediments is likely to occur in low energy areas within the marina. Coastal processes outside the marina are managed through the Sediment Management Plan. The Marina is built on an anthropogenic sand spit that since creation has been subject to ongoing coastal process shaping and slowly eroding the sand spit with the Marina not identified to constitute any new threat to aquatic sediments. Sediment transport modelling was also conduced (Baird 2020) which identified the location displaying an erosional trend since ~2003 with the marina providing a stabilising benefit.	Low
Hydrodynamics	Changes to local patterns of waves, currents or changes to frequency and duration of tidal inundation above MSL. Ponding of marine water.	Physical modification of the Spoilbank, such as increases in depth of the Marina and access channel, and artificial structures such as breakwalls, can affect local current and tidal exchange patterns and contribute to the loss or degradation of habitat. Hydrodynamic modelling identified minor, highly localised shifts ion hydrodynamics from the approved design.	Low
Bacteria/pathogens	Bacteria, viruses, protozoans or fungi which cause disease.	Pathogens have the potential to enter the marine system through discharges of sewage from commercial and recreational vessels. Commercial vessel activity is managed by the federal government and locally by Pilbara Ports Authority. Recreational vessels using the facility may include liveaboard vessels, such as houseboats or yachts.	Moderate

Pressure	Description of Pressure	Rationale	Risk
Biota (animal) removal or disturbance	Removal, loss or disturbance of individual organisms of a specific species, not areas of habitat.	Recreational vessel currently operate from the Richardson Street Marina. As the Spoilbank Marina replaces this aged facility, there is not considered to be any additional threat over and above current recreational activities. The Marina is also adjacent to a major Port facility and is considered a far lower risk to biota.	Low
Litter	Human made rubbish/debris.	Litter entering the marine system from recreational vessel activities can detract from the visual amenity, can harm animals (entanglement, starvation, suffocation) and toxic substances can leach out of litter.	Moderate
Nutrients	Change to load, bioavailability and/or concentrations of nutrients.	Waters of Port Hedland are typically nutrient poor and anthropogenic influences such as agriculture runoff and discharge from sewage treatment plants/ablution facilities are a very low risk.	Low
Altered physiochemistry[1]	Changes to natural temperature, salinity, turbidity, dissolved oxygen or pH.	The enclosed embayment within the Marina has the potential to change locale physiochemistry of the water quality leading to potential biological impacts.	Moderate

1: This pressure combined multiple single pressures from Sheltinga et al. (2004) to acknowledge their shared potential for impact

4.2. Environmental Quality Indicators

Scheltinga *et al.* (2004) provides recommendations of potential indicators to monitor for changes in natural condition related to a change in each pressure. These indicators are separated into three categories: ‘Physico-chemical condition’, ‘Biological condition’ and ‘Extent and Distribution’. The physico-chemical condition indicators represent the definition of indicators in EPA (2016) relevant for determining EQG. Similarly, biological and extent and distribution indicators represent the definition of indicators in EPA (2016) relevant for determining EQS. To increase certainty in detecting levels of stress in the marine environment, a number of EQIs are selected for individual pressures providing a ‘multiple lines of evidence’ approach to monitoring as recommended in EPA (2016) (Table 6).

Table 6: Environmental Quality Indicators for the Marina

Pressure	Environmental Quality Indicators		
	Physico-chemical	Biological	Extent and Distribution
Bacteria/pathogens	• Water Quality (toxicants) • Aesthetics • Targeted pathogen counts	• Targeted pathogen counts • Toxicants in biota	• Aesthetics (extent of visible surface scums)
Litter	• Water Quality (toxicants) • Aesthetics	• Animals killed or injured by litter (entanglement, starvation, suffocation)	• Aesthetics (extent of litter)
Altered physiochemistry	• Water Quality (pH, Dissolved oxygen, salinity, temperature • Turbidity/reduced light • Aesthetics	• Reported animal deaths • Animal disease/lesions • Condition of subtidal benthic communities and habitat (BCH)	• Extent/distribution of animal kills • Extent/distribution of BCH
Toxicants	• Water Quality (toxicants) • Sediments Quality (toxicants) • Aesthetics	• Toxicants in biota • Animal kills • Animal species abundance	• Extent and concentration of reported contamination

4.3. Environmental Quality Criteria

4.3.1. EQO1 – Ecosystem Health

4.3.1.1. Environmental Quality Guidelines

EQGs for Ecosystem Health have been developed largely on pre-existing guideline trigger values and unimpacted background levels for marine waters and sediments in the area. The proposed EQGs applicable to the EV *'Ecosystem Health'* and corresponding EQO1 *'Maintenance of ecosystem integrity'* are presented below.

In respect of EQO1, EQGs have been derived for the following EQI constituents (Table 6).

- Toxicants in water (see Table 7).
- Toxicants in sediments (see Table 8); and
- Physical and chemical stressors in water (Table 9).

It should be noted however, that site specific EQGs for presented for physical and chemical stressors in water are calculated from three years of reference site data collected in accordance with the Port Hedland Marine Environmental Monitoring Quality Sampling and Analysis Plan (PHMEQSAP). The PHMEQSAP reference sites were positioned within nearby creek systems, and as such are not considered representative of the Marina's environmental setting. As such these EQGs are considered to be interim EQGs until data from a suitable reference site (included in this program) representative of the Marina's environmental setting has been collected and analysed to ensure suitability.

Toxicants in water

EQGs for toxicants in water are summarised in Table 7.

Table 7: Environmental Quality Guidelines for Toxicants in Water

EQI	Units	Numerical EQG		Narrative EQG
		Moderate	High	
Arsenic[1]	(µg/L)	3.0		The EQG is not considered achieved if the numerical EQG is exceeded at all sample locations for a single variable during a single sampling event **OR** Any numerical EQG for a single site is exceeded over two consecutive sampling events **AND** the median from reference sites is within acceptable range[3].
Cadmium	(µg/L)	14	0.7	
Chromium III/VI	(µg/L)	49/20	7.7/0.14	
Copper	(µg/L)	3	0.3	
Lead	(µg/L)	6.6	2.2	
Mercury	(µg/L)	0.7	0.1	
Nickel	(µg/L)	200	7	
Zinc	(µg/L)	23	7	
TRH-Silica C6-C14	(µg/L)	25	25	
TRH-Silica C15-C36	(µg/L)	100	100	
BTEXN - Benzene - Toluene - Ethylbenzene - Xylene[2] - Napthalene	(µg/L)	 900 230 110 100 90	 500 110 50 50 50	

1 Calculated from three-year database from PH MEQSAP (O2 Marine 2023)

2 Xylene based upon m-Xylene from ANZG (2018)

3 Acceptable range refers to the EQGs applied to the High LEP

Toxicants in sediment

EQGs for toxicants in sediment are summarised in Table 8.

Elutriate and Bioavailability of Sediment Toxicants

Elutriate and Bioavailability testing of sediments is the next point of investigation following an exceedance of the EQGs for toxicants in sediments. Elutriate testing assesses impacts to water quality from contaminated sediment and the subsequent ability for uptake by biota. For the elutriate testing, the EQGs for toxicants in water (Table 7) are applied. Bioavailability testing assesses the ability for toxicants in sediments to dissolved into the gut of an organism and the subsequent potential bioavailability to biota. For the bioavailability testing, the EQGs for toxicants in sediments (Table 8) are applied.

Table 8: Environmental Quality Guidelines for toxicants in Sediment

EQI	Units	Numerical EQGs		Narrative EQG
		Moderate	High	
Aluminium[1]	mg/kg	9100	9100	The EQG is not considered achieved if the numerical EQG is exceeded at all sample locations for a single variable during a single sampling event **OR** Any numerical EQG for a single site is exceeded over two consecutive sampling events **AND** the median from reference sites is within acceptable range[5].
Arsenic	mg/kg	20	20	
Cadmium	mg/kg	1.5	1.5	
Chromium	mg/kg	80	80	
Copper	mg/kg	65	65	
Lead	mg/kg	50	50	
Mercury	mg/kg	0.15	0.15	
Nickel	mg/kg	21	21	
Zinc	mg/kg	200	200	
TRH[2] Total C6-C14 C15-C36	mg/kg	 250 25 100	 250 25 100	
Low Molecular weight PAHs[3]	µg/kg	552	552	
High Molecular weight PAHs[4]	µg/kg	1700	1700	
Total PAHs	µg/kg	4000	4000	

1 Calculated from three-year database from PH MEQSAP (O2 Marine 2023)

2 Derived using the lowest limits of reporting available

3 Low molecular weight PAHs are the sum of acenaphthalene, anthracene, fluorene, 2-methylnaphthalene, naphthalene and phenanthrene

4 High molecular weight PAHs are the sum of benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenzo (a, h) anthracene, fluoranthene and pyrene

5 Acceptable range refers to the EQGs applied to the High LEP

Physical and chemical stressors in water

EQG for physical and chemical stressors in water are summarised in Table 9.

Table 9: Environmental Quality Guidelines for physical and chemical stressors in water

<table>
<tr><th rowspan="3">EQI</th><th rowspan="3">Units</th><th colspan="4">Numerical EQG</th><th rowspan="3">Narrative EQG</th></tr>
<tr><th colspan="2">Moderate</th><th colspan="2">High</th></tr>
<tr><th>Summer</th><th>Winter</th><th>Summer</th><th>Winter</th></tr>
<tr><td>Dissolved oxygen[1]</td><td>% saturation</td><td>>74.3</td><td>>97.3</td><td>>74.3</td><td>>99.6</td><td rowspan="6">The EQG is not considered achieved if the numerical EQG is exceeded at all sample locations for a single variable during a single sampling event
OR
Any numerical EQG for a single site is exceeded over two consecutive sampling events
AND
the median from reference sites is within acceptable range[2].</td></tr>
<tr><td>Temperature[1]</td><td>°C</td><td>27.5-31.3</td><td>20.9-25.5</td><td>27.5-31.0</td><td>21.4-24.0</td></tr>
<tr><td>Salinity[1]</td><td>o/oo</td><td>35.2-38.8</td><td>32.8-38.9</td><td>36.2-38.8</td><td>32.9-38.9</td></tr>
<tr><td>pH[1]</td><td>pH</td><td>7.34-8.28</td><td>7.9-8.35</td><td>7.41-8.21</td><td>8.17-8.35</td></tr>
<tr><td>Turbidity[1]</td><td>NTU</td><td><9.1</td><td><9.1</td><td><6.7</td><td><6.7</td></tr>
<tr><td>Chlorophyll-α[1]</td><td>μg/L</td><td><0.0020</td><td><0.0020</td><td><0.0010</td><td><0.0010</td></tr>
</table>

1 Calculated from three-year database from PHMEQSAP (O2 Marine 2023)

2 Acceptable range refers to the EQGs applied to the High LEP

4.3.1.2. Environmental Quality Standards

Any assessment against the EQS for the purpose of this plan will be consistent with the EPA Technical Guidance (EPA 2016), however any EQS investigation will be developed through the selection of selecting suitable biological indicators and scaled to the appropriate size based on the magnitude and scale of the EQG exceedance.

Thus, the EQS assessment is considered reactive and investigatory in nature, and therefore no methods are presented herein, just a description of the criteria required to be achieved to ensure projection of the EV.

Toxicants in Biota

Testing for Toxicants in Biota is only required if there is an exceedance of an EQG for toxicants in water. The EGS for Toxicants in Biota are derived from EPA (2016) guidelines (Table 10).

Table 10: Environmental quality standards for toxicants in biota

Analyte	Units	EQS	
		Moderate	High
Aluminium	mg/kg	-	Median ≤P80 of natural background
Arsenic	mg/kg		
Cadmium	mg/kg		
Chromium	mg/kg		
Copper	mg/kg		
Lead	mg/kg		
Mercury	mg/kg		
Nickel	mg/kg		
Zinc	mg/kg		
Tributyltin (as Tin)	mg/kg		
PAH	mg/kg		

Benthic Communities and Habitats and benthic Infauna

Investigative sampling for Benthic Communities and Habitat (BCH), and Benthic Infauna is only required following an exceedance of an EQG or EQS for Water Physiochemistry or Toxicants in Sediment and the relevant EQS are presented in Table 11.

Table 11: Environmental Quality Standards for benthic communities and habitat and infauna

EQI	EQS	
	Moderate	High
Benthic Communities and Habitat	Not applicable	No detectable change beyond natural variation within BCH
Benthic Infauna Community	Not applicable	No detectable change beyond natural variation within benthic fauna communities

4.3.2. EQ03, EQO4 and EQ05 - Recreation and Aesthetics

The proposed EQS applicable to the EV of *'Recreation & Aesthetics'* and the corresponding EQOs of '*Water quality is safe for primary contact recreation (e.g. swimming and diving)' (EQO3)*, '*Water quality is safe for secondary contact recreation (e.g. fishing and boating)' (EQO4*), and '*Aesthetic values of the marine environment are protected'* (*EQO5*) are presented in Table 12.

Table 12: Environmental Quality Standards for the Protection of the EV '*Recreational and Aesthetics*'

EQI	Safe for Primary contact (EQO3)	Safe for Secondary contact (EQO4)	Aesthetic Values Protected (EQO5)
Pathogenic Bacteria	The 95th percentile^ bacterial content of marine waters will not exceed 200 enterococci/100 mL	The 95th percentile^ bacterial content of marine waters will not exceed 2,000 enterococci/100 mL	NA
Nuisance Organisms$	The toxic phytoplankton cell count* from a single site, will not: – Exceed 10 000 cells/mL; or – Detect DoHWA watch list species or exceed their trigger levels. OR There will be no reports of skin, eye or respiratory irritation or potential algal poisoning of recreational users considered by a medical practitioner as potentially resulting from toxic algae when less than 10 000 cells/mL is present in the water column.	The median toxic phytoplankton cell count* for a defined sampling area (either from one sampling run or from a single site over an agreed period of time) will not exceed 25 000 cells/mL. OR There will be no reports of skin, eye or respiratory irritation or potential algal poisoning of recreational users considered by a medical practitioner as potentially resulting from toxic algae when less than 25 000 cells/mL is present in the water.	Phytoplankton scums, filamentous algal mats, blue-green algae and sewage fungus will not be present in excessive amounts (i.e. Moderate/High levels as defined in Table 3-7).
pH	The median of the depth profile will not exceed the range of 5–9 pH units.	The median of the depth profile will not exceed the range of 5–9 pH units.	NA
Fauna Deaths	NA	NA	There will be no reported incidents of large-scale deaths of marine organisms resulting from un-natural causes.
Oil/Debris/Wrack	NA	NA	Oil and petrochemicals will not be noticeable as a visible film on the water nor will they be detectable by odour. Water surfaces will be free of floating debris, dust and other objectionable matter, including substances that cause foaming. Floating seagrass / macroalgal wrack will not exceed 25% surface coverage.
Odour	There will be no objectionable odour.		

^ The Department of Health Western Australia (DoHWA) has produced The Enterotester for calculating 95th percentile statistics from five consecutive years of data for enterococci bacteria.

** Phytoplankton cell counts include cyanobacteria and eukaryotic organisms.*

† Algal scums are defined as dense accumulations of algal cells at or near the surface of the water forming a layer of distinct discolouration (green, blue, brown, or red) (Gov QLD, 2002).

$ See Table 13 and Table 14 for more details on nuisance organisms and algal scums.

The DoH watch list species and associated trigger levels that are defined as EQG for the EQI *'Nuisance Organisms'* are documented in **Table 13**. DoH (2017) has also developed a risk assessment for algal scum in marine waters shown in **Table 14** and these have been adopted as EQGs to ensure EQO5 is met.

Table 13: DoH watch list for potentially toxic algae in recreational waters

Algal Group	Algal Genus/Complex	Key Species	EQG (DoH Watch List Trigger Levels) (cells/L)	EQS (DoH Watch List Action Levels) (cells/L)
Cyanobacteria	*Lyngbya*	*L. majuscula*	≥0.01	Relatively widespread visible presence of algal filaments (NHMRC 2008)
	Trichodesmium		Detected	Presence of algal scums (NHMRC 2008)
	Other		≥5,000	≥15,000
Dinoflagellates	*Karenia*	*K. brevis*	≥5,000	≥10,000*
		Other sp.	≥50,000	≥100,000*
	Pfiesteria		≥0.01	Presence of algal scums (NHMRC 2008)

** This is a temporarily assigned action level for which the DoH may consider it appropriate to issue a public health warning and/or provide information/advice, having consideration for the specific monitoring event and result in the overall situation/context.*

Table 14: DoH risk assessment for algal scum in marine waters to inform aesthetic EQG assessment for EQO5

Algal Scum		~ Total Area of Scum (m^2)			
Characteristics	Location	1 to 25	25 to 100	>100	
Patchy/sporadic in nature	1. along shoreline at recreational beach/area	Moderate	High	High	Risk Level
	2. within swimming zone at recreational beach (< 500m from shoreline)	Low	Moderate	High	
	3. > 500m offshore	Low	Low	Moderate	
	4. along shoreline (nonrecreational area) e.g. rocky outcrop, boat harbour/marina.	Low	Low	Moderate	
	5. < 500m from shoreline (nonrecreational area) e.g. rocky outcrop, boat harbour/marina	Low	Low	Moderate	
Continuous aggregation	1. along shoreline at recreational beach/area	Moderate	High	High	
	2. within swimming zone at recreational beach (< 500m from shoreline)	Moderate	High	High	
	3. > 500m offshore	Low	Low	Moderate	
	4. along shoreline (non-recreational area) e.g. rocky outcrop, boat harbour/marina.	Low	Low	Moderate	
	5. < 500m from shoreline (non-recreational area) e.g. rocky outcrop, boat harbour/marina	Low	Low	Moderate	

5. Monitoring and Assessment

5.1. Marine Environmental Quality Monitoring

5.1.1. Monitoring Framework

This monitoring program adopts a tiered approach consisting of (Figure 4):

- routine monitoring;
- investigative monitoring; and
- reactive monitoring.

5.1.1.1. Routine Monitoring

Routine monitoring represents the core of the monitoring program which will be implemented in accordance with Section 5.1.2 and Table 17. Routine monitoring includes sampling and assessment of EQGs for EQO1 (Section 4.3.1.1). If one or more EQGs are not met, there is a need to examine the cause of this exceedance, as there is some uncertainty about meeting the associated EQO. Where reasonable uncertainty exists that the associated EQO has not been achieved, an assessment against the EQS is triggered.

Routine monitoring also includes sampling for 'routine EQS' for assessment of EQO3, EQO4 and EQO5 (Section 4.3.2).

If any EQGs are not met following a routine monitoring event, escalation to a higher level of assessment will be required. This escalation will involve an assessment of the relevant routine EQS, and/or further investigative monitoring. The failure to meet a routine EQS will also trigger investigative monitoring.

5.1.1.2. Investigative Monitoring

Investigative monitoring involves additional (unscheduled) sampling event(s) and is only implemented if an EQG or routine EQS is not met following routine monitoring. Investigative monitoring includes sampling and assessment of EQSs for toxicants in biota, benthic communities and habitats and benthic infauna to determine if the EQSs are met (Section 4.3.1.2). The scale and scope of the investigative monitoring is dependent on the EQG(s)/routine EQS(s) which are not met. This investigative monitoring is undertaken to determine the extent and severity of any impacts and provide an assessment of whether any EVs are at risk. If, following the investigative studies, one or more EQS are not met, then a management response shall be triggered (Figure 4).

5.1.1.3. Reactive Monitoring

Reactive monitoring is only implemented if a significant environmental event occurs, such as a hydrocarbon spill or fish kill event (Figure 4). The scale and scope of the reactive monitoring is outside the scope of this EQMF but will be dependent on the nature of the environmental event and the potential impacts and in consultation with relevant authorities and stakeholders.

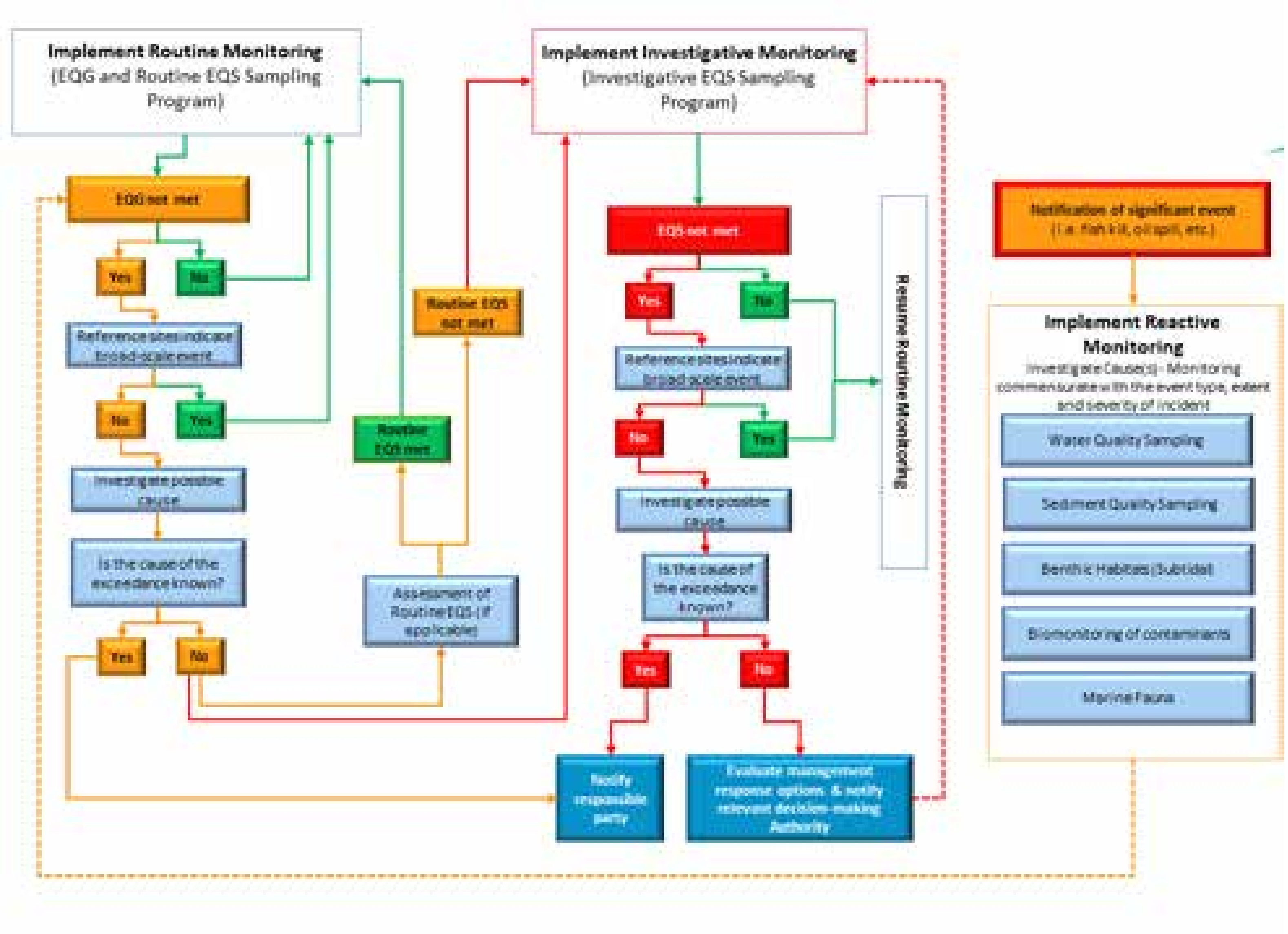

Figure 4: Marine Environmental Quality Monitoring Process

5.1.2. Routine Sampling Locations

The Marina sampling program will incorporate the following sites:

- One impact site within the High LEP.
- One impact site within the Moderate LEP; and
- One reference monitoring site within High LEP.

Details of the monitoring locations and associated routine sampling tasks to be completed at each location are provided in Table 15 and illustrated in Figure 5.

5.1.3. Routine Sample Program

A summary of the sampling program, including requirement, frequency, parameters, methodology and sample locations is for routine sampling activities is presented in Table 17.

Table 15: Monitoring locations and sampling tasks. Coordinate reference system EPSG:7850 - GDA2020 / MGA Zone 50

Site Name	Site Reference	Level of Ecological Protection	Easting	Northing	Routine Sampling Tasks					
					Aesthetic Observations	Physico-chemical Water Column Profiling	Water Sample Collection			Sediment Sampling
							General Water Sample Analysis	Bacterial Sample Analysis	Phytoplankton Sample Analysis	
SBM1	This site is located within the Marina north of the vessel pens and adjacent to the recreational launching ramp	Moderate	666047	7753746	X	X	X	X	X	X
SBM2	This site is located to the north-west of the marina within the channel	High	665686	7754176	X	X	X	X	X	X
REF4	This site is located away from anthropogenic activities associated with Port and Marina operations, at a similar environmental setting (proximity to creek system, depth distance from shore) to the impact sites.	High	658167	7755976	X	X	X	X	X	X

Figure 5: Sampling locations

5.2. Assessment of Monitoring Results

Monitoring results are to be assessed in the context of the MEQMP (Refer Section 3) to enable determination of whether the EQOs are being achieved, and hence whether the EVs for the marina are protected. A summary is presented in Table 17.

The Environmental Quality Criteria presented in Section 4 provide a basis upon which to assess marine environmental quality monitoring results and subsequently determine whether or not the EQOs have been achieved. A traffic light assessment of the monitoring results will be made for each Environmental Quality Indicator, at each site, and for each sampling event.

In reporting the results of the traffic light assessment, 'Green' identifies that the interim EQG have been met, indicating there is a high degree of certainty that an EQO has been achieved within that sampling event. 'Amber' indicates the results do not meet the interim EQG and there is uncertainty as to whether an EQO is likely to be achieved within that sampling event. 'Red' indicates the results do not meet the EQS and that the EQO is not likely to be achieved and subsequently the respective EV may be at risk.

An overview of the traffic light assessment is presented in Table 16.

Table 16: Traffic light assessment of monitoring results against each EQC and subsequently against each EQO

Traffic Light Assessment	Green	Amber	Red
Monitoring Results	EQG Met	EQG Not Met	EQS Not Met
Risk of Harm to Environmental Values			
Environmental Quality Objectives	EQO Achieved	EQO Potentially at Risk	EQO Not Achieved
Outcome: Post-Year 3	Continue Routine Monitoring	Monitor & Investigate	Evaluate Management Response Options

Table 17: Overview of monitoring and assessment

Element	Sample requirement	Parameters	Number of sites	Method	Frequency	EQG Assessment Criteria	EQG Exceedance Management Actions	EQS Assessment Criteria	EQS Exceedance Management Actions
Recreation and aesthetics	Physical observations of operational areas and monitoring sites and water sample collection	Observations: • nuisance organisms • largescale deaths/disease • oil/film • odour • floating debris, rubbish, surface slicks Water Sampling: • nuisance organisms • pathogens • pH • toxic algae	3 routine sites Public notification within entire operational area	Observational	Quarterly routine or as identified by public or other notification	Not applicable	Not applicable	Refer to Table 12, Table 13, Table 14	Refer Section 6.4, Table 18 and Figure 4
Physical and Chemical Stressors	Water column profiling and water sample collection	Water column profiling: • temperature • dissolved oxygen • pH • salinity • turbidity Water Sample Collection: • chlorophyll α	3 routine sites	Water column profiling and depth averaged water sampling	Quarterly	Refer Table 9	Refer Section 6.3 and Figure 4	Refer Table 9	Refer Section 6.4, Table 18 and Figure 4
Toxicants in Water	Water sample collection	Water sample collection for: • dissolved metals • hydrocarbons	3 routine sites	depth averaged water sampling	Quarterly	Refer Table 7	Refer Section 6.3 and Figure 4	Refer Table 7	Refer Section 6.4, Table 18 and Figure 4
Toxicants in sediments	Sediment sample collection	Sediment sample collection for: • total metals • hydrocarbons	3 routine sites	Sediment grab sample	Annual	Refer Table 8	Refer Section 6.3 and Figure 4	Refer Table 8	Refer Section 6.4, Table 18 and Figure 4

6. Management and Response

6.1. Assessment of Monitoring results

Upon receival of monitoring data a comparison is required to be conducted against the EQC as presented in Section 4.3 and outlined in Figure 4.

6.2. Management Actions

Where an assessment of monitoring data identifies an exceedance of any Environmental Quality Criteria, escalation of the monitoring program from an EQG exceedance to and EQS assessment will follow the basic process defined within Figure 4. This is further described below, with specific monitoring actions presented in Table 18.

Table 18: Overview of Management Actions

EQS Exceedance	Recommended Actions	Responsibility
EQG Exceedance (Any)	• Assess data against reference sites to ensure the exceedance is Marina related • Undertake an investigation within 7 days of becoming aware of the exceedance to determine the cause of the exceedance and identify potential for biological impacts. • Implement reactive monitoring program as required based on the nature, location, severity, and scale of the exceedance.	• DoT
EQS Exceedance (Any)	<u>Reporting Requirements</u>: • Refer to Section 7 <u>Management Actions</u>: • Determine the source of the impact and eliminate, or temporarily remove the pathway until the source can be eliminated, to prevent further biological impacts. • Implement engineering solutions (manual aeration, flushing, pumping, removal etc) if required to prevent further impacts. • Modify and revise operating procedures where a controlled activity has been identified as the source. • Investigate remediation of the impacted area. • Develop and implement recovery monitoring program to determine whether the impacted biological community recovers over an appropriate timeframe	• DoT
Marine Fauna EQS Exceedances	Consider over and above initial EQS exceedance actions: • Implement relevant DoT Fauna Management and Incident Response Procedures	• DoT
All EQS from **Table 13** and **Table 14**	• Notify the DoH with regards to public safety to ensure no personnel recreate within an unsuitable area which may put their health at risk.	• DoT

	• Consider signage or other onsite notification mechanisms to reduce public health risk • Consider notifying the public through social media, public websites, or stakeholder consultation groups as appropriate.	
EQS for toxicants in sediments	• Assess requirement to notify the Department of Water and Environmental Regulation Contaminated Sites Branch in accordance with the *Contaminated Sites Act* 2003.	• DoT

6.3. EQG Response Action

In the event an EQG exceedance is reported, an investigation will be required which will, at a minimum, be required to identify:

- Assess the data against reference sites to determine if the exceedance is a natural occurrence, a Marina related impact or other.
- Assess the exceedance along with any other available lines of evidence available to further assist establishing the cause.
- Complete an investigation in accordance with the Spoilbank Marina Operator incidence response procedures to determine the cause of the exceedance and identify potential for biological impacts and identify/propose potential management actions required including:
    - Identify potential source and avoid further impacts.
    - Enact oil spill response and recovery procedures.
    - Remove debris, rubbish or other identified offending material.
    - Place signage at area notifying of potential health impacts of primary or secondary recreation.
    - Investigate pumping or flushing options to remediate water quality issue.
    - Investigate removing and relocating or treating contaminated sediment to remediate sediment quality issue.
    - Investigate requirement to conduct a reactive biological investigation to assess against the EQS based on scale and magnitude of EQG exceedance and the potential for a biological impact.
    - Identify sites and biological community at risk to tailor suitable reactive investigation if required.

Where an EQG exceedance has been identified, the investigation is required to determine the likelihood of a biological impact, including the nature, location, severity, and scale of the exceedance. Any subsequent EQS investigation is then determined by the response pathway from the identified water quality or sediments quality impact to the known biological communities. For example, where sediment quality exceeds the EQGs at the HEPA location, the investigation may identify the biological community of benthic infauna adjacent to the exceedance as at-risk, and therefore the appropriate locations should be selected, and a reactive sampling program implemented to facilitate an assessment against the EQS.

6.4. EQS Response Action

In the event of an EQS exceedance, the CEO of DWER will be notified within 24 hours of the non-determination and a report sent within 7 days of the determination including any management actions which were undertaken. The reporting to the CEO is required whether the cause of the exceedance is known or not and will describing any subsequent investigations, management actions put into place and success of the actions in returning marine environmental quality to within requirements.

Based on the defined monitoring program, an EQS exceedance is possible to be detected through routine sampling programs, or as required by reactive program directed by any EQG exceedances identified to have the potential for a biological impact.

7. Reporting and Review

7.1. Annual Compliance Reports

DoT will prepare a compliance report for each 12 month period following the date of commencement of the action, or otherwise in accordance with an annual date that has been agreed to in writing by the Minister. The approval holder will:

a. publish each compliance report on the website within 60 business days following the relevant 12 month period;

b. notify the Department by email that a compliance report has been published on the website and provide the weblink and documentary evidence providing proof of the date of publication for the compliance report within five business days of the date of publication;

c. keep all compliance reports publicly available on the website until this approval expires;

d. exclude or redact sensitive ecological data from compliance reports published on the website; and

e. where any sensitive ecological data has been excluded from the version published, submit the full compliance report to the Department within 5 business days of publication

7.2. Non-compliance Reporting

DoT will notify the Department in writing of any: incident; non-compliance with the conditions; or non-compliance with the commitments made in plans. The notification will be given as soon as practicable, and no later than two business days after becoming aware of the incident or non-compliance. The notification will specify:

f. any condition which is or may be in breach;

g. short description of the incident and/or non-compliance; and

h. the location (including co-ordinates), date, and time of the incident and/or non-compliance. In the event the exact information cannot be provided, provide the best information available.

DoT will provide to the Department the details of any incident or noncompliance with the conditions or commitments made in plans as soon as practicable and no later than 10 business days after becoming aware of the incident or non-compliance, specifying:

a. any corrective action or investigation which the approval holder has already taken or intends to take in the immediate future;

b. the potential impacts of the incident or non-compliance; and

c. the method and timing of any remedial action that will be undertaken by the approval holder

7.3. Internal Reporting

Results from this program will be incorporated into Quarterly and Annual reports including, but not limited to:

- Summary of the methods applied, including any deviations from this Plan.
- Tables and figures of monitoring results (including physicochemical water column profiles).

- Review of historical trends in water and sediment quality as appropriate).
- Assessment against the EQC (including traffic light assessment).
- All laboratory reports; and
- A summary of data validation and QA/QC.

7.4. Review

DoT is committed to conducting activities in an environmentally responsible manner and aims to implement reviews of its environmental management as part of a program of continual improvement. This commitment to continual improvement means that the Plan will be reviewed annually or following any major changes within Marina waters that could affect the EVs. Consideration will be given to:

- Overall effectiveness of the Plan.
- Appropriateness of EVs, EQOs, LEPs, and EQC.
- New threats to marine environmental quality within Marina waters.
- Lessons learned during sampling or analysis.
- To refine EQC as confidence in baseline data grows.
- Changes in industry best practice.
- Changes in environmental risk; and
- Any changes in methodology or equipment used.

Provided a review of the Plan does not change the structure of the Environmental Quality Management Framework; and existing or new measuring and reporting of marine environmental quality captures any changes within port waters that could affect the EVs, then resubmission to the State or Commonwealth agencies for review/approval is not required.

7.5. Approval requirements for revised OEMP

This OEMP has been developed to meet the approval conditions detailed within EPBC 2019/8520.

DoT may, at any time, apply to the Minister for a variation to an action management plan approved by the Minister under condition 5, by applying in accordance with the requirements of section 143A of the EPBC Act. If the Minister approves a revised action management plan (RAMP) then, from the date specified, the approval holder must implement the RAMP in place of the previous action management plan.

Provided a review of the Plan does not change the structure of the OEMP, DoT may choose to revise an action management plan approved by the Minister under conditions 5 or as subsequently revised in accordance with these conditions, without submitting it for approval under section 143A of the EPBC Act, if the taking of the action in accordance with the RAMP would not be likely to have a new or increased impact.

If DoT makes the choice under condition 21 to revise an action management plan without submitting it for approval, the approval holder must:

a) notify the Department in writing that the approved action management plan has been revised and provide the Department with:
    i. an electronic copy of the RAMP;

ii. an electronic copy of the RAMP marked up with track changes to show the differences between the approved action management plan and the RAMP;
iii. an explanation of the differences between the approved action management plan and the RAMP;
iv. the reasons the approval holder considers that taking the action in accordance with the RAMP would not be likely to have a new or increased impact; and
v. written notice of the date on which the approval holder will implement the RAMP (RAMP implementation date), being at least 20 business days after the date of providing notice of the revision of the action management plan, or a date agreed to in writing with the Department.

b) subject to condition 24 implement the RAMP from the RAMP implementation date.

8. Reference List

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Appendix B. Artificial Light Management Plan

PILBARA PORTS AUTHORITY

PORT HEDLAND SPOILBANK MARINA ARTIFICIAL LIGHT MANAGEMENT PLAN

Prepared by

Pendoley Environmental Pty Ltd

For

Pilbara Ports Authority

30 July 2024

DOCUMENT CONTROL INFORMATION

TITLE: PORT HEDLAND SPOILBANK MARINA ARTIFICIAL LIGHT MANAGEMENT PLAN

Disclaimer and Limitation

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Document History

Revision	Description	Date received	Date issued	Personnel
Draft	Report Draft		11/07/2023	S. Bruzzese
Rev IA	Internal Review	11/07/2023	14/07/2023	K. Pendoley
Rev IB	Technical Review	14/07/2023	24/07/2023	A. Mitchell
Rev A	Client Review	24/07/2023	14/09/2023	M. Logue
Rev B	Second Draft	14/09/2023	27/09/2023	S. Bruzzese
Rev B	Client Review	27/09/2023	29/09/2023	D. Walker
Rev 0	Report Issued	29/09/2023	29/09/2023	S. Bruzzese
Rev 1	DBCA Feedback	08/12/2023	13/12/2023	S. Bruzzese
Rev 1	Client Review	13/12/2023	15/12/2023	D. Walker
Rev 1	Report Issued	15/12/2023	15/12/2023	S. Bruzzese
Rev 2	ToPH/DBCA Feedback	09/01/2024	11/01/2024	S. Bruzzese
Rev 3	DCCEEW Comments	03/05/2024	24/05/2024	S. Bruzzese / K. Pendoley
Rev 4	DCCEEW Comments Round 2	18/07/2024	30/07/2024	S. Bruzzese / K. Pendoley

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Client	Pilbara Ports Authority
Client representative:	A. Stanley / M. Logue / D. Walker / Z. Keller
Report number:	J11301
Cover photo:	Pendoley Environmental Pty Ltd

Declaration of Accuracy

I declare that to the best of my knowledge, all the information contained in, or accompanying this document is complete, current, and correct. I am duly authorised to sign this declaration on behalf of the approval holder. I am aware that:

a. Section 490 of the Environment Protection and Biodiversity Conservation Act 1999 (Cwth) (EPBC Act) makes it an offence for an approval holder to provide information in response to an approval condition where the person is reckless as to whether the information is false or misleading.

b. Section 491 of the EPBC Act makes it an offence for a person to provide information or documents to specified persons who are known by the person to be performing a duty or carrying out a function under the EPBC Act or the Environment Protection and Biodiversity Conservation Regulations 2000 (Cwth) where the person knows the information or document is false or misleading.

c. The above offences are punishable on conviction by imprisonment, a fine or both.

Signed:

Full name: Shelley Grice

Organisation: Department of Transport

EPBC Referral Number: **2019/8520**

Name of Action Management Plan this document and declaration refers to: **Spoilbank Marina Artificial Light Management Plan**

Date: 16 August 2024

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1 INTRODUCTION

1.1 Project Background

The Port Hedland Spoilbank Marina Project ('the Marina') is located on approximately 36, 000 hectares of land on the artificial spoil bank in Port Hedland, approximately 1 km east of Port Hedland Town Centre, adjacent to West End and approximately 3 km east of the Port of Port Hedland (**Figure 1**).

The Marina development is described in the Port Hedland Marina and Waterfront Masterplan (Town of Port Hedland 2019) and includes the following components (**Figure 2**):

- Public open spaces, such as the community node and recreation areas
- Toilets, shade structures, barbeque, and picnic facilities
- Parking for cars, caravans, and boat trailers
- Four-lane boat ramp
- Public jetty
- Boat pens
- Two breakwaters
- Roads and footpaths

The Pilbara Ports Authority (PPA) is the proponent responsible for the building of the Marina development in Port Hedland. The Marina is directly adjacent to a known flatback turtle nesting site on Cemetery Beach and has the potential to impact hatchling and nesting turtle behaviour (**Figure 4**). In 2020, the RPS Group conducted an Artificial Lighting Impact Assessment (RPS 2020; **Appendix A**) for the proposed Marina development. The report analysed and described the initial lighting design, the population, and behaviour of sensitive wildlife in the area, and presented an impact assessment based on the project light information and wildlife present along with proposed mitigation and management of light.

1.2 Environmental Objectives

To meet the *Environment Protection and Biodiversity Conservation* (EPBC) *Act 1999* approval conditions the PPA is required to develop and submit an Artificial Light Management Plan (ALMP) prior to operation (EPBC2019/8520 condition 5a).

The ALMP ensures artificial lighting associated with the operation of the Marina does not impact flatback turtle nesting on Cemetery Beach. The ALMP must be consistent with the National Light Pollution Guidelines for Wildlife including Marine Turtles, Seabirds and Migratory Shorebirds (Commonwealth of Australia 2020) and include the following:

i. The finalised artificial lighting design of the Marina;

ii. justification of how the proposed design will prevent impacts to flatback turtle hatchlings on Cemetery Beach;

iii. a monitoring and reporting program, which includes baseline data that monitoring and reporting will be evaluated against, to be undertaken for a minimum length of two years post commencement of operation of the Marina to provide certainty that the artificial lighting of the Marina is not impacting flatback turtle hatchlings or nesting on Cemetery Beach; and

iv. management measures and corrective actions to be implemented should monitoring indicate that the Marina's artificial lighting is likely to impact flatback turtle hatchlings on Cemetery Beach.

The PPA has therefore requested PENV prepare an ALMP based on the Port Hedland Marina Artificial Lighting Impact Assessment Report (RPS 2020) and 'issued construction' lighting designs, which consider the findings of that report.

The initial artificial lighting impact assessment (RPS 2020) and lighting design (including procurement; **Appendix B—D**) was completed with reference to the National Light Pollution Guidelines for Wildlife including Marine Turtles, Seabirds and Migratory Shorebirds (Commonwealth of Australia 2020). This ALMP aligns with the National Light Pollution Guidelines for Wildlife (Version 2.0), which was released in May 2023 (Commonwealth of Australia 2023). The updates to the National Light Pollution Guidelines have no effect on the requirements of this ALMP.

1.3 Scope

The ALMP consists of the following components, as outlined by the National Light Pollution Guidelines for Wildlife (Version 2.0; Commonwealth of Australia 2023) and will address the EPBC approval conditions.

1. Description of the light environment.
2. Description of the sensitive wildlife.
3. Sensitive wildlife risk assessment.
4. Artificial light mitigation and management.
5. A proposed monitoring program to inform an adaptive management framework to support continuous improvement in light management.
6. Auditing and reporting schedule.

1.4 Conditions of Approval References

The conditions of approval references, which includes the EPBC approval conditions and key commitments, are shown in **Table 1**.

Table 1: Conditions of approval reference table for Port Hedland Spoilbank Marina Project, WA (EPBC2019/8520)

Ref.	Cond.	Condition requirement	Plan reference	Demonstration of how the plan addresses condition requirement and commitments made in the plan to address condition requirements.
1	5(a)	Include an Artificial Lighting Management Plan (ALMP) that ensures artificial lighting associated with the operation of the Marina does not impact upon flatback turtle nesting on Cemetery Beach. The ALMP must be consistent with the Department's National Light Pollution Guidelines for Wildlife including Marine Turtles, Seabirds and Migratory Shorebirds (2020) and addresses conditions 5(a).	This ALMP	This ALMP is consistent with the National Guidelines for Wildlife (Version 2.0; Commonwealth of Australia 2023) and addresses conditions 5(a).
2	5(a)i	The ALMP must include the finalised artificial lighting design of the Marina.	Section 2.1.2 Appendix B Appendix C Appendix D Appendix F	The final lighting of design includes the following: • Lighting objectives (Section 2.2.1). • 'Issued construction' engineering lighting designs for the Marina waterfront, jetty, gangway, and boat pens (Appendix B and D). • Line-of-sight analysis of the Marina waterfront from Cemetery Beach (Appendix F) • Lighting inventory for the Marina development (Section 2.2.1). • Further details of the lighting design, such as spectral energy distribution of LEDs and fixture designs (Appendix C).

Ref.	Cond.	Condition requirement	Plan reference	Demonstration of how the plan addresses condition requirement and commitments made in the plan to address condition requirements.
3	5(a)ii	The ALMP must include justification of how the proposed design will prevent impacts to flatback turtle hatchlings on Cemetery Beach.	Section 4.3 Section 5	The impact and risk assessment in Section 4.3 justifies how the lighting design prevents impacts to flatback turtle hatchlings on Cemetery Beach. Section 5 describes in detail the mitigation and control measures implemented in the lighting design, **including the commitment to install low-intensity, PC Amber LED lighting throughout the Marina**.
4	5(a)iii	The ALMP must include a monitoring and reporting program, which includes baseline data that monitoring and reporting will be evaluated against, to be undertaken for a minimum length of two years post commencement of operation of the Marina to provide certainty that the artificial lighting of the Marina is not impacting flatback turtle hatchlings or nesting on Cemetery Beach.	Section 3.2 Section 6.2 Table 14	Flatback turtle hatchling orientation data collected from Cemetery Beach during the 2023/24 season is used as baseline data and the results are presented in this ALMP (Section 3.2). The baseline data was statistically analysed to determine trigger and threshold criteria to determine if there any significant impacts to hatchling turtle sea-finding behaviour post commencement of operations (Section 3.2). **The post commencement of operations monitoring program will be undertaken for a minimum of three years (Section 6.2).** **The baseline and post commencement of operations hatchling orientation monitoring data will be statistically analysed and compared to baseline trigger and threshold criteria to determine if there any significant impacts to hatchling turtle**

Ref.	Cond.	Condition requirement	Plan reference	Demonstration of how the plan addresses condition requirement and commitments made in the plan to address condition requirements.
				sea-finding behaviour post commencement of operations (Section 6.2). **The results of the monitoring survey including a comparison to baseline trigger and threshold criteria will be presented in a report after each monitoring season (Section 6.2).** **Table 14 provides a summary of the monitoring, auditing, and reporting plan.**
5	5(a)iv	The ALMP must include management measures and corrective actions to be implemented should monitoring indicate that the Marina's artificial lighting is likely to impact flatback turtle hatchlings on Cemetery Beach.	Section 6.6 Table 15	**If hatchling orientation monitoring data exceeds the trigger/threshold criteria, indicating a significant change in hatchling behaviour, then the steps in the response plan outlined in Table 15 will be followed.** Section 6.6 outlines **adaptive management and continuous improvement solutions that will be implemented if monitoring indicates significant changes in hatchling behaviour**. The corrective actions will be identified in an assessment based on the results of monitoring and auditing, as described in Table 15.
6	7	All plans required under these conditions must be consistent with the Department's Environmental Management Plan Guidelines.	This ALMP	The ALMP is consistent with the Department's Environmental Management Plan Guidelines (Commonwealth of Australia 2014) and addresses condition 7.
7	7(a)	The ALMP includes environmental objectives, relevant protected matters, and a	Section 1	Adequately addressed in Section 1.

Ref.	Cond.	Condition requirement	Plan reference	Demonstration of how the plan addresses condition requirement and commitments made in the plan to address condition requirements.
		reference to EPBC Act approval conditions to which the plan refers.		
8	7(b)	The ALMP includes a table of commitments made in the plan to achieve the objectives, and a reference to where the commitments are detailed in the plan.	Section 1.4 Table 1	Adequately addressed in Section 1.4 and Table 1.
9	7(c)	The ALMP includes reporting and review mechanisms, and documentation standards to demonstrate compliance with the commitments made in the plan.	Section 6 Table 14	**Section 6 includes a comprehensive monitoring, auditing, and reporting, which is summarised in Table 14**.
10	7(d)	The ALMP includes an assessment of risks to achieving the environmental objectives and risk management strategies that will be applied.	Section 3.2.3	A risk assessment for flatback turtle nesting and hatchlings on Cemetery beach is presented in Section 3.2.3 in line with the Department's Environmental Management Plan Guidelines (Commonwealth of Australia 2014).
11	7(e)	The ALMP includes impact avoidance, mitigation and/or repair measures, and their timing.	Section 5 Section 6.6	Section 5 describes in detail the mitigation and control measures implemented in the lighting design, **including the commitment to install low-intensity, PC Amber LED lighting throughout the Marina**. Section 6.6 outlines **adaptive management and continuous improvement solutions that will be implemented if monitoring indicates significant changes in hatchling behaviour.**
12	7(f)i-iv	The ALMP includes a monitoring program with; i. measurable performance indicators;	Section 6 Table 15	Section 6 outlines a **comprehensive flatback turtle hatchling orientation monitoring program**.

Ref.	Cond.	Condition requirement	Plan reference	Demonstration of how the plan addresses condition requirement and commitments made in the plan to address condition requirements.
		ii. trigger values for corrective actions; iii. the timing and frequency of monitoring to detect trigger values and changes in the performance indicators; iv. proposed corrective actions, if trigger values are reached.		**If hatchling orientation monitoring data exceeds the trigger/threshold criteria, indicating a significant change in hatchling behaviour, then the steps in the response plan outlined in Table 15 must be followed.** Section 6.6 outlines **adaptive management and continuous improvement solutions that will be implemented if monitoring indicates significant changes in hatchling behaviour**. The solutions will be identified in an assessment based on the results of further monitoring and auditing, as described in Table 15.
13	12	The approval holder must; a. submit plans electronically to the Department; b. unless otherwise agreed to in writing by the Minister, publish each plan on the website within 20 business days of the date; i. of this approval, if the version of the plan to be implemented is specified in these conditions; or ii. that the plan is submitted to the Department, if the plan does not require the approval of the Minister but was not finalised before the date of this approval; or iii. that the plan	This ALMP Section 6	The proponent confirms that this ALMP will be made publicly available and will be updated should revisions be made.

Ref.	Cond.	Condition requirement	Plan reference	Demonstration of how the plan addresses condition requirement and commitments made in the plan to address condition requirements.
		has been approved by the Minister in writing, if the plan requires the approval of the Minister; c. exclude or redact sensitive ecological data from plans published on the website or provided to a member of the public; and d. keep plans published on the website until the end date of this approval.		
14	13	The approval holder must ensure that any monitoring data (including sensitive ecological data), surveys, maps, and other spatial and metadata required under a plan, is prepared in accordance with the Department's Guidelines for biological survey and mapped data (2018) and submitted electronically to the Department in accordance with the requirements of the plan.	Section 2.1.2 Section 3.2 Section 6	The proponent confirms that monitoring data will be submitted annually.
15	20	The approval holder may, at any time, apply to the Minister for a variation to an action management plan approved by the Minister under conditions 4 and 5, or as subsequently revised in accordance with these conditions, by submitting an application in accordance with the requirements of section 143A of the	This ALMP Section 6	The proponent confirms that if the Minister approves a revised action management plan (RAMP) then, from the date specified, the approval holder must implement the RAMP in place of the previous action management plan.

Ref.	Cond.	Condition requirement	Plan reference	Demonstration of how the plan addresses condition requirement and commitments made in the plan to address condition requirements.
		EPBC Act. If the Minister approves a revised action management plan (RAMP) then, from the date specified, the approval holder must implement the RAMP in place of the previous action management plan.		
16	21	The approval holder may choose to revise an action management plan approved by the Minister under conditions 4 and 5 or as subsequently revised in accordance with these conditions, without submitting it for approval under section 143A of the EPBC Act, if the taking of the action in accordance with the RAMP would not be likely to have a new or increased impact.	This ALMP Section 6	The proponent confirms that this ALMP may be revised as stated in condition 21.
17	22	If the approval holder makes the choice under condition 21 to revise an action management plan without submitting it for approval, the approval holder must: a. notify the Department in writing that the approved action management plan has been revised and provide the Department with: i. an electronic copy of the RAMP; ii. an electronic copy of the RAMP marked up with track changes to	This ALMP Section 6	The proponent confirms that the steps outlined in condition 22 will be taken if a choice is made to revise this ALMP without submitting it for approval.

Ref.	Cond.	Condition requirement	Plan reference	Demonstration of how the plan addresses condition requirement and commitments made in the plan to address condition requirements.
		show the differences between the approved action management plan and the RAMP; iii. an explanation of the differences between the approved action management plan and the RAMP; iv. the reasons the approval holder considers that taking the action in accordance with the RAMP would not be likely to have a new or increased impact; and v. written notice of the date on which the approval holder will implement the RAMP (RAMP implementation date), being at least 20 business days after the date of providing notice of the revision of the action management plan, or a date agreed to in writing with the Department. b. subject to condition 24 implement the RAMP from the RAMP implementation date.		

Ref.	**Cond.**	**Condition requirement**	**Plan reference**	**Demonstration of how the plan addresses condition requirement and commitments made in the plan to address condition requirements.**
18	23	The approval holder may revoke their choice to implement a RAMP under condition 21 at any time by giving written notice to the Department. If the approval holder revokes the choice under condition 21, the approval holder must implement the action management plan in force immediately prior to the revision undertaken under condition 21.	This ALMP Section 6	The proponent confirms that they may revoke their choice to implement a RAMP and if they do so then condition 23 will apply.
19	24	If the Minister gives a notice to the approval holder that the Minister is satisfied that the taking of the action in accordance with the RAMP would be likely to have a new or increased impact, then: a. condition 21 does not apply, or ceases to apply, in relation to the RAMP; and b. the approval holder must implement the action management plan specified by the Minister in the notice.	This ALMP Section 6	The proponent confirms that if the Minister gives notice that the RAMP would be likely to have a new or increased impact then condition 24 will apply.
20	25	At the time of giving the notice under condition 24, the Minister may also notify that for a specified period of time, condition 21 does not apply for one or more specified action management plans.	This ALMP Section 6	The proponent confirms that condition 25 may apply if the Minister gives notice.

Ref.	Cond.	Condition requirement	Plan reference	Demonstration of how the plan addresses condition requirement and commitments made in the plan to address condition requirements.
		Note: conditions 21, 22, 23 and 24 are not intended to limit the operation of section 143A of the EPBC Act which allows the approval holder to submit a revised action management plan, at any time, to the Minister for approval.		

J11301 Spoilbank Marina Artificial Light Management Plan

Drawn: S. Bruzzese
Date: 15/06/2023
Drawing File Ref: PENV-J11301-1354-A

PENDOLEY ENVIRONMENTAL

Figure 1: Port Hedland Spoilbank Marina development site location.

Figure 2: Spoilbank Marina and Waterfront Masterplan. Source: Port Hedland Marina and Waterfront Masterplan (Town of Port Hedland, 2019)

1.5 Responsibilities

The roles and responsibilities of the Department of Transport (DoT), as the party responsible for the operational management of the Spoilbank Marina, are summarised in **Table 2.**

Table 2: Roles and responsibilities of the Department of Transport.

Role	Responsibility
Manager Environment and Approvals	• Ensure monitoring and auditing is conducted as per this ALMP. • Ensure reporting to the appropriate regulatory agencies is undertaken as per this ALMP. • Ensure self-reporting of any non-compliances to appropriate authorities. • Ensure response plan is implemented if ongoing monitoring detects a statistically significantly change in hatchling orientation behaviour as per this ALMP.
Environmental Advisors	• Assist in ensuring monitoring and auditing is conducted as per this ALMP. • Assist in ensuring monitoring and auditing data and reporting is submitted as per this ALMP. • Participate in implementation of response plan if ongoing monitoring detects a statistically significant change in hatchling orientation behaviour as per this ALMP.

2 DESCRIBE THE LIGHTING ENVIRONMENT

To put the Marina lighting into a regional context, relevant information on Port Hedland lighting is summarised from the Spoilbank Marina Bassline Hatchling Orientation and Light Monitoring survey conducted in 2024 (PENV 2024) and from current satellite imagery of Port Hedland. The final approved Marina lighting design currently under construction (i.e., 'issued construction' lighting design) is described and all details regarding the light mitigation measures and best practice lighting implemented as recommended in Section 9 of the Port Hedland Marina Artificial Lighting Impact Assessment Report (RPS 2020) are identified.

Section 2.1.2 presents the final lighting design meeting condition 5(a)i of the Port Hedland Spoilbank Marina EPBC 2019/8520 approval.

2.1 Regional Lighting Context

The Marina development is located approximately 3 km east of the Port of Port Hedland, which is the largest port for bulk exports globally, facilitating the shipment of commodities such as iron ore, lithium, and salt (PPA 2022). The facility operates 24 hours a day and is comprised of 19 operational shipping berths including Finucane Island, Utah Point, East Side, Nelson Point, Stanley Point and Anderson Point (PPA 2022). The extensive operations at the port, which include loading, processing, and stockpiling, contribute significantly to the sky glow in the region. The Marina is located adjacent to the Port Hedland Town Centre and West End residential and commercial areas, which also contribute towards visible sky glow as well as directly visible unshielded lights from local streetlights and buildings (as identified in **Section 2.1.2**).

2.1.1 Satellite Imaging

Current satellite imaging of the Port Hedland region derived from the Visible Infrared Imaging Radiometer Suite (VIIRS) Day/Night Band (DNB) detectors can be used to obtain quantitative data about the existing artificial light across the region. The processed images provide yearly, averaged measurements of artificial light, between 500 and 900 nanometers (nm), from space, in terms of radiance (measured in W/cm^2/sr; Elvidge et al. 2017). The existing regional light sources within 20 km of the Marina development site, as detected by VIIRS/DNB, are shown in **Figure 3**.

The main sources of artificial light in the region are:

- Port Hedland Port Facilities
    - Utah Point
    - Finucane Island
    - Anderson Point
    - Nelson Point
    - East Side Port
- Port Hedland Town Centre and West End

- Wedgefield
- South Hedland
- Port Hedland Airport

The three brightest sources of existing artificial light in the region are emitted from the Port Hedland Port Facilities at Utah Point, East Side Port and Nelson Point all within 6 km of the turtle nesting areas on Cemetery Beach. The light from Utah Point also merges with light from Finucane Island, which is in the same direction (west) as the Marina development site, as viewed from Cemetery Beach.

2.1.1.1 Satellite Imaging Limitations

The VIIRS/DNB detectors measure light between 500 and 900 nm, which overlaps with human and turtle vision. However, the detectors are not sensitive to light in the blue part of the visible spectrum (< 500 nm) and are sensitive to infrared light (> 700 nm), which is beyond the visible spectrum (Liao et al. 2013). This means that the VIIRS/DNB satellite imagery is less sensitive to light emitted by white LED lights and more sensitive to heat sources, such as flares and fires (Elvidge et al. 2013; 2015). Therefore, if there is an excess of white LEDs used in the Port Hedland region, the measurements from the VIIR/DNB would underrepresent the true radiance values. It should be noted that marine turtle vision is more sensitive to blue light compared to human vision (Commonwealth of Australia 2023).

In addition, the VIIRS/DNB radiance measurements do not account for how the Earth's atmosphere affects light as it travels towards the detector, such as scattering and absorption, reducing the overall radiance values significantly (Horvath 1993; Cinzano et al. 2001). Due to these limitations, the radiance values presented in **Figure 3** are not to be considered an accurate measurement of light intensity. However, **Figure 3** provides the best available regional scale representation of light emissions and is used to identify and quantify the main sources of artificial light in the region.

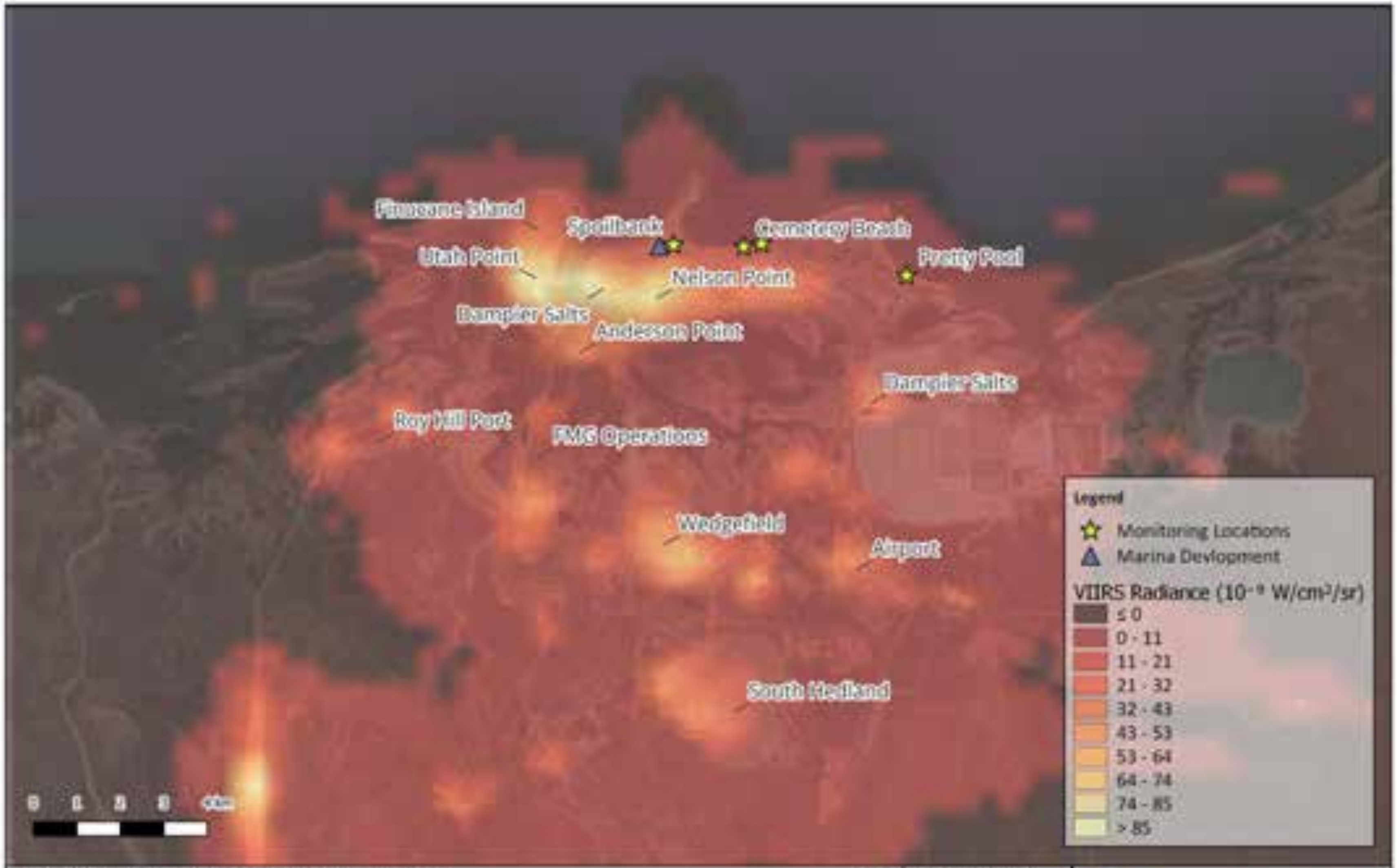

Figure 3: Radiance of existing light sources in the Port Hedland region from VIIRS 2022 satellite imagery. Source: www.lightpollutionmap.info

2.1.2 Summary of 2024 Baseline Artificial Light Survey

This section is taken from the Spoilbank Marina Baseline Hatchling Orientation and Light Monitoring report (PENV 2024), which is located in **Appendix E**. All future light monitoring must be conducted using the same methodology, under new moon conditions, to ensure a suitable comparison between datasets.

PENV conducted a benchmark ‘baseline’ artificial light survey, using a specialised digital camera and fish-eye lens, to quantify the existing artificial light environment from the Cemetery Beach turtle nesting area (PENV 2024). Two survey locations were selected on Cemetery Beach, one at the east end of the beach (Cemetery Beach East) and one at the west end of the beach (Cemetery Beach West; **Figure 4**). Light monitoring cameras were deployed for 4 nights between the 8th and 15th of January 2024, which was scheduled to coincide with new moon conditions. Suitable data was successfully collected from both survey locations on 8th January 2024, which had the clearest atmospheric conditions, and have been presented in this report.

The port facilities were the most dominant source of sky glow in Port Hedland and were visible from both survey locations. This was followed by Port Hedland residential and commercial lighting. From both monitoring locations, the port facilities overlap with the position of the Spoilbank Marina facilities. Streetlights along Sutherland Street are visible as high intensity point sources of light towards the northeast. Lower-intensity point sources of light corresponding to offshore vessels are visible on the horizon to the northwest from both locations (**Figure 5** and **Figure 6**).

From Cemetery Beach East, high-intensity, direct light is visible from the Gratwick Aquatic Centre, which also produces light spill that extends beyond the dunes onto the beach (**Figure 6**). Hatchling fan data collected as part of the benchmark ‘baseline’ hatchling orientation survey collected at the same time as the light monitoring data, indicates that majority of the nests fans that were considered highly dis-orientated were also located in front of the Aquatic Centre (see **Section 3.2.2** for details).

The sky brightness from each survey location correlates strongly with the visibility and proximity of the identified light sources. Cemetery Beach East, which is located further from the port facilities with higher dunes, recorded fainter sky brightness values. Whereas Cemetery Beach West which is located closer to the port facilities and has lower dunes, had the brightest sky brightness values.

Figure 4: Artificial light and hatchling orientation survey locations along Cemetery Beach. Source: PENV 2024

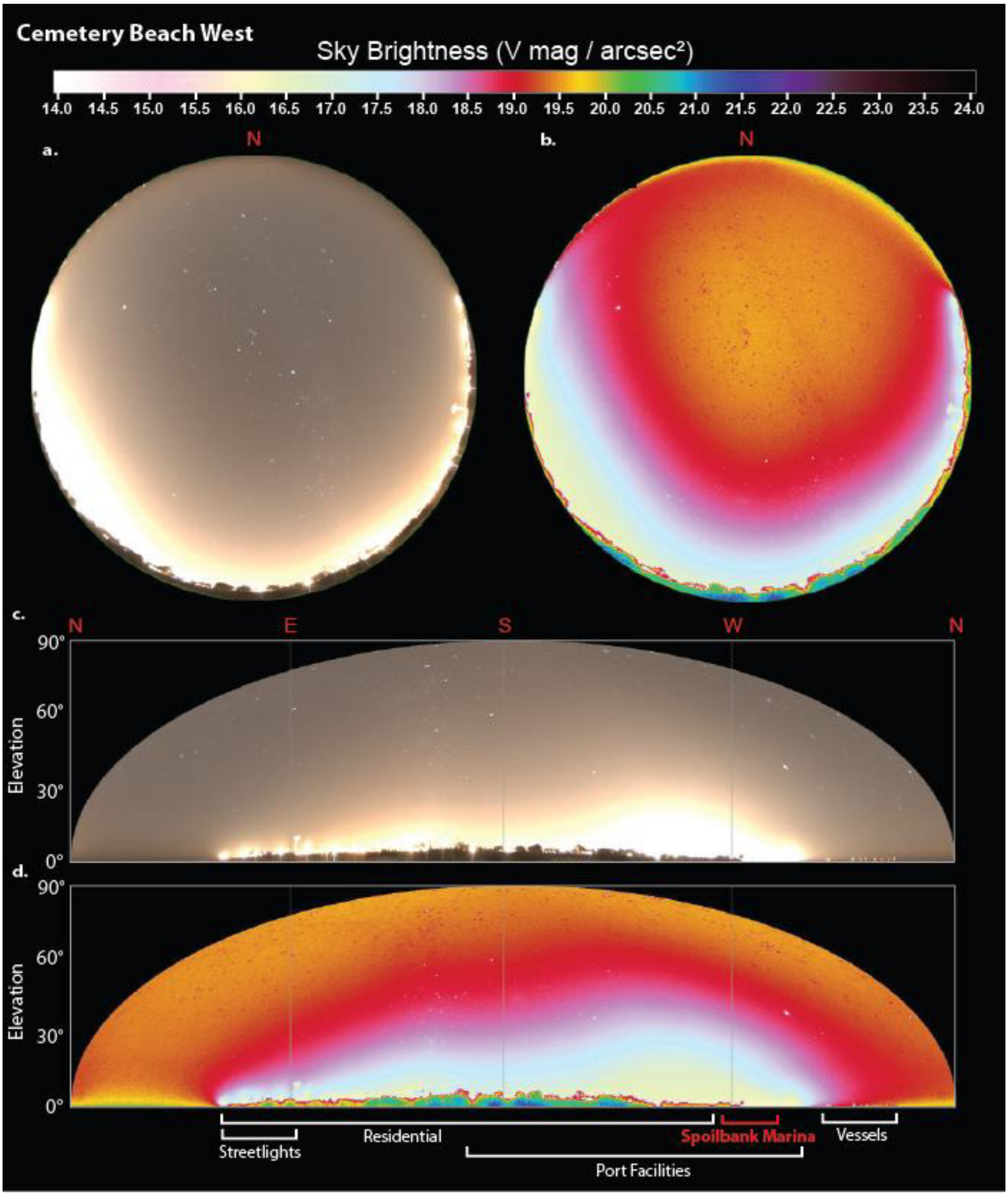

Figure 5: Median artificial light monitoring results from Cemetery Beach West on 8th January 2024. a. raw circular image; b. Processed circular image; c. Raw hammer-aitoff image; d. Processed hammer-aitoff image. White labels = current light sources, red labels = location of Spoilbank Marina. NOTE: Lower Vmag values indicate brighter light sources. The location of the Marina development is included for reference. Source: PENV 2024

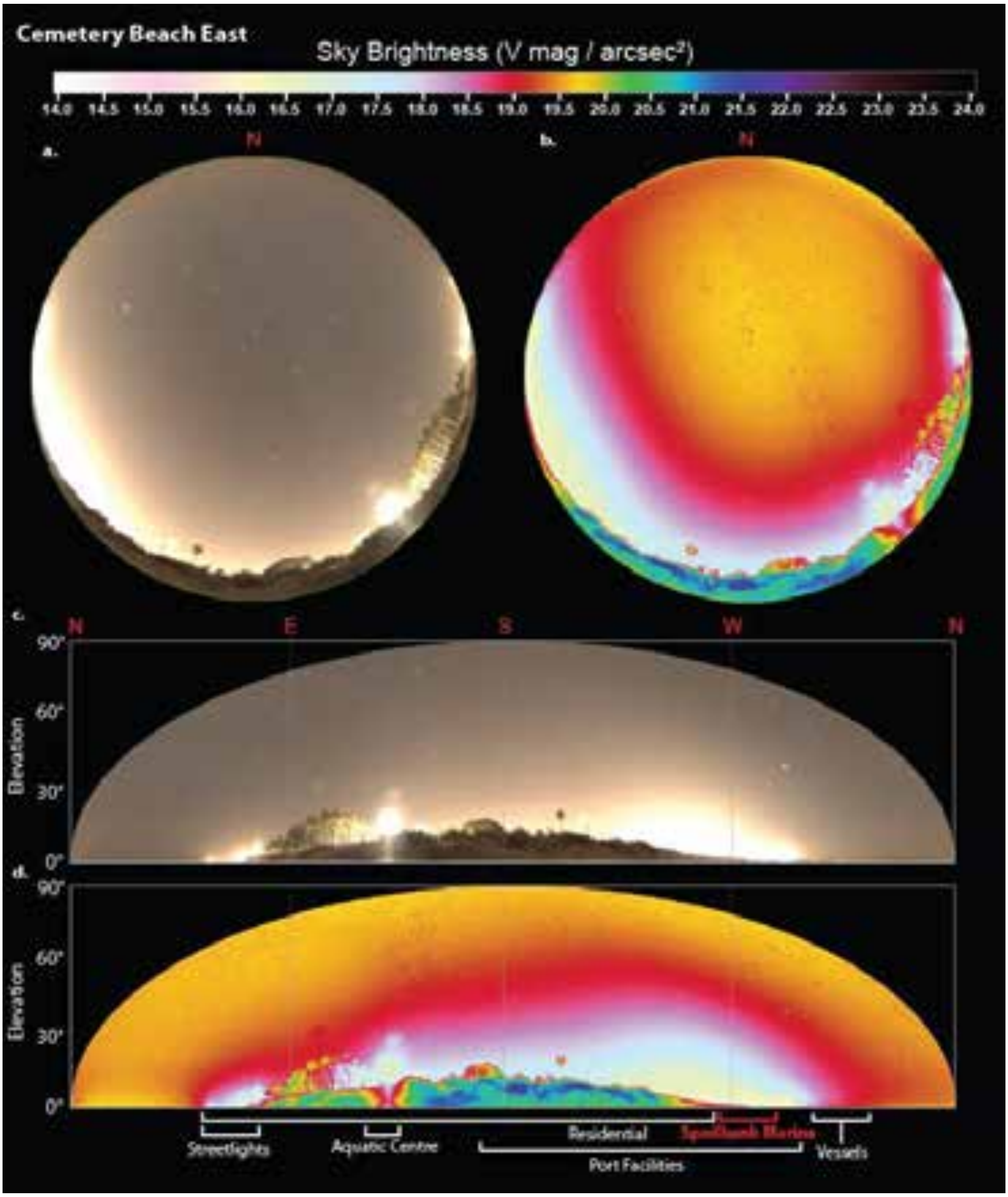

Figure 6: Median artificial light monitoring results from Cemetery Beach East on 8th January 2024. a. raw circular image; b. Processed circular image; c. Raw hammer-aitoff image; d. Processed hammer-aitoff image. White labels = current light sources, red labels = location of Spoilbank Marina. NOTE: Lower Vmag values indicate brighter light sources. The location of the Marina development is included for reference**.** Source: PENV 2024

2.2 Marina Development Lighting Design

This section presents the finalised Marina lighting design meeting condition 5(a)i of the Port Hedland Spoilbank Marina EPBC 2019/8520 approval.

2.2.1 Lighting Objectives

To ensure compliance with Australian legislation, regulations, and safety standards for human safety, the Marina development requires the installation of artificial lighting. This includes lighting requirements for roads, parking, footpaths, and marine navigation.

As the Marina is close to a known flatback turtle nesting site the lighting designs were developed in line with existing best practice lighting principles for protecting marine turtles from artificial light at night. These guidelines included the Environmental Assessment Guidelines for Protecting Marine Turtles from Light (EAG5; Environmental Protection Authority (EPA) 2010) and the National Light Pollution Guidelines for Wildlife (Commonwealth of Australia 2023). These guidelines specify mitigation measures such as keeping lights off, on low mounts, and using low-intensity, long-wavelength light with shielding (EPA 2010, Commonwealth of Australia 2023).

2.2.1 Lighting Inventory

2.2.1.1 Marina Waterfront Development

The ‘issued construction’ lighting design for the Marina waterfront was developed by JDSi Consulting Engineers (JDSi; **Appendix B).** All lights and fittings are sourced from WE-EF Australia and include PC Amber LEDs, which are filtered LEDs that emit a higher proportion of longer wavelength light and limited blue light (see **Appendix C** for spectral distribution). The estimated total visible light output of the waterfront marina development is 567,237 lumens (lm), based on information provided by JDSi and WE-EF (see **Appendix C** and **Table 3**).

Table 3: Lighting inventory for waterfront marina lighting. All lights are WE-EF PC Amber LEDs. *ADSA Certified Lighting. ** ADSA Prized Wildlife Certified Lighting (ADSA 2023; https://www.australasiandarkskyalliance.org/adsa-approved).

Description	Quantity	Height (m)	Mount	Light output (lm)	Total light output (lm)
KTY234 7W	71	1	Bollard	433	30,799
VFL530 26W*	32	4	Pole	1,735	55,526
VFL530-SE 26W**	6	4	Pole	1,735	10,411
VFL530 52W	24	6	Pole	3,470	83,289
VFL540 78W	61	6	Pole	5,205	317,541
PLS420 13W	20	3	Downlights on underside of shade structures	867	17,352
QR1354 13W	41	0.5	Recessed into retaining walls	867	35,571
Projector Light FLC121	20	3	Pole up-lights on main shade structure	924	18,480
				Total	567,237

The installation areas and usage of this lighting is as follows:

- The bollard lights (WE-EF KTY234 at 1m) and wall-mounted lights (WE-EF QRI1352 at 0.5m) illuminate footpaths and stairs around the Marina.
- The 4m high pole lights (WE-EF VFL530 26W) illuminate footpaths in the recreational area, along the southern promenade and adjacent vegetation area, along the south-western breakwater and eastern road entrance. Most of these lights are facing away from Cemetery Beach while still illuminating the intended area.
- The 6m high pole lights (WE-EF VFL530 52W) illuminate the eastern road (closest to Cemetery Beach), southern street parking and western road entrance. All lights face away from Cemetery Beach while illuminating the intended area.
- The 4m pole lights (WE-EF VFL530-SE) illuminate the western promenade, eight of these lights point towards Cemetery Beach. The 8m pole lights (WE-EF VFL540) illuminate the car, caravan, and trailer parking at the north-eastern end of the Marina, closest to Cemetery Beach. Twelve of these lights are facing towards Cemetery Beach.
- The projector lights (WE-EF FLC121) are mounted at 3m height on the supporting poles of the main shade structure on the south-eastern promenade. The lights will be facing upwards to illuminate the artwork on the underside of the roof of the structure.
- The downlights (WE-EF PLS420) illuminate the smaller shade structures located around the recreational area.

A detailed overview of each light is provided in **Appendix C**, which includes drawings of the fittings and renderings of the light distribution for each light. An overview of the areas within the Marina waterfront is shown in **Figure 2.**

WE-EF VFL530 26W light is certified by the Australian Dark Sky Alliance (ADSA) and WE-EF VFL530-SE light is ADSA Prized Wildlife certified. These lights meet specific criteria that minimise light pollution and the impact on wildlife (ADSA 2023; https://www.australasiandarkskyalliance.org/adsa-approved).

2.2.1.2 Boat Pens, Gangway and Jetty

The lighting designs for the boat pens, gangway and jetty were developed by AIE Engineering and Construction Management (AIE; **Appendix D**). Three different lights are used to illuminate these areas all fitted with PC Amber LEDs. The estimated total visible light output of this area of the Marina development is 17,211 lm, based on information provided by AIE, Compuspec, Klik Systems and Dialight (see **Appendix C** and **Table 4**).

The installation areas and usage of this lighting is as follows:

- LEDpod50 PC Amber lights installed on the underside of handrails illuminate the walkway along the gangway and jetty. The lights on the upper level of the jetty located on the western side of the breakwater are mounted at 6.5 m (AHD). The lights on the handrails of the gangway are located at various heights that change (-2.1 m to 6.5 m; AHD) as the gangway is sloped towards the water and moves vertically with the tides.

- Vigilant LED PC Amber Bulkheads on the boat pens illuminate the area around the security gate at a fixed height of 7.1 m (AHD) and on the jetty to illuminate the upper and lower levels at a fixed height of 5.6 m and 7.7 m (AHD), respectively.

- T10 LED PC Amber lights mounted on marine pillars illuminate the walkway along the boat pens and are located at various heights (-2.3 m to 5.1 m AHD) as the boat pens moves vertically with the tides.

Table 4: Lighting inventory for boat pens and jetty. *Heights are based on Australian Height Datum (AHD) values (AHD71; Australian mainland).

Brand	Description	Quantity	*Height (m)	Light output (lm)	Total light output (lm)
Klik Systems	LEDpod50 PC Amber	80	-2.1 to 6.5	99	7,920
Dialight	Vigilant LED Bulkhead (BxE4UAx3xxxxxN) PC Amber	3	5.6, 6.5, 7.7	2,145	6,435
Compuspec	T10 LED Bulb PC Amber	12	-2.3 to 5.1	238	2,856
				Total	17,211

The lights from the boat pens, gangway and jetty are unlikely to be directly visible from Cemetery Beach due to shielding by existing topography of the Marina basin. A detailed overview of each light is provided in **Appendix C**, which includes drawings of the fittings and renderings of the light distribution for each light (if available).

2.2.2 Line-of-Sight Analysis

JDSi conducted a line-of-sight analysis (**Appendix F**), based on the finalised lighting design, to assess the lighting that will be visible to flatback turtles from the nesting areas of Cemetery Beach. The analysis was based on a drone survey conducted by MP Rogers and Associates in 2019, which was used to inform the topography of Cemetery Beach (RPS 2020). The area of highest density flatback turtle nesting at ground level was used as the reference point for the assessment (RPS 2020). The analysis takes three sections from the location on Cemetery Beach eastwards towards the most seaward part of the Marina, the trailer parking and towards the yacht club (presented in **Appendix F**).

Based on the analysis, the pole mounted (4 – 8 m) lighting positioned along the access roads, parking areas, and within the recreational area, community node and hardstand areas (such as promenade) will be directly visible to flatback turtles on Cemetery Beach. The low bollards and wall mounted lighting may be shielded by existing topography, internal retaining walls or future vegetation within the Marina Waterfront areas and are unlikely to be directly visible to flatback turtles on the Cemetery Beach nesting area (RPS 2020).

2.2.3 Difference Between Lighting Design Modelling and Impact on Turtles

Lighting design consultants have designed and modelled the illuminance levels throughout the Marina development to ensure the lighting meets the minimum required safety standards (see **Appendix B** and **Appendix D**). Illuminance is a measurement of how much incoming light illuminates a surface and is measured in units of lux. Lux levels decrease as the distance from the source increases (proportional to $\frac{1}{d^2}$) and will never completely reach zero. However, lux levels are unable to indicate whether a source of light will be directly visible by humans, marine turtles, or other wildlife.

2.2.4 Proposed Lighting Mitigation Measures from Impact Assessment

The Artificial Lighting Impact Assessment Report (RPS 2020) identified the following mitigation measures, based on best practice lighting design (and impact assessment results), to further reduce the risk of marina lighting on flatback turtles at Cemetery Beach. The implementation of these measures based on the 'issued construction' lighting design, landscape design and the Spoilbank Marina and Waterfront Masterplan are identified and discussed (see **Table 5** for a summary).

a) Switching off the pole-mounted lighting during turtle hatching season (December to mid-February) when not in use. Alternatively, a curfew time could be implemented for marina operations with the pole-mounted lights being switched off from a particular time during turtle hatching (RPS 2020).

   - Switching off the marina lighting may be an option if hatchling orientation monitoring data indicates impact to turtles. Turning off lights now occurs along beachside streets and water tower near Cemetery Beach and is accepted within the community.

b) Planting screening vegetation along the eastern side of the main access road (RPS 2020).

   - The landscape design for the Marina was developed by Emerge Associates (**Appendix G**). The design includes the planting of *Delonix regia*, a flowering, spreading tree that can grow to 15 m (New South Wales Flora Online 1998). These trees will be planted approximately every 10 m along the eastern side of the main access road, which may provide shielding to the 6 m pole lights illuminating the road. *Peltophorum pterocarpum,* a flowering, spreading tree that can grow 15-24 m (Cabi Digital Library 2019), will be planted in the recreational area, which may provide shielding to the 4 m pole lights illuminating that area. *Wodyetia bifurcate*, a palm growing to 15 m (Commonwealth Government 1999) will be planted along the east side of the car and trailer parking, which may shield some of the 8 m pole lights illuminating that area.

   - Semi-mature trees of each species will be planted as part of the landscaping design; however, it may take years for the trees to reach a height that shields the pole-mounted lights from Cemetery Beach. In addition, the trees are planted sparsely and may not provide sufficient shielding from all lines of sight across the Cemetery Beach nesting area.

c) Shielding on the eastern-facing side of the pole-mounted lighting in the parking and hardstand areas to the extent that compliance with AS/NZS 1158.3.1:2018 is not reasonably compromised (RPS 2020).

- Shielding may be installed post-construction if hatchling orientation data and reporting indicates impact to turtles.

d) Shielding should be installed on the eastern-facing side (i.e., side facing towards the Cemetery Beach nesting area) of the pole-mounted lights along the main access road to assist in reducing the line-of-sight visibility of these lights to hatchlings within the Cemetery Beach nesting area (RPS 2020).

- Shielding may be installed post-construction if hatchling orientation data and reporting indicates impact to turtles.

Table 5: Summary of proposed control measures from the Artificial Lighting Impact Assessment Report (RPS, 2020), implementation in construction design, and PENV's response.

RPS Proposed Mitigation Measures	Implementation in Construction Design	PENV Response
Switching off pole-mounted lighting during turtle hatchling season. Curfew for switching off pole-mounted lighting during turtle hatchling season.	Switching off the Marina lighting may be an option if hatchling orientation monitoring data indicates impact to turtles.	Included in **Section 5.**
Planting screening vegetation along the eastern side of the main access road.	Landscape design indicates that three different types of large, spreading trees (>10 m) will be planted along eastern main access road and throughout the waterfront area.	Semi-mature saplings will take years to reach the height of the pole-mounted lights. Trees are planted sparsely and may not provide sufficient shielding.
Shielding on the eastern-facing side of the pole-mounted lighting in the parking and hardstand areas.	Shielding may be installed post-construction if hatchling orientation data indicates impact to turtles.	Included in **Section 5.**
Shielding should be installed on the eastern-facing side of the pole-mounted lights along the main access road.	Shielding may be installed post-construction if hatchling orientation data indicates impact to turtles.	Included in **Section 5.**

3 DESCRIBE THE SENSITIVE WILDLIFE

Sections 3.1.1 to 3.1.2 summarises information regarding flatback turtles from the Spoilbank Marina Artificial Lighting Impact Assessment Report (RPS 2020; **Appendix A**).

Section 3.2 presents the baseline hatchling orientation methodology that form part of the monitoring and reporting program meeting conditions 5(a)iii of the Port Hedland Spoilbank Marina EPBC 2019/8520 approval.

3.1 Flatback Turtles

Flatback turtles (*Natator depressus*) are considered as 'Vulnerable' under the EPBC Act (Department of Environment and Energy (DEE) 2019). Flatback turtles are widely distributed across the northern Australia continental shelf with their nesting locations restricted to tropical and sub-tropical Australian beaches (Limpus 2007). There are distinct flatback turtle genetic stocks established in Eastern Queensland, Arafura Sea, Cape Dommett, South-west Kimberly, and Pilbara Coast. The breeding population of flatback turtles in Port Hedland is part of the Pilbara Coast genetic stock, which has key nesting areas that include, Barrow Island, Mundabullangana Station and Delambre Island with Cemetery Beach identified as a minor nesting area in the region (DEE 2017; PENV 2019). In addition to Cemetery Beach, nesting flatback turtles in Port Hedland also utilise Pretty Pool Beach (to a lesser extent), which is located further from the Marina and is not considered to be impacted by artificial light from its operations (RPS 2020).

3.1.1 Cemetery Beach Adult Flatback Turtles

The Cemetery Beach flatback turtle nesting rookery is approximately 1.7 km east of the Marina site and 3.3 km from Port Hedland Town Centre (**Figure 1**). Female turtles nest at Cemetery Beach between mid-October and January, with a peak in late November (Imbricata Environmental 2016). The population of nesting turtles appears to be relatively stable between 148 to 202 females/year (PENV 2019) and is minor when compared to the size of other Pilbara Coast rookeries but significant to Port Hedland (RPS 2020; Table 2). Nesting flatback turtles at Cemetery Beach lay a comparable average number of eggs to the major nesting rookeries of the Pilbara Coast genetic stock with a notably lower hatch success rate when compared to typical flatback rookeries (Pendoley et al. 2014). Cemetery Beach flatback turtles display a strong nest fidelity, frequently returning to the same beach to lay subsequent clutches (Whittock 2014).

The mating season for flatback turtles at Cemetery Beach is expected to take place between September and January, spanning the entire nesting period, with the mating sites situated about 7 km offshore, approximately 33 km north-west of Port Hedland (PENV 2019). Inter-nesting activities are expected to occur between mid-October to January (PENV 2019), with the most important habitat located in the nearshore zone within 50 km north-east of Cemetery Beach and some activity also occurring to the north-west (PENV 2010; Figure C). Nearshore waters along the Pilbara Coast are the primary foraging grounds for juvenile flatback turtles from Cemetery Beach, while adults migrate to the Kimberly and Gulf of Carpentaria (PENV 2009; 2019).

3.1.2 Cemetery Beach Hatchling Flatback Turtles

Hatchlings at Cemetery Beach begin to emerge from their nests in early December, with the highest numbers observed in early January, continuing until mid-February (Imbricata Environmental 2016). Once emerged, hatchlings instinctively navigate towards the sea, a behaviour known as sea-finding. This process is guided by various cues, including the wavelength, intensity, shape, and form of light (Lohmann et al. 1997; Tuxbury & Salmon 2005). In Port Hedland, it is thought that nearshore tide-driven currents are the primary influence of hatchling turtle dispersal (Wilson et al. 2018). During incoming flood tides, currents generally flow in a south-southeast easterly direction, while outgoing ebb tides cause currents to flow in a north-northwest direction (Cardno 2011).

3.2 Summary of 2023/24 Baseline Hatchling Orientation Survey

This section presents the baseline hatchling orientation survey results that form part of the monitoring and reporting program meeting condition 5(a)iii of the Port Hedland Spoilbank Marina EPBC 2019/8520 approval.

This summary is taken from the Spoilbank Marina Baseline Hatchling Orientation and Light Monitoring report (PENV 2024), which is located in **Appendix E**.

3.2.1 Methodology

PENV conducted a benchmark ‘baseline’ hatchling orientation survey, over a 14-day period between the 4th and 18th of January 2024. It was scheduled to coincide with the peak hatching season for flatback turtles on Cemetery Beach in Port Hedland, Western Australia, and the new moon on the 11th of January 2024. The hatchling orientation survey area consisted of an approximately 1.2 km stretch of Cemetery Beach (**Figure 4**) across the entire 14-day period.

The survey was conducted following the methodology guidance of Pendoley (2005), recording the angles of hatchling tracks left on the beach after they emerge from the nest (**Figure 7**). All future hatchling orientation monitoring programs must be conducted using the same methodology as the 2023/24 season, under new moon conditions, to ensure that the baseline data can be statistically compared to the post-baseline data. The full report and methodology are located in **Appendix E**.

Hatchling orientation data were statistically analysed to provide:

- **Spread Angle:** The range of dispersion of tracks from the emergence point, describing the degree of dispersion of all hatchling pathways toward the ocean (**Figure 7**). A larger value indicates greater dispersion or variation in ocean-finding bearings and may indicate disruption to natural hatchling sea-finding ability.
- **Offset Angle:** The degree of deflection of tracks from the most direct route to the ocean (**Figure 7**). A smaller value indicates a more direct route (i.e., less deviation from the most direct route) and a larger value demonstrates a greater deviation from the most direct route which may indicate disruption to natural hatchling sea-finding ability.

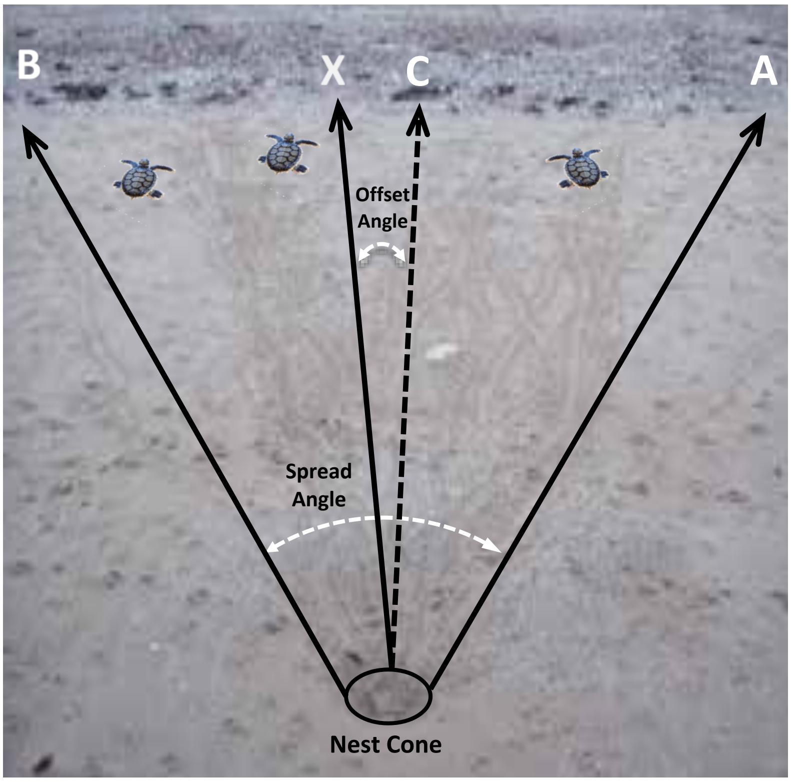

Figure 7: Hatchling orientation angles recorded for a nest fan and associated spread and offset angles. Black arrows indicate metrics that are captured in the field. Dashed black arrow indicates middle indices between A and B that is used to calculate the offset angle.

3.2.2 Hatchling Orientation

A total of 135 nest emergences were recorded over the 14-day survey conducted between the 4th and 18th of January 2024. Of these, 107 nest fans were recorded with at least five hatchling tracks and were included in the statistical analysis (79.2 % of the original sample).

The spread and offset angles from the baseline data were statistically analysed using a Bayesian projected normal regression model for circular data (Cremers 2018a). The mean spread and offset angles, and the lower and upper bounds for the baseline hatchling orientation data are shown in **Table 6**. The upper and lower bounds indicate that there is a 95 % probability that the true mean lies between the upper and lower bounds, based on the data.

Of an estimated 1,886 individual hatchling tracks within the recorded nest fans, 97 individual tracks (5.1 %) were outliers and removed from the data analysis. For an individual track to be considered an outlier it must be > 30° from the primary nest fan.

Table 6: The mean offset and spread angle, upper bound and lower bound for baseline data.

Metric	Number of nest fans	Mean (°)	Lower Bound (°)	Upper Bound (°)
Spread angle	107	79	63	96
Offset angle	107	24	16	32

The spread angle and offset angle for each recorded nest fan, with more than five hatchlings tracks, are shown in **Figure 8** and **Figure 9**, respectively.

Furthermore, 12 nests had hatchling tracks showing signs of severe disorientation by heading in all directions, with no main nest fan identifiable (**Figure 10**). As a result, spread and offset angles were unable to be determined for each nest and they were excluded from the statistical analysis. Of the 12 severely dis-orientated hatchling nests, 8 were located directly in front of the Civic Centre and Gratwick Aquatic Centre (**Figure 10**).

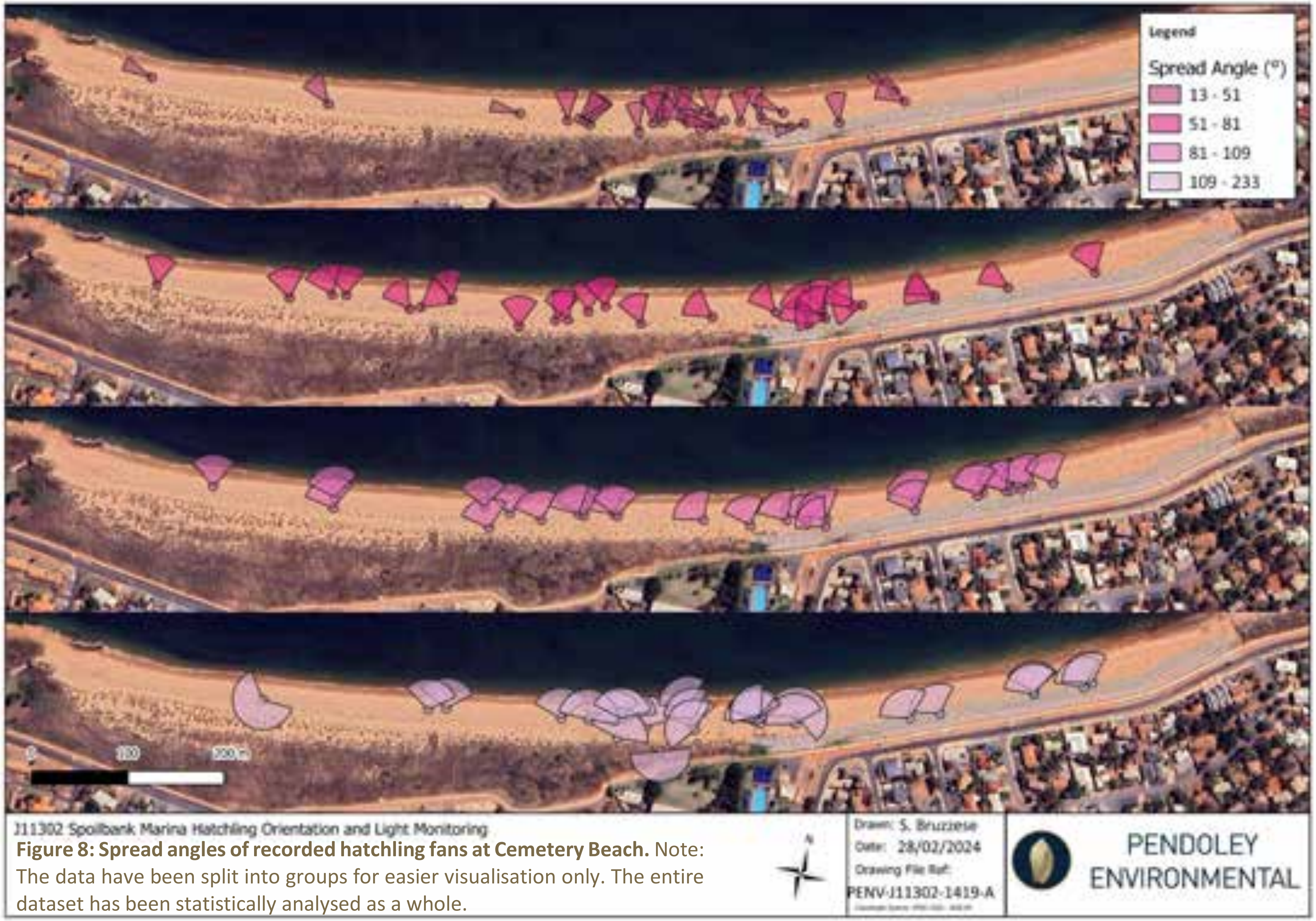

Figure 8: Spread angles of recorded hatchling fans at Cemetery Beach. Note: The data have been split into groups for easier visualisation only. The entire dataset has been statistically analysed as a whole.

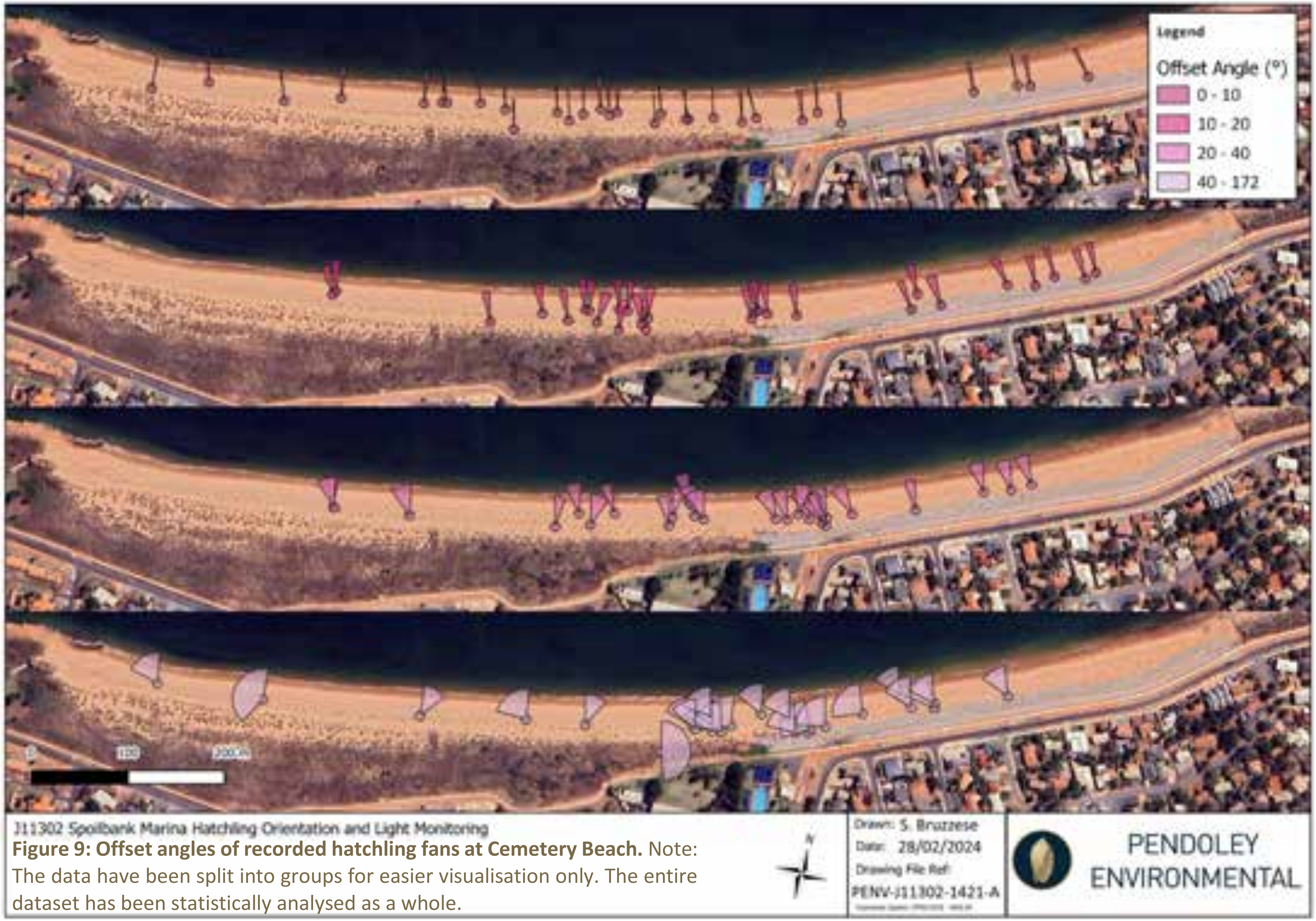

Figure 9: Offset angles of recorded hatchling fans at Cemetery Beach. Note: The data have been split into groups for easier visualisation only. The entire dataset has been statistically analysed as a whole.

Figure 10: Location of hatchling nests displaying signs of severe disorientation. Note: Severe disorientation is defined as where no 'A' or 'B' angles could be determined – track bearings are scattered across a complete 360°.

3.2.3 Post-baseline Trigger and Threshold Criteria

As per the Environmental Management Plan Guidelines (Commonwealth of Australia 2014), trigger and threshold criteria are defined based on spread and offset angles. These criteria are outcome-based and specific to the baseline hatchling turtle orientation data presented in this report. Trigger criteria are intended to forewarn of the approach of the threshold criteria and must be set at a conservative level to ensure trigger level actions are implemented well in advance of the threshold criteria. Threshold criteria are indicators selected to represent the limit of acceptable impact beyond which there is likely to be a significant impact on hatchling sea-finding behaviour.

The upper and lower bounds of the baseline mean (for both spread angle and offset angle; see **Section 3.2.2**) can be used to test if the post-baseline data are different to the baseline data, following the method outlined in Cremers 2018a. If the post-baseline mean is beyond the upper bound of the baseline data but the lower bound is within the baseline upper bound, then this implies that there *may* be a difference between the baseline and post-baseline data (**Figure 11a**). However, if the post-baseline lower bound is not within the upper bound of the baseline data, then this implies that there is a significant difference between the baseline and post-baseline data (**Figure 11b**). Specifically, trigger and threshold criteria are as follows:

Trigger criteria:

- The mean of the post-baseline offset angle exceeds the upper bound of the baseline offset angle but the post-baseline lower bound is still within the baseline upper bound; **or**
- The mean of the post-baseline spread angle exceeds the upper bound of the baseline spread angle but the post-baseline lower bound is still within the baseline upper bound.

Threshold criteria:

- The lower bound of the post-baseline offset angle exceeds the upper bound of the baseline offset angle; **or**
- The lower bound of the post-baseline spread angle exceeds the upper bound of the baseline spread angle.

Trigger and threshold criteria are determined from the mean and lower bound of the spread and offset angles of the baseline hatchling orientation data presented in **Table 6**. The trigger and threshold criteria based on the baseline hatchling orientation data are presented in **Table 7**. These criteria will be used to activate corrective actions, as outlined in the response plan (**Table 15**), along with adaptive management measures for continuous improvement as outlined in **Section 6.6**.

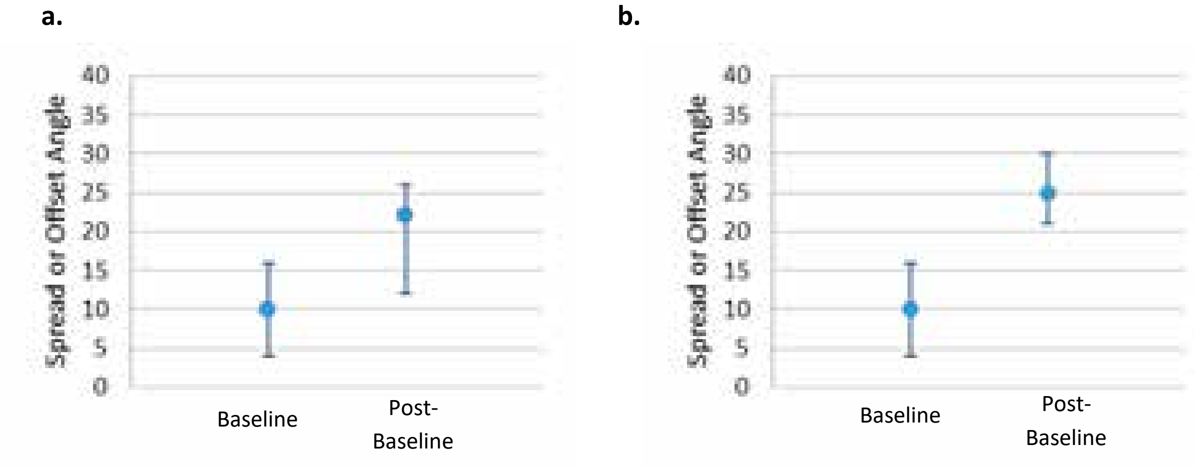

Figure 11: Examples of comparisons between baseline and post-baseline datasets. a. Possible change (trigger criteria): The lower bound of the post-baseline dataset is above the baseline mean, but below the baseline upper bound; b. Significant change (threshold criteria): The lower bound of the post-baseline dataset exceeds the upper bound of the baseline dataset.

Table 7: Trigger and threshold criteria for post-baseline data.

Metric	Trigger Criteria	Threshold Criteria
Spread angle	The mean exceeds 96° but the lower bound is less than 96°	The lower bound exceeds 96°
Offset angle	The mean exceeds 32° but the lower bound is less than 32°	The lower bound exceeds 32°

4 SENSITIVE WILDLIFE RISK ASSESSMENT

The potential impacts of artificial light on flatback turtles are summarised from the Artificial Lighting Impact Assessment Report (RPS 2020; **Appendix A**) along with additional research. The potential impacts together with the information provided in **Section 2** and **Section 3** are used to conduct a formal risk assessment of the impacts due to the final lighting design on nesting and hatchling turtles on Cemetery Beach.

This risk assessment also provides justification of how the proposed lighting design will prevent impacts to flatback turtle nesting and hatchlings on Cemetery meeting condition 5(a)ii of the Port Hedland Spoilbank Marina EPBC 2019/8520 approval.

4.1 Methods

The potential impacts of lighting associated with the Marina during operation are assessed utilising a risk assessment matrix. The risk assessment process is modified from the Great Barrier Reef Marine Park Authority (GBRMPA) Risk Assessment Permission System (GBRMPA 2017) and the Environmental Management Plan Guidelines (Commonwealth of Australia 2014). The risk assessment matrix is presented in **Table 8** with descriptions of the consequence and likelihood definitions provided in **Table 10** and **Table 9,** respectively. The likelihood is an indicator of how likely it is that the impact will occur, and consequence is an indicator of the result of the impact if it were to occur (Commonwealth of Australia 2014). In this section, we assess the risk before (inherent) and after (residual) mitigation measures (**Section 5**) are applied.

The risk assessment has been conducted as follows:

- The ***inherent risk*** is based on the line-of-sight analysis and 'issued construction' lighting design, which includes lighting control measures, such as low-intensity PC Amber LEDs.
- The ***residual risk*** accounts for the implementation of the proposed additional light mitigation measures outlined in **Section 5.**

Table 8: Risk Assessment Matrix. Modified from GBRMPA 2017.

Likelihood (see **Table 9** for definitions)	**Consequence** (see **Table 10** for definitions)				
	Negligible	*Minor*	*Moderate*	*Major*	*Extreme*
Almost certain	**Low** 5	**Medium** 12	**High** 17	**Very high** 22	**Very high** 25
Likely	**Low** 4	**Medium** 11	**High** 16	**High** 19	**Very high**24
Possible	**Low** 3	**Low** 8	**Medium** 13	**High** 18	**Very high** 23
Unlikely	**Low** 2	**Low** 7	**Low** 10	**Medium** 15	**High** 21
Rare	**Low** 1	**Low** 6	**Low** 9	**Medium** 14	**High** 20

Table 9: Definition of likelihood. Modified from GBRMPA 2017.

Description	**Frequency**	**Probability**
Almost certain	Expected to occur continuously throughout a year (e.g., more than 250 days per year)	96 – 100 %
Likely	Expected to occur once or many times in a year (e.g., 1 to 250 days per year)	71 – 95 %
Possible	Expected to occur once or more in the period of 1 to 10 years	31 – 70 %
Unlikely	Expected to occur more than once in the period of 10 or more years	5 – 30 %
Rare	Expected to occur once or less over project life	0 – 5 %

Table 10: Definition of consequence. Modified from GBRMPA 2017.

Description	Definition
Negligible	Little to no impact on the overall ecosystem. Very small levels of impact on turtles, and their habitats. Only occasional injury to, or mortality of, turtles. Local scale: Impact is within the natural variation and tolerance of the system. Recovery <5 years. Regional and widespread scales: No impact at the population or sub-population level, or impact is not discernible or not clearly linked to the activity.
Minor	Impacts are present, but not to the extent that the overall condition of turtle populations or their habitats are impaired in the long term. Low levels of mortality of turtles and their habitats. Recovery would generally be measured in years for habitats. Local scale: Short-term (< 5years) impact to a site or population which is not sensitive or unique. With minimal human interventions, the value reverts within 10 years to its pre-disturbance state. Regional scale: Temporary (<6 months) impact. With minimal human intervention, the value reverts within 5 years to its pre-disturbance state. Widespread scale: No discernible impact at the population level. No sensitive or unique sites/populations are damaged or modified, even temporarily.
Moderate	Turtles and their habitats are significantly affected, as outlined in the Significant Impact Guidelines (Commonwealth of Australia 2013). Recovery at habitat level would take at least a decade, with recovery of turtle populations taking several decades. Local scale: Long-term (>5 years) impact to the value. With human intervention the value can be rehabilitated within 10 years to its pre-disturbance state. Regional scale: Short-term (<5 years) impact to a site or population which is not sensitive or unique. With minimal human intervention the value reverts within 10 years to it pre-disturbance state. Widespread scale: Temporary (<6 months) impact at the population level or to sensitive or unique site or population. With minimal human intervention, the value reverts within 5 years to its pre-disturbance state.
Major	Significant impact on turtle populations and their habitats, as outlined in the Significant Impact Guidelines (Commonwealth of Australia 2013), with high level of mortality. Recovery of habitats would take a few decades with populations taking several decades. Local scale: Impact may be irreversible at the most affected site. Site/population not unique or sensitive. At less affected sties, with human intervention the value can be rehabilitated within 20 years to its pre-disturbance state. Regional scale: Long-term (>5 years) impact to value. With human intervention the value reverts within 20 years to it pre-disturbance state. Widespread scale: Short term (<5 years) impact at the population level or to sensitive or unique site or population. With minimal human intervention, the value reverts within 10 years to its pre-disturbance state.
Extreme	Turtle habitat is irretrievably compromised. Mass mortality of turtles and local extinction of species. Recovery over several decades for habitat values and centuries for turtle populations. All scales: Clear and probably irreversible impact to the value’s condition or trend over multiple locations. Recovery period greater than 20 years, even with significant human intervention. Permanent loss of the value is a real possibility.

4.2 Adult Turtles

4.2.1 Artificial Light Impacts

Artificial light can impact various aspects of adult female turtle nesting behaviours, such as the location of beach emergence, nest construction, nesting abandonment, egg deposition success, hatchling production, and adult return to the sea (Witherington & Martin 1996). The presence of artificial lighting on or near nesting beaches results in lower nesting densities compared to dark beaches (Witherington & Martin 2003; Salmon 2003; Hu et al. 2018). On illuminated beaches, higher nesting densities are observed in shadowed areas, such as those near dunes or buildings (Salmon & Witherington 1995). In general, artificial lights that are most disruptive to flatback turtles are those with a high proportion of short blue wavelength light (< 500 nm). Nesting densities do not appear to be negatively affected by light types that exclude shorter wavelengths (below 540 nm), such as low-pressure sodium (LPS), filtered high-pressure sodium (HPS) lights and filtered LEDs (e.g., PC Amber; Pennell 2000).

It has been postulated that neophytes (females breeding for the first time) are more vulnerable to nesting disruption by artificial light compared to experienced females that had nested at a given beach prior to the introduction of light sources (pers. comm. C. Limpus, Department of Environment and Science, Queensland Government). Anecdotal outcomes of long-term marine turtle monitoring programs across Australia suggest that (assumed) neophyte turtles favour nesting on dark beaches unaffected by onshore light pollution, whereas experienced nesters continue to use light-affected beaches. Over time this could result in changes in nesting distribution in response to artificial light.

In addition to potential impacts on nesting females prior to or during nesting, artificial light also has the potential to impact post-nesting behaviour. On completion of laying, nesting females are thought to use light cues to return to the open ocean, orientating towards the brightest light (Witherington & Martin 2003). However, observations of nesting females and emerging hatchlings at the same beach showed that females were disorientated much less frequently than hatchlings (Witherington & Bjorndal 1991; Shimada et al. 2023), indicating that nesting females are less vulnerable to impacts of artificial light on sea-finding behaviour post nesting. Recent studies have also shown that adult female flatback turtles may also be impacted by sky glow from artificial light up to 50 km away (Shimada et al. 2023).

4.2.2 Risk Assessment

The line-of-sight analysis indicates that flatback turtles on Cemetery Beach would have direct visibility of the pole-mounted lighting along the access roads, parking areas and within the hardstand areas, such as the promenade (see **Section 2.2.2** and **Appendix F**). This is due to some of the pole lighting in the marina being elevated above the line-of sight level from Cemetery Beach, which means that the lighting will be directly visible even with current mitigation measures in place (described in **Section 5**). In addition to direct visibility of lights, there will also be some sky glow visible. However, the intense sky glow from the existing lighting (port facilities and residential; see **Figure 5** and **Figure 6**) will likely make it impossible to detect the sky glow contribution from the Marina lighting.

The 'issued construction' lighting design utilises low-intensity, PC Amber LEDs throughout the Marina, which reduces the total intensity of light and the amount of short wavelength, blue light that is emitted. The proposed colour and intensity of light would minimise the likelihood of any potential disturbance. In addition, where possible lights are pointed away from Cemetery Beach towards the western side of the Marina (e.g., along the eastern access road) and low-mounted lights are used to prevent direct visibility. Therefore, the Marina lighting is unlikely to have a significant impact on experienced adult females returning to Cemetery Beach as they do not appear to be as sensitive to artificial light as hatchlings. However, it is possible that neophyte turtles attempting to nest for the first time may be disrupted by the Marina lighting causing them to return to the ocean without nesting at Cemetery Beach to favour darker beaches. This may cause the population of nesting adults at Cemetery Beach to decline as the population of returning experienced adults reduces over time.

Therefore, without any additional control measures the probability that nesting adults (including neophytes) will be impacted by artificial light throughout the nesting season on Cemetery Beach is considered **possible**. However, neophytes are able to move to other nearby darker beaches in the area and therefore the impact at a local and at a regional scale is negligible; this would not significantly impact the genetic stock of flatback turtles in the region. As a result, the consequence of this impact is considered **negligible** resulting in an inherent risk ranking of **low**.

With the additional control measures applied, specifically the addition of shielding or turning lights off during nesting season, (outlined in **Section 5**), the direct visibility of the pole-mounted lighting would be mitigated, further minimising any potential impact on nesting adults. If artificial light is controlled as described, it is considered **unlikely** that there will be impacts to nesting turtles and the consequence of this impact is considered **negligible,** resulting in a residual risk ranking of **low**. A summary of the inherent and residual risk assessment is provided in **Table 11**.

Table 11: Summary of the risk assessment for nesting turtles.

Risk	Consequence	Likelihood	Ranking
Inherent	Negligible	Possible	Low (3)
Residual	Negligible	Unlikely	Low (2)

4.3 Hatchling Turtles

4.3.1 Emerging Hatchling

4.3.1.1 Artificial Light Impacts

Hatchling turtles typically emerge from the nest at night (Mrosovsky & Shettleworth 1968) and must rapidly reach the ocean to avoid predation (Salmon 2003). Artificial lighting can negatively impact hatchling sea-finding behaviour in two ways: disorientation and misorientation. Disorientation refers to hatchlings crawling on indirect paths, while misorientation involves moving in the wrong direction, often attracted to artificial lights (Witherington & Martin 2003; Lohmann et al. 1997; Salmon 2003). These disruptions increase mortality rates due to prolonged exposure to predators, dehydration, and exhaustion (Witherington & Martin 1996; Salmon 2006).

Emerging hatchlings exhibit a natural tendency to orient themselves towards the lower, brighter horizon away from higher, dark silhouettes (Mrosovsky 1972; Salmon et al. 1992) and are more influenced by sky glow that is low on the horizon compared to brighter point sources of light (Limpus 1971; Salmon et al. 1992 Pendoley & Kamrowski 2015; Shimada 2023). Therefore, in the presence of inland artificial light sources, an effective management strategy is to maintain a dark, high dune or vegetation silhouette behind nesting beaches (Tuxbury & Salmon 2005).

Hatchling orientation has been shown to be disrupted by light produced at distances of up to 18 km from the nesting beach (Hodge et al. 2007; Kamrowski et al. 2014). Hatchling turtles are more likely to be attracted to shorter wavelength light (e.g., blue, green, white, and ultra-violet) and less attracted to longer wavelength light (e.g., red and orange; Pendoley 2005; Fritches 2012). The intensity of light has also been shown to have a disruptive effect on hatchling sea-finding behaviour and a high-intensity red/orange light can have a similar effect to a lower-intensity blue/white light (Pendoley 2005; Pendoley & Kamrowski 2016).

4.3.1.2 Risk Assessment

The line-of-sight analysis indicates that emerging hatchlings on Cemetery Beach would have direct visibility of the pole-mounted lighting along the access roads, parking areas and within the hardstand areas, such as the promenade (**Section 2.2.2** and **Appendix F**). The pole-mounted lights will be visible along the beach to the west (as opposed to behind the dunes at the back of the beach) and could potentially override the influence of other sea-finding cues.

Compared to adults, hatchling turtles are influenced by sky glow on the horizon during sea-finding. Hatchlings integrate light cues on the horizon, across a field of view ~30° high and ~180° wide (Lohmann et al. 1997) and consequently any sky glow visible from the Marina, low on the hatchings horizon, could also impact hatchling sea-finding ability. However, the intense sky glow from the existing lighting (port facilities and residential; **Figure 5** and **Figure 6**) will make it impossible to detect the sky glow contribution from the Marina lighting.

The results of the 2023/24 baseline hatchling orientation analysis (**Section 3.2**) indicate mis-orientation and dis-orientation of hatchling turtles on Cemetery Beach, due to the existing artificial lighting in the region both as direct light and as sky glow (**Section 2.1**). The artificial lighting from the Marina would cumulatively contribute to the direct light and sky glow already visible from Cemetery Beach.

The 'issued construction' lighting design utilises low-intensity, PC Amber LEDs throughout the Marina, which reduces the overall intensity of light and the amount of short wavelength, blue light that is emitted. The proposed colour and intensity of light would therefore substantially reduce the likelihood of any potential disturbance relative to the existing area lighting. In addition, where possible lights are pointed away from Cemetery Beach towards the western side of the Marina (e.g., along the eastern access road) and low-mounted lights are used to prevent direct visibility. However, without shielding or turning off all/some of the lights during nesting season, it is considered **almost certain** that there will be impacts on hatchling turtles from the direct visibility of the lights during nest emergence. The exposure to light will potentially cause hatchling turtles to become dis-orientated and mis-orientated leading to exhaustion and increased predation. Resulting in increased annual mortality and in the long term reduce the size of the population on Cemetery Beach. However, this would not significantly impact the genetic stock of flatback turtles in the region. The overall consequence of this impact is considered **minor,** resulting in an inherent risk ranking of **medium**.

With the additional control measures applied, specifically shielding of lights or turning the lights off during nesting season (outlined in **Section 5**), the direct visibility of the pole-mounted lighting would be mitigated, further minimising any potential impact on hatchling turtles. If artificial light is controlled as described, it is considered **unlikely** that there will be cumulative impacts on hatchling turtles. The consequence of this impact is considered **minor** resulting in a residual risk ranking of **low**. A summary of the inherent and residual risk assessment is provided in **Table 12**.

Continued monitoring of hatchling orientation data will identify if the artificial lighting from the Marina is causing an increase in the rate of mis-orientation in hatchling turtles on Cemetery Beach above the 2023/24 mis-orientation levels. If this increase in misorientation is proven, adaptive management measures and corrective actions will be implemented (**Section 6**).

Table 12: Summary of risk assessment for emerging hatchling turtles.

Risk	Consequence	Likelihood	Ranking
Inherent	Minor	Almost certain	Medium (12)
Residual	Minor	Unlikely	Low (7)

4.3.2 Hatchling Dispersal

4.3.2.1 Artificial Light Impacts

Artificial light from sky glow and coastal structures can also disrupt flatback hatchling dispersal, resulting in delayed movement, disorientation in the nearshore, and the exertion of energy as they swim against ocean currents towards the source of light, along with the possibility of increased predation rates (Wilson et al., 2018).

Dispersing hatchlings rely on an internal compass, which is set while crawling down the beach, and cues from the waves to navigate offshore (Lohmann & Lohmann 1992; Stapput & Wiltschko 2005). When wave cues are absent, swimming hatchlings have been observed to orientate towards light cues (Lorne & Salmon 2007; Harewood & Horrocks 2008) and in some instances, the influence of light cues has been found to override wave cues (Thums et al. 2013, 2016; Wilson et al. 2018).

The speed and direction of hatchling turtle dispersal are likely influenced by tidal currents in Port Hedland. However, Wilson et al. (2018) demonstrated that when flatback hatchlings were within 150 m of the beach, they were able to swim against currents up to 0.3 m/s. This suggests that hatchling turtles can swim in any direction when their speed exceeds that of the nearshore current.

4.3.2.2 Risk Assessment

The lights from the Marina, which is located on an artificial spoil bank that extends into the water, will be visible to dispersing hatchlings both as direct light and sky glow. Therefore, there is the potential for hatchling turtles to swim towards the artificial lights from the Marina causing exhaustion and increasing their exposure to predation.

The 'issued construction' lighting design utilises low-intensity, PC Amber LEDs throughout the Marina, which reduces the overall intensity of light and the amount of short wavelength, blue light that is emitted. The proposed colour and intensity of light would therefore reduce the likelihood of any potential disturbance. In addition, where possible lights are pointed away from Cemetery Beach towards the western side of the Marina (e.g., along the eastern access road) and low-mounted lights are used to prevent direct visibility. However, due to the direct visibility of the unshielded pole-mounted lighting from the nearshore area of Cemetery Beach, it is considered **almost certain** that these lights will be visible to hatchlings turtles during dispersal through nearshore waters. The impacts could include attraction to the spoil bank where hatchlings may crawl out of the water towards the lights, increased risk of predation by fish as they linger in the nearshore waters or decreased fitness due to the consumption of energy reserves as they linger in nearshore waters. The consequence of this is an increased annual mortality and in the long-term a reduction in the size of the population on Cemetery Beach. However, this would not have a discernible impact at the genetic stock population level of flatback turtles in the region. The overall consequence of this impact is considered **minor**, resulting in an inherent risk ranking of **medium.**

With the additional control measures applied (outlined in **Section 5**), the direct visibility of the pole-mounted lighting would be mitigated, further minimising any potential impact on hatchling turtles. If artificial light is controlled as described, it is considered **unlikely** that there will be impacts on hatchling turtles due to the lack of direct visibility of the lights that the shielding provides. The consequence of this impact is considered **minor** resulting in a residual risk ranking of **low**. A summary of the inherent and residual risk assessment is provided in **Table 13**.

Table 13: Summary of risk assessment for offshore hatchling turtles.

Risk	Consequence	Likelihood	Ranking
Inherent	Minor	Almost certain	Medium (12)
Residual	Minor	Unlikely	Low (7)

5 ARTIFICIAL LIGHT MITIGATION AND MANAGEMENT

This section outlines control measures included in the 'issued construction' lighting design, providing further justification of how the proposed lighting design prevents impacts to flatback turtles nesting on Cemetery Beach, meeting condition 5(a)ii of the Port Hedland Spoilbank Marina EPBC 2019/8520 approval.

This section describes the best practice lighting design principles, provides an evaluation of the Marina lighting design in the context of the best practice lighting design principles, and recommended additional control measures.

5.1 Best Practice Light Design Principles

The following best practice light design principles for external light sources, summarised in **Figure 12**, are modified from Appendix A of the National Light Pollution Guidelines for Wildlife (Commonwealth of Australia 2023) to be specific to this project and flatback turtles.

Figure 12: Summary of best practice lighting design principles applicable to the proposed project.

5.2 Use Minimum Number and Intensity of Lights

Starting from a base case of no lights, only the minimum number and intensity of lights needed to provide safe and secure illumination and to meet the lighting objectives, including health and safety requirements, will be installed. For flatback turtles, the intensity of light is as important as colour

(Mrosovsky 1972; Mrosovsky & Shettleworth 1968; Pendoley & Kamrowski 2015). Intensity will be reduced to as low as possible, regardless of the type, colour, and planned operation of the light.

5.2.1 Issued Construction Lighting Design Control Measures

- Lighting design uses the minimum number and intensity of lights required to meet lighting objectives while addressing safety standards, regulations, and legislation (**Appendix B**).

5.2.2 Additional Control Measures

- Turn the lights off during nesting season. This has the disadvantage that no lighting for public safety during this period. However, this strategy has been applied to other roads, parks and other public spaces in Port Hedland.

5.3 Adapting for Colour, Intensity and Timing

The potential for biological impacts from white light is universal across fauna groups (Commonwealth of Australia 2023). Flatback turtles are most sensitive to short wavelengths of light (UV to blue/green). Therefore, where compliant with health and safety requirements, white lights should be avoided, and amber/orange lights used instead. Because long wavelength light scatters much less than white light and produces less sky glow, the impacts on flatback turtles will be reduced. If white lights are required, filters to block green, blue, violet, and ultra-violet wavelengths should be applied.

For lights that are not required to be continuously lit, smart LED technology should be implemented to allow for switching off when not in use, or the use of intermittent flashing lights. LED lights most suitable for use in protecting wildlife are Amber LED (narrow wavelength peak at 580nm) or PC Amber LED which has a phosphor coating that filter, and therefore minimises, the short wavelength components of the light emissions.

5.3.1 Issued Construction Lighting Design Control Measures

- All lighting (marina waterfront, jetty, gangway, and boat pens) utilises low-intensity, PC Amber LED technology (**Section 2.1.2**).
- Pole-mounted lights WE-EF VFL530 26W are ADSA certified and VFL530-SE 26W are ADSA Prized Wildlife Certified.

5.3.2 Additional Control Measures

- Lights that are not required to be continuously lit to be motion activated, put on a timer, or wired to allow manual ON/OFF operation.
- Lights that are not required to be continuously lit be turned off at a predetermined curfew hour, for example 11pm each night, during nesting season.

5.4 Light Only the Intended Area

Light spill is light that falls outside the area that is intended to be lit. Vertical light spill is light that spills above the horizontal plane, which contributes directly to artificial sky glow and is known to disorient flatback turtle hatchlings. Light spill that spills into adjacent areas is known as light trespass. To avoid any form of light spill, light fittings will be designed, located, and directed to avoid lighting anything but the target area.

5.4.1 Issued Construction Lighting Design Control Measures

- All pole-mounted lights in the Marina waterfront (except upward projector lights) are directed downwards to illuminate only the specific areas of need.
- All WE-EF pole-mounted lights in the Marina waterfront area and along access roads have upward a waste of 0%.
- Pole-mounted lights WE-EF VFL530 26W are ADSA certified and VFL530-SE 26W are ADSA Prized Wildlife Certified.
- Majority of the pathways and walkways in the community node and recreational area of the waterfront are illuminated using low-mounted shielded lights, such as the bollards and wall recessed lights (**Appendix B** and **Figure 1**).
- Walkway lighting on the jetty and gangway is mounted on the underside of the railing pointing downwards.
- Majority of the pole-mounted lights in the Marina waterfront are pointed away from Cemetery Beach to minimise direct visibility of lights.
- The pole-mounted lights along the eastern main access road will be located on the eastern side of the road (furthest from Cemetery Beach) and facing away from the nesting area.
- Trees have been planted throughout the Marina waterfront and along the eastern access road, which will provide additional shielding. It should be noted that it will take time for these trees to reach a height and cover that will provide sufficient shielding. The amount of shielding will also depend on the specific line-of-sight of a turtle from Cemetery Beach as trees along the eastern access road are sparely planted (approximately 10 m apart).

5.4.2 Additional Control Measures

- Shielding to be installed on the east facing side (i.e., side facing towards the Cemetery Beach nesting area) of the pole mounted lights along the main access road to assist in reducing the line-of-sight visibility of these lights to hatchlings within the Cemetery Beach nesting area (RPS 2020).
    - Retrofitting with internal glare shields. This option has the disadvantage that the lights wouldn't meet the lighting design requirements all year around.
    - Retrofitting external shielding to the light fittings. This option has the disadvantage of voiding warrantees and potentially reducing operational life of the lighting.
- Shielding to be installed on the eastern facing side of the pole mounted lights located within the parking and hardstand areas to the extent that compliance with AS/NZS 1158.3.1:2018 is not unreasonably compromised (RPS 2020).

  - Retrofitting with internal glare shields. This option has the disadvantage that the lights wouldn't meet the lighting design requirements all year around.
  - Retrofitting external shielding to the light fittings. This option has the disadvantage of voiding warrantees and potentially reducing operational life of the lighting.
- Ensure that the bulkhead lighting on the jetty and boat pens is installed facing downwards to reduce upward spill of light.
- Ensure that projector lighting used to illuminate art on the underside of the shade structure does not spill out beyond the structure.

5.5 Use Non-reflective, Dark Coloured Surfaces

Light reflected from highly polished, shiny, or light-coloured surfaces can contribute to sky glow. Use of dark matte surfaces can reduce reflectance and scattering of light that contributes to sky glow.

5.5.1 Issued Construction Lighting Design Control Measures

- None

5.5.2 Additional Control Measures

- None

6 MONITORING PROGRAM, LIGHTING AUDIT AND REPORTING

This section presents a comprehensive monitoring and reporting program, which includes management and corrective measures, meeting conditions 5(a)iii, 5(a)iv, 12, 13 and 20 – 22 of the Port Hedland Spoilbank Marina EPBC 2019/8520 approval.

The monitoring, auditing, and reporting program outlined in this section is the responsibility of the DoT, as the party responsible for the operation of the Spoilbank Marina.

A summary of the monitoring, auditing, and reporting schedule is presented in **Table 14**. If hatchling orientation monitoring data exceeds the trigger/threshold values, indicating a significant change in hatchling behaviour, then the steps in the response plan outlined in **Table 15** must be followed.

The full monitoring, auditing, and reporting schedule will be conducted post-commencement of operations, once ***all lighting*** in the Marina is ***fully operational***. However, hatchling orientation monitoring must also be conducted post-commencement of any operations, such as limited operations (e.g., marine and carpark lighting only).

Major changes to project facilities or facility lighting involve significant alterations that could impact hatchling turtle behaviour on Cemetery Beach. These changes include:

1. Facility upgrades or expansions
    a. Construction of any new structures and/or facilities, which require additional lighting and meet the lighting modifications requirements below.
    b. Expansion of any existing structures and/or facilities, which require additional lighting and meet the lighting modifications requirements below.
2. Lighting modification requirements
    a. Installation of new lighting of more than 146,000 lumens (approximately 25 % of existing lighting, cumulatively over the lifetime of the project).
    b. Modification of existing resulting in an increase in lighting output of more than 146,000 lumens (approximately 25 % of existing lighting, cumulatively over the lifetime of the project).
    c. Modification to more than 90 of the existing lighting (approximately 25 % of the existing number of lights, cumulatively over the lifetime of the project). This includes any changes in intensity, wavelength, height, light distribution and/or shielding.

6.1 DBCA Stakeholder Consultation

The DBCA is recognised as a stakeholder for ongoing consultation regarding Marina construction and operations. This ongoing consultation will include:

- Submission of all reports and monitoring results to DBCA for review, with requirements for further monitoring and/or implementation of corrective measures to be determined in consultation with DBCA.

- DBCA endorsement of any future reviews of the ALMP that are triggered by monitoring results indicating that corrective actions are unsuccessful and/or following any major changes in project facilities or building lighting.

See **Table 14** and **Table 15** for a summary of monitoring and reporting requirements and response plan.

6.2 Flatback Turtle Hatchling Monitoring and Reporting

Post-commencement of operations, hatchling orientation monitoring surveys must be conducted using the same method as the baseline data as described in the Spoilbank Marina Baseline Hatchling Orientation and Light Monitoring report (**Appendix E**). The monitoring program must be conducted for a minimum of two weeks per season, to collect sufficient data (Commonwealth of Australia 2023). If adequate sample are not collected additional surveys will be required. At least, 30 nest emergences with 5 or more tracks are needed as a minimum for the statistical analysis. The hatchling orientation survey must also include artificial light monitoring survey conducted concurrently, as described in the Spoilbank Marina Baseline Hatchling Orientation and Light Monitoring report (**Appendix E**).

The baseline and post-baseline hatchling orientation metrics (spread and offset angle) will be statistically analysed and compared to determine if there is a significant change in the hatchling turtle orientation behaviour, as described in as described in the Spoilbank Marina Baseline Hatchling Orientation and Light Monitoring report (**Appendix E**). Any statistically significant changes in hatchling orientation behaviour (either spread angle or offset angle) will be used to activate corrective actions, as outlined in the response plan (**Table 15**), along with adaptive management measures for continuous improvement as outlined in **Section 6.6**.

This monitoring program includes one report annually (per monitoring season) describing the methods and results of the hatchling orientation monitoring data, following the methodology described in the Spoilbank Marina Baseline Hatchling Orientation and Light Monitoring report (PENV 2024; **Appendix E**) and must contain a statistical comparison to baseline trigger and threshold criteria (**Section 3.2.3**).

Additional hatchling orientation surveys must be scheduled following major changes in project facilities or buildings, or if trigger/threshold criteria exceedances are recorded in the hatchling orientation monitoring as outlined in the response plan (**Table 15**).

6.3 Artificial Light Monitoring and Reporting

A pre-construction baseline artificial light monitoring survey was conducted from Cemetery Beach East, Cemetery Beach West during the new moon period in January 2024 (**Section 2.1.2**). The survey was conducted using a specialised digital camera with a fisheye lens as outlined in the National Light Pollution Guidelines for Wildlife (Commonwealth of Australia 2023).

At least one artificial light survey must be conducted within the first-year post-commencement of full operations, to quantify changes in the artificial light environment due to marina operations. This survey must be conducted using the same methodology as the baseline light monitoring survey, during a new moon period. As outlined in the National Light Pollution Guidelines for Wildlife (Commonwealth of Australia 2023), light monitoring must be undertaken by personnel qualified in environmental light monitoring and considered in consultation with an appropriately qualified biologist or ecologist.

This monitoring program will include a report describing the methods and results of the light monitoring survey following the methodology described in the Spoilbank Marina Baseline Hatchling Orientation and Light Monitoring report (**Appendix E**). Light monitoring survey results will inform the adaptive management measures for continuous improvement if hatchling orientation monitoring reports an exceedance in trigger/threshold criteria, as outlined in the response plan located in **Table 15** along with adaptive management measures for continuous improvement as outlined in **Section 6.6**.

Additional light monitoring surveys must be scheduled following any major changes in project facilities or buildings, or if trigger/threshold criteria exceedances are recorded in the hatchling orientation monitoring as outlined in the response plan (**Table 15**).

6.4 Lighting Audit and Reporting

A lighting audit of the Marina site must be conducted as soon as practicable following commencement of full operation of the lights, and prior to the commencement of the 2024/25 peak turtle nesting season (peak nesting season - being 1 December 2024, consistent with EPBC 2019/8520) to ensure:

- Compliance with control measures and lighting design.
- Identification of, and measures taken to reduce, impacts of problem lights.
- Identification of any new information regarding potential impact pathways between artificial light associated with the project and biological receptors, and any adaptive management measures that could further reduce potential impacts.

Any additional controls identified during the initial lighting audit must be implemented prior to the 2024/25 peak turtle nesting season.

As outlined in the National Light Pollution Guidelines for Wildlife (Commonwealth of Australia 2023), audits must be undertaken by personnel qualified in environmental light auditing and considered in consultation with an appropriately qualified biologist or ecologist. This includes a report describing the methods and results of the lighting audit, including any non-compliance, as described above.

Additional lighting audits must be scheduled following major changes in project facilities or buildings, or if trigger/threshold criteria exceedances are recorded in the hatchling orientation monitoring as outlined in the response plan (**Table 15**).

6.5 Desktop Review

If two or more consecutive seasons of hatchling orientation monitoring report an exceedance in trigger level criteria or if any season of hatchling orientation monitoring reports an exceedance in threshold level criteria, then a desktop review of the artificial light monitoring, lighting audit and hatchling orientation monitoring must be conducted to determine the likely cause of impact. The assessment will rate the level of impact associated with the reported exceedance, the likely cause of impact, and recommend actions, as described in **Section 6.6**.

The desktop assessment must be undertaken by an appropriately qualified biologist or ecologist and considered in consultation with personnel qualified in environmental light monitoring.

6.6 Adaptive Management and Continuous Improvement

If the operations monitoring identifies an impact (i.e. trigger/threshold criteria exceedances are recorded in the hatchling orientation monitoring as outlined in the response plan; **Table 15**) that can be directly linked to the Marina project (as identified in desktop review; **Section 6.5**), then the artificial light will be assessed with a project lighting audit to identify any additional engineering and/or operational solutions that will be implemented where practicable, while also addressing relevant safety standards, regulations and legislation, to control the 'problem light(s)', such as:

- Changing the wavelength/intensity of light.
- Additional shielding of light.
- Changing the orientation and direction of the light fittings.
- Use of adaptive controls such as sensors or timers on lights.
- Turning lights that are not required by Australian legislation, regulations, and safety standards off during flatback turtle nesting season.
- Planting vegetation to increase natural shielding.

Additional hatchling orientation monitoring, light monitoring and lighting audits survey must be undertaken after the implementation of any proposed actions to determine whether the actions have been successful.

If engineering/operational solutions fail, DBCA must be consulted, in the first instance, to discuss appropriate mitigation responses including potential section 40 Ministerial authorisations under the *Biodiversity Conservation (BC) Act 2016*.

If adaptive management and continuous improvement actions have not been successful, then a review of the ALMP will be conducted. The ALMP must also be reviewed following any major changes in project facilities or buildings lighting. The ALMP review will consider changes to project facilities, environmental monitoring records, corrective actions, and the results of any audits.

It is important to recognise that the Cemetery Beach rookery is exposed to a range of impacts from third parties not associated with the Marina project. Assessment of the monitoring results, identification of sources of impact and any adaptive management mitigation responses must take these cumulative impacts into account when making recommendations for adaptive management and continuous improvement actions.

6.7 Annual Compliance Reports

DoT will prepare a compliance report for each 12 month period following the date of commencement of the action, or otherwise in accordance with an annual date that has been agreed to in writing by the Minister. The approval holder will:

a) publish each compliance report on the website within 60 business days following the relevant 12 month period;

b) notify the Department by email that a compliance report has been published on the website and provide the weblink and documentary evidence providing proof of the date of publication for the compliance report within five business days of the date of publication;

c) keep all compliance reports publicly available on the website until this approval expires;

d) exclude or redact sensitive ecological data from compliance reports published on the website; and

e) where any sensitive ecological data has been excluded from the version published, submit the full compliance report to the Department within 5 business days of publication.

6.8 Non-compliance Reporting

DoT will notify the Department in writing of any: incident; non-compliance with the conditions; or non-compliance with the commitments made in plans. The notification will be given as soon as practicable, and no later than two business days after becoming aware of the incident or non-compliance. The notification will specify:

a) any condition which is or may be in breach;

b) short description of the incident and/or non-compliance; and

c) the location (including co-ordinates), date, and time of the incident and/or non-compliance. In the event the exact information cannot be provided, provide the best information available.

DoT will provide to the Department the details of any incident or noncompliance with the conditions or commitments made in plans as soon as practicable and no later than 10 business days after becoming aware of the incident or non-compliance, specifying:

a) any corrective action or investigation which the approval holder has already taken or intends to take in the immediate future;

b) the potential impacts of the incident or non-compliance; and

c) the method and timing of any remedial action that will be undertaken by the approval holder.

6.9 Revision of Management Plan

This ALMP has been developed to meet the approval conditions detailed within EPBC 2019/8520.

DoT may, at any time, apply to the Minister for a variation to an action management plan approved by the Minister under condition 5, by applying in accordance with the requirements of section 143A of the EPBC Act. If the Minister approves a revised action management plan (RAMP) then, from the date specified, the approval holder must implement the RAMP in place of the previous action management plan.

Provided a review of the Plan does not change the structure of the OEMP, DoT may choose to revise an action management plan approved by the Minister under conditions 5 or as subsequently revised in accordance with these conditions, without submitting it for approval under section 143A of the EPBC Act, if the taking of the action in accordance with the RAMP would not be likely to have a new or increased impact.

If DoT makes the choice under condition 21 to revise an action management plan without submitting it for approval, the approval holder must:

a) Notify the Department in writing that the approved action management plan has been revised and provide the Department with:

   i. an electronic copy of the RAMP;

   ii. an electronic copy of the RAMP marked up with track changes to show the differences between the approved action management plan and the RAMP;

   iii. an explanation of the differences between the approved action management plan and the RAMP;

   iv. the reasons the approval holder considers that taking the action in accordance with the RAMP would not be likely to have a new or increased impact; and

   v. written notice of the date on which the approval holder will implement the RAMP (RAMP implementation date), being at least 20 business days after the date of providing notice of the revision of the action management plan, or a date agreed to in writing with the Department.

b) Subject to condition 24 implement the RAMP from the RAMP implementation date.

Table 14: Summary of monitoring, auditing, and reporting schedule.

Monitoring/auditing/ compliance/review	Timing and frequency	Reporting
Hatchling orientation monitoring (**Section 6.2**)	Monitoring must be undertaken post commencement of operations (e.g., limited operations) and for a minimum of three years post commencement of full operations. Additional monitoring will be required if trigger/threshold criteria are exceeded (**Table 15**) and/or recommended in desktop review (**Section 6.5**) or following major changes in project facilities or buildings lighting.	One report describing the results of each hatchling orientation monitoring survey, including comparison against trigger and threshold criteria (see **Section 6.2** for details).
Light monitoring (**Section 6.3**)	At least one light monitoring survey must be undertaken in the first year post commencement of full operations. Additional monitoring will be required if trigger/threshold criteria are exceeded (**Table 15**) and/or recommended in desktop review (**Section 6.5**) or following major changes in project facilities or buildings lighting.	One report describing the results of the light monitoring survey (see **Section 6.3** for details).
Lighting audit (**Section 6.4**)	At least one lighting audit of the Marina site must be conducted as soon as practicable following commencement of full operation of the lights, and prior to the commencement of the 2024/25 peak turtle nesting season. Additional lighting audits will be required if trigger/threshold criteria are exceeded (**Table 15**) and/or recommended in desktop review (**Section 6.5** and **Table 15**) or following major changes in project facilities or buildings lighting.	One report describing the results of the lighting audit, identifying any problem lighting and ensuring compliance with lighting design and control measures (see **Section 6.4** for details).
Desktop review (**Section 6.5**)	If two or more consecutive seasons of hatchling orientation monitoring reports an exceedance in trigger level criteria or if any season of	One report describing the desktop review of the artificial light monitoring, lighting audit and hatchling orientation data to determine

Monitoring/auditing/ compliance/review	Timing and frequency	Reporting
	hatchling orientation monitoring reports an exceedance in threshold level criteria.	the cause of impact and recommended actions (see **Section 6.5** for details).
ALMP review (**Section 6.6**)	If continued monitoring indicates that adaptive management and continuous improvement actions are unsuccessful, then the ALMP will be reviewed. ALMP must also be reviewed following any major changes in project facilities or buildings lighting.	The ALMP will be reviewed and consider changes to project facilities, environmental monitoring records, corrective actions, and the results of any audits (see **Section 6.6** for details).
Annual compliance	DoT will prepare a compliance report for each 12 month period following date of commencement of the action.	The compliance report will address all outcomes stated in **Section 6.7**.
Non-compliance	DoT will notify the Department in writing of any: incident; non-compliance with the conditions; or non-compliance with the commitments made in plans. The notification will be given as soon as practicable, and no later than two business days after becoming aware of the incident or non-compliance.	The compliance report will address all outcomes stated in **Section 6.8**.

Table 15: Outcome-based trigger and threshold response plan for flatback turtle hatchling orientation.

EPBC matter of significance: Nationally threatened species – Hatchling flatback turtles **Outcome:** There will be no significant increase in hatchling misorientation or disorientation at Cemetery Beach. **Key impacts and risks:** Change in hatchling sea-finding ability, reduced survivability/fitness.				
Outcome-based				
• **Trigger criteria** • **Threshold criteria**	**Response actions:** • **Trigger level actions** • **Threshold level actions**	**Monitoring**	**Timing and frequency of monitoring**	**Reporting**
Condition: 5(a)iii a monitoring and reporting program, which includes baseline data that monitoring and reporting will be evaluated against, to be undertaken for a minimum length of two years post commencement of operation of the Marina to provide certainty that the artificial lighting of the Marina is not impacting flatback turtle hatchlings or nesting on Cemetery Beach.				
<u>Hatchling Orientation: Spread angle</u> **Trigger criteria** • The mean spread angle exceeds 96° and the lower bound (95 % highest posterior density interval) is below 96°. **Threshold criteria** • The lower bound spread angle (95 % highest posterior density interval) exceeds 96°. **<u>Hatchling Orientation: Offset angle</u>** **Trigger criteria** • The mean offset angle exceeds 32° and the lower bound (95 % highest posterior density interval) is below 32°. **Threshold criteria**	**<u>Trigger level action (for spread or offset angle)</u>** **If a single season of monitoring reports an exceedance in trigger criteria:** Hatchling orientation monitoring must continue for another season to determine if this is a trend. **If two or more consecutive seasons of monitoring report an exceedance in trigger criteria:** Undertake desktop review of artificial light monitoring, lighting audit and hatchling orientation data to determine cause. The assessment will rate the level of impact associated with this exceedance and recommend actions (as described in	**Indicators: Spread angle, offset angle** Hatchling orientation monitoring will be conducted seasonally at Cemetery Beach during peak flatback turtle hatching period and to coincide with new moon conditions.	Hatchling orientation monitoring will be undertaken post commencement of operations (e.g., limited operation) and for a minimum of three years post commencement of full operations. If trigger/threshold criteria are exceeded, additional seasons of monitoring may be required pending the outcome of a desktop review. Additional monitoring surveys may be required in the event adequate samples are not	One report annually (per monitoring season) describing the results of the monitoring survey, including comparison against trigger and threshold criteria.

EPBC matter of significance: Nationally threatened species – Hatchling flatback turtles **Outcome:** There will be no significant increase in hatchling misorientation or disorientation at Cemetery Beach. **Key impacts and risks:** Change in hatchling sea-finding ability, reduced survivability/fitness.				
Outcome-based				
• **Trigger criteria** • **Threshold criteria**	**Response actions:** • **Trigger level actions** • **Threshold level actions**	**Monitoring**	**Timing and frequency of monitoring**	**Reporting**
Condition: 5(a)iii a monitoring and reporting program, which includes baseline data that monitoring and reporting will be evaluated against, to be undertaken for a minimum length of two years post commencement of operation of the Marina to provide certainty that the artificial lighting of the Marina is not impacting flatback turtle hatchlings or nesting on Cemetery Beach.				
• The lower bound offset angle (95 % highest posterior density interval) exceeds 32°.	**Section 6.5** of the Spoilbank Marina Artificial Light Management Plan). **<u>Threshold level action (for spread or offset angle)</u>** **If any season of monitoring reports an exceedance in threshold criteria:** Undertake review of artificial light monitoring, lighting audit and hatchling orientation data to determine cause. The assessment will rate the level of impact associated with this exceedance and recommend actions (as described in **Section 6.5** of the Spoilbank Marina Artificial Light Management Plan).		collected (minimum 30 nests with 5 or more tracks).	

7 GLOSSARY

ADSA	Australian Dark Sky Alliance
ALMP	Artificial Light Management Plan
DBCA	Department of Biodiversity Conservation and Attractions
DEE	Department of Environment and Energy
DNB	Day/Night Band
EPA	Environmental Protection Authority.
EAG5	Environmental Assessment Guidelines for Protecting Marine Turtles from Light
Highest density posterior	There is a 95 % probability that the true mean lies within the upper and lower bound based on the data.
Inherent risk	Risk before control measures have been applied.
Intensity	A measure of the power of visible light emitted in a particular direction per solid angle.
LED	Light emitting diode
Lumen (lm)	The unit for luminous flux, which is a measure of the total quantity of visible light emitted by a source per unit time.
Marina	Port Hedland Spoilbank Marina
Nets fan	The angles of hatchling tracks emerging from a nest.
Offset angle	Describes the degree of deflection of tracks from the most direct route to the ocean. A smaller value indicates a more direct route (i.e., less deviation from the most direct route) and a larger value demonstrates a greater deviation from the most direct route, which may indicate disruption to natural hatchling sea-finding ability.
PENV	Pendoley Environmental
PPA	Pilbara Ports Authority
PC Amber LED	A filtered LED that emits a higher proportion of longer wavelength visible light (red/orange) and limited shorter wavelength light (blue/UV).
Residual risk	Risk after the implementation of additional control measures.
RAMP	Revised Action Management Plan
Sky glow	The brightening of the night sky, mostly over urban areas, due to reflection and scattering of artificial light at night.
Spread angle	Describes track dispersion from the emergence point, capturing the spread of all hatchling pathways toward the ocean. A larger value indicates greater dispersion or variation in ocean-finding bearings and may indicate disruption to natural hatchling sea-finding ability.

Threshold criteria	Represent the limit of acceptable impact beyond which there is likely to be significant impact.
Trigger criteria	Forewarn of the approach of the threshold criteria and are set at a conservative level to ensure trigger actions are implemented well in advance of the threshold criteria.
VIIRS	Visible Infrared Imaging Radiometer Suite

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Appendix A: Artificial Lighting Impact Assessment: Port Hedland Marina

ARTIFICIAL LIGHTING IMPACT ASSESSMENT REPORT

Port Hedland Marina

EEL19121.001
Artificial lighting impact assessment report
Rev 0
14 February 2020

Document status

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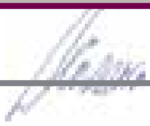
Giles Glasson  14 February 2020

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ACKNOWLEDGEMENTS

This Artificial Lighting Impact Assessment Report has been prepared by RPS Australia West Pty Ltd for DevelopmentWA and has been based upon the following key subconsultant deliverables:

1. Preliminary Lighting Design and Line of Site analysis prepared JDSi Consulting Engineers
2. Benchmark Artificial Light at Night Survey prepared by Pendoley Environmental.

A technical review of the draft Artificial Lighting Impact Assessment Report was undertaken by Dr. Kellie Pendoley and Adam Mitchell of Pendoley Environmental. Reference sources were not read in conjunction with the review, which focused specifically on the content contained with the draft Artificial Lighting Impact Assessment Report.

Kellie was a co-author of and Adam a co-contributor to the draft document upon which the draft National Light Pollution Guidelines for Wildlife including marine turtles, seabirds and migratory shorebirds (Department of the Environment and Energy 2019a) are based.

SUMMARY

Location and land use

The Port Hedland marina (the marina) is proposed to be constructed on the spoilbank and is approximately 1.5 kilometres (km) north-east of the Port Hedland town centre (Figure A).

The spoilbank consists of both naturally occurring coastal land and reclaimed (man-made) land formed from the deposition of dredge spoil from the Port Hedland harbour and adjoining navigation channel. The spoilbank is predominantly vacant land with the only significant development on the spoilbank is a yacht club and dry dock area.

The spoilbank is primarily reserved for 'Parks and Recreation' under the Town of Port Hedland's (ToPH) Local Planning Scheme No. 5 (Figure B). The spoilbank is managed by the ToPH for informal recreation purposes, including fishing, four-wheel driving and general recreation.

Proposed marina development

The marine and terrestrial components of the proposed marina development include:

- Four-lane boat ramp
- Two breakwaters and internal revetment walls
- A separate access channel to exit into deeper water, plus long-term capacity up to 80 boat pens
- Public open recreational space and improved public access
- Parking
- Toilet facilities
- Areas for pop-up stalls.

The concept design for the Port Hedland marina is presented in Figure 1.

Flatback turtle context

Of the regionally important flatback turtle nesting areas for the Pilbara coast flatback turtle genetic stock, Mundabullangana Station and Cemetery Beach are proximate to Port Hedland (Figure D).

Mundabullangana Station is a major flatback turtle nesting rookery, situated approximately 60 km southwest of Port Hedland. Mundabullangana Station supports a substantial reproductive flatback turtle population, with an estimated 1,861 female turtles nesting annually (Pendoley et al 2014).

Cemetery Beach is a minor flatback turtle nesting rookery, with the nesting area situated approximately 1.7 km to the east of the marina. Females nest between mid-October and January, with a peak in late November (Imbricata Environmental 2016). The population of nesting turtles appears to be relatively stable between 148 to 202 females/year (Pendoley Environmental (PENV) 2019).

Flatback turtles are protected species under both the Western Australian *Biodiversity Conservation Act 2016* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

Purpose of this report

The purpose of this Artificial Light Impact Assessment report is to demonstrate that artificial light generated by the operation of the proposed marina development can be managed so that flatback turtles are:

- Not disrupted within, nor displaced from, important habitat
- Able to undertake critical behaviours such as reproduction and dispersal.

This Artificial Light Impact Assessment report addresses:

- Potential artificial light impacts from the operational marina only

- The first three steps in the Commonwealth's recently released draft National Light Pollution Guidelines for Wildlife including marine turtles, seabirds and migratory shorebirds (draft Light Pollution Guidelines; Department of the Environment and Energy (DEE) 2019a) only. It is anticipated that an artificial light management plan, inclusive of biological and artificial light monitoring and auditing requirements, would be prepared for the proposed marina development to accord with steps four and five of the draft Light Pollution Guidelines (DEE 2019a) framework.

Benchmark artificial light at night survey

A benchmark artificial light at night survey (PENV 2020; Appendix B) was undertaken by PENV in late September – early October 2019 to obtain a qualitative set of benchmark data for the existing Cemetery Beach night environment, with specific reference to the Cemetery Beach flatback turtle nesting area (Cemetery Beach nesting area), to inform the likely effect of the proposed marina development.

The port operations, inclusive of loading, processing and stockpiling activities, was identified as the most dominant source of skyglow in Port Hedland (Figure F; PENV 2020). Point sources of artificial light that were directly visible from the Cemetery Beach nesting area included the Port Hedland Community Park, water tower, streetlighting, Port Hedland council building, Ibis Styles Port Hedland hotel and offshore vessels (Figure F; PENV 2020).

Existing artificial light impacts to flatback turtles at Cemetery Beach

Nesting female turtles

The relative stability of the nesting population suggests that existing artificial light impacts are not deterring adult females from nesting at Cemetery Beach. However, the relative density of nests between 2004 to 2013 does indicate that the nesting turtles prefer the eastern side of Cemetery Beach, where the dunes are higher providing a taller darker horizon cue behind the beach for orientation and some shielding from onshore artificial light sources (Figure E; Imbricata Environmental 2016).

Hatchlings

The Care for Hedland Environmental Association's hatchling orientation data for the 2018/2019 and 2019/2020 nesting seasons shows a wide spread of tracks with a minor bias towards western sources of artificial light (PENV 2020), which include the Port Hedland Community Park, Sutherland Street streetlights and skyglow from the port operations.

Key impact and proposed mitigation measures

Pole mounted lighting along the main access road and within the parking and hardstand areas of the proposed marina development is visible to hatchlings from the Cemetery Beach nesting area. The visible pole mounted lights could increase hatchling disorientation towards the west of Cemetery Beach.

The preliminary lighting design (JDSi Consulting Engineers; Appendix A) for the marina has been prepared to accord with the draft Light Pollution Guidelines (DEE 2019a), and the Environmental Protection Authority's (EPA) Environmental Assessment Guideline for Protecting Marine Turtles from Light Impacts (EAG 5; EPA 2010), while meeting legislative and regulatory requirements for human safety. In respect to the visible pole mounted lights, the preliminary lighting design uses:

- Minimum number and intensity of lights required to safely light the main access road and parking and hardstand areas to accord with road and outdoor public space requirements
- Amber LED lights (i.e. primarily long wavelength emitting lighting). The use of amber LED lights is considered suitable for use proximate to marine turtle habitat by DEE (2019a).

Given that artificial light pollution in Port Hedland is moderated by distance to the port operations, and together with the low lumen outputs of the proposed lighting, it is considered unlikely that the implementation of the proposed marina development would cumulatively add to the existing skyglow levels (Pendoley Environmental 2020).

To further reduce the potential for increased hatchling disorientation:

- Shielding should be installed on the east facing side (i.e. side facing towards the Cemetery Beach nesting area) of the pole mounted lights along the main access road to assist in reducing the line of sight visibility of these lights to hatchlings within the Cemetery Beach nesting area
- As part of the preparation of the artificial light management plan, consideration should also be provided to
  - Switching off the pole-mounted lighting during turtle hatching (early December to mid-February) when use is not required. Alternatively, a curfew time could be implemented for marina operations with the pole mounted lights being switched off from a particular time during turtle hatching
  - Planting screening vegetation along the eastern side of the main access road. The planted vegetation may assist in reducing the number of lights visible to hatchlings from the Cemetery Beach nesting area. Further, hatchlings are known to orient away from the elevated darker silhouettes of the dunes and / or vegetation, toward the lower, brighter seaward horizon. The planting of screening vegetation may assist in creating a less homogenous, more elevated horizon between the proposed marina development and the Cemetery Beach nesting area
  - Shielding on the eastern facing side of the pole mounted lights located within the parking and hardstand areas to the extent that compliance with AS/NZS 1158.3.1:2018 is not unreasonably compromised.

After the implementation of the best practice lighting design principles identified in the draft Light Pollution Guidelines (DEE 2019a), and EAG 5 (EPA 2010) key principles for lighting management:

- The residual risk to hatchling disorientation towards the west of Cemetery Beach being increased from the implementation of the proposed marina development is anticipated to be minimal in the context the existing artificial light impacts from point sources including the Port Hedland Community Park and Sutherland Street streetlights as well as skyglow from the port operations.
- The lighting design for the proposed marina development will meet legislative and regulatory requirements for human safety whilst addressing the biological diversity and ecological integrity of flatback turtles.

1 BACKGROUND

Artificial light at night provides for human safety, amenity and increased productivity, the provision of which is regulated by Australian legislation, regulation and standards for the purpose of human safety. Where there are competing objectives for lighting, creative solutions need to be employed which address both human safety requirements for artificial light and critical behaviours and physiology of conservation significant fauna species, such as marine turtles (Department of the Environment and Energy (DEE) 2019a).

1.1 Port Hedland artificial lighting

The industrialised landscape of Port Hedland's West End is home to the world's largest bulk export port, which primarily facilitates the export of iron ore. The port is comprised of 19 shipping berths including Utah Point, Nelson Point, Finucane Island, Anderson Point and Stanley Point, which provide for the continuous shipping operations (24 hours a day). Shipping operations, coupled processing, stockpiling and loading activities surrounding and servicing the port collectively contribute a significant amount of artificial light to the existing Port Hedland night environment. Other residential and commercial sources of artificial light include public open space lighting, sporting oval lights, and streetlights.

Artificial light from existing development in Port Hedland represents a significant increase in light levels that would otherwise be present from natural sources (stars and the moon). Due to the proximity of the port and associated industrial activities, the night environment in the West End is substantially more illuminated (from artificial light) when compared to the undeveloped rural areas around Port Hedland.

1.2 Port Hedland marina

1.2.1 Background

The Port Hedland marina (the marina) has been the subject of numerous environmental and planning studies over recent years in response to a recognised need for marina facilities in the community, including boat launching facilities.

The Port Hedland Land Use Masterplan (Town of Port Hedland (ToPH) 2007) identified that planning for the development of a new marina on the western side of the spoilbank was underway. In 2011 the ToPH appointed a "Port Hedland Spoil Bank Marina Stakeholder Committee" to work with the project managers (then LandCorp)[1] in the development of the spoilbank into a waterfront tourist attraction.

In 2012, LandCorp prepared a State Government submission for the development of marina infrastructure, land for marina associated uses (including hardstand including provision for a boat lifter, boat repair and service, outboard / diesel mechanic chandler, fibreglass and shipwright, marine electronic, refuelling jetty facility and tank farm) and a caravan park site on the spoilbank. The concept plan also proposed high density permanent residential development surrounding the marina as well as other retail and commercial uses. The ToPH also committed $40 million of funding towards development projects on the spoilbank. The marina subsequently received State Government approval for the allocation of $112 million of State funding in July 2012, with LandCorp assigned the role of project manager.

The scale and land use of the marina was to be confirmed via a scheme amendment seeking to rezone the land to include permanent residential development. LandCorp and the ToPH commenced the rezoning process for the proposed residential land use in August 2012. The process included extensive consultation with the respective government agencies. In February 2014, the Environmental Protection Authority (EPA) formally advised the environmental issues pertaining to the Scheme Amendment could not be resolved prior to the publication of the health risk assessment for particulate matter by the Department of Health.

[1] Now DevelopmentWA

In May 2014, the ToPH, BHP Billiton and the state government agreed to a joint funding arrangement to investigate Cooke Point in greater detail as an alternative marina location to the government approved spoilbank location. In June 2014, the Port Hedland Waterfront Place Plan (Village Well 2014) was finalised to assist with site selection as well as briefs for future design works and to communicate the project vision to the community and potential partners. The completion of this additional due diligence was considered at the ToPH's 13 May 2015 Special Council meeting where Council resolved as follows:

1. Reconfirms its commitment to the spoilbank as its preferred location for the development of a Marina Waterfront Development (Stage 1) as part of the ToPH's Waterfront Precinct Development Plan.
2. Endorses the Marina Waterfront Development (Stage 1) containing, but not limited to the following key components:
    a. Marina development with a maximum of 100 boat pens together with 4 boat launching ramps in Stage 1
    b. There being no residential development in the Marina Waterfront Development (Stage 1)
    c. A lagoon style swimming facility
    d. A community events space
    e. Commercial/retail space
    f. Continued public access to the balance of the spoilbank
    g. A suitable site being identified for an eco-tourism/caravan park development
3. Note that the following issues are supported:
    a. At the completion of the Marina Waterfront Development project that the existing Richardson Street boat ramp be removed
    b. Continued support for the development on the hospital site (proposed Finbar development) for a residential development
    c. The investigation of a suitable Town Planning instrument to be applied across the West End to restrict future densification of residential development
    d. The ToPH pursue the granting of the current Gratwick Aquatic Centre site in freehold title to assist in funding community amenities such as a new waterfront lagoon swimming facility after the completion of the Marina Waterfront Development project
4. Requests the Chief Executive Officer to review all works to-date and finalise a detailed Business Case for the Spoilbank Marina Waterfront Development (Stage 1) to be presented to Council for consideration at a later date.
5. Notes that further reports on a risk assessment (including shipping channel) and economic analysis of the Spoilbank Marina Waterfront Development (Stage 1) will be presented to Council for consideration at a later date as part of the Business Case.
6. Commence negotiations towards a funding agreement with the Western Australian Government for $112 million for the Marina Waterfront Development (Stage 1), while at the same time exploring further grant and/or partnership funding opportunities to further support the development of the project.
7. Continues to engage and inform the community and stakeholders on the Marina Waterfront Development Plan.

The ToPH and LandCorp have progressed further investigations to confirm the scope, demand and ongoing operational feasibility of the marina including:

- Community consultation and engagement to confirm demand for community space and for take-up of boat pens
- Needs analysis and preliminary feasibility of a proposed cultural and community centre building
- Design and costing for the development of a recreation swimming facility within the precinct
- Demand, feasibility and economic impact assessments of a caravan park/ transit park.

The Spoilbank Boating Facilities Taskforce was established in October 2017, with its membership including the Pilbara Development Commission, Department of Primary Industries and Regional Development, LandCorp and the Department of Transport (DoT).

Two concept plans were developed, with preference being given to the design which included a separate channel from the main Port Hedland shipping channel. On 15 October 2018 the State Government approved the preferred concept for the marina (Figure 1), confirmed a $94 million contribution to the delivery of the marina and endorsed the DoT progressing the proposal to the detailed design phase.

(Source: DoT 2019)

Figure 1: Preferred marina concept

Concurrently the ToPH allocated $13 million to prepare a masterplan and associated feasibility, with the balance utilised for landside public and civil infrastructure works. The draft Port Hedland Marina and Waterfront Masterplan (Taylor Burrell Barnett 2019) was subsequently prepared to explore the transformation of the spoilbank into a vibrant waterfront development, focusing on exploring an appropriate structure of recreation spaces, infrastructure and amenities and the inter-relationship with the public realm.

1.2.2 Location and land use

The marina is located approximately 1.5 km north-east of the Port Hedland town centre (Figure A) and is situated on two parcels of Crown Land that make up the spoilbank (Crown Reserve 30768):

1. Lot 5550 on Deposited Plan 240246 on Certificate of Crown Land Title Volume LR3060 Folio 414
2. Lot 5751 on Deposited Plan 91579 on Certificate of Crown Land Title Volume LR3060 Folio 422.

Lot 370 on Deposited Plan 35619 on Certificate of Crown Land Title Volume LR3118 Folio 753 includes the marine portion of the marina footprint and is managed by Pilbara Ports Authority.

The spoilbank consists of both naturally occurring coastal land and reclaimed (man-made) land formed from the deposition of dredge spoil from the West End port and adjoining navigation channel. The spoilbank is predominantly vacant land with the only significant development on it being a yacht club and dry dock area. The spoilbank is managed by the ToPH for informal recreation purposes, including fishing, four-wheel driving and general recreation.

1.2.3 Zoning

The spoilbank is primarily reserved for 'Parks and Recreation' under the ToPH's Local Planning Scheme (LPS) No. 5. A small portion of the spoilbank is also reserved for 'Waterways' under LPS No. 5 (Figure B).

1.2.4 Description

Development of the marina will assist in facilitating the planning outcomes envisioned for the West End precinct by the ToPH's Pilbara's Port City Growth Plan (ToPH 2011), Waterfront Place Plan (Village Well 2014) and draft Port Hedland Marina and Waterfront Masterplan (Taylor Burrell Barnett 2019).

The marina includes the following marine and terrestrial components:

- Four-lane boat ramp
- Two breakwaters and internal revetment walls
- A separate access channel to exit into deeper water, plus long-term capacity up to 80 boat pens
- Public open recreational space and improved public access
- Parking
- Toilet facilities
- Areas for pop-up stalls.

1.2.5 Flatback turtles

The marina is situated approximately 1.7 km from the Cemetery Beach flatback turtle nesting area (Cemetery Beach nesting area). The flatback turtle is a protected species under the Western Australian *Biodiversity Conservation Act 2016* (BC Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Flatback turtles are also recognised in the EPA's Environmental Assessment Guideline for Protecting Marine Turtles from Light Impacts (EAG 5; EPA 2010), which identifies Cemetery Beach as being exposed to significant lighting from existing and planned residential development and iron ore shipping.

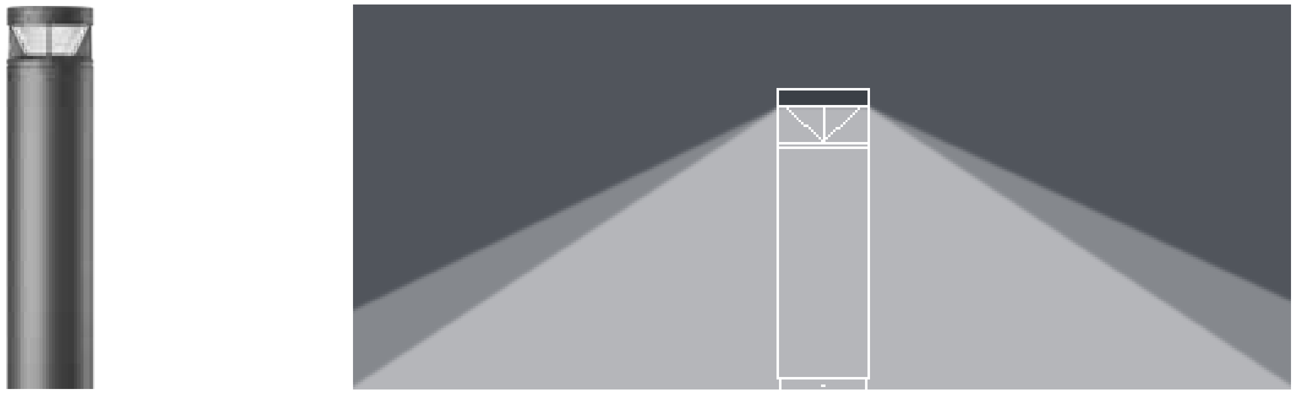
1.2.6 Lighting requirements

Artificial light is required for the proposed marina development to comply with Australian legislation, regulation and standards for human safety.

A preliminary lighting design for the marina has been developed by JDSi Consulting Engineers (JDSi; Appendix A). Bollard lighting is proposed to be implemented within the marina's basin, with pole mounted lighting required along the main access road and within the adjacent parking and hardstand areas. Amber LED lights (i.e. primarily long wavelength emitting lighting) are proposed to be used.

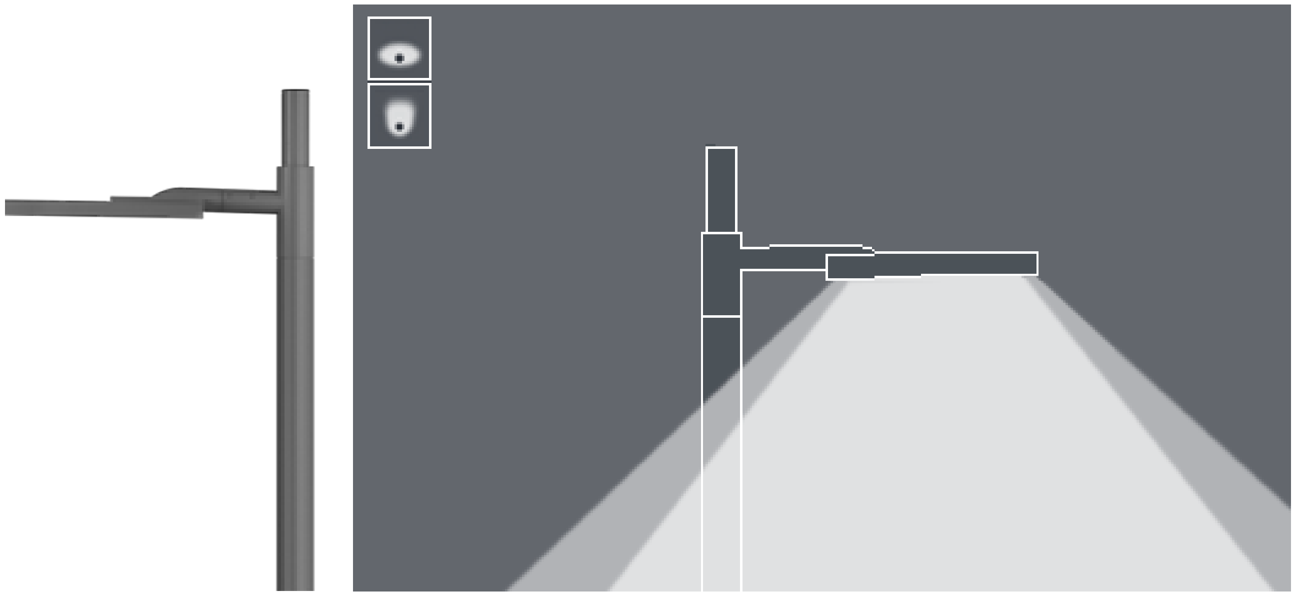
The bollard lights (we-ef KTY234) are approximately one metre high (Figure 2). The pole mounted lights (we-ef VFL530-SE, we-ef VFL530 and we-ef VFL540) vary in height between approximately four and eight metres (Figure 3 and Figure 4).

The pole mounted lights are proposed to be mounted horizontally relative to the ground to prevent light from shining above the horizontal plane and contributing to skyglow (Figure 3 and Figure 4). The pole mounted lights have been certified by independent assessors as meeting the Australian Dark Sky Alliance's (ADSA) night light criteria (ADSA 2019).



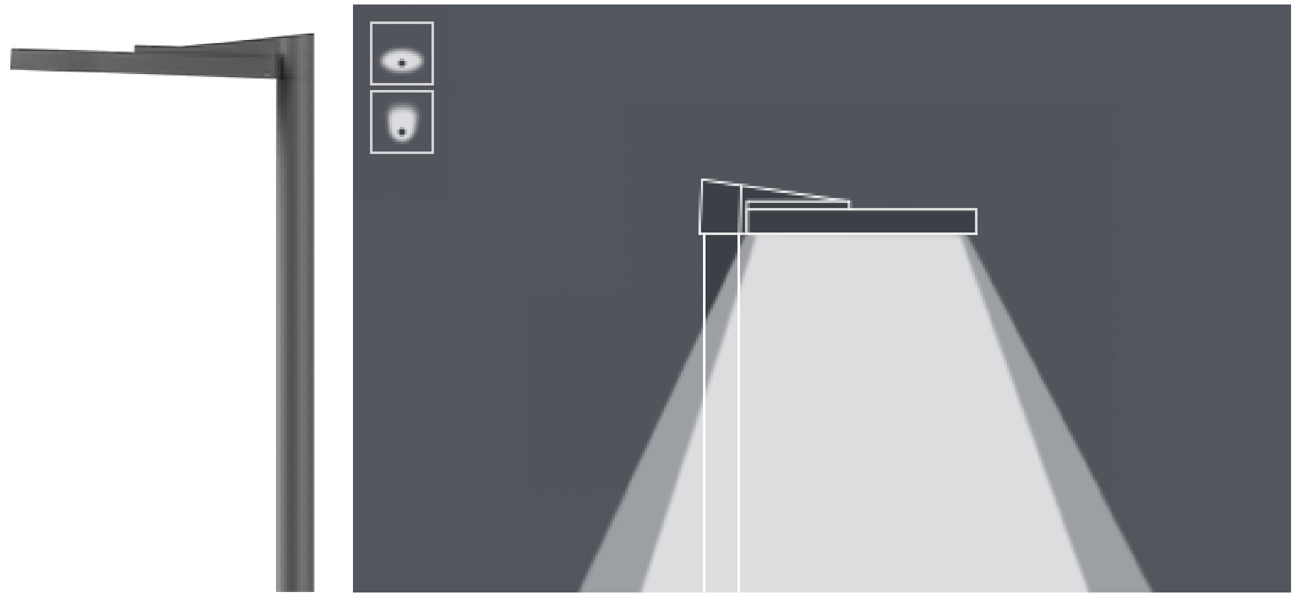
(Source: we-ef 2020a)

Figure 2: we-ef KTY234, light is approximately one metre high



(Source: we-ef 2020b)

Figure 3: we-ef VFL530-SE, light to be mounted on a four metre pole



(Source: we-ef 2020b)

Figure 4: we-ef VFL530 / we-ef VFL540, light to be mounted on a six / eight metre pole

1.3 Purpose of this report

The purpose of this Artificial Light Impact Assessment report is to demonstrate that artificial light generated by the operation of the proposed marina development can be managed so that flatback turtles, and other species of marine turtles, are:

- Not disrupted within, nor displaced from, important habitat
- Able to undertake critical behaviours such as reproduction and dispersal.

This Artificial Lighting Impact Assessment Report addresses potential artificial light impacts from the operational marina only. Other potential impacts to marine turtles during the construction and operation of the marina, such as entrainment during dredging and boat strike, will be addressed as part of a holistic environmental impact assessment for the proposed marina development.

1.4 Structure of this report

This Artificial Light Impact Assessment Report reviews the existing night environment at Cemetery Beach, with specific reference to the Cemetery Beach nesting area, to inform the significance of the potential artificial light impacts of the proposed marina development upon flatback turtles. Specifically, this outcome has been achieved through:

- Providing a description and overview of lighting requirements for the proposed marina development (Section 1.2.6)
- Detailing the legislative and regulatory context relating to flatback turtles (Section 2)
- Reviewing the key biological attributes of flatback turtle (Section 3)
- Identifying the potential artificial light impacts to marine turtles (Section 4)
- Describing the local and regional significance of the Cemetery Beach nesting area (Section 5)
- Reviewing the existing artificial light sources proximate to Cemetery Beach (Section 6)
- Identifying and assessing potential artificial light impacts from the proposed marina development to flatback turtles (Section 7)
- Providing design outcomes to reduce potential artificial light impacts to flatback turtles from the proposed marina development (Section 8)
- Reviewing the residual impacts to flatback turtles from the proposed marina development after the implementation of the preliminary lighting design (Section 9).

This Artificial Light Impact Assessment Report addresses the first three steps in the Commonwealth's draft National Light Pollution Guidelines for Wildlife including marine turtles, seabirds and migratory shorebirds (draft Light Pollution Guidelines; DEE) 2019a):

1. Describe the project lighting
2. Describe wildlife
3. Risk assessment
4. Artificial light management plan
5. Biological and artificial light monitoring and auditing.

It is anticipated that an artificial light management plan, inclusive of biological and artificial light monitoring and auditing requirements, would be prepared for the proposed marina development to accord with steps four and five of the draft Light Pollution Guidelines (DEE 2019a) framework.

2 LEGISLATIVE AND REGULATORY CONTEXT

2.1 State legislation and guidance

2.1.1 *Biodiversity Conservation Act 2016* (BC Act)

The objectives of the BC Act are to provide for the conservation and protection of biodiversity and biodiversity components; and promote the ecologically sustainable use of biodiversity components. The BC Act is administered by the Director General of the Department of Biodiversity Conservation and Attractions (DBCA) under the direction and control of the Minister for the Environment.

The BC Act provides for taxa of fauna to be listed as specially protected, Threatened (Critically Endangered, Endangered or Vulnerable) or Extinct in Western Australia.

The BC Act affords seven levels of special protection:

- Schedule 1 – being fauna that is rare or likely to become extinct, as critically endangered fauna, are declared to be fauna that needs special protection
- Schedule 2 – being fauna that is rare or likely to become extinct, as endangered fauna, are declared to be fauna that needs special protection
- Schedule 3 – being fauna that is rare or likely to become extinct, as vulnerable fauna, are declared to be fauna that needs special protection
- Schedule 4 – being fauna that is presumed to be extinct, are declared to be fauna that needs special protection
- Schedule 5 - being birds that are subject to international agreements relating to the protection of migratory birds, are declared to be fauna that needs special protection
- Schedule 6 - being fauna that are of special conservation need being species dependent on ongoing conservation intervention, are declared to be fauna that needs special protection
- Schedule 7 - are declared to be fauna that needs special protection otherwise than for the reasons mentioned in Schedules 1 to 6.

The flatback turtle is listed in Schedule 3 under the BC Act as Vulnerable.

2.1.2 Environmental protection authority guidance

2.1.2.1 Environmental factor guideline marine fauna

The EPA's environmental factor guideline for marine fauna:

- Describes the factor Marine Fauna and explains the associated objective
- Describes environmental impact assessment considerations for this factor
- Discusses the environmental values of marine fauna, and their significance
- Describes issues commonly encountered by the EPA during environmental impact assessment of this factor
- Identifies activities that can impact on marine fauna
- Provides a summary of the type of information that may be required by the EPA to undertake environmental impact assessment related to this factor.

2.1.2.2 Environmental assessment guideline for protecting marine turtles from light impacts

The EPA developed EAG 5 to specifically address approaches to proposal design and implementation to protect marine turtles from the adverse impacts of light. EAG 5 sets out:

- Guidance on an array of approaches available for avoiding, reducing, managing and mitigating light impacts on marine turtles to be considered when preparing documentation relevant to the environmental impact assessment process and during the implementation of proposals or planning schemes
- Alternative methods for the avoidance and management of light impacts that can be applied using a risk-based approach and by applying best practice methods.

Specifically, EAG 5 identifies the following key principles for light management applicable to coastal development projects from Shark Bay northwards:

- Keep it OFF (keep light off the beach and lights off when not needed)
- Keep it LOW (mount lights low down with the lowest intensity for the job)
- Keep it SHIELDED (stop all light escaping upwards and outwards)
- Keep it LONG (use long wavelength lights).

2.2 Commonwealth legislation and guidance

2.2.1 Environmental Protection and Biodiversity Conservation Act 1999

The objectives of the EPBC Act are to:

- Provide for the protection of the environment, especially Matters of National Environmental Significance (MNES)
- Conserve Australian biodiversity.
- Provide a streamlined national environmental assessment and approvals process.
- Enhance the protection and management of important natural and cultural places.
- Control the international movement of plants and animals (wildlife), wildlife specimens and products made or derived from wildlife.
- Promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources.
- Recognise the role of Indigenous people in the conservation and ecologically sustainable use of Australia's biodiversity.
- Promote the use of Indigenous peoples' knowledge of biodiversity with the involvement of, and in cooperation with, the owners of the knowledge.

The EPBC Act protects MNES, with state legislation providing for the protection of matters of state and local significance. MNES that relate to native fauna are:

- Listed threatened species
- Migratory species protected under international agreements.

The flatback turtle is listed as Vulnerable under the EPBC Act indicating that the species is not critically endangered or endangered but is facing a high (10%) risk of extinction in the wild in the medium-term future (DEE 2019b).

2.2.1.1 Recovery Plan for Marine Turtles in Australia

The Recovery Plan for Marine Turtles in Australia (DEE 2017) identifies that habitat critical to the survival of a species for marine turtle stocks has been identified by consensus of a panel of experts in marine turtle biology. Specifically, regarding flatback turtles nesting and inter-nesting habitat has been identified based on the following criteria:

- Nesting habitat critical to the survival of flatback turtles includes at least 70% of nesting for the stock.
- Nesting habitat critical to survival of marine turtles is of a geographically relevant scale.
- Where relevant, nesting habitat determined to be critical to the survival of marine turtles includes areas that are: geographically dispersed; major and minor rookeries; mainland and island beaches; and winter or summer nesting.
- To ensure the validity of long-term monitoring programs for assessing trends in nesting turtle abundance, all index beaches are considered habitat critical to survival of marine turtles.
- Inter-nesting habitat critical to the survival of marine turtles is located immediately seaward of designated nesting habitat critical to the survival of marine turtles. The inter-nesting habitat critical buffer for flatback turtles is 60 km.

Cemetery Beach is identified as minor nesting rookery and an index beach, as it has monitored by the Care for Hedland Environmental Association’s (CHEA) Community Volunteer Turtle Monitoring Program monitoring program since 2004/05 and is representative of the Pilbara Coast stock (Imbricata Environmental 2016; DEE 2017). Cemetery Beach and a 60km inter-nesting buffer area are designated as habitat critical to the survival of the flatback turtle (Figure C; DEE 2017).

2.2.1.2 Draft national Light Pollution Guidelines for Wildlife Including marine turtles, seabirds and migratory shorebirds

Light pollution was identified as a high-risk threat in the Recovery Plan for Marine Turtles in Australia (DEE 2017) because artificial light can disrupt critical behaviours such adult nesting and hatchling orientation, sea finding and dispersal, and can reduce the reproductive viability of turtle stocks. A key action identified in the Recovery Plan was the development of guidelines for the management of light pollution in areas adjacent to biologically sensitive turtle habitat.

The draft Light Pollution Guidelines for Wildlife (DEE 2019a) have been developed to address potential impacts to critical behaviours in wildlife from artificial light. The aim of the draft Light Pollution Guidelines for Wildlife is that artificial light will be managed so wildlife is:

1. Not disrupted within, nor displaced from, important habitat[2]
2. Able to undertake critical behaviours such as reproduction and dispersal.

The draft Light Pollution Guidelines for Wildlife (DEE 2019a) recommend:

1. Always using best practice lighting design to reduce light pollution and minimise the effect on wildlife. Best practice lighting design principles that can be used to reduce light pollution, including:
    a. Start with natural darkness and only add light for specific purposes.
    b. Use adaptive light controls to manage light timing, intensity and colour.
    c. Light only the object or area intended – keep lights close to the ground, directed and shielded to avoid light spill.
    d. Use the lowest intensity lighting appropriate for the task.
    e. Use non-reflective, dark-coloured surfaces.
    f. Use lights with reduced or filtered blue, violet and ultra-violet wavelengths.

[2] Important habitat for marine turtles includes all areas that have been designated as habitat critical to survival of marine turtles and biologically important areas (DEE 2019a).

2. Undertaking an environmental impact assessment for effects of artificial light on wildlife for listed species for which artificial light has been demonstrated to affect behaviour, survivorship or reproduction.

This Artificial Lighting Impact Assessment Report addresses these two key recommendations for potential artificial light impacts to flatback turtles, and other species of marine turtles, from the proposed marina development.

3 FLATBACK TURTLE BIOLOGICAL ATTRIBUTES

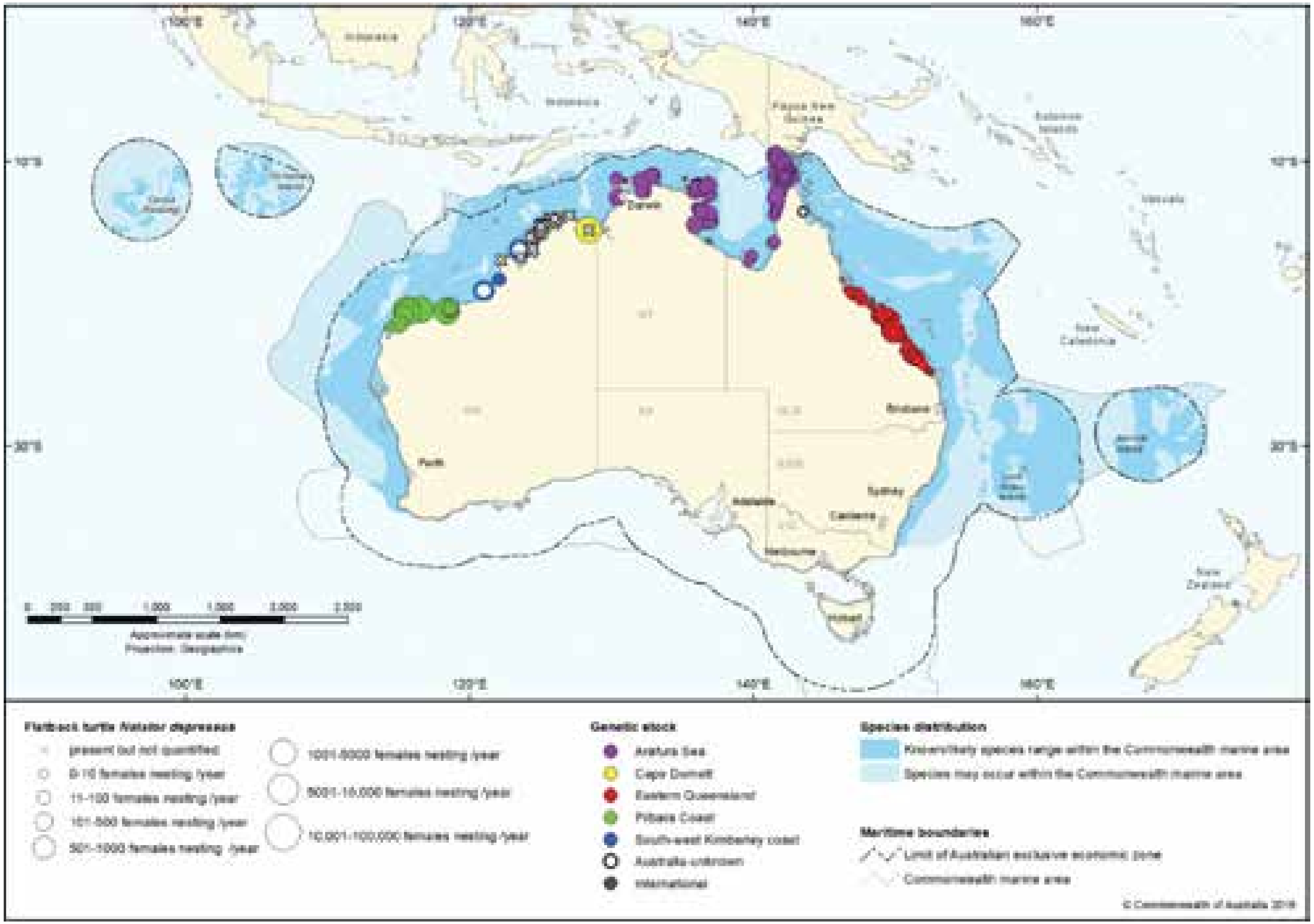
3.1 Distribution

Flatback turtles are widely distributed across northern Australian continental shelf (Limpus et al. 1989; Limpus 2007), Gulf of Papua New Guinea (Spring 1982), coastal waters of West Papua in Indonesia (Samertian and Noija 1994) and Kei in Eastern Indonesia (Suarez 2000). Their nesting distribution is restricted to tropical and subtropical Australian beaches (Limpus et al. 1981; 1983a; 1983b; Parmenter 1990; Schauble et al. 2006; Whiting and Guinea 2006; Limpus 2007; Whiting et al. 2008 and Waayers and Fitzpatrick 2013). Genetic studies have demonstrated that this restricted distribution is attributed to large distances between rookeries, lack of trans-oceanic migrations (Limpus 2007), and high nest site fidelity between nesting seasons.

The Recovery Plan for Marine Turtles in Australia (DEE 2017) identifies that five genetically distinct flatback turtle stocks have been established around Australia, however a recently published study by Fitzsimmons et al (2020) have identified seven distinct flatback turtle stocks. For the purpose of providing a general overview of flatback turtle distribution the DEE (2017) identified flatback turtle stocks have been referenced. These are:

1. Eastern Queensland
2. Arafura Sea
3. Cape Dommett
4. South-west Kimberly
5. Pilbara Coast.

Nesting sites for the Pilbara Coast genetic stock extend between Exmouth to the Lacepede Islands and across the Pilbara coast (Figure 5). Key nesting areas include Barrow Island, Mundabullangana Station and Delambre Island. Minor nesting areas are Thevenard, Varanus, Murion Islands, Montebello Group, Cemetery Beach and the Dampier Archipelago (DEE 2017). Post migration satellite tracking indicates that the Pilbara Coast stock is likely to forage along the coast of Western Australia and north to the Gulf of Carpentaria, and several likely important foraging grounds have been identified (Figure C; DEE 2017).



(Source: DEE 2017)

Figure 5: Flatback turtle nesting sites in Australia and surrounding regions

3.2 Biology

The flatback turtle belongs to the cheloniid family of turtles and is the only extant species in the genus. The flatback turtle has a low domed, fleshy carapace with reflexed margins and is grey, pale grey–green or olive in colour (Bustard 1972; Cogger 1996, Limpus 1971).

Flatback turtles appear to be primarily carnivorous throughout their lives, feeding on a variety of soft bodied invertebrates (DEE 2017). Juveniles eat gastropod molluscs, squid, siphonophores (Zangerl et al. 1988). Limited data indicate that cuttlefish (Chatto et al. 1995) and crinoids (Zangerl et al. 1988) and are also eaten. This combination of benthic and pelagic prey means they can forage in a range of habitats.

3.3 Habitat

Post-hatchling and young juvenile flatback turtles do not have the wide dispersal phase in the oceanic environment like other sea turtles and are thought to remain in waters over the Australian continental shelf (Walker and Parmenter 1990; DEE 2017). Juvenile to adult flatback turtles are known to favour soft bottom habitats that support benthic invertebrates.

Post-nesting satellite tracking indicates foraging occurs along the Western Australian coast in water shallower than 130 m and within 315 km of shore. High use areas include waters around Thevenard Island, adjacent to Eighty Mile Beach and Quondong Point, Lynher Banks and the Holothuria Banks (DEE 2017). Figure 6 shows the indicative dispersal for the Pilbara Coast as well as the four other genetic stocks.

3.4 Nesting and inter-nesting

Flatback turtles are believed to reach sexual maturity after 21 years of age (Limpus 2007) with reproductive half-life estimated at 10.1 years (Parmenter and Limpus 1995). Flatback turtles breed at intervals between one to five years (i.e. remigration interval) with a mean of 2.7 years (Limpus et al. 1983a; 1983b).

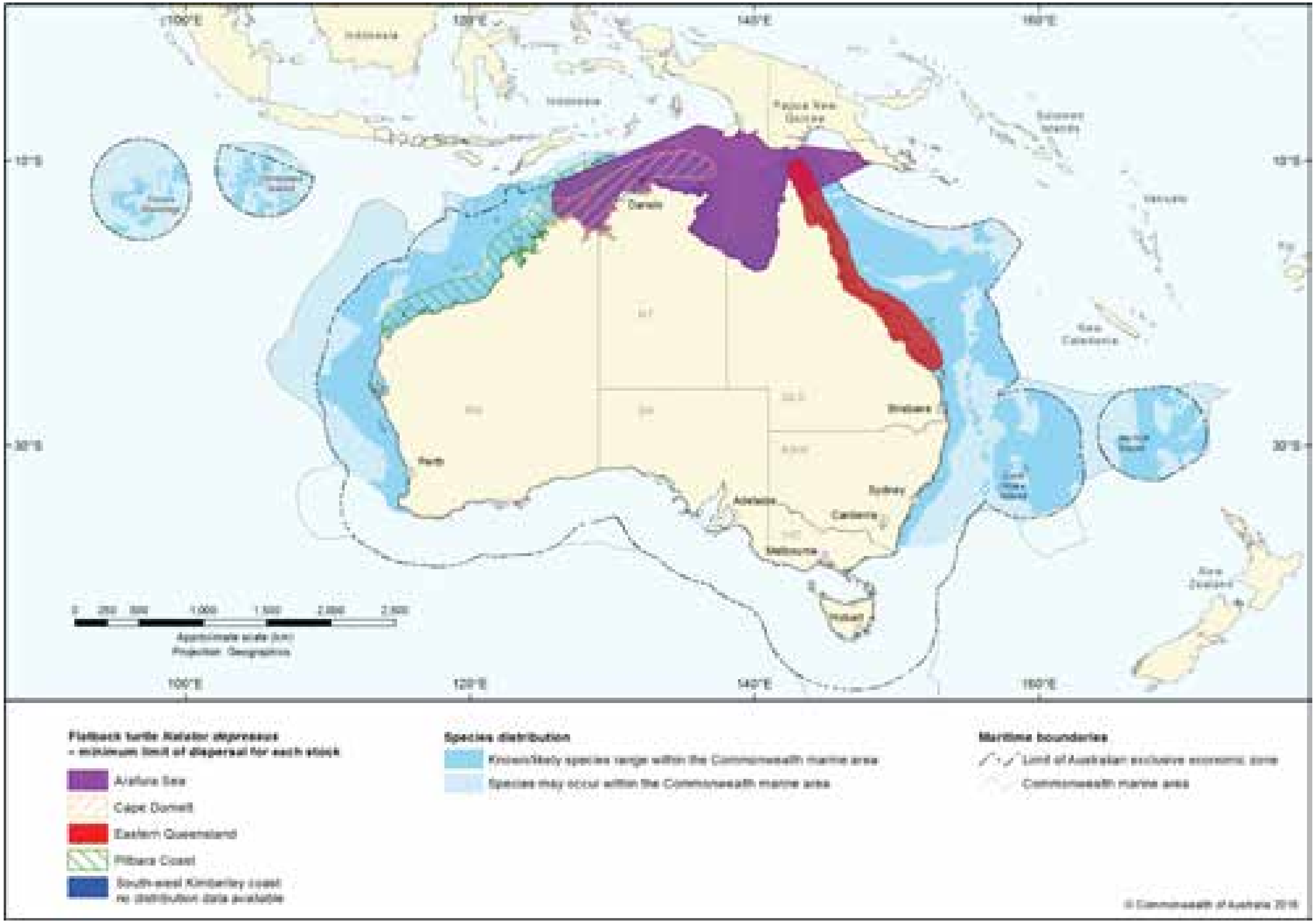
Females lay an average of 2.8 clutches per season on sandy beaches at an inter-nesting interval (i.e. time taken between laying successive egg clutches) of approximately 15 days. Clutches contain approximately 50 eggs with an average size of 5.2 centimetres (cm) in diameter and 78 grams in weight. Clutches are laid at a depth of 55 cm (Limpus 1971). The temperature of the sand around the nest is thought to determine the sex ratio of the hatchlings with more females hatching from warmer nests (> 29 °C) (Limpus 1995).

Successful incubation of eggs requires temperatures within the nest of between 25 ºC and 33 ºC, good ventilation, low salinity, high humidity and no disturbance (such as rotation) of the egg (Limpus 2007). Eggs incubate for around six weeks before hatchlings emerge from the nest and enter the sea.

Flatback turtle hatchlings are the largest of the marine turtle hatchlings and are strong swimmers. Once the hatchlings reach the water they swim away from the beach and begin their juvenile life, presumably in the coastal zone around their natal beach. Post-hatchlings are surface-water dwelling, feeding on macroplankton (Limpus 2007).

Little is known of the habits of juvenile flatback turtles, but after several decades they mature, return to the nearshore waters to breed and thus complete the lifecycle. Survivorship from hatchling emergent to maturity is estimated at less than 0.0026 (Parmenter and Limpus 1995).

The female flatback turtle displays a high degree of fidelity to her chosen nesting beach, with most females returning to the same beach within a nesting season and in successive nesting seasons (Limpus 2007). It is not known, however, whether this fidelity is the result of imprinting to the natal beach during the egg or hatchling phase (Limpus 2007). Flatback turtles show a preference for nesting in sand dunes or the steep seaward slope of beaches and rarely come ashore to nest on beaches fronted by intertidal coral reef flats (Limpus 2007).



(Source: DEE 2017)

Figure 6: Indicative dispersal for the flatback turtle stocks

4 LIGHTING AND MARINE TURTLES

4.1 Threats to turtles

The Recovery Plan for Marine Turtles in Australia (DEE 2017) identifies that the key threats to the Pilbara Coast flatback turtle stocks are:

- Climate change and variability is anticipated to cause changes in dispersal patterns, food webs, species range, primary sex ratios, habitat availability, reproductive success and survivorship.
- Acute chemical and terrestrial discharge refers to any release of pollutants and/or sediment into marine turtle habitat, including spills from land sources, vessels, drilling operations, and natural sources.
- Light pollution can inhibit nesting by females and disrupt hatchling orientation and sea finding behaviour.
- Coastal development around nesting beaches has the potential to reduce the reproductive success of a stock by direct mortality where nests are destroyed, reducing availability of suitable nesting habitat and impacting the quality of the nesting habitat.
- Coastal infrastructure, such as marinas, can reduce the availability of important marine turtle habitat.

4.1.1 Life stages considered to be at risk

Marine turtles are long-lived animals and therefore, changes to reproductive success and/or mortality rates can potentially exert substantial long-term demographic effects. Based on the findings of previous studies in the region, the marine turtle life stages considered to be at potential risk from artificial lighting from the marina include:

- Nesting female flatback turtles during the summer breeding season (mid-October to late January)
- Post-hatchling flatback turtles emerging from the nest and crawling across Cemetery Beach (early December to mid-February)
- Post-hatchling flatback turtles swimming from Cemetery Beach in the nearshore waters (early December to mid-February).

4.1.1.1 Effect of light on marine turtles

Artificial lighting has the potential to reduce the reproductive success of marine turtles by deterring adult females from approaching nesting beaches or nesting; and disorienting and / or misorienting hatchlings on the beach and in the nearshore environments (DEE 2019a).

The physical aspects of light that have the greatest effect on marine turtles include intensity, colour (wavelength), and elevation above beach. Management of these aspects assist in reducing potential artificial light impacts to marine turtles (DEE 2019a).

4.1.1.1.1 Nesting

Artificial lighting on or near nesting beaches has been shown to disrupt the nesting behaviour of marine turtles (Witherington and Martin 2003). Although lighting may not be the primary cause, nesting densities are typically lower at beaches exposed to artificial light than dark beaches (Salmon 2003). Artificial light may also mediate variations in adult female turtle nesting behaviours, such as the location of beach emergence, nest construction and whether nesting is abandoned, success of egg deposition, hatchling production and seaward return of adults (Witherington and Martin 1996).

Light types which exclude shorter wavelengths (i.e. blue to green light) do not appear to adversely affect nesting densities (Pennell 2000). On beaches exposed to light, higher nesting densities have been found in areas that are shadowed (e.g. from dunes and buildings), compared with illuminated areas (Salmon and Witherington 1995). Moving sources of artificial light may also deter nesting or cause disturbance to nesting females (e.g. flash photography) (Salmon 2006).

4.1.1.1.2 Beach environment

Artificial lighting may adversely affect hatchling sea-finding behaviour in two ways:

1. Disorientation – where hatchlings crawl on circuitous paths
2. Misorientation – where they move in the wrong direction, possibly attracted to artificial lights.

The consequence of this disruption to sea finding is often mortality, resulting from increased exposure to predation, dehydration and exhaustion (Witherington and Martin 1996; Salmon 2006). Table 1 provides a list of key environmental cues shown to inform hatchling sea-finding behaviour and identifies hatchling response to alteration of these cues by artificial light.

Table 1: Environmental cues and observed behaviour

Environmental cue	Observed hatchling behaviour
Light wavelength	Short wavelength light (i.e. blue to green and white light) is highly attractive to hatchlings. Long wavelength light (i.e. orange to red light) is relatively less attractive to hatchlings
Light intensity	• High intensity light is more attractive than low intensity light • High intensity long wavelength light may be more attractive than low intensity short wavelength light
Beach silhouettes (shape and form)	Hatchlings orient away from the elevated darker silhouettes of the dunes and / or vegetation, toward the lower, brighter seaward horizon
Light directivity	• Hatchlings integrate light over a broad area (~180°). They often ignore bright point sources of light • Broad skyglow may be more attractive than a single bright point source of light
Trapping effect of light	Hatchlings that enter a bright pool of light may be trapped within the spill of light and be unable to crawl away from the light spill area, both onshore and in the sea
Moon light	Bright moonlight may override the effects of artificial light
Clouds	Artificial light reflected off clouds creates a broad area of skyglow that may be attractive to hatchlings

(Sources: Pendoley 2005; Lohmann et al. 1997; Tuxbury and Salmon 2005; Limpus and Kamrowski 2013; Pendoley and Kamrowski 2016)

Hatchlings have a strong tendency to orient towards the brightest direction, with brightness being a function of light intensity, wavelength and hatchling spectral sensitivity (Witherington and Martin 2003). Hatchlings are notably more responsive to light of shorter wavelengths (i.e. blue to green light) than to lights of longer wavelengths (i.e. orange to red light) (Pendoley 2005; Fritches 2012). Flatback turtles are attracted to light <600 nanometers (nm), with a preference for ultra-violet (365 -400 nm) and blue light (400 – 450 nm) over longer wavelength light (Pendoley 2005; Fritches 2012). Although longer wavelengths of light are less attractive than shorter wavelengths, they can still disrupt sea finding behaviour, and if bright enough can elicit a similar response to shorter wavelength light. Hence, the disruptive effect of light on hatchlings is also strongly correlated with intensity (Pendoley 2005; Pendoley and Kamrowski 2016; Roberson et al 2016).

Based on the variable responses of turtles to lights of different wavelengths, several light types have been trialled with the aim of reducing hatchling attractions to lights. Lights emitting large proportions of short wavelength light are the most disruptive to sea finding behaviour, while lights which emit large proportions of longer wavelength light are only weakly attractive to hatchlings and are therefore less disruptive (Witherington and Bjorndal 1991a; Witherington and Bjorndal 1991b; Witherington and Martin 1996).

Studies have shown that hatchlings respond to shape cues during sea finding (Limpus 1971; Salmon et al. 1992). Hatchlings crawl away from higher dark silhouettes and toward the lower bright horizon (Mrosovsky 1972; Salmon et al. 1992). However, in situations where both cues are present, hatchlings are more responsive to the effects of silhouettes and darkened horizon elevation than to differences in brightness. On a natural beach this behaviour would direct the hatchlings away from dunes and vegetation and towards the more open horizon over the ocean (DEE 2019a). Hatchlings are most influenced by skyglow when it is situated low in the horizon relative to the hatchling (Limpus 1971; Salmon et al. 1992, Pendoley and Kamrowski 2015). Maintaining a dark, high dune or vegetation silhouette behind nesting beaches is therefore an effective management strategy for inland light sources (Tuxbury and Salmon 2005).

4.1.1.1.3 Nearshore environment

Artificial cues, such as light, may override or disrupt the dispersal process. The presence of artificial light has been shown to disrupt flatback hatchling dispersal, causing them to linger, become disoriented in the nearshore and expend energy swimming against ocean currents towards the light source (Wilson et al 2018). In addition to interfering with swimming it can influence predation rates, where hatchlings were predated more in areas with significant skyglow. Since the nearshore area tends to be predator-rich, hatchling survival may depend on them rapidly leaving this area (Gyuris 1994).

Hatchlings have also been anecdotally reported swimming around lights on boats at seas and in laboratory studies lights have attracted swimming hatchlings (Salmon and Wyneken 1990; White and Gill 2007). Metal halide light was shown by Wilson et al (2018) to be more attractive to flatback hatchlings than high pressure sodium light (80% attracted compared to 63%) and could have a trapping effect on hatchlings. This could become an issue when light sources are associated with coastal structures that also attract fish (e.g. jetties and marinas) as there is likely to be an increase in predation levels (Wilson et al 2018).

5 FLATBACK TURTLES IN PORT HEDLAND

Numerous flatback turtle studies have been undertaken in Port Hedland to support development projects including BHP Billiton's Outer Harbour Development (PENV 2009, 2010, 2011a, 2011b) and DevelopmentWA 's Pretty Pool Development (RPS 2009; 2010a, 2010b, 2012a, 2012b and 2013). A review of potential impacts to flatback turtles was also completed by PENV for the marina (PENV 2019).

Baseline data on the breeding biology of flatback turtles at three rookeries (Barrow Island, Mundabullangana Station and Cemetery Beach) of the Pilbara Coast genetic stock has been documented by Pendoley et al (2014). Inter-nesting behaviours of flatback turtles from four rookeries (Barrow Island, Thevenard Island, Mundabullangana Station and Cemetery Beach) have been recorded using satellite tracking by Whittock et al 2014). The findings of CHEA's Community Volunteer Turtle Monitoring Program monitoring program at Cemetery Beach and Pretty Pool have been documented by Conservation Volunteers Australia (2013) and Imbricata Environmental (2016).

5.1 Adult flatback turtles

5.1.1 Nesting

5.1.1.1 Regional significance

The nesting period for the Pilbara Coast stock occurs during the summer months, primarily between October and February (Pendoley et al 2014). Of the regionally important flatback turtle nesting areas identified by DEE (2017), Mundabullangana Station and Cemetery Beach are proximate to Port Hedland (Figure D).

Mundabullangana Station is a major flatback turtle nesting rookery, approximately 60 km southwest of Port Hedland (DEE 2017). The primary nesting site is Cowrie Beach, a 3.3 km long, narrow, low energy beach bounded by a mangrove creek to the northeast and a rocky headland to the southwest (Pendoley et al 2014). Mundabullangana Station is index beach which has been monitored since 1992 and is also used by PENV as a reference site for Barrow Island to assist with quantifying potential impacts of constructing and operating a gas facility proximate to turtle nesting beaches (DEE 2017; Pendoley et al 2014). Mundabullangana Station supports a substantial reproductive flatback turtle population with an estimated 1,861 female turtles nesting annually (Pendoley et al 2014).

Cemetery Beach is a minor flatback turtle nesting rookery, approximately 1.7 km east of the marina site and 3.3 km from the Port Hedland town centre (Figure E). Female turtles nest at Cemetery Beach between mid-October and January, with a peak in late November (Imbricata Environmental 2016). The population of nesting turtles appears to be relatively stable between 148 to 202 females/year (PENV 2019).

5.1.1.2 Local significance

Nesting sites within the Port Hedland townsite are Cemetery Beach and Pretty Pool Beach (other flatback turtle nesting rookery) (Figure D).

Pretty Pool Beach is a north-east facing marine embayment, sheltered by Cooke Point, on the eastern side of Port Hedland. The flatback turtle nesting area is situated approximately 6 km east of the marina and over 7 km from the Port Hedland town centre. The population of female turtles nesting on Pretty Pool Beach ranges between 31 to 222 females/year (PENV 2019).

Other nesting sites proximate to Port Hedland include Reefs Island, Downes Island, Paradise Beach, Spit Point and various unnamed beaches (PENV 2009; Figure D). The relative abundance of turtle tracks attained from snap-shot aerial track count surveys during the peak nesting period in December 2009 indicate that these other nesting sites support low nesting densities with approximately 6.7 tracks/km recorded at Paradise Beach and 1.4 tracks/km recorded at Downes Island (PENV 2009).

A comparison of the population size of the Port Hedland nesting sites (i.e. Cemetery and Pretty Pool beaches) to the major flatback turtle nesting rookeries in the Pilbara Coast genetic stock (i.e. Barrow Island and Mundabullangana Station) identifies that the Port Hedland nesting sites support significantly smaller numbers of nesting turtles (Table 2).

Table 2: Size of Pilbara Coast genetic stock major nesting rookeries and Port Hedland nesting sites

Nesting site	Estimated annual population size (females/year)
Barrow Island	1,512
Mundabullangana Station	1,861
Cemetery Beach	148 to 202
Pretty Pool Beach	31 to 222

(Sources: Pendoley et al 2014, PENV 2019)

Due to the spatial separation of Pretty Pool Beach from the marina it is not considered that the operation of the marina would result in artificial light impacts to flatback turtles at Pretty Pool Beach.

5.1.2 Offshore

5.1.2.1 Mating

Mating for Cemetery Beach flatback turtles is likely to occur from September and continue over the duration of the nesting period until January (PENV 2019). A flatback turtle breeding ground is located approximately 7 km offshore, in an area 33 km north-west of Port Hedland (PENV 2019). Flatback turtle mating has not been reported proximate to the marina.

5.1.2.2 Inter-nesting

Inter-nesting for Cemetery Beach flatback turtles is likely to occur over the same timeframe as the nesting period (i.e. between mid-October and January) (PENV 2019). Flatback turtle inter-nesting periods at Cemetery Beach have been recorded as 12 days (Whittock et al. 2014; Imbricata Environmental 2016).

The offshore movements of flatback turtles fitted with satellite tags from Cemetery Beach has been reviewed by PENV (2010) and Whittock et al. (2014).The most important inter-nesting habitat for flatback turtles nesting at Cemetery Beach appears to be the nearshore zone within 50 km stretching north-east along the coast which mostly consists of bare sediment or bare sediment over hard substrate (PENV 2010; Figure C), however habitat to the north-west of Cemetery Beach is also utilised by inter-nesting turtles (Whittock et al. 2014).

Cemetery Beach turtles show a high level of nest site fidelity, primarily returning to same beach where the transmitter was applied for subsequent clutches (Whittock et al. 2014). Although one turtle was recorded traveling approximately 60 km south–west of Cemetery Beach to nest at Mundabullangana Station (Whittock et al. 2014). Inter-nesting turtles have also been recorded within the existing shipping channel (BHP Billiton 2011).

5.1.2.3 Foraging

After the cessation of the mating and nesting periods, adult flatback turtles migrate to their Kimberly and Gulf of Carpentaria foraging grounds (PENV 2019).

Juvenile flatback turtles are known to use the shallow nearshore waters of the Pilbara coast for foraging (PENV 2009). Anecdotal reports indicate that juvenile flatback turtles are present within the tidal creeks of the inner harbour (PENV 2009). Biota Environmental Services (2004) also identified that flatback turtles are known to utilise habitats within the tidal creeks of the inner harbour, although no contextual information on age class is provided.

5.1.2.3.1 Other marine turtles

Adult green turtles are commonly observed in the inner harbour (BHP Billiton 2011). While mangroves are not considered a primary food source for adult green turtles, they are probably used as a supplemental or opportunistic food source along the Pilbara coast (PENV 2009; Pendoley and Fitzpatrick 1999). Juvenile green turtles have also been reported to shelter in the tidal creeks of the inner harbour (Biota Environmental

Services 2004; PENV 2009) suggesting that they may be foraging on green algal mats and *Sargassum* species within the surrounding creeks (Fortescue Metals Group 2008). An adult loggerhead turtle was also reported in the inner harbour to the south of Finucane Island in 2007, therefore loggerhead turtles may also use the area for foraging (PENV 2009).

5.2 Hatchling flatback turtles

5.2.1 Reproductive output

The average number of eggs laid by nesting flatback turtles at Cemetery Beach is similar to the Pilbara Coast genetic stock major nesting rookeries (Table 3). The average hatch success at Barrow Island is comparable to other flatback turtle rookeries, however the average hatch success recorded for Mundabullangana Station and Cemetery Beach are very low for flatback rookeries (Pendoley et al 2014). The low hatch success at Mundabullangana Station and Cemetery Beach is most likely due to the elevated natural sand temperature experienced during egg incubation compared to the more southerly populations within the Pilbara Coast genetic stock (PENV 2019). Alternatively, storm surges associated with high cyclonic activity in the region affecting the embryonic development may also be a factor (DEE 2017).

Table 3: Reproductive outputs of Pilbara Coast genetic stock major nesting rookeries and Port Hedland nesting sites

Nesting site	Average clutch size (number of eggs)	Average hatch success (%)
Barrow Island	46.6	83.4
Mundabullangana Station	46.6	68.2
Cemetery Beach	46.6	57.3

(Source: Pendoley et al 2014)

5.2.2 Nest emergence

Hatchlings start emerging from the nests at Cemetery Beach in early December, with a peak in early January, and continue until mid-February (Imbricata Environmental 2016).

After emerging from nests hatchlings crawl directly towards the sea, a behaviour known as sea finding. The sea finding process is directed by several cues including light wavelength, light intensity and shape and form (Lohmann et al. 1997; Tuxbury and Salmon 2005). Beach slope and sound are considered secondary cues relative to vision and are overruled by light (Lohmann et al. 1997).

5.2.3 Nearshore disbursal

The disbursal of flatback hatchlings entering the water have been shown to be primarily influenced by ocean currents under natural conditions (Wilson et al 2018). Nearshore currents in the Port Hedland region are primarily driven by astronomical tides, which causes a periodic inflow (flood tide) and outflow (ebb tide) of oceanic water to/from the Northwest shelf region (Cardno 2011). On an incoming flood tide currents generally flow in a south-southeast easterly direction, whilst on an outgoing ebb tide currents generally flow in a north-northwest direction (Cardno 2011).

6 ARTIFICIAL LIGHT ON CEMETERY BEACH

There are two ways by which artificial light may influence the Cemetery Beach night environment:

- Direct light – sources of artificial light that can be seen directly from the beach or from the nearshore waters (i.e. point source lighting)
- Indirect light or skyglow – artificial light illuminates water vapour, dust or any other airborne particles suspended in the night sky which indirectly scatters light into the surrounding environment.

Imbricata Environmental (2016) reported that the following management actions have been implemented to reduce direct light levels at Cemetery Beach:

- Turning the water tower off during turtle nesting and hatching periods
- Installation of orange LED lights along Sutherland Street and the footpath connecting the Civic Centre to the Port Hedland Community Park, including Ibis Styles Port Hedland hotel
- Installation of turtle friendly dual lighting system at the Port Hedland Community Park and the back of the Civic Centre.

6.1 Previous artificial light assessments

6.1.1 Stage 3 investigation area, Pretty Pool development

A light monitoring survey was undertaken at Cemetery Beach on 18 April 2013, in conjunction with light surveys for DevelopmentWA's Stage 3 Investigation Area, Pretty Pool Development, to identify and assess the influence of artificial light from direct sources and skyglow. The light survey identified that the existing Cemetery Beach night environment is dominated by skyglow produced by the port operations and to a lesser extent the Colin Matheson Oval lights, when in use. Skyglow from the port operations was found to be the dominant source of artificial light influencing the Cemetery Beach night environment (RPS 2013).

Direct artificial light sources detected by the RPS (2013) survey included:

- Sutherland Street streetlights
- Ibis Styles Port Hedland hotel
- Port Hedland Community Park[3]
- Water tower[4].
- Port Hedland council building
- Offshore lighting such as navigational markers and ships.

Figure F shows the key direct artificial light and skyglow sources proximate to the Cemetery Beach nesting area and the marina.

6.2 Port Hedland Marina – Benchmark Artificial Light Survey

Due to the period of time that has elapsed since the previous light study (RPS 2013), limited amount of monitoring data derived for the Cemetery Beach night environment and advancements in the quantification techniques for artificial light, it was considered that a contemporary set of light data was required to inform this artificial lighting impact assessment for the marina proposal.

In recognition of the inherent limitations of the previous investigations and their derived data sets leading marine turtle and light monitoring consultancy, PENV, were commissioned to undertake a benchmark artificial light at night survey for Cemetery Beach (PENV 2020; Appendix B).

[3] Port Hedland Community Park switches to turtle friendly lighting during turtle nesting and hatching periods

[4] Water tower is turned off during turtle nesting and hatching periods

6.2.1 Objective

The objective of the benchmark artificial light at night survey was to obtain a qualitative set of benchmark data for the existing Cemetery Beach light at night t environment, with specific reference to the Cemetery Beach nesting area, to inform the likely effect of the development of the marina.

6.2.2 Scope of works

The survey involved the collection of light data from the Cemetery Beach nesting area using PENV's Sky42™ cameras, which are globally recognised as a leading tool in artificial light measurement and management. These calibrated cameras capture high resolution, non-attenuated, full 360° images of the horizon every 15 minutes.

6.2.3 Methodology

To date no standard protocols, methodologies or accepted practices have been established for the measurement of artificial light emissions in Australia. To address the lack of a standardised method to quantify light emissions from point sources (i.e. streetlights, buildings) and diffuse sources (i.e. skyglow) PENV and RPS met with officers from the DBCA on 12 September 2019 to confirm the proposed approach for the implementation of the light survey.

The key outcome of the meeting was that the proposed approach for the implementation of the light survey was acceptable. The DBCA also recommended that in addition to the proposed monitoring sites at Cemetery and Pretty Pool Beaches a third site be established on the spoilbank. Consultation was also undertaken with Kelly Howlett (CHEA) to confirm the proposed light survey approach.

6.2.3.1 Timing of the light survey

The light survey was undertaken between 30 September and 03 October 2019 to coincide with the September new moon phase thereby avoiding ambient light generated by the full moon. Moore (2001) identifies the following additional environmental factors are known affect the amount of direct and scattered light visible in the sky at a particular point in time:

- Presence of clouds
- Pollutants
- Airborne particulates (dust)
- Humidity.

There were no adverse weather conditions encountered during the survey, with all nights free of rain and cloud cover (PENV 2020).

6.2.3.2 Field program

6.2.3.2.1 Monitoring locations

Four monitoring locations were selected for the light survey:

1. Cemetery Beach East was located within the Cemetery Beach nesting area.
2. Cemetery Beach West was located was located within the Cemetery Beach nesting area.
3. Pretty Pool Beach was used to compare the night environments of the two known turtle nesting beaches in Port Hedland.
4. Spoilbank was monitored to accord with DBCA advice.

Cameras were deployed at the two Cemetery Beach monitoring locations for three nights between 30 September and 02 October, with Pretty Pool Beach monitored on 30 September and the spoilbank monitored on 02 October (Figure 7).

(Source: PENV 2020)

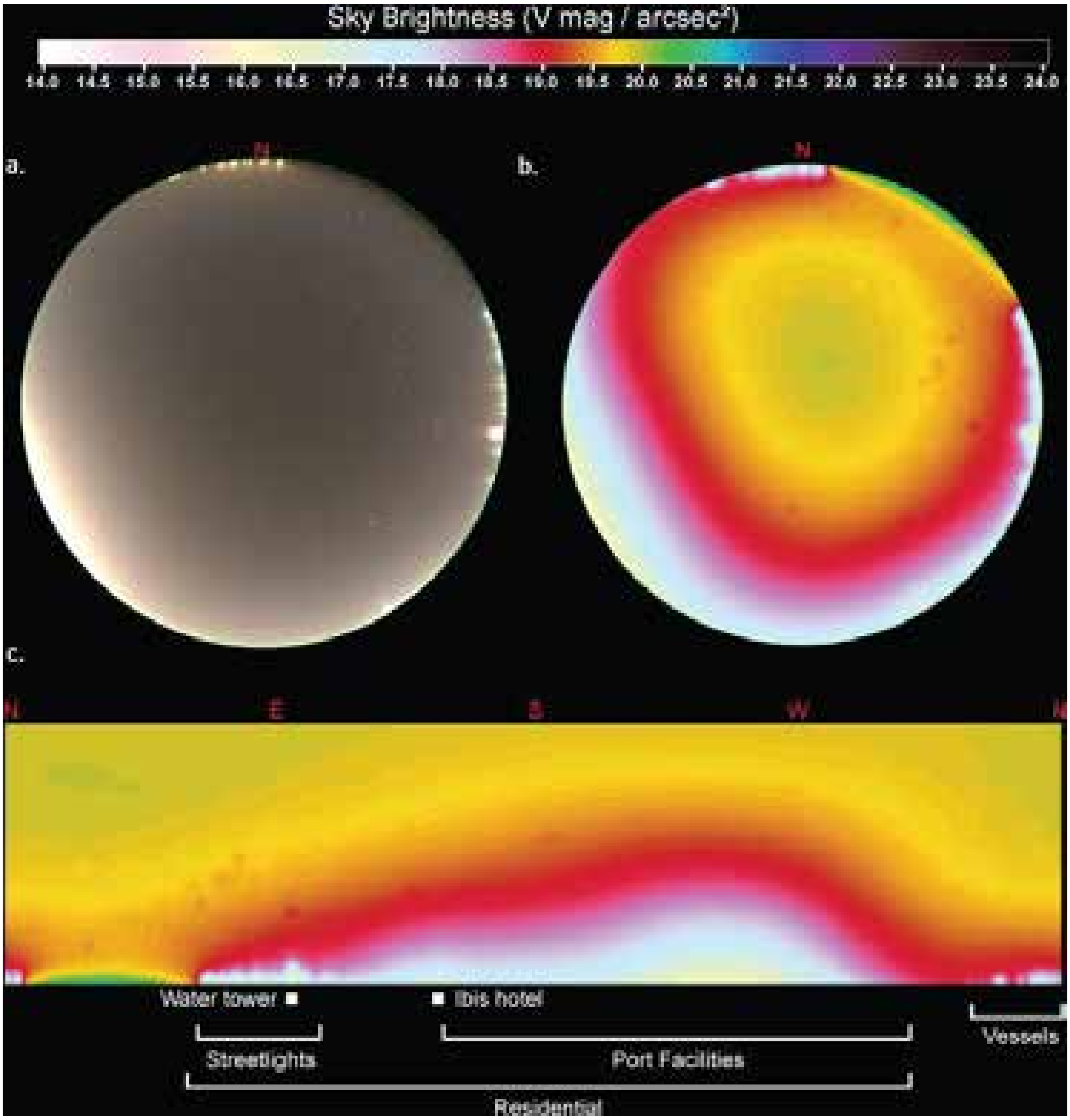
Figure 7: Light survey monitoring location

6.2.3.2.2 Image capture

Images were captured using automated Sky42™ light monitoring cameras that feature a Canon EOS 700D camera and fish-eye lens with custom built hardware to acquire low light night sky images of the entire sky (PENV 2020). The cameras are built into a rigid housing with a protective lid that automatically opens during image capture and closes between capture intervals (PENV 2020). The cameras were deployed at each survey location and were programmed to automatically begin taking photos in 15-minute intervals between sunset and sunrise. Images were downloaded from the cameras each day. processing and data analysis (PENV 2020).

6.2.4 Results

All suitable raw images captured by the Sky42™ light monitoring cameras were processed by PENV using custom built software to determine sky brightness levels. As an example, Figure 8 presents the raw image captured by the Sky42™ camera (a), processed image (b), and panorama showing location of visible light sources (c) for the Cemetery Beach West monitoring site on 30 September 2019.



(Source: PENV 2020)

Figure 8: Light survey results at Cemetery Beach West on 30 September 2019

Sky brightness was quantified in units of visual magnitudes/arcsec^2 (vmag/arcsec^2; a standard unit used in astronomical measurements and emerging as a standard for skyglow monitoring globally) (PENV 2020). The vmag/arcsec^2 unit quantifies light intensity on an inverted logarithmic scale (i.e. higher values represent lower intensity light, while lower values represent higher intensity light) (PENV 2020). Values between 21-22 vmag/arcsec^2 represent an ideal natural dark sky and values between 17 -18 vmag/arcsec2 are representative of a poor urban night sky (PENV 2020).

The spoilbank monitoring location recorded the brightest mean values (Whole-of-sky18.12, Zenith 19.57 and Horizon 18.12 vmag/arcsec^2), which is typical of an urban night sky and considered to be a high (artificial light impacted) recording (PENV 2020). Pretty Pool Beach recorded the darkest mean values (Whole-of-sky 19.49, Zenith 20.43 and Horizon 19.09) which is typical of a suburban night sky and considered to be a moderate (artificial light impacted) recording (PENV 2020). This finding indicates that sky brightness levels are influenced by proximity to the port operations and artificial light sources in the townsite (i.e. the brightest mean values were recorded at the spoilbank which is the closest monitoring location to the port operations and townsite whilst the darkest mean values were recorded at Pretty Pool Beach which is the furthest monitoring location from these light sources).

The port operations, inclusive of loading, processing and stockpiling activities, was identified as the most dominant source of skyglow in Port Hedland and was visible from all four monitoring locations (PENV 2020). Point sources of artificial light that were directly visible from the Cemetery Beach nesting area included the Port Hedland Community Park, water tower, streetlighting, Port Hedland council building, Ibis Styles Port Hedland hotel and offshore vessels (Figure F; PENV 2020). These findings are consistent with outcomes of the RPS (2013) light monitoring survey at Cemetery Beach (Section 6.1.2).

7 ARTIFICIAL LIGHT IMPACTS

Artificial lighting has the potential to reduce the reproductive success of marine turtles by deterring adult females from approaching nesting beaches or nesting; and disorienting and / or misorienting hatchlings on the beach and in the nearshore environments (DEE 2019a). The Cemetery Beach nesting area is approximately 1.7 km to the east of the marina. Over this distance, artificial light sources are considered unlikely to be bright enough to deter experienced flatback turtles from nesting (PENV 2019). Hatchlings are considered to be more sensitive to light, with impacts recorded at nesting habitat situated over 18 km away from a light source (Hodge et al 2007).

7.1 Existing artificial light impacts to flatback turtles at Cemetery Beach

7.1.1 Adult flatback turtles

7.1.1.1 Nesting

CHEA's Community Volunteer Turtle Monitoring Program has monitored the number of nesting turtles at Cemetery Beach since 2004. CHEA's population estimates identify that Cemetery Beach supports a stable nesting population. This finding is underpinned by a less than 30% variation between consecutive nesting seasons, which is characteristic of flatback turtle populations elsewhere in Australia (Imbricata Environmental 2016). Minor fluctuation in seasonal abundance is attributed to relatively short (1-2 year) remigration intervals, which is likely influenced by ecological change, sea surface temperatures, remigration rates and the health of foraging grounds that are outside the Port Hedland area (Figure C; Imbricata Environmental 2016).

The relative stability of the nesting population suggests that existing artificial light impacts are not deterring experienced adult females from nesting at Cemetery Beach. However, the relative density of nests between 2004 to 2013 does indicate that the nesting turtles prefer the eastern side of Cemetery Beach, where the dunes are higher providing a taller darker horizon cue behind the beach for orientation and some shielding from onshore artificial light sources (Figure E; Imbricata Environmental 2016).

7.1.2 Hatchling flatback turtles

7.1.2.1 Hatchling orientation

7.1.2.1.1 Previous hatchling orientation assessments

Imbricata Environmental (2016) reported that artificial light visible from Cemetery Beach appears to have an impact on hatchling orientation. The mean spread (112.4º) and offset (24.4º) angles recorded in 2013 for 124 fan maps were higher than those previously reported by PENV (2011b), which were 62.5º and 9.2º, respectively (Imbricata Environmental 2016). Anecdotal records of hatchlings being misoriented (PENV 2009) and disorientated (Limpus 2007; Imbricata Environmental 2016) by artificial light on Cemetery Beach have also been reported.

7.1.2.1.2 Benchmark artificial light at night survey

Hatchling orientation data recorded over the 2018/2019 and 2019/2020 nesting seasons by CHEA was reviewed and cross checked for errors by PENV. Records where confidence in data accuracy was high where used to provide an indicative benchmark for hatchling orientation, prior to the implementation of the proposed marina development. Records where confidence in data accuracy was low where removed from the CHEA dataset.

The hatchling orientation data shows a wide spread of tracks with a minor bias towards western sources of artificial light (PENV 2020), which include the Port Hedland Community Park, Sutherland Street streetlights and skyglow from the port operations.

8 PROPOSED MARINA DEVELOPMENT LIGHTING DESIGN

New sources of artificial light visible to flatback turtles within the Cemetery Beach nesting area were considered by PENV (2020) as having the potential to increase hatchling disorientation in a westerly direction along Cemetery Beach.

The siting of the marina and approach to the reduction of artificial light emissions implemented by the preliminary lighting design has sought to limit the introduction of new sources of artificial light visible to flatback turtles within the Cemetery Beach nesting area.

The physical aspects of light that have the greatest effect on marine turtles include intensity, colour (wavelength), and elevation above beach (DEE 2019a). In addition to limiting the introduction of new sources of artificial light, these aspects have been considered holistically across the entire development footprint to assist in reducing any potential increase in hatchling disorientation as a result of the proposed marina development.

8.1 Development siting

The proposed marina development is sited in the same westerly alignment from the Cemetery Beach nesting area as the port operations, which are the dominant source of skyglow at Cemetery Beach. Skyglow from the port operations was found to be the dominant source of artificial light influencing the Cemetery Beach night environment (RPS 2013). Situating the marina on the western side of the spoilbank maximises the separation distance between the marina and the Cemetery Beach nesting area, when compared to situating the marina on the eastern side of the spoilbank. The western siting of the marina also provides the opportunity for the existing topography of the spoilbank to be used to shield the new point sources of artificial light.

8.1.1 Line of sight analysis

A line of sight analysis was undertaken by JDSi to determine the proposed lighting features likely to be visible to flatback turtles within the Cemetery Beach nesting area (Appendix C).

The area of highest density flatback turtle nests, as identified by Imbricata Environmental (2016), was used as the reference point for the assessment, with the ground level (i.e. hatchling height) used to indicate the projected hatchling line of sight. A recent drone survey undertaken by MP Rogers and Associates in May 2019 was used to inform the Cemetery Beach topographic levels (Figure E).

The outcomes of this investigation, for which three indicative sections (i.e. most seaward light, through the car park and to yacht club) have been taken through the development, are presented in Appendix C.

The line of site analysis indicates that the pole mounted lighting along the main access road and within the parking and hardstand areas will be directly visible to flatback turtles. The bollard lighting within the marina's basin will either be shielded by the existing topography or the future breakwaters / internal revetment walls and will not be directly visible to flatback turtles from the Cemetery Beach nesting area.

8.2 Approach to reduction of light emissions

The preliminary lighting design (Appendix A) for the marina has been prepared to accord with the draft Light Pollution Guidelines (DEE 2019a) while meeting legislative and regulatory requirements for human safety. This has been achieved through implementing the following the draft Light Pollution Guidelines (DEE 2019a) best practice lighting design principles:

1. Start with natural darkness and only add light for specific purposes.
2. Use adaptive light controls to manage light timing, intensity and colour.
3. Light only the object or area intended – keep lights close to the ground, directed and shielded to avoid light spill.
4. Use the lowest intensity lighting appropriate for the task.
5. Use non-reflective, dark-coloured surfaces.
6. Use lights with reduced or filtered blue, violet and ultra-violet wavelengths.

The implementation of the draft Light Pollution Guidelines (DEE 2019a) best practice lighting design principles provide a contemporary framework to address the four key principles for lighting management identified in EAG 5 (EPA 2010):

- Keep it OFF (keep light off the beach and lights off when not needed)
- Keep it LOW (mount lights low down with lowest intensity for the job)
- Keep it SHEILDED (stop all light escaping upwards and outwards)
- Keep it LONG (use long wavelength lights).

The following sections detail the application of the draft Light Pollution Guidelines (DEE 2019a) best practice lighting design principles, and the EPA (2010) key principles for lighting management, in respect to the preliminary lighting design for the marina.

8.2.1 Start with natural darkness and only add light for specific purposes

The preliminary lighting design has been prepared to accord with Australian / New Zealand Standard, Lighting for Roads and Public Spaces (AS/NZS 1158.3.1:2018) thereby meeting minimum human safety requirements.

This principle has been addressed by the preliminary lighting design through using the minimum number of lights required to safely light the proposed marina development to accord with road and outdoor public space requirements detailed in AS/NZS 1158.3.1:2018 in situations where the visual requirements of pedestrians are the primary consideration (e.g. local roads, outdoor car parks).

8.2.2 Use adaptive light controls to manage light timing, intensity and colour

The use of LED lighting provides the opportunity for lighting controls to be fitted allowing for:

- Remotely managed lights (computer controls)
- Instant on and off switching of lights
- Control of light colour
- Dimming, timers, flashing rate, motion sensors
- Well defined directivity of light.

Although lighting controls have not been proposed to be implemented at the proposed marina development, the intent of this principle has been addressed by the preliminary lighting design through:

- Maintaining a permanent amber light colour
- Permanently shielding bollard lighting (i.e. we-ef KTY234; Figure 2) and permanently directing pole mounted lighting downwards (i.e. we-ef VFL530-SE; Figure 3, we-ef VFL530 and we-ef VFL54; Figure 4) reduces light trespass to the Cemetery Beach nesting area.

As part of the preparation of the artificial light management plan, consideration should also be provided to switching off the pole-mounted lighting during turtle hatching (early December to mid-February) when use is not required. Alternatively, a curfew time could be implemented for marina operations with the pole mounted lights being switched off from a particular time during turtle hatching.

8.2.3 Light only the object or area intended – keep lights close to the ground, directed and shielded to avoid light spill

To mitigate the potential for light spill to occur (i.e. light that falls outside the area intended to be lit) and ensure that only the target area is lit, the following actions have been implemented by the preliminary lighting design to address this principle:

- Keeping lights as close to the ground as possible

- Pole mounted lights are proposed to be mounted horizontally relative to the ground to prevent light from shining above the horizontal plane and contributing to skyglow (Figure 3 and Figure 4)
- Permanently shielding bollard lighting (i.e. we-ef kty234; Figure 3) and permanently directing pole mounted lighting downwards (i.e. we-ef vfl530-se; Figure 4, we-ef vfl530 and we-ef vfl54; Figure 5) reduces light trespass to the Cemetery Beach Nesting Area
- Installing the pole mounted lighting (i.e. we-ef VFL530) on the eastern side of the main access road so that the lights face to the west away from the Cemetery Beach nesting area.

Shielding should be installed on the east facing side (i.e. side facing towards the Cemetery Beach nesting area) of the pole mounted lights along the main access road to assist in reducing the line of sight visibility of these lights to hatchlings within the Cemetery Beach nesting area.

As part of the preparation of the artificial light management plan, consideration should also be provided to:

- planting screening vegetation along the eastern side of the main access road. The planted vegetation may assist in reducing the number of lights visible to hatchlings from the Cemetery Beach nesting area. Further, hatchlings are known to orient away from the elevated darker silhouettes of the dunes and / or vegetation, toward the lower, brighter seaward horizon (Table 1). The planting of screening vegetation may assist in creating a less homogenous, more elevated horizon between the proposed marina development and the Cemetery Beach nesting area.
- shielding on the eastern facing side of the pole mounted lights located within the parking and hardstand areas to the extent that compliance with AS/NZS 1158.3.1:2018 is not unreasonably compromised.

8.2.4 Use the lowest intensity lighting appropriate for the task

The preliminary lighting design has used only the minimum number and intensity of lights required to safely light the proposed marina development to accord with road and outdoor public space requirements detailed in AS/NZS 1158.3.1:2018, in situations where the visual requirements of pedestrians are the primary consideration (e.g. local roads, outdoor car parks). The pole mounted lights have also been certified by independent assessors as meeting the ADSA night light criteria (ADSA 2019).

Due to the low lumen outputs of the proposed lighting, it is not considered that the implementation of the proposed marina development would cumulatively add to the existing skyglow levels (PENV 2020).

8.2.5 Use non-reflective, dark-coloured surfaces

This principle has been addressed by the preliminary lighting design by using bollard housings, pole mounted fixtures and masts that are dark in colour. The use of reflective or white infrastructure within the lighting area also is proposed to be avoided.

8.2.6 Use lights with reduced or filtered blue, violet and ultra-violet wavelengths

This principle has been addressed by the preliminary lighting design through the use amber LED lights (i.e. primarily long wavelength emitting lighting) for the proposed marina development. The use of amber LED lights is considered suitable for use proximate to marine turtle habitat by DEE (2019a).

The use of lights containing ultra-violet, violet and blue light (i.e. short wavelength emitting lighting) to which hatchlings are more attracted has been avoided.

9 POTENTIAL IMPACTS AND PROPOSED MITIGATION MEASURES

The benchmark artificial light at night survey (PENV 2020; Appendix B) and line of sight analysis (JDSi; Appendix C) identify that pole mounted lighting along the main access road and within the parking and hardstand areas is visible to hatchlings from the Cemetery Beach nesting area. The visible pole mounted lights could increase hatchling disorientation towards the west of Cemetery Beach.

The preliminary lighting design (JDSi; Appendix A) for the marina has been prepared to accord with the draft Light Pollution Guidelines (DEE 2019a) best practice lighting design principles, and EAG 5 (EPA 2010), while meeting legislative and regulatory requirements for human safety (Section 8.2 demonstrates how this has been achieved). In respect to the visible pole mounted lights, the preliminary lighting design uses:

- Minimum number and intensity of lights required to safely light the main access road and parking and hardstand areas to accord with road and outdoor public space requirements
- Amber LED lights (i.e. primarily long wavelength emitting lighting). The use of amber LED lights is considered suitable for use proximate to marine turtle habitat by DEE (2019a).

Given that artificial light pollution in Port Hedland is moderated by distance to the port operations, and together with the low lumen outputs of the proposed lighting, it is considered unlikely that the implementation of the proposed marina development would cumulatively add to the existing skyglow levels (PENV 2020).

To further reduce the potential for increased hatchling disorientation:

- Shielding should be installed on the east facing side (i.e. side facing towards the Cemetery Beach nesting area) of the pole mounted lights along the main access road to assist in reducing the line of sight visibility of these lights to hatchlings within the Cemetery Beach nesting area
- As part of the preparation of the artificial light management plan, consideration should also be provided to
  - switching off the pole-mounted lighting during turtle hatching (early December to mid-February) when use is not required. Alternatively, a curfew time could be implemented for marina operations with the pole mounted lights being switched off from a particular time during turtle hatching
  - planting screening vegetation along the eastern side of the main access road
  - shielding on the eastern facing side of the pole mounted lights located within the parking and hardstand areas to the extent that compliance with AS/NZS 1158.3.1:2018 is not unreasonably compromised.

After the implementation of the best practice lighting design principles identified in the draft Light Pollution Guidelines (DEE 2019a), and EAG 5 (EPA 2010) key principles for lighting management:

- The residual risk to hatchling disorientation towards the west of Cemetery Beach being increased from the implementation of the proposed marina development is anticipated to be minimal in the context the existing artificial light impacts from point sources including the Port Hedland Community Park and Sutherland Street streetlights as well as skyglow from the port operations.
- The lighting design for the proposed marina development will meet legislative and regulatory requirements for human safety whilst addressing the biological diversity and ecological integrity of flatback turtles.

Table 4 summarises the key potential impacts to flatback turtles from artificial light from the proposed marina development, identified by the PENV (2019) review, and proposes mitigation measures to address the potential impacts consistent with the EPA's mitigation hierarchy, the draft Light Pollution Guidelines (DEE 2019a) and EAG 5 (EPA 2010) for the environmental factor of Marine Fauna.

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Table 4: Key potential impacts to flatback turtles from artificial light emitted from the proposed marina development

Marine fauna	
EPA objective	To protect marine fauna so that biological diversity and ecological integrity are maintained.
Policy and guidance	• *Environment Protection and Biodiversity Conservation Act 1999* • Draft national light pollution guidelines for wildlife, including marine turtles, seabirds and migratory shorebirds (DEE 2019a) • *Biodiversity Conservation Act 2016* • Environmental Factor Guideline: Marine Fauna (EPA 2016) • EAG 5 for Protecting Marine Turtles from Light Impacts (EPA 2010)
Potential impacts	**Adult flatback turtles** • The relative stability of the nesting population suggests that existing artificial light impacts are not deterring experienced adult females from nesting at Cemetery Beach. Informed by the separation distance between the marina and the Cemetery Beach nesting area (approximately 1.7 km), the findings of the benchmark artificial light at night survey (PENV 2020; Appendix B) and the proposed approach adopted for reducing light emissions by the preliminary lighting design it is not considered likely that experienced adult females would be deterred from nesting at Cemetery Beach as a result of the implementation of the proposed marina development. • Artificial light from the proposed marina development is not considered likely to significantly impact turtles when in the ocean. Some studies suggest that marine turtles may be attracted to lights when foraging, however inter-nesting flatback turtles are not considered to feed during the breeding season (Limpus et al. 2013) meaning they are unlikely to move to well-lit areas, with their foraging grounds situated away from Port Hedland (Figure C; PEV 2019). **Hatchling flatback turtles** • Pole mounted lighting along the main access road and within the parking and hardstand areas is visible to hatchlings from the Cemetery Beach nesting area. The visible pole mounted lights could increase hatchling disorientation towards the west of Cemetery Beach. • Artificial light from the marina is not considered likely to significantly impact hatchlings when in the ocean. Hatchlings entering the water will orient into the waves and will be swept along with local currents resulting in the hatchlings moving offshore and away from the marina (PENV 2019). In the event that a hatchling turtle situated offshore was attracted to artificial light sources, the presence of the spoilbank would act as a physical barrier and inhibit any further movement in a westerly direction (PENV 2019). The lack of any reported or anecdotal evidence from this extremely well monitored rookery showing that hatchlings crawl back ashore at Cemetery Beach towards the highly illuminated landward horizon suggests that the local oceanographic conditions and strong in- water cues used by hatchlings migrating offshore are sufficient to prevent hatchlings crawling back ashore.
Mitigation	Preliminary lighting design for the proposed marina development has been prepared to accord with the best practice lighting design principles identified in the draft Light Pollution Guidelines (DEE 2019a), and EAG 5 (EPA 2010) key principles for lighting management, while meeting legislative and regulatory requirements for human safety. **Avoid** • Bollard lighting within the marina will either be shielded by the existing topography or the future breakwaters / internal revetment walls and will not be directly visible to turtles from the Cemetery Beach nesting area **Minimise** • Pole mounted lighting along the main access road and within the parking and hardstand areas will be directly visible to hatchlings. To minimise the potential for increased hatchling disorientation from light sources which are directly visible to hatchlings, whist also reducing skyglow, the following management actions have been implemented: – Minimising the number of lights needed – Keeping lights as close to the ground as possible – Permanently shielding all bollard lighting – Permanently directing all pole mounted lighting downwards to reduces light trespass to the Cemetery Beach nesting area – Using pole mounted lights which are mounted horizontally relative to the ground prevents light from shining above the horizontal plane and contributing to skyglow – Using lowest intensity lighting to meet human safety requirements – Using bollard housings, pole mounted fixtures and masts that are dark in colour only – Using amber LED lighting (i.e. primarily long wavelength emitting lighting) only. • To further reduce the potential for increased hatchling disorientation: – Shielding should be installed on the east facing side (i.e. side facing towards the Cemetery Beach nesting area) of the pole mounted lights along the main access road to assist in reducing the line of sight visibility of these lights to hatchlings within the Cemetery Beach nesting area – As part of the preparation of the artificial light management plan, consideration should be provided to switching off the pole-mounted lighting during turtle hatching (early December to mid-February) when use is not required. Alternatively, a curfew time could be implemented for marina operations with the pole mounted lights being switched off from a particular time during turtle hatching – As part of the preparation of the artificial light management plan, consideration should be provided to shielding on the eastern facing side of the pole mounted lights located within the parking and hardstand areas to the extent that compliance with AS/NZS 1158.3.1:2018 is not unreasonably compromised. **Rehabilitate** • As part of the preparation of the artificial light management plan, consideration should be provided to planting screening vegetation along the eastern side of the main access road.
Outcome	After the implementation of the best practice lighting design principles identified in the draft Light Pollution Guidelines (DEE 2019a), and EAG 5 (EPA 2010) key principles for lighting management: • the residual risk to hatchling disorientation towards the west of Cemetery Beach being increased from the implementation of the proposed marina development is anticipated to be minimal in the context the existing artificial light impacts from point sources including the Port Hedland Community Park and Sutherland Street streetlights as well as skyglow from the port operations • the lighting design for the proposed marina development will meet legislative and regulatory requirements for human safety whilst addressing the biological diversity and ecological integrity of flatback turtles.

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FIGURES

Figure A

Site Location

GDA 1994 MGA Zone 50

0 200 400 800 m

Scale: Map 1:15,000 Overview 1:8,000,000 @ A4

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Doc Number: 001
Date: 22.01.20
Created by: RL
Source: Imagery - Landgate

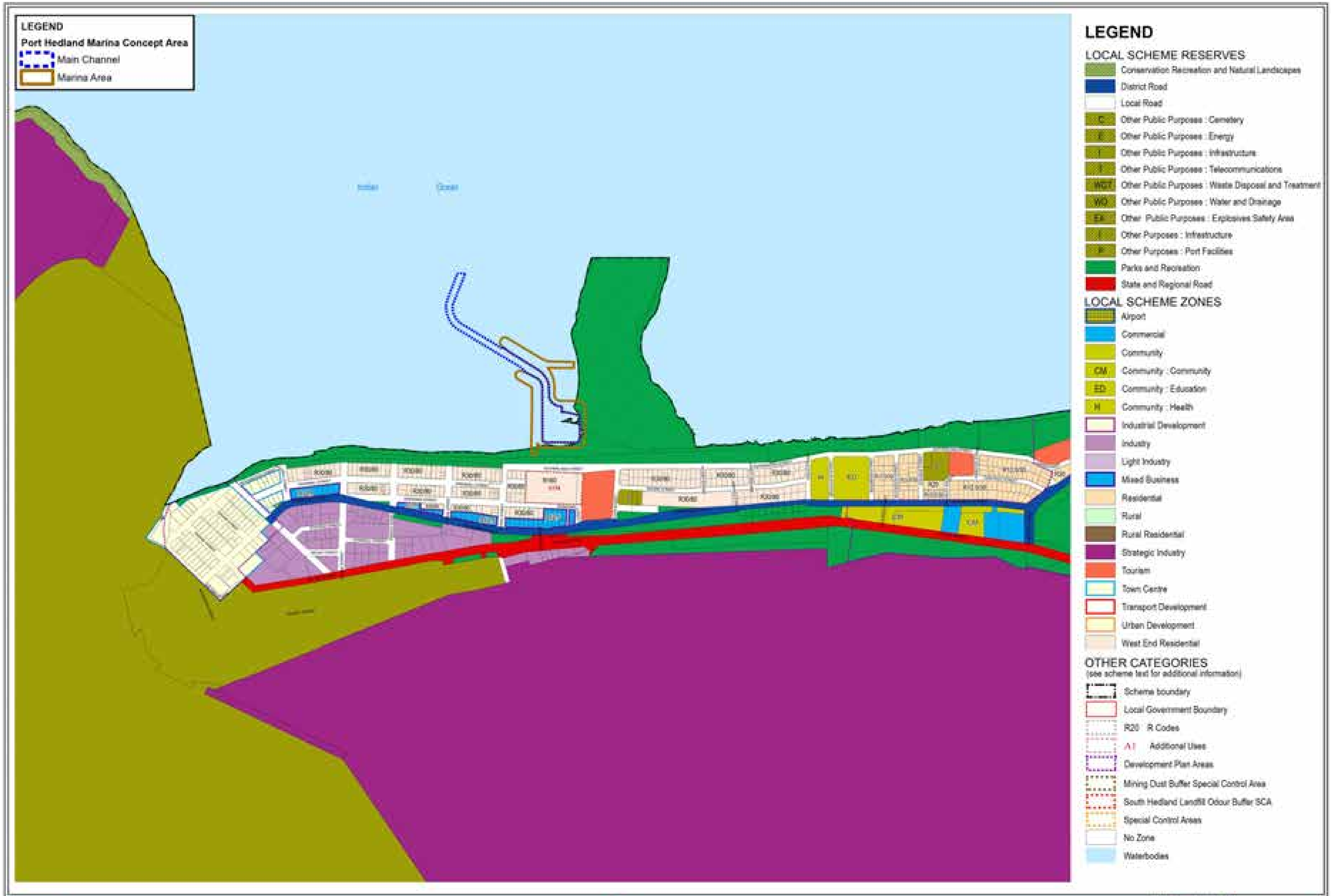

Figure B

Local Planning Scheme No. 5 mapping

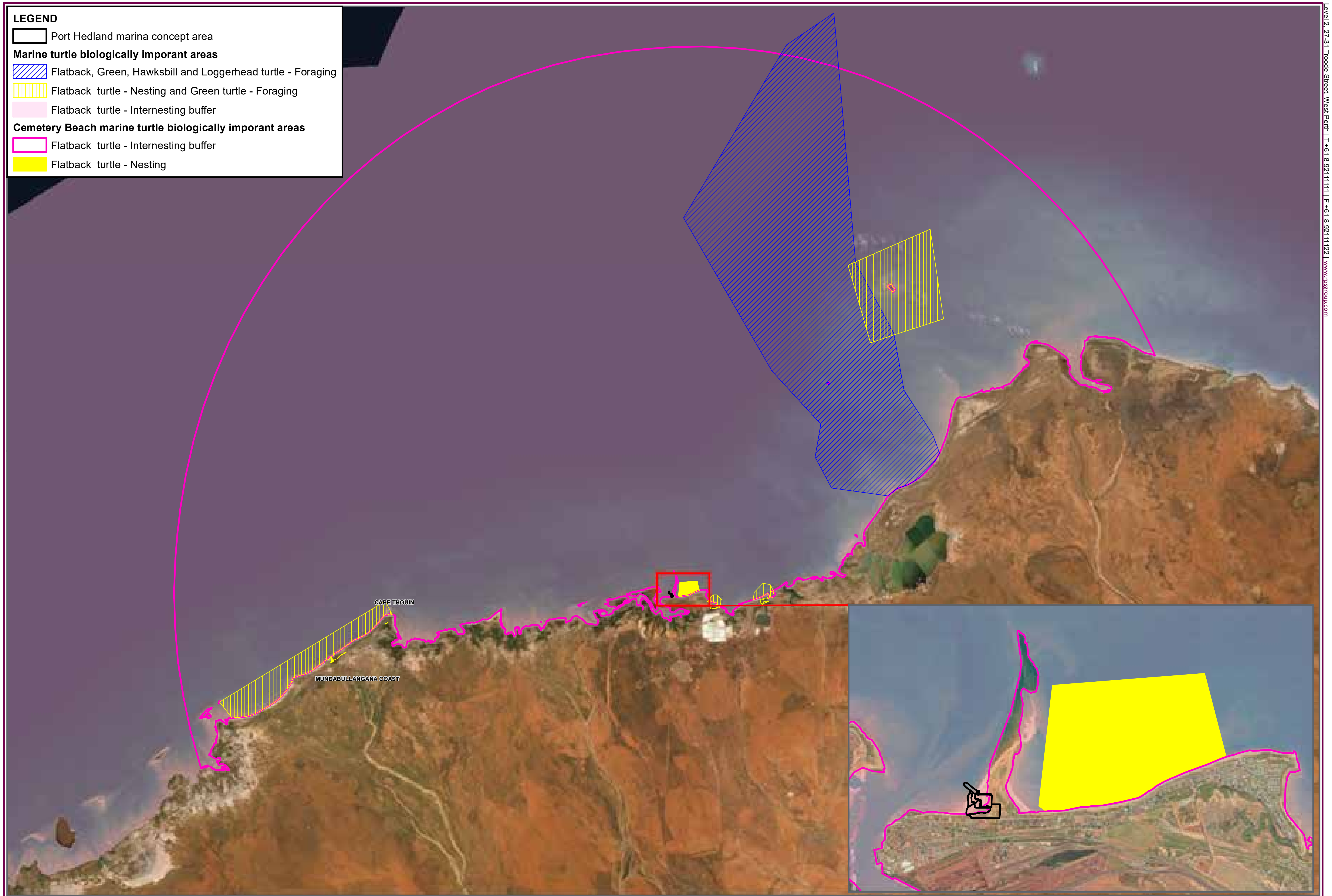

Figure C

Marine turtle biologically important areas

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Date: 05.02.20
Scale: 1:56,522 @ A3
Created by: MA
Source: Cadastre - Landgate, 2019 Orthophoto - Landgate, 2018

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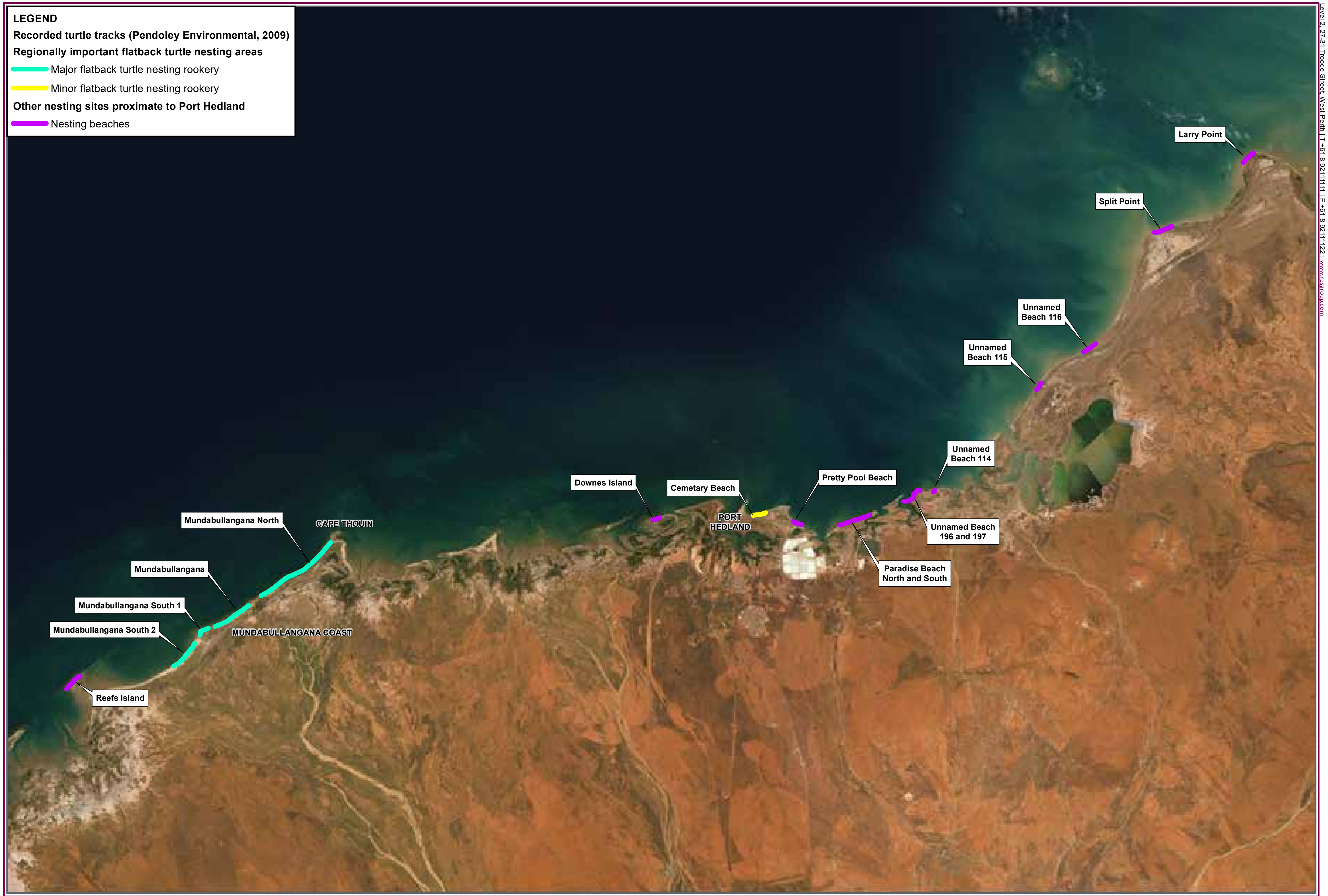

Figure D

Marine turtle nesting sites proximate to Port Hedland

GDA 1994 MGA Zone 50

0 2.5 5 10 km

Job Number: L19121-001
Doc Number: 004
Date: 05.02.20
Scale: 1:350,000 @ A3
Created by: MA

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Figure E

Cemetery Beach flatback turtle nesting area

Job Number: L19121-001
Doc Number: 005
Date: 02.05.20
Scale: 1:4,613 @ A3
Created by: MA
Source: Cadastre - Landgate, 2019 Orthophoto - Landgate, 2018

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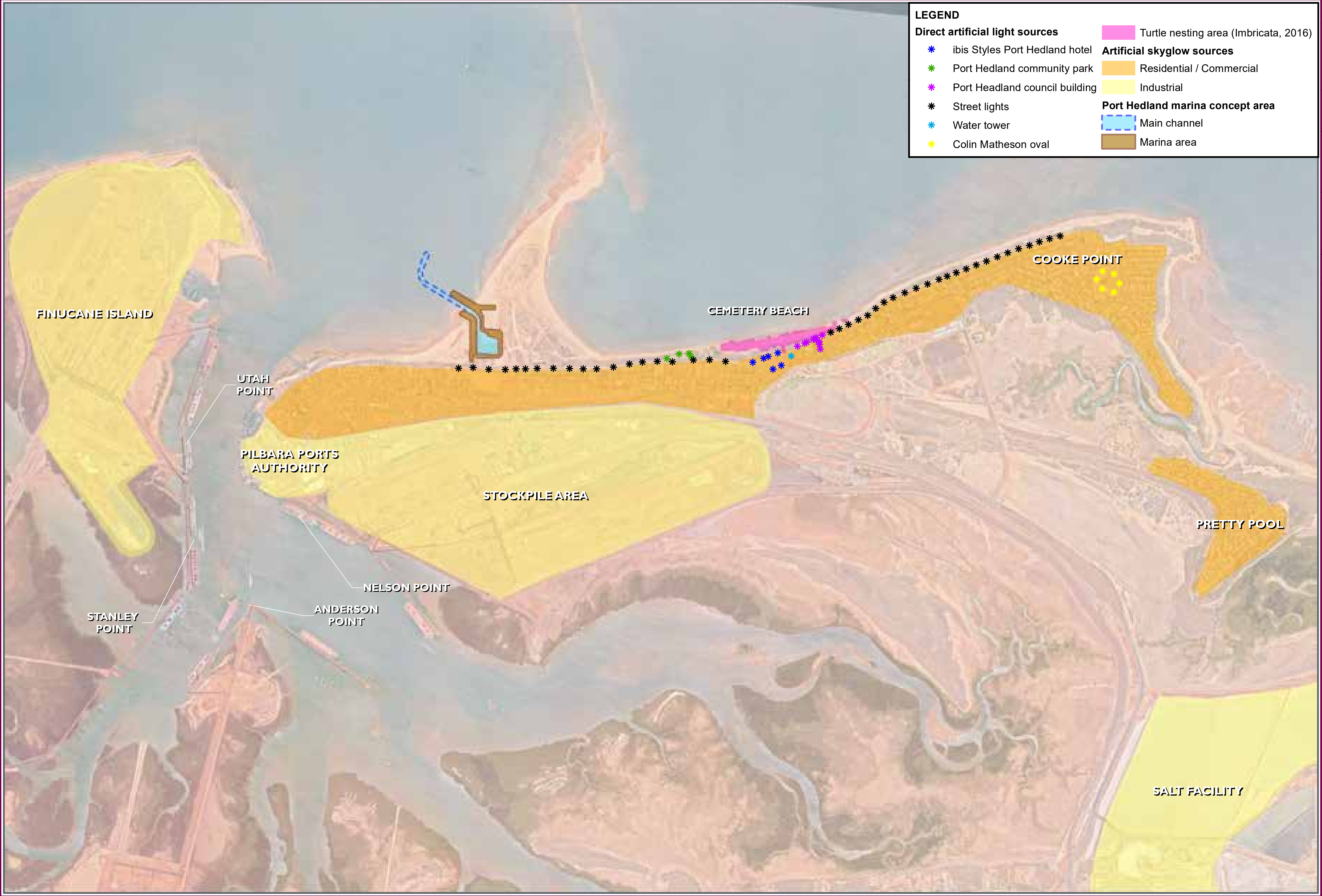

Figure F

Key artificial light sources proximate to Cemetery Beach

Job Number: L19121-001
Doc Number: 006
Date: 02.05.20
Scale: 1:25,000 @ A3
Created by: MA
Source: Cadastre - Landgate, 2019 Orthophoto - Landgate, 2018

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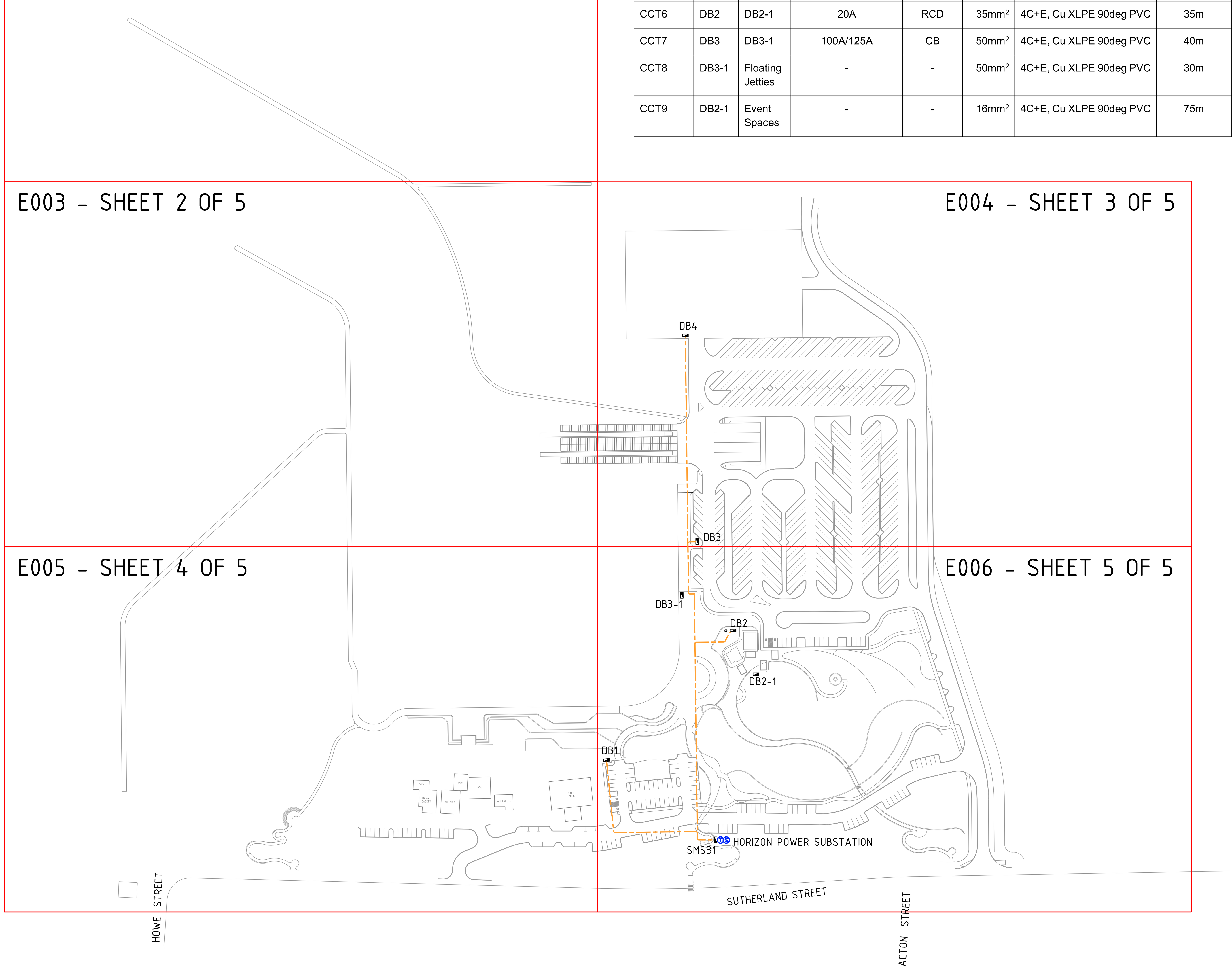
Appendix A

Preliminary lighting design

N

E002 – SHEET 1 OF 5



Spoilbank Marina – Electrical Design Cable and Load Schedule

Circuit Number	Source	To	Protection (Trip Setting/Rating)	Protection Type	Cable Size	Cable Type	Approximate Cable Length	Load (AS3000)	Comments
CCT1	TX-1	SMSB	300A/630A	SPD-CB	400mm²	3C+E, Cu XLPE 90deg PVC	5m	297A	
CCT2	SMSB	DB1	40A	CB	35mm²	4C+E, Cu XLPE 90deg PVC	120m	40A	
CCT3	SMSB	DB2	32A	CB	35mm²	4C+E, Cu XLPE 90deg PVC	120m	32A	
CCT4	SMSB	DB3	125A	CB	70mm²	4C+E, Cu XLPE 90deg PVC	150m	125A	
CCT5	SMSB	DB4	90A/100A	CB	120mm²	4C+E, Cu XLPE 90deg PVC	320m	100A	
CCT6	DB2	DB2-1	20A	RCD	35mm²	4C+E, Cu XLPE 90deg PVC	35m	20A	
CCT7	DB3	DB3-1	100A/125A	CB	50mm²	4C+E, Cu XLPE 90deg PVC	40m	100A	
CCT8	DB3-1	Floating Jetties	-	-	50mm²	4C+E, Cu XLPE 90deg PVC	30m	100A	
CCT9	DB2-1	Event Spaces	-	-	16mm²	4C+E, Cu XLPE 90deg PVC	75m	20A	

LEGEND

CONDUIT
- POWER – DISTRIBUTION
- POWER – RETICULATION
- POWER – LIGHTING
- POWER – 4x150mm SPARE

POWER INFRASTRUCTURE
- T TRANSFORMER
- S SWITCHGEAR
- SWITCHBOARD

GOLDEN SAFETY RULES ARE INDICATIVE ONLY – ALWAYS PERFORM A DETAILED HAZARD ANALYSIS.

Dimensions and scales to be checked prior to measuring cable lengths.
(Scale bar only valid for sections of drawing that are as per specified scale)

0 15 30 60 90m
SCALE 1:1500 @ ORIGINAL SHEET SIZE A1

NO CHANGES TO DESIGN UNLESS APPROVED BY DESIGN MANAGER

PRELIMINARY ISSUE ONLY

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PRELIMINARY ISSUE ONLY

REV	DATE	DRAWN	PROJECT REVIEW	CHECKED	APPROVED	REVISION DESCRIPTION
B	-	LC	-	-	-	-
A	08.01.19	LC	BT	NMcK	NMcK	ISSUED TO CLIENT FOR COMMENT

NOTE
This drawing shall be preliminary only until it is Issued for Construction.

Certified Quality System to ISO 9001

JDSi CONSULTING ENGINEERS
Workzone, Level 6, 1 Nash Street, Perth WA 6000
P: (08) 9227 0595 F: (08) 9227 8617

CLIENT: TOWN OF PORT HEDLAND

PROJECT: SPOILBANK MARINA

DRAWING TITLE: PRIVATE POWER AND LIGHTING SITE OVERVIEW

DRAWN	L.CONTEMPRATO	WAPC No.	
DESIGNED	L.CONTEMPRATO	SCALE @ A1	1:1500
PROJECT MANAGER	D.HELLMUTH	DATUM/COORD	AHD/PHG94
HP REFERENCE	NA		
JDSi PROJECT No.	JDS14736.0	DRAWING No.	E001
REVISION	B		

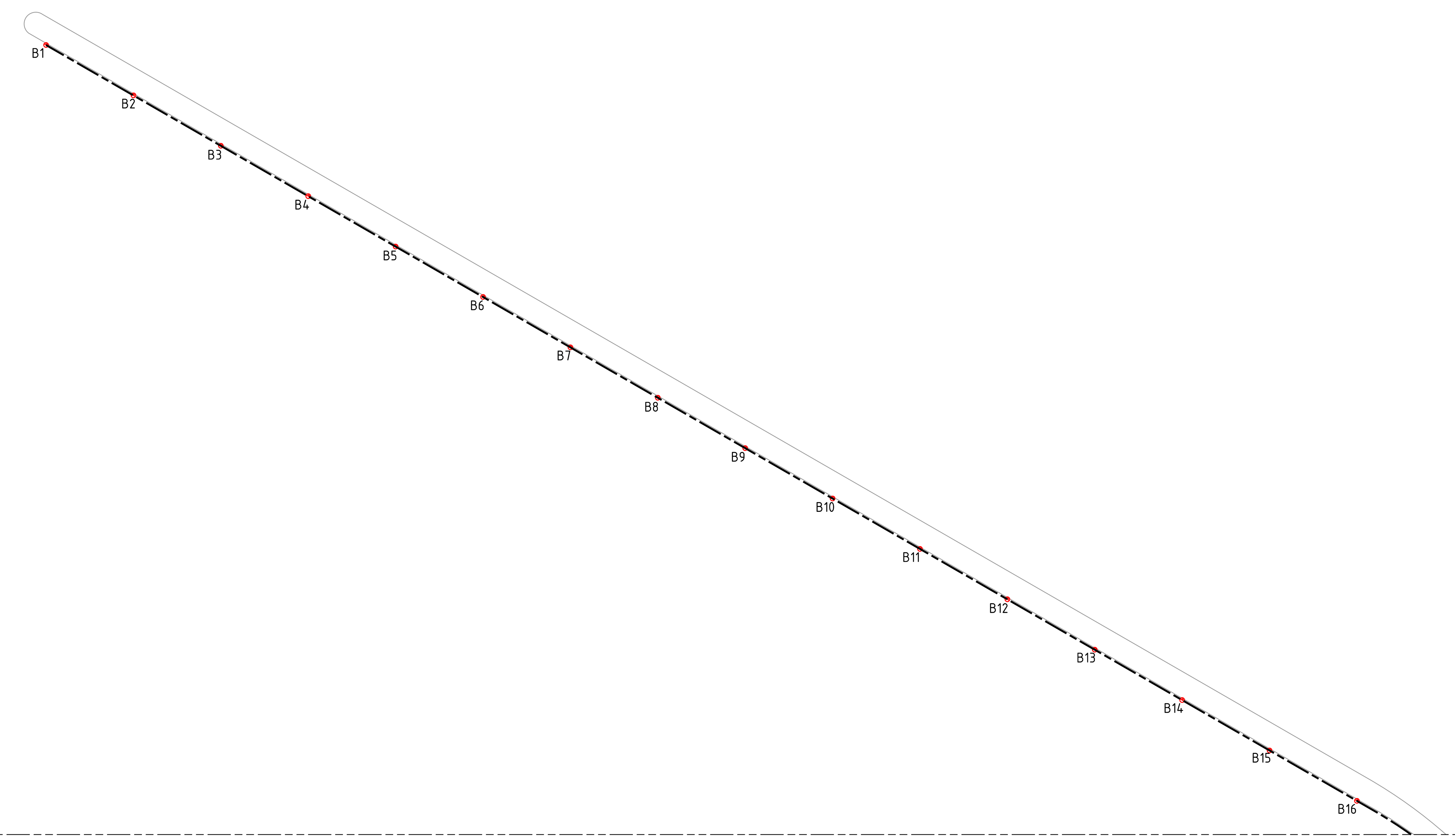
LIGHTING SCHEDULE

SYMBOL	LABEL	ARRANGEMENT	DESCRIPTION	LUM. WATTS	LUM. LUMENS	LLF	MH (m)	QTY
	Bxx	SINGLE	114-XXXX KTY234 R65.BEAM 3 LED 6W/700mA PC AMBER BOLLARD IP66 ALU LEC	6	198	0.800	1	
	S1-xx	SINGLE	108-XXXX VFL530 P65.BEAM 12 LED 700mA PC AMBER IP66 ALU LEC	28	1766	0.800	4	
	S1A-xx	SINGLE	108-XXXX VFL530-SE P65.BEAM 12 LED 700mA PC AMBER IP66 ALU LEC	28	1766	0.800	4	
	S1B-xx	BACK-BACK	108-XXXX VFL530-SE P65.BEAM 12 LED 700mA PC AMBER IP66 ALU LEC	28	1766	0.800	4	
	S3-xx	SINGLE	108-XXXX VFL530 R65.BEAM 24 LED 700mA PC AMBER IP66 ALU LEC	55	3312	0.800	6	
	S5-xx	SINGLE	108-XXXX VFL540 R65.BEAM 36 LED 700mA PC AMBER IP66 ALU LEC	84	4997	0.800	6	
	S5A-xx	BACK-BACK	108-XXXX VFL540 R65.BEAM 36 LED 700mA PC AMBER IP66 ALU LEC	84	4997	0.800	8	

LEGEND

CONDUIT
POWER - DISTRIBUTION
POWER - RETICULATION
POWER - LIGHTING
POWER - 4x150mm SPARE

POWER INFRASTRUCTURE
TRANSFORMER
SWITCHGEAR
SWITCHBOARD



MATCHLINE A REFER DRG E003

Dimensions and scales to be checked prior to measuring cable lengths.
(Scale bar only valid for sections of drawing that are as per specified scale)

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SCALE 1:500 @ ORIGINAL SHEET SIZE A1

NO CHANGES TO DESIGN UNLESS APPROVED BY DESIGN MANAGER

PRELIMINARY ISSUE ONLY

NOT FOR CONSTRUCTION

PRELIMINARY ISSUE ONLY

REV	DATE	DRAWN	PROJECT REVIEW	CHECKED	APPROVED	REVISION DESCRIPTION
A	08.01.19	LC	BT	NMcK	NMcK	ISSUED TO CLIENT FOR COMMENT

NOTE
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Certified Quality System to ISO 9001

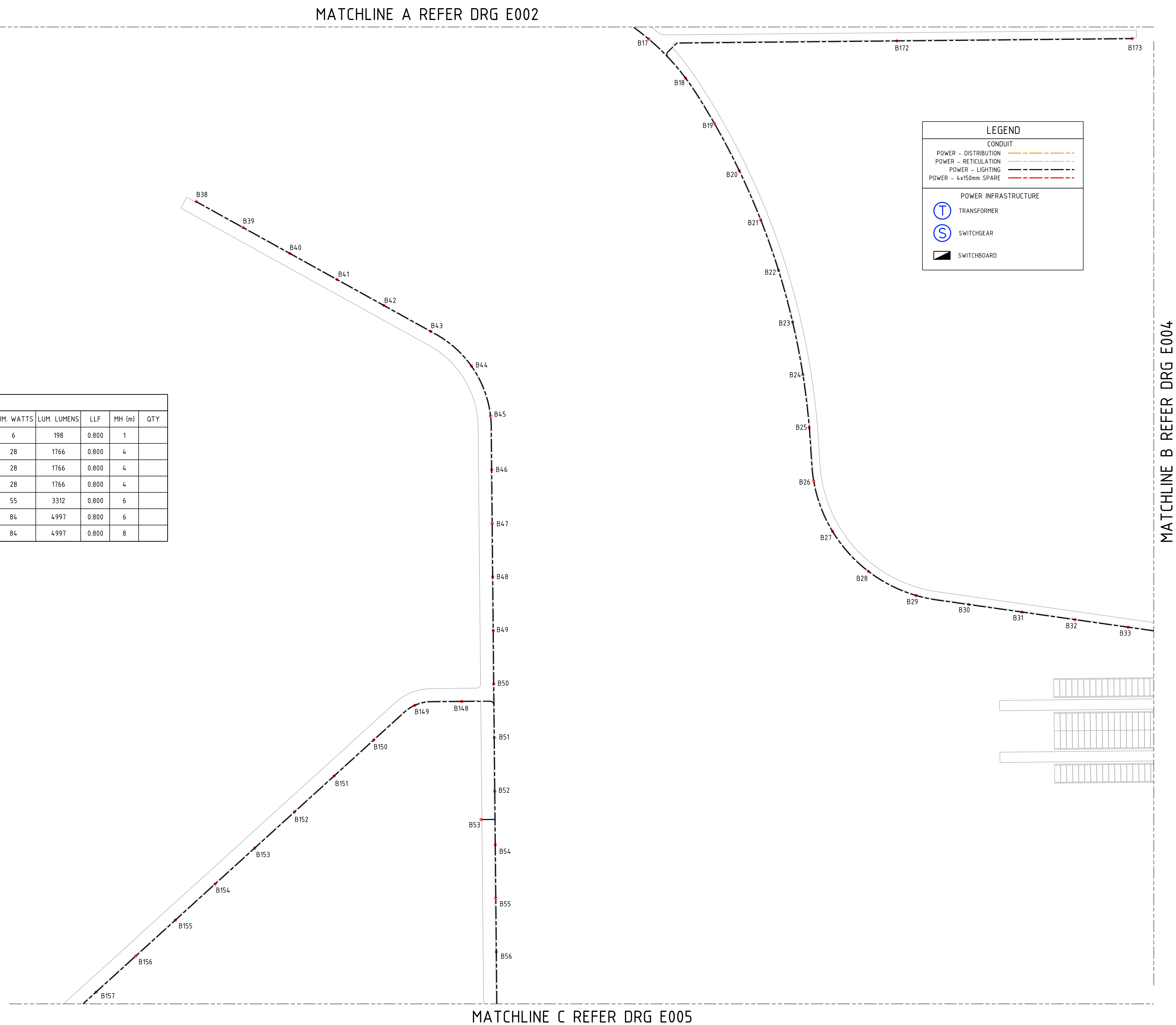
JDSi CONSULTING ENGINEERS
Workzone, Level 6, 1 Nash Street, Perth WA 6000
P: (08) 9227 0595 F: (08) 9227 8617

CLIENT: TOWN OF PORT HEDLAND

PROJECT: SPOILBANK MARINA

DRAWING TITLE: PRIVATE POWER AND LIGHTING DESIGN LAYOUT SHEET 1 OF 5

DRAWN	L.CONTEMPRATO
DESIGNED	L.CONTEMPRATO
PROJECT MANAGER	D.HELLMUTH
WAPC No.	
SCALE @ A1	1:500
DATUM/COORD	AHD/PHG94
HP REFERENCE	NA
JDSi PROJECT No.	JDS14736.0
DRAWING No.	E002
REVISION	B



LIGHTING SCHEDULE								
SYMBOL	LABEL	ARRANGEMENT	DESCRIPTION	LUM. WATTS	LUM. LUMENS	LLF	MH (m)	QTY
	Bxx	SINGLE	114-XXXX KTY234 R65.BEAM 3 LED 6W/700mA PC AMBER BOLLARD IP66 ALU LEC	6	198	0.800	1	
	S1-xx	SINGLE	108-XXXX VFL530 P65.BEAM 12 LED 700mA PC AMBER IP66 ALU LEC	28	1766	0.800	4	
	S1A-xx	SINGLE	108-XXXX VFL530-SE P65.BEAM 12 LED 700mA PC AMBER IP66 ALU LEC	28	1766	0.800	4	
	S1B-xx	BACK-BACK	108-XXXX VFL530-SE P65.BEAM 12 LED 700mA PC AMBER IP66 ALU LEC	28	1766	0.800	4	
	S3-xx	SINGLE	108-XXXX VFL530 R65.BEAM 24 LED 700mA PC AMBER IP66 ALU LEC	55	3312	0.800	6	
	S5-xx	SINGLE	108-XXXX VFL540 R65.BEAM 36 LED 700mA PC AMBER IP66 ALU LEC	84	4997	0.800	6	
	S5A-xx	BACK-BACK	108-XXXX VFL540 R65.BEAM 36 LED 700mA PC AMBER IP66 ALU LEC	84	4997	0.800	8	

Dimensions and scales to be checked prior to measuring cable lengths.
(Scale bar only valid for sections of drawing that are as per specified scale)

0 5 10 20 30m
SCALE 1:500 @ ORIGINAL SHEET SIZE A1

NO DESIGN CHANGES WITHOUT MANAGER APPROVAL

NO CHANGES TO DESIGN UNLESS APPROVED BY DESIGN MANAGER

PRELIMINARY ISSUE ONLY

NOT FOR CONSTRUCTION

PRELIMINARY ISSUE ONLY

REV	DATE	DRAWN	PROJECT REVIEW	CHECKED	APPROVED	REVISION DESCRIPTION
A	08.01.19	LC	BT	NMcK	NMcK	ISSUED TO CLIENT FOR COMMENT

NOTE
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Certified Quality System to ISO 9001

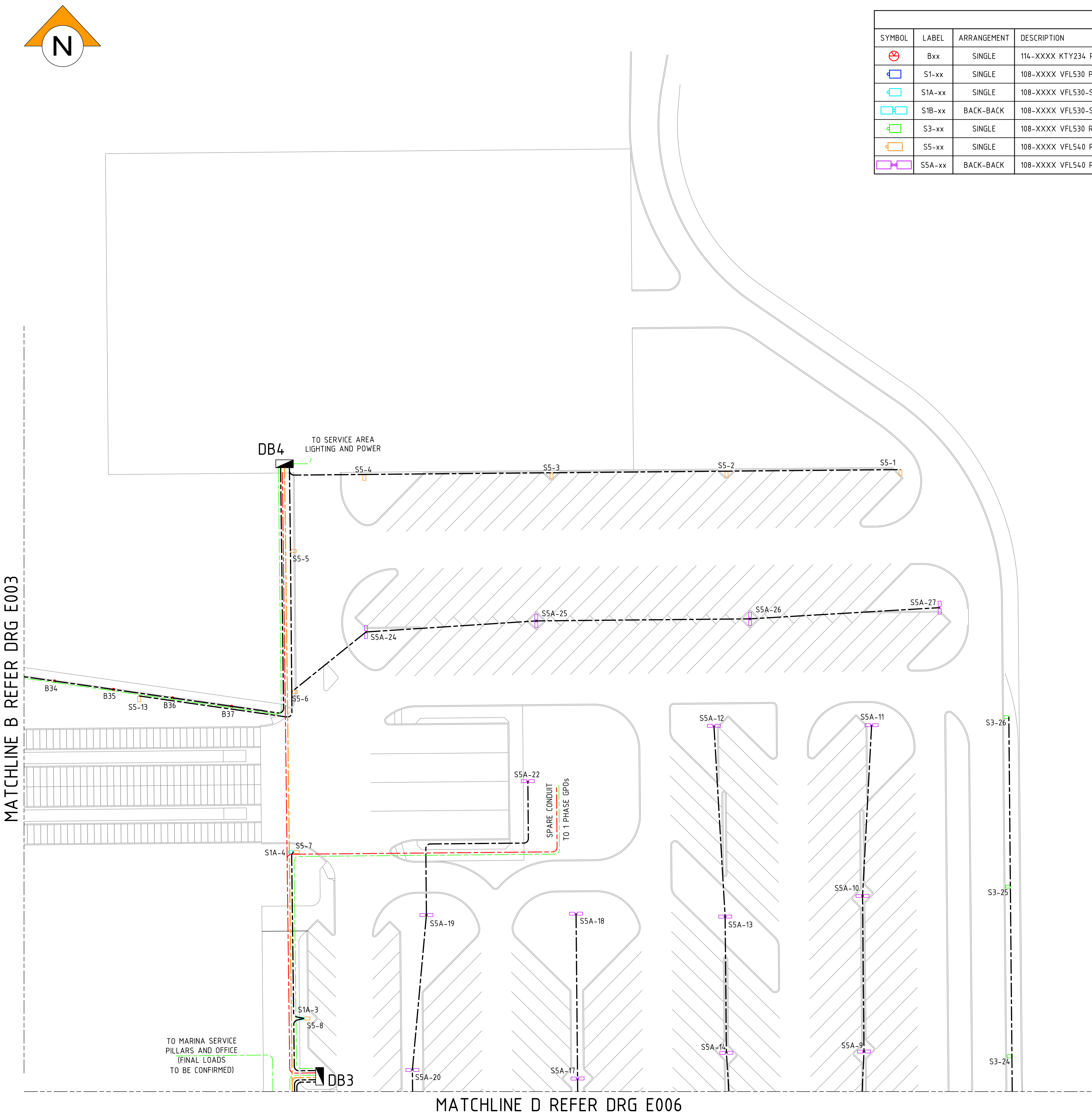
CONSULTING ENGINEERS
Workzone, Level 6, 1 Nash Street, Perth WA 6000
P: (08) 9227 0595 F: (08) 9227 8617

CLIENT: TOWN OF PORT HEDLAND

PROJECT: SPOILBANK MARINA

DRAWING TITLE: PRIVATE POWER AND LIGHTING DESIGN LAYOUT SHEET 2 OF 5

DRAWN	L.CONTEMPRATO
DESIGNED	L.CONTEMPRATO
PROJECT MANAGER	D.HELLMUTH
WAPC No.	
SCALE @ A1	1:500
DATUM/COORD	AHD/PHG94
HP REFERENCE	NA
JDSi PROJECT No.	JDS14736.0
DRAWING No.	E003
REVISION	B



LIGHTING SCHEDULE

SYMBOL	LABEL	ARRANGEMENT	DESCRIPTION	LUM. WATTS	LUM. LUMENS	LLF	MH (m)	QTY
	Bxx	SINGLE	114-XXXX KTY234 R65.BEAM 3 LED 6W/700mA PC AMBER BOLLARD IP66 ALU LEC	6	198	0.800	1	
	S1-xx	SINGLE	108-XXXX VFL530 P65.BEAM 12 LED 700mA PC AMBER IP66 ALU LEC	28	1766	0.800	4	
	S1A-xx	SINGLE	108-XXXX VFL530-SE P65.BEAM 12 LED 700mA PC AMBER IP66 ALU LEC	28	1766	0.800	4	
	S1B-xx	BACK-BACK	108-XXXX VFL530-SE P65.BEAM 12 LED 700mA PC AMBER IP66 ALU LEC	28	1766	0.800	4	
	S3-xx	SINGLE	108-XXXX VFL530 R65.BEAM 24 LED 700mA PC AMBER IP66 ALU LEC	55	3312	0.800	6	
	S5-xx	SINGLE	108-XXXX VFL540 R65.BEAM 36 LED 700mA PC AMBER IP66 ALU LEC	84	4997	0.800	6	
	S5A-xx	BACK-BACK	108-XXXX VFL540 R65.BEAM 36 LED 700mA PC AMBER IP66 ALU LEC	84	4997	0.800	8	

LEGEND

CONDUIT
POWER - DISTRIBUTION
POWER - RETICULATION
POWER - LIGHTING
POWER - 4x150mm SPARE

POWER INFRASTRUCTURE
TRANSFORMER
SWITCHGEAR
SWITCHBOARD

NOTES:

1. DB3-1 AT TOP OF REVETMENT WALL WILL PROVIDE MARINA SERVICE PILLAR RETICULATION TO FINAL CIRCUITS.

Dimensions and scales to be checked prior to measuring cable lengths.
(Scale bar only valid for sections of drawing that are as per specified scale)

0 5 10 20 30m
SCALE 1:500 @ ORIGINAL SHEET SIZE A1

NO DESIGN CHANGES
WITHOUT MANAGER APPROVAL

NO CHANGES TO DESIGN UNLESS APPROVED BY DESIGN MANAGER

PRELIMINARY ISSUE ONLY

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REV	DATE	DRAWN	PROJECT REVIEW	CHECKED	APPROVED	REVISION DESCRIPTION
A	08.01.19	LC	BT	NMcK	NMcK	ISSUED TO CLIENT FOR COMMENT

NOTE
This drawing shall be preliminary only until it is Issued for Construction.
Certified Quality System to ISO 9001

JDSi
CONSULTING ENGINEERS
Workzone, Level 6, 1 Nash Street, Perth WA 6000
P: (08) 9227 0595 F: (08) 9227 8617

CLIENT: TOWN OF PORT HEDLAND

PROJECT: SPOILBANK MARINA

DRAWING TITLE: PRIVATE POWER AND LIGHTING DESIGN LAYOUT SHEET 3 OF 5

DRAWN	L.CONTEMPRATO
DESIGNED	L.CONTEMPRATO
PROJECT MANAGER	D.HELLMUTH
WAPC No.	
SCALE @ A1	1:500
DATUM/COORD	AHD/PHG94
HP REFERENCE	NA
JDSi PROJECT No.	JDS14736.0
DRAWING No.	E004
REVISION	B

N

LEGEND

CONDUIT

- POWER - DISTRIBUTION
- POWER - RETICULATION
- POWER - LIGHTING
- POWER - 4x150mm SPARE

POWER INFRASTRUCTURE

- T TRANSFORMER
- S SWITCHGEAR
- SWITCHBOARD

Dimensions and scales to be checked prior to measuring cable lengths.
(Scale bar only valid for sections of drawing that are as per specified scale)

0 5 10 20 30m

SCALE 1:500 @ ORIGINAL SHEET SIZE A1

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PRELIMINARY ISSUE ONLY

NOT FOR CONSTRUCTION

LIGHTING SCHEDULE

SYMBOL	LABEL	ARRANGEMENT	DESCRIPTION	LUM. WATTS	LUM. LUMENS	LLF	MH (m)	QTY
	Bxx	SINGLE	114-XXXX KTY234 R65.BEAM 3 LED 6W/700mA PC AMBER BOLLARD IP66 ALU LEC	6	198	0.800	1	
	S1-xx	SINGLE	108-XXXX VFL530 P65.BEAM 12 LED 700mA PC AMBER IP66 ALU LEC	28	1766	0.800	4	
	S1A-xx	SINGLE	108-XXXX VFL530-SE P65.BEAM 12 LED 700mA PC AMBER IP66 ALU LEC	28	1766	0.800	4	
	S1B-xx	BACK-BACK	108-XXXX VFL530-SE P65.BEAM 12 LED 700mA PC AMBER IP66 ALU LEC	28	1766	0.800	4	
	S3-xx	SINGLE	108-XXXX VFL530 R65.BEAM 24 LED 700mA PC AMBER IP66 ALU LEC	55	3312	0.800	6	
	S5-xx	SINGLE	108-XXXX VFL540 R65.BEAM 36 LED 700mA PC AMBER IP66 ALU LEC	84	4997	0.800	6	
	S5A-xx	BACK-BACK	108-XXXX VFL540 R65.BEAM 36 LED 700mA PC AMBER IP66 ALU LEC	84	4997	0.800	8	

PRELIMINARY ISSUE ONLY

REV	DATE	DRAWN	PROJECT REVIEW	CHECKED	APPROVED	REVISION DESCRIPTION
A	08.01.19	LC	BT	NMcK	NMcK	ISSUED TO CLIENT FOR COMMENT

NOTE
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JDSi CONSULTING ENGINEERS
Workzone, Level 6, 1 Nash Street, Perth WA 6000
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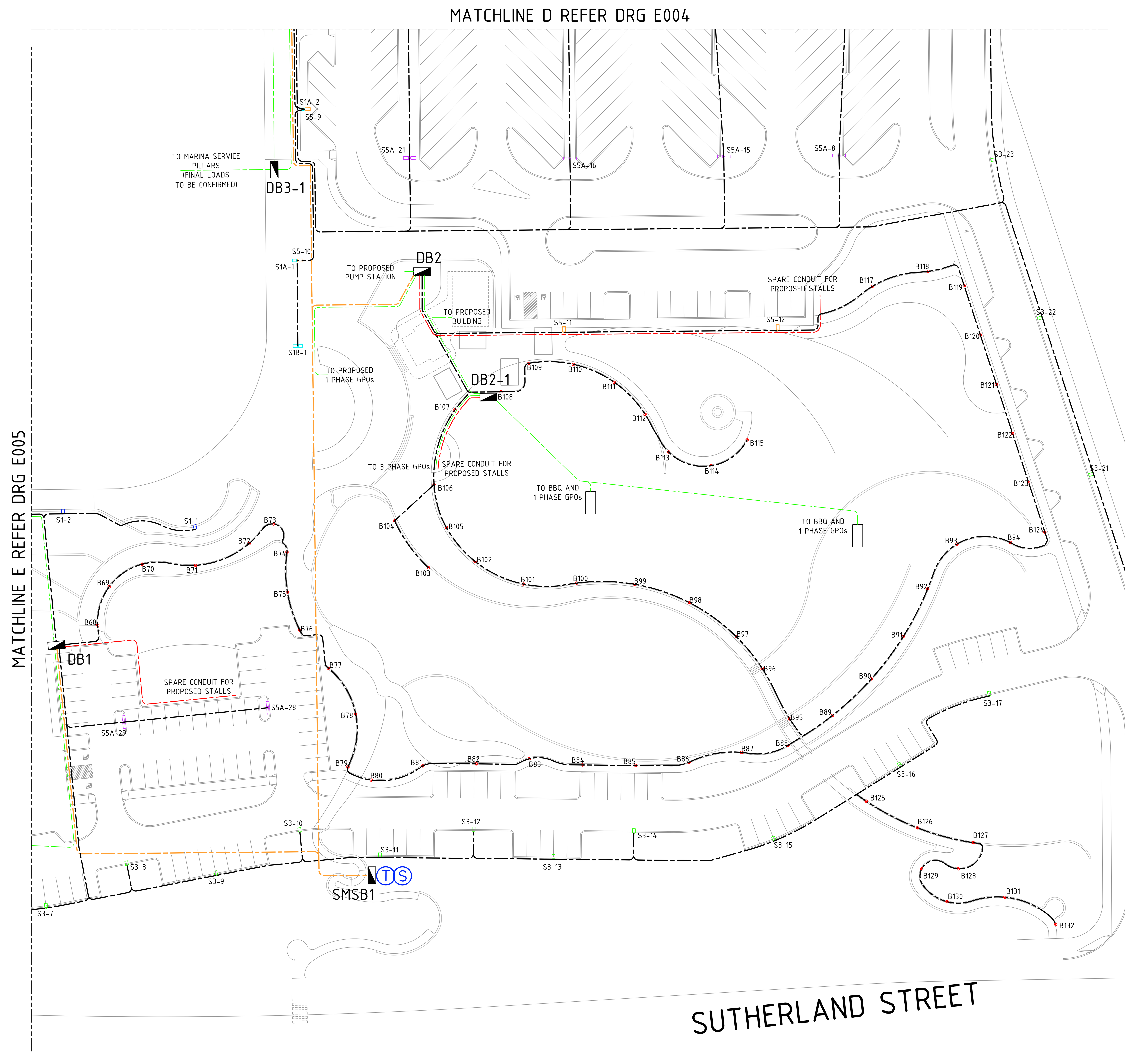
CLIENT: TOWN OF PORT HEDLAND

PROJECT: SPOILBANK MARINA

DRAWING TITLE: PRIVATE POWER AND LIGHTING DESIGN LAYOUT SHEET 4 OF 5

DRAWN	L.CONTEMPRATO
DESIGNED	L.CONTEMPRATO
PROJECT MANAGER	D.HELLMUTH
WAPC No.	
SCALE @ A1	1:500
DATUM/COORD	AHD/PHG94
HP REFERENCE	NA
JDSi PROJECT No.	JDS14736.0
DRAWING No.	E005
REVISION	B



LEGEND

CONDUIT
POWER - DISTRIBUTION
POWER - RETICULATION
POWER - LIGHTING
POWER - 4x150mm SPARE

POWER INFRASTRUCTURE
TRANSFORMER
SWITCHGEAR
SWITCHBOARD

N

LIGHTING SCHEDULE									
SYMBOL	LABEL	ARRANGEMENT	DESCRIPTION	LUM. WATTS	LUM. LUMENS	LLF	MH (m)	QTY
	Bxx	SINGLE	114-XXXX KTY234 R65.BEAM 3 LED 6W/700mA PC AMBER BOLLARD IP66 ALU LEC	6	198	0.800	1	
	S1-xx	SINGLE	108-XXXX VFL530 P65.BEAM 12 LED 700mA PC AMBER IP66 ALU LEC	28	1766	0.800	4	
	S1A-xx	SINGLE	108-XXXX VFL530-SE P65.BEAM 12 LED 700mA PC AMBER IP66 ALU LEC	28	1766	0.800	4	
	S1B-xx	BACK-BACK	108-XXXX VFL530-SE P65.BEAM 12 LED 700mA PC AMBER IP66 ALU LEC	28	1766	0.800	4	
	S3-xx	SINGLE	108-XXXX VFL530 R65.BEAM 24 LED 700mA PC AMBER IP66 ALU LEC	55	3312	0.800	6	
	S5-xx	SINGLE	108-XXXX VFL540 R65.BEAM 36 LED 700mA PC AMBER IP66 ALU LEC	84	4997	0.800	6	
	S5A-xx	BACK-BACK	108-XXXX VFL540 R65.BEAM 36 LED 700mA PC AMBER IP66 ALU LEC	84	4997	0.800	8	

Dimensions and scales to be checked prior to measuring cable lengths.
(Scale bar only valid for sections of drawing that are as per specified scale)

0 5 10 20 30m
SCALE 1:500 @ ORIGINAL SHEET SIZE A1

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Certified Quality System to ISO 9001

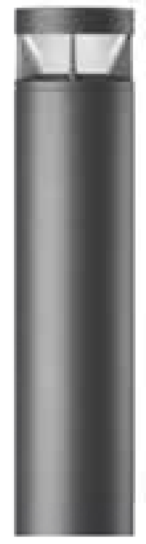
JDSi CONSULTING ENGINEERS
Workzone, Level 6, 1 Nash Street, Perth WA 6000
P: (08) 9227 0595 F: (08) 9227 8617

CLIENT: TOWN OF PORT HEDLAND

PROJECT: SPOILBANK MARINA

DRAWING TITLE: PRIVATE POWER AND LIGHTING DESIGN LAYOUT SHEET 5 OF 5

DRAWN: L.CONTEMPRATO
DESIGNED: L.CONTEMPRATO
PROJECT MANAGER: D.HELLMUTH
WAPC No.:
SCALE @ A1: 1:500
DATUM/COORD: AHD/PHG94
HP REFERENCE: NA
JDSi PROJECT No.: JDS14736.0
DRAWING No.: E006
REVISION: B

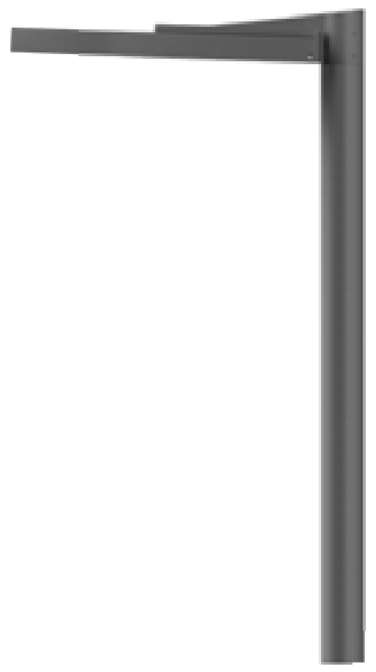


BOLLARD LIGHTING

WE-EF
KTY234

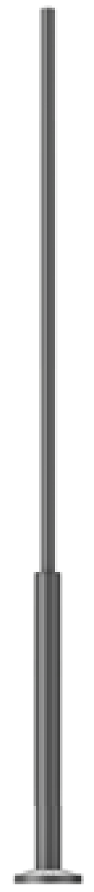
POLE TOP LIGHTING

WE-EF
VFL530 & VFL540



POLE TOP LIGHTING

WE-EF
VFL530-SE



LIGHTING POLE

WE-EF
AMF-S
270-9388 4.0m
270-9320 6.0m
270-9324 8.0m

LIGHTING DESIGN TO AUSTRALIAN STANDARD AS/NZS1158.3.1
LIGHTING FOR PEDESTRIAN AREAS - CATEGORY P4
GENERAL STREET LIGHTING - CATEGORY P4
CAR PARK LIGHTING - CATEGORY P11C

LIGHTING SCHEDULE

SYMBOL	LABEL	ARRANGEMENT	DESCRIPTION	LUM. WATTS	LUM. LUMENS	LLF	MH (m)	QTY
	Bxx	SINGLE	114-XXXX KTY234 R65.BEAM 3 LED 6W/700mA PC AMBER BOLLARD IP66 ALU LEC	6	198	0.800	1	
	S1-xx	SINGLE	108-XXXX VFL530 P65.BEAM 12 LED 700mA PC AMBER IP66 ALU LEC	28	1766	0.800	4	
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	S5-xx	SINGLE	108-XXXX VFL540 R65.BEAM 36 LED 700mA PC AMBER IP66 ALU LEC	84	4997	0.800	6	
	S5A-xx	BACK-BACK	108-XXXX VFL540 R65.BEAM 36 LED 700mA PC AMBER IP66 ALU LEC	84	4997	0.800	8	

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PRELIMINARY ISSUE ONLY

REV	DATE	DRAWN	PROJECT REVIEW	CHECKED	APPROVED	REVISION DESCRIPTION
A	08.01.19	LC	BT	NMcK	NMcK	ISSUED TO CLIENT FOR COMMENT

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Certified Quality System to ISO 9001

CONSULTING ENGINEERS
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P: (08) 9227 0595 F: (08) 9227 8617

CLIENT: TOWN OF PORT HEDLAND

PROJECT: SPOILBANK MARINA

DRAWING TITLE: PRIVATE POWER AND LIGHTING DESIGN DETAILS

DRAWN: L.CONTEMPRATO
DESIGNED: L.CONTEMPRATO
PROJECT MANAGER: D.HELLMUTH
WAPC No.:
SCALE @ A1: N/A
DATUM/COORD: AHD/PHG94
HP REFERENCE: NA
JDSi PROJECT No.: JDS14736.0
DRAWING No.: E007
REVISION: B

Appendix B

Port Hedland Marina - Benchmark Artificial Light Survey

RPS AUSTRALIA WEST

PORT HEDLAND MARINA – BENCHMARK ARTIFICIAL LIGHT AT NIGHT SURVEY

Prepared by

Pendoley Environmental Pty Ltd

For

RPS Australia West

15th November 2019

DOCUMENT CONTROL INFORMATION

TITLE: PORT HEDLAND MARINA - BENCHMARK ARTIFICIAL LIGHT AT NIGHT SURVEY

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Document History

Revision	Description	Date received	Date issued	Personnel
Draft	Report Draft		14/11/2019	A. Mitchell
Rev A	Internal Review	14/11/2019	14/11/2019	K. Pendoley
Rev B	Client review	17/12/2019	17/12/2019	G. Glasson
Rev 0	Final report issued		06/02/2019	A. Mitchell

Printed:	6 February 2020
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Author:	Adam Mitchell
Project manager:	Dr Kellie Pendoley
Name of organisation:	Pendoley Environmental Pty Ltd
Name of project:	Port Hedland Marina – Benchmark ALAN Survey
Client	RPS Australia West
Client representative:	Giles Glasson
Report number:	J69001
Cover photo:	Drone footage of Port Hedland at night – Paul Whittock

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1 INTRODUCTION

1.1 Project Background

The Western Australia (WA) Department of Transport (DoT) and LandCorp are proposing to construct a marina on the western side of a man-made spoilbank in Port Hedland. The proposed marina is located immediately west of Cemetery Beach, which is a known nesting site for flatback turtles (*Natator depressus*). Flatback turtles are a threatened species, listed as Vulnerable under the WA *Biodiversity Conservation Act 2016* and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

One of the potential impacts to flatback turtles is from new lighting installed as part of the proposed marina development. RPS Australia West (RPS) partnered with Pendoley Environmental (PENV) to assist with delivering an artificial lighting impact assessment for the Port Hedland marina with specific reference to the Cemetery Beach flatback turtle rookery.

The approach adopted to address the potential impact of the marina development's artificial light to nesting adult turtles and emergent hatchlings included early engagement with key project stakeholders, a benchmark light monitoring survey, and this survey report.

The stakeholder engagement included consultations with:

- Michelle Corobellini and David Pickles of the Environmental Management Branch, and Dr Scott Whiting of the Department of Biodiversity Conservation and Attractions (DBCA) were consulted on 13th September 2019 by Kellie Pendoley (PENV) and John Halleen (RPS) to confirm the proposed lighting impact assessment methodology. DBCA were satisfied with the proposed approach and asked only that an additional survey location on the spoilbank be included.

- Kelly Howlett (Care for Hedland) was contacted by Kellie Pendoley on 23rd September to discuss the marina proposal, lighting impact assessment methods, and proposed light monitoring locations in respect to the turtle nesting data held by Care for Hedland. She offered to provide her hatchling orientation data for Cemetery Beach and this data has been requested.

The results of the benchmark light monitoring survey of Cemetery Beach is provided in this report.

1.2 Deliverables

The DBCA and Care for Hedland confirmed the scope of works for the benchmark light survey included:

1. Overview of benchmark light monitoring methodology;
2. Identification of the existing Cemetery Beach night light environment;
3. Provide an estimation of light outputs from the marina in respect to the existing surrounding light levels recorded by the benchmark light monitoring; and
4. Liaison with the consulting engineer group (JDSi) to review the outputs of the final lighting design to inform preparation of this report.

Figure 1: Artificial light survey locations in Port Hedland.

2 METHODOLOGY

2.1 Survey Locations and Schedule

Two survey locations were selected on Cemetery Beach (see **Figure 1**); one situated at the east end of the beach and the second at the western end of the beach. The exact survey locations at Cemetery Beach were refined on site following:

- Daytime and night-time site reconnaissance of potential locations to ascertain ease-of-access to specific geographic locations and line of sight visibility of the light dome over Port Hedland.
- Assessment of survey location security (with regards to leaving equipment on site overnight unattended).

Cameras were deployed at these survey locations for each of the three monitoring nights.

Two additional survey locations (Spoilbank and Pretty Pool) were monitored for several hours on one night each (see **Figure 1**). These survey locations were included following consultation with Care for Hedland (K. Howlett) and DBCA (S. Whiting).

GPS coordinates of each survey location were recorded to enable comparison with future lighting surveys if required. The survey sites and GPS positions for the cameras are shown in **Table 1** and the monitoring schedule and camera locations are shown in **Table 2**.

Table 1: Survey locations and GPS positions.

Survey location	Latitude	Longitude
CB East	-20.307010	118.612659
CB West	-20.307670	118.608730
Pretty Pool	-20.314001	118.644642
Spoilbank	-20.307220	118.593262

Table 2: Monitoring schedule.

Date	Survey location: Overnight Deployment	Survey location: Short-term Deployment
30/09/2019	CB East, CB West	Pretty Pool
01/10/2019	CB East, CB West	NA
02/10/2019	CB East, CB West	Spoilbank

2.2 Data Capture

Sky brightness data was gathered using automated Sky42™ light monitoring cameras that feature a Canon EOS 700D camera and fish-eye lens with custom built hardware to acquire low light night sky images of the entire sky. The cameras are built into a rigid housing with a protective lid that automatically opens during image capture and closes between capture intervals. The cameras were deployed at each survey location and were programmed to automatically begin taking photos in 15-minute intervals between sunset and sunrise. Images were downloaded from the cameras each day.

Flatback hatchling fan data was captured by Care For Hedland (CFH) over the 2018/19 and 2019/20 nesting seasons and then quality checked for errors by PENV. However, as no information on CFH data collection methods is currently available to PENV, this was only a high-level check looking for obvious errors. Records with uncertainty around their validity were completely removed from the dataset (approximately 30 records).

2.3 Data Analysis

The quality of an image captured by a Sky42 light monitoring camera can be influenced by atmospheric factors such as the presence of the moon, twilight, cloud, rain, dust, humidity, or physical factors such as accumulation of sand or dust on the lens. Any images that were affected by physical factors were removed from the analysis, as well as any images that were affected by the moon or twilight.

All suitable images were processed to determine "whole-of-sky", "zenith", and "horizon" sky brightness levels. Zenith is the mean value of sky glow in magnitudes within 0° – 30° field of view directly overhead, whole-of-sky (WOS) is the mean value of sky glow in the entire image, and horizon is the mean value of sky glow within the 60° – 90° outer band (**Figure 2**).

Sky brightness was quantified in units of visual magnitudes/arcsec^2 (a standard unit used in astronomical measurements and emerging as a standard for sky glow monitoring globally). The visual magnitudes/arcsec^2 unit quantifies light intensity on an inverted logarithmic scale, i.e. higher values represent lower intensity light, while lower values represent higher intensity light (**Table 3**). The image with the median value of sky brightness for each site on a clear night was selected for complete analysis and presentation in this report.

Table 3: Qualitative interpretation of magnitude band values (source: Unihedron Sky Quality Meter). Use as guide only. **Values <17 Vmag/arcsec^2 not provided by source (considered to represent light level greater than 'very high' and representative of skies brighter than an urban night sky horizon).

Magnitude (Vmag/arcsec^2)	Qualitative Intepretation	Qualitative Example of Interpretation
21 – 22	Very low	Ideal natural dark night sky horizon
20 – 21	Low	Typical rural night sky horizon
19 – 20	Moderate	Typical suburban night sky horizon
18 – 19	High	Typical urban night sky horizon
17 – 18	Very High**	Poor urban night sky horizon

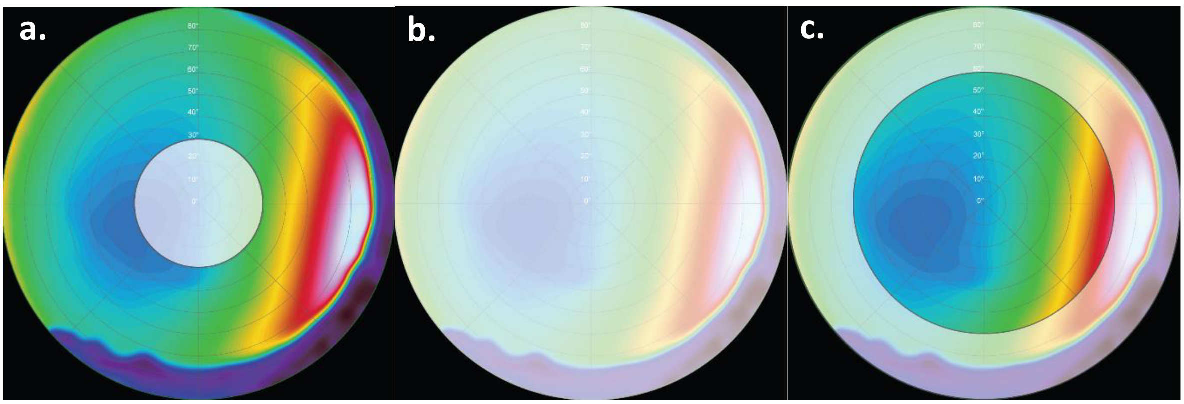

Figure 2: Measurement of mean pixel values; a. Zenith brightness (0° – 30°); b. WOS brightness (full image); c. Horizon brightness (60° – 90°). White shaded areas denote the region of the sky being measured.

Note that the colour coding used in the isophote map represents the scale of intensity of light and is not representative of the colour of light as perceived by a human/turtle eye or Sky42 camera.

3 RESULTS

Data was successfully collected from the four survey locations during three nights between 31st September and 2nd October 2019. There was no adverse weather and all nights were free of rain and cloud cover. The m sky brightness from each median image at each survey site are shown in **Table 4** and **Figure 3**. The Spoilbank survey location recorded the brightest WOS, zenith, and horizon values, and the Pretty Pool survey location recorded the darkest WOS, zenith, and horizon values (**Table 4**).

Table 4: Mean sky brightness (Vmag/arcsec^2) for zenith, whole-of-sky, and horizon brightness from a median image captured on a clear night at each survey location. Note survey locations are ordered by closest distance from the proposed marina development.

Survey location	Sky Brightness (Vmag/arcsec^2)		
	Whole-of-sky	Zenith	Horizon
Spoilbank	18.55	19.57	18.12
CB West	18.73	19.80	18.28
CB East	18.99	19.85	18.63
Pretty Pool	19.49	20.43	19.09

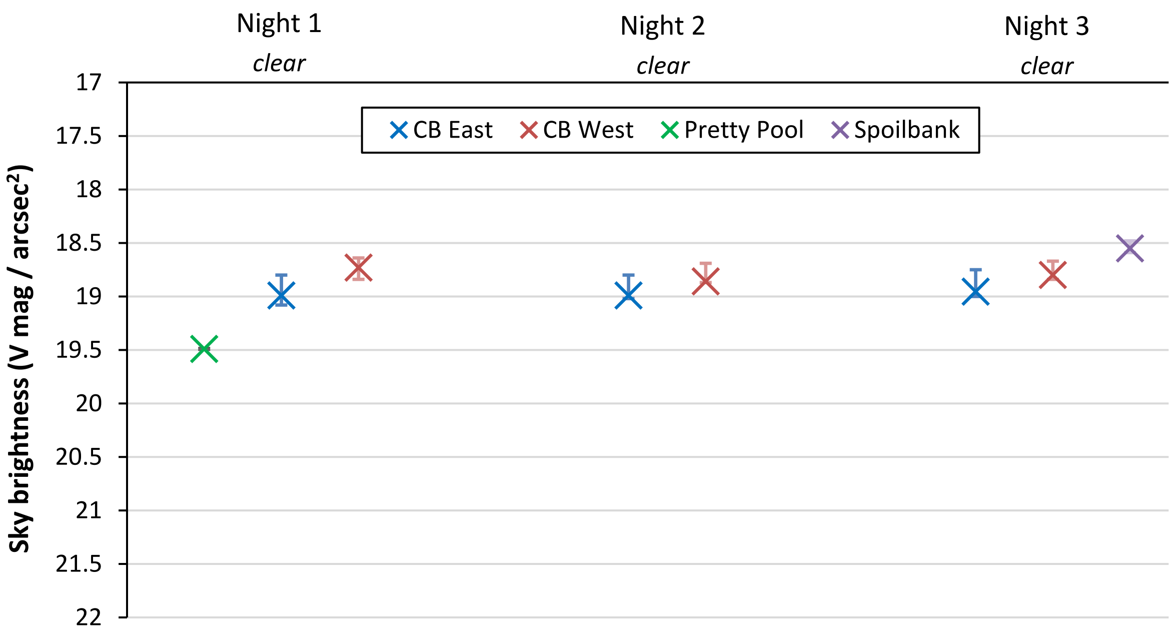

Figure 3: Whole-of-sky brightness at all sites over the survey period. An 'X' represents the median value for that site on a particular night, with the error bars indicating the range. The y-axis has been reversed to show brighter values towards the top and darker values towards the bottom of the graph.

The port facilities were the most dominant source of sky glow in Port Hedland and were visible from each survey location (see **Figures 4 – 7**). This was closely followed by Port Hedland residential and commercial lighting. Point sources of light that were directly visible from each survey location have been identified and are summarised in **Table 5**. Hatchling fan data collected on Cemetery Beach during the 2018/19 and 2019/20 nesting season shows a wide spread of tracks with minor bias towards the western light sources (**Figure 8**).

Table 5: Bearing to visible point sources of light from each survey location.

Survey location	Point source of light	Bearing from survey location
Spoilbank (Figure 4)	Street lighting	280° – 320°
	CB Turtle Park	90°
CB West (Figure 5)	Water tower	95°
	CB Turtle Park	260°
	Street lighting	60° - 100°
	Ibis hotel	140°
	Offshore vessels on moorings	330° - 10°
CB East (Figure 6)	Water tower	200°
	Council building	180°
	Aquatic centre	90°
	Street lighting	70° - 85°, 240° - 280°
	Offshore vessels on moorings	330° - 10°
	CB Turtle Park	260°
Pretty Pool (Figure 7)	Street lighting	300° - 340°
	Offshore vessels on moorings	350° - 360°

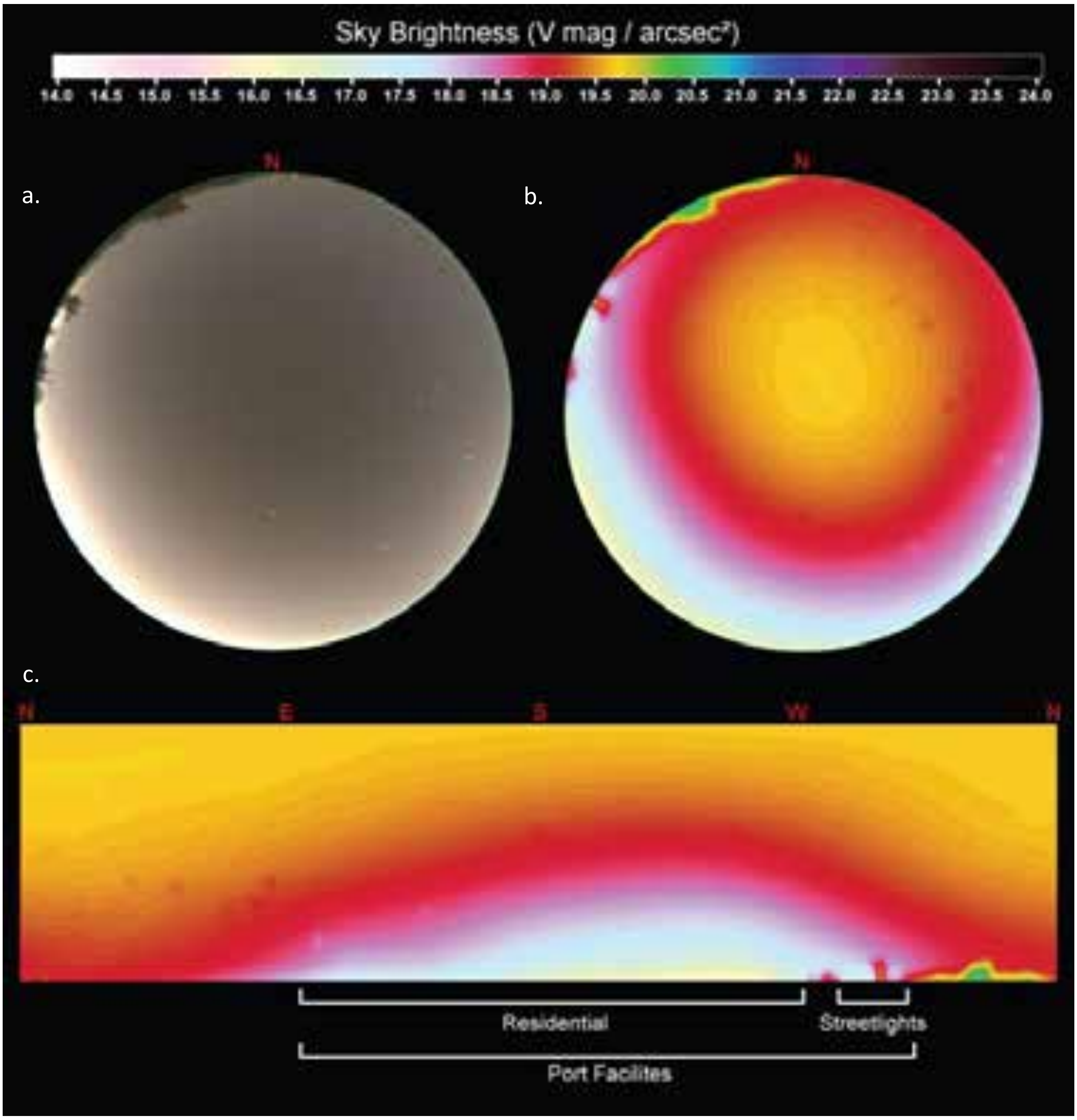

Figure 4: Artificial light monitoring results at Spoilbank on 2nd October 2019; a. Median raw image; b. Processed isophote image; c. Processed equirectangular panorama showing location of visible light sources.

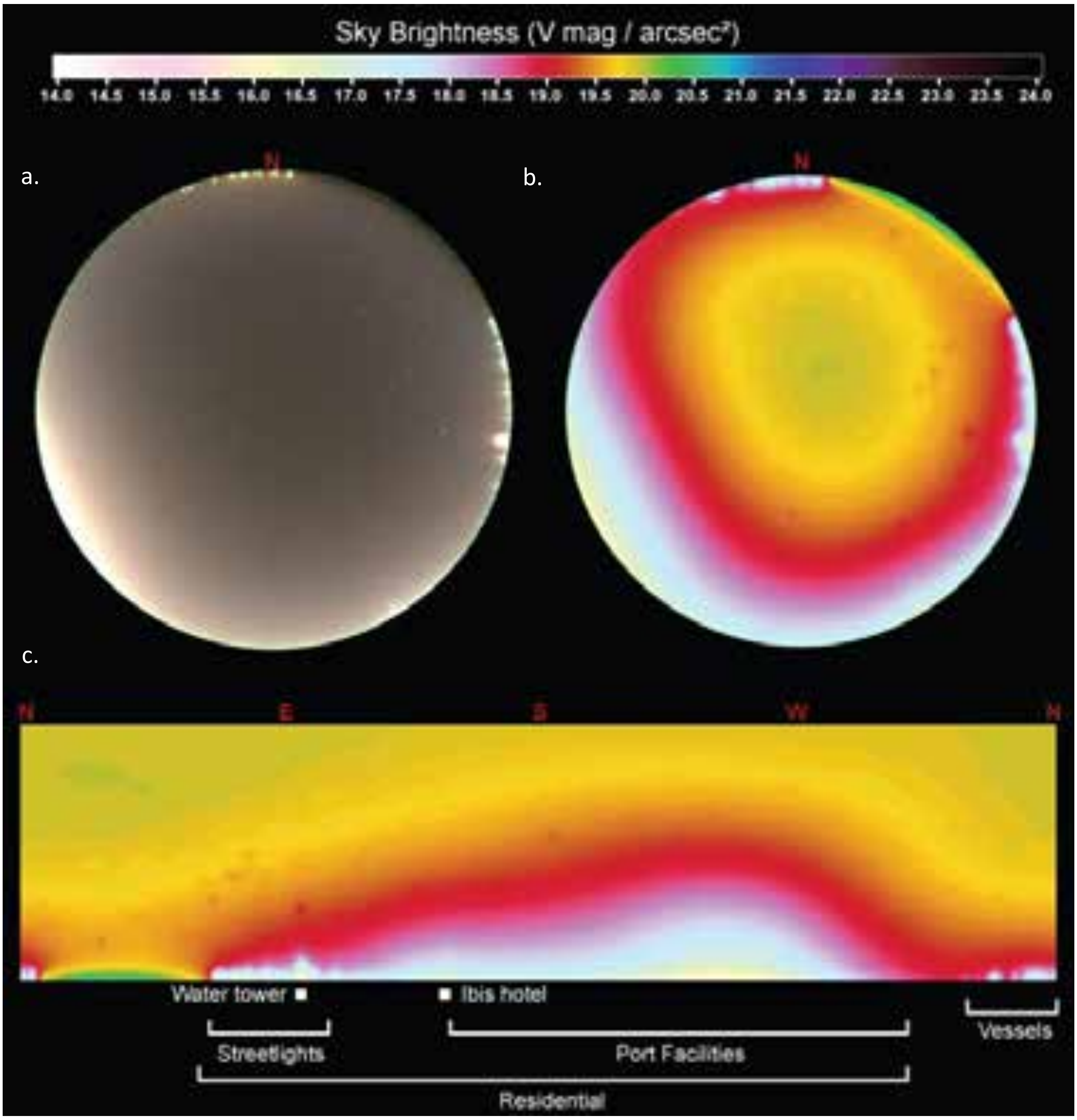

Figure 5: Artificial light monitoring results at CB West on 30th September 2019; a. Median raw image; b. Processed isophote image; c. Processed equirectangular panorama showing location of visible light sources.

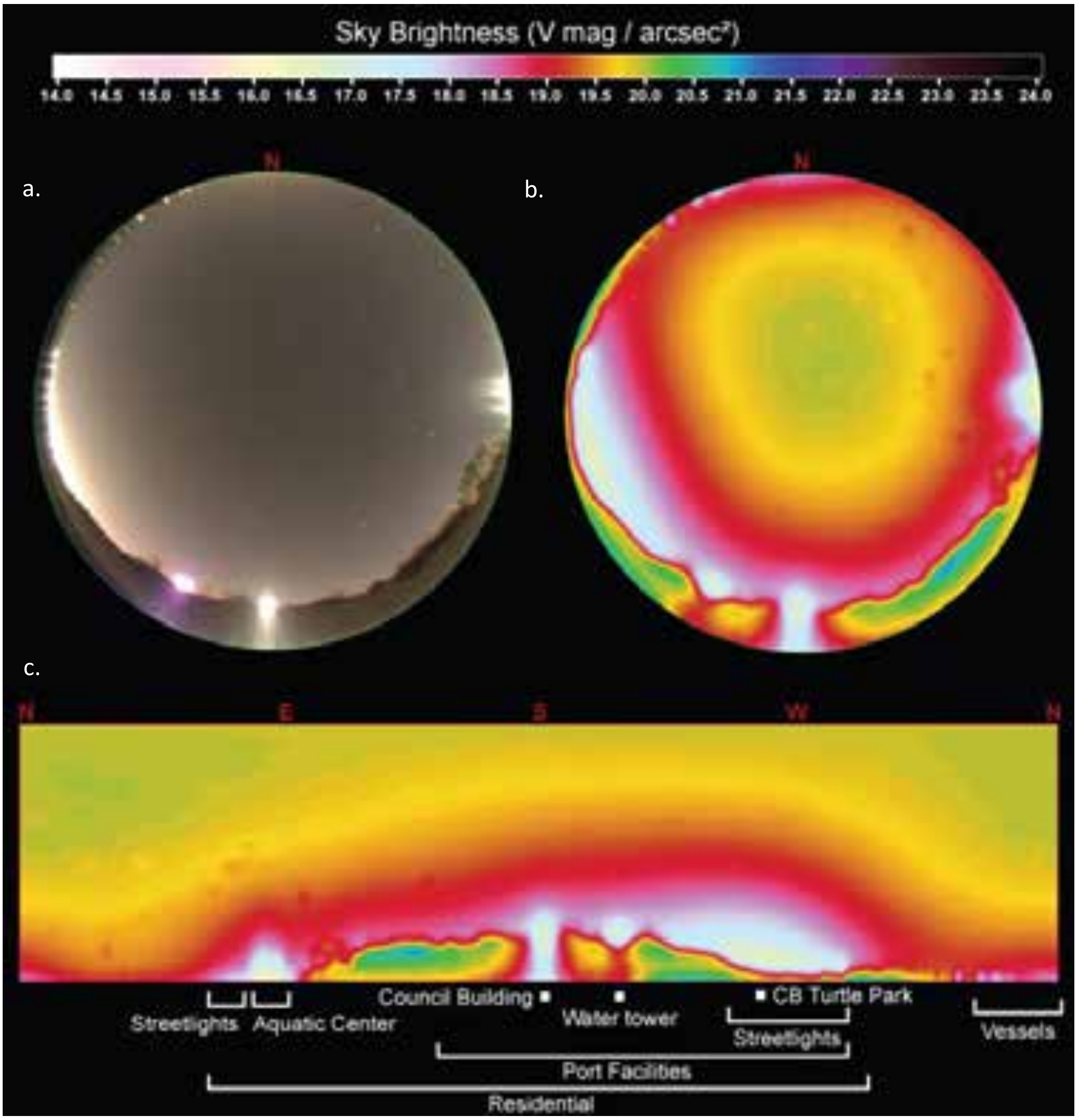

Figure 6: Artificial light monitoring results at CB East on 30th September 2019; a. Median raw image; b. Processed isophote image; c. Processed equirectangular panorama showing location of visible light sources.

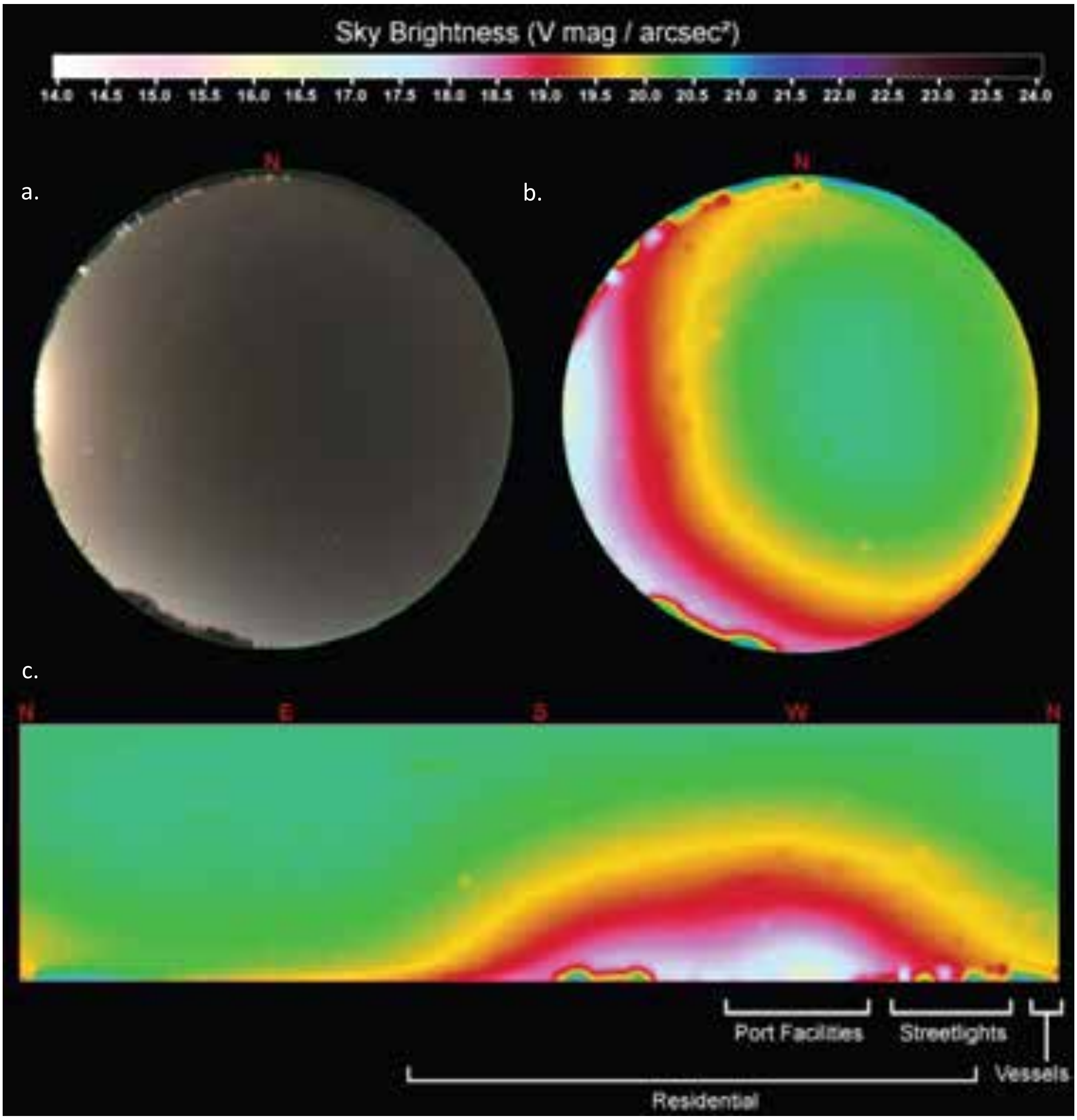

Figure 7: Artificial light monitoring results at Pretty Pool on 30th September 2019; a. Median raw image; b. Processed isophote image; c. Processed equirectangular panorama showing location of visible light sources.

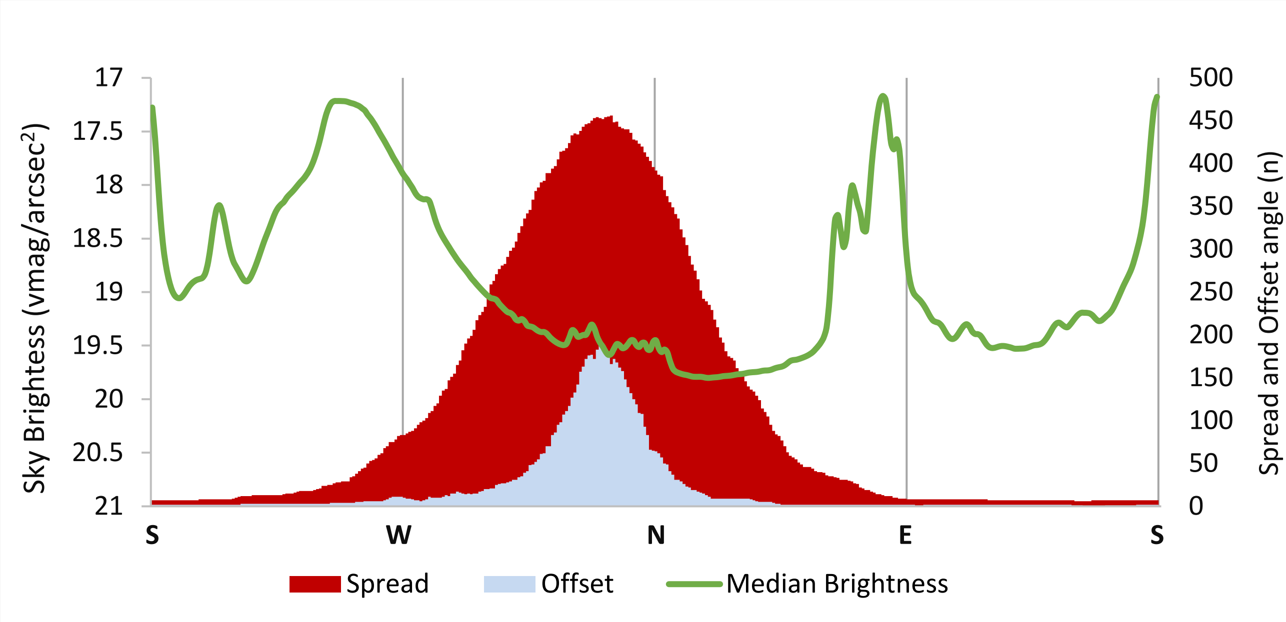

Figure 8: CFH hatchling fan data from Cemetery Beach in relation to brightness levels on the horizon (0° – 30°). Red: Histogram of hatchling fan spread angles; Blue: Histogram of hatchling fan angles offset from the ocean; Green: Horizon sky brightness levels from the CB East Sky42 camera location on cemetery beach.

4 DISCUSSION

The sky glow visible from all four survey locations was dominated by the port loading, processing and stockpiling facilities followed by urban residential and commercial lighting. The benchmark study results found a spatial relationship with distance from the proposed marina site with the brightest values recorded at the Spoilbank survey location, closest to the port light sources, and the darkest values recorded at Pretty Pool, furthest away from the light sources (**Table 4**). The two survey locations on Cemetery Beach showed that there is currently significant sky glow originating primarily from the port facilities, and residential lighting on a lesser scale, in the direction of the proposed marina site (approximately 260° – 290° bearing). A highly visible, bright source of unshielded bright white light (the light frequency considered most disruptive to sea turtles) originates from the Turtle Centre facility situated at the western end of Cemetery Beach (**Figures 5** and **6**), and is a potential cause of minor hatchling disorientation (**Figure 8**). Other unshielded point sources of light visible from the beach include commercial and council facilities and streetlights adjacent to Cemetery Beach.

Lighting design plans from JDSi indicate the intent for lowered bollard-style walkway lighting throughout the site, and taller pole-mounted street lighting on the access road and parking areas. The bollard-style lighting will not be directly visible from the beach and have a negligible effect on sky glow due to the low lumen output and low height above ground. The pole-mounted lighting, while unlikely to increase sky glow more than the current measured levels, will be directly visible from the beach in some locations. As this has the potential to further increase hatchling disorientation towards the west end of Cemetery Beach, it is recommended that shielding be placed on these east-facing side of these lights to prevent or reduce line-of-sight visibility from Cemetery Beach.

5 REFERENCES

DEPARTMENT ENERGY AND ENVIRONMENT (*in review*) DRAFT National Light Pollution Guidelines for Wildlife - including Marine Turtles, Seabirds and Migratory Shorebirds.

Appendix C

Line of sight analysis

EXISTING SURFACE LEVEL	4.92	7.05	6.82	6.16	5.39	4.51	3.83	4.36	4.25					0.53	-0.19	-0.93	-1.52	-1.72	-1.80	-1.82	-1.92		
CENTRE LINE CHAINAGE	100.00	150.00	200.00	250.00	300.00	350.00	400.00	450.00	500.00	550.00	600.00	650.00	700.00	750.00	800.00	850.00	900.00	950.00	1000.00	1050.00	1100.00	1150.00	1200.00

EXISTING SURFACE LEVEL												-0.92	-0.73	-0.48	-0.27	-0.08	0.13	0.28	0.56	1.55	2.59	4.01	4.26
CENTRE LINE CHAINAGE	1250.00	1300.00	1350.00	1400.00	1450.00	1500.00	1550.00	1600.00	1650.00	1700.00	1750.00	1800.00	1850.00	1900.00	1950.00	2000.00	2050.00	2100.00	2150.00	2200.00	2250.00	2300.00	2350.00

SECTION TO MOST SEAWARD LIGHT

EXISTING SURFACE LEVEL	4.81	7.05	9.39	8.86	7.99	6.24	5.41	5.72	4.07	4.52	4.68	2.69	1.99	1.14	0.07	-1.03	-1.20	-1.47	-1.54	-1.55	-1.58	-1.61	-1.64
CENTRE LINE CHAINAGE	100.00	150.00	200.00	250.00	300.00	350.00	400.00	450.00	500.00	550.00	600.00	650.00	700.00	750.00	800.00	850.00	900.00	950.00	1000.00	1050.00	1100.00	1150.00	1200.00

EXISTING SURFACE LEVEL	-1.68	-1.60	-1.48	-1.41				-0.92	-0.76	-0.56	-0.29	-0.28	-0.22	-0.16	0.03	0.28	0.42	0.86	1.53	2.25	3.12	4.06	4.26
CENTRE LINE CHAINAGE	1250.00	1300.00	1350.00	1400.00	1450.00	1500.00	1550.00	1600.00	1650.00	1700.00	1750.00	1800.00	1850.00	1900.00	1950.00	2000.00	2050.00	2100.00	2150.00	2200.00	2250.00	2300.00	2350.00

SECTION THROUGH CARPARK

EXISTING SURFACE LEVEL	7.11	7.99	8.87	10.34	9.57	8.28	7.20	6.54	5.58	3.47	3.42	4.02	4.80	3.93	2.22	-0.07	-0.07	-0.13	-0.15	-0.12	-0.14	-0.16	-0.21
CENTRE LINE CHAINAGE	100.00	150.00	200.00	250.00	300.00	350.00	400.00	450.00	500.00	550.00	600.00	650.00	700.00	750.00	800.00	850.00	900.00	950.00	1000.00	1050.00	1100.00	1150.00	1200.00

EXISTING SURFACE LEVEL	-0.22	-0.23	-0.27	-0.26	-0.20	-0.12	-0.01	0.39	2.38	1.93	1.80	1.55	1.30	1.25	1.40	1.59	1.89	2.23	2.57	3.11	3.96	4.06	4.26
CENTRE LINE CHAINAGE	1250.00	1300.00	1350.00	1400.00	1450.00	1500.00	1550.00	1600.00	1650.00	1700.00	1750.00	1800.00	1850.00	1900.00	1950.00	2000.00	2050.00	2100.00	2150.00	2200.00	2250.00	2300.00	2350.00

SECTION TO YACHT CLUB

PRELIMINARY

REV	DATE	DRAWN	CHECKED	APPROVED

NOTE
This drawing shall be preliminary only until it is issued for Construction.

Certified Quality System to ISO 9001

JDSi CONSULTING ENGINEERS
Workzone, Level 6, 1 Nash Street, Perth WA 6000
P: (08) 9227 0595 F: (08) 9227 8617

CLIENT: TOWN OF PORT HEDLAND

PROJECT: SPOILBANK MARINA

DRAWING TITLE: SECTIONS TOWARDS CEMETERY BEACH WITH EXTENDED SURVEY SHOWING TURTLE NESTING AREAS

DRAWN: STEVE PARK	WAPC No.		
DESIGNED: STEVE PARK	SCALE @ A1: 1:3000		
PROJECT MANAGER: D HELLMUTH	DATUM: AHD	CO-ORDS: PHG94	
JDSi PROJECT No.: JDS14736.0	DRAWING No.: SK503	REVISION: A	

Plotted By: drullo Plot Date: 29/11/19 - 17:02 Cad File: I:\JDS14736\Drawings\DWG\Sketches\JDS14736.0_SK500.dwg

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Appendix B: Marina Waterfront Lighting Design

LEGEND

CONDUIT

- POWER – DISTRIBUTION
- POWER – RETICULATION
- POWER – LIGHTING
- POWER – 2x150mm SPARE
- POWER – 4x150mm SPARE

POWER INFRASTRUCTURE

- TRANSFORMER
- SWITCHBOARD
- ACO CABLEMATE TYPE 66 CABLE PIT
- ACO CABLEMATE TYPE 99 CABLE PIT

LIGHTING

- BOLLARD – WE-EF KTY234 6W
- 4m SINGLE OUTREACH – WE-EF VFL530 28W
- 4m SINGLE OUTREACH – WE-EF VFL530-SE 28W
- 4m DOUBLE OUTREACH – WE-EF VFL530 28W
- 6m SINGLE OUTREACH – WE-EF VFL530 55W
- 6m SINGLE OUTREACH – WE-EF VFL540 84W
- 8m DOUBLE OUTREACH – WE-EF VFL540 84W
- BATON LIGHT XXXXXXXXXXXXX
- RECESSED WALL MOUNTED – WE-EF QRI354 12W
- DOWNLIGHT – WE-EF FLC121 12W (PIPE CLAMP)

NOTES:

1. DRAWING TO BE READ IN CONJUNCTION WITH THE ELECTRICAL SPECIFICATION AND ALL OTHER SERVICES WHICH FORMS PART OF THIS PROJECT.
2. PIT SURROUNDS INCLUDING DIMENSIONS, COLLARS, REINFORCING, BACKFILL, CONCRETE ENCASING (SIDE & BASE), BEDDING, ETC. ARE NOMINAL ONLY AND ARE TO BE PROVED AND INSTALLED IN ACCORDANCE WITH THE PIT MANUFACTURERS RECOMMENDATIONS TO ACHIEVE SPECIFIC PIT LOADING/CLASS RATING. ENSURE PIT BASE DRAINS TO LOCATION OF DRAINAGE CONDUIT.
3. POWER PITS SHALL BE OF DEPTH REQUIRED TO SUIT ALL CONDUITS SHOWN ON THE DRAWING AND ALL CONDUIT SPACING REQUIREMENTS SHOWN HERE IN. CONDUIT MINIMUM 500mm BELOW FINISHED GROUND LEVEL TO MEET AS/NZS 3000.
4. ALL CABLING IS TO BE CONCEALED WITHIN THE HOLLOW SHADE STRUCTURE. CABLE PATHS ARE TO BE COORDINATED WITH STRUCTURAL CONTRACTOR TO ENSURE PENETRATIONS BETWEEN CROSS MEMBERS ARE MADE AND DRAW WIRE INSTALLED.
5. CABLE AND CONDUIT PENETRATIONS INTO THE SHADE STRUCTURE ARE TO BE SUITABLY GLANDED AND SEALED TO PREVENT MOISTURE INGRESS.

Dimensions and scales to be checked prior to measuring cable lengths.
(Scale bar only valid for sections of drawing that are as per specified scale)

0 5 10 20 30m
SCALE 1:500 @ ORIGINAL SHEET SIZE A1

NO DESIGN CHANGES
WITHOUT MANAGER APPROVAL

NO CHANGES TO DESIGN UNLESS APPROVED BY DESIGN MANAGER

ISSUED FOR CONSTRUCTION
THIS DRAWING IS NOT TO BE USED FOR OPERATIONAL PURPOSES.
THIS DRAWING IS NOT TO BE USED TO IDENTIFY EXISTING WESTERN POWER ASSETS.
CONTRACTOR MUST REQUEST THIS INFORMATION FROM APPOINTED CONSTRUCTION MANAGER.
PLEASE CONTACT JDSi FOR ANY DRAWING CLARIFICATIONS.

REV	DATE	DRAWN	PROJECT REVIEW	CHECKED	APPROVED	REVISION DESCRIPTION
1	04.04.23	DC	AS	–	–	NOTE REMOVED FOR CLARITY
0	31.03.23	LC	AS	NMcK	NMcK	ISSUD FOR CONSTRUCTION
G	30.09.22	LC	BT	NMcK	NMcK	ISSUED FOR TENDER
F	04.08.22	LC	BT	NMcK	NMcK	ISSUED FOR TENDER
E	15.07.22	LC	BT	NMcK	NMcK	ISSUED FOR TENDER
D	28.04.22	LC	BT	LC	BT	ISSUED FOR JDAP APPROVAL
C	23.07.20	LC	DH	LC	–	ISSUED FOR DA
B	17.03.20	LC	BT	NMcK	NMcK	ISSUED FOR APPROVAL
A	08.01.19	LC	BT	NMcK	NMcK	ISSUED TO CLIENT FOR COMMENT

NOTE
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Certified Quality System to ISO 9001

JDSi CONSULTING ENGINEERS
Level 1, 432 Murray Street, Perth WA 6000
P: (08) 9227 0595 F: (08) 9227 8617

CLIENT: PILBARA PORTS AUTHORITY

PROJECT: SPOILBANK MARINA
PACKAGE 4 – CIVIL AND LANDSCAPING

DRAWING TITLE: PRIVATE LIGHTING RETICULATION
DESIGN LAYOUT
SHEET 1 OF 3

DRAWN: L.CONTEMPRATO	WAPC No.		
DESIGNED: L.CONTEMPRATO	SCALE @ A1: 1:500		
PROJECT MANAGER: D.HELLMUTH	DATUM/COORD: AHD/PHG94	HP REFERENCE: NA	
JDSi PROJECT No.: JDS14736.0	DRAWING No.: E102		REVISION: 1

N

LEGEND

CONDUIT

- POWER – DISTRIBUTION
- POWER – RETICULATION
- POWER – LIGHTING
- POWER – 2x150mm SPARE
- POWER – 4x150mm SPARE

POWER INFRASTRUCTURE

- T TRANSFORMER
- SWITCHBOARD
- ACO CABLEMATE TYPE 66 CABLE PIT
- ACO CABLEMATE TYPE 99 CABLE PIT

LIGHTING

- BOLLARD – WE-EF KTY234 6W
- 4m SINGLE OUTREACH – WE-EF VFL530 28W
- 4m SINGLE OUTREACH – WE-EF VFL530-SE 28W
- 4m DOUBLE OUTREACH – WE-EF VFL530 28W
- 6m SINGLE OUTREACH – WE-EF VFL530 55W
- 6m SINGLE OUTREACH – WE-EF VFL540 84W
- 8m DOUBLE OUTREACH – WE-EF VFL540 84W
- BATON LIGHT XXXXXXXXXXXXX
- RECESSED WALL MOUNTED – WE-EF QRI354 12W
- DOWNLIGHT – WE-EF FLC121 12W (PIPE CLAMP)

NOTES:

1. DRAWING TO BE READ IN CONJUNCTION WITH THE ELECTRICAL SPECIFICATION AND ALL OTHER SERVICES WHICH FORMS PART OF THIS PROJECT.
2. PIT SURROUNDS INCLUDING DIMENSIONS, COLLARS, REINFORCING, BACKFILL, CONCRETE ENCASING (SIDE & BASE), BEDDING, ETC. ARE NOMINAL ONLY AND ARE TO BE PROVED AND INSTALLED IN ACCORDANCE WITH THE PIT MANUFACTURERS RECOMMENDATIONS TO ACHIEVE SPECIFIC PIT LOADING/CLASS RATING. ENSURE PIT BASE DRAINS TO LOCATION OF DRAINAGE CONDUIT.
3. POWER PITS SHALL BE OF DEPTH REQUIRED TO SUIT ALL CONDUITS SHOWN ON THE DRAWING AND ALL CONDUIT SPACING REQUIREMENTS SHOWN HERE IN. CONDUIT MINIMUM 500mm BELOW FINISHED GROUND LEVEL TO MEET AS/NZS 3000.

Dimensions and scales to be checked prior to measuring cable lengths.
(Scale bar only valid for sections of drawing that are as per specified scale)

0 5 10 20 30m
SCALE 1:500 @ ORIGINAL SHEET SIZE A1

NO DESIGN CHANGES
WITHOUT MANAGER APPROVAL

NO CHANGES TO DESIGN UNLESS APPROVED BY DESIGN MANAGER

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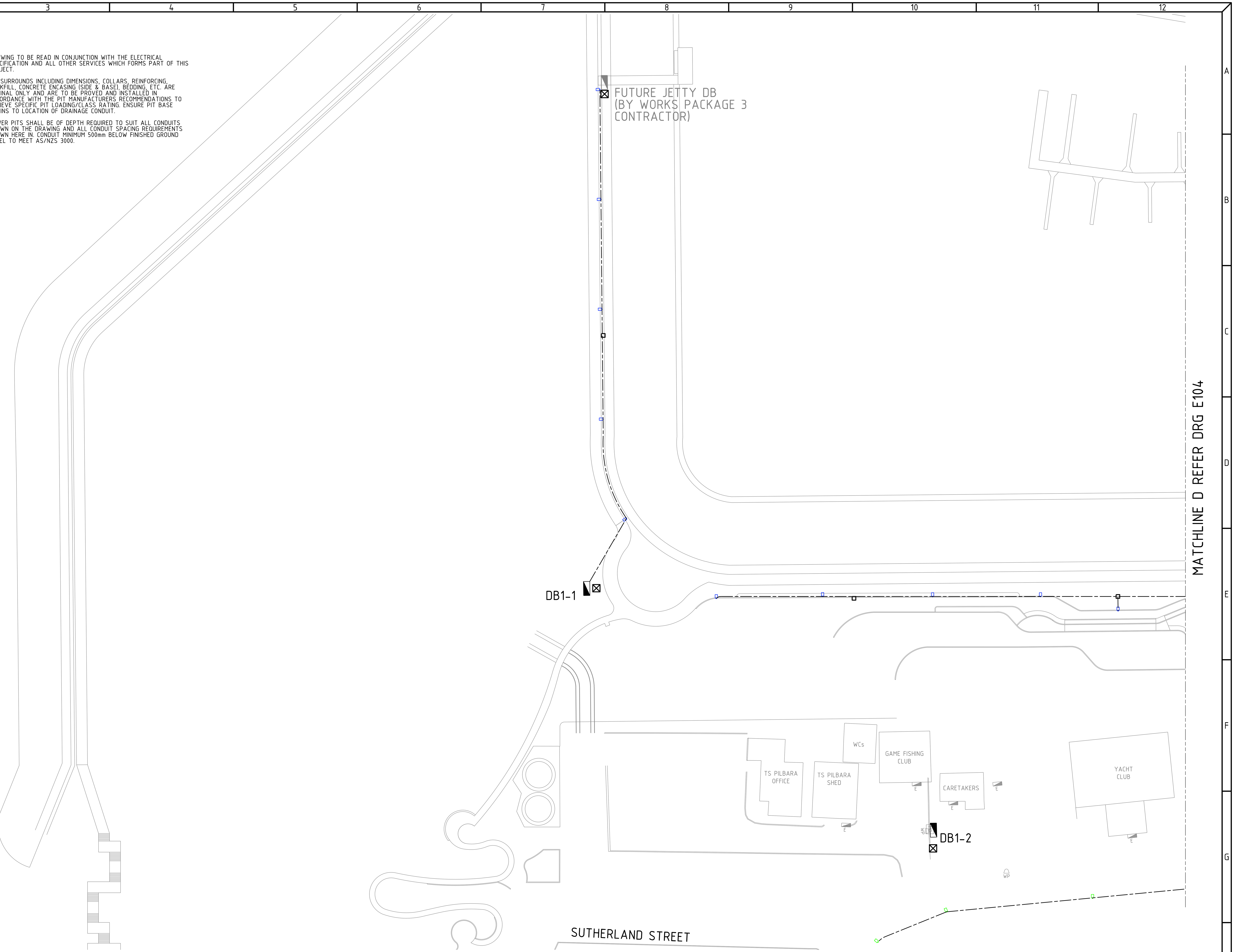

REV	DATE	DRAWN	PROJECT REVIEW	CHECKED	APPROVED	REVISION DESCRIPTION
1	04.04.23	DC	AS	-	-	NOTE REMOVED FOR CLARITY
0	31.03.23	LC	AS	NMcK	NMcK	ISSUED FOR CONSTRUCTION
G	30.09.22	LC	BT	NMcK	NMcK	ISSUED FOR TENDER
F	04.08.22	LC	BT	NMcK	NMcK	ISSUED FOR TENDER
E	15.07.22	LC	BT	NMcK	NMcK	ISSUED FOR TENDER
D	28.04.22	LC	BT	LC	BT	ISSUED FOR JDAP APPROVAL
C	23.07.20	LC	DH	LC	-	ISSUED FOR DA
B	17.03.20	LC	BT	NMcK	NMcK	ISSUED FOR INFORMATION
A	08.01.19	LC	BT	NMcK	NMcK	ISSUED TO CLIENT FOR COMMENT

NOTE
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Certified Quality System to ISO 9001

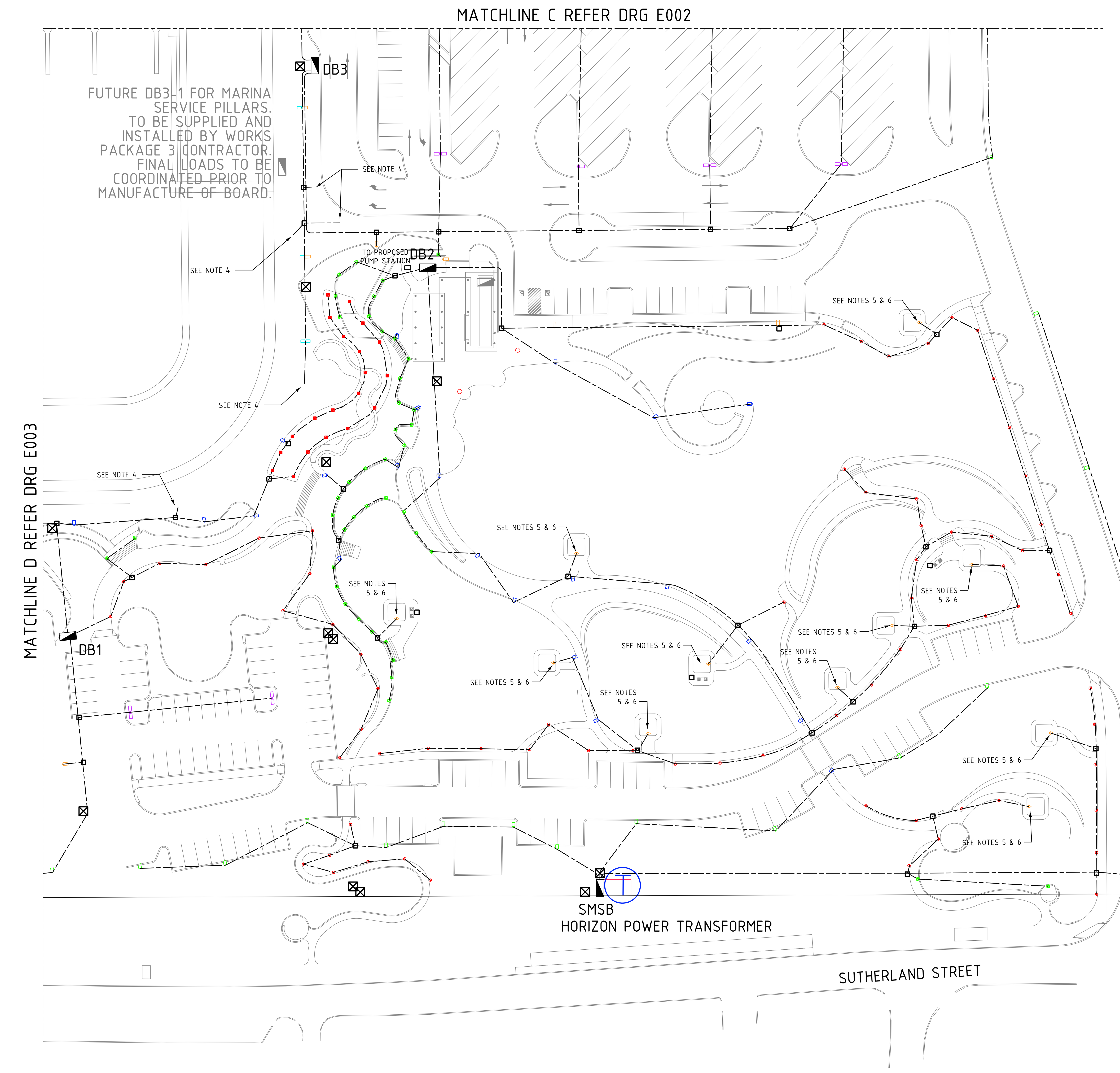
JDSi
CONSULTING ENGINEERS
Level 1, 432 Murray Street, Perth WA 6000
P: (08) 9227 0595 F: (08) 9227 8617

CLIENT: PILBARA PORTS AUTHORITY

PROJECT:
SPOILBANK MARINA
PACKAGE 4 – CIVIL AND LANDSCAPING

DRAWING TITLE:
PRIVATE LIGHTING RETICULATION
DESIGN LAYOUT
SHEET 2 OF 3

DRAWN: L.CONTEMPRATO	WAPC No.		
DESIGNED: L.CONTEMPRATO	SCALE @ A1: 1:500		
PROJECT MANAGER: D.HELLMUTH	DATUM/COORD: AHD/PHG94	HP REFERENCE: NA	
JDSi PROJECT No.: JDS14736.0	DRAWING No.: E103	REVISION: 1	



NOTES:

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3. POWER PITS SHALL BE OF DEPTH REQUIRED TO SUIT ALL CONDUITS SHOWN ON THE DRAWING AND ALL CONDUIT SPACING REQUIREMENTS SHOWN HERE IN. CONDUIT MINIMUM 500mm BELOW FINISHED GROUND LEVEL TO MEET AS/NZS 3000.
4. CONTRACTOR TO COORDINATE LIGHTING CIRCUIT WITH SEAT INSTALL.
5. ALL CABLING IS TO BE CONCEALED WITHIN THE HOLLOW SHADE STRUCTURE. CABLE PATHS ARE TO BE COORDINATED WITH STRUCTURAL CONTRACTOR TO ENSURE PENETRATIONS BETWEEN CROSS MEMBERS ARE MADE AND DRAW WIRE INSTALLED.
6. CABLE AND CONDUIT PENETRATIONS INTO THE SHADE STRUCTURE ARE TO BE SUITABLY GLANDED AND SEALED TO PREVENT MOISTURE INGRESS.

LEGEND

CONDUIT
- POWER - DISTRIBUTION
- POWER - RETICULATION
- POWER - LIGHTING
- POWER - 2x150mm SPARE
- POWER - 4x150mm SPARE

POWER INFRASTRUCTURE
- TRANSFORMER
- SWITCHBOARD
- ACO CABLEMATE TYPE 66 CABLE PIT
- ACO CABLEMATE TYPE 99 CABLE PIT

LIGHTING
- BOLLARD - WE-EF KTY234 6W
- 4m SINGLE OUTREACH - WE-EF VFL530 28W
- 4m SINGLE OUTREACH - WE-EF VFL530-SE 28W
- 4m DOUBLE OUTREACH - WE-EF VFL530 28W
- 6m SINGLE OUTREACH - WE-EF VFL530 55W
- 6m SINGLE OUTREACH - WE-EF VFL540 84W
- 8m DOUBLE OUTREACH - WE-EF VFL540 84W
- SHELTER LIGHTING (SURFACE MOUNTED) WE-EF PLS420 15W
- RECESSED WALL MOUNTED - WE-EF QRI354 12W
- DOWNLIGHT - WE-EF FLC121 12W (PIPE CLAMP)

N

Dimensions and scales to be checked prior to measuring cable lengths.
(Scale bar only valid for sections of drawing that are as per specified scale)

0 5 10 20 30m
SCALE 1:500 @ ORIGINAL SHEET SIZE A1

ISSUED FOR CONSTRUCTION
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NO DESIGN CHANGES
WITHOUT MANAGER APPROVAL

NO CHANGES TO DESIGN UNLESS APPROVED BY DESIGN MANAGER

REV	DATE	DRAWN	PROJECT REVIEW	CHECKED	APPROVED	REVISION DESCRIPTION
1	04.04.23	DC	AS	-	-	NOTE REMOVED FOR CLARITY
0	31.03.23	LC	AS	NMcK	NMcK	ISSUED FOR CONSTRUCTION
G	30.09.22	LC	BT	NMcK	NMcK	ISSUED FOR TENDER
F	04.08.22	LC	BT	NMcK	NMcK	ISSUED FOR TENDER
E	15.07.22	LC	BT	NMcK	NMcK	ISSUED FOR TENDER
D	28.04.22	LC	BT	LC	BT	ISSUED FOR JDAP APPROVAL
C	23.07.20	LC	DH	LC	-	ISSUED FOR DA
B	17.03.20	LC	BT	NMcK	NMcK	ISSUED FOR INFORMATION
A	08.01.19	LC	BT	NMcK	NMcK	ISSUED TO CLIENT FOR COMMENT

NOTE
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Certified Quality System to ISO 9001

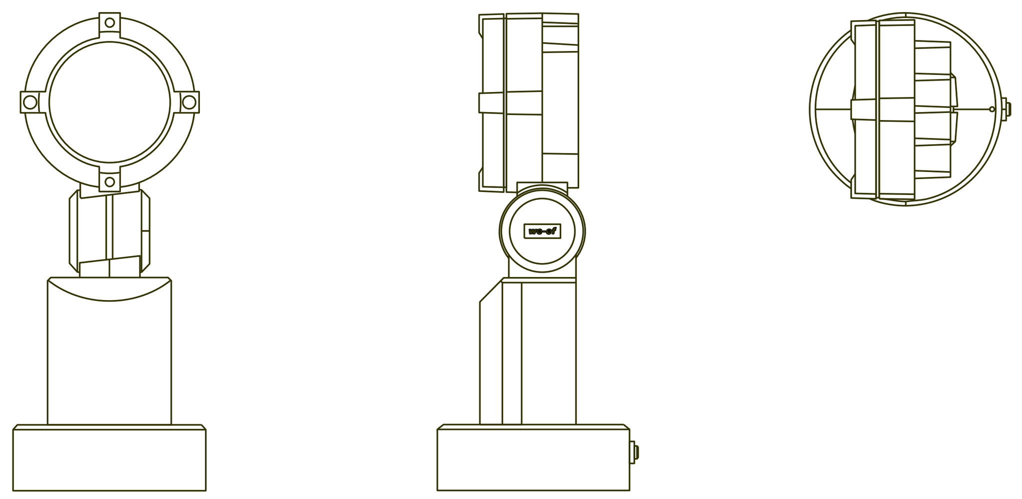
JDSi CONSULTING ENGINEERS
Level 1, 432 Murray Street, Perth WA 6000
P: (08) 9227 0595 F: (08) 9227 8617

CLIENT: PILBARA PORTS AUTHORITY

PROJECT: SPOILBANK MARINA
PACKAGE 4 - CIVIL AND LANDSCAPING

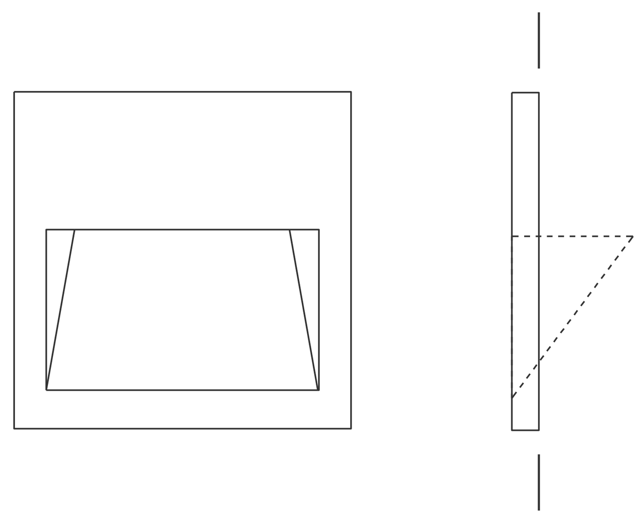
DRAWING TITLE: PRIVATE LIGHTING RETICULATION DESIGN LAYOUT SHEET 3 OF 3

DRAWN	WAPC No.	
L.CONTEMPRATO		
DESIGNED	SCALE @ A1	
L.CONTEMPRATO	1:500	
PROJECT MANAGER	DATUM/COORD	HP REFERENCE
D.HELLMUTH	AHD/PHG94	NA
JDSi PROJECT No.	DRAWING No.	REVISION
JDS14736.0	E104	1



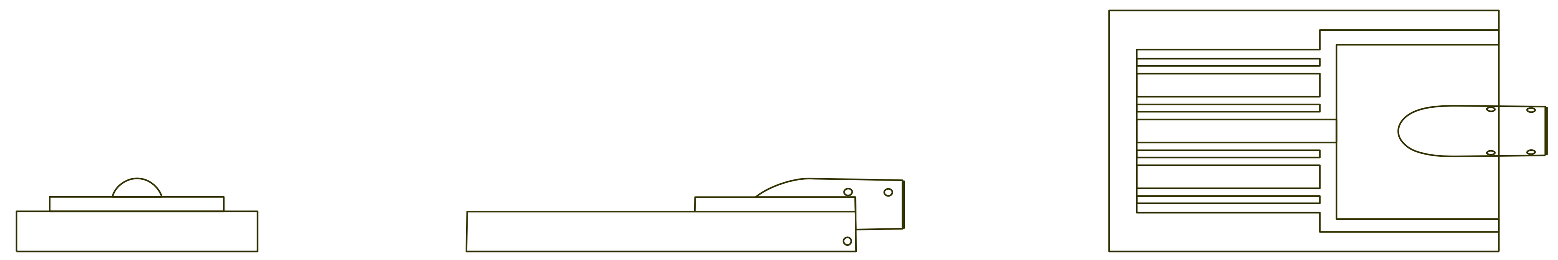
SHADE LIGHTING

WE-EF
FLC121



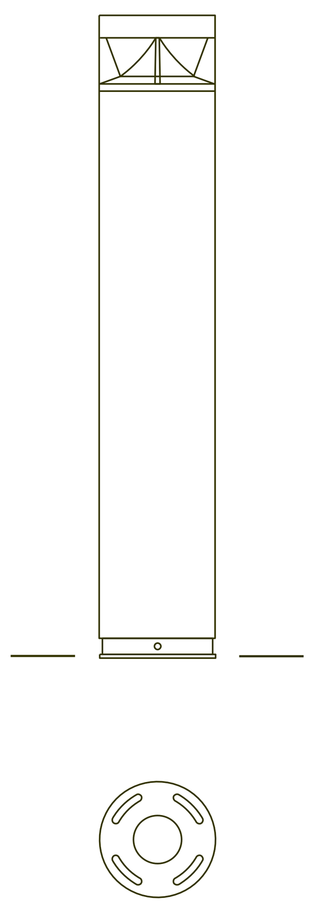
WALL MOUNTED LIGHTING

WE-EF
VFL530
VFL530-SE
VFL540



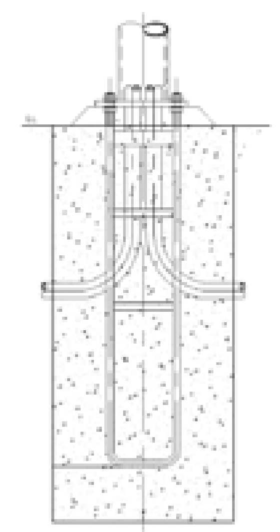
POLE TOP LIGHTING

WE-EF
VFL530
VFL530-SE
VFL540



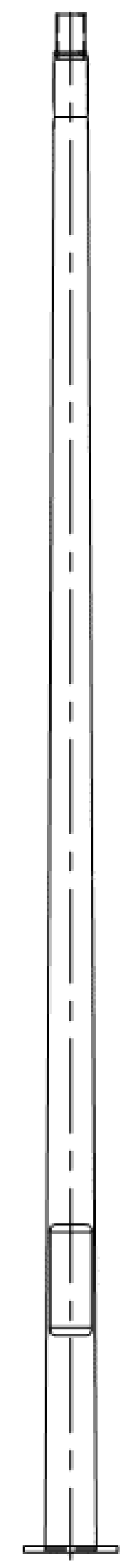
BOLLARD LIGHTING

WE-EF
KTY234



TYPICAL LIGHTING POLE FOOTING

WP-CAGE-20
(AS REQUIRED FOR REGION D WIND)



TYPICA LIGHTING POLE

TAPERED POLE
WP-X4-S2-GA 4.0m
WP-X6-S2-GA 6.0m
WP-X8-S2-GA 8.0m
(AS REQUIRED FOR REGION D WIND)

NOTES:

1. DRAWING TO BE READ IN CONJUNCTION WITH THE ELECTRICAL SPECIFICATION AND ALL OTHER SERVICES WHICH FORMS PART OF THIS PROJECT.
2. ALL DIMENSIONS, AND MATERIAL SIZES ARE INCLUDED FOR AESTHETIC INTENT AND GENERAL ARRANGEMENT ONLY. ALL ITEMS TO BE MANUFACTURED, BOLTED AND INSTALLED TO SUIT THE APPLICATION AND SITE CONDITIONS.
3. ALL POLES TO BE HOT DIP GALVANISED STEEL. REFER TO WEST POLE DRAWINGS.
4. ALL WE-EF LUMINAIRES AND BOLLARD LIGHTS TO BE MARINE GRADE ALUMINIUM WITH POWDERCOAT FINISH. (CONFIRM COLOUR WITH SUPERINTENDENT)

LIGHTING SCHEDULE

SYMBOL	LABEL	ARRANGEMENT	DESCRIPTION	LUM. WATTS	LUM. LUMENS	LLF	MH (m)	QTY
	Bxx	SINGLE	114-0182 KTY234 R65.BEAM 3 LED 9W/700mA PC AMBER BOLLARD IP66 ALU LEC	12	1110	0.800	1	75
	S1-xx	SINGLE	108-2241 VFL530 P65.BEAM 12 LED 700mA PC AMBER IP66 ALU LEC	28	2796	0.800	4	32
	S1A-xx	SINGLE	108-2418 VFL530-SE P65.BEAM 12 LED 700mA PC AMBER IP66 ALU LEC	28	2796	0.800	4	3
	S1B-xx	BACK-BACK	108-2418 VFL530-SE P65.BEAM 12 LED 700mA PC AMBER IP66 ALU LEC	28	2796	0.800	4	1
	S3-xx	SINGLE	108-2330 VFL530 R65.BEAM 24 LED 700mA PC AMBER IP66 ALU LEC	55	5592	0.800	6	24
	S5-xx	SINGLE	108-2380 VFL540 R65.BEAM 42 LED 700mA PC AMBER IP66 ALU LEC	84	9786	0.800	6	21
	S5A-xx	BACK-BACK	108-2380 VFL540 R65.BEAM 42 LED 700mA PC AMBER IP66 ALU LEC	84	9786	0.800	8	20
	S5A-xx	SINGLE	131-9626 PLS420 A60.BEAM 6 LED 700mA PC AMBER IP66 ALU LEC	15	1398	0.800	8	20
	S5A-xx	SINGLE	197-9091 QRI354 R65.BEAM 6 LED 700mA PC AMBER IP66 ALU LEC	15	1980	0.800	8	20
	S5A-xx	SINGLE	108-XXXX VFL540 R65.BEAM 36 LED 700mA PC AMBER IP66 ALU LEC	84	4997	0.800	8	20

LIGHTING DESIGN TO AUSTRALIAN STANDARD AS/NZS1158.3.1
LIGHTING FOR PEDESTRIAN AREAS - CATEGORY P4
GENERAL STREET LIGHTING - CATEGORY P4
CAR PARK LIGHTING - CATEGORY P11C

ISSUED FOR CONSTRUCTION
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NO CHANGES TO DESIGN UNLESS APPROVED BY DESIGN MANAGER

REV	DATE	DRAWN	PROJECT REVIEW	CHECKED	APPROVED	REVISION DESCRIPTION
1	04.04.23	DC	AS	-	-	NOTE REMOVED FOR CLARITY
0	31.03.23	LC	AS	NMcK	NMcK	ISSUED FOR CONSTRUCTION
G	30.09.22	LC	BT	NMcK	NMcK	ISSUED FOR TENDER
F	04.08.22	LC	BT	NMcK	NMcK	ISSUED FOR TENDER
E	15.07.22	LC	BT	NMcK	NMcK	ISSUED FOR TENDER
D	28.04.22	LC	BT	LC	BT	ISSUED FOR JDAP APPROVAL
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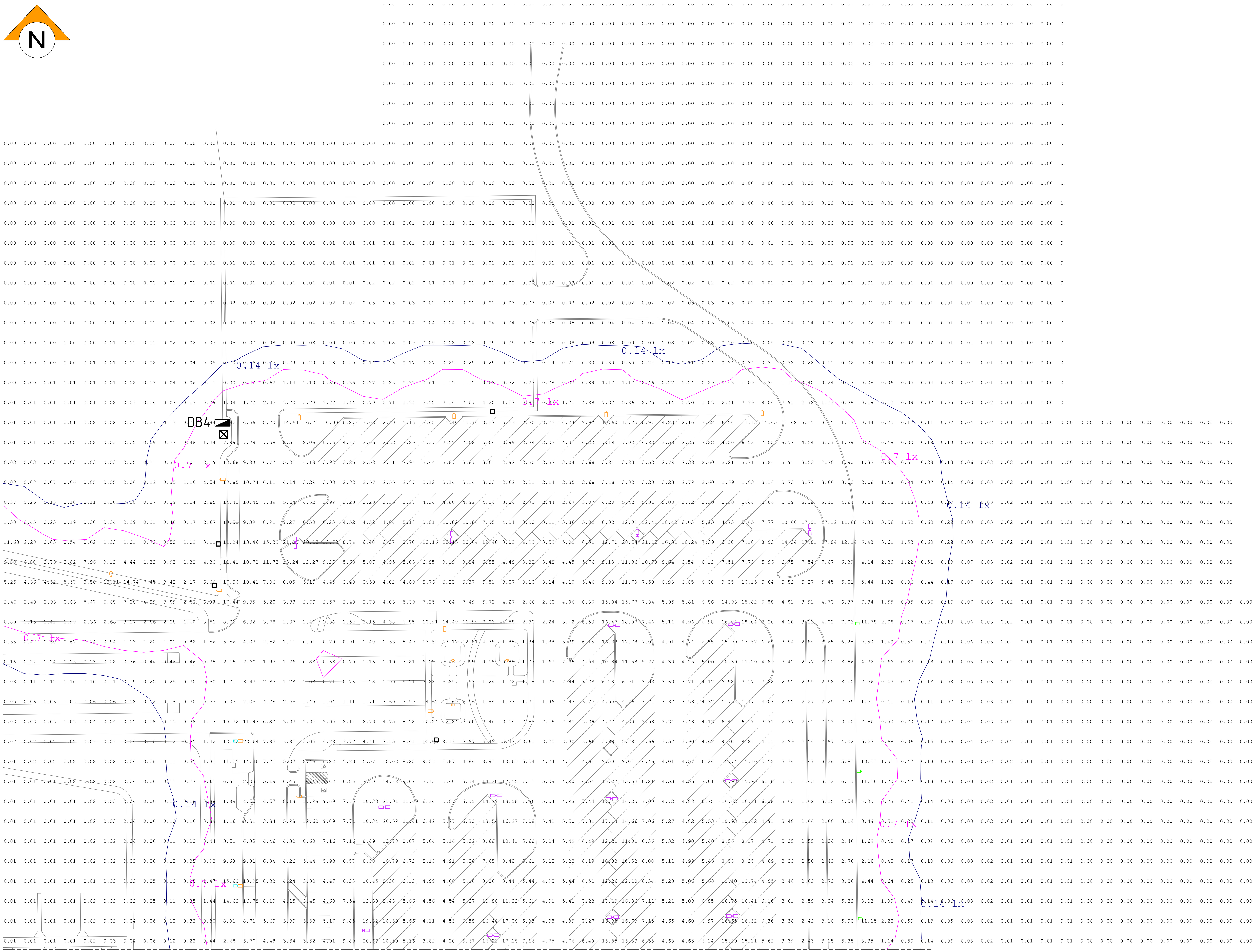
JDSi CONSULTING ENGINEERS
Level 1, 432 Murray Street, Perth WA 6000
P: (08) 9227 0595 F: (08) 9227 8617

CLIENT: PILBARA PORTS AUTHORITY

PROJECT: SPOILBANK MARINA
PACKAGE 4 - CIVIL AND LANDSCAPING

DRAWING TITLE: PRIVATE LIGHTING
LUMINAIRE AND FITTING DETAILS
SHEET 1 OF 2

DRAWN	L.CONTEMPRATO
DESIGNED	L.CONTEMPRATO
PROJECT MANAGER	D.HELLMUTH
WAPC No.	
SCALE @ A1	N/A
DATUM/COORD	AHD/PHG94
HP REFERENCE	NA
JDSi PROJECT No.	JDS14736.0
DRAWING No.	E105
REVISION	1



MATCHLINE D REFER DRG SK-E003

LEGEND

ILLUMINANCE ISOLINE

- 0.14 LUX
- 0.7 LUX

POWER INFRASTRUCTURE

- TRANSFORMER
- SWITCHBOARD

LIGHTING

- BOLLARD - WE-EF KTY234 6W
- SINGLE OUTREACH - WE-EF VFL530 28W
- SINGLE OUTREACH - WE-EF VFL530-SE 28W
- DOUBLE OUTREACH - WE-EF VFL530 28W
- SINGLE OUTREACH - WE-EF VFL530 55W
- SINGLE OUTREACH - WE-EF VFL540 84W
- DOUBLE OUTREACH - WE-EF VFL540 84W
- DOWNLIGHT - WE-EF DOR120 12W
- RECESSED WALL MOUNTED - WE-EF QR1354 12W

Dimensions and scales to be checked prior to measuring cable lengths.
(Scale bar only valid for sections of drawing that are as per specified scale)

0 5 10 20 30m
SCALE 1:500 @ ORIGINAL SHEET SIZE A1

NO DESIGN CHANGES WITHOUT MANAGER APPROVAL

NO CHANGES TO DESIGN UNLESS APPROVED BY DESIGN MANAGER

SKETCH ONLY

NOT FOR CONSTRUCTION

REV	DATE	DRAWN	PROJECT REVIEW	CHECKED	APPROVED	REVISION DESCRIPTION
D	26.06.23	DC	AS	LC	-	REVISED LIGHTING LOCATIONS AND QTY'S
C	18.11.20	LC	-	-	-	RE-ISSUED FOR INFORMATION - CALCULATION POINTS INCLUDED
B	23.07.20	LC	-	-	-	ISSUED FOR INFORMATION
A	08.01.19	LC	BT	NMcK	NMcK	ISSUED TO CLIENT FOR COMMENT

NOTE
This drawing shall be preliminary only until it is Issued for Construction.

Certified Quality System to ISO 9001

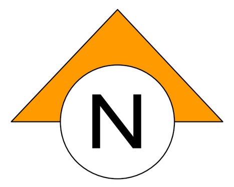
JDSi CONSULTING ENGINEERS
Workzone, Level 6, 1 Nash Street, Perth WA 6000
P: (08) 9227 0595 F: (08) 9227 8617

CLIENT: TOWN OF PORT HEDLAND

PROJECT: SPOILBANK MARINA

DRAWING TITLE: PRIVATE POWER AND LIGHTING LUX LEVEL LAYOUT SHEET 1 OF 3

DRAWN	L.CONTEMPRATO
DESIGNED	L.CONTEMPRATO
PROJECT MANAGER	D.HELLMUTH
WAPC No.	
SCALE @ A1	1:500
DATUM/COORD	AHD/PHG94
HP REFERENCE	NA
JDSi PROJECT No.	JDS14736.0
DRAWING No.	SK-E001
REVISION	D



LEGEND

ILLUMINANCE ISOLINE
0.14 LUX
0.7 LUX

POWER INFRASTRUCTURE
TRANSFORMER
SWITCHBOARD

LIGHTING
BOLLARD - WE-EF KTY234 6W
SINGLE OUTREACH - WE-EF VFL530 28W
SINGLE OUTREACH - WE-EF VFL530-SE 28W
DOUBLE OUTREACH - WE-EF VFL530 28W
SINGLE OUTREACH - WE-EF VFL530 55W
SINGLE OUTREACH - WE-EF VFL540 84W
DOUBLE OUTREACH - WE-EF VFL540 84W
DOWNLIGHT - WE-EF DOR120 12W
RECESSED WALL MOUNTED - WE-EF QR1354 12W

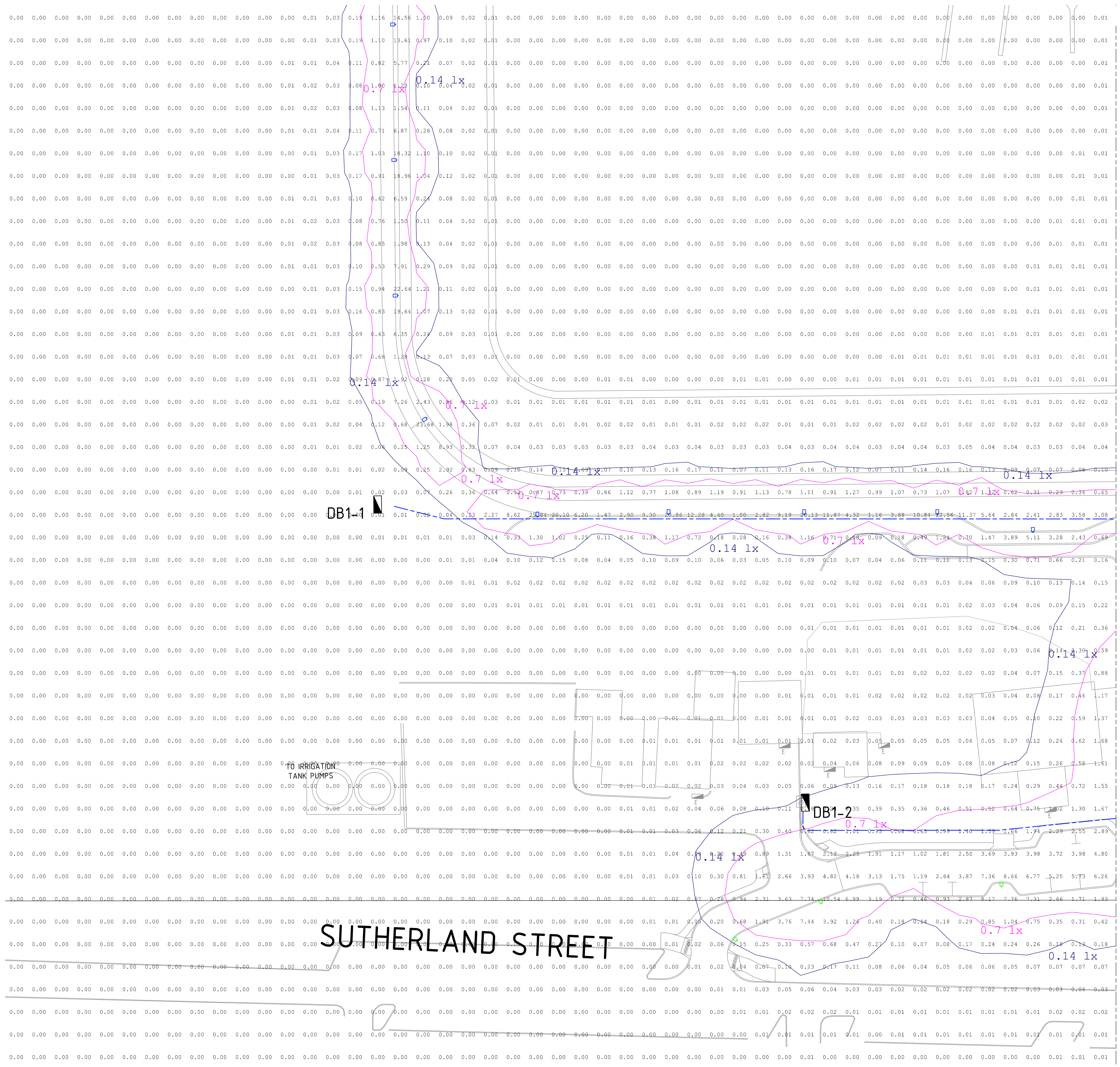
Dimensions and scales to be checked prior to measuring cable lengths.
(Scale bar only valid for sections of drawing that are as per specified scale)

0 5 10 20 30m
SCALE 1:500 @ ORIGINAL SHEET SIZE A1

NO CHANGES TO DESIGN UNLESS APPROVED BY DESIGN MANAGER

SKETCH ONLY

NOT FOR CONSTRUCTION



MATCHLINE E REFER DRG SK-E003

REV	DATE	DRAWN	PROJECT REVIEW	CHECKED	APPROVED	REVISION DESCRIPTION
D	26.06.23	DC	AS	LC	-	REVISED LIGHTING LOCATIONS AND QTY'S
C	18.11.20	LC	-	-	-	RE-ISSUED FOR INFORMATION - CALCULATION POINTS INCLUDED
B	23.07.20	LC	-	-	-	ISSUED FOR INFORMATION
A	08.01.19	LC	-	-	-	ISSUED TO CLIENT FOR COMMENT

NOTE
This drawing shall be preliminary only until it is Issued for Construction.
Certified Quality System to ISO 9001

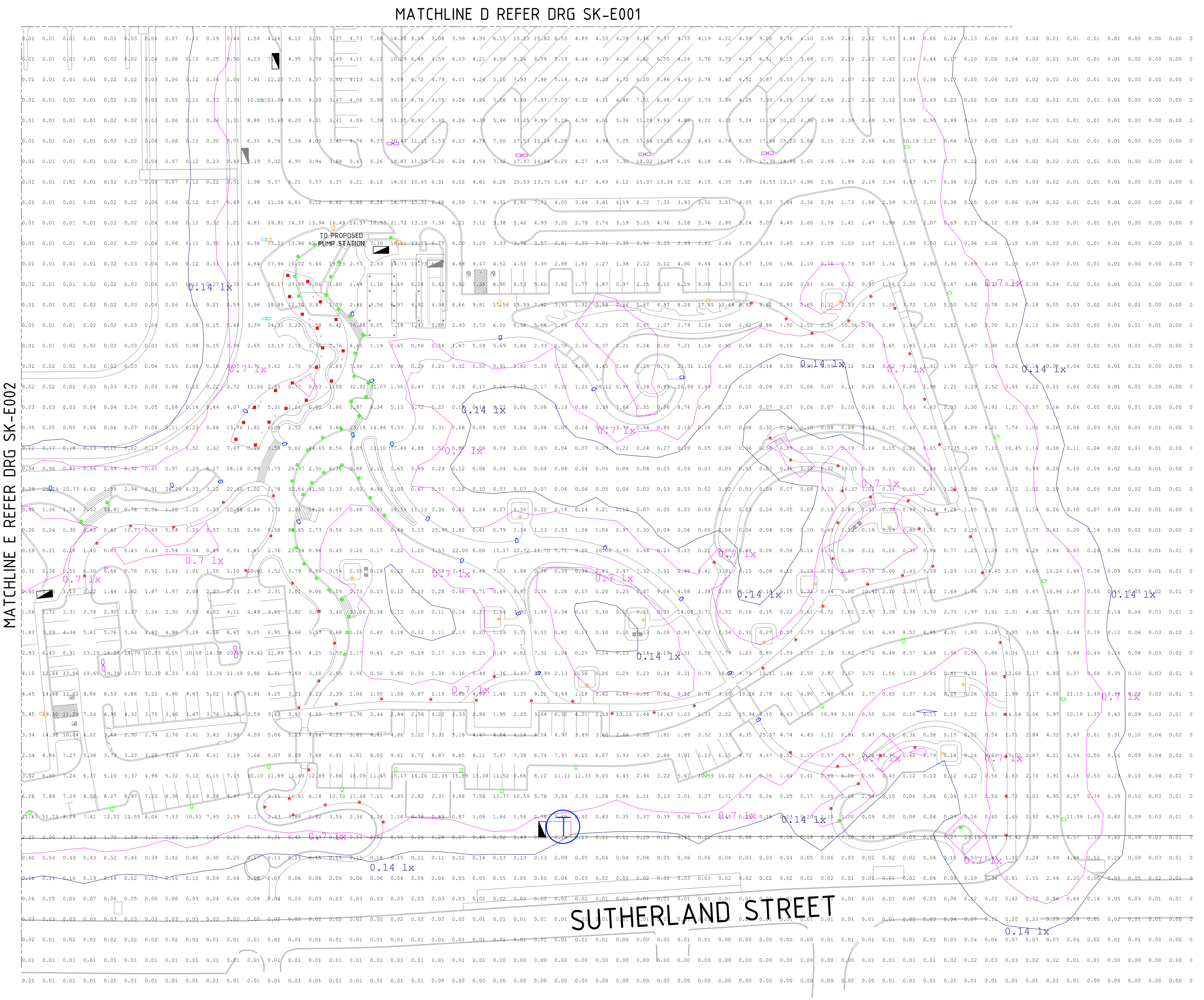
JDSi CONSULTING ENGINEERS
Workzone, Level 6, 1 Nash Street, Perth WA 6000
P: (08) 9227 0595 F: (08) 9227 8617

CLIENT: TOWN OF PORT HEDLAND

PROJECT: SPOILBANK MARINA

DRAWING TITLE: PRIVATE POWER AND LIGHTING LUX LEVEL LAYOUT SHEET 2 OF 3

DRAWN	WAPC No.	
L.CONTEMPRATO		
DESIGNED: L.CONTEMPRATO	SCALE @ A1: 1:500	
PROJECT MANAGER: D.HELLMUTH	DATUM/COORD: AHD/PHG94	HP REFERENCE: NA
JDSi PROJECT No.: JDS14736.0	DRAWING No.: SK-E002	REVISION: D



LEGEND

ILLUMINANCE ISOLINE

- 0.14 LUX
- 0.7 LUX

POWER INFRASTRUCTURE

- TRANSFORMER
- SWITCHBOARD

LIGHTING

- BOLLARD – WE-EF KTY234 6W
- 4m SINGLE OUTREACH – WE-EF VFL530 28W
- 4m SINGLE OUTREACH – WE-EF VFL530-SE 28W
- 4m DOUBLE OUTREACH – WE-EF VFL530 28W
- 6m SINGLE OUTREACH – WE-EF VFL530 55W
- 6m SINGLE OUTREACH – WE-EF VFL540 84W
- 8m DOUBLE OUTREACH – WE-EF VFL540 84W
- SHELTER LIGHTING (SURFACE MOUNTED) WE-EF PLS420 15W
- RECESSED WALL MOUNTED – WE-EF QRI354 12W
- DOWNLIGHT – WE-EF FLC121 12W (PIPE CLAMP)

N

Dimensions and scales to be checked prior to measuring cable lengths.
(Scale bar only valid for sections of drawing that are as per specified scale)

0 5 10 20 30m
SCALE 1:500 @ ORIGINAL SHEET SIZE A1

NO DESIGN CHANGES
WITHOUT MANAGER APPROVAL

NO CHANGES TO DESIGN UNLESS APPROVED BY DESIGN MANAGER

SKETCH ONLY

NOT FOR CONSTRUCTION

REV	DATE	DRAWN	PROJECT REVIEW	CHECKED	APPROVED	REVISION DESCRIPTION
D	26.06.23	DC	AS	LC	-	LUX LINES UPDATED TO SUIT LATEST LAYOUT
C	18.11.20	LC	-	-	-	RE-ISSUED FOR INFORMATION - CALCULATION POINTS INCLUDED
B	23.07.20	LC	-	-	-	ISSUED FOR INFORMATION
A	08.01.19	LC	-	-	-	ISSUED TO CLIENT FOR COMMENT

NOTE
This drawing shall be preliminary only until it is Issued for Construction.
Certified Quality System to ISO 9001

JDSi CONSULTING ENGINEERS
Workzone, Level 6, 1 Nash Street, Perth WA 6000
P: (08) 9227 0595 F: (08) 9227 8617

CLIENT: TOWN OF PORT HEDLAND

PROJECT: SPOILBANK MARINA

DRAWING TITLE: PRIVATE POWER AND LIGHTING LUX LEVEL LAYOUT SHEET 3 OF 3

DRAWN	L.CONTEMPRATO
DESIGNED	L.CONTEMPRATO
PROJECT MANAGER	D.HELLMUTH
WAPC No.	
SCALE @ A1	1:500
DATUM/COORD	AHD/PHG94
HP REFERENCE	NA
JDSi PROJECT No.	JDS14736.0
DRAWING No.	SK-E003
REVISION	D

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Appendix C: Lighting Information

PILBARA PORTS AUTHORITY

APPENDIX C: SPOILBANK MARINA LIGHTING DESIGN INFORMATION

Prepared by

Pendoley Environmental Pty Ltd

For

Pilbara Ports Authority

29 September 2023

PENDOLEY ENVIRONMENTAL

DOCUMENT CONTROL INFORMATION

TITLE: APPENDIX C: SPOILBANK MARINA LIGHTING DESIGN

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Document History

Revision	Description	Date received	Date issued	Personnel
Draft	Report Draft		11/07/2023	Dr S. Bruzzese
Rev IA	Internal Review	11/07/2023	14/07/2023	Dr K. Pendoley
Rev IB	Technical Review	14/07/2023	24/07/2023	A. Mitchell
Rev A	Client review	24/07/2023	14/09/2023	M. Logue
Rev B	Second Draft	14/09/2023	27/09/2023	Dr S. Bruzzese
Rev B	Client review	27/09/2023	29/09/2023	D. Walker
Rev 0	Final report issued	29/09/2023	29/09/2023	Dr S. Bruzzese

Printed:	29 September 2023
Last saved:	29 September 2023 11:05 AM
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Author:	Dr S. Bruzzese
Project manager:	Dr S. Bruzzese
Name of organisation:	Pendoley Environmental Pty Ltd
Name of project:	Port Hedland Spoilbank Marina
Client	Pilbara Ports Authority
Client representative:	A. Stanley / M. Logue
Report number:	J11301
Cover photo:	Pendoley Environmental Pty Ltd

TABLE OF CONTENTS

LIST OF FIGURES

1 MARINA WATERFRONT LIGHTING

All lighting in the marina waterfront is sources from WE-EF Australia and utilises PC Amber LEDs. The spectral distribution of the PC Amber LEDs that WE-EF uses is shown in **Figure 1.**

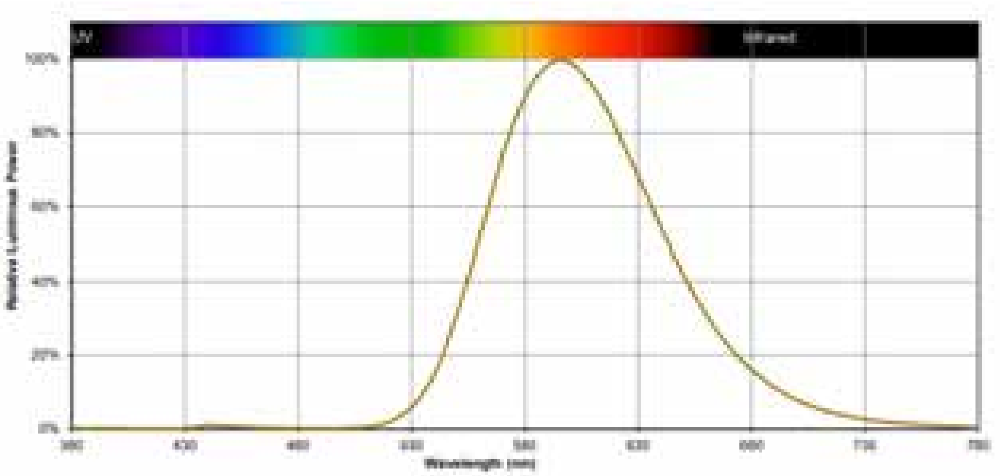

Figure 1: Spectral energy distribution of Cree XP-E2 PC Amber LEDs used by WE-EF.

1.1 WE-EF KTY234 7W PC Amber Bollard Lighting

KTY234 7W PC Amber lights are low luminosity (433.8 lm) 1 m shielded, bollard lighting to illuminate footpaths around the marina (see **Figure 2**).

Figure 2: WE-EF KTY234 light and IES light distribution. Source: https://www.we-ef.com/aus

1.2 WE-EF VFL530 26W and 52W PC Amber Pole Lighting

VFL530 26W PC Amber low-medium luminosity (1735.2 lm) lights are mounted on 4 m high poles that illuminate the paths in the recreational area, along the southern promenade and adjacent vegetation area, along the south-western breakwater and the eastern road entrance (see **Figure 3**). ADSA Approved.

VFL530 52W PC Amber medium luminosity (3470.4 lm) lights are mounted on 6 m high poles that illuminate the eastern road (closest to Cemetery Beach but facing away), southern street parking and western road entrance (see **Figure 3**).

Figure 3: WE-EF VFL530 26W and 52W lights and IES light distributions. Source: https://www.we-ef.com/aus.

1.3 WE-EF VFL530-SE 26W PC Amber Pole Lighting

VFL530-SE 26W Amber low-medium luminosity (1735.2 lm) lights are mounted on 4 m poles illuminating the western promenade (see **Figure 4**). ADSA Prized Wildlife approved.

Figure 4: WE-EF VFL530-SE 26W light and IES light distribution. Source: https://www.we-ef.com/aus

1.4 WE-EF VFL540 78W PC Amber Pole Lighting

VLF540 78W PC Amber high luminosity (5205.6 lm) lights are mounted on 8 m poles illuminating the car, caravan and trailer parking at the northern-eastern end of the marina (see **Figure 5**). Twelve of these lights are facing towards Cemetery Beach. ADSA Prized Wildlife approved.


Figure 5: WE-EF VFL540 78W light and IES light distribution. Source: https://www.we-ef.com/aus

1.5 WE-EF PLS420 13W PC Amber Baton Light

PLS420 13W PC Amber low luminosity (867.6 lm) baton lights are mounted at 3 m high on each of the multiple shade structures located in the recreational area (see **Figure 6**).


Figure 6: We-EF PLS420 13W light and IES light distribution. Source: https://www.we-ef.com/aus

1.6 WE-EF QRI1354 13W PC Amber Wall Light

QR11354 13 W PC Amber low luminosity (867.6 lm) lights are recessed at 0.5 m high into retaining walls illuminating footpaths along the south-eastern promenade (see **Figure 7**).

Figure 7: WE-EF QRI1354 13W light and IES light distribution. Source: https://www.we-ef.com/aus

1.7 WE-EF FLC121 12W PC Amber Projector Light

FLC121 12W PC Amber low-medium luminosity (1254.2 lm) projector lights are mounted at 3 m high on supporting poles of the main shade structure on the south-eastern promenade. The lights will be facing upwards to illuminate the artwork on the underside of the roof of the shade structure (see **Figure 8**).

Figure 8: WE-EF FLC121 light and 145-0284 IES light distribution. Source: https://www.we-ef.com/aus

2 BOAT PENS, GANGWAY AND JETTY LIGHTING

The lighting design for the boat pens and jetty was developed by AIE (AIE) Engineering and Construction Management. Three different lights are used to illuminate these areas all fitted with PC Amber LEDs.

2.1 Klik Systems LEDpod50 PC Amber

LEDpod50 PC Amber low luminosity (99 lm) lights installed on the handrails of the gangway to the boat pens and jetty to illuminate the walkway (see). These lights will be installed on the upper level of the public jetty located on the western side of the breakwater at 6.5 m (AHD). These lights will also be installed on the handrails of the gangway at various heights (-2.1 m to 6.5 m; AHD) as the gangway is sloped towards the water, and both the gangway changes height with the tides (see **Appendix D).**

Figure 9: Kliksystems LEDpod50 and IES light distribution. Source: https://kliksystems.com.au

2.2 Dialight Vigilant LED Bulkhead PC Amber

Vigilant LED PC Amber Bulkheads are low-medium luminosity (2145 lm) lights installed on the boat pens to illuminate the security gate at a fixed height of 7.1 m (AHD) and on the jetty to illuminate the upper and lower levels at a fixed height of 5.6 m and 7.7 m (see **Figure 10**).

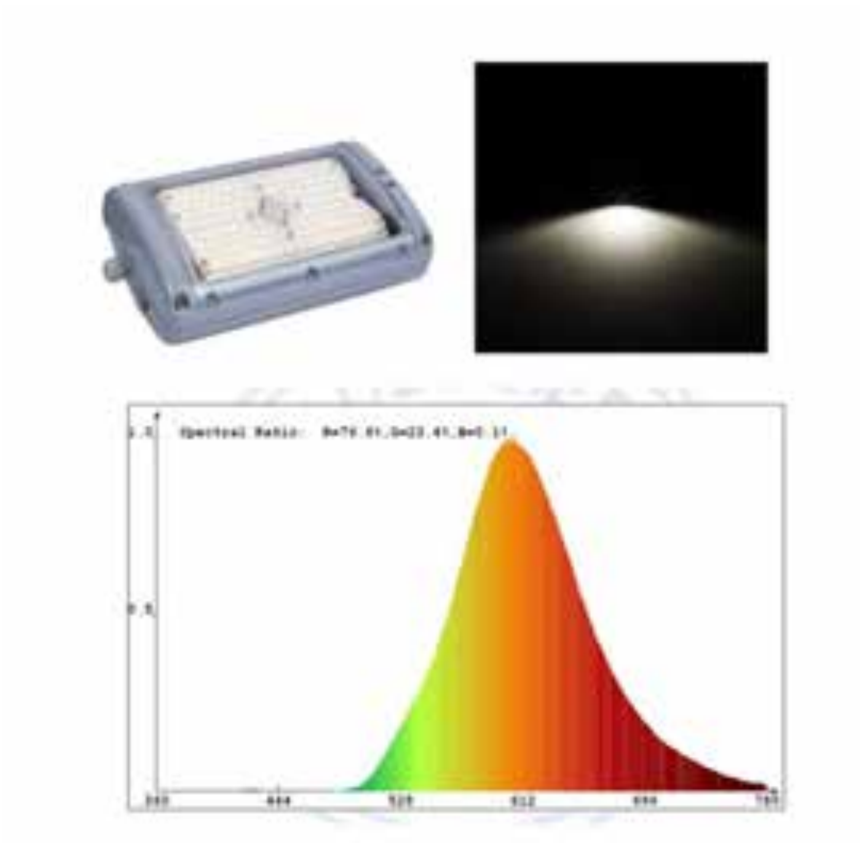

Figure 10: Dialight Vigilant LED Bulkhead (Clear Lens Wide 3klm Amber BxE4UAx3xxxxxN), IES light distribution and spectral power distribution. Source: https://www.dialight.com

2.3 Compuspec T10 LED Bulb PC Amber

T10 LED PC Amber are low-luminosity (238 lm) lights installed in the marine pillars along the boat pens (see **Figure 11**). These lights illuminate the walkway along the boat pens and are at various heights (-2.3 m to 5.1 m AHD) as the boat pens change height with the tide. The T10 LED Bulb contains Lumileds Lexeon PC Amber LED chips with the spectral power distribution shown in **Figure 11.**

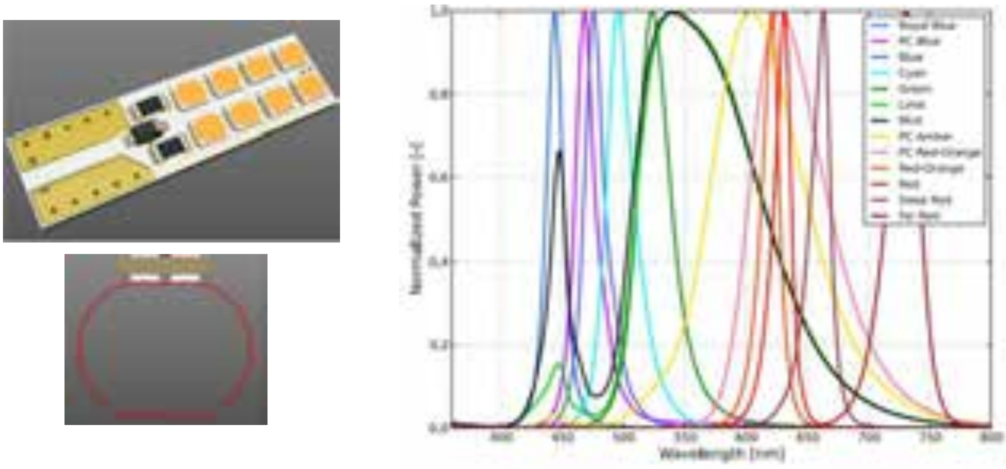

Figure 11: Compuspec T10 LED Bulb with polar radiation distribution and spectral power density.
Source: Compuspec

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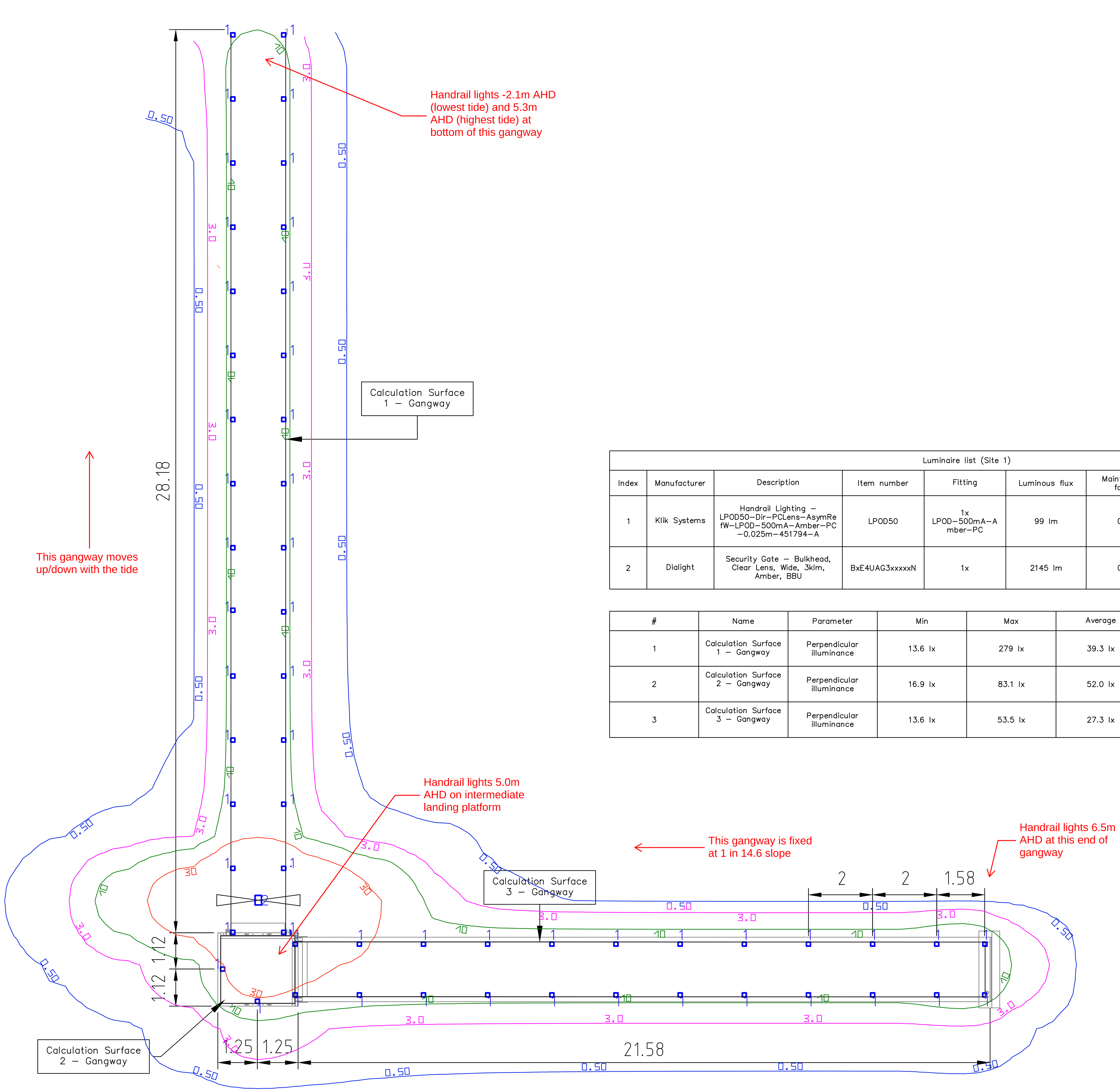
Appendix D: Boat Pens, Gangway and Jetty Lighting Design

NOTES:

1. CALCULATIONS ARE SUBJECT TO ACCURACIES AND TOLERANCES NOMINATED IN AUSTRALIAN AND NEW ZEALAND STANDARDS AS/NZS 3827.1:1998 AND AS/NZS 3827.2:1998.
2. ALL KLIK SYSTEMS HANDRAIL LEDS ARE SPACED 2m APART, UNLESS OTHERWISE SPECIFIED.
3. REFER TO NEN021-000-ELE-PLN-001 FOR LAYOUT INFORMATION



Lux Legend	
(blue line)	0.5 LUX
(magenta line)	3 LUX
(green line)	10 LUX
(red line)	30 LUX

Luminaire list (Site 1)

Index	Manufacturer	Description	Item number	Fitting	Luminous flux	Maintenance factor	Connected load	Quantity	Height (metres AHD)
1	Klik Systems	Handrail Lighting – LPOD50–Dir–PCLens–AsymRefW–LPOD–500mA–Amber–PC –0.025m–451794–A	LPOD50	1x LPOD–500mA–A mber–PC	99 lm	0.80	1.9 W	56	Varies, see markup on plan
2	Dialight	Security Gate – Bulkhead, Clear Lens, Wide, 3klm, Amber, BBU	BxE4UAG3xxxxxN	1x	2145 lm	0.80	27 W	1	7.1

#	Name	Parameter	Min	Max	Average	Min/average	Min/max
1	Calculation Surface 1 – Gangway	Perpendicular illuminance	13.6 lx	279 lx	39.3 lx	0.35	0.049
2	Calculation Surface 2 – Gangway	Perpendicular illuminance	16.9 lx	83.1 lx	52.0 lx	0.32	0.20
3	Calculation Surface 3 – Gangway	Perpendicular illuminance	13.6 lx	53.5 lx	27.3 lx	0.50	0.25

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY –
VERTICAL DATUM AHD
DES CALC –
COORDINATE SYS MGA2020–50
DES CHD –
ASCON SURVEY –
DES REF –
DRN D.KELLY
Q.C. CHD –
NORTH POINT

AIE ENGINEERING AND CONSTRUCTION MANAGEMENT PTY LTD

WEBSITE: www.aie-australia.com

ADDRESS: 18 EDGAR ST, PORT HEADLAND, WA, 6721

RECOMMENDED
MIKE WATSON 15–07–2022
SENIOR ENGINEER
APPROVED
DEAN KELLY ??–??–2022
PRINCIPAL ENGINEER

SPOIL BANK MARINA DEVELOPMENT
BOAT PENS

FILE –
PLAN SMC
CAD
ISSUE
PROJECT AU22–049

ORIGINAL SHEET SIZE A1

D:\NEN ONEDRIVE\NEN CONSULTING\NENET – CLIENTS\AIE\240322 SPOIL BANK MARINA\WORKINGS\DRAWINGS\L

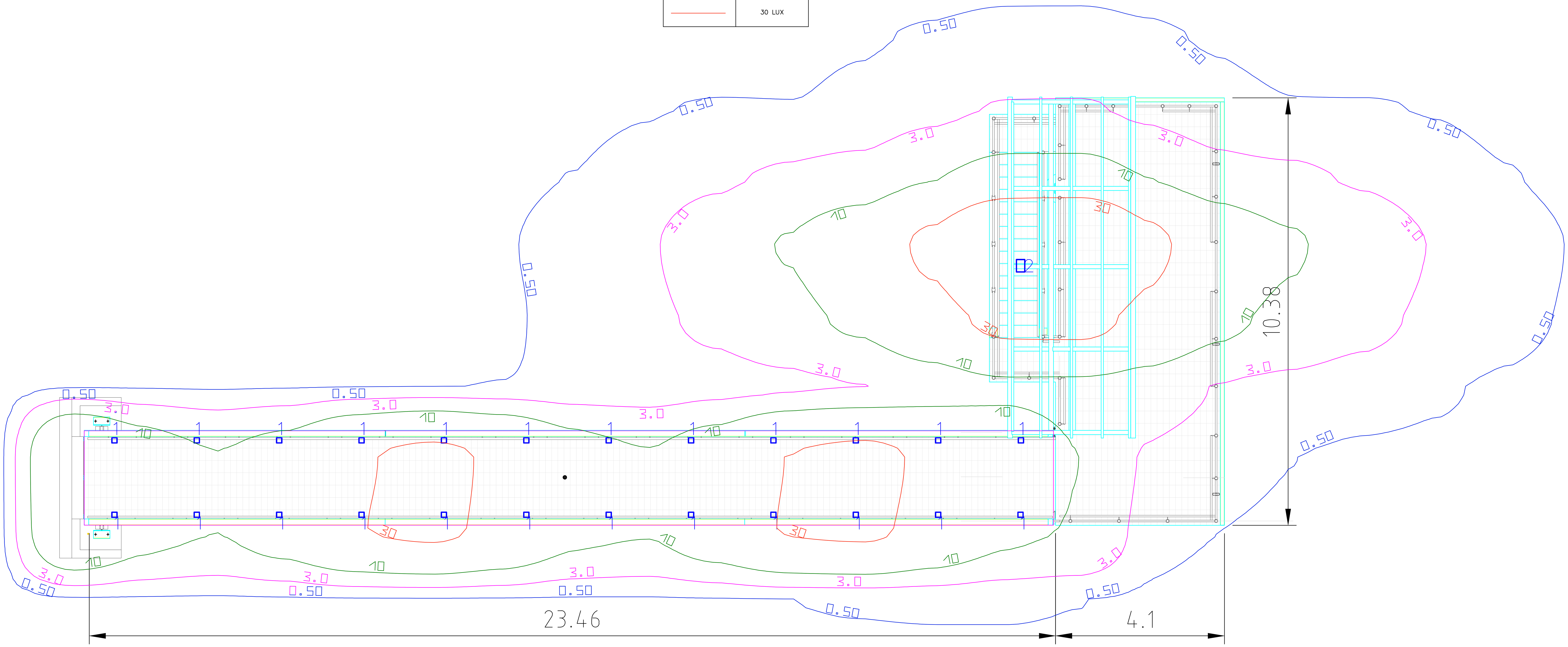
566
810
SHEET

Lux Legend	
(blue line)	0.5 LUX
(magenta line)	3 LUX
(green line)	10 LUX
(red line)	30 LUX

N

NOTES:

1. CALCULATIONS ARE SUBJECT TO ACCURACIES AND TOLERANCES NOMINATED IN AUSTRALIAN AND NEW ZEALAND STANDARDS AS/NZS 3827.1:1998 AND AS/NZS 3827.2:1998.
2. ALL KLIK SYSTEMS HANDRAIL LEDS ARE SPACED 2m APART, UNLESS OTHERWISE SPECIFIED.
3. REFER TO NEN021-000-ELE-PLN-002 FOR LAYOUT INFORMATION



Luminaire list (Site 1)

Index	Manufacturer	Description	Item number	Fitting	Luminous flux	Maintenance factor	Connected load	Quantity	Height (metres AHD)
1	Klik Systems	Handrail Lighting – LPOD50–Dir–PCLens–AsymRefW–LPOD–500mA–Amber–PC –0.025m–451794–A	LPOD50	1x LPOD–500mA–Amber–PC	99 lm	0.80	1.9 W	24	6.5
2	Dialight	Stairway Light – Bulkhead, Clear Lens, Wide, 3klm, Amber, BBU	BxE4UAG3xxxxxN	1x	2145 lm	0.80	27 W	1	7.7

#	Name	Parameter	Min	Max	Average	Min/average	Min/max
1	Calculation Surface 1 – Gangway	Perpendicular illuminance	13.7 lx	35.1 lx	23.9 lx	0.57	0.39
2	Calculation Surface 2 – Platform	Perpendicular illuminance	0.43 lx	70.9 lx	12.8 lx	0.03	0.06

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY –	VERTICAL DATUM AHD	DES CALC –	NORTH POINT
	COORDINATE SYS MGA2020–50	DES CHD –	
ASCON SURVEY –	DES REF –	DRN D.KELLY	
		Q.C. CHD –	

ENGINEERING AND CONSTRUCTION MANAGEMENT PTY LTD

WEBSITE: www.aie-australia.com
ADDRESS: 18 EDGAR ST, PORT HEADLAND, WA, 6721

RECOMMENDED		
MIKE WATSON	15–07–2022	SENIOR ENGINEER
APPROVED		
DEAN KELLY	??–??–2022	PRINCIPAL ENGINEER

SPOIL BANK MARINA DEVELOPMENT
FISHING JETTY LIGHTING ASSESSMENT (UPPER LEVEL)

FILE	–	PLAN SMC	CAD	ISSUE A
PROJECT	AU22–049			

ORIGINAL SHEET SIZE A1

D:\NEN ONEDRIVE\NEN CONSULTING\NENET – CLIENTS\AIE\240322 SPOIL BANK MARINA\WORKINGS\DRAWINGS\L

566 810

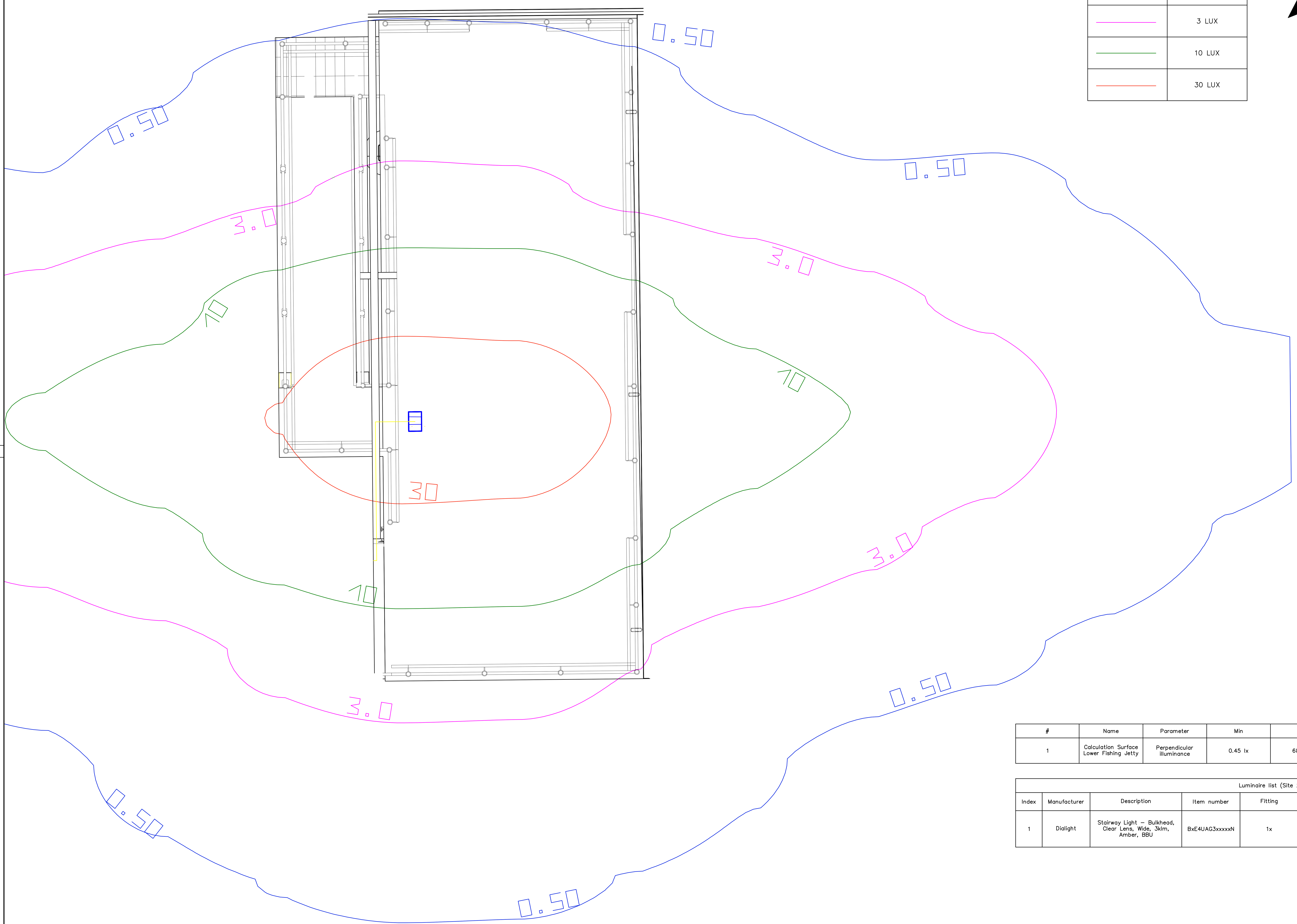
SHEET

NOTES:

1. CALCULATIONS ARE SUBJECT TO ACCURACIES AND TOLERANCES NOMINATED IN AUSTRALIAN AND NEW ZEALAND STANDARDS AS/NZS 3827.1:1998 AND AS/NZS 3827.2:1998.
2. ALL KLIK SYSTEMS HANDRAIL LEDS ARE SPACED 2m APART, UNLESS OTHERWISE SPECIFIED.
3. REFER TO NEN021-000-ELE-PLN-002 FOR LAYOUT INFORMATION

Lux Legend	
	0.5 LUX
	3 LUX
	10 LUX
	30 LUX

N



#	Name	Parameter	Min	Max	Average	Min/average	Min/max
1	Calculation Surface Lower Fishing Jetty	Perpendicular illuminance	0.45 lx	68.7 lx	16.4 lx	0.027 lx	0.007 lx

Luminaire list (Site 2)

Index	Manufacturer	Description	Item number	Fitting	Luminous flux	Maintenance factor	Connected load	Quantity	Height (metres AHD)
1	Dialight	Stairway Light – Bulkhead, Clear Lens, Wide, 3klm, Amber, BBU	BxE4UAG3xxxxxN	1x	2145 lm	0.80	27 W	1	5.6

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY	VERTICAL DATUM	DES CALC
–	AHD	–
	COORDINATE SYS MGA2020–50	DES CHD –
ASCON SURVEY –	DES REF –	DRN D.KELLY
		Q.C. CHD –

NORTH POINT

ENGINEERING AND CONSTRUCTION MANAGEMENT PTY LTD

WEBSITE: www.aie-australia.com

ADDRESS: 18 EDGAR ST, PORT HEADLAND, WA, 6721

RECOMMENDED		
MIKE WATSON	15–07–2022	
SENIOR ENGINEER		
APPROVED		
DEAN KELLY	??–??–2022	
PRINCIPAL ENGINEER		

SPOIL BANK MARINA DEVELOPMENT
FISHING JETTY LIGHTING ASSESSMENT (LOWER LEVEL)

FILE –
PLAN SMC
CAD
ISSUE
PROJECT AU22–049

ORIGINAL SHEET SIZE
A1

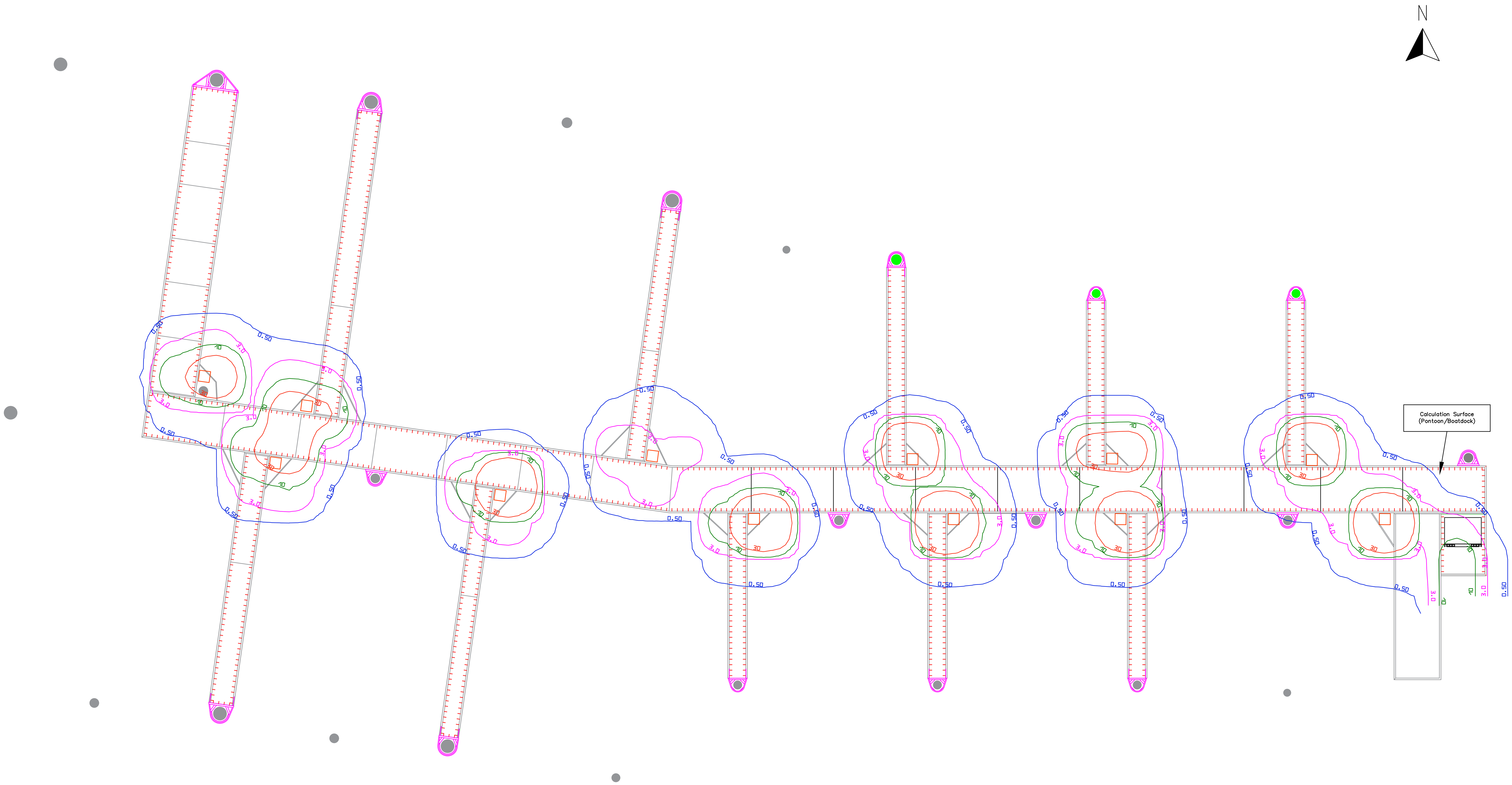
566
810

D:\NEN ONEDRIVE\NEN CONSULTING\NENET – CLIENTS\AIE\240322 SPOIL BANK MARINA\WORKINGS\DRAWINGS\L

SHEET

NOTES:

1. CALCULATIONS ARE SUBJECT TO ACCURACIES AND TOLERANCES NOMINATED IN AUSTRALIAN AND NEW ZEALAND STANDARDS AS/NZS 3827.1:1998 AND AS/NZS 3827.2:1998.
2. ALL KLIK SYSTEMS HANDRAIL LEDS ARE SPACED 2m APART, UNLESS OTHERWISE SPECIFIED.
3. GANGWAY EVALUATION CONTINUED ON SHEET 2
3. REFER TO NEN021-000-ELE-PLN-001 FOR LAYOUT INFORMATION



Lux Legend	
(blue line)	0.5 LUX
(magenta line)	3 LUX
(green line)	10 LUX
(red line)	30 LUX

Luminaire list (Site 1)

Index	Manufacturer	Description	Item number	Fitting	Luminous flux	Maintenance factor	Connected load	Quantity
1	Compuspec	Marine Pillar LED Lighting (Modelled lighting is indicative only)	T10 LED BULB	N/A	99 lm	0.80	1.9 W	12

Height (metres AHD)

Varies between -2.3 (lowest tide) and +5.1 (highest tide)

#	Name	Parameter	Min	Max	Average	Min/average	Min/max
1	Calculation Surface 1 – Pontoon	Perpendicular illuminance	0 lx	461	15.5	0	0

85% DESIGN REVIEW
NOT FOR CONSTRUCTION

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY –	VERTICAL DATUM AHD	DES CALC –	NORTH POINT
	COORDINATE SYS MGA2020–50	DES CHD –	
ASCON SURVEY –	DES REF –	DRN D.KELLY	
		Q.C. CHD –	

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DEAN KELLY ??–??–2022
PRINCIPAL ENGINEER

SPOIL BANK MARINA DEVELOPMENT
BOAT PENS

FILE –
PROJECT AU22–049
PLAN SMC
CAD
ISSUE A
ORIGINAL SHEET SIZE A1

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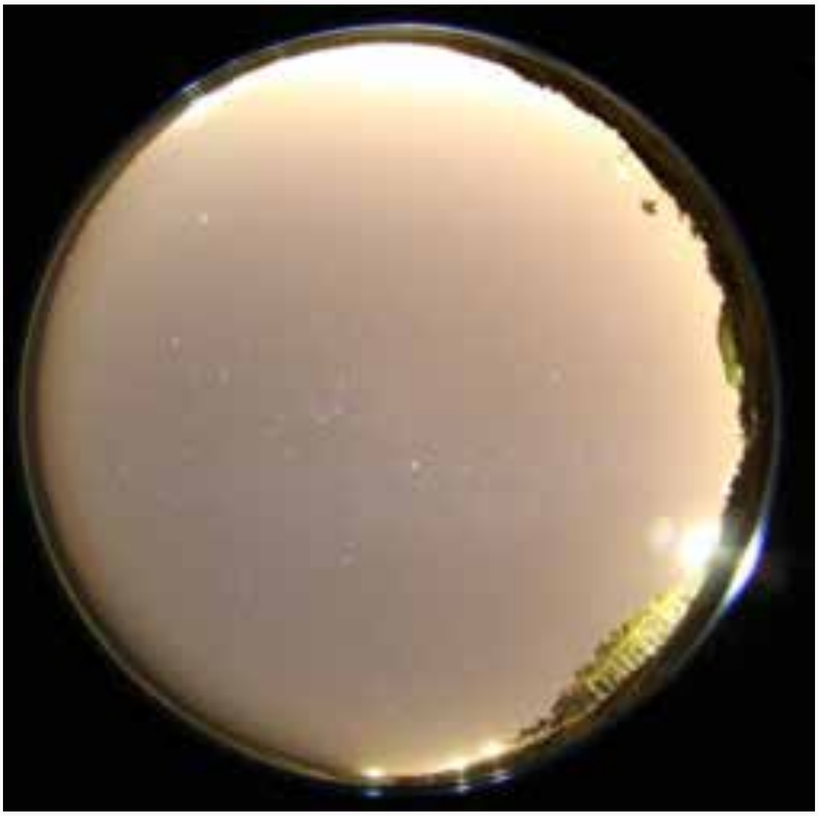
Appendix E: Spoilbank Marina Baseline Hatchling Orientation and Light Monitoring

PILBARA PORTS AUTHORITY

SPOILBANK MARINA: BASELINE HATCHLING ORIENTATION AND LIGHT MONITORING



Prepared by

Pendoley Environmental Pty Ltd

For

Pilbara Ports Authority

25 March 2024

PENDOLEY ENVIRONMENTAL

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Disclaimer and Limitation

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1 INTRODUCTION

1.1 Project Description

The Pilbara Ports Authority (PPA) is the proponent responsible for the construction of the Spoilbank Marina Project (the 'Marina') in Port Hedland. The project is adjacent to a known flatback turtle (*Natator depressus)* nesting site on Cemetery Beach and has the potential to impact hatchling and nesting turtle behaviour.

In 2020, the RPS Group conducted an Artificial Light Impact Assessment (RPS 2020) for the Spoilbank Marina Project. This report analysed and described the existing lighting environment along with the population, and behaviour of sensitive receptors. The report also conducted an impact assessment based on the project lighting information and wildlife present, which included proposed mitigation and management of light measures.

In August 2023, PPA engaged Pendoley Environmental (PENV) to develop an Artificial Light Management Plan (ALMP) to meet *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) approval conditions to ensure artificial lighting associated with the operation of the Marina does not impact flatback turtle nesting on Cemetery Beach.

1.2 Scope of Work

During the development of the ALMP, it was found that the results of the baseline artificial light monitoring survey, undertaken by PENV in 2019 were no longer suitable for comparison due to a substantially altered lighting environment. Since the 2019 baseline monitoring, the water tower lighting and some of the streetlights adjacent to Cemetery Beach are now turned off during turtle nesting season. As a result, a new set of baseline data for both artificial lighting and hatchling orientation were required to enable a suitable comparison between operational monitoring and pre-construction conditions.

As part of the Spoilbank Marina ALMP, a commitment was made to undertake new baseline hatchling orientation and light monitoring surveys, to meet EPBC conditions:

i. A monitoring and reporting program, which includes baseline data that monitoring and reporting will be evaluated against, to be undertaken for a minimum length of two years post commencement of operation of the marina to provide certainty that the artificial lighting of the marina is not impacting flatback turtle hatchlings or nesting on Cemetery Beach; and

ii. Management measures and corrective actions to be implemented should monitoring indicate that the marina's artificial lighting is likely to impact flatback turtle hatchlings on Cemetery Beach.

Consequently, PPA requested PENV undertake a new baseline survey in line with the above conditions. The baseline data would be used to develop trigger and threshold criteria to demonstrate any potential future impact of artificial light from the project on hatchling behaviour and support an update to the ALMP.

2 METHODOLOGY

2.1 Survey Locations and Schedule

The field survey was conducted over a 14-day period between the 4th and 18th of January 2024. It was scheduled to coincide with the peak hatching season for flatback turtles on Cemetery Beach in Port Hedland, Western Australia, and the new moon on the 11th of January 2024. All future monitoring must be conducted under new moon conditions to ensure a suitable comparison between datasets.

The hatchling orientation survey area consisted of an approximately 1.2 km stretch of Cemetery Beach (**Figure 1**) across the entire 14-day period. Two light monitoring survey locations were selected on Cemetery Beach (**Figure 1** and **Table 1**). One situated on the western end of the beach and the second towards the eastern end. These survey locations were based on previous light monitoring surveys (PENV 2020). Light monitoring cameras were deployed for 4 nights between the 8th and 15th of January 2024.

Atmospheric conditions varied across the light monitoring survey with the clearest conditions occurring on the 8th of January 2024. Images captured from the 8th of January were analysed and presented in this report.

Table 1: Light monitoring survey locations and GPS positions: Latitude and Longitude coordinates have been provided. (datum: WGS84).

Location	Latitude (°)	Longitude (°)
Cemetery Beach East	-20.3069958	118.6128535
Cemetery Beach West	-20.3077190	118.6088212

Figure 1: Hatchling orientation survey area and light monitoring survey locations.

2.2 Data Capture

2.2.1 Artificial Light

Artificial light data was captured at each monitoring site using a Sky42 light monitoring camera. The camera is a calibrated Canon EOS 700D DSLR combined with a fish-eye lens and custom-built hardware to acquire low-light images of the entire night sky. The cameras are built into a weatherproof housing with a protective lid that automatically opens during image capture and closes between capture intervals.

The cameras were deployed on tripods at the survey locations each night and were programmed to automatically begin taking photos in 10-minute intervals between sunset and sunrise. Images were downloaded the following morning, and camera maintenance and pre-deployment checks were performed to ensure correct operation for the next monitoring night.

2.2.2 Hatchling Orientation

The most common method to monitor the influence of existing artificial light on the dispersal behaviour of hatchling turtles within their important habitat is to record the angles of their tracks left on the beach (Pendoley 2005).

The field team will locate any recently emerged nests by following sighted hatchling tracks to the emergence point. The emergence point is indicated by a depression (the ‘nest cone’) in the sand from where the hatchlings emerged. The field team will use a sighting compass to measure angles of the fan of tracks from the emergence point to where the tracks cross the high tide line on a flat beach surface (removes variation caused by undulating nesting landscapes i.e., from body pits made by nesting turtles), or at a distance of 5 m, whichever is greater. Angles that will be measured include the outer tracks that form the outside arms of the fan (A and B angles) and the most direct line to the ocean (X) (**Figure 2**). The approach allows for the determination of both the range of dispersion or ‘spread’ angle of emergent hatchlings and the degree of deflection or ‘offset’ angle from the most direct route toward the ocean.

A GPS location will be recorded at the emergence point of the nest. In addition, a circle will be drawn in the sand around the depression, and a line drawn through all hatchling tracks, to ensure the same nest fan is not recorded on subsequent monitoring days. Single hatchling tracks that were more than 30˚ from the outermost track of the main fan were recorded as outliers, following the methodology guidance of Pendoley (2005).

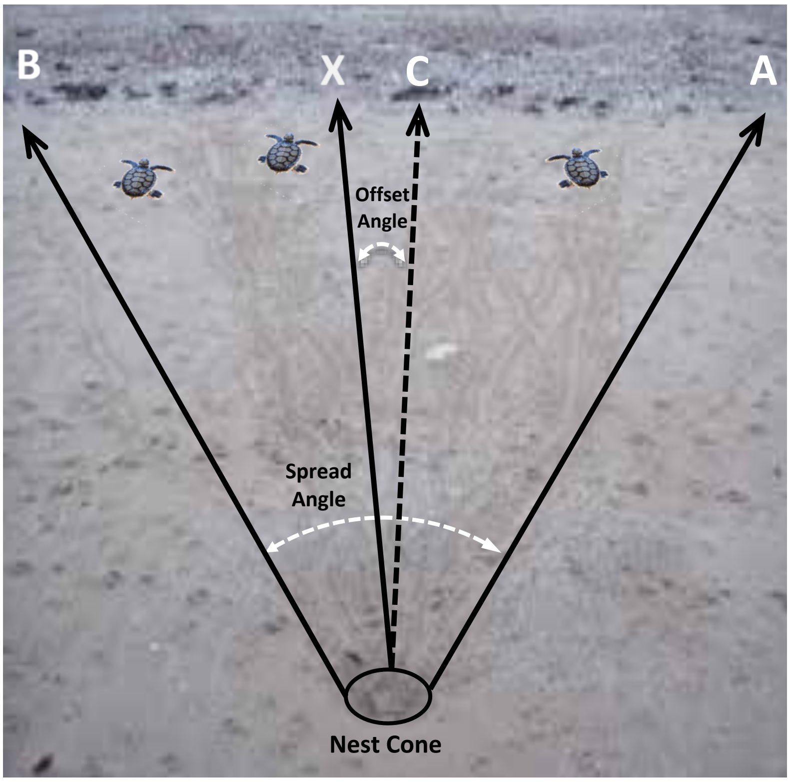


Figure 2: Hatchling orientation angles recorded for a nest fan and associated spread and offset angles. Black arrows indicate metrics that are captured in the field. Dashed black arrow indicates middle indices between A and B that is used to calculate the offset angle.

2.3 Data Analysis

2.3.1 Artificial Light

The quality of an image captured by a Sky42 light monitoring camera can be influenced by atmospheric factors such as the presence of the moon, twilight, cloud, rain, dust, humidity, or physical factors such as accumulation of sand or dust on the lens. Any images that are affected by physical factors were removed from the analysis, as well as any images that were affected by the moon or twilight.

All suitable images from each survey location were processed using specialised software to determine "whole-of-sky", "horizon" and "sector" sky brightness levels. Whole-of-sky (WOS) is the mean value of sky glow in the entire image (**Figure 3a**) and horizon is the mean value of sky glow within the 60° – 90° outer band (most relevant for hatchling marine turtles; **Figure 3b**). Sector is the mean value of sky glow within the 60° – 90° outer band constrained to the bearings of the Spoilbank Marina as viewed from the Cemetery Beach monitoring locations (263° – 280°; **Figure 3c**).

Sky brightness has been quantified in units of visual magnitudes per arcsecond (Vmag/arcsec^2; Vmag is a standard unit used in astronomical measurements and emerging as a standard for sky glow monitoring globally). The Vmag unit quantifies light intensity on an inverted logarithmic scale i.e. higher values represent lower-intensity light, while lower values represent higher-intensity light.

Additionally, for each monitoring location, a set of images was generated detailing the raw fisheye image, quantified fisheye image (in Vmag), and "unwrapped" versions as a re-projected all-sky benchmark image allowing horizon light sources to be easily identified. Note that the colour coding used in the processed imagery represents the scale of intensity of light and is not representative of the colour of light as perceived by a human or Sky42 camera.

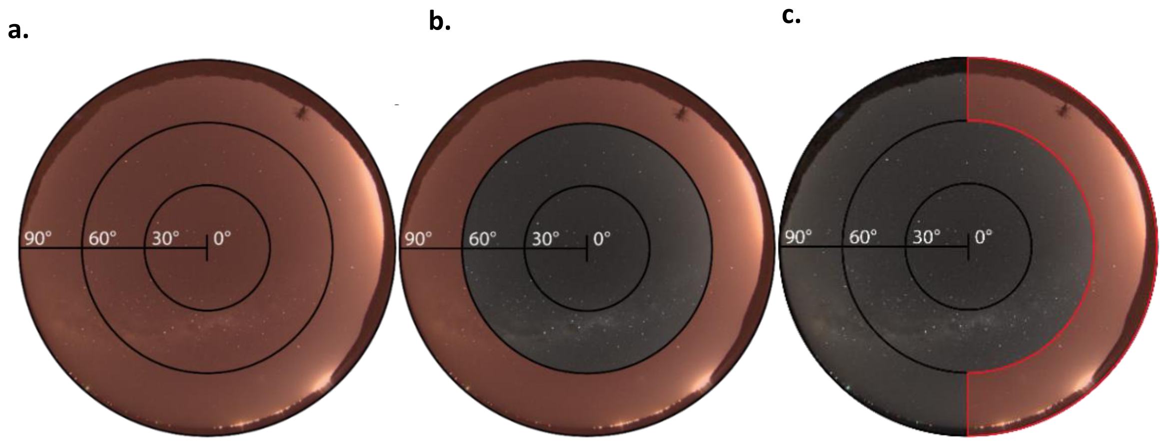


Figure 3: Measurement of mean pixel values within a specific view; a. Whole-of-sky brightness (full image); b. Horizon brightness (60° – 90°). c. Sector brightness 30° vertically, spanning the bearings of the Spoilbank Marina horizontally. Shaded areas denote the region of the sky being measured.

2.3.2 Hatchling Orientation

Hatchling orientation data were analysed to provide:

- **Spread Angle:** The range of dispersion of tracks from the emergence point, describing the degree of dispersion of all hatchling pathways toward the ocean. A larger value indicates greater dispersion or variation in ocean-finding bearings and may indicate disruption to natural hatchling sea-finding ability.
- **Offset Angle:** The degree of deflection of tracks from the most direct route to the ocean. A smaller value indicates a more direct route (i.e., less deviation from the most direct route) and a larger value demonstrates a greater deviation from the most direct route which may indicate disruption to natural hatchling sea-finding ability.

The data were filtered to improve the quality of the statistical analysis by removing any nest fans with less than five hatchling tracks.

The spread and offset angles from the baseline data were statistically analysed using a Bayesian projected normal regression model for circular data (Cremers 2018a). These types of analyses are robust, as they can account for multiple variables that may influence the data as well as random effects. A circular data analysis is important when analysing bearings and angles as they are periodic in nature and results may be misinterpreted if using typical linear analysis methods (Cremers 2018b).

The statistical analysis provides and estimation of the mean of the spread angle and offset angle, as well as an upper bound and lower bound for each mean. The upper and lower bounds indicate that there is a 95 % probability that the true mean lies between the upper and lower bounds, based on the data (this is also known as the 95 % highest posterior density interval; Cremers 2018a).

2.4 Post-baseline Trigger and Threshold Criteria

As per the Environmental Management Plan Guidelines (Commonwealth of Australia 2014), trigger and threshold criteria were defined based on spread and offset angles. These criteria are outcome-based and specific to the baseline hatchling turtle orientation data presented in this report. Trigger criteria are intended to forewarn of the approach of the threshold criteria and must be set at a conservative level to ensure trigger level actions are implemented well in advance of the threshold criteria. Threshold criteria are indicators selected to represent the limit of acceptable impact beyond which there is likely to be a significant impact on hatchling sea-finding behaviour.

The upper and lower bounds of the baseline mean (for both spread angle and offset angle; see **Section 2.3.2**) can be used to test if the post-baseline data are different to the baseline data. If the post-baseline mean is beyond the upper bound of the baseline data but the lower bound is within the baseline upper bound, then this implies that there *may* be a difference between the baseline and post-baseline data (**Figure 4a**). However, if the post-baseline lower bound is not within the upper bound of the baseline data, then this implies that there is a significant difference between the baseline and post-baseline data (**Figure 4b**) (Cremers 2018a). Specifically, trigger and threshold criteria are as follows:

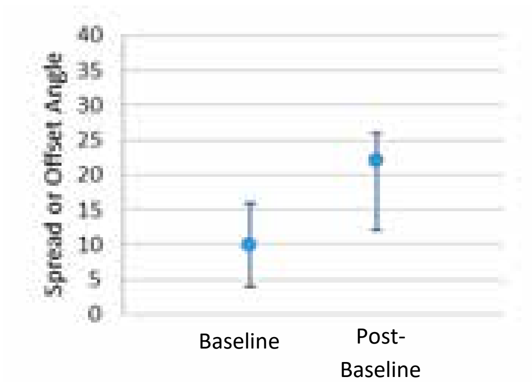
Trigger criteria:

- The mean of the post-baseline offset angle exceeds the upper bound of the baseline offset angle but the post-baseline lower bound is still within the baseline upper bound; **or**
- The mean of the post-baseline spread angle exceeds the upper bound of the baseline spread angle but the post-baseline lower bound is still within the baseline upper bound.

Threshold criteria:

- The lower bound of the post-baseline offset angle exceeds the upper bound of the baseline offset angle; **or**
- The lower bound of the post-baseline spread angle exceeds the upper bound of the baseline spread angle.

a.



b.

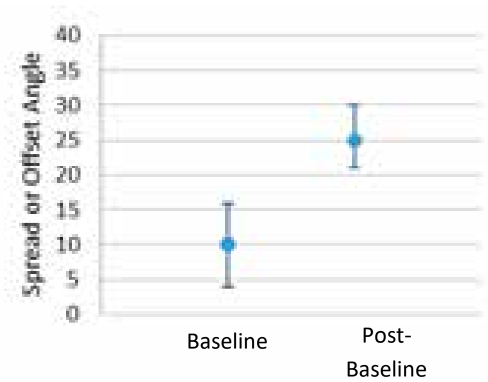


Figure 4: Examples of comparisons between baseline and post-baseline datasets. a. Possible change (trigger criteria): The lower bound of the post-baseline dataset is above the baseline mean, but below the baseline upper bound; b. Significant change (threshold criteria): The lower bound of the post-baseline dataset exceeds the upper bound of the baseline dataset.

3 RESULTS

3.1 Artificial Light

Suitable data was successfully collected from the two survey locations on 8th January 2024, which had the clearest atmospheric conditions. The median image from each monitoring location for this night has been analysed and included in this report (**Figure 5 – Figure 6**).

The port facilities were the most dominant source of sky glow in Port Hedland and were visible from both survey locations. This was followed by Port Hedland residential and commercial lighting. From both monitoring locations, the port facilities overlap with the position of the Spoilbank Marina facilities. Streetlights along Sutherland Street are visible as high intensity point sources of light towards the northeast. Lower-intensity point sources of light corresponding to offshore vessels are visible on the horizon to the northwest from both locations (**Figure 5 – Figure 6**).

From Cemetery Beach East, high-intensity, direct light is visible from the Gratwick Aquatic Centre, which also produces light spill that extends beyond the dunes onto the beach (**Figure 5**). A large proportion of the recorded nests fans that were highly dis-orientated were also located in front of the Aquatic Centre lighting (see **Section 2.3.2** for details).

The median WOS, horizon, and sector sky brightness from each survey location correlates strongly with the visibility and proximity of the identified light sources. Cemetery Beach East, which is located further from the port facilities with higher dunes, recorded fainter sky brightness values (18.66 Vmag, 18.29 Vmag and 17.38 Vmag, respectively; **Table 2** and **Figure 5**). Whereas, Cemetery Beach West which is located closer to the port facilities and has lower dunes, had the brightest WOS, horizon and Marina sector sky brightness values (18.38 Vmag, 17.96 Vmag and 17.29 Vmag, respectively; **Table 2** and **Figure 6**).

Table 2: Median sky brightness in Vmag for whole-of-sky, horizon and Spoilbank Marina sector at each survey location. Note that Vmag is an inverse logarithmic scale meaning higher values represent a lower level of brightness, while lower values represent a higher level of sky brightness.

Survey Location	Median Sky Brightness (Vmag)		
	WOS	Horizon	Marina Sector
Cemetery Beach East	18.66	18.29	17.38
Cemetery Beach West	18.38	17.96	17.29

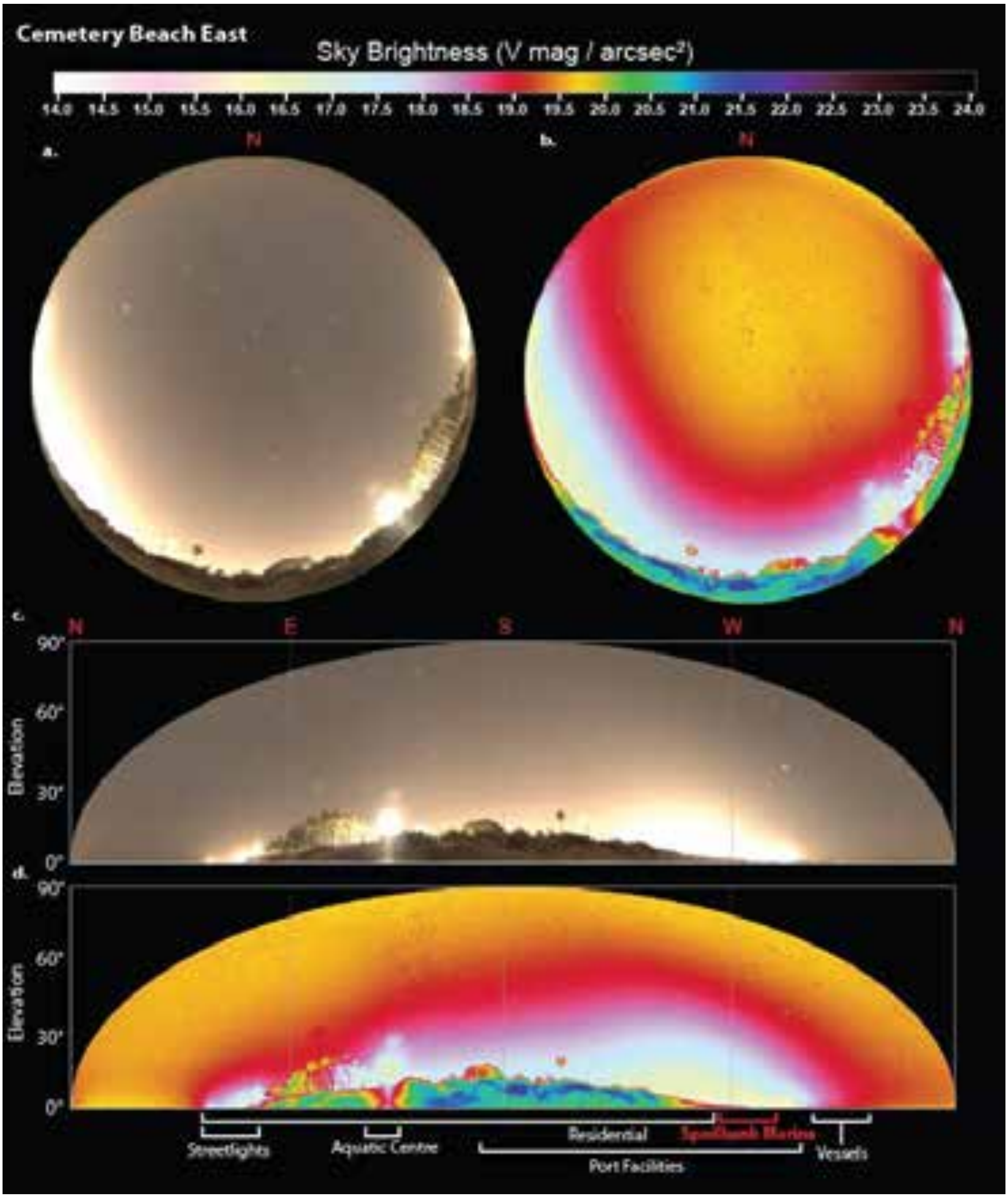


Figure 5: Median artificial light monitoring results from Cemetery Beach East on 8th January 2024. a. raw circular image; b. Processed circular image; c. Raw hammer-aitoff image; d. Processed hammer-aitoff image. White labels = current light sources, red labels = location of Spoilbank Marina.

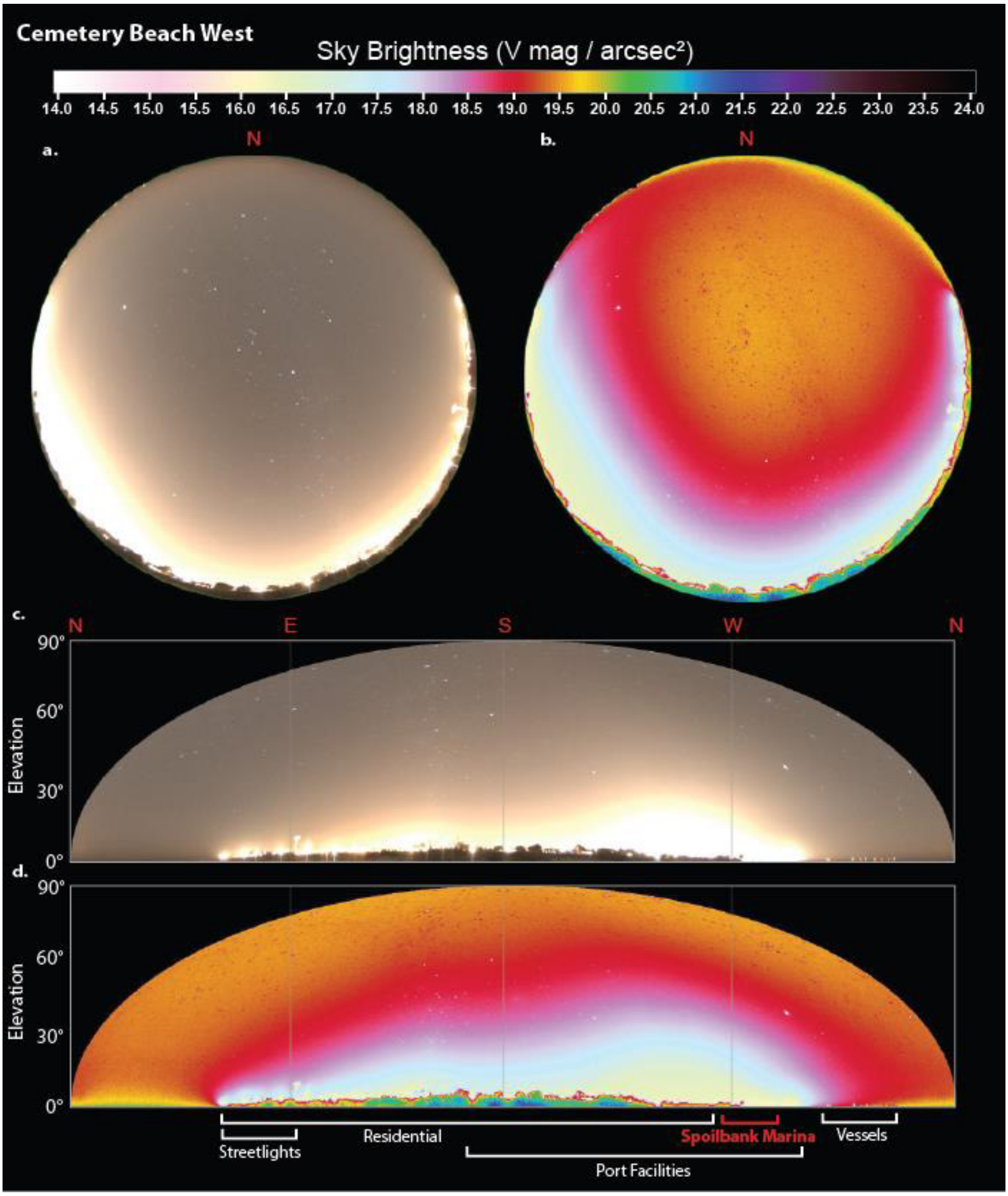


Figure 6: Median artificial light monitoring results from Cemetery Beach West on 8th January 2024. a. raw circular image; b. Processed circular image; c. Raw hammer-aitoff image; d. Processed hammer-aitoff image. White labels = current light sources, red labels = location of Spoilbank Marina.

3.2 Hatchling Orientation

A total of 135 nest emergences were recorded over the 14-day survey conducted between the 4th and 18th of January 2024. Of these, 107 nest fans were recorded with at least five hatchling tracks (**Appendix A**) and were included in the statistical analysis (79.2 % of the original sample). The mean spread and offset angles, and the lower and upper bounds for the baseline hatchling orientation data are shown in **Table 3**. See **Section 2.3.2** for details.

Of an estimated 1,886 individual hatchling tracks within the recorded nest fans, 97 individual tracks (5.1 %) were outliers and removed from the data analysis. For an individual track to be considered an outlier it must be > 30° from the primary nest fan (**Section 2.2.2**).

Table 3: The mean offset and spread angle, upper bound and lower bound for baseline data.

Metric	Number of nest fans	Mean (°)	Lower Bound (°)	Upper Bound (°)
Spread angle	107	79	63	96
Offset angle	107	24	16	32

The spread angle and offset angle for each recorded nest fan, with more than five hatchlings tracks, are shown in **Figure 7** and **Figure 8**, respectively.

Furthermore, 12 nests had hatchling tracks showing signs of severe disorientation by heading in all directions, with no main nest fan identifiable (**Figure 9**). As a result, spread and offset angles were unable to be determined for each nest and they were excluded from the statistical analysis. Of the 12 severely dis-orientated hatchling nests, 8 were located directly in front of the Civic Centre and Gratwick Aquatic Centre (**Figure 9**).

3.3 Post-baseline Trigger and Threshold Criteria

Trigger and threshold criteria for baseline datasets were determined from the mean and lower bound of the spread and offset angles of the baseline hatchling orientation data (see **Section 3.2** and **Table 3**). The trigger and threshold criteria are presented in **Table 4**.

An updated outcome-based trigger and threshold response plan for flatback turtle hatchling orientation on Cemetery Beach for inclusion in the Spoilbank Marina ALMP is located in **Appendix B.**

Table 4: Trigger and threshold criteria for post-baseline data.

Metric	Trigger Criteria	Threshold Criteria
Spread angle	The mean exceeds 96° but the lower bound is less than 96°	The lower bound exceeds 96°
Offset angle	The mean exceeds 32° but the lower bound is less than 32°	The lower bound exceeds 32°

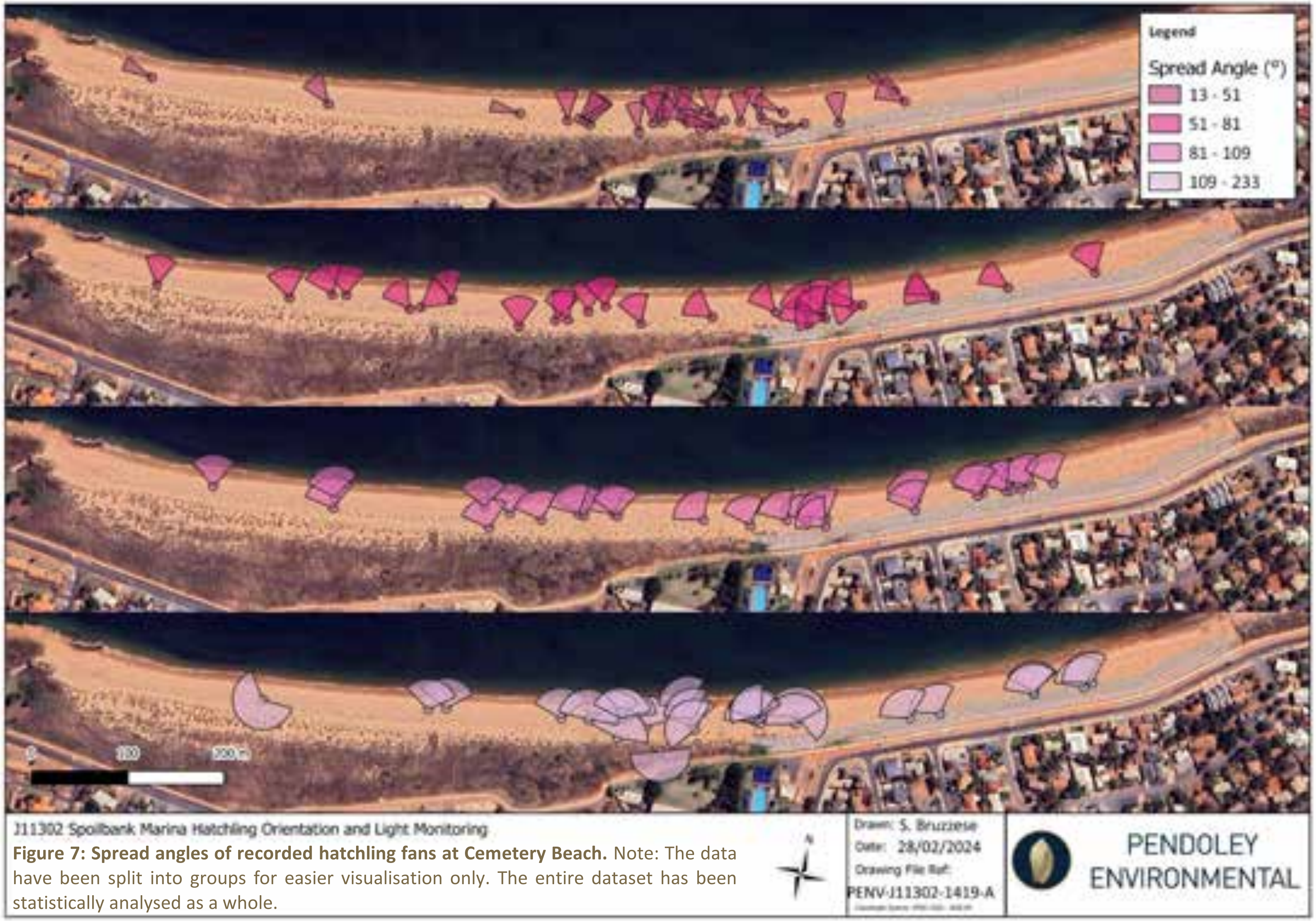


Figure 7: Spread angles of recorded hatchling fans at Cemetery Beach. Note: The data have been split into groups for easier visualisation only. The entire dataset has been statistically analysed as a whole.

Figure 8: Offset angles of recorded hatchling fans at Cemetery Beach. Note: The data have been split into groups for easier visualisation only. The entire dataset has been statistically analysed as a whole.

Figure 9: Location of hatchling nests displaying signs of severe disorientation. Note: Severe disorientation is defined as where no ‘A’ or ‘B’ angles could be determined – track bearings are scattered across a complete 360°.

4 SUMMARY

Hatchling orientation and artificial light monitoring were conducted over a 14-day period at Cemetery Beach in Port Hedland, Western Australia, during January 2024. This survey was undertaken during the peak hatching period for flatback turtles within the region and to coincide with new moon conditions. The purpose of the baseline monitoring program was to provide updated hatchling orientation trigger and threshold criteria along with updated light monitoring data to quantify the existing lighting environment. This will allow for suitable comparison against future artificial light and hatchling orientation monitoring as part of the operational reporting and monitoring program outlined in the Spoilbank Marina ALMP. All future monitoring must be conducted under new moon conditions to ensure a suitable comparison between datasets.

The artificial light monitoring results show that the dominant sources of sky glow from both locations are the port facilities followed by residential and commercial lighting from the Port Hedland urban area. Additionally, sky glow from the port facilities overlaps with the Spoilbank Marina from the perspective of both monitoring locations (approximately 263° – 280°). Streetlights from Sutherland Street are visible as direct light from both monitoring locations, while direct light from the Gratwick Aquatic Centre is visible from Cemetery Beach East, with light spill extending into the adjacent dunes (**Figure 5 – Figure 6**). The results also indicate a spatial relationship between the distance to port facilities and sky brightness values from monitoring locations. Cemetery Beach West recorded the brightest WOS sky brightness and is closest to the port facilities. Lower levels of WOS sky brightness were recorded at Cemetery Beach East, which is further from the port facilities (**Table 2**).

A total number of 135 nest emergences were recorded over the hatchling orientation survey period. Of these nests, 107 recorded five or more individual hatchling tracks and were analysed using a Bayesian projected normal regression model suitable for circular data. This analysis allows for the estimation of the mean offset and spread angles as well as upper and lower bounds for each mean. The upper and lower bounds indicate that there is a 95 % probability that the true mean lies within the bounds, based on the data. The mean spread angle for the baseline dataset was estimated to be 79° with lower and upper bounds of 63° and 96°, respectively. The mean offset angle was estimated to be 24° with lower and upper bounds of 16° and 32°, respectively (**Table 3**).

Trigger and threshold criteria for the baseline data were determined based on the upper bounds of the spread and offset angles of the 2023/24 baseline data (**Table 4**). These values were used to create an updated outcome-based trigger and response plan for flatback turtle hatchling orientation for inclusion in the Spoilbank Marina ALMP (**Appendix B**).

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Appendix A: Hatchling Orientation Data

Latitude (°)	Longitude(°)	A (°)	B (°)	X (°)
-20.30712	118.61128	35	295	340
-20.30688	118.61229	10	265	340
-20.30690	118.61263	60	300	340
-20.30668	118.61359	7	325	340
-20.30658	118.61377	350	310	345
-20.30652	118.61417	25	285	345
-20.30640	118.61429	20	300	345
-20.30602	118.61516	15	270	340
-20.30721	118.61065	48	295	350
-20.30732	118.61112	20	280	345
-20.30688	118.61241	65	294	345
-20.30702	118.61263	355	320	348
-20.30658	118.61420	325	265	340
-20.30579	118.61579	5	265	345
-20.30570	118.61605	359	268	345
-20.30750	118.60956	25	278	355
-20.30739	118.61032	340	280	350
-20.30711	118.61160	15	280	345
-20.30693	118.61230	40	278	344
-20.30698	118.61258	358	295	346
-20.30677	118.61285	35	350	347
-20.30647	118.61418	347	270	345
-20.30612	118.61518	10	278	345
-20.30566	118.61615	20	285	335
-20.30750	118.60957	335	290	348
-20.30697	118.61200	20	285	348
-20.30560	118.61624	358	265	340
-20.30539	118.61683	3	290	340
-20.30547	118.61675	15	265	335
-20.30708	118.61237	85	285	345
-20.30626	118.61467	283	215	341
-20.30604	118.61535	312	246	332
-20.30575	118.61603	317	264	340
-20.30654	118.61421	250	230	335
-20.30766	118.60781	297	270	350
-20.30757	118.60886	325	92	357
-20.30757	118.60913	15	300	340
-20.30741	118.60967	25	305	355
-20.30730	118.61141	22	310	343
-20.30712	118.61102	30	294	339
-20.30696	118.61195	5	270	350
-20.30698	118.61204	20	310	347
-20.30706	118.61215	34	355	355
-20.30678	118.61307	35	275	335
-20.30670	118.61330	4	321	343
-20.30645	118.61406	127	260	340
-20.30572	118.61601	352	270	328
-20.30552	118.61645	10	277	335
-20.30713	118.61144	283	260	352
-20.30777	118.60782	27	325	358
-20.30757	118.60835	30	302	341
-20.30739	118.60956	30	282	355
-20.30720	118.61070	4	307	339
-20.30689	118.61232	28	290	352
-20.30679	118.61279	4	322	340
-20.30680	118.61306	310	264	346
-20.30678	118.61304	4	324	344
-20.30631	118.61458	340	265	333
-20.30601	118.61500	296	282	340

-20.30600	118.61534	310	258	341
-20.30654	118.61385	332	278	342
-20.30670	118.61343	271	224	352
-20.30687	118.61284	349	298	348
-20.30370	118.61149	345	299	346
-20.30715	118.61175	33	339	345
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-20.30607	118.61542	13	260	336
-20.30647	118.61431	355	277	337
-20.30743	118.60953	2	285	341
-20.30726	118.61048	51	302	347
-20.30697	118.61204	86	270	342
-20.30688	118.61236	63	282	345
-20.30652	118.61405	46	255	347
-20.30659	118.61365	42	258	347
-20.30541	118.61682	13	258	323
-20.30656	118.61367	25	276	345
-20.30661	118.61298	16	259	345
-20.30671	118.61306	11	260	349
-20.30672	118.61316	358	258	347
-20.30648	118.61435	289	230	345
-20.30619	118.61514	17	259	331
-20.30566	118.61628	28	265	341
-20.30705	118.61208	45	359	347
-20.30703	118.61203	46	12	345
-20.30678	118.61336	280	255	344
-20.30666	118.61322	295	260	345
-20.30666	118.61362	11	283	342
-20.30651	118.61370	350	239	349
-20.30682	118.61310	16	216	347
-20.30711	118.61282	252	68	348
-20.30735	118.61041	70	8	354

Appendix B: Updated outcome-based trigger and threshold response plan for the Spoilbank Marina Artificial Light Management Plan.

<table>
<tr><td colspan="5">EPBC matter of significance: Nationally threatened species – Hatchling flatback turtles
Outcome: There will be no significant increase in hatchling misorientation or disorientation at Cemetery Beach.
Key impacts and risks: Change in hatchling sea-finding ability, reduced survivability/fitness.</td></tr>
<tr><td colspan="5">Outcome-based</td></tr>
<tr><td>Trigger criteria
Threshold criteria</td><td>Response actions:
Trigger level actions
Threshold level actions</td><td>Monitoring</td><td>Timing and frequency of monitoring</td><td>Reporting</td></tr>
<tr><td colspan="5">Condition: 5(a)iii a monitoring and reporting program, which includes baseline data that monitoring and reporting will be evaluated against, to be undertaken for a minimum length of two years post commencement of operation of the Marina to provide certainty that the artificial lighting of the Marina is not impacting flatback turtle hatchlings or nesting on Cemetery Beach.</td></tr>
<tr><td><u>Hatchling Orientation: Spread angle</u>
Trigger criteria
The mean spread angle exceeds 96° and the lower bound (95 % highest posterior density interval) is below 96°.
Threshold criteria
The lower bound spread angle (95 % highest posterior density interval) exceeds 96°.
<u>Hatchling Orientation: Offset angle</u>
Trigger criteria
The mean offset angle exceeds 32° and the lower bound (95 % highest posterior density interval) is below 32°.
Threshold criteria
The lower bound offset angle (95 % highest posterior density interval) exceeds 32°.</td><td><u>Trigger level action (for spread or offset angle)</u>

If a single season of monitoring reports an exceedance in trigger criteria: Hatchling orientation monitoring must continue for another season to determine if this is a trend.

If two or more consecutive seasons of monitoring report an exceedance in trigger criteria: Undertake desktop review of artificial light monitoring, lighting audit and hatchling orientation data to determine cause. The assessment will rate the level of impact associated with this exceedance and recommend actions (as described in Section 6.5 of the Spoilbank Marina Artificial Light Management Plan).</td><td>Indicators: Spread angle, offset angle

Hatchling orientation monitoring will be conducted seasonally at Cemetery Beach during peak flatback turtle hatching period and to coincide with new moon conditions.</td><td>Hatchling orientation monitoring will be undertaken post commencement of operations (e.g., limited operation) and for a minimum of three years post commencement of full operations.

If trigger/threshold criteria are exceeded, additional seasons of monitoring may be required pending the outcome of a desktop review.

Additional monitoring surveys may be required in the event adequate samples are not collected.</td><td>One report annually (per monitoring season) describing the results of the monitoring survey, including comparison against trigger and threshold criteria.</td></tr>
</table>

EPBC matter of significance: Nationally threatened species – Hatchling flatback turtles **Outcome:** There will be no significant increase in hatchling misorientation or disorientation at Cemetery Beach. **Key impacts and risks:** Change in hatchling sea-finding ability, reduced survivability/fitness.				
Outcome-based				
• **Trigger criteria** • **Threshold criteria**	**Response actions:** • **Trigger level actions** • **Threshold level actions**	**Monitoring**	**Timing and frequency of monitoring**	**Reporting**
Condition: 5(a)iii a monitoring and reporting program, which includes baseline data that monitoring and reporting will be evaluated against, to be undertaken for a minimum length of two years post commencement of operation of the Marina to provide certainty that the artificial lighting of the Marina is not impacting flatback turtle hatchlings or nesting on Cemetery Beach.				
	<u>Threshold level action (for spread or offset angle)</u> **If any season of monitoring reports an exceedance in threshold criteria:** Undertake review of artificial light monitoring, lighting audit and hatchling orientation data to determine cause. The assessment will rate the level of impact associated with this exceedance and recommend actions (as described in **Section 6.5** of the Spoilbank Marina Artificial Light Management Plan).			

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Appendix F: Line-of-Sight Analysis

DATUM RL -20.0

CENTRE LINE CHAINAGE	EXISTING SURFACE LEVEL
100.00	5.03
150.00	7.55
200.00	7.07
250.00	6.30
300.00	6.28
350.00	4.54
400.00	4.13
450.00	4.42
500.00	3.68
550.00	1.97
600.00	-0.33
650.00	-0.77
700.00	-0.92
750.00	-1.00
800.00	
850.00	
900.00	-1.52
950.00	-1.72
1000.00	-1.80
1050.00	-1.82
1100.00	-1.92
1150.00	
1200.00	
1250.00	
1300.00	
1350.00	
1400.00	
1450.00	
1500.00	
1550.00	
1600.00	
1650.00	
1700.00	
1750.00	
1800.00	-0.92
1850.00	-0.73
1900.00	-0.48
1950.00	-0.27
2000.00	-0.08
2050.00	0.13
2100.00	0.28
2150.00	0.56
2200.00	1.55
2250.00	2.59
2300.00	4.01
2350.00	4.26

SECTION TO MOST SEAWARD LIGHT

DATUM RL -20.0

CENTRE LINE CHAINAGE	EXISTING SURFACE LEVEL
100.00	
150.00	7.24
200.00	9.22
250.00	8.87
300.00	7.98
350.00	6.15
400.00	5.77
450.00	6.22
500.00	3.98
550.00	4.60
600.00	4.30
650.00	2.97
700.00	0.00
750.00	-0.77
800.00	-0.98
850.00	
900.00	-1.20
950.00	-1.47
1000.00	-1.54
1050.00	-1.55
1100.00	-1.58
1150.00	-1.61
1200.00	-1.64
1250.00	-1.68
1300.00	-1.60
1350.00	-1.48
1400.00	-1.41
1450.00	
1500.00	
1550.00	
1600.00	-0.92
1650.00	-0.76
1700.00	-0.56
1750.00	-0.29
1800.00	-0.28
1850.00	-0.22
1900.00	-0.16
1950.00	0.03
2000.00	0.28
2050.00	0.42
2100.00	0.86
2150.00	1.53
2200.00	2.25
2250.00	3.12
2300.00	4.06
2350.00	4.26

SECTION THROUGH CARPARK

DATUM RL -20.0

CENTRE LINE CHAINAGE	EXISTING SURFACE LEVEL
100.00	7.09
150.00	8.01
200.00	9.19
250.00	10.35
300.00	9.78
350.00	8.76
400.00	7.68
450.00	7.01
500.00	5.93
550.00	4.01
600.00	2.86
650.00	4.28
700.00	4.98
750.00	4.15
800.00	1.81
850.00	-0.07
900.00	-0.07
950.00	-0.13
1000.00	-0.15
1050.00	-0.12
1100.00	-0.14
1150.00	-0.16
1200.00	-0.21
1250.00	-0.22
1300.00	-0.23
1350.00	-0.27
1400.00	-0.26
1450.00	-0.20
1500.00	-0.12
1550.00	-0.01
1600.00	0.39
1650.00	2.38
1700.00	1.93
1750.00	1.80
1800.00	1.55
1850.00	1.30
1900.00	1.25
1950.00	1.40
2000.00	1.59
2050.00	1.89
2100.00	2.23
2150.00	2.57
2200.00	3.11
2250.00	3.96
2300.00	4.06
2350.00	4.26

SECTION TO YACHT CLUB

PRELIMINARY

REV	DATE	DRAWN	CHECKED	APPROVED	
B		SP			UPDATED TO LATEST LAYOUT
A	29/11/19	SP			ISSUED FOR REVIEW

NOTE
This drawing shall be preliminary only until it is Issued for Construction.

Certified Quality System to ISO 9001

JDSi CONSULTING ENGINEERS

CLIENT: PILBARA PORTS AUTHORITY

PROJECT: SPOILBANK MARINA

DRAWING TITLE: SECTIONS TOWARDS CEMETERY BEACH WITH EXTENDED SURVEY SHOWING TURTLE NESTING AREAS

DRAWN: STEVE PARK	WAPC No.		
DESIGNED: STEVE PARK	SCALE @ A1: 1:3000		
PROJECT MANAGER: D HELLMUTH	DATUM: AHD	CO-ORDS: PHG2020	
JDSi PROJECT No.: JDS14736	DRAWING No.: SK503		REVISION: B

Plotted By: SPark Plot Date: 12/07/23 - 14:48 Cad File: I:\JDS14736\Drawings\DWG\Sketches\JDS14736.0_SK500-503.dwg

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Appendix G: Landscape Design


Delonix regia


Cupaniopsis anacardioides


Adansonia gregorii


Bauhinia x blackeana


Millettia pinnata


Peltophorum pterocarpum


Plumeria obtusa


Melaleuca leucadendra


Roystonea regia


Hibiscus tiliaceus


Terminalia catappa


Wodyetia bifurcata


STANDARD NOTES

1. **SET OUT & DIMENSIONS.** THE CONTRACTOR SHALL SET OUT ALL PATHS, WALLS, HARD SURFACES AND ELEMENTS EITHER ON OR OFFSITE PRIOR TO CONSTRUCTION AND SHALL OBTAIN THE SUPERINTENDENTS SET OUT APPROVAL PRIOR TO WORKS COMMENCING. WRITTEN DIMENSIONS SHALL TAKE PRECEDENCE OVER SCALE. CHECK ALL DRAWING SCALES IN CONJUNCTION WITH DRAWING SIZE.
2. **SERVICES & SITE ASSETS.** THE CONTRACTOR SHALL INVESTIGATE THE NATURE AND LOCATION OF ALL EXISTING SERVICES AND RETAINED SITE ASSETS AFFECTED BY THEIR WORKS. FAILURE TO TAKE DUE CARE SHALL NOT LIMIT THE CONTRACTORS LIABILITIES.
3. **REFERENCE.** THE CONTRACTOR SHALL REFER TO ALL CONTRACT DOCUMENTS, THE SPECIFICATION AND DRAWINGS PRIOR TO AND DURING THE WORKS.
4. **DISCREPANCIES.** NOTIFY SUPERINTENDENT OF ANY SUSPECTED OR KNOWN DISCREPANCIES OR ERRORS PRIOR TO THE ORDERING OF AFFECTED MATERIALS AND OR CONSTRUCTION OF AFFECTED WORKS.
5. **RELEVANT STANDARDS.** THE CONTRACTOR SHALL UNDERTAKE ALL PRICING AND WORKS IN ACCORDANCE WITH CURRENT INDUSTRY BEST PRACTICE AND ALL RELEVANT AUSTRALIAN STANDARDS.
6. **SERVICE LOCATOR.** THE CONTRACTOR SHALL UNDERTAKE A DIAL BEFORE YOU DIG PROCESS PRIOR TO COMMENCING WORKS ON SITE. THE CONTRACTOR SHALL ENGAGE A SERVICE LOCATOR TO MAP THE SPECIFIC LOCATIONS AND DEPTH OF ALL SERVICES AND ADVISE ALL RELEVANT STAFF AND SUBCONTRACTORS IN WRITING PRIOR TO COMMENCING WORKS ON SITE.

PERTH ONE CALL SYSTEM DIAL 1100 DIAL BEFORE YOU DIG

REV	DATE	BY	ISSUE OR AMENDMENT
0	300323	PFB	ISSUE FOR CONSTRUCTION

THIS IS AN UNCONTROLLED DOCUMENT ISSUED FOR INFORMATION ONLY UNLESS SIGNED BELOW AT EACH RELEVANT STAGE.

INTERNAL DESIGN REVIEW
THIS DESIGN IS NOT AUTHORISED WITHOUT BEING INTERNALLY REVIEWED AND IS SIGNED HERE
EMERGE DIRECTOR DATE

INTERNAL PRETENDER REVIEW
THIS DRAWING IS NOT AUTHORISED FOR TENDER WITHOUT BEING INTERNALLY REVIEWED AND IS SIGNED HERE
EMERGE DIRECTOR DATE

AUTHORISED FOR CONSTRUCTION
THIS DRAWING IS NOT AUTHORISED FOR CONSTRUCTION UNLESS IT IS MARKED REV 1 OR HIGHER AND IS SIGNED HERE
PFB
EMERGE DIRECTOR DATE

emerge ASSOCIATES
Integrated Science & Design
PERTH (08) 9380 4988 • MARGARET RIVER (08) 9758 8159

PROJECT
SPOILBANK MARINA
PORT HEDLAND, WA
STAGE OR PHASE
WORK PACKAGE 4
LANDSCAPE
DRAWING TITLE
TREE STRATEGY MASTERPLAN

CLIENT
PILBARA PORTS AUTHORITY

DESIGNED BY	EC	PRELIM DESIGN REVIEWED BY	EC
DRAWN BY	AN	PRELIM DWG REVIEWED BY	PB
DATE INITIALLY DRAWN	13.10.2021		

SCALE 1: 1000 @ A1 METRES
0 10 20 30 40 50

DRAWING NUMBER
PH-SM-05-201
REV 0

REF U:\CURRENT PROJECTS\NORTH WEST PROJECTS\SPOILBANK\(JOB CODE) DRAWINGS\(JOB CODE) AUTOCAD\(JOB CODE) LANDSCAPE\2023\PH-SM-05_ ...020_B.DWG

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Appendix C. Cemetery Beach Sediment Management Plan

m p rogers & associates pl ABN 14 062 681 252

creating better coasts and ports

R1665 Rev 7

July 2024

Pilbara Ports Authority

EPBC 2019/8520 Port Hedland Spoilbank Marina
Cemetery Beach Sediment Management Plan

marinas

boat harbours

canals

breakwaters

jetties

seawalls

dredging

reclamation

climate change

waves

currents

tides

flood levels

water quality

siltation

erosion

rivers

beaches

estuaries

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creating better coasts and ports

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e: admin@coastsandports.com.au
w: www.coastsandports.com.au

K1973, Report R1665 Rev 7
Record of Document Revisions

Rev	Purpose of Document	Prepared	Reviewed	Approved	Date
0	Issued for Use	J Costin	C Doak	C Doak	30/6/23
1	Revised with Client comments	J Costin	C Doak	C Doak	17/7/23
2	Revised with Client comments	J Costin	C Doak	C Doak	28/9/23
3	Revised with Client comments	J Costin	C Doak	C Doak	29/9/23
4	Revised with Client comments	W Gardiner	J Costin	C Doak	21/11/23
5	Updated with September 2023 monitoring data	J Costin	C Doak	C Doak	14/12/23
6	Revised with regulator comments	J Costin	J Costin	C Doak	29/05/24
7	Revised with regulator comments	J Costin	C Doak	C Doak	01/08/24

Form 035 18/06/2013

Limitations of this Document

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Declaration of Accuracy

I declare that:

1. To the best of my knowledge, all information contained in, or accompanyining this Cemetery Beach Sediment Management Plan (R1665 Rev 7) is complete, current and correct.

2. I am duly authorised to sign this declaration on behalf of the approval holder.

3. In making this declaration I am aware that Section 491 of the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) makes it an offence in certain circumstances to knowingly provide false or misleading information or documents to specified persons who are known to be performing a duty or carrying out a function under the EPBC Act or the Environment Protection and Biodiversity Conservation Regulations 2000 (Cth). The offence is punishable on conviction by imprisonment or a fine, or both. I am authorised to bind the approval holder to this declaration and that I have no knowledge of that authorisation being revoked at the time of making this declaration.

Signed	
Date:	16 August 2024
Full Name:	Shelley Grice
Orginisation:	Department of Transport
EPBC Act Referral:	2019/8520

Summary

<table>
<tr><th>Proposal detail</th><th colspan="2">Description</th></tr>
<tr><td>Title of Proposal</td><td colspan="2">Port Hedland Spoilbank Marina Project</td></tr>
<tr><td>Proponent</td><td colspan="2">Pilbara Ports Authority</td></tr>
<tr><td>EPBC number</td><td colspan="2">EPBC 2019/8520</td></tr>
<tr><td>Purpose of monitoring plan</td><td colspan="2">Monitor the coastal processes associated with the Spoilbank in Port Hedland and surrounding beaches, including the turtle nesting grounds at Cemetery Beach, and, the potential impacts to coastal processes associated with the implementation of the Spoilbank Marina Project.

The monitoring plan will also inform management responses if denuding of the turtle nesting grounds at Cemetery Beach occurs as a result of the Spoilbank Marina Project.</td></tr>
<tr><td rowspan="2">Condition clause/s</td><td>5(b)</td><td>Include a Sediment Management Plan (SMP) that ensures anthropogenic activities of the action do not result in, or contribute to, the denuding of Cemetery Beach. The SMP must include measures to monitor for denuding of Cemetery Beach and specify intervention measures to be implemented should denuding of Cemetery Beach be predicted or detected as a result of:

i. anthropogenic activities; and/or

ii. environmental factors in combination with anthropogenic activities.</td></tr>
<tr><td>7</td><td>All plans required under these conditions must be consistent the with Departments Environmental Management Plan Guidelines, and must include:

a) The environmental objectives, relevant to protected matters and a reference to EPBA Act approval conditions to which the plan refers;

b) A table of commitments made in the plan to achieve the objectives; and a reference to where the commitments are detailed in the plan;

c) Reporting and review mechanisms, and documentation standards to demonstrate compliance with the commitments made in the plan;

d) An assessment of risks to achieving the environmental objectives and risk management strategies that will be applied;

e) Impact avoidance, mitigation and/or repair measures, and their timing; and

f) A monitoring program, which must include:

i. measurable performance indicators;

ii. trigger values for corrective actions;

iii. the timing and frequency of monitoring to detect trigger values and changes in the performance indicators; and

iv. proposed corrective actions, if trigger values are reached.</td></tr>
<tr><td>Key provisions in the plan</td><td colspan="2">This plan outlines the monitoring requirements for Cemetery Beach and presents intervention measures to manage any impacts caused by the development.</td></tr>
</table>

1. Introduction

1.1 General

The Pilbara Ports Authority (PPA) is delivering the Spoilbank Marina in Port Hedland. The Spoilbank Marina is a recreational boating and waterfront precinct that is being constructed on the western shoreline of the Spoilbank. The project has been through a detailed design and environmental approval process and is currently in the later phases of construction with the marina expected to be operational at the end of 2023, with landscaping expected to finish mid to late 2024. A layout plan for the marina development is provided in Figure 1.1.

Figure 1.1 Spoilbank Marina Design

In accordance with the environmental approval requirements, this Sediment Management Plan (SMP) has been prepared to consider the potential impacts of the development on the nearby turtle nesting site known as Cemetery Beach. The location of Cemetery Beach is shown in Figure 1.2.

Figure 1.2 Location of Cemetery Beach (Source: Nearmap, Date: May 2023)

1.2 Environmental Objectives

This Sediment Management Plan (SMP) has been prepared in response to the Australian Government, Department Climate Change, Energy, the Environment and Water approval for the Port Hedland Spoilbank Marina (EPBC 2019/8520).

Commensurate with the requirement for management of environmental impacts associated with the construction and operation of the Spoilbank Marina, the primary objective of this SMP is as follows.

- To minimise the impacts of the Port Hedland Spoilbank Marina Project on sediment transport pathways within the region surrounding the Spoilbank Marina and Cemetery Beach and associated impacts to relevant protected matters under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).

In accordance with Condition 7(a) of EPBC 2019/8520, it is noted that this SMP relates to the protection of Flatback Turtle nesting at Cemetery Beach.

The purpose of this SMP is to outline the monitoring requirements and subsequent management actions to ensure that the construction and operation of the Spoilbank Marina will not result in, or contribute to, the denuding of sediment from Cemetery Beach. Importantly, this plan has been prepared with a focus on the changes to coastal process and sediment transport pathways that are the result of, or contributed to by, the implementation of the Spoilbank Marina. This is commensurate with the objective of Condition 5(b) which focuses on the impacts associated with the construction and operation of the development.

To achieve the primary objective outlined above, the secondary objectives of this SMP are as follows.

- To quantify the existing sediment transport pathways within the region surrounding the Spoilbank Marina and Cemetery Beach, including details of how these sediment transport pathways are expected to change in the future.

- To outline a coastal monitoring regime that can be used to assess changes in the sediment transport pathways and subsequent positions of the shoreline.

- To outline a methodology to investigate any changes observed during the coastal monitoring and to determine whether the changes were a result of the construction or operation of the Spoilbank Marina.

- To specify appropriate intervention measures to be implemented should the investigations show that any denuding of sediment from Cemetery Beach is caused, or contributed to, by the construction or operation of the Spoilbank Marina.

1.3 Condition Requirements & Commitments

In accordance with Condition 7(b), the requirements of Conditions 5(b) and 7 of EPBC 2019/8520 and the commitments outlined within this SMP are presented in Table 1.1 below.

Table 1.1 Condition Requirements and In-Plan Section References

Condition no.	Condition	Section in this Plan
5(b)	Include a Sediment Management Plan (SMP) that ensures anthropogenic activities of the action do not result in, or contribute to, the denuding of Cemetery Beach. The SMP must include measures to monitor for denuding of Cemetery Beach and specify intervention measures to be implemented should denuding of Cemetery Beach be predicted or detected as a result of: i. anthropogenic activities; and/or ii. environmental factors in combination with anthropogenic activities.	Entire Document
7	All plans required under these conditions must be consistent the with Departments Environmental Management Plan Guidelines, and must include:	
	a) The environmental objectives, relevant to protected matters and a reference to EPBA Act approval conditions to which the plan refers;	1.2
	b) A table of commitments made in the plan to achieve the objectives; and a reference to where the commitments are detailed in the plan;	1.3
	c) Reporting and review mechanisms, and documentation standards to demonstrate compliance with the commitments made in the plan;	6
	d) An assessment of risks to achieving the environmental objectives and risk management strategies that will be applied;	1.5
	e) Impact avoidance, mitigation and/or repair measures, and their timing; and	4.3
	f) A monitoring program, which must include:	
	i. measurable performance indicators;	4.1
	ii. trigger values for corrective actions;	4.2 & 4.3
	iii. the timing and frequency of monitoring to detect trigger values and changes in the performance indicators; and	3, 4.1 & 4.2
	iv. proposed corrective actions, if trigger values are reached.	4.3

1.4 Rationale & Approach

This document has been prepared to provide details of the local sediment transport regime surrounding the Spoilbank Marina and outlines the monitoring requirements and associated environmental management actions that will be implemented, if required, during operation of the Proposal.

The identified potential impacts have been determined and informed based on an understanding of the local metocean conditions and the resultant sediment transport regime.

The management approach is for an adaptive management strategy where further investigations and/or management actions are required if monitoring results suggest that trigger values have been exceeded. A key component of these investigations will be to determine the cause of any trigger exceedance, and specifically, whether the trigger exceedance was attributable to the construction of the Spoilbank Marina.

1.5 Risk Assessment

In accordance with Condition 7(d), a risk assessment has been completed to determine the level of risk associated with the construction and operation of the Spoilbank Marina insofar as its construction could result in, or contribute to, the denuding of sediment from Cemetery Beach. This risk assessment has been completed on the basis of the information presented in the latter sections of this report.

The risk assessment process has been modified from the Great Barrier Reef Marine Park Authority Environmental Assessment and Management Risk Management Framework (GBRMPA 2009). The risk matrix is presented in Table 1.2 with descriptions of the likelihood and consequence definitions provided in Tables 1.3 and 1.4, respectively. The risk assessment provided in Table 1.5 presents the risks before and after (residual risk) mitigation measures.

As outlined in Section 1.2, this SMP has been prepared with a focus on the changes to coastal process and sediment transport pathways that are attributable to construction and operation of the Spoilbank Marina. As outlined in Section 2, various changes to the local sediment transport pathways and subsequent movement of Cemetery Beach, including shoreline recession, have occurred in the past and are predicted to continue into the future independent of the Spoilbank Marina. The risk assessment presented in Table 1.5 considers the risk of the Spoilbank Marina impacting sediment transport and subsequent potential impacts to Cemetery Beach, in addition to, or beyond, these predicted independent changes.

Table 1.2 Risk Matrix

		Consequence				
		Insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Catastrophic (5)
Probability (Likelihood)	Almost Certain (5)	Medium (8)	High (16)	High (18)	Extreme (22)	Extreme (25)
	Likely (4)	Low (4)	Medium (10)	High (17)	Extreme (21)	Extreme (24)
	Possible (3)	Low (3)	Medium (9)	Medium (12)	High (19)	Extreme (23)
	Unlikely (2)	Low (2)	Low (6)	Medium (11)	Medium (14)	High (20)
	Rare (1)	Low (1)	Low (5)	Low (7)	Medium (13)	Medium (15)

Table 1.3 Likelihood Rating

Likelihood	Description	Indicative Return Period	Indicative Probability (over the timeframe)
5 – Almost Certain	Common/frequent occurrence. Expected to occur on an annual basis.	Every year or more	> 0.9
4 – Likely	Is known to occur or has happened regularly. The event has occurred a number of times in the last decade.	Every three years	> 0.3, < 0.9
3 – Possible	Could occur, or known to occur based on anecdotal evidence. The event might occur once per decade.	Every ten years	> 0.1, < 0.3
2 – Unlikely	Not likely to occur very often, but does occur from time to time.	Every thirty years	> 0.03, < 0.1
1 – Rare	Conceivable but only in exceptional circumstances.	Every fifty years	> 0.03

Table 1.4 Consequence Rating

Consequence	Description
5 – Catastrophic	Turtle habitat is irretrievably compromised. Mass mortality of turtles and local extinction of species. Recovery over several decades for habitat values and centuries for turtle populations.
4 – Major	Major loss of turtle habitat. Recovery of habitats would take a few decades with populations taking several decades.
3 – Moderate	Turtle habitat is significantly affected. Recovery at habitat level would take at least a decade.
2 – Minor	Impacts are present, but not to the extent that the overall condition of turtle populations or their habitat are impaired in the long term. Recovery would generally be measured in years for habitats.
1 – Insignificant	Very small to no impact on the overall nesting habitat area.

Table 1.5 Risk Assessment

Risk	Risk Rating (without mitigation measures)			Mitigation Measures	Residual Risk Rating		
	Likelihood	Consequence	Rating		Likelihood	Consequence	Rating
Construction and operation of the Spoilbank Marina resulting in, or contributing to, the denuding of sediment from Cemetery Beach	1	3	7	- Coastal Processes Monitoring to determine; (i) if denuding of Cemetery Beach occurs; (ii) if the denuding is attributable to the construction or operation of the Spoilbank Marina; and (iii) inform the implementation of management strategies. - Implementation of Shoreline Management Strategies to mitigate impacts if required – ie sand bypassing/back passing and/or sand nourishment.	1	2	5

As shown in Table 1.5, the risk of construction and operation of the Spoilbank Marina causing or contributing to, the denuding of sediment from Cemetery Beach is considered to be low; however, with the mitigation measures of coastal processes monitoring and, if required, the implementation of shoreline management strategies, this risk is reduced.

1.5.1 Mitigation Measures

As outlined in Table 1.5, mitigation measures includes coastal processes monitoring and shoreline management strategies. The Coastal Processes Monitoring measures are outlined in Section 3. The Shoreline Management Strategies are outlined in Section 4.3.

1.6 Roles & Responsibilities

To provide clarity surrounding the implementation of the requirements of Conditions 5(b) and 7 of EPBC 2019/8520, the relevant roles and responsibilities of the SMP shall be consistent with roles and responsibilities outlined in Section 5.6, Table 6 of the *Port Hedland Spoilbank Marina Project Operational Environmental Management Plan* (O2 Marine, 2024).

It is noted that, as outlined in latter sections of this document, an experienced coastal engineer will be required to review and interpret results of the coastal monitoring regime to determine if any impacts are attributable to the construction of the Spoilbank Marina. The experienced coastal engineer will be appointed by the relevant party to assist with the coastal monitoring, analyses and reporting as per the requirements of the SMP.

The experienced coastal engineer must be a chartered professional engineer with at least 5 years of relevant coastal engineering experience. They may be either an engineering consultant or an 'in house' employee of the relevant party.

2. Background Information

2.1 Metocean Conditions

The following sections summarise the local metocean conditions which influence the local sediment transport regime.

2.1.1 Water Levels

Astronomical Tides

Port Hedland is subjected to a semi-diurnal tidal regime with a spring tidal range typically around 6 m.

A submergence curve for Port Hedland has been prepared by the Department of Transport (DoT). Some of the key tidal levels are provided in the following table.

Table 2.1 Port Hedland Tidal Characteristics

Key Tidal Level	Chart Datum (mCD)	Australian Height Datum (mAHD)
Highest Astronomical Tide (HAT)	7.53	3.63
Mean Sea Level (MSL)	3.93	0.03
Lowest Astronomical Tide (LAT)	0.00	-3.90

Extreme Water Levels

Extreme water levels at the site result from storm surge events.

Extreme storm surge events in Port Hedland are typically associated with the passage of cyclones. Storm surges are typically made up of a number of factors, as shown in Figure 2.1.

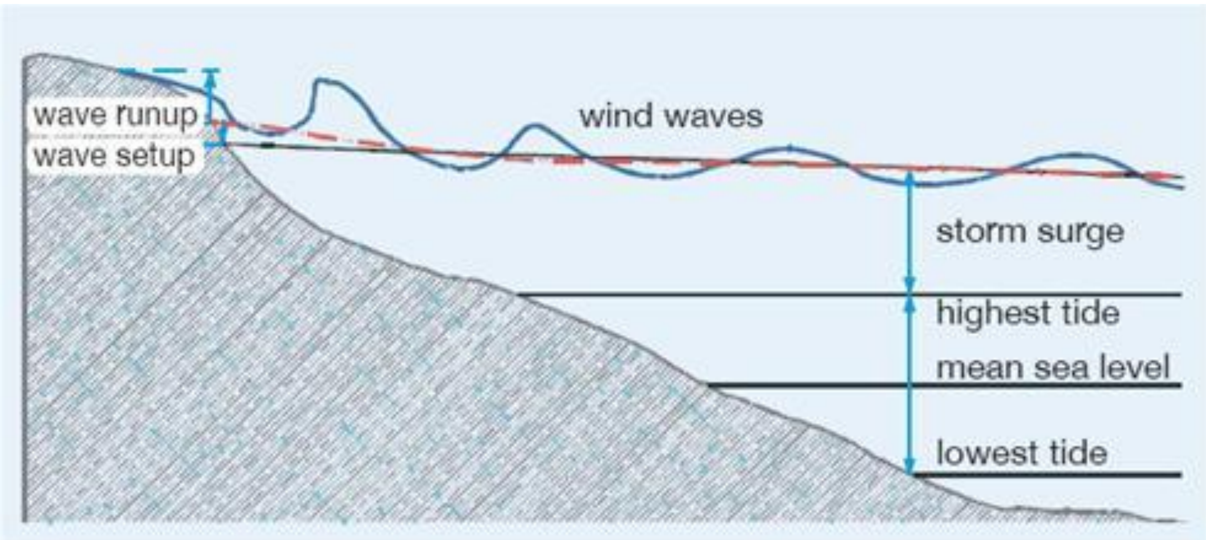


Figure 2.1 Coastal Inundation Mechanism

Strong cyclonic winds can push water against the shoreline, resulting in an elevated water level from wind and wave setup. A reduction in atmospheric pressure also results in increased water levels.

Modelling of inundation and extreme water levels relevant for the Spoilbank have been completed by Baird (2020) and Cardno (2011). MRA (2023) reviewed these water levels and determined different extreme levels applicable for the western and eastern shorelines of the Spoilbank for the Spoilbank Marina Coastal Hazard Risk Management and Adaptation Plan. The extreme water levels determined by MRA are presented in Table 2.2.

Table 2.2 Port Hedland Extreme Water Levels – Present Day

ARI (years)	Peak Steady Water Level (mAHD)	
	Port Hedland Entrance & Western Spoilbank[1]	Port Hedland Eastern Spoilbank to Pretty Pool[1]
20	4.31	4.90
100	5.11	6.10
500	5.71	6.80

Note: 1. These estimates include allowances for wave setup.

Sea Level Rise

Extreme and ambient water levels are expected to increase in the future with sea level rise as a result of climate change.

The Intergovernmental Panel on Climate Change (IPCC) has presented various scenarios of possible climate change and the resultant sea level rise in the coming century. The range of these projections is shown in Figure 2.2 (IPCC 2023).

As shown in Figure 2.2, a range of potential sea level rise scenarios may occur into the future depending on the global response to climate change and green house gas emission reductions. The intermediate scenario indicates approximately 0.4 m of sea level rise over the next 50 years.

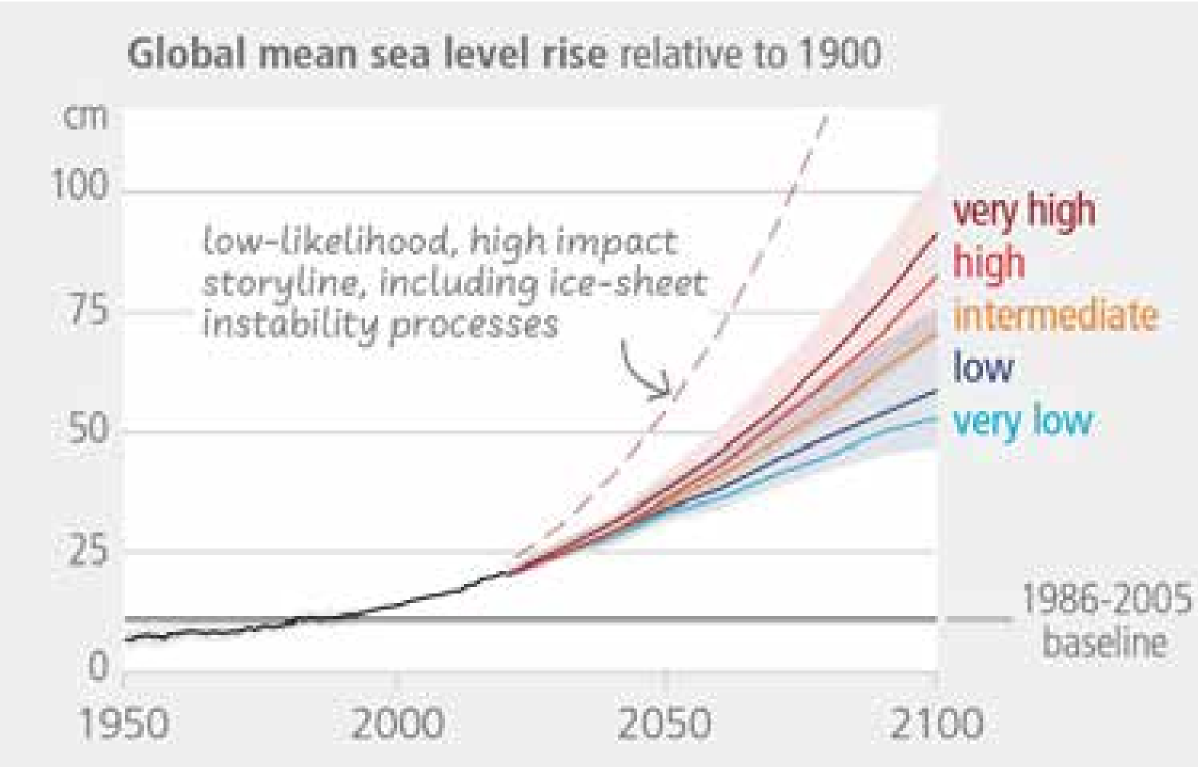


Figure 2.2 IPCC Scenarios for Sea Level Rise (IPCC 2023)

2.1.2 Winds

The Port Hedland region has a seasonal wind pattern. Wind speeds and directions have been recorded by the Bureau of Meteorology (BoM) at Port Hedland Airport since 1942.

In winter (May to October), medium to strong winds (>20 km/hr) are typically experienced from the east and south-east during the morning. This wind direction generally swings to a lighter north to north-west wind direction in the afternoon. In summer (November to April), winds are variable in the morning; however, winds in the afternoon are consistently medium to strong from the north-west. These general trends are reinforced by land and sea breezes induced by temperature differences between the land and water. Wind roses for the broad summer and winter periods are presented in Figure 2.3.

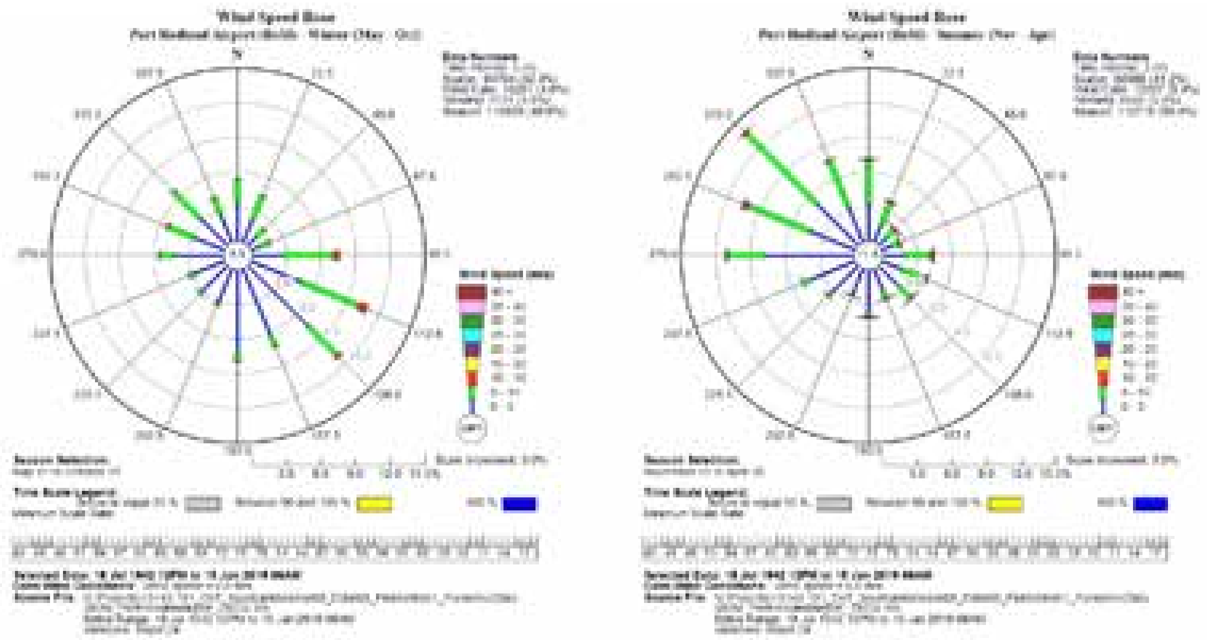


Figure 2.3 Port Hedland Wind Roses for Winter (left) and Summer (right) (Source: Baird, 2020)

These wind patterns are important for wave generation and sand transport, as detailed in the following sections.

2.1.3 Waves

Waves in the Port Hedland region are generated by three main processes, as listed below.

- Locally generated seas (wind waves).
- Indian Ocean swell.
- Cyclonic waves.

As with the winds, the wave climate at Port Hedland displays a seasonal pattern. In winter, seas are typically from the east in the mornings due to the dominant wind directions, with an underlying north-westerly swell component. In summer, seas swing to the west and north-west direction in line with the winds. Summer swell conditions are typically smaller than winter swells.

The directionality of the wave climate is shown in Figure 2.4 which presents wave roses prepared from measurements at Beacons 15 – located approximately 15 km offshore. These wave roses show the combined effect of the Indian ocean swell and locally generated seas, with the overwhelming direction of incident waves from the north-westerly quadrant.

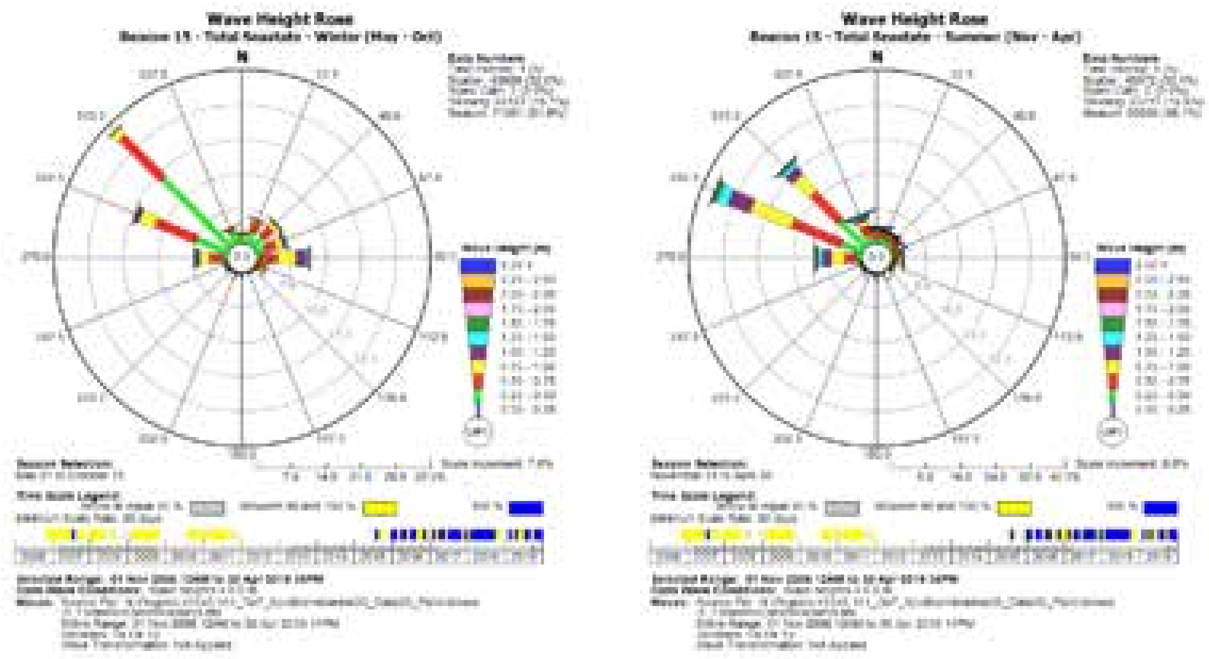


Figure 2.4 Wave Roses from Beacon 15; Winter (Left) & Summer (Right)

Cyclones are most likely to occur in summer between November and April. Waves generated by cyclones can be very large, with the direction highly dependent on the cyclone track. Cyclones passing at a large distance from the coast can also generate swell that reaches the coast, with minimal associated seas.

2.2 Sediment Transport Regime

Understanding the local sediment transport regime is critical when considering the potential for the construction of the Spoilbank Marina to have an impact on Cemetery Beach. Relevant details regarding the local sediment transport regime are presented hereafter.

2.2.1 Sediment Cells

Seashore (2014), on behalf of DoT, have classified the Pilbara coastline between Giralia and Beebingarra Creek in terms of primary, secondary and tertiary level sediment cells. Seashore (2014) define sediment cells as "*spatially discrete areas of the coast within which marine and terrestrial landforms are likely to be connected through processes of sediment exchange*" and proposed that the cells could facilitate better integration of coastal management decision making between governance, science and engineering at a regional and local level.

The differences in cell hierarchy reflect the varying timescales for assessment of each sediment cell level. Characteristics of each cell level are described below (Seashore 2014).

- Primary cells are related to areas with sediment supply from river systems and large rock barriers to alongshore sediment transport. They are most relevant to potential change in large landform assemblages or land systems over extended coastal management timescales of more than 50 years.

- Secondary cells incorporate contemporary sediment movement on the shoreface, variation in supratidal landforms and potential landform responses to inter-decadal changes in coastal processes.

- Tertiary cells are defined by the reworking and movement of sediment in the nearshore and are most relevant for seasonal to inter-annual changes to the intertidal landforms on the beachface. Mapping of tertiary cells was limited to the beachface point because of insufficient resolution of the available datasets.

The extent of the sediment cells defined by Seashore (2014) around the Spoilbank shoreline are presented in Figure 2.5.

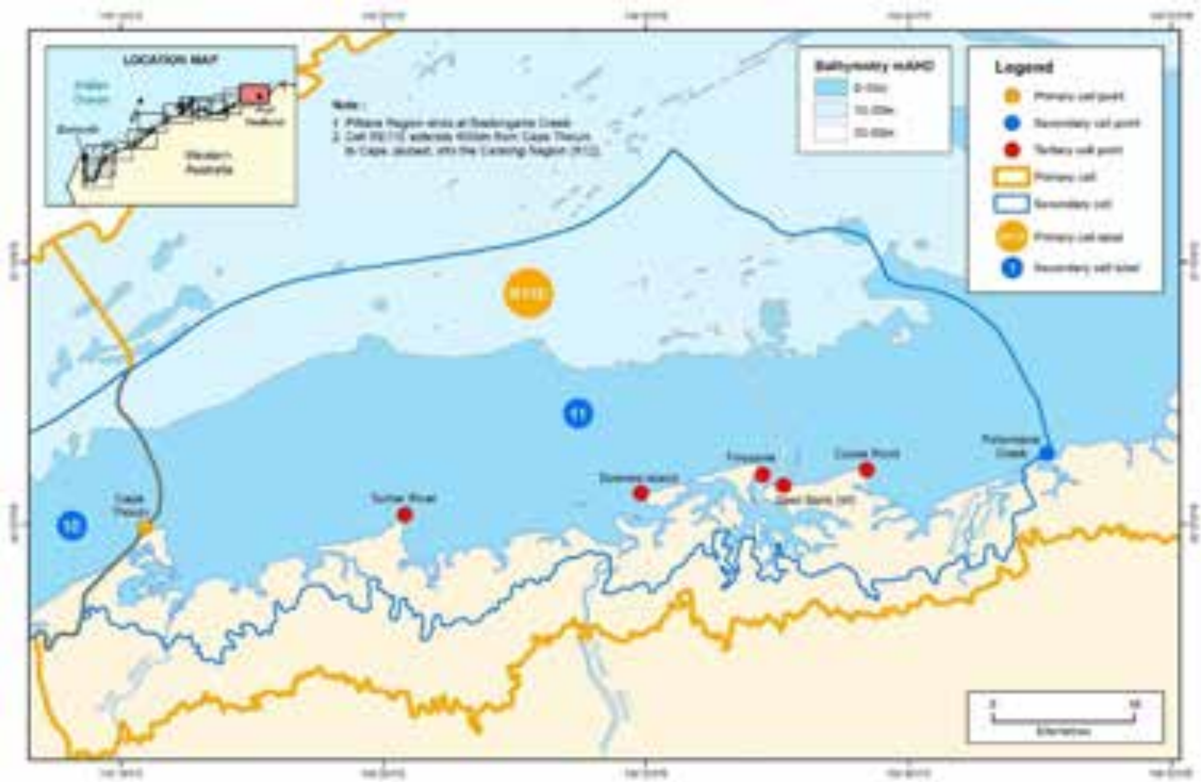


Figure 2.5 Sediment Cell Boundaries (Seashore 2014)

The study area for this report is within the primary sediment cell R11E, which extends 455 km from Cape Thouin to Cape Jaubert. It is within secondary cell 11 which extends from the primary cell boundary at Cape Thouin to Petermarer Creek.

Within this secondary cell, there are 5 tertiary cells, outlined below:

- Turner River.
- Downes Island.
- Finucane.
- Spoilbank.
- Cooke Point.

The Spoilbank cell will be the primary focus for this assessment.

2.2.2 Geology & Geomorphology

The general coastal morphology of the Port Hedland area is described as a Plistocene limestone barrier system with a shoreline consisting of low coastal cliff and rock formations (Cardno 2011, GHD 2015). This has resulted in the creation of a mixture of high tide sand beaches and low craggy beachrock bluffs along the shoreline. The general layout of the area is shown in Figure 2.6.

Figure 2.6 Existing Geomorphological Setting of Port Hedland Shoreline Source: Nearmap, Date: May 2023)

The Cemetery Beach and Spoilbank shorelines are described below. Recent photographs showing the condition of these locations prior to construction of the Spoilbank Marina are presented in Figures 2.8, 2.9 and 2.10. The locations and orientations of these photos are shown in Figure 2.7.

Figure 2.7 Spoilbank & Cemetery Beach Shorelines

Cemetery Beach is described as a steep reflective high tide beach, fronted by inter to low tide calcarenite flats (Short 2006), as shown in Figure 2.8. Cemetery Beach is generally bound by sections of beachrock which extend along the coast in easterly and westerly directions. Whilst sediment transport can occur along the sections of beachrock during certain tides, there are generally only small volumes of sediment that move along this area, largely due to the predominately sediment starved nature of this section of coastline.

Figure 2.8 View of Cemetery Beach Looking West towards the Spoilbank (Photograph taken on 24 March 2022)

The Spoilbank shorelines are generally characteristic of the macrotidal Pilbara region and are made up of a mostly flat subtidal area with partly emergent rock features and mobile sediments forming a gently graded intertidal beach (Eliot et al. 2013).

Photos shown in Figures 2.9 and 2.10 display the mostly flat beach shoreline along the western facing beach of the Spoilbank. The body of water located at the base of the Spoilbank landform is a manifestation of a historical basin and channel that was used by the Port Hedland Yacht Club and is now the location for the construction of the Spoilbank Marina. The historical dredged channel is barely visible and the historical basin was only connected to the ocean at high water levels.

Figure 2.9 Typical Pre-Construction Spoilbank Shoreline Looking Southwest (Left) & Southeast (Right) (Photograph taken on 24 March 2019)

As shown in Figure 2.10, the site features sandy material that slopes gently back from the shoreline to a low level vegetated dune system. There are small rocks ranging in size along the beach as well as a flat rock platform that extends out from the shoreline.

Figure 2.10 Typical Spoilbank Shoreline Looking North (Photograph taken on 29 May 2018)

The eastern facing beach of the Spoilbank spans 2.9 km in length and is fronted by low tide sand flats. Historically, sand has accumulated at the base of the eastern beach causing it to prograde 100-200 m along the northern beach rock shoreline (Short 2006). Further details regarding the history of the Spoilbank are provided in the following section.

The entrance to the Port of Port Hedland Inner Harbour is located approximately 1 km west of the Spoilbank. The Port of Port Hedland shipping channel extends approximately 22 nautical miles in a generally north to north westerly direction from the Inner Harbour Entrance. The channel varies in width and depth over its length with a minimum width of 163 m and minimum depth of 14.9 m (Pers Comm Andrew Stanley, 18 July 2023). Finucane Island and surrounding shallow areas are located further west of the shipping channel, which allows the Spoilbank to be somewhat sheltered from the immediate westerly direction. These features are shown by the nautical chart extract provided in Figure 2.11.

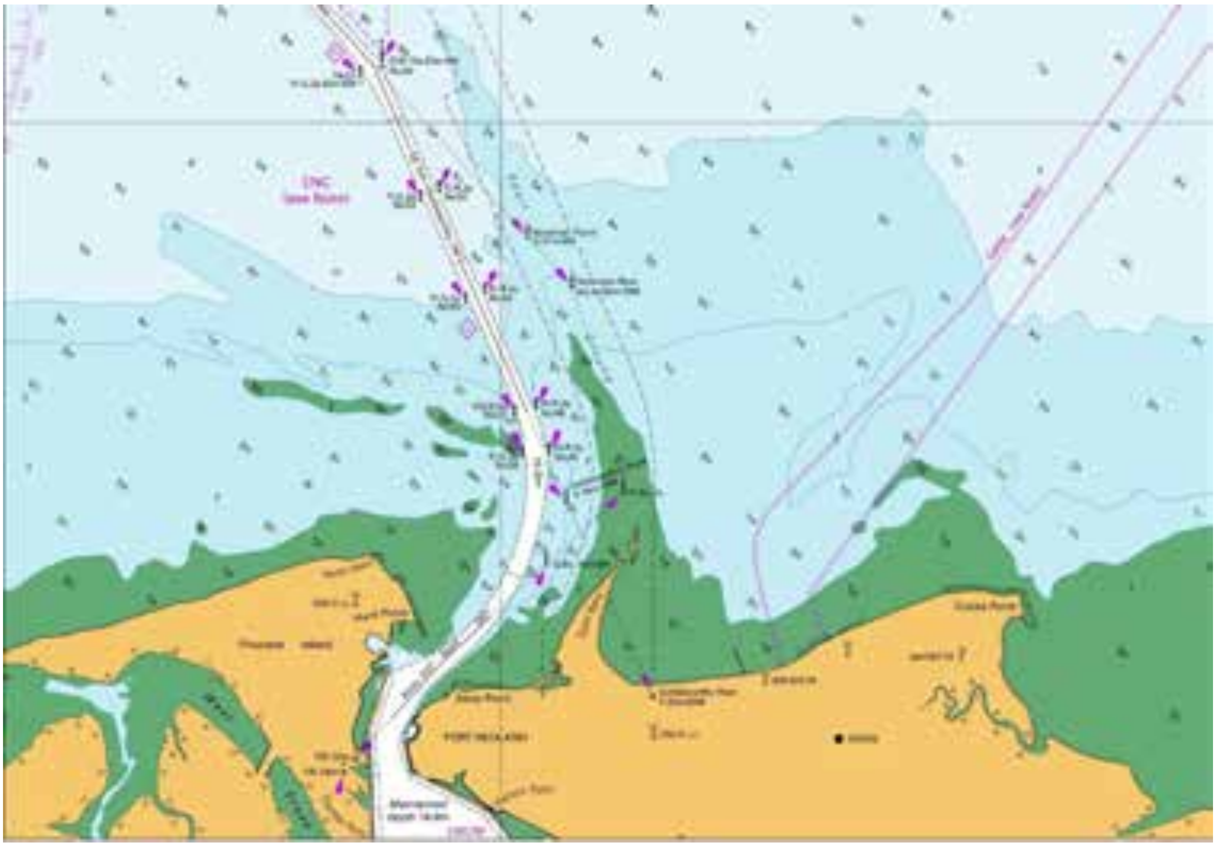


Figure 2.11 Nautical Chart Extract (Port Hedland Port Authority)

2.2.3 Historical Movement of Cemetery Beach

Changes to the alignment of the Cemetery Beach shoreline have been experienced over the past several decades, as reported by Cardno (2011). Figure 2.12 shows the historical shoreline movement plot for the shoreline. This figure shows that a reasonably dramatic change to the shoreline alignment occurred between the 1949 and 1968 alignments and the alignments from 1976 onwards. The timing of this change in alignment is coincident with the creation of the Spoilbank (as outlined in the following section).

Ultimately the change in alignment of the shoreline prior to and following the 1976 position exhibits an overall rotation of the shoreline that is consistent with sheltering of the shoreline from the prevailing north westerly conditions.

Following the realignment of the shoreline, a reasonably consistent erosion trend has been noted, with an assessed average annual rate of erosion over the period assessed by Cardno (2011) of around 0.7 m/year.

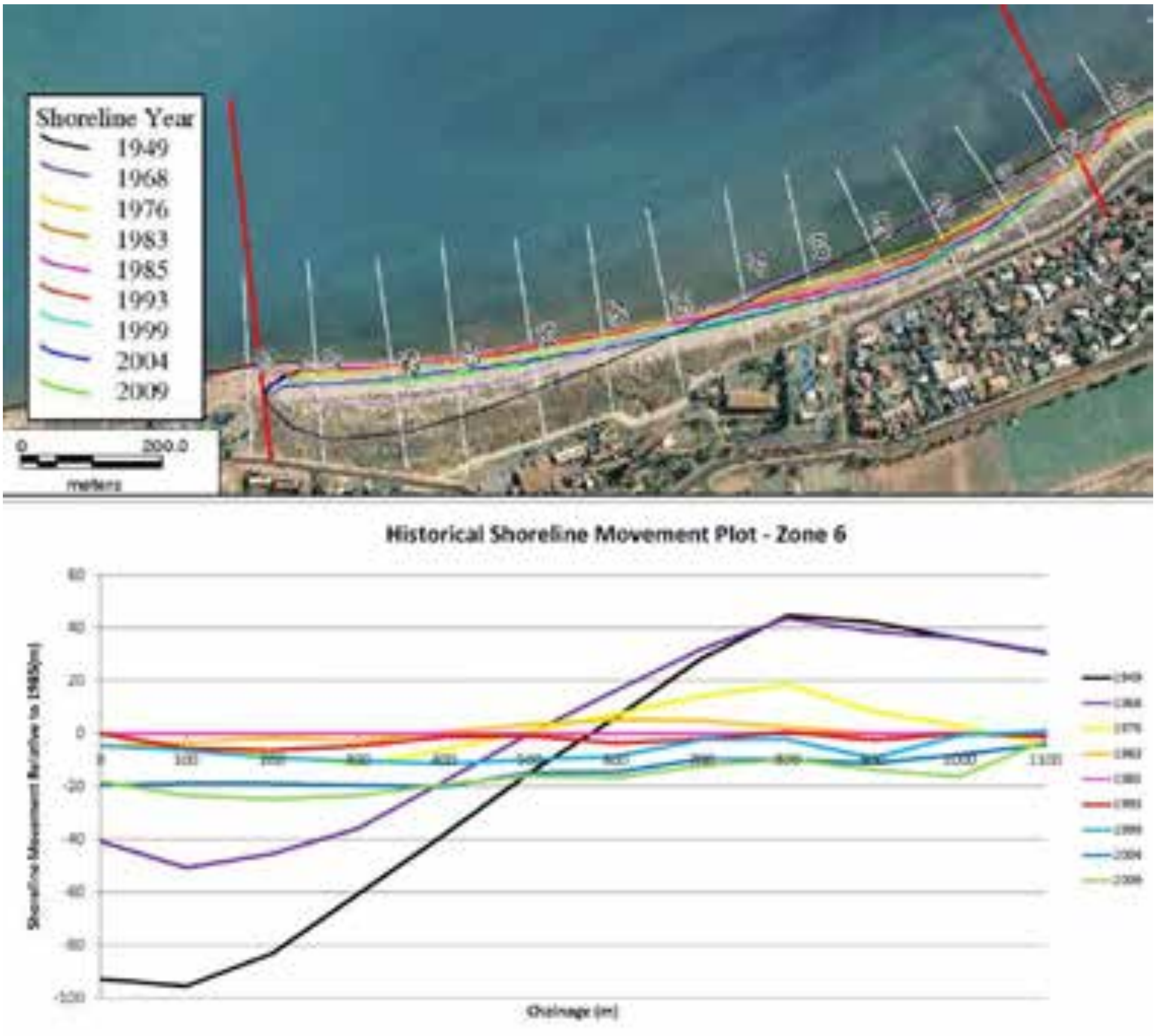
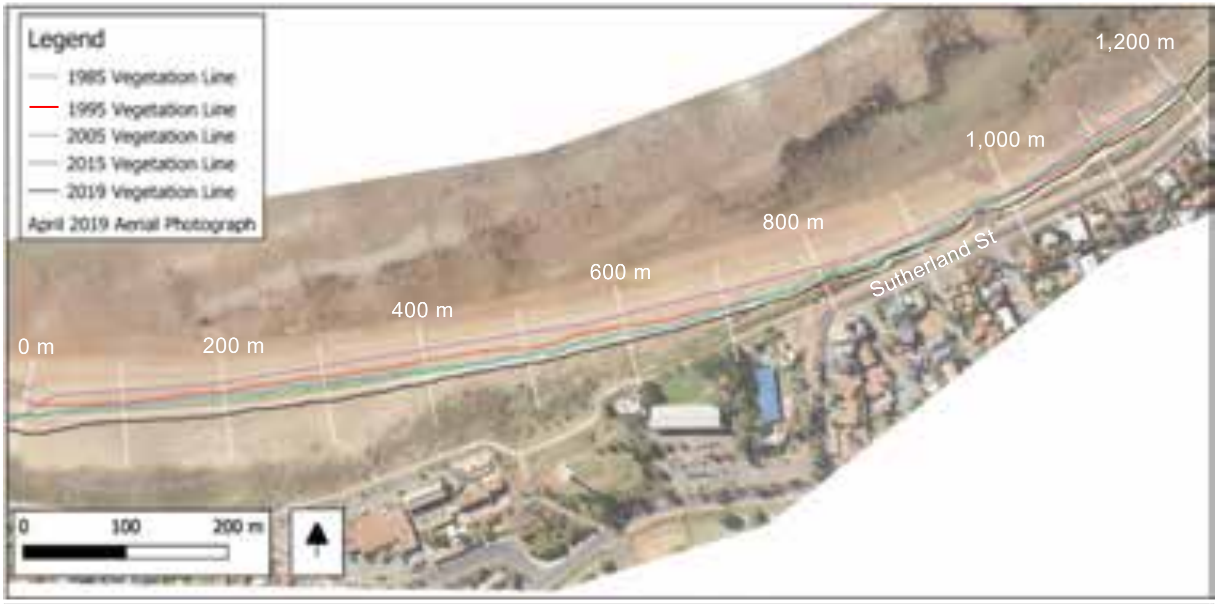


Figure 2.12 Historical Shoreline Movement Plot for Cemetery Beach (Cardno 2011)

In addition to the above, shoreline mapping has been completed for the period to 2019 to provide further context. This shoreline mapping is presented in Figure 2.13.

Shoreline mapping data provided by DoT has been included for 1995 and 2015. The accuracy of the position of these vegetation lines is believed to be in the order of ±5 m, depending on the resolution of the aerial photographs and the rectification process. In the absence of a consistently present vegetation line along the beach at the site, the inferred location of the high water mark was mapped.

Figure 2.13 shows a continuing relatively steady erosion trend in the order of 0.7 m/year for the period of 1985 to around 2005 to 2015, with some fluctuation from year to year towards the eastern end of Cemetery Beach in the area fronting Sutherland Street. The significant erosion caused by TC Veronica is also evident in the 2019 vegetation line.



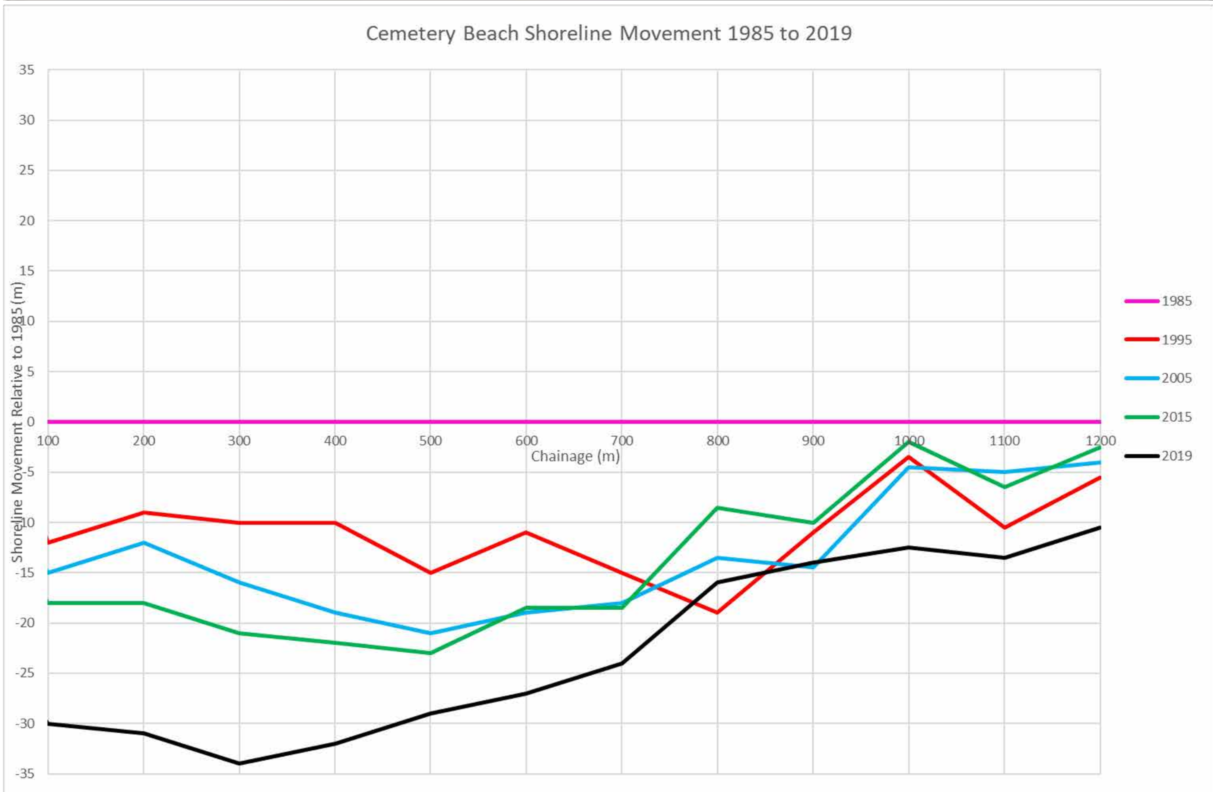


Figure 2.13 Shoreline Movement Plot for Cemetery Beach

2.2.4 History of the Spoilbank

The Port Hedland Spoilbank was formed in the late 1960's. Its formation was the result of sidecasting of dredge spoil associated with the dredging of the Port Hedland Harbour and shipping channel. Upon completion of the dredging in 1970 the Spoilbank was an island that was located approximately 500 m from the mainland. This gap between the mainland and the Spoilbank was left so minimal interference with the natural littoral drift of the mainland coast would occur (Department of Planning and Urban Development 1992).

Paul and Lustig (1975) estimated that the north westerly wave conditions that are prominent in the Port Hedland area caused a 50 m/yr southerly transport of the Spoilbank between 1970 and 1975. Further work by Rendel Scott Furphy (1980) estimated that the rate of southerly sediment transport along the Spoilbank between 1970 and 1978 was around 14,000 m^3/yr, with the vast majority of this transport occurring on the western side of the Spoilbank.

In the early 1980's, the extent of southerly transport of the Spoilbank resulted in it connecting to the mainland, though access was only possible during low tides. Concern was raised that this represented a potential public safety issue due to the potential for members of the public to become stranded at high tides. As a result, additional material was placed at the mainland end of the Spoilbank to ensure a permanent connection was maintained with the mainland during all tides. The net southerly migration of material along the Spoilbank has continued over time, resulting in a narrowing of the northern end and a widening in the south as sediment is deposited. The northern end of the Spoilbank is shown to curve to the east, suggesting that eastward sediment transport is the dominant sediment transport direction.

A more recent estimate of the southerly transport of sediment along the Spoilbank is provided by MAK JaP (2005). This estimate of 50,000 m^3/yr is significantly larger than the early estimates made by Rendel Scott Furphy (1980).

Due to this large variation in the prediction of shoreline movement rates, MRA completed calculations on the shoreline movement based on differences between 1999 and 1984 surveys. These calculations indicated that around 35,000 m^3 of sediment appeared to be transported south along the western side of the Spoilbank each year. The historical movement has winnowed the sand and finer material from parts of the Spoilbank. Due to the presence of cobbles and less sand it is estimated that roughly 18,000 m^3 of transport occurs near the northern end of the Spoilbank each year.

The evolution of the Spoilbank is illustrated in Figures 2.14 and 2.15 which contain a collection of historical aerial imagery. Currently, the Spoilbank has vegetation growing on it which helps to stabilise the shoreline particularly from the effects of the wind. Whilst this progression of vegetation will help to stabilise the area, the Spoilbank will continue to change until such time as its alignment is consistent with the prevailing wind and wave conditions.

Figure 2.14 Evolution of the Spoilbank – 1949 to 2009 (Cardno 2011)

Figure 2.15 Evolution of the Spoilbank – 2011 to 2023 (Source: PPA)

2.2.5 Metocean Conditions & Predicted Future Spoilbank Evolution

As part of a coastal processes assessment for the Spoilbank Marina, specialist coastal and marine engineers Baird Australia (Baird) prepared the *Metocean Design Criteria and Coastal*

Processes Study (2020). This included preliminary sediment transport modelling, which was used to inform the design of the Marina.

Baird identified three phases of observed Spoilbank behaviour; accretion, stable and erosive phases. From this study and the analysis of historical shorelines, the Spoilbank has been in an erosive state since the mid 1990's. The Spoilbank sediment cell was identified by Baird (2020) and it was concluded that sediment is being efficiently transported along the east and west shorelines of the Spoilbank and away from the Spoilbank sediment cell itself.

A high temporal resolution historical shoreline dataset covering approximately 30 years of satellite imagery, was used to predict future Spoilbank evolution. Due to the macrotidal environment, the shoreline position can be highly dependent on the tide level. As such, each satellite image was correlated with Port Hedland predicted tides to allow the mapped shoreline images to be grouped into tide level ranges. From the satellite images, the shoreline position of the Spoilbank was extracted along 4 profiles and plotted against time. This timeseries data confirmed the three phases of Spoilbank evolution and indicated a trend of erosion across all transects since 2003. Data from 2003 onwards was used to extrapolate the shoreline position for the years 2030, 2040 and 2070 which are shown in Figure 2.16. It must be noted that these predictions of future shoreline location do not account for or include the presence of the Spoilbank Marina.

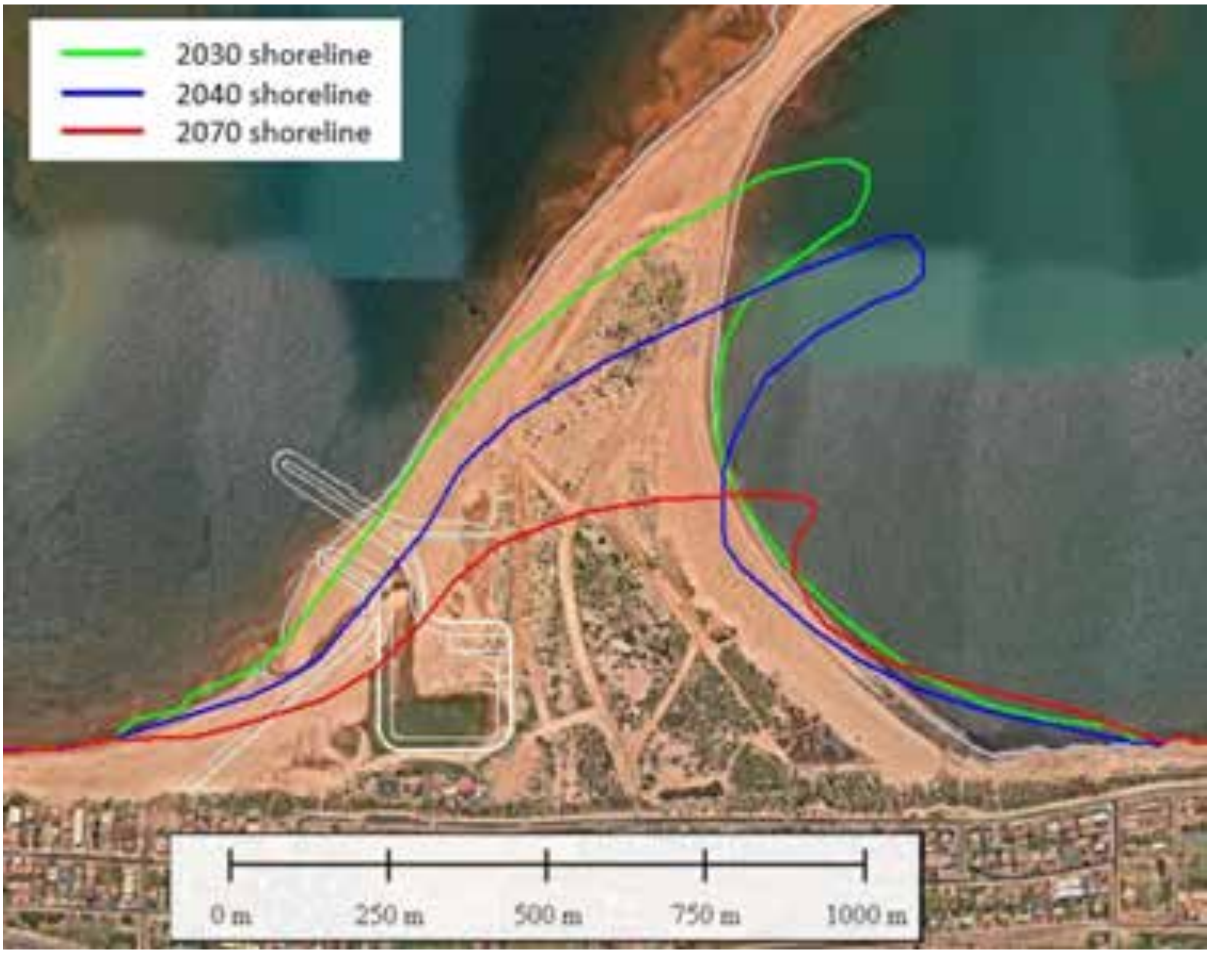


Figure 2.16 Estimated Future Shoreline Positions (Baird 2020)

2.2.6 Summary of Expected Future Port Hedland Sediment Transport Regimes

As outlined above, Baird (2020) completed preliminary sediment transport modelling and identified three phases of expected future sediment transport of the Spoilbank. In chronological order, these predicted phases are the erosive (ie the current phase), the stabilisation/accretion phase and then a later erosive phase.

Currently, the Spoilbank is in an erosive phase. The prevailing conditions in Port Hedland are dominated by the afternoon sea breezes that arrive from the north west (as demonstrated by the wind and wave roses presented in Section 2.1). These north westerly winds generate wind waves that result in a net transport of sediment in an easterly direction along the coastline, or generally in a southerly direction along the Spoilbank in its current form. Whilst the prevailing conditions in the morning are from the east to south east, these conditions are predominately land breezes (travelling from the land to offshore) and therefore result in waves moving away from the coastline – thus they do not contribute meaningfully to sediment transport along the coastline.

This means that, under typical conditions, the current net annual sediment transport along the Port Hedland coastline will be in an easterly direction (noting that there will be periods of time when there are waves from other directions arriving at the shoreline that will transport sediment, but any sediment transport at these times will be overwhelmed by volumes of sediment transport occurring from the north westerly winds). This is also why the PPA predominately need to dredge material from the western side of the Goldsworthy Channel, as the banks on the western side are constantly moving towards the channel.

Further to the above, the formation of the Spoilbank has provided a large source of sediment, however in its current form the Spoilbank acts almost like a breakwater, sheltering the areas either side of it from wave energy that could move material along the coastline. This results in accumulation of sediment at the shoreward end of the Spoilbank, particularly on the more protected eastern side. Nevertheless, as more sediment is transported in a southerly direction along the Spoilbank, the overall offshore length of the Spoilbank is expected to decrease and so too will the sheltering that the Spoilbank provides.

Progressively, the offshore length of the Spoilbank is expected to decrease and this will increase the rate of eastward sediment transport along the Port Hedland coastline. Eventually the Spoilbank itself will contribute to the feed of sediment along the coastline towards the east, however this will not occur until the angle of the western shoreline of the Spoilbank changes so that sediment begins to transport in an easterly direction rather than a southerly direction.

The simplified net sediment transport regime described above is illustrated in Figures 2.17 to 2.19 which show snapshots of the sediment transport regimes for present day, 2040 and 2070 respectively.

As described above, and shown in the figures, changes to the Spoilbank are expected to significantly change the sediment dynamics surrounding Cemetery Beach over the coming decades. Simplistically, it is anticipated that Cemetery Beach may experience the following phases associated with the evolution of the Spoilbank over this time.

- Erosive phase – this phase is expected to continue as the offshore extent of the Spoilbank reduces and the Cemetery Beach shoreline therefore becomes less sheltered from prevailing conditions. The rate of easterly sediment transport along the shoreline is expected to increase, which is likely to result in loss of sediment from Cemetery Beach as material is transported east along the sections of beachrock shoreline. This phase is predicted to progress over the next 2 to 3 decades based on the modelling completed by Baird (2020).

- Stabilisation/Accretion phase – this phase is predicted to occur once the Spoilbank has realigned and material begins to be transported in an easterly direction along the coastline. During this phase the total flux of sediment through Cemetery Beach is expected to be quite high compared to historical levels; however, whether this results in a net accretion of sediment at Cemetery Beach or just a stabilisation of the beach would depend on the rate of sediment transport from the Spoilbank and how this compares to the rate of sediment transport out of Cemetery Beach at its eastern end. This phase is predicted to occur over decades 3 to 6 based on the modelling completed by Baird (2020).

- Erosive phase – this phase is predicted to occur once the sediment supply from the Spoilbank has been exhausted. Cemetery Beach would be largely unsheltered (other than by the rocky remnants of the Spoilbank that will remain on the seabed) yet there would be no input of sand from the western shoreline. This will likely result in erosion of Cemetery Beach as the shoreline realigns to better match the incident wave directions (the realignment could possibly return the shoreline to the alignment shown by the 1949 shoreline position in Figure 2.12). This phase is predicted to occur in approximately 6 decades based on the modelling completed by Baird (2020).

Figure 2.17 Simplified Expected Sediment Transport Regime – Present Day

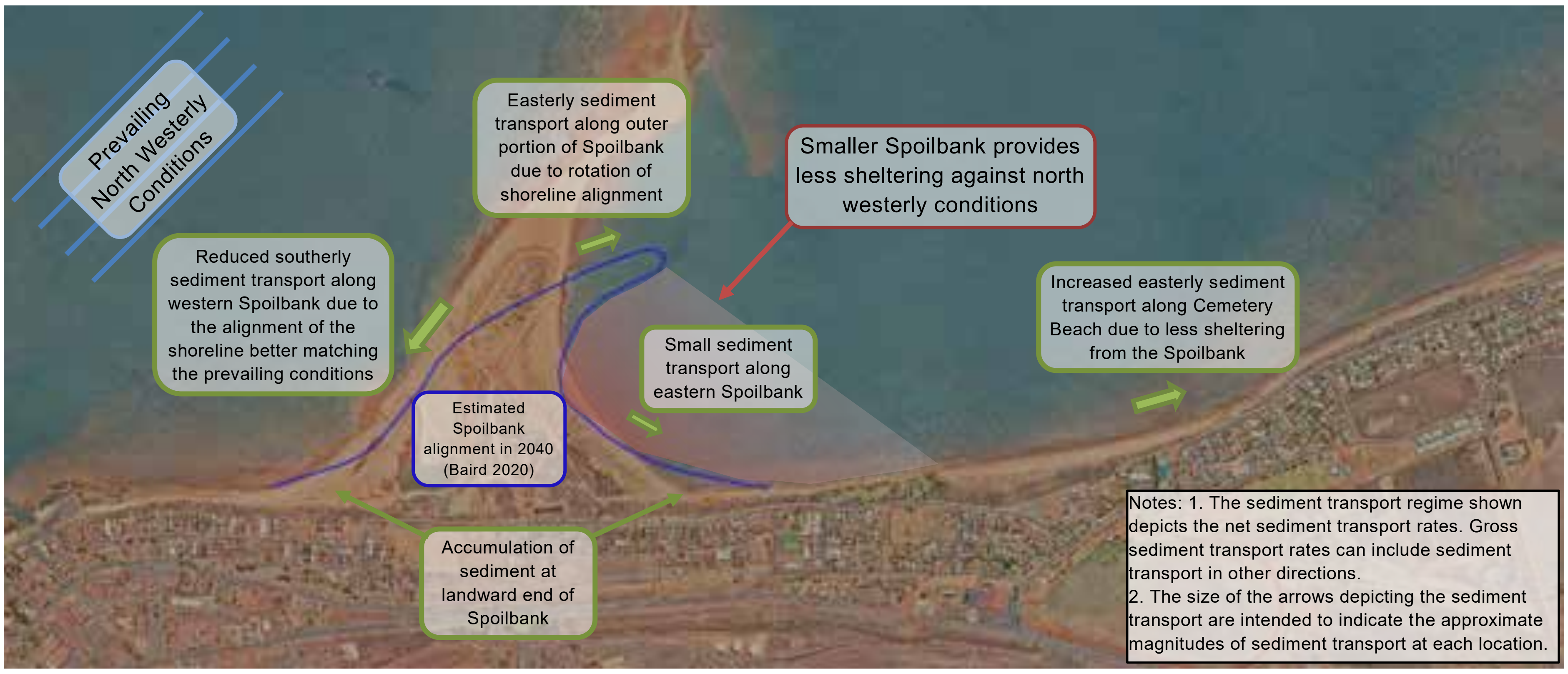


Figure 2.18 Simplified Expected Sediment Transport Regime – 2040

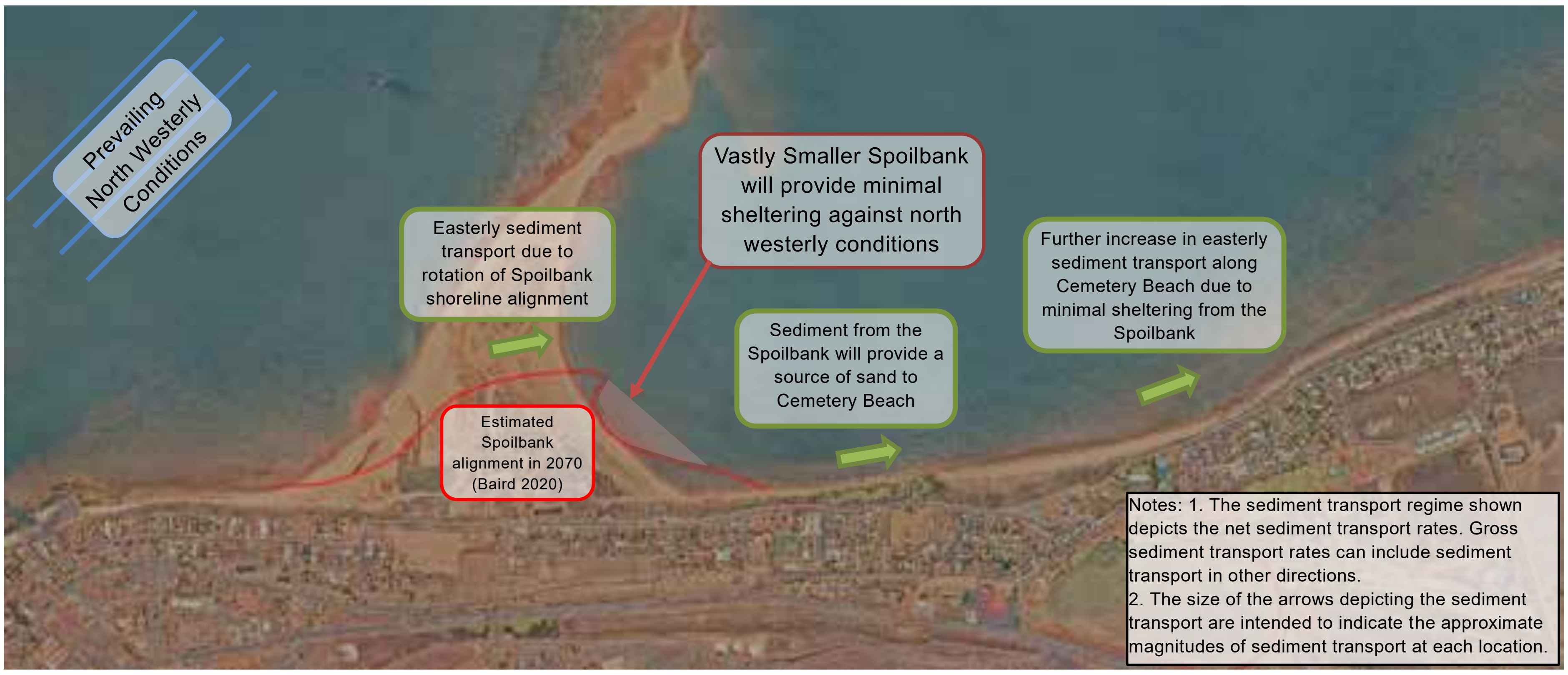


Figure 2.19 Simplified Expected Sediment Transport Regime – 2070

Significantly, the construction of the Spoilbank Marina is not expected to considerably alter the sediment dynamics discussed above. The Spoilbank Marina will be located at the landward end of the western shoreline of the Spoilbank. As shown in Figures 2.17 to 2.19, it is the rate of rotation of the western shoreline that is expected to impact the evolution of the Spoilbank and subsequently impact Cemetery Beach. The construction of the Spoilbank Marina will not present a barrier to this process occurring so would have little bearing on the overall outcomes other than by protecting a portion of the Spoilbank which would mean the volume of protected sediment will not feed into the nearshore littoral system.

It must be noted that the above descriptions of the sediment transport regime reflect the long term expectations, though severe cyclone events can give rise to short term conditions resulting in vastly different sediment transport rates and directions. Nevertheless, the Spoilbank remains the dominant feature with respect to sediment transport processes along the coastline, with the construction of the Spoilbank Marina not expected to alter the sediment transport regime along Cemetery Beach.

3. Coastal Processes Monitoring

There will be natural variation in sediment fluxes from one year to another due to fluctuations in weather conditions and the resultant wave climate. As a result, a coastal monitoring program is critical to measure actual changes to the beach and inform the appropriate management actions.

Coastal monitoring will be completed to monitor and quantify changes to the shoreline in the vicinity of Cemetery Beach and to review whether the construction of the Spoilbank Marina is having an impact on Cemetery Beach. The monitoring program includes the following.

- Aerial topographic surveys;
- Beach profiles;
- Photographic monitoring; and
- Shoreline mapping.

A plan showing the coastal monitoring locations is provided in Appendix A.

This monitoring program has been developed in liaison with the PPA and rationalised to provide a cost effective and practical coastal monitoring program. Details of the monitoring program are provided below.

3.1 Aerial Topographic Surveys

3.1.1 Purpose

Aerial topographic surveys can be completed relatively cost effectively using drone surveys. Surveying contractors have advised that drone surveys can be completed using rectified imagery methods and are generally accurate to within 0.05 m when used in combination with survey control points. This provides a cost-efficient means of capturing a significant scale of highly detailed data.

Replicated aerial surveys of the exact same coverage area provides the opportunity to review how the shoreline changes over time. For example, survey difference plots can be prepared using future surveys to demonstrate changes over time.

3.1.2 Monitoring Locations / Zone

The aerial surveys will be completed over the full extent of the coverage area shown in Figure 3.1. Locations of beach profiles, as discussed in Section 3.2, are also shown.

Figure 3.1 Aerial Topographic Survey Area & Beach Profile Locations

3.1.3 Methodology

The aerial topographic surveys will be undertaken as follows.

- Aerial drone surveys to be accurate to within 0.05 m.
- The aerial surveys are to be completed during spring tides and timed to coincide with low tide. The surveys should capture an offshore extent out to approximately the -2 mAHD contour.
- General changes to the beach levels will be reviewed and if necessary, survey level difference plots can be prepared.
- The raw survey data is to be processed using consistent methods across all surveys.
- The vertical datum shall be Australian Height Datum (AHD) and the horizontal datum shall be GDA 2020.
- The date of the survey will be recorded and included with all presentations of the survey data.

3.1.4 Frequency & Timing

The aerial topographic surveys will be completed bi-annually, once during April/May and once during September, until at least September 2025. By conducting surveys at both the end of summer (April) and late winter (September) each year, seasonal fluctuations will be captured.

The September timing coincides with the commencement of the Flatback Turtle Nesting season. This will allow for an accurate capture of the contemporary sand levels at Cemetery Beach turtle nesting commences.

It is expected that the behaviour of the shoreline within the Monitoring Area, including seasonal fluctuations, should be well understood following the September 2025 monitoring campaign.

Following September 2025, aerial topographic surveys will be completed annually, during September until at least September 2027.

3.2 Beach Profiles

3.2.1 Purpose

Beach profile analysis provides an efficient means of tracking the extent of beach change in both alongshore and cross shore directions. Monitoring the exact same profile alignments provides the opportunity to review how the shoreline changes over time. Beach width, beach slope, beach scarps and high tide mark changes will be determined from reviewing these profiles. Any observed changes can then be reviewed to determine whether these changes are attributable to the construction of the Spoilbank Marina.

Furthermore, beach profiles can either be 'cut' from the aerial topographic survey data outlined in Section 3.1, or collected by surveyors on foot at low tide using a survey staff and RTK positioning, for example.

3.2.2 Monitoring Locations / Zone

A total of 11 profiles will be collected.

The profiles have been located appropriately to ensure a thorough analysis can be completed for the shoreline and various sections of coast. The spacing of the profiles has been varied depending on whether the shoreline is rocky or sandy, with a greater relative coverage of profiles along the sandy shorelines given the greater potential for change.

The locations of the beach profiles are shown in Figure 3.1 and outlined in Table 3.1.

Table 3.1 Spoilbank Marina Coastal Monitoring Beach Profile Coordinates

Profile	Profile Coordinates (GDA 2020)			
	Start		[1] End	
	Easting (m)	Northing (m)	Easting (m)	Northing (m)
1	666,277	7,754,329	666,158	7,754,397
2	666,657	7,754,445	666,657	7,754,445
3	666,433	7,753,791	666,695	7,753,954
4	666,666	7,753,577	666,66	7,753,763
5	667,375	7,753,538	667,365	7,753,712
6	667,615	7,753,554	667,596	7,753,735
7	667,770	7,753,565	667,762	7,753,753
8	667,977	7,753,539	667,945	7,753,787
9	668,174	7,753,588	668,113	7,753,834
10	668,373	7,753,634	668,293	7,753,893
11	669,090	7,754,017	669,007	7,754,181

Notes 1. End coordinates may vary depending on the exact offshore extent achieved by the aerial topographic survey. The orientation of future beach profiles should correspond to the above.

3.2.3 Methodology

The beach profiles shall be completed as follows.

- Profiles shall extend from the maximum inshore extent to the maximum offshore extent of the survey area coverage. The position along the profile (ie chainage) shall be recorded and presented on all plans to allow comparison with future monitoring campaigns.
- In each monitoring report, the relative position of the MSL (0 mAHD) and the +4.0 mAHD contours (the approximate elevation of the ephemeral vegetation line) will be recorded for each profile. The movement of these contours will then be identified and any significant changes noted.
- The vertical datum shall be Australian Height Datum (AHD).
- In future years the profiles will be plotted on the same axes to demonstrate changes over time.

3.2.4 Frequency & Timing

The 11 beach profiles will be collected bi-annually, once during April/May and once during September until at least September 2025. By conducting surveys at both the end of summer

(April) and late winter (September) each year, seasonal fluctuations will be captured and able to be assessed.

It is expected that the behaviour of the shoreline within the Monitoring Area, including seasonal fluctuations, should be well understood following the September 2025 monitoring campaign.

Following September 2025, beach profile surveys will be collected annually, during September until at least September 2027.

The requirement for, and frequency of, further monitoring measures will be considered following capture of the September 2025 monitoring data, and again following capture of the September 2027 monitoring data. The requirement(s) for future monitoring will be considered based on a thorough review of survey results by an experienced coastal engineer in consultation with relevant stakeholders, and to the approval of the Australian Government, Department Climate Change, Energy, the Environment and Water.

Importantly, if the coastal processes monitoring measures outlined in this SMP are to be reduced, a revised SMP will be prepared accordingly and submitted to the Australian Government, Department Climate Change, Energy, the Environment and Water for approval prior to proceeding with the reduced monitoring measures.

3.3 Photographic Monitoring

3.3.1 Purpose

Photographic monitoring allows a visual history of the changes to the shoreline to be developed and documented. This can provide context and clarity to the assessment of measured changes in surveyed profiles.

3.3.2 Monitoring Locations / Zone

Eight photographic monitoring locations have been chosen within the coverage of the aerial topographic survey area.

The locations for photographic monitoring were chosen to capture key stretches of shoreline types (ie rocky sandy etc) over the full extent of the area of potential change.

The locations of the photographic monitoring locations are shown in Figure 3.4 and outlined in Table 3.2.

Figure 3.2 Photographic Monitoring Locations

Table 3.2 Photographic Monitoring Location Coordinates & Details

Photo No.	Coordinates (GDA 2020)		Approximate Heading
	Easting (m)	Northing (m)	
1	665,975	7,753,947	35º
2	666,282	7,754,417	215º, 40º
3	666,533	7,754,644	225º, 190º
4	666,847	7,753,612	310º, 80º
5	667,729	7,753,679	85º, 260º
6	668,464	7,753,770	65º, 250º
7	668,945	7,753,986	235º
8	668,963	7,754,029	50º

3.3.3 Methodology

The photographic monitoring is completed by handheld cameras and/or phones from the locations outlined in Table 3.2, with a consistent field of view in each photo. This methodology ensures that the extent of the images is consistent across the data set and can therefore provide a comparative review of coastal changes over time.

3.3.4 Frequency & Timing

The photographic monitoring will be completed bi-annually, prior to and following the turtle nesting season (October to March) – ie during April/May and September - until at least September 2025.

It is expected that the behaviour of the shoreline within the Monitoring Area, including seasonal fluctuations, should be well understood following the September 2025 monitoring campaign.

Following September 2025, photographic monitoring will be completed annually, during September until at least September 2027.

The requirement for, and frequency of, further monitoring measures will be considered following capture of the September 2025 monitoring data, and again following capture of the September 2027 monitoring data. The requirement(s) for future monitoring will be considered based on a thorough review of photographic monitoring results by an experienced coastal engineer in consultation with relevant stakeholders, and, to the approval of the Australian Government, Department Climate Change, Energy, the Environment and Water.

Importantly, if the coastal processes monitoring measures outlined in this SMP are to be reduced, a revised SMP will be prepared accordingly and submitted to the Australian Government, Department Climate Change, Energy, the Environment and Water for approval prior to proceeding with the reduced monitoring measures.

3.4 Shoreline Mapping

3.4.1 Purpose

Regular mapping of the shoreline will provide spatial context to broader shoreline change. The movement of a shoreline can be estimated through mapping the position of the coastal vegetation line from aerial photography. The vegetation line is a good indicator of the shoreline position, as it generally represents the limit of coastal processes and is less susceptible to short term fluctuations than other markers such as the waterline. By mapping the position of the vegetation line, changes to the shoreline can therefore be estimated.

For the Spoilbank Marina, mapping of the entire shoreline along the stretch of coast spanning the Spoilbank to Cooke Point sediment cell (refer Figure 2.5) will be completed. This expands upon the survey and photographic monitoring captured by PPA and will provide context in terms of broader sediment movement within the sediment call, beyond the area of expected influence of the Spoilbank Marina.

3.4.2 Monitoring Locations / Zone

The shoreline along the length of the Spoilbank to Cooke Point sediment cell will be mapped.

3.4.3 Methodology

Assessment of shoreline movement will be completed by mapping the coastal vegetation line. This will be mapped from ortho-rectified aerial photographs. Aerial imagery is captured routinely on behalf of Landgate and the PPA and can be sourced under agreement from these agencies.

Shoreline mapping will be completed in accordance with DoT (2009). The movement of the shoreline will then be assessed with each monitoring report. Over time, a database will be built up which will allow longer terms trends in shoreline movement to be determined.

3.4.4 Frequency & Timing

Shoreline mapping is planned to be undertaken annually, though the exact timing will depend on the timing of the aerial photographs capture. PPA's aerial images have previously generally been collected between August and December.

It is expected that the behaviour of the shoreline within the Monitoring Area, including seasonal fluctuations, should be well understood following the September 2025 monitoring campaign.

The requirement for, and frequency of, further monitoring measures will be considered following capture of the September 2025 monitoring data, and again following capture of the September 2027 monitoring data. The requirement for future monitoring will be considered based on a thorough review of shoreline mapping results by an experienced coastal engineer in consultation with relevant stakeholders, and, to the approval of the Australian Government, Department Climate Change, Energy, the Environment and Water.

Importantly, if the coastal processes monitoring measures outlined in this SMP are to be reduced, a revised SMP will be prepared accordingly and submitted to the Australian Government, Department Climate Change, Energy, the Environment and Water for approval prior to proceeding with the reduced monitoring measures.

3.5 Post Cyclone Monitoring

As noted previously, tropical cyclones can cause very severe metocean conditions and result in transport of large volumes of sediment. The quantum and direction of this sediment transport would be entirely dependent on the direction and severity of the cyclone event. To ensure the impact of a tropical cyclone on the coastal processes is captured and understood, the following monitoring will occur following the occurrence of a tropical cyclone impacting Port Hedland.

- Beach profiles.
- Photographic Monitoring.
- Shoreline Mapping (pending availability of accurate orthorectified aerial imagery).

Severe cyclone events have the potential to cause transport of significant volumes of sediment across the Spoilbank and Cemetery Beach shorelines. It is acknowledged that the above monitoring may not provide sufficient information to assess the quantum and direction of this sediment transport in sufficient detail in the event of a severe cyclone. In this regard the following additional monitoring is included for severe cyclones.

- Aerial topographic surveys, if a category 3 cyclone or higher passes within 100 km of the Spoilbank Marina.

4. Shoreline Movement Analysis & Management

An analysis of the monitoring information collected, as outlined in Section 3, will be completed by an experienced coastal engineer on an annual basis to determine any trends in shoreline movement or significant change to coastal processes. These trends or changes, will be referenced against expected shoreline movements as discussed in Section 2.2. This analysis will:

1. identify significant changes in shoreline behaviour or movement;
2. inform further investigations where identified shoreline changes are different to expectations; and
3. where changes are identified to be a result of the construction of the Spoilbank Marina, make recommendations in terms of management actions required to address the issue.

Details of each of the steps in the process are provided inf the following sections, with a brief summary of the process provided in Table 4.1.

4.1 Assessment of Shoreline Change Significance

The review of the coastal monitoring data will be completed to assess the significance of any shoreline change that is observed. As noted in Section 2.2.5, Cemetery Beach has an erosion trend, as a result it should be expected that this erosion trend may continue into the future. The significance of any shoreline change observed at Cemetery Beach, in any of the monitoring data that is collected, should therefore allow for a continuation of the observed rate of erosion (approximately 0.7 m/yr).

Fluctuations in shoreline position are also possible in addition to the long term trends of shoreline movement. This is expected as shorelines are complex dynamic features of the natural environment and experience a large degree of natural fluctuation. These fluctuations can be the result of abnormal seasonal influences or other short term events. There are many examples of this ing the period since 1976. Two examples of this can be seen in the fluctuations of the vegetation line at Cemetery Beach during the 6 year period from 1993 to 1999 (refer Figure 2.12) and the 9 year period between 1995 and 2004 (refer Figure 2.13).

- From 1993 to 1999 the vegetation line at Cemetery Beach eroded by around 6 m at the western end and up to 10 m at the eastern end. This constitutes fluctuations of around 2 m to 6 m respectively from the position of the shoreline based on application of the approximately 0.7 m/yr erosion trend alone.

- From 1995 to 2004 the vegetation line at Cemetery Beach eroded by around 4 m at the western end up to 12 m at the eastern end. This constitutes fluctuations of around -2 m (ie less erosion) to 6 m respectively from the position of the shoreline based on application of the approximately 0.7 m/yr erosion trend alone.

Fluctuations of scales similar to the above, about an overall trend, are common along coasts throughout Western Australia. Based on this fact, the assessment of shoreline change significance will set the following trigger for further investigation.

- Where the observed rate of recession of the shoreline or beach profile on Cemetery Beach is greater than 5 m plus the assessed rate of long term shoreline recession (approximately 0.7 m/yr) as measured from the baseline survey location, or assessed by an experienced coastal engineer, further investigation will be required to ascertain the potential cause of the erosion.

This 5 m allowance is commonly used for other coastal monitoring plans in Western Australia, including the Ocean Reef Marina. It is noted that the 5 m allowance is smaller than the 6 m fluctuation that have been observed at the site (as discussed above). In this regard, the 5 m allowance is considered conservative.

The rate of recession at Cemetery Beach will be determined by comparison of shoreline mapping along with beach profiles and/or aerial topographic surveys. To determine this, the annual distance of recession of the vegetation line, 0 mAHD contour line and +4.0 mAHD contour line will be assessed (ie September 2023 lines will be compared to September 2024 lines). The photographic monitoring will be used to provide further context and a qualitative perspective to this assessment.

Beyond the extent of Cemetery Beach, a general trigger will be included to assess whether there are other changes occurring that are not in keeping with the expected future shoreline behaviour. This trigger can only be general as the rate and extent of change of the Spoilbank will be variable over time, as indicated in the modelling completed by Baird (2020). For the areas beyond the Spoilbank and to the east of the Sutherland Street Seawall, given the coastal processes in the area and the distance from Cemetery Beach, the risk of significant changes occurring and in turn affecting Cemetery Beach is relatively low. Nonetheless a conservative approach has been taken to monitoring these area just in case. This trigger will be as follows.

- Where the observed shoreline movement outside of Cemetery Beach is significantly different to the expected shoreline changes (approximately greater than 10 m plus the assessed rate of long term approximately 0.7 m/yr rate of shoreline recession as measured from the baseline, or as assessed by an experienced coastal engineer), further investigation will be required to ascertain the potential cause of the difference.

The rate of recession for areas outside of Cemetery Beach will be determined by comparison of shoreline mapping along with beach profiles and/or aerial topographic surveys.

4.2 Further Investigation of Shoreline Change

Where a trigger relating to the movement of the shoreline has been realised, further investigation will be completed to determine the cause of the trigger. This investigation will be completed by an experienced coastal engineer. The following will generally be completed as part of the further investigations.

- Review of metocean conditions – the local metocean conditions over the period associated with the trigger exceedance will be reviewed and compared to the average conditions over the longer term. Such a review will provide an indication of whether the observed shoreline changes are likely to have been caused by abnormal metocean conditions, which could include seasonal differences in incident directions, or could be the result of one or more severe events.

- Review of the overall sediment transport pathway – the data collated as part of the monitoring program will enable an assessment of how sediment has moved over the relevant period. For instance, the spatial survey together with the extracted profiles can help to explain whether material has moved along the coastline or whether it has moved in a cross shore direction and deposited in the nearshore area. The oblique imagery can then be used to confirm the findings and provide further information regarding the relative extent of the changes.

The review of both of these items will provide detail of how, and most likely why, the observed shoreline movement has occurred. This will then enable a determination to be made, by an experienced coastal engineer, about whether these changes were a result of, or contributed to by, the construction of the Spoilbank Marina.

Where it is considered that the outcomes are likely to have been caused by the Spoilbank Marina and these outcomes have had, or are likely to have, an impact on Cemetery Beach, then management actions will be completed to rectify the issue. Where the changes are not found to be the result of the Spoilbank Marina, then no action will be required of the marina operator, however the marina operator will notify the relevant stakeholders of the findings of the assessment.

4.3 Shoreline Management Strategies

Where it is identified that the construction of the Spoilbank Marina is likely to have had an impact on Cemetery Beach then management actions will be taken to address the issue. Where changes have occurred that are attributable to the Spoilbank Marina but have not impacted Cemetery Beach, then management actions will only be undertaken if there is the potential for these changes to have an impact on Cemetery Beach and, in turn, an impact on the relevant EPBC Act protected matters of Flatback Turtle nesting at Cemetery Beach.

In both of these cases adaptive management strategies form the basis of this management process. Importantly, it is noted that the shoreline management strategies themselves need to be programmed and managed in a way that minimises, as far as reasonably practical, impacts on the surrounding habitats, including turtle nesting.

Management strategies are only likely to be required in response to erosive pressure on or around Cemetery Beach. As discussed in Section 2.2.6, the Spoilbank Marina itself is not expected to considerably alter the predicted future evolution of the Spoilbank, which in turn is not expected to impact Cemetery Beach. In the longer term, the marina structures would protect a small portion of the Spoilbank from erosion which would mean the volume of protected sediment will not feed into the nearshore littoral system. This is a minor change to one phase of the overall evolution of the temporary artificial coastal feature that is the Spoilbank. Baird (2020) predict this situation may occur during the Spoilbank's later erosive phase in several decades time, ie when the alignment of the Spoilbank shoreline is comparable to the Baird (2020) 2070 predicted shoreline alignment.

The erosion of the Port Hedland shoreline is ultimately due to the combined effects of a number of previous actions, including the dredging of the Goldsworthy Channel and the creation of the Spoilbank. The channel prevents net easterly sediment transport. The manmade Spoilbank and its evolution are a temporary factor. As noted above, marina structures likely won't have a significant influence on the behaviour of the Spoilbank.

Future management strategies will likely be required to intervene and combat the loss of sediment from Cemetery Beach given the net easterly sediment transport. In theory this could either be achieved by altering the sediment transport processes along Cemetery Beach or the placement or redistribution of sediment in these areas. Altering the sediment transport along Cemetery Beach would require modifications to the shoreline with coastal structures (ie groynes etc.) built on the beach. This is not appropriate due to the potential direct impacts to the nesting habitat. Hence potentially appropriate management actions are therefore likely to only consist of one or both of the following.

- Sand bypassing or back passing – this process would likely involve the excavation of accumulated sand from an area of deposition and the transportation and placement of this sand in the area where erosion has occurred. The aim of this process would be to return the shoreline, as much as practical, to the characteristics shown in the baseline survey.

- Sand nourishment – this process would aim to import sand and place it in the area where shoreline erosion has occurred. This process would be used when there is no clear area of sediment accumulation that would provide a source for bypassing or back passing, or where it is impractical to access the accumulated sediment.

It must be noted that in the event that either of these management actions are required, the detailed review of the proposed management action would need to carefully consider the physical properties of any sediment that is to be placed on Cemetery Beach. Sediment placed on Cemetery Beach would need to be a close match to the native material. Sediment would also need to be clear of all rocks or other deleterious materials.

The requirements for and scope of management strategies would vary depending on the severity of the impacts to Cemetery Beach and the quantum of sand required.

The timing for any such works would also need to be programmed carefully, and planned in consultation with relevant stakeholders, to obtain the relevant approvals and mitigate the potential environmental impacts. At a minimum all works would need to be completed outside of the turtle nesting period.

PPA are completing sampling and monitoring of the physical properties of the sand at Cemetery Beach in accordance with the standalone *Cemetery Beach Sediment Sampling & Analysis Plan* (MRA 2023). Under this plan, sediment samples were collected from Cemetery Beach during March 2024 and analysed. The analyses included particle size distribution, clay content, colour, general composition (carbonates, potassium, quartz etc.) and acidity. As per this plan, future monitoring including sampling and analyses of the contemporary sand at Cemetery Beach will occur every five years.

4.4 Stakeholder Consultation

As outlined above, relevant stakeholders are to be consulted in the event that the triggers outlined in Section 4.1, are exceeded. This shall include notification of funding for further investigations of shoreline change and, if required, consultation associated with the implementation of shoreline management strategies.

The stakeholders to be consultant are expected to include, but not necessarily be limited to, the following.

- PPA.

- The Town of Port Hedland

- Care for Hedland

- The Department of Biodiversity Conservation and Attractions

- Relevant indigenous heritage stakeholders including Traditional Owner groups.

- The Port Hedland Industry Counsel.

Table 4.1 Coastal Processes Management Triggers, Review & Management Actions

<table>
<tr><th>Location</th><th>Trigger</th><th>Monitoring & Timing</th><th>Review</th><th>Contingency Management Action(s)</th></tr>
<tr><td>Cemetery Beach</td><td>Where the observed rate of recession of the shoreline or beach profile at Cemetery Beach is greater than 5 m plus the assessed rate of long term shoreline recession (approximately 0.7 m/yr) as measured from the baseline, or as assessed an experienced coastal engineer, further investigation will be required to ascertain the potential cause of the erosion</td><td rowspan="2">Baseline monitoring completed in May/June 2023 and September/November 2023.
Monitoring will then be completed biannually (in May and September) each year, until at least September 2025.
Monitoring will then be annually (in September) each year, until at least September 2027.
Monitoring will include the following.
Aerial Topographic Survey.
Profile Monitoring.
Photographic Monitoring.
Shoreline Mapping (annually only).
Post Cyclone Monitoring.</td><td rowspan="2">Review will be carried out by an experienced coastal engineer and will include the following.
Review of local metocean conditions to determine if there were any differences over the relevant period that could have contributed to the observed shoreline movement.
Detailed review of sediment transport pathways using the data collected as part of the monitoring. This will likely provide an understanding of how and why the shoreline has responded the way that it did.
Results of the above assessments will be used to determine if the changes have occurred as a result of the Spoilbank Marina.</td><td>If the changes to Cemetery Beach are considered likely to be attributable to the construction of the Spoilbank Marina then a plan will be developed to rectify / remediate the impacts. Rectification / remediations options may include the following:
Sand bypassing or back passing
Sand nourishment</td></tr>
<tr><td>Other areas within the Monitoring Area</td><td>Where the observed shoreline movement outside of Cemetery Beach is significantly different to the expected shoreline changes (approximately greater than 10 m plus the assessed rate of long term approximately 0.7 m/yr rate of shoreline recession as measured from the baseline, or as assessed by an experienced coastal engineer), further investigation will be required to ascertain the potential cause of the difference.</td><td>If changes are observed to areas that are outside of Cemetery Beach, then these changes will be assessed to determine if they have the potential to impact Cemetery Beach in the short term. If there is the potential for Cemetery Beach to be impacted then the following management actions may be completed:
Sand bypassing or back passing
Sand Nourishment</td></tr>
</table>

5. Baseline Monitoring Data

Baseline data from the May/June 2023 and September/November 2023 round of coastal monitoring is outlined below. This data is intended to provide a baseline against which future shoreline change can be assessed.

To ensure seasonal influences are taken into account going forward, shoreline change will be reviewed using comparisons between monitoring data collected during similar times of the year. This will include the following.

- April/May monitoring data compared to April/May monitoring data from the previous year.
- September monitoring data compared to September monitoring data from the previous year.
- To consider the seasonal changes within each year, monitoring data from April/May and September will also be compared.

Brief commentary on the seasonal changes from April/May 2023 to September/November 2023 is included below. With only one winter-summer comparison available at this stage, brief commentary only can be made. Seasonal changes during future years will be monitored and considered in more detail.

5.1 Aerial Topographic Surveys

Plans showing the September 2023 aerial topographic survey, along with the May/June 2023 and September 2023 beach profiles, are included in Appendix A.

5.2 Beach Profiles

Plans showing the May 2023 aerial topographic survey, along with the beach profiles, are included in Appendix A.

The plans in Appendix A show a slight difference in the beach profile between May 2023 and September 2023. This is broadly consistent with typical beach profile changes that occur as a result of summer and winter met-ocean conditions.

As outlined in Section 3.2, the location of the MSL (0 mAHD) and 4 mAHD (the approximate elevation of the ephemeral vegetation line) contours will be recorded and, compared with future surveys, to monitor the movement of each contour.

5.3 Photographic Monitoring

The full set of the June 2023 and November 2023 monitoring photos are included in Appendix B.

These photographs indicate similar shoreline changes to the beach profiles, with a generally flatter sloped beach present in November 2023.

5.4 Shoreline Mapping

Cardno (2011) have previously mapped shorelines and assessed shoreline movements for the years 1949 to 2009. As outlined above, this assessment identified a reasonably consistent erosion trend at Cemetery Beach of around 0.7 m/year until 2009.

For this baseline assessment shoreline mapping data provided by DoT for the following years have been included.

- 1995.
- 2004.
- 2015.

The accuracy of the position of these vegetation lines is believed to be in the order of ±5 m, depending on the resolution of the aerial photographs and the rectification process. In the absence of a consistently present vegetation line along the beach at the site, the inferred location of the high water mark was mapped.

In addition to these years, MRA purchased aerial photographs and mapped vegetation lines from April 2019 and December 2022. These vegetation lines were mapped in accordance with DoT's methodology and specification of mapping (DoT 2009). The relative movements of the coastal vegetation line were estimated at 100 m intervals along the study coast. These chainages are presented in Figure 5.1. The shoreline movement plan is included in Appendix C.

The movement plot of the shoreline at Cemetery Beach relative to the 1995 vegetation line is presented in Figure 5.2. The reasonably consistent erosion trend between 1995 and 2015 is generally evident, with apparent recovery occurring between 2009 and 2015 at the eastern end of Cemetery Beach. It is noted that this may be due to growth of ephemeral vegetation in front of the coastal dune, not necessarily accretion of the shoreline. The significant erosion caused by TC Veronica is also evident in the 2019 vegetation line. The December 2022 and August 2023 vegetation lines suggests some recovery of coastal vegetation has occurred following TC Veronica. However as shown in Figure 5.3 much of this is attributable to ephemeral vegetation growth, particularly at the eastern end of Cemetery Beach, and not any significant coastal accretion.

Figure 5.1 Chainage Plan

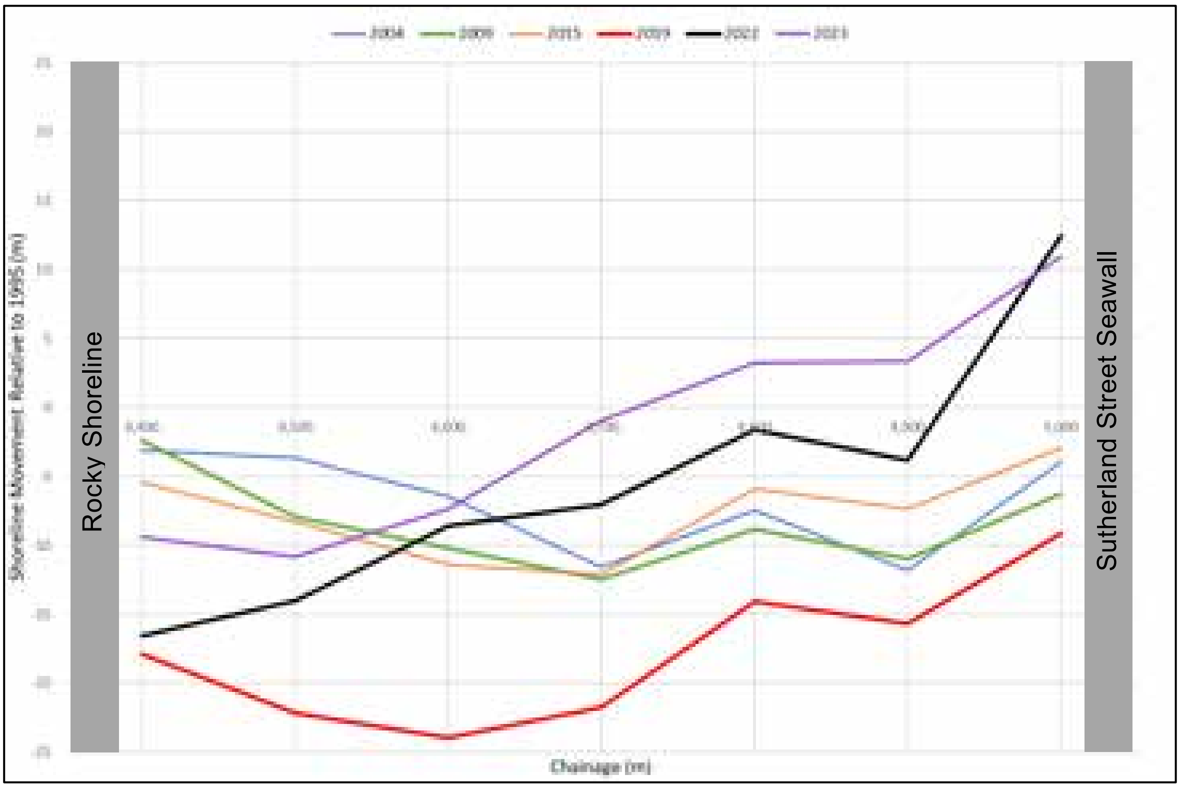


Figure 5.2 Relative Shoreline Movement of Cemetery Beach Since 1995

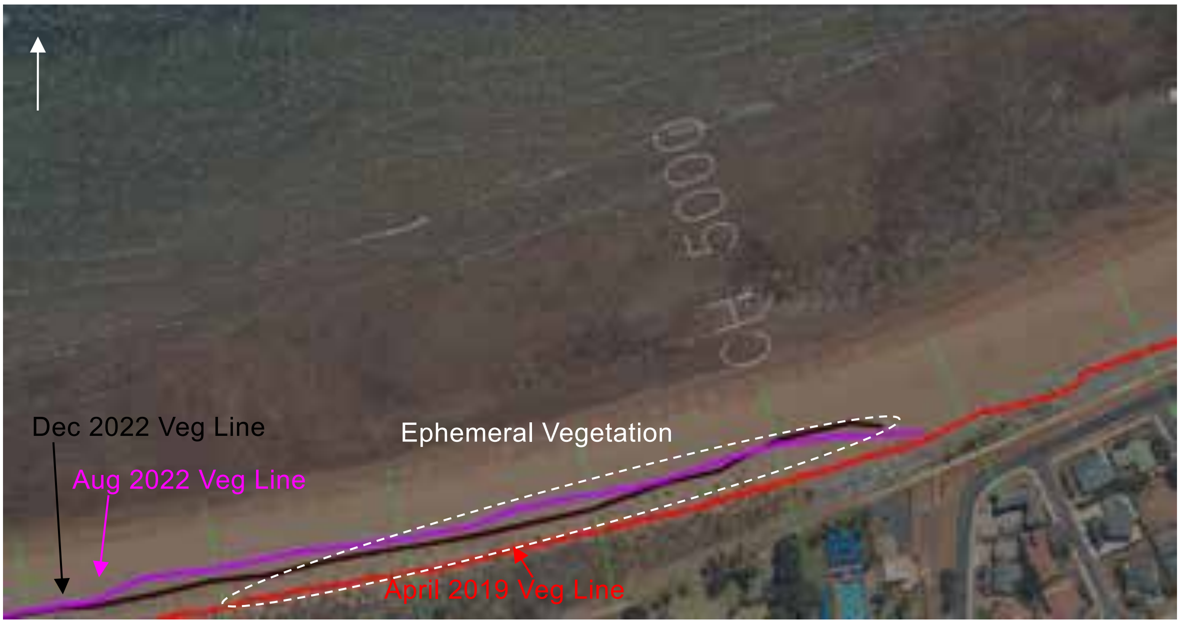


Figure 5.3 April 2019, December 2022 & August 2023 Vegetation Lines

6. Reporting

6.1 SMP Reporting

Reporting of the monitoring described within this plan will be completed annually following the collection of monitoring data in September.

The report will include:

- results of all survey and monitoring;
- review/assessment of all survey and monitoring data collected over the period;
- evaluation against triggers; and
- any measures taken and strategies implemented, which could include additional investigations or management actions.

Reporting completed in September 2027 will also consider the required frequency of monitoring given the extent of variability observed in the monitoring data up to this point.

6.2 Trigger Exceedance Reporting

In accordance with the requirements of EPBC 2019/8520, in the event of exceedance of the triggers, as reported in the SMP, the Australian Government Department Climate Change, Energy, the Environment and Water shall be notified. This notification of the exceedance outcome shall occur within 21 days of reporting. Notification to the Department of Agriculture Water and the Environment shall be the responsibility of the Marina Operator.

7. Review & Revision

Over time it will be necessary to review and revise this plan to ensure that the monitoring, review and management practices remain relevant and are in line with contemporary requirements. Review of this SMP will be undertaken on an as required basis and, in particular, following the September 2025 monitoring campaign.

It is expected that the behaviour of the shoreline within the Monitoring Area, including seasonal fluctuations, should be reasonably well understood following the September 2025 monitoring campaign. At this stage, provided the shoreline is behaving as predicted, and no impacts to Cemetery Beach are attributable to construction and operation of the Spoilbank Marina, it is planned to reduce the frequency of the coastal monitoring to annually for 2026 and 2027. Such changes would only be contemplated after the local dynamics are well understood which would be dependent on the outcomes of the monitoring.

It is expected that the behaviour of the shoreline within the Monitoring Area should be very well understood following the September 2027 monitoring campaign. At this stage, provided the shoreline is behaving as predicted, and no impacts to Cemetery Beach are attributable to construction and operation of the Spoilbank Marina, there may be an opportunity to further revise this SMP and potentially to refine the monitoring measures.

Any alterations to the SMP will be completed in consultation with key stakeholders and in accordance with the requirements of EPBC 2019/8520 including conditions 20, 21, 22, 24 and 25.

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9. Appendices

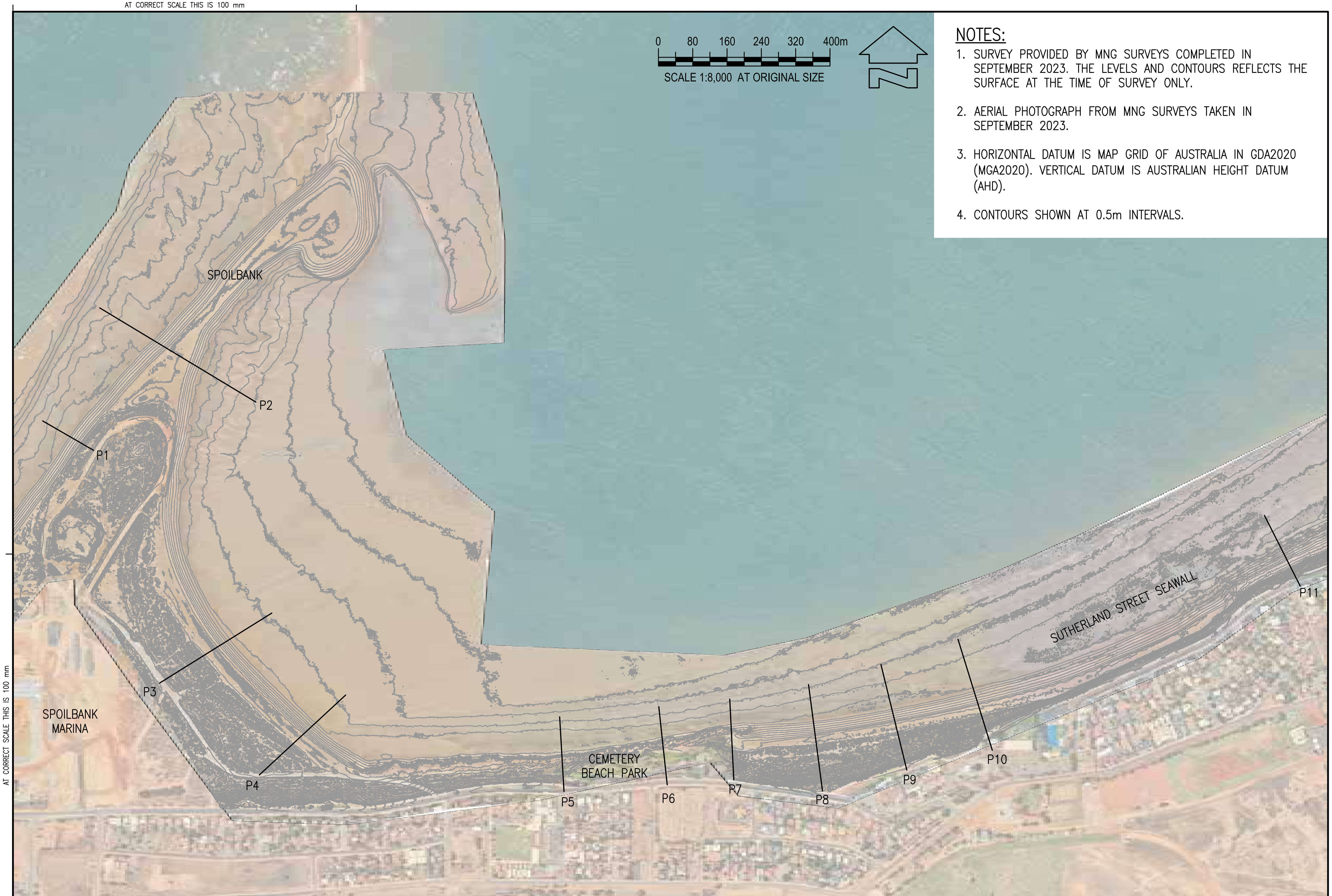
Appendix A Baseline Aerial Topographic Survey & Beach Profiles

Appendix B Baseline Photographic Monitoring

Appendix C Shoreline Movement Plan

Appendix A Baseline Aerial Topographic Survey & Beach Profiles

AT CORRECT SCALE THIS IS 100 mm



NOTES:

1. SURVEY PROVIDED BY MNG SURVEYS COMPLETED IN SEPTEMBER 2023. THE LEVELS AND CONTOURS REFLECTS THE SURFACE AT THE TIME OF SURVEY ONLY.
2. AERIAL PHOTOGRAPH FROM MNG SURVEYS TAKEN IN SEPTEMBER 2023.
3. HORIZONTAL DATUM IS MAP GRID OF AUSTRALIA IN GDA2020 (MGA2020). VERTICAL DATUM IS AUSTRALIAN HEIGHT DATUM (AHD).
4. CONTOURS SHOWN AT 0.5m INTERVALS.

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CHECKED	J COSTIN

SEPTEMBER 2023 AERIAL TOPOGRAPHIC SURVEY & BEACH PROFILES

CEMETERY BEACH SEDIMENT MANAGEMENT PLAN

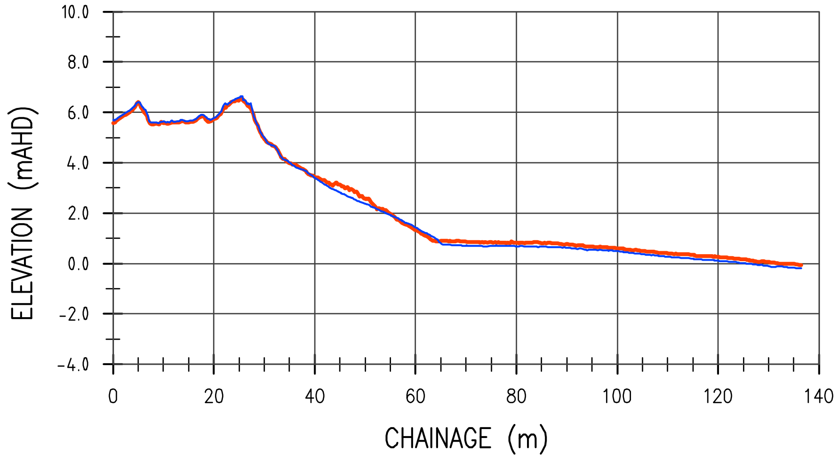
SCALE AT A3 1:8,000

DECEMBER 2023

SK1973-02-00C

P:\MRA Paying Jobs\K1973 PPA – Cemetery Bch Monitoring\5 MRA Dwgs\Sketches\SK1973-02 – Survey Profiles

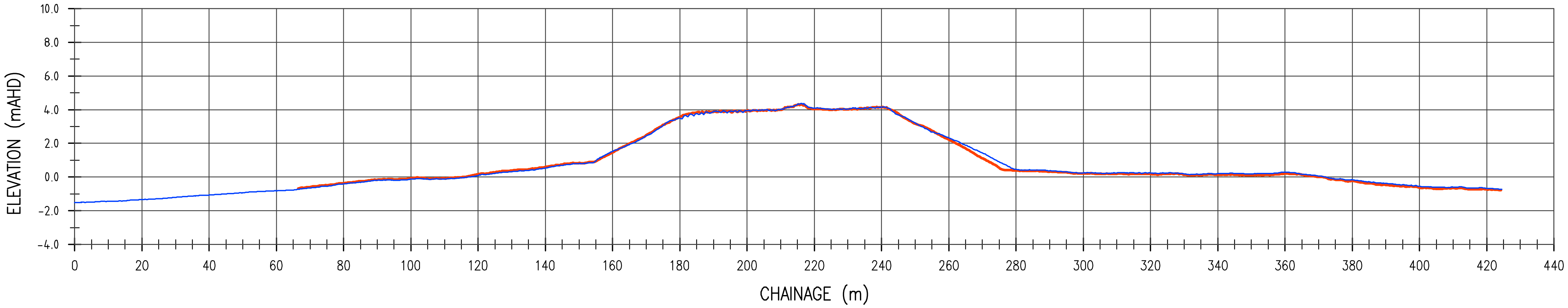
AT CORRECT SCALE THIS IS 100 mm



LEGEND:
2023 SEPTEMBER PROFILE LINE
2023 MAY PROFILE LINE

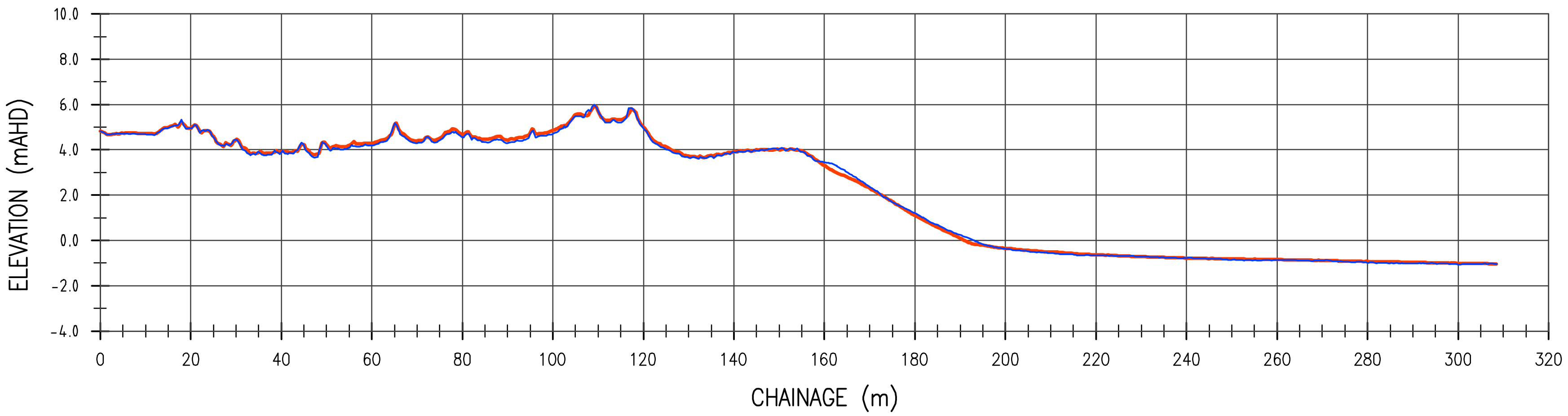
PROFILE 1

VERTICAL SCALE: 1:150
HORIZONTAL SCALE: 1:1,000



PROFILE 2

VERTICAL SCALE: 1:150
HORIZONTAL SCALE: 1:1,500



PROFILE 3

VERTICAL SCALE: 1:150
HORIZONTAL SCALE: 1:1,500

AT CORRECT SCALE THIS IS 100 mm

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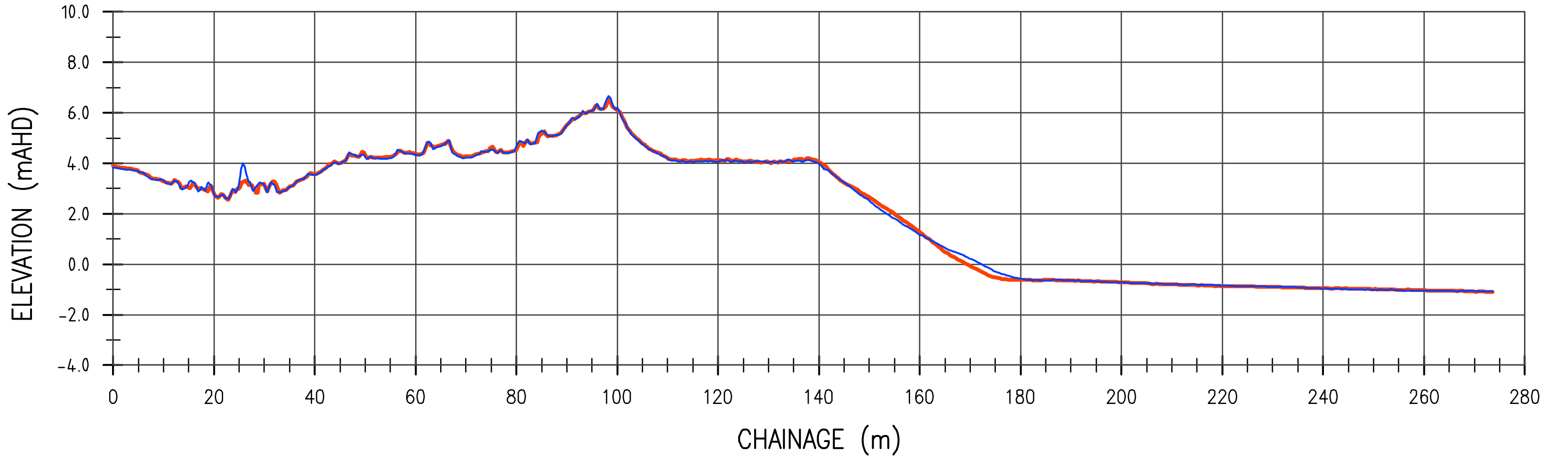
SURVEY BEACH PROFILES - SHEET 1 OF 3
CEMETERY BEACH SEDIMENT MANAGEMENT PLAN

SCALE AT A3 AS SHOWN

DECEMBER 2023
SK1973-02-01C

P:\MRA Paying Jobs\K1973 PPA – Cemetery Bch Monitoring\5 MRA Dwgs\Sketches\SK1973-02 – Survey Profiles

AT CORRECT SCALE THIS IS 100 mm



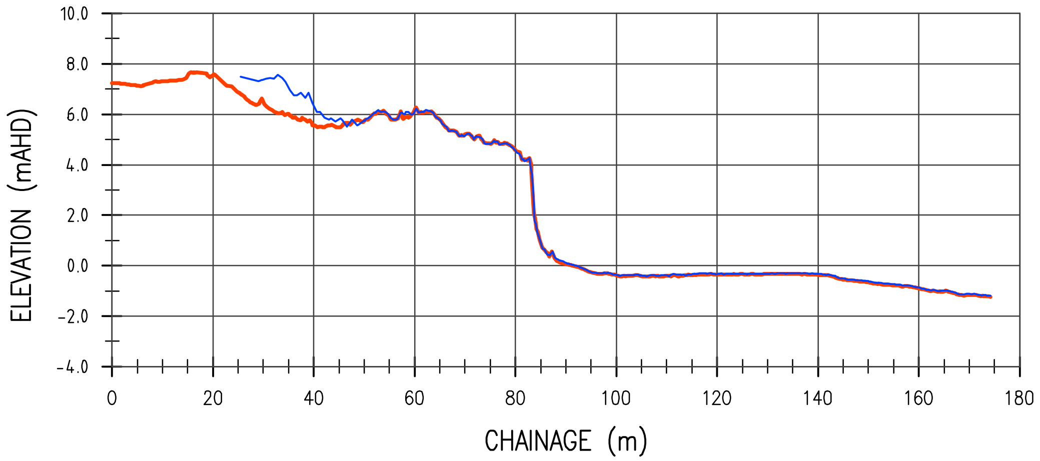
PROFILE 4

VERTICAL SCALE: 1:150
HORIZONTAL SCALE: 1:1,500

LEGEND:

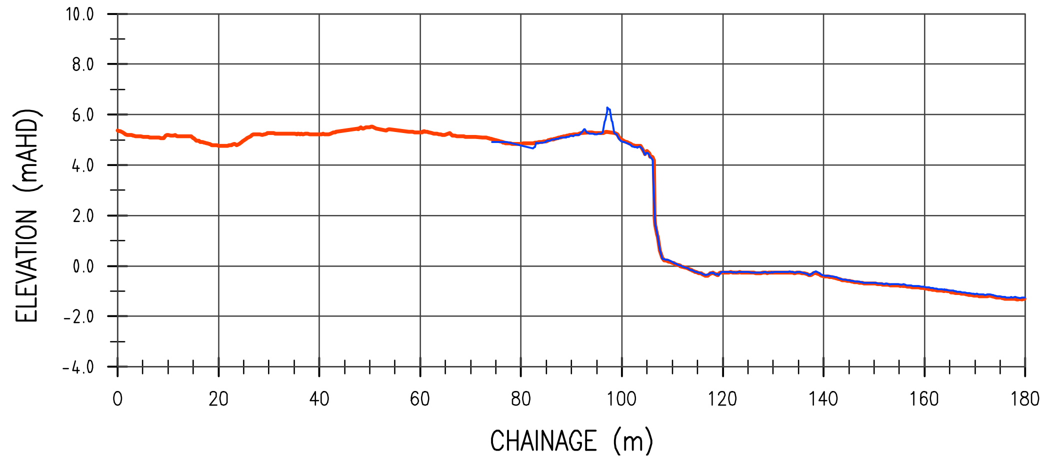
2023 SEPTEMBER PROFILE LINE

2023 MAY PROFILE LINE



PROFILE 5

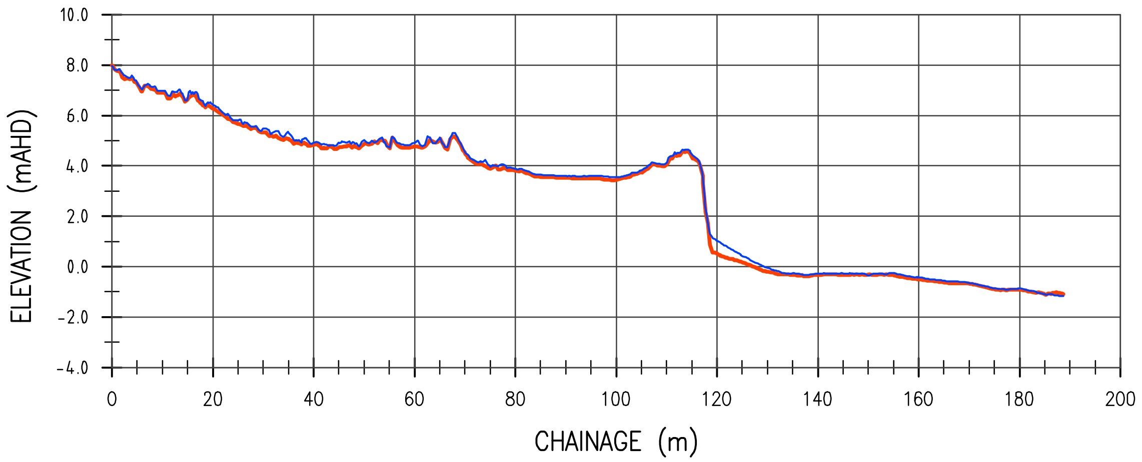
VERTICAL SCALE: 1:150
HORIZONTAL SCALE: 1:1,500



PROFILE 6

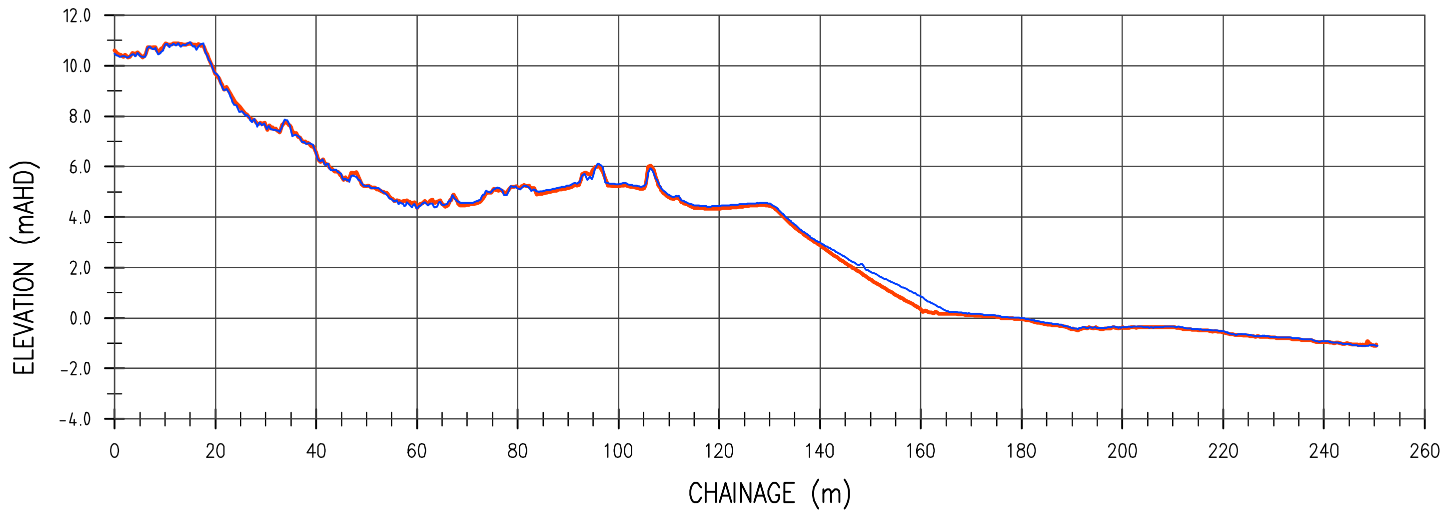
VERTICAL SCALE: 1:150
HORIZONTAL SCALE: 1:1,500

AT CORRECT SCALE THIS IS 100 mm



PROFILE 7

VERTICAL SCALE: 1:150
HORIZONTAL SCALE: 1:1,500



PROFILE 8

VERTICAL SCALE: 1:150
HORIZONTAL SCALE: 1:1,500

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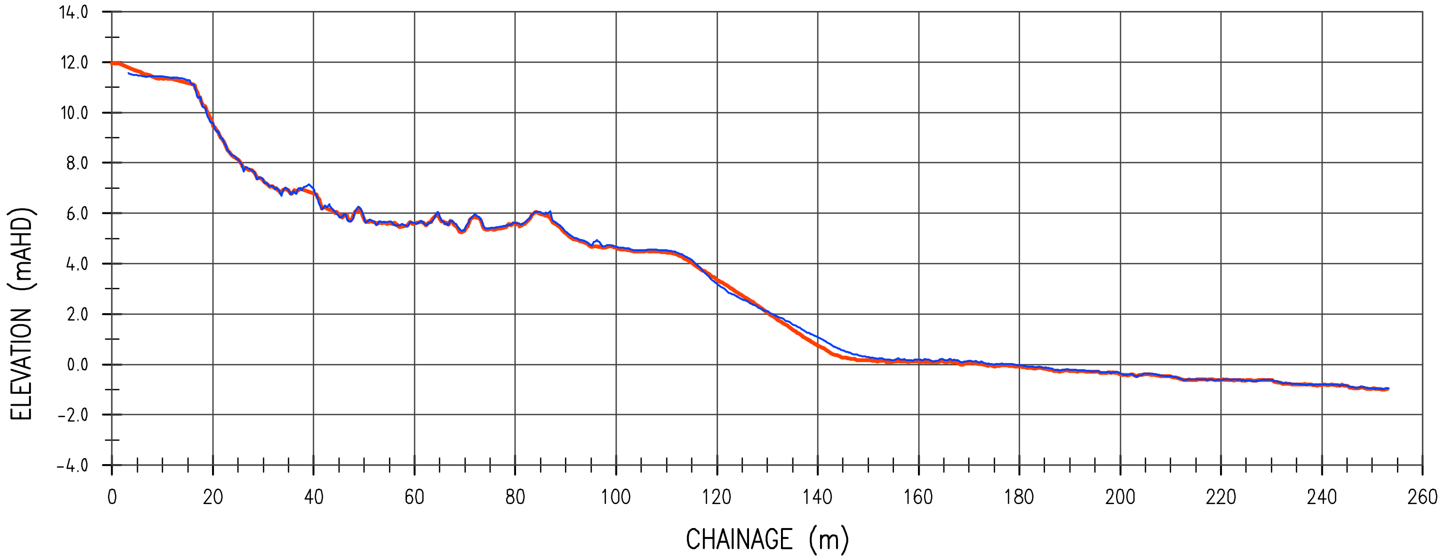
SURVEY BEACH PROFILES - SHEET 2 OF 3

CEMETERY BEACH SEDIMENT MANAGEMENT PLAN

SCALE AT A3 AS SHOWN

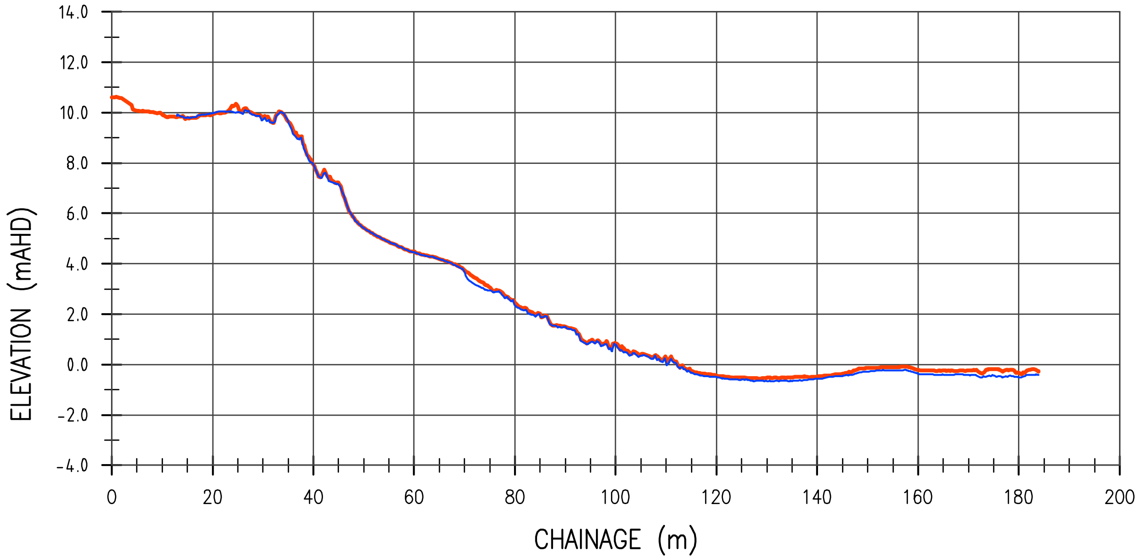
DECEMBER 2023

SK1973-02-02C



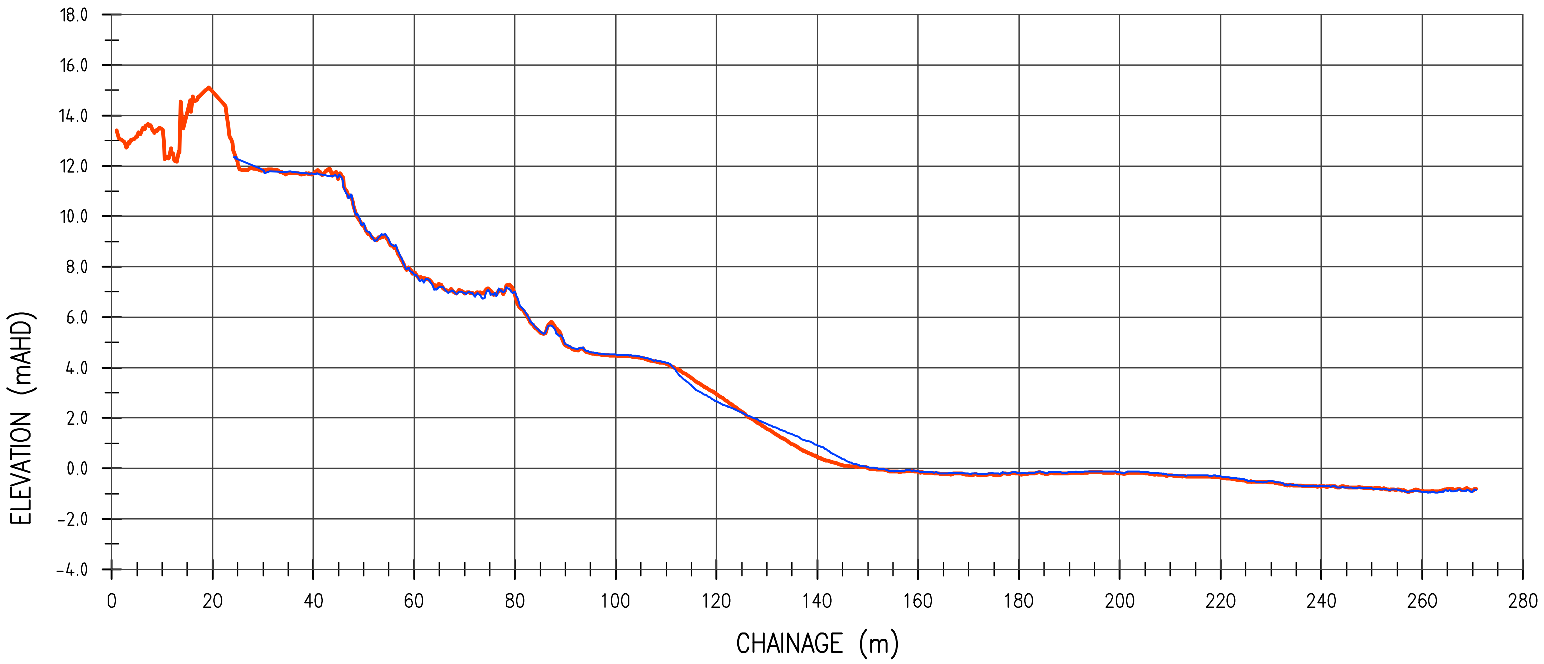
PROFILE 9

VERTICAL SCALE: 1:150
HORIZONTAL SCALE: 1:1,500



PROFILE 11

VERTICAL SCALE: 1:150
HORIZONTAL SCALE: 1:1,500



PROFILE 10

VERTICAL SCALE: 1:150
HORIZONTAL SCALE: 1:1,500

LEGEND:

2023 SEPTEMBER PROFILE LINE

2023 MAY PROFILE LINE

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CHECKED	J COSTIN

SURVEY BEACH PROFILES - SHEET 3 OF 3

CEMETERY BEACH SEDIMENT MANAGEMENT PLAN

SCALE AT A3 AS SHOWN

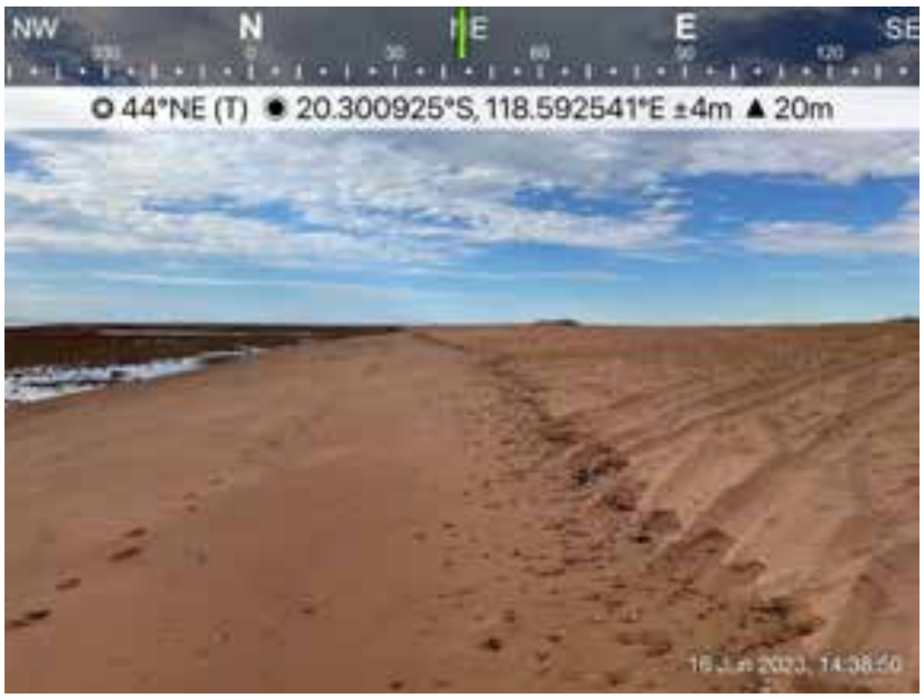
DECEMBER 2023

SK1973-02-03C

Appendix B Baseline Photographic Monitoring

P1. June 2023.

P1. November 2023.



P2 – North. June 2023.

P2 – North. November 2023.

P2 – South. June 2023.

P2 – South. November 2023.

P3 – South West. June 2023.

P3 – South West. November 2023.

P3 – South East. June 2023.

P3 – South East. November 2023.

P4 – North West. June 2023.

P4 – North West. November 2023.

P4 – East. June 2023.

P4 – East. November 2023.

P5 – West. June 2023.

P5 – West. November 2023.

P5 – East. June 2023.

P5 – East. November 2023.

P6 – East. June 2023.

P6 – East. November 2023.

P6 – West. June 2023.

P6 – West. November 2023.

P7. June 2023.

P7. November 2023.

P8. June 2023.

P8. November 2023.

Appendix C Shoreline Movement Plan

AT CORRECT SCALE THIS IS 100 mm

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SHORELINE MOVEMENT PLAN - SHEET 1 OF 2

CEMETERY BEACH SEDIMENT MANAGEMENT PLAN

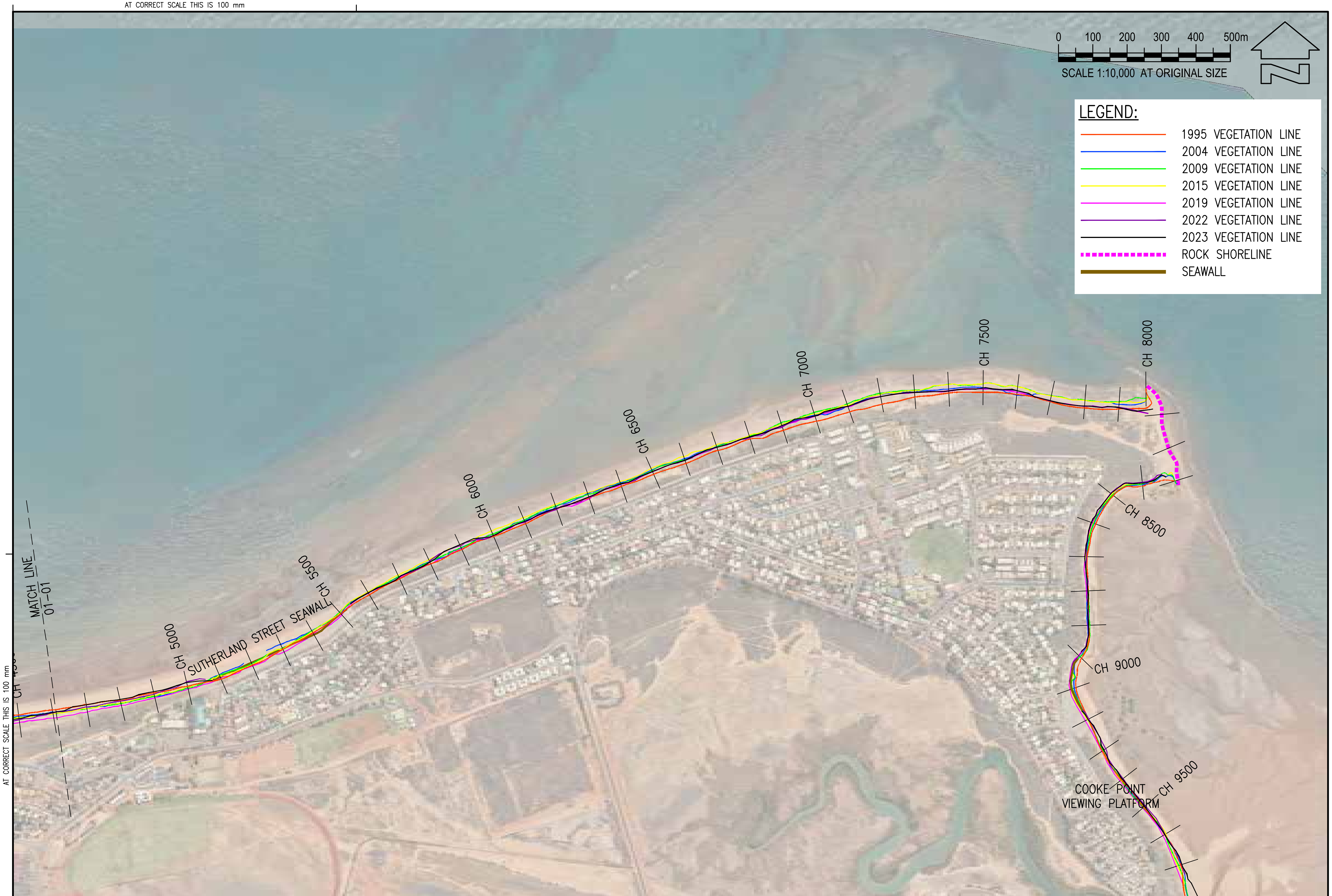
SCALE AT A3 1:10,000

DECEMBER 2023

SK1973-01-01B

P:\MRA Paying Jobs\K1973 PPA – Cemetery Bch Monitoring\5 MRA Dwgs\Sketches\SK21973-01 – SMP

AT CORRECT SCALE THIS IS 100 mm



AT CORRECT SCALE THIS IS 100 mm

m p rogers & associates pl coastal and port engineers	Suite 1, 128 Main Street Osborne Park 6017 t: +61 8 9254 6600 Western Australia admin@coastsandports.com.au	DRAWN R BORJA CHECKED J COSTIN	SHORELINE MOVEMENT PLAN - SHEET 2 OF 2 CEMETERY BEACH SEDIMENT MANAGEMENT PLAN SCALE AT A3 1:10,000 DECEMBER 2023 SK1973-01-02B

P:\MRA Paying Jobs\K1973 PPA - Cemetery Bch Monitoring\5 MRA Dwgs\Sketches\SK21973-01 - SMP m p rogers & associates pl

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