Gorgon Gas Development and Jansz Feed Gas Pipeline

Five-year Environmental Performance Report 2015–2020

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Contents

Tables

Figures

1 Introduction

1.1 Proponent

Chevron Australia Pty Ltd (CAPL) is the Proponent and the person taking the action for the Gorgon Gas Development and Jansz Feed Gas Pipeline (collectively referred to hereafter as the Gorgon Gas Development [the 'Project']) on behalf of these companies (collectively known as the Gorgon Joint Venture Participants):

- Chevron Australia Pty Ltd
- Chevron (TAPL) Pty Ltd
- Shell Australia Pty Ltd
- Mobil Australia Resources Company Pty Ltd
- Osaka Gas Gorgon Pty Ltd
- Tokyo Gas Gorgon Pty Ltd
- JERA Gorgon Pty Ltd.

1.2 Purpose of this Environmental Performance Report

CAPL, as the Proponent, is required to prepare a Five-year Environmental Performance Report (EPR) in accordance with:

- Condition 5 and Schedule 3 of Ministerial Statement (MS) 800 (and Condition 2 of MS 965)
- Condition 5 and Schedule 3 of MS 769
- Condition 4 and Schedule 3 of EPBC 2003/1294
- Condition 4 and Schedule 3 of EPBC 2008/4178
- relevant systems, programs, and plans as amended or replaced from time to time approved under MS 800, MS 769, MS 965, and EPBC 2003/1294 and 2008/4178.

1.3 Contents of this EPR

This EPR covers the period from 10 August 2015 to 9 August 2020 (the 'Reporting Period') unless otherwise stated. Table 1-1 lists the State and Commonwealth Condition requirements of this EPR and the sections in this EPR that fulfil them. This includes the EPR requirements under Schedule 3 of MS 800, MS 769, EPBC 2003/1294, and EPBC 2008/4178 and any additional EPR commitments contained in relevant systems, programs, and plans.

Table 1-1: Environmental Performance Reporting Requirements Addressed in this EPR

Environmental Aspect	MS 800	MS 769	EPBC 2003/1294	EPBC 2008/4178	EMP Commitment	Section in this EPR
Terrestrial and Subterranean Environment State	✓	✓	✓	✓	✓	2
Terrestrial and Marine Quarantine (including weed management)	✓		✓	✓		3
Marine Turtles (including light and noise management)	✓		✓	✓		4
Short-range Endemics and Subterranean Fauna	✓		✓	✓		5
Fire Management	✓	✓	✓	✓		6
Carbon Dioxide Injection Project	✓		✓	✓		7
Air Quality	✓					8
Coastal Stability	✓		✓	✓		9
Terrestrial Rehabilitation	✓				✓	10
Greenhouse Gas Abatement	✓					11
Spill Management		✓				12

1.4 Project

CAPL is developing the gas reserves of the Greater Gorgon Area. The gas is processed in a Gas Treatment Plant (GTP) on Barrow Island, which is located off the Pilbara coast 85 km north-north-east of Onslow in Western Australia (WA) (Figure 1-1).

Subsea gathering systems and pipelines deliver feed gas from the Gorgon and Jansz–Io gas fields to the west coast of Barrow Island. The underground feed gas pipeline system then traverses Barrow Island to the east coast where the GTP is located. The GTP includes natural gas trains that produce liquefied natural gas (LNG) as well as condensate and domestic gas (DomGas). Carbon dioxide (CO_2), which occurs naturally in the feed gas, is separated during the production process, and injected into deep rock formations below Barrow Island. The LNG and condensate are loaded onto tankers from a jetty, and then transported to international markets. Gas for domestic use is exported by pipeline from Barrow Island to the DomGas collection and distribution network on the WA mainland.

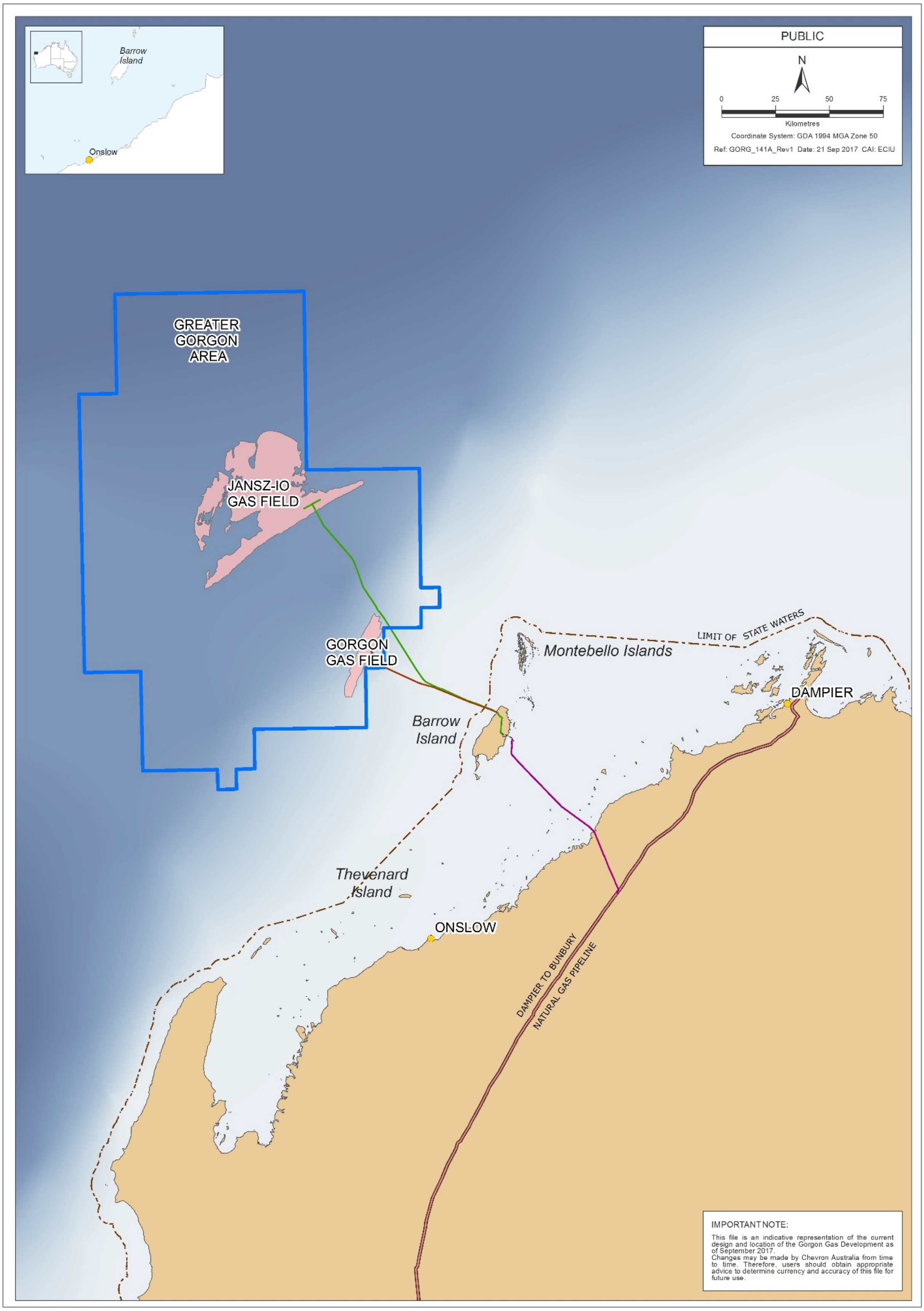


Figure 1-1: Location of Gorgon Gas Development and Greater Gorgon Area

1.4.1 Status of Implementation

Significant progress has been made on the Gorgon Gas Development since construction commenced in December 2009.

During the Reporting Period, CAPL:

- completed the safe start-up and operation of the Gorgon and Jansz fields' subsea pipelines, wellheads, and associated facilities
- completed the safe start-up and operation of LNG Trains 1, 2, and 3
- completed the safe start-up and operation of the DomGas plant on Barrow Island
- dismantled and demobilised redundant construction infrastructure on Barrow Island
- commenced the Gorgon Stage Two drilling campaign of 11 additional wells, which were part of the Gorgon Gas Development's original development plan
- commenced the safe start-up and operation of the carbon dioxide injection system. With its first million tonnes of CO_2 injected by February 2020, this facility will reduce Gorgon's greenhouse emissions by around 40 percent, or more than 100 million tonnes over the life of the system
- undertook a major maintenance 'turnaround' on Train 1 (Oct–Nov 2019) and Train 2 (May 2020 and ongoing as at close of Reporting Period). Turnarounds are routine major maintenance shutdowns involving numerous inspections, repairs, and equipment change outs.

2 Terrestrial and Subterranean Environment State

Table 2-1: EPR Reporting Requirements for Terrestrial and Subterranean Environment

Item	Source	Section in this EPR
Results of monitoring and any measurable impacts from the Project, including any changes from the baseline	MS 800, Schedule 3(1i) MS 769, Schedule 3(1i) EPBC 2003/1294 and 2008/4178, Schedule 3(1i)	2.1
Conclusions as to the Project stressors (if any) causing the impacts identified	MS 800, Schedule 3(1ii) MS 769, Schedule 3(1ii) EPBC 2003/1294 and 2008/4178, Schedule 3(1ii)	Not applicable (N/A)[1]
Any mitigation measures applied during the Reporting Period, and results of that mitigation	MS 800, Schedule 3(1iii) MS 769, Schedule 3(1iii) EPBC 2003/1294 and 2008/4178, Schedule 3(1iii)	N/A[2]
Any changes to monitoring sites	MS 800, Schedule 3(1iv) MS 769, Schedule 3(1iv) EPBC 2003/1294 and 2008/4178, Schedule 3(1iv)	2.1
Any changes to monitoring sites below the minimum number required	Terrestrial and Subterranean Environment Monitoring Program (TSEMP) (Ref. 1), Section 3.4	N/A[3]
Any changes to ecological elements	TSEMP (Ref. 1), Section 5	2.1
Threatened or listed fauna cared for, injured, or killed within the Terrestrial Disturbance Footprint (TDF)	Terrestrial and Subterranean Environment Protection Plan (Ref. 2), Section 7.2	2.2
A five-year overview of environmental performance	MS 800, Condition 5.3(iii) MS 769, Condition 5.3(ii) EPBC 2003/1294 and 2008/4178, Condition 4.2(iii)	2.3
Proposed environmental management improvements	MS 800, Condition 5.3(iv) MS 769, Condition 5.3(iii) EPBC 2003/1294 and 2008/4178, Condition 4.2(iv)	2.4

1 *No Project-related adverse impacts to ecological elements (as listed in Condition 6.1 of MS 800 and MS 769, and Condition 5.1 EPBC 2003/1294 and 2008/4178) were identified outside the TDF during the Reporting Period; therefore, reporting is not applicable at this time.*

2 *No mitigation measures were implemented in response to Project-related adverse impacts outside the TDF during the Reporting Period; therefore, reporting is not applicable at this time.*

3 *No changes were made to the TSEMP monitoring sites during the Reporting Period.*

2.1 Monitoring Results

The objective of the TSEMP (Ref. 1), as defined by Ministerial conditions, is to establish a statistically valid ecological monitoring program to detect any Material or Serious Environmental Harm to the ecological elements outside the TDF.

The ecological elements considered at risk from the Gorgon Gas Development that require monitoring on Barrow Island are listed in the TSEMP (Ref. 1).

At Risk zones (located within the relevant TDF—a zone where potential impacts are predicted to occur) and Reference zones (located in comparable areas beyond the TDF) were established for each monitoring program to detect changes attributable to Gorgon Gas Development activities.

Where applicable, monitoring data are presented in time-series control charts used to diagnose trends in population abundance and identify deviations from baseline estimates. Trends identified in control charts act as early-warning signals to guide a tiered management approach. A management response is triggered if a parameter demonstrates a trend towards or changes beyond statistical deviations (±1, ±2, or ±3 statistical deviations [e.g. standard deviation (SD)]) from baseline conditions or other reference point (e.g. the zero centreline of a ratio).

This is the first five-year Reporting Period in which an annual difference between the standardised At Risk and Reference zone population density metric (standardised density difference ratio) was applied to control charts for mammals and birds, to improve diagnosis of trends. Alternative analyses are applied to groundwater and surface water landform monitoring data, where control charting was inappropriate for comparing trends over time.

Formal monitoring of Silver Gull abundance and distribution ceased in 2016 after a review of results since 2009, when monitoring began. Silver Gull monitoring results remained within control limits for At Risk zones for all years monitored, and CAPL has demonstrated ongoing management of waste, surface water, and light, which were identified as potential drivers for an increase in Silver Gull abundance. However, data on Silver Gull abundance and nesting distribution continued to be collected in 2019 during the marine turtle nesting season, and opportunistically on islands monitored for migratory seabird nesting.

The Gorgon Gas Development is now in the operations phase. Consequently, Golden Bandicoot monitoring, which was last completed in 2018, is being undertaken at least every five years, or in response to three consecutive years of above- or below-average annual rainfall.

The 2015–2020 monitoring results for the ecological elements listed in the TSEMP (Ref. 1) are summarised in the following tables.

Ecological Element: Vegetation	
Objective:	• To detect loss of diversity—attributable to the Gorgon Gas Development—over time.
Methodology:	• Survey Method: Biennial survey of up to 124 vegetation monitoring transects across 15 vegetation associations encompassing both At Risk and Reference sites. Parameters comprised: percentage foliage cover (PFC); total species richness; known, suspected, or potential non-indigenous species (NIS); and plant health. • Analysis Method: An exponentially weighted moving average (EWMA) control chart approach was applied to total species richness, PFC, and plant health. A permutation-based multivariate analysis of variance was used to examine if there were differences in floristic composition and health of plants between the At Risk and Reference sites, or between years. The site type by year interaction was also tested for significance.
Changes to Monitoring Sites:	• Two additional transects were added during the 2016–2017 Reporting Period for the Reference treatment group within three vegetation associations (D5b2, L7d2, and L8d5). These transects corresponded to sites near the GTP flare box. • A total of 108 transects were monitored in 2017; 16 previously established transects were not monitored due to time constraints.
Results:	• No significant decline was recorded in species richness, PFC, or plant health during the 2015–2020 Reporting Period compared to the results of the previous vegetation monitoring surveys (Figure 2-1). • All monitored variables, when considered individually by vegetation type, remained within the 3 SD control limit (Ref. 21). • During 2016–2017 Reporting Period, one of the two variables that exceeded a 2 SD limit within a vegetation type occurred because of a favourable trend relative to Reference values. The other had a greater decrease in PFC in the TDF, relative to the Reference sites, and occurred in the limestone habitat (Ref. 21). • During 2018–2019 Reporting Period, within the vegetation associations, five variables exceeded the 2 SD or 3 SD control limits due to a favourable trend at the

Ecological Element: Vegetation

At Risk sites, relative to Reference sites, except for C3b1 in the coastal dune system, which recorded a higher rate of decline in perennial species health at the At Risk sites, relative to Reference sites (Ref. 25).

- No known, suspected, or potential NIS were identified in the transects (Ref. 25).
- Analysis of the multivariate species assemblage did not detect an impact to At Risk sites (Ref. 25).

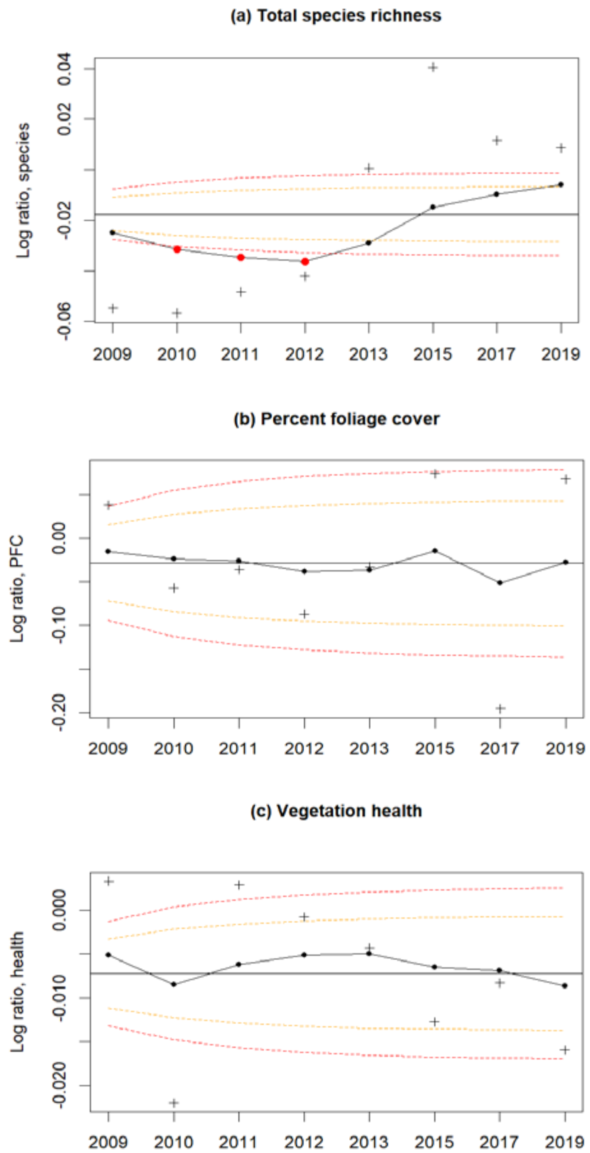


Figure 2-1: Control Charts for: (a) Total Species Richness, (b) Percent foliage Cover and (c) Vegetation Health[1]

Ecological Element: Vegetation	
Conclusions:	• Monitoring has not detected an adverse impact (attributable to the Gorgon Gas Development) on total species richness or PFC within the TDF since vegetation monitoring began in 2009 (Ref. 25). • No significant and detrimental change in plant health has been detected, either spatially or temporally within or outside the TDF, since vegetation monitoring began in 2009 (Ref. 25). • Vegetation health remains strongly linked to rainfall, with no distinct differences observed when comparing TDF transect data to Reference data in years of either high or low rainfall. • Vegetation affected by the bushfire (caused by lightning) in October 2013 (Ref. 24) continues to progress towards a similar structure to that surveyed before being burnt (Ref. 25).

1 *EWMA Chart: Solid horizontal line = random effects estimate of all sampled seasons. Solid dots = smoothed log response ratio metric based on an EWMA. Crosses = the calculated log response ratio metric for the At Risk sites compared with the Reference sites. Positive values show an effect that is higher at the At Risk site compared to the Reference site, and vice versa. Red dots = exceedances of the 3 SD control limit. Orange dotted line = 2 SD control limit. Red dotted line = 3 SD control limit.*

Ecological Element: White-winged Fairy-wren (Barrow Island)	
Objective:	• Detect variation in abundance—attributable to the Gorgon Gas Development—over time.
Methodology:	• Survey method: Annual distance sampling was carried out to compare the densities of White-winged Fairy-wrens within the At Risk and Reference zones. • Analysis method: Changes in relative density were determined by the degree of variation observed between At Risk and Reference zones, and were plotted using time-series control charts to understand trends in abundance over time.
Changes to Monitoring Sites:	• The transect layout was modified during the 2015–2016 Reporting Period, resulting in more even surveillance coverage across Barrow Island. Transect length was extended from 400 m to 2 km. • The number of transects monitored increased from 55 during the 2015–2016 Reporting Period to 102 during the 2016–2017 Reporting Period. The combined length of the transects was 174.1 km, with 107.4 km of transects in the Reference zone and 66.7 km in the At Risk zone. • During the 2016–2017 Reporting Period, changes in relative density were determined by the degree of variation observed between At Risk and Reference zones, and were plotted using time-series control charts to understand trends in abundance over time. • The number of transects monitored increased to 128 during the 2017–2018 Reporting Period. • The number of transects monitored increased to 132 during the 2018–2019 Reporting Period. The combined total length of the transects was 228 km, with 137 km of transects located in the Reference zone and 89 km in the At Risk zone. • A new transect layout was trialled successfully during the 2019–2020 Reporting Period, in which horizontal east–west transects spaced at 500 m were overlain over the entirety of Barrow Island. The transects ranged in length from a few hundred metres to several kilometres. • There was a considerable increase in the total distance sampled during the 2019–2020 Reporting Period, with 79 transects totalling 270 km completed during the 2019–2020 Reporting Period, compared to 132 transects totalling 226 km completed during the 2018–2019 Reporting Period. The increase in effort is predominantly a result of a change in transect length and orientation meaning there was less ‘down time’ moving between transects.

<table>
<tr><th colspan="2">Ecological Element: White-winged Fairy-wren (Barrow Island)</th></tr>
<tr><td>Results:</td><td>

The Barrow Island-wide population estimate of White-winged Fairy-wrens ranged between 4,611 during the 2015–2016 Reporting Period to 4,268 (± 414) during the 2019–2020 Reporting Period.
The estimated number of White-winged Fairy-wrens in the At Risk zone ranged between 3,150 (± 908) during the 2015–2016 Reporting Period to 2188 (± 263) during the 2019–2020 Reporting Period (Ref. 41; Ref. 42).
The changes to the estimated number of White-winged Fairy-wrens in the Reference zone was less pronounced than in the At Risk zone. The estimate number ranged from 2,149 (± 667) during the 2015–2016 Reporting Period to 2,080 ± 241 during the 2019–2020 Reporting Period (Ref. 41; Ref. 42).
These abundance estimates reflect the underlying density estimates of 14.18 ± 1.64 individuals per km^2 (equivalent to 0.14 ± 0.02 individuals per ha) within the Reference zone and 24.37 ± 2.93 individuals per km^2 (equivalent to 0.24 ± 0.03 individuals per ha) in the At Risk zone (Ref. 41; Ref. 42).
The ratio between estimated At Risk and Reference zone densities has decreased from 2.47 during the 2015–2016 Reporting Period to 1.71 during the 2019–2020 Reporting Period, approaching the long-term (2009–2019) average of 2.0 ± 0.5. The control chart metric has declined during the 2015–2020 Reporting Period and exceeded the −1 SD alert trigger (Ref. 41; Ref. 42).

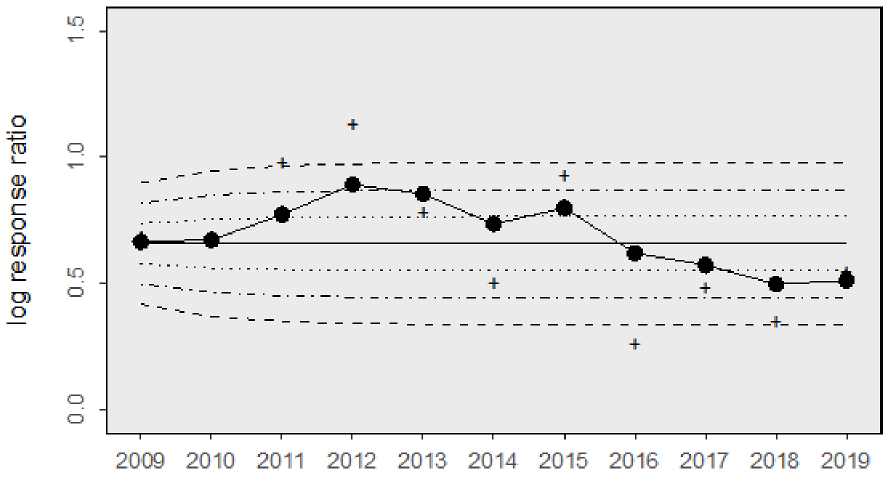


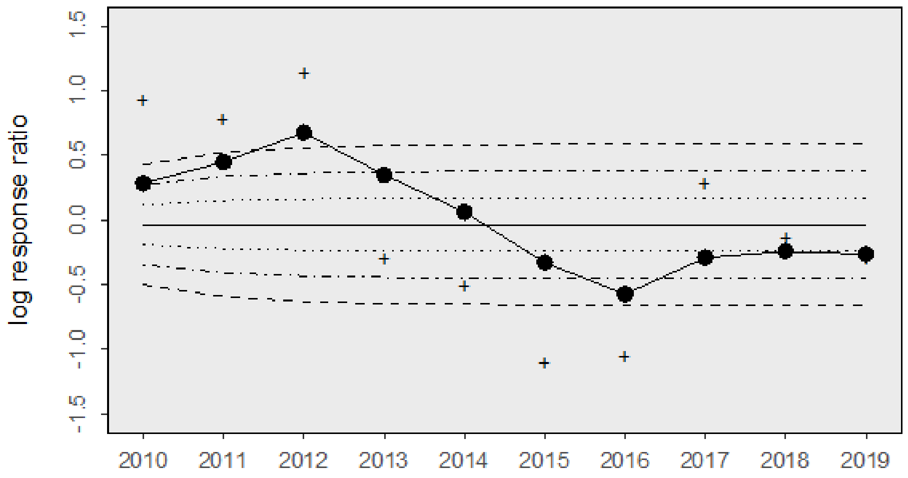
Figure 2-2: White-winged Fairy-wren Population Density EWMA Chart; Difference between At Risk and Reference Zone[1]
</td></tr>
<tr><td>Conclusions:</td><td>

The −1 SD Alert trigger level was exceeded during the 2017–2018, 2018–2019, and 2019–2020 Reporting Periods.
Monitoring has not detected an adverse impact (attributable to the Gorgon Gas Development) to the Barrow Island White-winged Fairy-wren population outside the TDF (Ref. 41; Ref. 42).
The greater variability in density estimates within the At Risk zone is not surprising given that the zone supports better quality habitat for White-winged Fairy-wrens, a greater abundance of White-winged Fairy-wrens and therefore a potentially greater population growth rate. The driver for the variation is presumed to be rainfall, but this has not been tested (Ref. 41).

</td></tr>
</table>

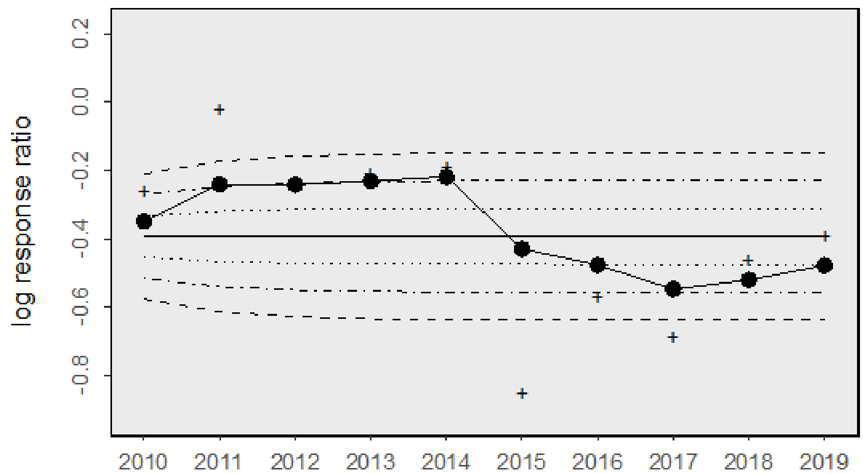
1 *EWMA Chart: + = standardised difference metric; • = smoothed standardised difference metric based on exponentially weighted 3-year moving average; dotted curves represent ±1 SD, ±2 SD, and ±3 SD; solid line = zero centreline. Bar chart shows island-wide annual population estimates. Positive values show an effect that is higher at the At Risk site compared to the Reference site, and vice versa.*

Monitoring Program: Euro (Barrow Island)	
Objective:	• Detect variation in abundance—attributable to the Gorgon Gas Development—over time.
Methodology:	• Survey method: Annual distance sampling was carried out to compare the densities Euros within the At Risk and Reference zones. • Analysis method: Changes in relative density were determined by the degree of variation observed between At Risk and Reference zones, and were plotted using time-series control charts to understand trends in abundance over time.
Changes to Monitoring Sites:	• The number of transects monitored during the 2015–2016 Reporting Period was 58 (48 fixed and 10 randomly allocated each year to maximise sampling accuracy). • In response to the 2015–2016 Action trigger, the number of nocturnal transects monitored increased from 65 during the 2015–2016 Reporting Period to 119 during the 2016–2017 Reporting Period. • The program design used in the 2016–2017 Reporting Period marked a departure from previous Reporting Periods, and represented a management action in response to the −2 SD management trigger level reached in the 2015–2016 Reporting Period. The scattered, 1 km long transects used previously were replaced with a randomly placed, systematic design suitable for both Conventional Distance Sampling (CDS) analysis and Density Surface Modelling (DSM). Each transect was 2 km long (shorter at the coastline). This resulted in 110 km of transects being surveyed, an increase on the 61 km of transects surveyed in 2015. • Nocturnal Euro monitoring was run concurrently with the Spectacled Hare-wallaby program in the 2018–2019 Reporting Period. The number of nocturnal transects monitored decreased from 119 in 2017 to 100 in 2018. • During the 2019–2020 Reporting Period, Euros were monitored diurnally, concurrently with the White-winged Fairy-wren monitoring program. This represents a departure from previous years, which used nocturnal sampling for the species, and follows successive trials that demonstrated that Euros were more detectable during the early morning and late afternoon than they were at night, leading to greater numbers of observations. The low detection of Euros at night-time was a key limitation for monitoring this species in previous years and this modified approach is a major improvement in the program. • A total of 79 transects were walked, covering ~270 km of on-ground effort during the 2019–2020 Reporting Period.
Results:	• Overall, the estimated number of Euros on Barrow Island decreased from 1,965 (± 681) in 2015 to 1,264 (± 293) in 2019. The estimated abundance in the Reference zone decreased from 2,147 (± 952) in 2015 to 872 (± 207) in 2019. The estimated abundance in the At Risk zone declined from 421 (± 286) in 2015 to 392 (± 103) in 2019 (Ref. 41; Ref. 42). • The At Risk estimate number reached its highest point, 480 (± 226), when the Reference zone was at its lowest during the 2017–2018 Reporting Period (Ref. 22). • The ratio between the At Risk and Reference zone densities decreased during the 2015–2016 and 2016–2017 Reporting Periods, exceeding the −2 SD and −3 SD Alert trigger levels, respectively. An improvement was noted in the relative Euro densities between the At Risk and Reference zones during the 2017–2018 Reporting Period, resulting in an improvement in the EWMA control metric; however, the ratio between the At Risk and Reference zone densities still exceeds the −1 SD Alert trigger level (Ref. 42; Ref. 21; Ref. 22). • The ratio between the At Risk to Reference zones densities improved again during the 2018–2019 Reporting Period, and then marginally decreased during the 2019–2020 Reporting Period; however, both Reporting Periods remained within in the −1 SD Alert trigger level (Ref. 41; Ref. 34).

Monitoring Program: Euro (Barrow Island)	
	 **Figure 2-3: Control Chart for Euro Population Density at Barrow Island: Difference between At Risk and Reference Zone**[1]
Conclusions:	• Monitoring has not detected an adverse impact (attributable to the Gorgon Gas Development) to the Barrow Island Euro population outside the TDF.

1 *EWMA Chart: + = standardised difference metric; • = smoothed standardised difference metric based on exponentially weighted 3-year moving average; dotted curves represent ±1 SD, ±2 SD, and ±3 SD; solid line = zero centreline. Positive values show an effect that is higher at the At Risk site compared to the Reference site, and vice versa.*

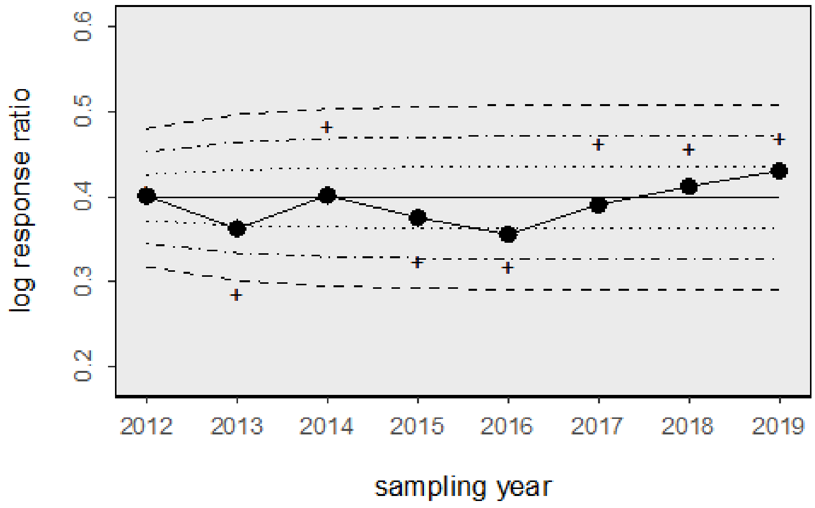
Monitoring Program: Spectacled Hare-wallaby (Barrow Island)	
Objective:	• Detect variation in abundance—attributable to the Gorgon Gas Development—over time.
Methodology:	• Survey method: Nocturnal distance sampling across 50 transects up to 6.66 km long was completed, with a total distance of 204 km walked. Transects totalled 75 km in the At Risk zone and 129 km in the Reference zone, reflecting the different area of each zone. • Analysis method: Changes in relative density (estimated from density surfaces) from 2018 were determined by the degree of variation observed between At Risk and Reference zones, and were plotted using time-series control charts to understand trends in abundance over time.
Changes to Monitoring Sites:	• The program design used in the 2016–2017 Reporting Period marked a departure from previous Reporting Periods, and represented a management action in response to the −1 SD management trigger level being exceeded in the 2015–2016 Reporting Period. The scattered, 1 km long transects used previously were replaced with a randomly placed, systematic design suitable for both CDS and DSM. Each transect was 2 km long (shorter at the coastline). This resulted in 110 km of transects being surveyed, an increase on the 61 km of transects surveyed in 2015. • Annual distance sampling across 119 transects up to 2 km long was completed in the 2017–2018 Reporting Period, with a total distance of 206 km walked. Transects totalled 85 km in the At Risk zone and 121 km in the Reference zone. Changes in relative density were determined by the degree of variation observed between At Risk and Reference zones, and were plotted using time-series control charts to understand trends in abundance over time. • The number of nocturnal transects monitored decreased from 119 in the 2017–2018 Reporting Period to 100 in 2018–2019 Reporting Period. This resulted in a decrease in the distance covered, from 206 km to 177 km respectively.

Monitoring Program: Spectacled Hare-wallaby (Barrow Island)	
	• A new transect layout was trialled successfully in the 2019–2020 Reporting Period, in which horizontal east–west transects spaced at 500 m were overlain over the entirety of Barrow Island. The transects ranged in length from a few hundred metres to several kilometres. Fifty transects of varying length were walked between sunset and sunrise, resulting in 204 km of on-ground nocturnal effort. Following successful trials in 2018, a single observer completed each transect, rather than two observers, resulting in a considerable increase in the sampling effort. High-precision global positioning system (GPS) devices were used to navigate transects and record observations.
Results:	• The estimated abundance of Spectacled Hare-wallabies during the 2015–2016 Reporting Period was 4,463 (± 1,085) in the At Risk zone and 8,817 (± 1,681) in the Reference zone. The ratio of the At Risk and Reference zones decreased compared to the previous year (Ref. 42). • During the 2016–2017 Reporting Period the estimated abundance reached its lowest point for the five-year period. The estimated abundance of Spectacled Hare-wallabies in the At Risk zone was 1,760 (± 355), with 5,217 (± 730) estimated in the Reference zone. The estimated densities decreased in both zones, with the decline in the Reference zone proportionally greater compared to the At Risk zone (Ref. 21). • The estimated abundance of Spectacled Hare-wallabies on Barrow Island increased to 10,768 (± 1081) in the 2017–2018 Reporting Period. The relative increase in density within the Reference zone was greater than that estimated for the At Risk zone, resulting in a continued decline of the At Risk to Reference zone density ratio (Ref. 22). • During the 2018–2019 Reporting Period the estimated number of Spectacled Hare-wallabies on Barrow Island increased to its highest point in the five-year period to 14,317 (± 1019). Although estimates of Spectacled Hare-wallaby abundance in each zone increased between 2017 and 2018, the density ratio increased only marginally (Ref. 34). • The estimated number of Spectacled Hare-wallabies on Barrow Island decreased to 12,400 (± 768) in the 2019–2020 Reporting Period (Ref. 41). • The At Risk to Reference zone density ratio changed marginally from 0.63 in the 2018–2019 Reporting Period to 0.67 in the 2019–2020 Reporting Period (Ref. 41). • The EMWA metric exceeded the −1 SD Alert trigger for each year of the 2015–2020 Reporting Period.  **Figure 2-4: Control Chart for Spectacled Hare-wallaby Population Density at Barrow Island: Difference between At Risk and Reference Zone[1]**
Conclusions:	• DSM showed that the Spectacled Hare-wallabies continued to occur in their highest densities in the two burnt areas in the north and south of Barrow Island; these areas are predominantly in the Reference zone (Ref. 3).

Monitoring Program: Spectacled Hare-wallaby (Barrow Island)	
	• Monitoring has not detected an adverse impact (attributable to the Gorgon Gas Development) to the Spectacled Hare-wallaby population outside the TDF.

1 *EWMA Chart: + = standardised difference metric; • = smoothed standardised difference metric based on exponentially weighted 3-year moving average; dotted curves represent ±1 SD, ±2 SD, and ±3 SD; solid line = zero centreline. Positive values show an effect that is higher at the At Risk site compared to the Reference site, and vice versa.*

Monitoring Program: Boodie (Barrow Island)	
Objective:	• Detect variation in abundance—attributable to the Gorgon Gas Development—over time.
Methodology:	• Survey method: Annual capture-mark-recapture sampling at 40 Boodie warrens. • Analysis method: The capture-mark-recapture analyses included all capture histories from 40 historically trapped warrens. New warrens were included to better incorporate warrens that form part of a social cluster of warrens.
Changes to Monitoring Sites:	• In the 2015–2016 Reporting Period four newly discovered warrens were surveyed to ascertain whether they were active. • During the 2016–2017 Reporting Period new Boodie warrens were surveyed within the At Risk zone to better capture all warrens that form part of a social cluster of mounds. These additional warrens were incrementally included into the monitoring program between 2012 and 2016 to capture individuals that were identified to routinely move between locations, as well as in response to requirements for the Additional Support Area (ASA) approved for the Gorgon Gas Development in 2014 (MS 965). • In the 2018–2019 Reporting Period, warren B045 (midway between the WAPET Landing and Terminal Tank [TT] clusters) was included as a trapping site for the first time. Warren B018 was not trapped because it had no discernible recent Boodie activity. • During the 2018–2019 Reporting Period only 39 warrens were trapped. • The field methodology used during the 2019–2020 Reporting Period was consistent with previous years, with minor alterations to trap effort at some of the warrens to reflect the previous year's abundance estimate at those warrens.
Results:	• In 2015, the estimated abundance of Boodies in the At Risk zone was 159 (± 9.0) and 112 (± 6.8) in the Reference zone. The density ratio was moderately lower than previous years and reflects a proportionally larger increase in the estimated number of Boodies in the Reference zone, relative to the increase in the At Risk zone, between 2014 and 2015 (Ref. 42). • During the 2016–2017 Reporting Period estimated abundance continued to decline from monitored warrens in both the At Risk and Reference zones, even though the Boodie population size EWMA control chart remained in control. However, the ratio metric was likely subject to bias due to the inclusion of additional warrens and hence additional individuals within the At Risk zone between 2012 and 2016. • There was an overall increase in the population estimates from the 40 monitored warrens during the 2017–2018 Reporting Period. The increase was mostly in the At Risk zone, which increased to 196 (Confidence Interval [CI] 181–226) in 2017. The Reference zone estimate was largely unchanged from 2016. The Boodie population EWMA control chart remained in control (Ref. 22). • There was a slight decline in the population estimates from the 39 monitored warrens during the 2018–2019 Reporting Period. The decrease in the At Risk zone was comparable to that estimated from the Reference zone. This was first year in the 2015–2020 Reporting Period to exceed the −1 SD Alert trigger (Ref. 34). • There was a decline in the overall population estimates from the warrens trapped as part of the monitoring program during the 2019–2020 Reporting Period, with the overall estimate of 244 individuals at its lowest since monitoring began in 2012. Despite the declines, the Boodie population size EWMA control chart remained in control (Ref. 41).

Monitoring Program: Boodie (Barrow Island)	
	 **Figure 2-5: Control Chart for Boodie Population Density at Barrow Island: Difference between At Risk and Reference Zone[1]**
Conclusions:	• Although the island-wide population estimate has declined slightly the relative ratio between the At Risk and Reference sites remains relatively stable, with the +1 SD trigger indicating a greater decline in abundance in the Reference zone than within the At Risk zone. • Monitoring has not detected an adverse impact (attributable to the Gorgon Gas Development) to the Barrow Island Boodie population outside the TDF.

1 *EWMA Chart: + = standardised difference metric; • = smoothed standardised difference metric based on exponentially weighted three-year moving average; dotted curves represent ±1 SD, ±2 SD, and ±3 SD. Solid line = zero centreline. Positive values show an effect that is higher at the At Risk site compared to the Reference site, and vice versa.*

Monitoring Program: Golden Bandicoot (Barrow Island)	
Objective:	• Detect variation in abundance—attributable to the Gorgon Gas Development—over time.
Methodology:	• Survey method: Annual spatially explicit capture-mark-recapture sampling at 24 trapping grids (11 monitored routinely, plus 13 randomly allocated grids), with 12 grids in each At Risk and Reference zone. Each grid contained 49 traps spaced at 40 m intervals on a 7 m × 7 m grid configuration. Trapping occurred over five consecutive nights. • Analysis method: Changes in relative abundance were determined by the degree of variation observed between the At Risk and Reference zones, and were plotted using time-series control charts to understand trends in abundance between the two zones over time.
Changes to Monitoring Sites:	• Monitoring moved to five-yearly frequency after the 2017–2018 Reporting Period after transition of the Gorgon Gas Development to the operational phase. The next monitoring will be conducted in 2022.
Results:	• The estimated density was 1.43 (CI 1.18–1.74) bandicoots per hectare in the At Risk zone and 1.34 (CI: 1.03–1.74) bandicoots per hectare in the Reference zone in the 2015–2016 Reporting Period. This represented an increase in density in both the At Risk and Reference zones relative to 2014. The ratio between the At Risk and Reference zone densities in 2015 was similar to all previous years, remaining between 1.04 and 1.08 since 2012. Overall, the density difference ratio is within management trigger limits (Ref. 42). • During the 2016–2017 Reporting Period bandicoot density in the At Risk zone was estimated to be 1.07 (± 0.10) individuals per hectare, while in the Reference zone the

Monitoring Program: Golden Bandicoot (Barrow Island)

density was slightly less at 1.06 (± 0.10) bandicoots per hectare; these are the lowest levels recorded to date for both zones. Despite a declining trend in the density of bandicoots across Barrow Island, the EWMA metric fluctuates around the centreline and remains within ±1 SD, indicating density estimates remained within management trigger limits (Ref. 21).

- During the 2017–2018 Reporting Period bandicoot density increased to the highest estimates recorded to date for both zones. Bandicoot density in the At Risk zone was estimated to be 2.36 (± 0.49) bandicoots per hectare, while in the Reference zone the density was higher at 2.79 (± 0.60) bandicoots per hectare (Ref. 22).

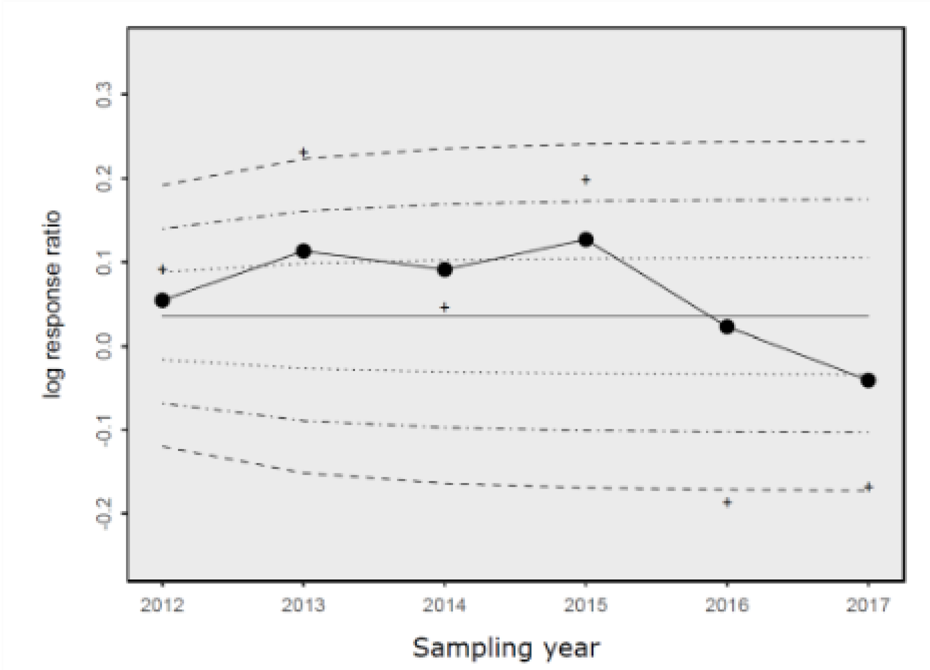


Figure 2-6: Control Chart for Boodie Population Density at Barrow Island: Difference between At Risk and Reference Zone[1] (top) and Island-wide population trend (bottom)[1]

Conclusions:

- The estimated density (and therefore overall abundance) of Golden Bandicoots increased in both zones during the Reporting Period. This was likely a consequence of cyclonic rainfall early in 2017, which resulted in increased breeding. As with the 2016 monitoring results, the Reference zone yielded a higher density estimate compared to the At Risk zone, which contrasts to the 2012–2015 period when the At Risk zone yielded higher estimates (Ref. 22).
- The relatively high density of Golden Bandicoots recorded from the Reference zone, which had been affected by a past bushfire, was likely attributable to better forage in the burnt areas (Ref. 22).
- Monitoring has not detected an adverse impact (attributable to the Gorgon Gas Development) to the Golden Bandicoot population outside the TDF (Ref. 22).

1 *EWMA Chart: + = standardised difference metric; • = smoothed standardised difference metric based on exponentially weighted three-year moving average; dotted curves represent ±1 SD, ±2 SD, and ±3 SD. Solid line = zero centreline. Positive values show an effect that is higher at the At Risk site compared to the Reference site, and vice versa.*

Monitoring Program: Wedge-tailed Shearwater	
Objective:	• Detect variation in abundance and demographics—attributable to the Gorgon Gas Development—over time.
Methodology:	• Survey method: Three fixed long-term transects (100 m × 10 m) on each of Double Island North, Double Island South (At Risk islands), and Ah Chong Island,

Monitoring Program: Wedge-tailed Shearwater	
	(Reference island), were surveyed twice during the summer breeding season. During the first survey (to measure Breeding Participation during early egg incubation period), all burrows within transects were counted, giving Burrow Density, and their contents checked using a purpose-built burrow scope to identify breeding attempts (as indicated by the presence of an egg). During the second visit (to measure Fledging Success), all burrows in the transects were re-examined to identify presence of chicks/fledglings. Nests containing live, well-developed fledglings at this time were considered to be fledged. • Analysis method: The three metrics used for control charting were: – Burrow Density = total number of burrows (active and inactive) in the transect per 100 m^2 – Breeding Participation = number of breeding attempts divided by the number of burrows (active and inactive), expressed as a percentage – Fledging Success = number of chicks/fledglings present during the second field visit divided by the number of breeding attempts derived from the first field visit, expressed as a percentage. • In the 2016 and 2017 seasons, burrows that contained a single adult Wedge-tailed Shearwater were included as a breeding attempt in the analysis, regardless of whether an egg was visually confirmed as being present. In the 2018 season, breeding attempts were only determined on the confirmed presence of an egg, since the presence of a single adult bird was not considered a reliable indicator of a breeding attempt. • Changes were determined by the degree of variation observed between At Risk and Reference islands, and were plotted using time-series control charts to understand trends in abundance over time. • Changes in how a burrow's contents are categorised has occurred over the course of the monitoring program. To allow for consistency over the monitoring program, the long-term dataset was reviewed and raw data were recategorised to be consistent over the monitoring program. The presence of a single adult is considered a breeding attempt across all seasons.
Changes to Monitoring Sites:	• From the 2018 season onward, Ah Chong Island (an island in the Montebello group, 31 km north-north-east of the Gorgon Gas Development) replaced Boodie Island as a Reference island for the Wedge-tailed Shearwater monitoring program.
Results:	• During the 2016–2017 Reporting Period the density of nests on Double Island South relative to Boodie Island reached the −1 SD Alert trigger, and Double Island North exceeded the −3 SD Action trigger. All other Reporting Periods remained within the management trigger limits (Ref. 21). • Breeding participation remained within the management trigger limits throughout the 2015–2020 Reporting Period (Ref. 40).

Monitoring Program: Wedge-tailed Shearwater

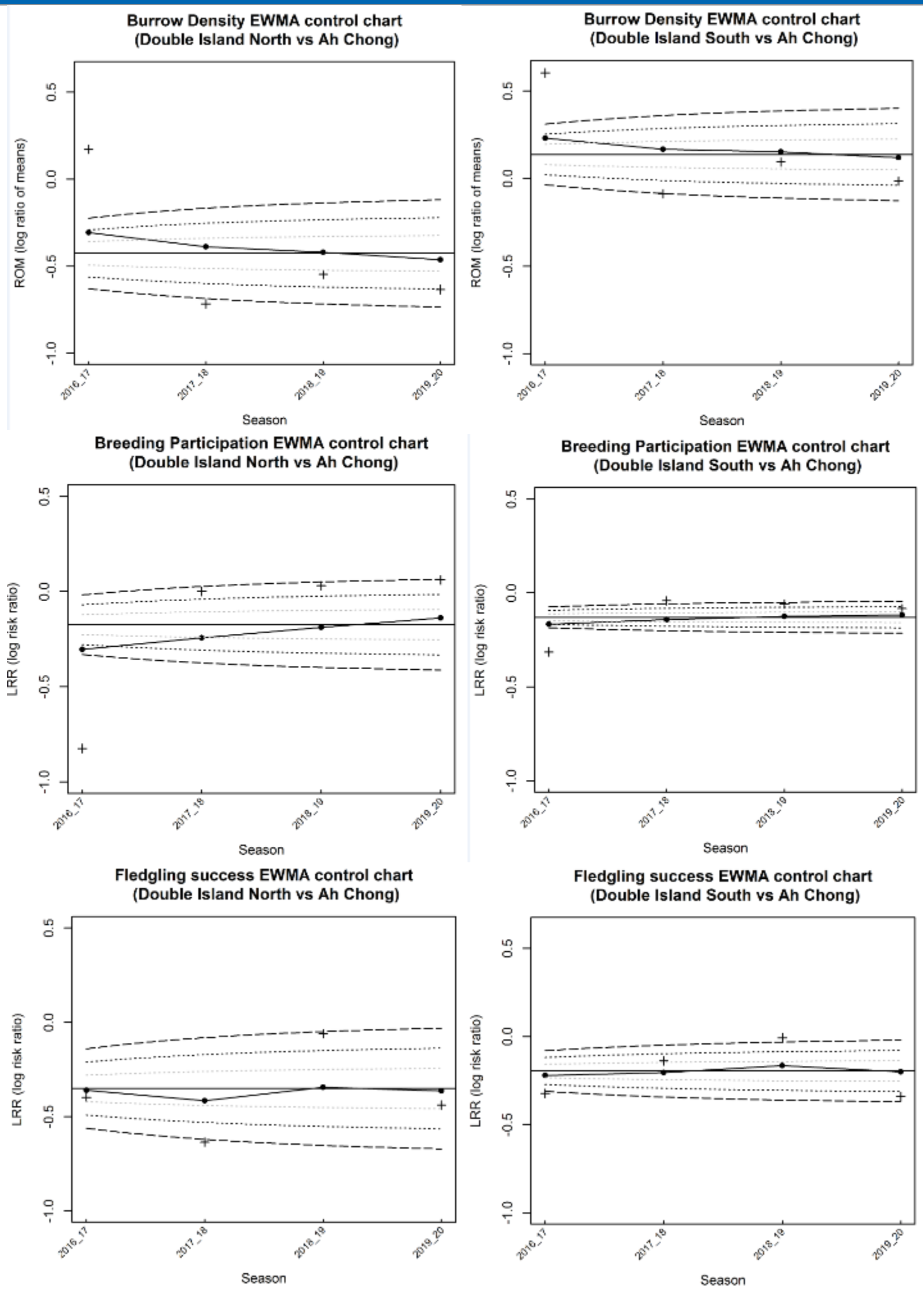


Figure 2-7: Control Charts for Wedge-tailed Shearwater[1, 2]

Conclusions:	• Wedge-tailed Shearwater Nest Density, Breeding Participation, and Fledging Success were within control limits for both At Risk islands, except for the 2016–2017 Reporting Period (Ref. 40). • Monitoring has not detected an adverse impact (attributable to the Gorgon Gas Development) to the Burrow Density, Breeding Participation, and Fledging Success of Wedge-tailed Shearwaters.

1 *EWMA Chart: + = log response ratio metric for the At Risk population compared with the Reference population, which is then centred around the random effects estimate of all sampled seasons (= thin horizontal line); • = smoothed log response ratio metric based on an exponentially weighted 3-year moving average; dotted curves represent ±1 SD, ±2 SD, and ±3 SD. Positive values show an effect that is higher at the At Risk site compared to the Reference site, and vice versa.*

2 *Notes: (i) The 2017 EPR (Ref. 21) referred to the control metric 'Breeding Participation' as 'Breed Rate', and 'Fledging Success' as 'Egg Success'. (ii) The Burrow Density metric for the Reporting Period included all nests, as was done in all seasons before 2016–2017, whereas only active nests were included in 2016–*

2017; therefore, the 2016–2017 data point has been removed from the relevant EWMA charts due to long-term dataset incompatibility. No fledgling success data were collected for the 2014–2015 Reporting Period.

Monitoring Program: Bridled Tern	
Objective:	• Detect variation in abundance and demographics—attributable to the Gorgon Gas Development—over time.
Methodology:	• Survey method: Three fixed long-term transects (100 m × 10 m) on each of Double Island North, Double Island South (At Risk islands), and Parakeelya Island (Reference island) were surveyed twice during the summer breeding season. During the first survey (to determine Breeding Participation during early egg incubation period), all nesting sites within transects were counted, giving Nest Density, and those containing either an egg or signs of a chick, were counted as a breeding attempt. During the second visit (to measure Fledging Success just before predicted fledging), all nests in the transects were re-examined for evidence of breeding activity, and nests identified as having a breeding attempt during the first survey were revisited to check for pre-fledging chicks. • Analysis method: The three metrics used for control charting were: – Nest Density = total number of nests (active and inactive) in the transect per 100 m^2 – Breeding Participation = number of breeding attempts divided by the number of nests (active and inactive), expressed as a percentage – Fledging Success = number of fledglings present during the second field visit divided by the number of breeding attempts derived from the first field visit, expressed as a percentage. • In 2017, a breeding attempt was determined if an egg, chick, chick scats, or adult tern was present. However, in 2018, the presence of a single adult tern was not considered a reliable indicator of a breeding attempt. A purpose-built scope was used to inspect deep rocky crevices or burrows (where terns are known to nest) that showed signs of activity. • Changes were determined by the degree of variation observed between At Risk and Reference islands, and were plotted using time-series control charts to understand trends in abundance over time. • Changes in how nest contents are categorised has occurred over the course of the monitoring program. To allow for consistency over the monitoring program, the long-term dataset was reviewed and raw data were recategorised to be consistent over the monitoring program. The presence of a single adult is considered a breeding attempt across all seasons.
Changes to Monitoring Sites:	• There were no changes to the monitoring sites during the Reporting Period
Results:	• While nest density exceeded the −2 SD review trigger on both Double Islands during the 2016–2017 Reporting Period, this was most likely because most of the eggs had already hatched at the time of the first survey. Breeding participation was within management trigger limits during this Reporting Period. All other Reporting Periods remained in the management trigger limits (Ref. 21). • Breeding participation remained within the management trigger limits throughout the 2015–2020 Reporting Period (Ref. 40).

Monitoring Program: Bridled Tern

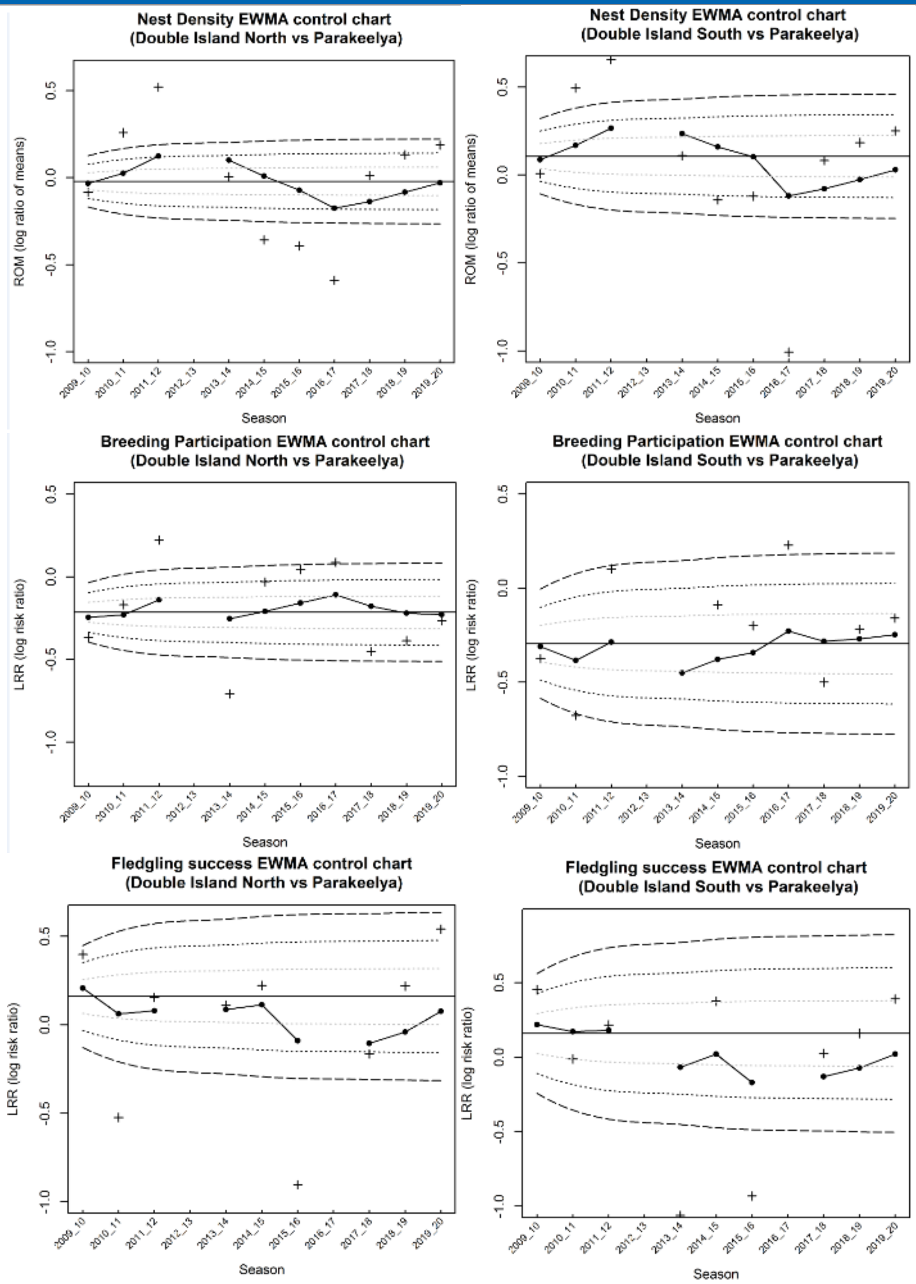


Figure 2-8: Control Charts for Bridled Tern[1, 2]

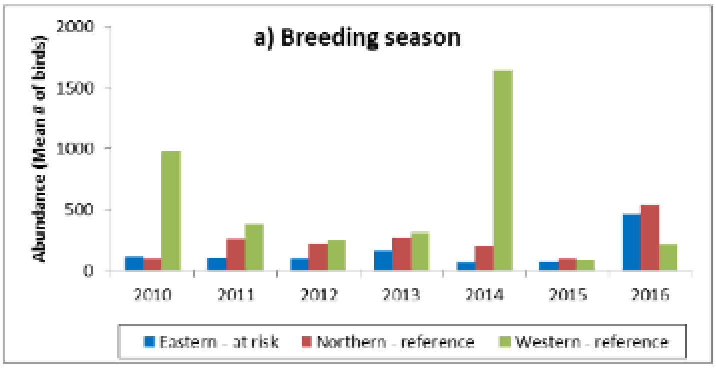
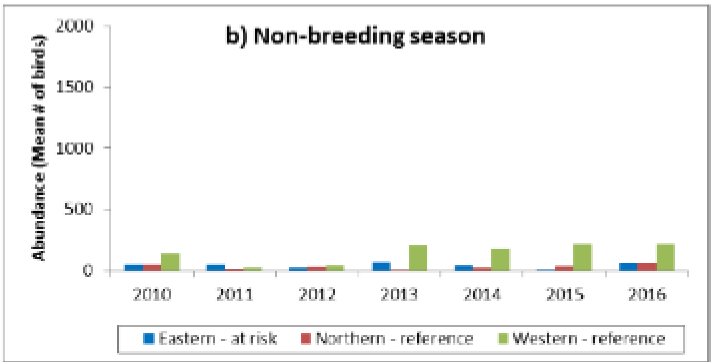
Conclusions:

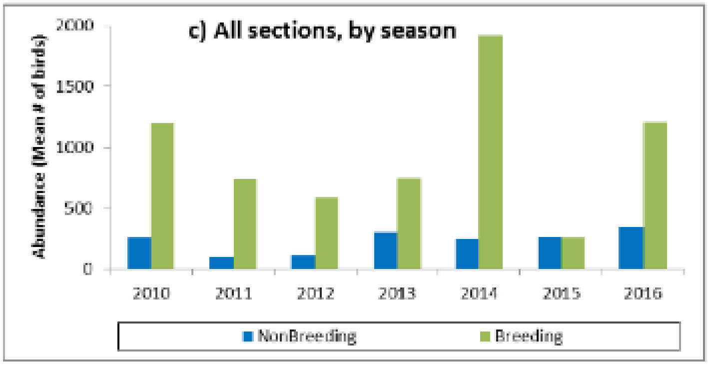
- All metrics for Bridled Tern remained within control limits for both At Risk islands during the 2015–2020 Reporting Period, except nest density during the 2016–2017 Reporting Period (Ref. 40).
- Monitoring has not detected an adverse impact (attributable to the Gorgon Gas Development) to the Nest Density, Breeding Participation, and Fledging Success of Bridled Terns.

1 *EWMA Chart: + = log response ratio metric for the At Risk population compared with the Reference population, which is then centred around the random effects estimate of all sampled seasons (= thin horizontal line); • = smoothed log response ratio metric based on an exponentially weighted 3-year moving average; dotted curves represent ±1 SD, ±2 SD, and ±3 SD. Positive values show an effect that is higher at the At Risk site compared to the Reference site, and vice versa.*

2 *Notes: (i) The 2017 EPR (Ref. 21) referred to the control metric 'Breeding Participation' as 'Breed Rate', and 'Fledging Success' as 'Egg Success'. (ii) The Nest Density metric for the Reporting Period included all nests, as was done in all seasons before 2016–2017, whereas only active nests were included in 2016–*

2017; therefore, the 2016–2017 data point has been removed from the relevant EWMA charts due to long-term dataset incompatibility. No data were collected for the 2012–2013 Reporting Period.

Monitoring Program: Silver Gull	
Objective:	• Detect variation in abundance—attributable to the Gorgon Gas Development—over time.
Methodology:	• Survey method: Silver Gull abundance was monitored twice a year during the breeding and non-breeding season on Barrow Island beaches. This included east coast At Risk and Reference zones along the west and north coasts of Barrow Island. If weather conditions permit, a Silver Gull breeding colony on Middle Island (Reference zone) was also monitored during the breeding season. • Analysis method: Bar charts were produced for Silver Gull abundance on each coastal section, for both breeding and non-breeding seasons to determine variation in annual abundance.
Changes to Monitoring Sites:	• Middle Island was not surveyed during 2015–2016 Reporting Period due to adverse weather conditions. • Silver Gull monitoring ceased after the 2015–2016 Reporting Period.
Results: (Ref. 42)	• Distribution of Silver Gulls varied across At Risk and Reference zones and seasons, with abundances generally higher during the breeding season (Figure 2-9 a, b). During the 2016 breeding season, the abundance of Silver Gulls on the eastern (At Risk) and northern (Reference) coastal zones were higher, relative to all previous seasons (Figure 2-9 a). • More Silver Gulls were observed in the 2016 breeding season on some east coast beaches, including Mushroom and Terminal beaches, as well as the LNG Jetty head, which has not previously been surveyed. • Mean Barrow Island-wide seasonal abundances in 2016 were higher than 2015; however, they reflected similar patterns of abundance to previous seasons (Figure 2-9 c). • There was no evidence of Silver Gull nesting activity in the primary dune areas adjacent to beaches surveyed on Barrow Island during the Reporting Period, nor were any Silver Gulls observed roosting in the dunes.  

Monitoring Program: Silver Gull	
	 **Figure 2-9: Annual Variation in Silver Gulls across Barrow Island Beaches from 2010 to 2016 (a. breeding season, b. non-breeding season and c. all monitored zones)**
Conclusions:	• Since monitoring began, Silver Gull numbers have varied annually. Higher Silver Gull abundances (at both Reference and At Risk zones) have generally been recorded during the breeding season, relative to the non-breeding season. • Similar patterns in At Risk and Reference zones suggest the observed variation in abundance on the northern (Reference) and eastern (At Risk) coastal zones of Barrow Island during the 2015–2016 Reporting Period is the result of natural variation as opposed to Gorgon Gas Development activities. However, the LNG Jetty head (a new structure not previously surveyed) within the eastern (At Risk) coastal zone was associated with higher abundance than elsewhere on Barrow Island and therefore likely provides additional habitat for Silver Gulls.

Monitoring Program: Groundwater	
Objective:	• Collect information on groundwater levels and the physicochemical parameters of the groundwater to diagnose observed changes—attributable to the Gorgon Gas Development and Jansz Feed Gas Pipeline—over time.
Methodology:	• During the 2015–2020 Reporting Period, activities at the site have transitioned from construction to operations. As such, the groundwater monitoring at the site has transitioned from construction phase groundwater monitoring, which covered construction and commissioning activities at the site (January 2010 to November 2016) to operations phase groundwater monitoring. The TSEMP (Ref. 1) was updated in October 2016 to reflect this transition from construction to operational activities at the site. • The latest revision of the Gorgon Groundwater Sampling and Analysis Quality Plan (operational SAQP; Ref. 4) was developed in accordance with the 2016 TSEMP and outlines the scope and methodology of the operational phase of groundwater monitoring. • Changes between the previous (2014) Sampling and Analysis Plan (SAP; Ref. 38) the 2015 SAP Addendum (Ref. 39), and the current (2017) operational SAQP (Ref. 4) include: – Monitoring programs outlined in the previous SAP (Ref. 38) and SAP Addendum (Ref. 39) were designed to address high-risk contaminant sources associated with the construction phase of the Gorgon Gas Development. The transition of the Gorgon Gas Development from the construction phase to operational phase has changed the potential contaminant sources present at the site. The operational SAQP (Ref. 4) focuses on the GTP and water disposal facilities (temporary and permanent) as possible source areas. – The transition to the operational SAQP resulted in a change to sampling frequency from quarterly to twice-yearly. – The pre-construction baseline and construction monitoring phases have satisfied the need for a broad baseline assessment of groundwater conditions. For the operational phase, the Chemicals of Potential Concern (COPC) were

<table>
<tr><th colspan="2">Monitoring Program: Groundwater</th></tr>
<tr><td></td><td>updated to reflect a narrowed focus of the groundwater assessment to potential contaminant sources at the site during operation of the GTP.
• In addition to the above changes, the monitoring network at the site has also changed. Over the five-year period, the number and location of the monitoring wells has changed, due to the change in the operational SAQP, construction activities, wells not being fit for purpose, or wells becoming damaged or inaccessible. Below is a summary of these changes.
– Background Wells: These wells surround or are up-hydraulic gradient of the GTP site (specifically GMW-RD6-01, GMW-RD6-03, GMW-RD6-04, GMW-RD7-01, GMW-RD7-02, GMW-RD7-04, GMW-RD7-05, and GMW-RD7-06). Former background wells include S1, S2, S3, S4, S5, and S6. These wells were sampled between May 2015 and February 2017 but monitoring was ceased later in 2017 when the operational monitoring program was optimised.
– GTP Wells: These wells are near the GTP. The Baseline SAQP referred to all wells near the GTP as the ‘GTP At Risk Wells’; however, the operational SAQP distinguishes between At Risk wells and Reference wells within this area:
▪ ‘At Risk wells’ are those hydraulically down-gradient of the GTP source. These wells act as sentinels for off-site impacts to groundwater from the GTP. The At Risk wells include GW-GTP-02A/B, GW-GTP-03A/B, GW-GTP-04A/B, GW05-B/E, and GW-GTP-14A (primary wells).
▪ ‘Reference wells’ are those on the boundary of the GTP that are hydraulically up- or cross-gradient of the GTP source. These wells provide an indication of background groundwater quality in the vicinity of the GTP. The Reference wells include GW-GTP-01A/B and GW-GTP-24A/B (primary wells) and GW-GTP-07A and GW-GTP15A (contingency wells).
– Permanent Disposal Wells: GW-RD5-02 (primary well) and GW-RD5-01, GW-RD5-03, and GMW-RD7-01 (contingency wells) in the Road 5 area monitor the permanent disposal wells in the area. These wells were referred to as the ‘Road 5 Wells’, before the operational SAQP (Ref. 4) was implemented.
– Temporary Disposal Wells: These three wells—DWDB1-MW2 and DWDB2-MW3 (primary wells) and DWDB1-MW3 (contingency well)—are located at the deep water injection disposal site and were first incorporated into the sampling program in September 2011. They are termed ‘temporary’ because they are expected to be removed from the monitoring program following the cessation of water disposal at the WA Oil Central Processing Facility. These wells were referred to as the ‘Disposal At Risk Wells’, before the operational SAQP (Ref. 4) was implemented.
Note: Contingency wells are only sampled if one of the primary wells is not able to be sampled during a particular monitoring event. Contingency wells were included in the program due to previous instances of wells not being able to be sampled due to well damage or simultaneous operations causing wells to be inaccessible.</td></tr>
<tr><td>Changes to Monitoring Sites:</td><td>Monitoring frequency
• Between September 2015 and November 2016 quarterly sampling was carried out at the site in accordance with the 2014 SAP (Ref. 38) and its 2015 addendum (Ref. 39). Six quarterly sampling events were undertaken during this.
• Between December 2016 and August 2020, twice-yearly sampling was undertaken at the site in accordance with the operational SAQP (Ref. 4). During the Reporting Period, seven biannual operational monitoring events were undertaken.
Sampling method
• Throughout the Reporting Period, samples were collected using low-flow and passive sampling techniques. Physical parameters (including water level, pH, electrical conductivity [EC], redox potential [ORP], dissolved oxygen [DO], and temperature) were recorded in the field. Samples were also sent to a National Association of Testing Authorities accredited laboratory for further analysis.
Sample Analysis
Background Wells (prior to operational SAQP)
• Laboratory analysis was conducted for inorganic parameters, nutrients, total recoverable hydrocarbons (TRH), metals (silver, arsenic, barium, cadmium, cobalt,</td></tr>
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<tr><th colspan="2">Monitoring Program: Groundwater</th></tr>
<tr><td></td><td>
chromium, hexavalent chromium, copper, lead, mercury, nickel, strontium, vanadium, and zinc), monocyclic aromatic hydrocarbons (MAH) including benzene, toluene, ethylbenzene, and xylene (BTEX), polycyclic aromatic hydrocarbons (PAH), volatile organic compounds (VOCs), halogenates benzenes, solvents, and additional stygofauna analytes (dissolved organic carbon [DOC], free, and total carbon dioxide).
GTP Wells – Shallow
• Laboratory analysis was conducted for physical parameters, major cations, major anions, mercury, monoethylene glycol (MEG), activated methyl diethanolamine (aMDEA), BTEX, TRH, and DOC.
GTP Wells – Deep
• Laboratory analysis was conducted for physical parameters, major cations, major anions, mercury, MEG, aMDEA, and DOC.
Permanent Disposal Wells
• Laboratory analysis was conducted for physical parameters, major cations, major anions, mercury, MEG, aMDEA, BTEX, TRH, DOC, and nutrients.
Temporary Disposal Wells
• Laboratory analysis was conducted for physical parameters, major cations, major anions, mercury, BTEX, TRH, DOC, and nutrients.
• Based on the primary analytical results, some wells were analysed for additional analytes such as TRH silica gel clean-up, PAH, MAH, and a full metals suite.
• Field and laboratory results were compared to published water quality criteria guidelines, limits of reporting (LORs), or baseline values. Changes in selected groundwater parameters are used as an indirect habitat indicator for stygofauna.
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<tr><td>Results:</td><td>
Background Wells
• Analysis of results for the background wells indicated that parameters were generally within the range of baseline results, were not detected above the LOR, or were below assessment criteria (as outlined in the SAP [Ref. 38] and the operational SAQP [Ref. 4]), with these exceptions:
– Physical parameters: Some ORP and EC values were recorded outside the 80% upper percentile limit (UPL) of baseline data from background wells. However, these results were consistent with historical maximum results at each individual well.
– Metals detected in background wells at concentrations exceeding baseline criteria during the Reporting Period include barium in GMW-RD06-04, which exceeded the criteria between September 2015 and August 2016, and vanadium in GMW-RD07-01, which exceeded the criteria in December 2015, March 2016, May 2016, and February 2017. GMW-RD06-04 was not sampled after the August 2016 monitoring event due to access issues; however, trends between September 2015 and August 2016 indicate that concentrations were decreasing slightly. The vanadium concentrations were above the baseline at GMW-RD07-01 by 0.001 mg/L and followed a stable trend between May 2016 and February 2017. In addition, nickel was recorded outside the 80% UPL of baseline data from background wells in GMW-RD07-01 in May 2016. However, nickel concentrations at this well had decreased to below the LOR by November 2016.
– Chloroform was detected slightly above the LOR at one well (GMW-RD7-01) in August 2016. This was the first detection of this analyte at this well and chloroform was not detected above the LOR at this well during subsequent monitoring.
– Naphthalene and toluene were detected in GMW-RD7-02 during the September 2015 monitoring. These detected concentrations may have been derived from residual drilling fluids as this was the first sampling event at this well since its installation. Naphthalene and toluene were not detected above the LOR at this well during subsequent monitoring.
GTP Wells
• Analysis of results for the GTP wells indicated that parameters were generally within the range of baseline results, were not detected above the LOR, or were below
</td></tr>
</table>

Monitoring Program: Groundwater	
	assessment criteria (as outlined in the SAP [Ref. 38] and the operational SAQP [Ref. 4]), with these exceptions: – Physical parameters: Some pH, DO, and EC values were recorded outside the baseline assessment criteria at GTP wells during the 2015–2020 Reporting Period. These results were within the maximum historical results at each individual well. In addition, some were attributed to either a change in the sampling methodology or use of laboratory pH in place of in situ readings because of issues with the field instrument. During the September 2019 monitoring, several GTP wells changed in redox state from 'neutral' (or 'neutral to reducing' for GW-GTP-02B, BW-GTP-24B and GW-RD5-02) to 'oxidising'. This was the first time oxidising conditions were reported at these wells. All these wells returned to 'neutral' or 'neutral reducing' during the February 2020 monitoring. DO content in GW-GTP-01A increased from 'low' levels during pre-operations to 'high' levels, and GW05-B reported slightly basic conditions relative to pre-operations during the February 2020 monitoring. – Nutrient concentrations were generally below the baseline range in the GTP wells, except for GW-GTP-24A where an increasing trend was noted between 2015 and 2017 (with the historical maxima in February 2017 above baseline concentrations). However, in subsequent monitoring, nutrient concentrations have remained below the LOR. – Strontium concentrations exceeded the maximum baseline concentration for the GTP well GW-GTP-04A between September 2015 and February 2017. Elevated strontium concentrations at GW-GTP-04A are considered to be a result of a change in monitoring well location from GW-GTP-04D to GW-GTP-04A and are likely from the screened lithology at this well. In December 2015, vanadium exceeded the baseline criteria for GTP wells in all sampled GTP wells except GW-GTP-15A, GW-GTP-24A, GW-GTP-24B. Cobalt (Ref. 44), hexavalent chromium (Ref. 44), and silver (Ref. 44) were recorded above the assessment criteria in at least one well between September 2015 and February 2017. However, metals with exceedances did not generally record significant increasing trends over this period. – aMDEA was detected at GW-GTP-01B (0.001 mg/L), GW05-B (0.001 mg/L), GW-GTP-04B (0.001 mg/L), and GW-GTP-24A (0.002 mg/L) at or above the laboratory LOR during the September 2019 monitoring. This is the only time aMDEA has been detected at these locations during the current Reporting Period (2015–2020). *Temporary Disposal Wells* • Analysis of results for the temporary disposal wells indicated that parameters were generally within the range of baseline results, were not detected above the LOR, or were below assessment criteria (as outlined in the SAP [Ref. 38] and the operational SAQP [Ref. 4]), with these exceptions: – Metals detected in the temporary disposal wells at concentrations exceeding assessment criteria between September 2015 and February 2017 include mercury (Ref. 44) and silver (Ref. 44). The concentrations of these metals did not record a significant increasing trend over the Reporting Period. No metal exceedances were reported between February 2017 and February 2020. – Styrene was detected above the LOR at all wells in August 2016 and February 2017. These were the only detections of styrene at these wells during the Reporting Period. Styrene is not an expected contaminant of concern in water from the waste streams disposed of at this location and may have been a result of cross-contamination. – Toluene was detected above the baseline criteria between September 2015 and March 2016 in DWDB1-MW2, DWDB1-MW3, and DWDB2-MW3. These detections were attributed to an external source rather than groundwater. Toluene was below LOR for the temporary disposal wells between August 2016 and February 2020. *Permanent Disposal Wells* • Analysis of results for the permanent disposal wells indicated that parameters were not detected above the LOR or were below assessment criteria (as outlined in the operational SAQP [Ref. 4]), with these exceptions:

Monitoring Program: Groundwater	
	– Physical parameters: Since August 2017, groundwater conditions at the permanent disposal wells GW-RD5-02 and GW-RD5-03 have reported trends of reduced salinity, increased DO, and a change in anionic composition relative to historical monitoring. GW-RD5-02 and GW-RD5-03 changed in redox state from 'neutral' (or 'neutral to reducing' for GW-RD5-02) to 'oxidising' for the first time in September 2019. These changes may indicate changes to aquifer conditions. – Metal concentrations were below the baseline criteria for the permanent disposal wells between 2015 and 2020, except for arsenic, which was only recorded above the baseline criteria once in GW-RD5-02 (September 2015). Silver was recorded above the assessment criteria (Ref. 44) at several wells between September 2015 and September 2018. However, the assessment criteria for silver is below the LOR and silver concentrations were recorded at or below LOR between September 2015 and September 2018. Therefore, although the silver concentrations were potentially greater than the assessment criteria, they are not considered to present a significant risk to the environment. Silver was removed as a primary analyte in the operational SAQP (Ref. 4), but retained as a trigger analyte. – TRH concentrations were reported below the LOR in the permanent disposal wells (Road 5 Wells) between September 2015 and February 2020, except at GW-RD5-01 in December 2015. The source of this TRH detection is not known. – MAH were reported below the LOR in the permanent disposal wells (Road 5 Wells) between September 2015 and February 2020, except for toluene in GW-RD5-01 (0.00088 mg/L) and GW-RD5-03 (0.00095 mg/L) in March 2016. The concentrations of toluene reported in March 2016 are believed to have come from an external source.
Conclusions:	• Groundwater monitoring during the Reporting Period is considered to have been completed in accordance with the TSEMP (Ref. 1). Transition to the operations phase of monitoring commenced with the implementation of the new TSEMP. • Monitoring near the GTP, permanent, and temporary disposal wells has generally indicated that no significant observable changes to groundwater attributable to the Gorgon Gas Development have occurred during the Reporting Period, except at GW-RD5-02 and GW-RD5-03 (permanent disposal wells), which reported increased DO and decreased salinity compared with pre-operations monitoring.

Monitoring Program: Surface Water Landform	
Objective:	• Detect impacts to surface water landforms extending beyond the TDF, which, over time, may be attributable to the Gorgon Gas Development.
Methodology:	• Desktop review of annual airborne light detection and ranging (LiDAR) survey results, coupled with field verification as required, to identify areas of potential significant erosion or sedimentation of surface water landforms.
Changes to Monitoring Sites:	• No changes were made to the 14 surface water landform monitoring sites during the Reporting Period.
Results:	• No significant erosion or sedimentation was observed at any of the 14 monitoring sites, based on spatial analysis interpretations during the 2015–2020 Reporting Period. • Follow-up field trips have not been required since the 2016–2017 Reporting Period.

Monitoring Program: Surface Water Landform	
Conclusion:	• Monitoring to date has not detected an adverse impact (attributable to the Gorgon Gas Development) to surface water landforms (Ref. 37). • In line with the TSEMP (Ref. 1), all 14 monitoring sites will now be transitioned from remote sensing scope to site-based inspection, when required to detect and manage future impacts (attributable to the Gorgon Gas Development).

2.2 Event Data

The Threatened or Listed fauna reporting undertaken during the Reporting Period is summarised in the following table.

Event Data: Threatened or Listed Fauna Reporting	
Reporting Requirement:	• Threatened or Listed fauna cared for, injured, or killed that are attributable to the Gorgon Gas Development.
Results:	• Table 2-2 lists the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Threatened or Listed fauna injured or killed during the 2015-2020 Reporting Period. • The Barrow Island Golden Bandicoot represents 67% of the deceased records, followed by the Barrow Island Spectacled Hare-wallaby (12%), Barrow Island Boodie (7%), and Barrow Island Euro (4%) (Table 2-2). The predominant cause of death for these species was vehicle strike (82%). The mortality counts[1] for these four main fauna species represent only a small proportion (~1.3%) of estimated Barrow Island abundance for these species. • Eight threatened or listed fauna were cared for[3] during the 2015-2020 Reporting Period; one died, six were released on Barrow Island, and one was transported to mainland WA for treatment.

Table 2-2: EPBC Act Threatened or Listed Fauna Recorded as Injured or Deceased

Common Name	Species Name	No. Injured[2]	No. Deceased[2]
Barrow Island Boodie	*Bettongia lesueur*	3	71
Barrow Island Euro	*Macropus robustus isabellinus*	3	42
Barrow Island Golden Bandicoot	*Isoodon auratus barrowensis*	3	729
Barrow Island Spectacled Hare-wallaby	*Lagorchestes conspicillatus*	4	130
Barrow Island White-winged Fairy-wren	*Malurus leucopterus edouardi*	0	3
Beach Stone Curlew	*Esacus magnirostris*	1	0
Bridled Tern	*Onychoprion anaethetus*	0	1
Brown Booby	*Sula leucogaster*	0	7
Crested Tern	*Sterna bergii*	0	1
Little Egret	*Ardea (Egretta) garzetta*	1	0
Nankeen Kestrel	*Falco cenchroides*	1	2
Osprey	*Pandion cristatus*	0	3
Red-capped Plover	*Charadrius ruficapillus*	0	1
Sacred Kingfisher	*Todiramphus sanctus*	0	1
Silver Gull	*Chroicocephalus novaehollandiae*	4	7
Sooty Shearwater	*Ardenea (Puffinus) griseus*	0	1
Wedge-tailed Shearwater	*Ardenna pacifica*	1	7
Welcome Swallow	*Hirundo neoxena*	2	16

Event Data: Threatened or Listed Fauna Reporting				
	White-Bellied Sea Eagle	*Haliaeetus leucogaster*	1	0

Note: A review of all terrestrial fauna events was conducted during the compilation of the Five-year EPR. The following criteria have been applied:

1. *Mortality count is calculated by dividing the sum of the mortality for the Barrow Island Golden Bandicoot, Barrow Island Spectacled Hare-wallaby, Barrow Island Boodie, and Barrow Island Euro over the 2015-2020 Reporting Period by the sum of the abundances for the four species as measured at the last monitoring event.*
2. *Injured and deceased fauna includes:*
   - *Events within the TDF where the cause of injury or mortality is attributed to the Gorgon Gas Development, or where the cause of injury or mortality is unknown.*
   - *Events outside the TDF where the cause of injury or mortality is attributable to the Gorgon Gas Development.*
   - *Does not include events where the cause of injury or mortality was natural.*
   - *Deceased fauna also includes sick and injured fauna that were cared for and subsequently euthanised.*
3. *Cared for fauna does not include fauna that is held temporarily which is not believed to be sick, diseased or abandoned. The following are not included as cared for fauna:*
   - *Fatigued fauna, such as storm-blown seabirds.*
   - *Fauna captured for relocation and held temporarily until dusk or dawn for release.*
   - *Injured fauna which is immediately euthanised.*
   - *Fledgling birds (uninjured and not sick) that are subsequently released on island.*

2.3 Five-year Overview of Environmental Performance

The 2015–2020 outcome for the Terrestrial and Subterranean Environment State is summarised in the table below.

Objectives[1]	Outcome
Establish a statistically valid ecological monitoring program to detect any Material or Serious Environmental Harm to the ecological elements outside the TDF.	Monitoring of fauna, vegetation, groundwater, and surface water, as per the requirements of the approved TSEMP (Ref. 1), throughout the five-year Reporting Period did not detect any Material or Serious Environmental Harm to the ecological elements outside the TDF that can be attributed to the Gorgon Gas Development.

1 *As defined in Condition 8.3 of MS 800 and Condition 7.3 of EPBC 2003/1294 and 2008/4178.*

2.4 Proposed Environmental Management Improvements

The key proposed management improvements for the TSEMP (Ref. 1) are summarised in the table below.

Proposed Management Improvement	Justification
Conclude monitoring of the Bridled Tern within the Seabird Monitoring Program and continue monitoring the Wedge-tailed Shearwater as a suitable indicator for both species	Long-term monitoring data does not support evidence for impact attributable to the Gorgon Gas Development: • Long-term monitoring of Bridled Tern population dynamics has shown that variability occurs across both At Risk and Reference sites within the same season and follows the same general dynamics observed in Wedge-tailed Shearwater colonies. The most likely explanation for broad-scale variation is that the causes are linked to regional environmental variables and therefore there is no evidence for impact attributable to the Gorgon Gas Development on these species. For example, regional variation in sea surface temperatures are known to influence breeding participation in seabird species (Ref. 45). • Monitoring of Wedge-tailed Shearwater nesting burrows is also a more reliable and repeatable method for assessing potential impacts on At Risk islands than assessing the condition of highly variable and often cryptic Bridled Tern nests. The proposal to focus on a single seabird species is further supported by assessing the long-term Breeding Participation

Proposed Management Improvement	Justification
	control charts that have remained within control limits over the duration of the program for both species, suggesting one species is a good indicator for the other. Fledgling Success control charts for Bridled Terns also indicate a higher success rate at the At Risk islands than observed on the Reference island, further supporting the conclusion that there is no apparent impact on this species attributable to the Gorgon Gas Development.
Conclude White-winged Fairy-wren monitoring	Long-term monitoring data does not support evidence for impact attributable to the Gorgon Gas Development: • The Barrow Island-wide population estimates for the White-winged Fairy-wren have been relatively stable over a 10-year period. The high estimates in 2009 and 2012, and to a lesser degree in 2011 and 2013, may represent years of high abundance, with the remaining years of relatively consistent estimates representing more typical population dynamics. • The control chart that represents the ratio between the At Risk area within the TDF and the rest of the island, or Reference area, indicates a higher density of wrens within the TDF and does not support or indicate impact (attributable to the Gorgon Gas Development) arising from construction or operating noise levels. • Over time, the control chart indicates a gradual change in the ratio between these two areas, with greater variation occurring within the TDF and relative stability in the Reference area driving the change. This higher variability of White-winged Fairy-wrens within the TDF may be associated with the greater abundance of quality habitat, a higher underlying density of wrens, and therefore greater potential population growth rate under favourable breeding conditions.
Conclude surface water landform monitoring	Long-term monitoring data does not support evidence for impact attributable to the Gorgon Gas Development: • The TSEMP (Ref. 1) provides for the surface water landform monitoring program to transition sites from inclusion in the remote sensing scope to site-based inspection after two or more years have passed since Gorgon Gas Development-related clearing or earthworks occurred and monitoring has not detected significant impact (attributable to the Gorgon Gas Development); therefore, remote monitoring will be concluded. • Future activities that involve clearing or earthworks may require the surface water landform monitoring program to monitor for impact at specific locations; therefore, revisions to the TSEMP will retain the capacity for surface water landform monitoring to be implemented as needed.
Alter the frequency of vegetation monitoring from 2- to 5-yearly	Long-term monitoring data does not support evidence for impact attributable to the Gorgon Gas Development: • To date, no adverse impact on vegetation species composition, species richness, vegetation cover, or plant health has been detected within or outside the TDF that can be attributed to Gorgon Gas Development activities. Changes in vegetation health have been linked to rainfall patterns, with the amount of rain in the preceding period being the primary driver for such changes. • Adjusting the frequency of vegetation monitoring to every five years will retain capability for impacts to be detected, but on a temporal scale that better represents the period over which changes to vegetation communities are likely to occur.

3 Terrestrial and Marine Quarantine

Table 3-1: EPR Reporting Requirements for Terrestrial and Marine Quarantine

Item	Source	Section in this EPR
Results of the audit and monitoring programs	MS 800, Schedule 3(2i) EPBC 2003/1294 and 2008/4178, Schedule 3(2i)	3.1, 3.2
Detected introduction(s) of non-indigenous terrestrial flora or fauna (NIS) and marine pest species, including procedure breaches and 'near misses' including special reference to weeds	MS 800, Schedule 3(2ii) EPBC 2003/1294 and 2008/4178, Schedule 3(2ii)	3.2, 3.3
Consequences of the introduction	MS 800, Schedule 3(2iii) EPBC 2003/1294 and 2008/4178, Schedule 3(2iii)	N/A[1]
Modification, if any, to the Quarantine Management System (QMS) because of: • audits and monitoring • detected introductions • 'best practice' improvements.	MS 800, Schedule 3(2iv) EPBC 2003/1294 and 2008/4178, Schedule 3(2iv)	3.4
Eradication actions if any taken; reasons for any action or non-action; changes to improve procedures and outcomes and progress	MS 800, Schedule 3(2v) EPBC 2003/1294 and 2008/4178, Schedule 3(2v)	N/A[2]
Mitigation actions	MS 800, Schedule 3(2vi) EPBC 2003/1294 and 2008/4178, Schedule 3(2vi)	N/A[2]
Results of any QMS-related studies, where conducted, to improve performance	MS 800, Schedule 3(2vii) EPBC 2003/1294 and 2008/4178, Schedule 3(2vii)	3.5, N/A[3]
Weed management incidents: • new infestations • proliferations	MS 800, Schedule 3(2viii) EPBC 2003/1294 and 2008/4178, Schedule 3(2viii)	N/A[1]
Weed eradication performance; and • areas treated • results against measurable indicators and limits	MS 800, Schedule 3(2xi) EPBC 2003/1294 and 2008/4178, Schedule 3(2ix)	N/A[1]
Targets proposed for the next year	MS 800, Schedule 3(2x) EPBC 2003/1294 and 2008/4178, Schedule 3(2x)	N/A[4]
A five-year overview of environmental performance	MS 800, Condition 5.3(iii) EPBC 2003/1294 and 2008/4178, Condition 4.2(iii)	3.6
Proposed environmental management improvements	MS 800, Condition 5.3(iv) EPBC 2003/1294 and 2008/4178, Condition 4.2(iv)	3.7

1 *No introductions of NIS or marine pests, or proliferations of existing weeds or new weed establishments, were recorded during the Reporting Period; therefore, reporting is not applicable at this time.*

2 *No eradication or mitigation actions in response to an introduction of a NIS or marine pest occurred during the Reporting Period; therefore, reporting is not applicable at this time.*

3 *No QMS-related studies were implemented during the Reporting Period; therefore, reporting is not applicable at this time.*

4 *Targets are developed in response to introductions of NIS or Marine Pests, or in response to proliferations of existing weeds or new weed establishment. During the Reporting Period, no introductions of NIS or*

Marine Pests, or proliferation of existing weeds or establishment of new weeds were recorded; therefore, reporting is not applicable at this time.

3.1 Audits

CAPL audits of the quarantine management measures described in the QMS (Ref. 5) are conducted at least twice a year during the operations phase of the Gorgon Gas Development operations. Outcomes of audits completed during the Reporting Period are described in the table below. One regulator audit was carried out on the QMS during the Reporting Period.

Audit Data	
Regulator Audits:	• One audit was undertaken on the QMS by the Office of the [WA] Environmental Protection Authority (OEPA) during the 2015–2016 Reporting Period. There were no non-compliances determined by the OEPA. • No other regulator audits were undertaken during the Reporting Period.
CAPL Audits[1]:	• CAPL completed 19 audits of the QMS during the 2015–2020 Reporting Period. These audits assessed compliance with the QMS and contractor quarantine processes. The May 2016 and May 2017 audits also assessed compliance with the Weed Hygiene Common User Procedure (Ref. 28) and the NIS Management Procedure (Ref. 29).[1] • Audits completed between 2015 and 2018 comprised both desktop and field-based assessments, which were based on interviews, physical inspections and observations, and reviews of records and documentation where applicable. Due to COVID-19 site access restrictions, the 2020 audit comprised desk-based assessments, web-based video interviews of contractor auditees, and reviews of records and documentation where applicable. • The 2015–2018 audits made 23 findings related to training, administration, and the implementation of procedures, and 34 improvement suggestions. The 2020 audit made three findings, related to quarantine induction training, weed hygiene control measures, and development and implementation of quarantine management plans. In addition, the 2020 audit made seven observations to strengthen existing safeguards and controls. • Audit outcomes from audits completed in 2015–2018 were addressed during the relevant Reporting Period. Actions are currently underway to address audit outcomes from the August 2020 audit. • According to the audit findings, the objectives of the QMS (Ref. 5) were met and no introductions of NIS or marine pests to Barrow Island and its surrounding waters occurred. • No substantive amendments were required to the QMS or supporting procedures or standards as a result of audit findings. • Those findings relating to implementation of the QMS were reported in the Annual Compliance Assessment Reports[2].

1 *CAPL assesses compliance with the requirements of the QMS in accordance with the Compliance Assessment Plan (Ref. 46) required by Condition 4.1 of MS 800.*

2 *Audit findings reported in the relevant Compliance Assessment Report relate to the implementation of the QMS as required under Condition 10.5 of MS 800, and Condition 8.5 of EPBC 2003/1294 and 2008/4178.*

3.2 Monitoring Results

A quarantine surveillance program determines the presence or absence of NIS (plants, invertebrates, and vertebrates) on Barrow Island and marine pests in the waters surrounding Barrow Island.

The results of surveillance programs implemented during the Reporting Period are summarised in the following tables.

Surveillance Program: Plant NIS	
Objective:	• Detect the presence and/or proliferation of plant NIS (weeds) on Barrow Island attributable to Gorgon Gas Development activities.
Methodology:	• Repeated weed surveillance at identified risk localities within the Gorgon Gas Development tenure and surrounding areas. • Repeated weed inspections of areas where weeds were previously recorded as a follow-up measure to ensure any further weed detections are immediately eradicated.
Results: **2015–2020**	• Twelve weed species—Wild Radish (*Raphanus raphanistrum*), Buffel Grass (*Cenchrus ciliaris),* Sow Thistle (*Sonchus oleraceus*), Rough Sow Thistle (*Sonchus asper*), Flaxleaf Fleabane (*Conyza bonariensis*), Blackberry Nightshade (*Solanum nigrum*), Capeweed (*Arctotheca calendula*), Hairy Hawkbit (*Leontodon saxatilis*), Tomato (*Lycopersicon esculentum*), Kapok Bush (*Aerva javanica*), Mediterranean Turnip (*Brassica tournefortii*), and Bulrush (*Typha* sp.)—were detected and controlled within the Gorgon Gas Development tenure and surrounding areas during this Reporting Period. • Two of the weed species were detected for the first time on Barrow Island—an individual seedling of Wild Radish (*R. raphanistrum*), and a single seedling of Mediterranean Turnip (*B. tournefortii*). Both seedlings were removed and the species were not detected again during the Reporting Period. • The remaining species have been recorded on Barrow Island previously. Of these, Bulrush, Capeweed, and Kapok Bush have been found in new locations. Bulrush and Capeweed were successfully remediated following each detection. The first-response phase is continuing for the Kapok Bush, with seedlings subsequently detected and controlled during the Reporting Period. No detections were considered proliferation events.
Conclusion:	• No introduction or proliferation of weed species that can be attributed to the Gorgon Gas Development were recorded during the Reporting Period.

Surveillance Program: Invertebrate NIS	
Objective:	• Detect the presence and/or proliferation of invertebrate NIS on Barrow Island attributable to Gorgon Gas Development activities.
Methodology:	• Surveillance effort focused on identified risk localities, using multiple Surveillance System Components (SSC). • The SSC in use for the Reporting Period were: pitfall traps, baited traps, biologist structured and unstructured surveys, window traps, vacuuming shrubs, litter extraction, wood baits, visual inspection of wood, and workforce observations/reporting.
Results: **2015–2020**	• Fourteen NIS invertebrate species were detected during the Reporting Period—Indian House Cricket (*Gryllodes sigillatus*), Jumping Spider (*Menemerus nigli*), Bronzed Field Beetle (*Adelium brevicorne*), Longicorn Beetle (*Coleocoptus senior*), Spitting Spider (*Scytodes thoracica*), Blister Beetle (*Palaestra sp.A*), Cupboard Spider (*Steatoda grossa*), Australian Eucalyptus Longhorn (*Phoracantha semipunctata*), Sand Grasshopper (*Urnisa guttulosa*), Green Stink Bug (*Plautia affinis*), and Seed Bug (*Udeocoris scudderi*); caterpillars of the White Cedar Moth (*Leptocneria reducta*), Indian Meal Moth (*Plodia interpunctella*), and Cigarette Beetle (*Lasioderma serricorne*)). • The Cigarette Beetle was recorded on Barrow Island before the Gorgon Gas Development commenced. Although the known populations of Cigarette Beetle were controlled successfully, a pest control program for this beetle remains in place as a safeguard. • The Indian House Cricket remains the subject of an ongoing first response. The outcome of this response will be reported in the next EPR. • Confirmation of identification of the jumping spider (*M. nigli*) was obtained during this Reporting Period. This species was first detected on Barrow Island in October 2011. A first response, including delineation surveillance, for this species has commenced and is ongoing. The outcome of these surveys will be reported in the next EPR.

Surveillance Program: Invertebrate NIS	
	• All other NIS detections were remediated as part of the first response and no NIS survived past the response. • Identification of some specimens from the 2019–2020 surveillance are still pending and any NIS detections will be included in the next EPR.
Conclusion:	• No non-indigenous invertebrate species became established on Barrow Island during this Reporting Period.

Surveillance Program: Vertebrate NIS	
Objective:	• Detect the presence and/or proliferation of vertebrate NIS on Barrow Island attributable to Gorgon Gas Development activities.
Methodology: 2015–2020	• Surveillance effort focused on identified risk localities, using several SSC. • The SSC in use for the Reporting Period were: cage traps, biologist unstructured surveys, biologist structured surveys (night, day, and wet areas), hair traps, chew cards, remote camera, Elliot traps, barrier pitfall traps, barrier funnel traps, gecko scat analysis, frog attracting devices, artificial habitats, environmental acoustic recognition sensors, print acquisition for wildlife sensors, and workforce observations/reporting.
Results:	• Three NIS vertebrate species were detected during this Reporting Period—Western Marbled Gecko (*Christinus marmoratus*), Asian House Gecko (*Hemidactylus frenatus*), and Buchanan's Snake-eyed Skink (*Cryptoblepharus buchanani*)). • All NIS detections were remediated as part of the first response and no NIS survived past this response.
Conclusion:	• No non-indigenous vertebrate species became established on Barrow Island during this Reporting Period.

Surveillance Program: Marine Pests	
Objective:	• Detect the presence of marine pests that might have occurred as a result of Gorgon Gas Development activities.
Methodology: 2015–2020	• The Marine Pest Surveillance Program conducted at Barrow Island during the Reporting Period included: – intertidal surveillance, using visual surveillance transects – visual examination of settlement arrays – analysis of environmental deoxyribonucleic acid (eDNA) from additional settlement arrays and water samples. DNA present on settlement arrays and in water samples is analysed using next-generation sequencing methodology, or real-time polymerase chain reaction testing, and these are compared against a reference database of targeted marine pests – observational surveillance around mainland Gorgon Gas Development supply ports at Dampier Supply Base and southern King Bay, using visual surveillance transects, settlement plates, and sediment sampling, and at Henderson material offloading facility, using settlement plates and/or snorkelling transects – Subtidal surveillance around Barrow Island using a remotely operated vehicle (ROV), epibenthic sled tow, and sediment grab • Surveillance and sampling locations focused on high-risk localities around operational areas. • Note: Due to the reduced risk of marine pest introduction, as a result of transition to operations (and associated reduction in construction-related vessel traffic), the marine pest surveillance program was modified in January 2016, January 2017, and again in December 2019. The 2016 modifications included changing the frequency of intertidal and subtidal surveillance and removing observational surveillance around the mainland Gorgon Gas Development supply ports. In January 2017, there was a transition towards sampling high-risk sites, and using advances in genetic testing for

Surveillance Program: Marine Pests	
	processing the material collected on settlement plates and in water samples. In 2019, there was an increase in focus on higher-risk localities in Barrow Island waters.
Results:	• *Didemnum perlucidum* has been recorded in Barrow Island waters since 2012 and it is considered likely that this species was present before the Gorgon Gas Development commenced. The detection of *D. perlucidum* during the 2015–2016 Reporting Period is not considered attributable to Gorgon Gas Development activities. • No marine pest species were detected during this Reporting Period in Barrow Island waters or around the mainland supply ports used for Gorgon Gas Development activities. • Identification of some specimens from this Reporting Period are still pending and any invasive marine pest detections will be included in the next EPR.
Conclusion:	• No introduction of marine pests that can be attributed to Gorgon Gas Development activities was recorded during the Reporting Period.

3.3 Event Data

The quarantine detections recorded during the Reporting Period are summarised in the following table.

Event Data: Quarantine Detections	
Reporting requirement:	• Detected introduction(s) of NIS and marine pest species, procedure breaches, and 'near misses', with special reference to weeds.
Results:	• During the Reporting Period, no Quarantine Introductions (including for marine pest species and weeds) were recorded. • During the Reporting Period, 45 Level 1 Quarantine Incidents, four Level 2 Quarantine Incidents, two Level 3 Quarantine Incidents, 643 Quarantine Near Misses, 184 Level 1 Quarantine Intercepts, two Level 2 Quarantine Intercepts, seven Level 3 Quarantine Intercepts, and 41 Quarantine Procedural Breaches were recorded (see Section 13 for quarantine detection terminology). • Two Level 3 Quarantine Incidents were recorded during the Reporting Period: – One was associated with NIS vertebrates. An Asian House Gecko (*H. frenatus*) was detected by the workforce during the discharge of a vessel on 8 September 2018. – There was one Level 3 Quarantine Incident associated with NIS weeds. A mature Kapok Bush (*A. javanica*) was detected during weed surveillance activities along Terminal Creek Road on 10 August 2016. • Four Level 2 Quarantine Incidents were recorded during the Reporting Period. Of these, two were associated with NIS invertebrates—alive and dead Indian House Crickets *(G. sigillatus)* were detected by the workforce during cyclone preparations at the GTP on 5 January 2020 and a separate detection of Indian House Crickets occurred within the accommodation facilities on 11 April 2020. The other two were associated with NIS vertebrates—a Western Marbled Gecko *(Christinus marmoratus)* was captured during structured quarantine surveillance activities at Butler Park on 13 November 2015 and a Snake-eyed Skink (*Cryptoblepharus buchananii*) was detected under the day store luggage rack, within the accommodation facility on 24 August 2020. • Most of the 45 Level 1 Incidents were associated with NIS invertebrates (45%) and weeds (36%). The NIS invertebrates were mostly Jumping Spider, Cigarette Beetles, Rust-red Flour Beetles, Bronzed Field Beetles, Longicorn Beetles, Shield Bugs, Seed Bugs, Cupboard Spider, Spitting Spider, Indian House Cricket, and Indian Meal Moth. The commonly found weeds species included Sow Thistle (*S. oleraceus*), Capeweed *(Arctotheca calendula)*, and Bulrush (*Typha* sp.). • There were two Level 3 Quarantine Intercepts associated with NIS vertebrates—one involved a rodent *(Rattus rattus)* that was sighted by vessel crew on the *BBC Brisbane* while it was berthed at the heavy lifting facility on 18 February 2016, and the other an Asian house gecko *(Hemidactylus frenatus)* detected inside a container during discharge on 29 May 2016.

Event Data: Quarantine Detections	
	• There were five Level 3 Quarantine Intercepts associated with NIS seeds—two Buffel Grass *(Cenchrus ciliaris),* and one each of Natal Grass *(Melinis* sp.*)*, Birdwood Grass *(Cenchrus setiger*), and Kapok Bush *(Aerva javanica).* • There were two Level 2 Intercepts, both associated with NIS invertebrates—one involved a Round Green Hister Beetle (*Spercheus cyaneaus*) detected on the upper deck of LNG tanker *Maran Gas Amphipolis* during a quarantine inspection on 13 November 2016; the other a Hide Beetle *(Dermestes frischii)* detected on top of a module on 26 November 2015. • Most intercepts were Level 1 Quarantine Intercepts and associated with NIS invertebrates (50%) and seed material (43%). These included, but were not limited to: – mostly Seed Bugs, Shield Bugs, Assassin Bugs, Cigarette Beetles, Rice Bugs, Weevils, Merchant Grain Beetle, Rove Beetles, Rust-red Flour Beetle, Drugstore Beetle, Ladybirds and cutworms – seeds of commonly found weed species, including African Fountain Grass (*Pennisetum setaceum*)*,* Sow Thistle (*S. oleraceus*), Tall Fleabane (*Conyza* sp.), and Bulrush (*Typha* sp.) • Most Quarantine Near Misses were associated with parachute seed material (62%) and NIS invertebrates (22%), including stored product pests, such as moths and beetles.
Conclusions:	• A quarantine first-response plan remains in place following the January 2020 detection of the Indian House Cricket *(Gryllodes sigillatus).* • A quarantine first-response plan and delineation surveillance program are underway in response to the Jumping Spider *(Menemerus nigli).* • A quarantine first-response plan remains in place for the Kapok Bush *(Aerva javanica)* until CAPL is confident no residual seed banks remain. • Outcomes of the above responses will be reported in the next EPR. • All other Quarantine Responses were successfully completed, with no further NIS detected. • A pest control program remained in place as a follow-up to the 2018 detection of the Cigarette Beetle *(Lasioderma serricorne).* • Following the Quarantine Incidents, Near Misses, and Procedural Breaches recorded, actions were taken to reinforce quarantine training, procedures, and Gorgon Gas Development requirements.

3.4 Changes to the Quarantine Management System

The Terrestrial and Marine QMS (Ref. 5) was revised once during the Reporting Period.

As an outcome of the Five-year EPR (August 2010–August 2015; Ref. 6) and commissioning, start-up, and operation of the Gorgon Gas Development, the QMS was updated between 2016 and 2017.

The document was transferred to the Gorgon Operations Environmental Management Plan (EMP) template and allocated a new document number (GOR-COP-01854), and was issued as Revision 1.0 once approved.

The key changes made in this revision included:

- adding commissioning, start-up, and operations activities and risks
- updating quarantine management measures
- updating detection, management, and control measures for NIS and marine pests.

Revision 1.0 of the QMS (Ref. 5) was approved by the OEPA in May 2017 and the Commonwealth Department of the Environment and Energy (DotEE) in July 2017.

The Weed Hygiene Common User Procedure (Ref. 28) was not revised during the Reporting Period.

3.5 Studies

No QMS-related studies were carried out during the Reporting Period.

3.6 Five-year Overview of Environmental Performance

The 2015–2020 outcome for terrestrial and marine quarantine is summarised in the table below.

Objectives[1]	Outcome
Ensure that there is no introduction or proliferation of Non-indigenous Terrestrial Species and Marine Pests to Barrow Island or the waters surrounding Barrow Island, as a consequence of the Proposal	The terrestrial NIS and marine pest surveillance programs, and the audit and inspection schedule, as per the requirements of the approved Terrestrial and Marine QMS (Ref. 5) throughout the five-year Reporting Period did not detect any confirmed introduction of Non-indigenous Terrestrial Species and Marine Pests to Barrow Island or the waters surrounding Barrow Island. Although there were several quarantine procedural deviations, intercepts, and incidents, no introductions of terrestrial NIS or marine pests, or proliferations of existing weeds or new weed establishment, to Barrow Island or the waters surrounding Barrow Island, were recorded during the Reporting Period. A quarantine first-response plan remains in place following the January 2020 detection of the Indian House Cricket *(Gryllodes sigillatus).* A quarantine first-response plan and delineation surveillance program are underway in response to the Jumping Spider *(Menemerus nigli)* A quarantine first-response plan remains in place for the Kapok Bush *(Aerva javanica)* until CAPL is confident no residual seed banks remain. Outcomes of the above responses will be reported in the next EPR
Prevent the introduction of Non-indigenous Terrestrial Species and Marine Pests	
Detect Non-indigenous Terrestrial Species (including weed introduction and/or proliferation) and Marine Pests	
Control and, unless otherwise determined by the Minister, eradicate detected Non-indigenous Terrestrial Species (including weeds) and Marine Pests	These objectives do not apply to this Reporting Period (as no introductions were recorded during the Reporting Period).
Mitigate adverse impacts of any control and eradication actions on indigenous species taken against detected Non-Indigenous Terrestrial Species (including weeds) and Marine Pests.	

1 *As defined in Condition 10.3 of MS 800, and Condition 8.3 of EPBC 2003/1294 and 2008/4178.*

3.7 Proposed Environmental Management Improvements

No management improvements related to the Terrestrial and Marine QMS (Ref. 5) are proposed as part of this Five-year EPR.

4 Marine Turtles

Table 4-1: EPR Reporting Requirements for Marine Turtles

Item	Source	Section in this EPR
Results of all marine turtle monitoring carried out by the Proponent, including any detected changes to the Flatback Turtle population	MS 800, Schedule 3(3i) EPBC 2003/1294 and 2008/4178, Schedule 3(3i)	4.1, 4.6
Reportable incidents involving harm to marine turtles	MS 800, Schedule 3(3ii) EPBC 2003/1294 and 2008/4178, Schedule 3(3ii)	4.3
Changes to the marine turtle monitoring program	MS 800, Schedule 3(3iii) EPBC 2003/1294 and 2008/4178, Schedule 3(3iii)	4.1
Conclusions about the status of Flatback and other marine turtle populations on Barrow Island	MS 800, Schedule 3(3iv) EPBC 2003/1294 and 2008/4178, Schedule 3(3iv)	4.1, 4.6
Changes (if any) to the Long-term Marine Turtle Management Plan	MS 800, Schedule 3(3v) EPBC 2003/1294 and 2008/4178, Schedule 3(3v)	4.5
Findings of the annual audit and review on the effectiveness of lighting design features, management measures, and operating controls including details of light management initiatives and activities undertaken during the year	MS 800, Schedule 3(3vi) EPBC 2003/1294 and 2008/4178, Schedule 3(3vi)	4.4
Results of studies undertaken	MS 800, Schedule 3(3vii) EPBC 2003/1294 and 2008/4178, Schedule 3(3vii)	4.2
Noise monitoring results and a discussion on the success (or otherwise) in meeting noise emission targets	MS 800, Schedule 3(3viii) EPBC 2003/1294 and 2008/4178, Schedule 3(3viii)	N/A[1]
A five-year overview of environmental performance	MS 800, Condition 5.3(iii) EPBC 2003/1294 and 2008/4178, Condition 4.2(iii)	4.7
Proposed environmental management improvements	MS 800, Condition 5.3(iv) EPBC 2003/1294 and 2008/4178, Condition 4.2(iv)	4.8
A review of whether there are any reasonably practicable management measures, operating controls or design features that can be implemented to reduce or eliminate the alteration of the light horizon on the east coast beaches of Barrow Island as a result of the implementation of the Proposal	MS 800, Condition 5.3(v) EPBC 2003/1294 and 2008/4178, Condition 4.2(v)	4.4

1 *No specific noise emission targets for the Gorgon Gas Development apply to environmental receptors; noise monitoring is considered in relation to monitoring results for the Flatback Turtle population. As reported in the Five-year EPR (Ref. 6): 'Given the results to date, the difficulty in detecting any onshore noise or vibration effects from Gorgon Gas Development activities on the beaches, and endorsement from the Marine Turtle Expert Panel (and subsequent regulatory approval), the noise and vibration monitoring program was suspended after the 2011–2012 season.' Therefore, reporting for this item is not applicable.*

4.1 Monitoring Results

An objective of the Long-term Marine Turtle Management Plan (LTMTMP) (Ref. 7), as defined by Ministerial conditions, is to establish a statistically valid monitoring program to measure and detect changes to the Flatback Turtle population on Barrow Island.

Key demographic parameters have been identified as necessary for understanding the population dynamics and population viability of the Flatback Turtle rookery on Barrow Island. A mainland Reference site (Mundabullangana [MDA]) has also been established. Where relevant, data related to these key parameters are also captured at MDA for comparison with the Barrow Island Flatback Turtle data (Ref. 7).

Changes in key demographic parameters are measured using time-series control charts. Trends identified in control charts act as early-warning signals to guide a tiered management approach. A management response is triggered if a demographic parameter demonstrates a trend towards, or changes beyond statistical deviations (±1, ±2, or ±3 SD, standard error [SE], or median absolute deviation [MAD]) from baseline conditions (Ref. 7).

The 2015–2020 results for the monitoring programs listed in the LTMTMP, including any changes detected to the Barrow Island Flatback Turtle population, are summarised in the following tables.

Monitoring Program: Flatback Turtle Abundance and Distribution	
Objective:	• To measure and detect changes to the abundance, distribution, and nesting behaviour of adult Flatback Turtles.
Methodology:	• Capture-recapture sampling of nesting adult female Flatback Turtles to estimate these demographic parameters: – adult female survival probability – adult female breeding omission probability – annual nester abundance – nesting activity (spatial and temporal distribution) – clutch frequency – internesting interval. • Only key demographic parameters are control-charted; these include adult female survival probability, adult female breeding omission probability, annual nester abundance, and clutch frequency. • Variation in modelled estimates can occur when models are re-run each year with additional data. Consequently, minor variations from year to year might occur in control-charted parameter estimates presented in this EPR.
Changes to Program:	• The amended LTMTMP (Ref. 7), which was approved in July 2018 (see Section 4.5), does not include the requirement to monitor the remigration interval, growth rate, and tag loss for the female Flatback Turtle population at Barrow Island and MDA. • No other changes were made to the Flatback Turtle Abundance and Distribution Monitoring Program during the Reporting Period.
Results: (Ref. 43; Ref. 42; Ref. 21; Ref. 22; Ref. 34)	*Adult Female Survival Probability* • The estimated annual survival probability for nesting Flatback Turtles on Barrow Island ranged from 0.92 (2015–2016 Reporting Period) to 0.94 (2019–2020 Reporting Period), which was comparable with the Reference location (MDA), which ranged from 0.90 (2015–2016 Reporting Period) to 0.95 (2019–2020 Reporting Period). The survival probability was consistently high during the construction period (2010–2011 Reporting Period to 2016-2017 Reporting Period), indicating a stable and demographically healthy population (Figure 4-1).

Monitoring Program: Flatback Turtle Abundance and Distribution

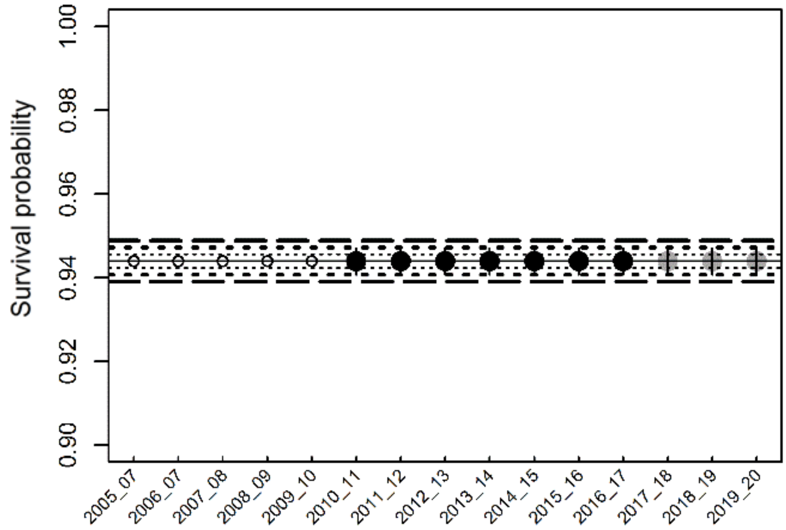


Figure 4-1: Control Chart for Adult Female Flatback Turtle Survival Probability at Barrow Island[1]

Adult Female Breeding Omission Probability

- Adult female breeding omission probability at Barrow Island ranged from 0.81 (95% CI: 0.78–0.83) during the 2015–2016 Reporting Period to ~0.84 (95% CI: 0.82–0.86) during the 2018–2019 Reporting Period, before decreasing to 0.77 (95% CI: 0.75–0.79) during the 2019–2020 Reporting Period. The breeding omission probability at MDA during the 2019–2020 Reporting Period was 0.36 (95% CI: 0.29–0.44), indicating that there was a lower probability of a turtle skipping a nesting season at MDA (if the turtle nested the previous season) compared to Barrow Island.
- The breeding omission probability at Barrow Island recorded management trigger limit exceedances ranging from +1 SD to +3 SD during the 2015–2020 Reporting Period (Figure 4-2).

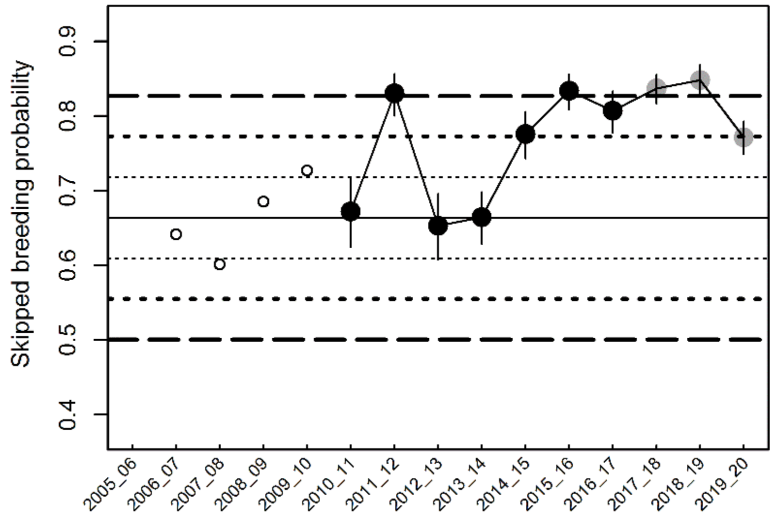


Figure 4-2: Control Chart for Adult Female Flatback Turtle Breeding Omission Probability at Barrow Island[1]

Annual Nester Abundance

- Annual nester abundance at Barrow Island increased from 1,847 during the 2015–2016 Reporting Period to 1,943 turtles during the 2019–2020 Reporting Period, a +3MDA cotrol limit exceedence (Figure 4-3). By comparison, MDA decreased from

Monitoring Program: Flatback Turtle Abundance and Distribution

2,103 during the 2015–2016 Reporting Period to 1,121 turtles during the 2019–2020 Reporting Period.

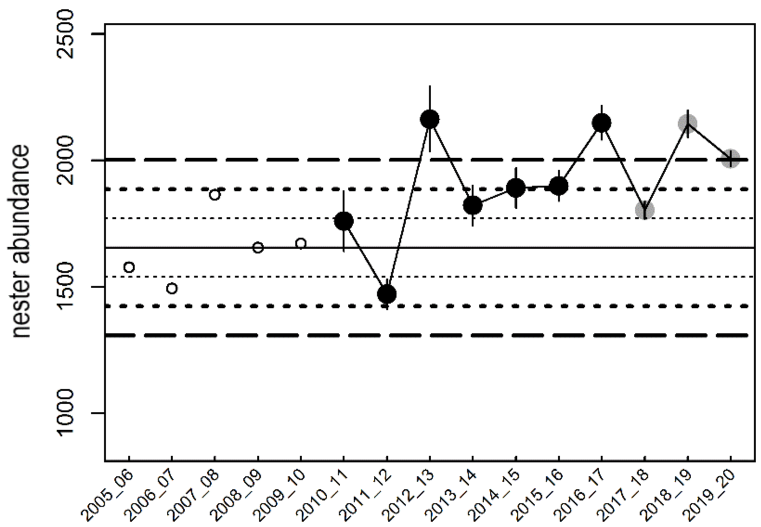


Figure 4-3: Control Chart for Adult Female Flatback Turtle Nester Abundance at Barrow Island[1]

- Population size modelling using a capture-mark-recapture multi-state open robust design (MSORD) model estimated an annual nester abundance of 2,006 female turtles at Barrow Island (a +3 MAD exceedance) and 1,931 female turtles at MDA during the 2019–2020 Reporting Period (Figure 4-4). The abundance estimates at Barrow Island and MDA followed a different trend, with Barrow Island abundance decreasing and MDA abundance increasing when compared to the previous season.

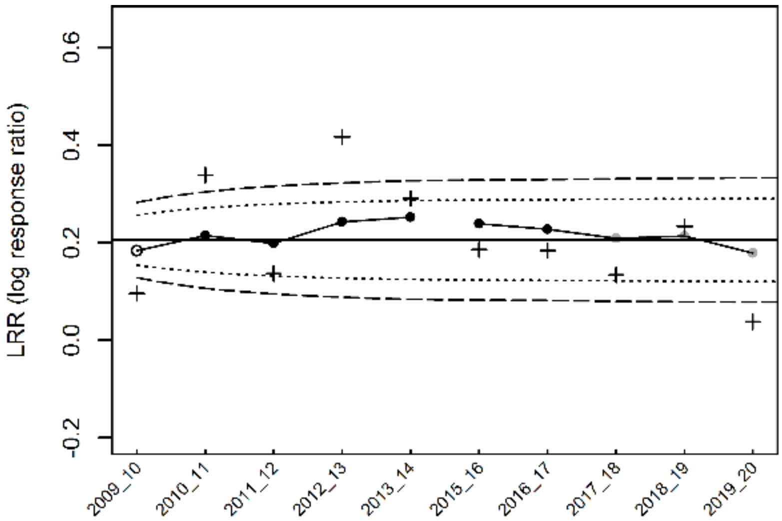


Figure 4-4: Control Chart for Adult Female Flatback Turtle Nester Abundance at Barrow Island: Difference between At Risk and Reference Sites[2]

Clutch Frequency

- The estimated clutch frequency at Barrow Island ranged from 3.7 clutches per female per season during the 2015-2016 Reporting Period to 3.4 clutches per female per season during the 2019–2020 Reporting Period, compared to MDA which was 3.7 clutches per female per season during the 2019–2020 Reporting Period. The +1 SD alert trigger was exceeded during the 2018–2019 Reporting Period (Figure 4-5).

Monitoring Program: Flatback Turtle Abundance and Distribution

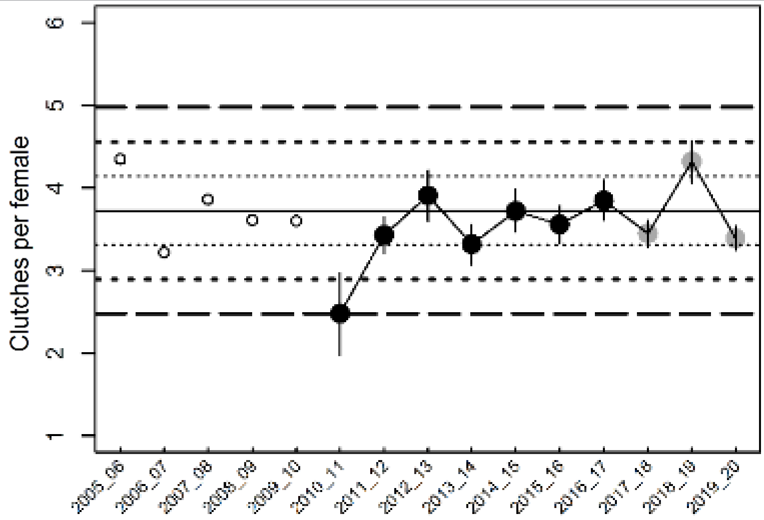


Figure 4-5: Control Chart for Adult Female Flatback Turtle Clutch Frequency at Barrow Island[1]

Internesting Interval

- The mean internesting interval for Flatback Turtles ranged from 14.8 ± 1.9 days during the 2015–2016 Reporting Period to 13.2 ± 2.3 days during the 2019–2020 Reporting Period at Barrow Island, and from 13.7 ± 4.3 days during the 2015–2016 Reporting Period to 13.8 ± 4.2 days during the 2019–2020 Reporting Period at MDA.

Nesting Activity (spatial and temporal distribution)

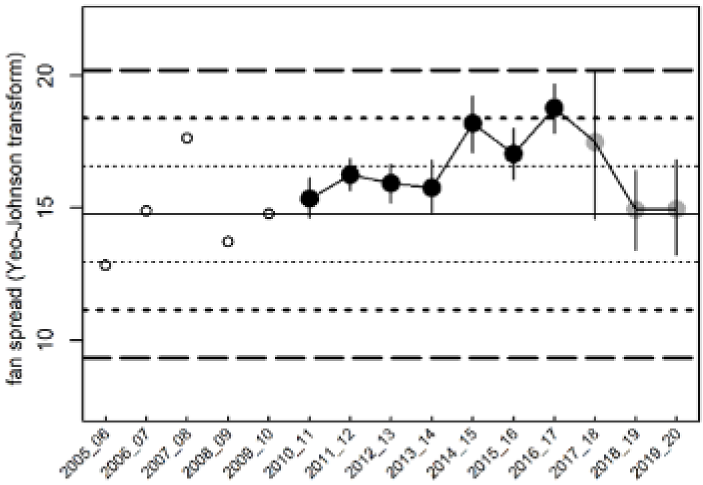
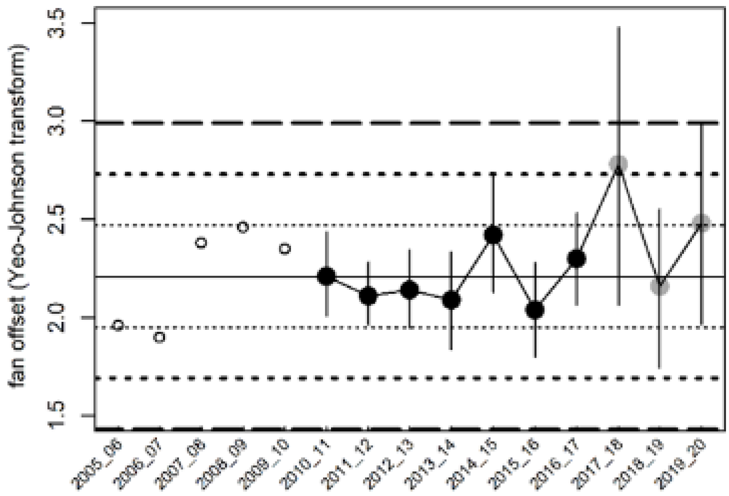
- During the 2019–2020 Reporting Period, Mushroom Beach recorded the highest ever percentage of sightings (34.7%) and individual turtles (32.4%) at an individual beach since monitoring began. By comparison, Bivalve Beach recorded the lowest ever percentage of turtle sightings (5.0%) and individuals (6.8%) at an individual beach since monitoring began. The 2019–2020 Reporting Period was the fourth consecutive season that Bivalve Beach has recorded the lowest percentage of turtle sightings and individuals.
- Nesting Flatback Turtles demonstrated a strong fidelity to the beach where they were first sighted. The beaches with the strongest fidelity were north of the causeway/Materials Offloading Facility (MOF) (Terminal Beach = 66.4% and Mushroom Beach = 78.3%). Bivalve Beach had the lowest fidelity of any long-term monitored beach (50.4%), closely followed by Inga Beach (50.6%). When turtles did move away from a beach, they were most frequently sighted on adjacent beaches.

1 *Open dots = baseline estimate derived from empirical data, black dots = construction parameter estimate, grey dots = operations parameter estimate, solid horizontal line = long-term expected estimate derived from baseline estimates (mean or median), dotted lines = ±1 SE (or 1 MAD for annual nester abundance), small dashed lines = ±2 SE (or 2 MAD), long dashed lines = ±3 SE (or 3 MAD). Error bars indicate 95% CI.*

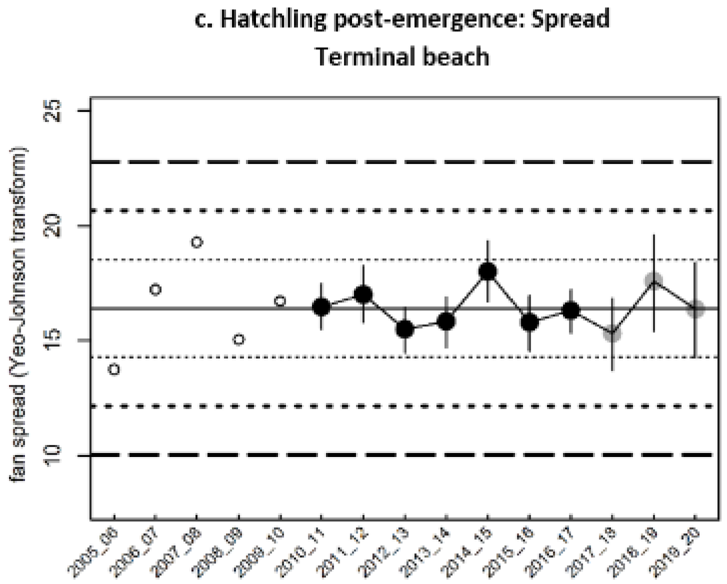
2 *EWMA chart based on an exponentially weighted 3-year moving average. Open dot = smoothed log response ratio (LRR) in baseline; black dots = smoothed LRR in construction; grey dots = smoothed LRR in operations; crosses = unsmoothed LRR. Positive values show an effect that is higher at the At Risk site compared to the Reference site, and vice versa. The solid horizontal centreline is the estimated average true LRR effect. Dotted curves = ±1 SD at each year for the smoothed metric, and dot-dashed curves = ±2 SD.* ***Note****: There was no annual abundance estimate for MDA in 2014–2015 due to the limited sampling in that season.*

Monitoring Program: Hatchling Orientation	
Objectives:	• To measure and detect variation in dispersal patterns of Flatback Turtle hatchlings following emergence from the nest.
Methodology:	• Measures of artificial light (magnitude and bearing) on marine turtle nesting beaches using specialised light-measurement cameras.

Monitoring Program: Hatchling Orientation	
	• Measures of the orientation (fan spread angle [disorientation] and fan offset angle [from most direct line to the ocean—misorientation]) of marine turtle hatchling tracks on beaches. These parameters are control-charted for Bivalve and Terminal beaches.
Changes to Program:	• No changes were made to the methodology used for measuring the orientation and fan offset angle of marine turtle hatchling tracks during the 2015-2020 Reporting Period. • Improvements in light camera technology and software were made throughout the Reporting Period. This software replaced the Sky Quality Meter and eliminated the ± 0.1 magnitude error associated with temperature effects and sensor stability. • The deployment location of the Sky42™ light monitoring cameras was revised for each monitored beach during the 2019–2020 Reporting Period. The new deployment location better represents the areas of turtle nesting activity on the beach. The updated and upgraded cameras were placed on a picket set at a height above ground level that is higher than the closest vegetation (cameras were previously placed directly on the sand). To ensure consistency in the monitoring location with future seasons, the height and location of the star picket was recorded using a real-time kinematic (RTK) GPS unit (<10 cm accuracy).
Light Results: (Ref. 43; Ref. 42; Ref. 21; Ref. 22; Ref. 34)	• Sources of night-time light emissions were similar throughout the 2015–2020 Reporting Period and included the LNG site (including the Permanent Operating Facility), ground flare, offshore infrastructure including the MOF, the LNG Jetty head (an LNG/condensate tanker was moored at the LNG Jetty head for five of the seven monitoring nights during the 2019–2020 Reporting Period), Main Camp, and Butler Park (BP). • The level of brightness at each monitoring site demonstrated a spatial relationship with the distance from the GTP; brighter values were recorded at the closest sites, while darker values were recorded at the sites furthest away. Night-time light emissions (whole-of-sky) were brightest at Bivalve Beach followed by (in order of descending magnitude) Inga, Terminal, Yacht Club North (YCN), Yacht Club South (YCS), and Mushroom beaches. • The presence of an LNG tanker moored at the LNG Jetty during each monitoring event since the 2017 Reporting Period resulted in an increase in the lighting footprint in the direction of the LNG Jetty head. The LNG Jetty head was directly visible from all monitoring sites except those at Terminal and Mushroom South beaches. • The night-time light emissions (whole-of-sky) were consistently brightest at Bivalve, Inga, and Terminal beaches throughout the 2015–2020 Reporting Period. Whole-of-sky brightness decreased at all monitoring sites compared to the 2018–2019 Reporting Period, with the biggest change at YCN (−65%) and Terminal (−49%) beaches.
Hatchling Orientation Results: (Ref. 43; Ref. 42; Ref. 21; Ref. 22; Ref. 34)	• The modelled hatchling post-emergence dispersion spread (disorientation) at Bivalve Beach fluctuated between exceeding +1 SD and +2 SD control limits (management alert triggers) from the 2015–2016 Reporting Period to the 2017–2018 Reporting Periods. The modelled hatchling post-emergence dispersion spread (disorientation) and hatchling post-emergence dispersion offset (misorientation) remained within control limits from the 2018–2019 Reporting Period onwards (Figure 4-6). • At Bivalve Beach, the modelled hatchling post-emergence dispersion offset (misorientation) exceeded the +2 SD control limit during the 2017–2018 Reporting Period for the first and only time since the start of baseline monitoring (Figure 4-6). • The modelled hatchling post-emergence dispersion offset (misorientation) at Terminal Beach exceeded the +1 SD and +2 SD control limits (management alert triggers) during the 2018–2019 and 2019–2020 Reporting Periods respectively (Figure 4-6).

Monitoring Program: Hatchling Orientation	
	a. Hatchling post-emergence: Spread **Bivalve beach**  **b. Hatchling post-emergence: Offset** **Bivalve beach** 

Monitoring Program: Hatchling Orientation



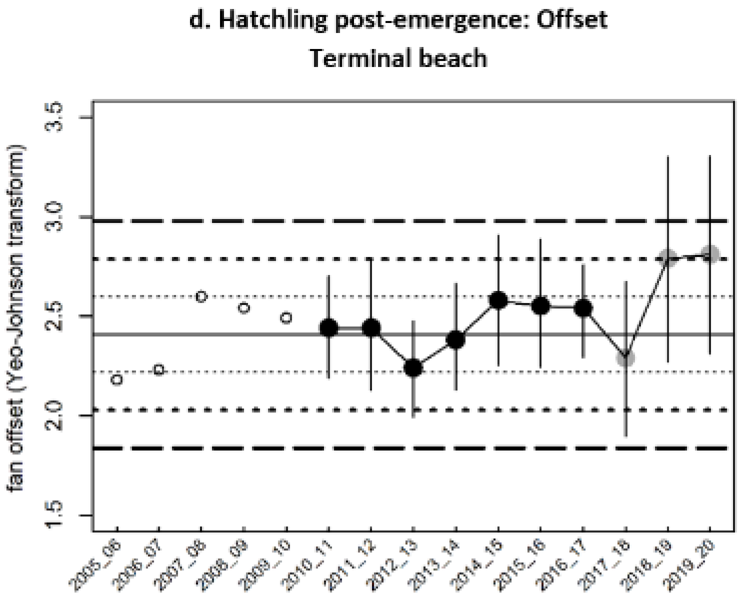


Figure 4-6: Control Charts for Hatchling Post-emergence Dispersion: Fan Spread and Offset Estimates at Terminal and Bivalve Beaches[1]

- In addition to the modelled control chart estimates for Bivalve and Terminal beaches, measures of orientation on these and other Barrow Island beaches (i.e. YCS, YCN, Inga, and Mushroom beaches) indicated:
  - that fan spread angle and offset fluctuated at all beaches over the 2015–2020 Reporting Period
  - there were significant differences in fan spread angle compared to the baseline on Bivalve and YCS beaches during the 2015–2016 Reporting Period, and on YCS, YCN, and Mushroom beaches during the 2016–2017 Reporting Period. There was no significant difference in fan spread angle on the beaches during the remaining Reporting Periods.

1 *Open dots = baseline estimate derived from empirical data, black dots = construction parameter estimate, grey dots = operations parameter estimate, solid horizontal line = long-term expected estimate derived from baseline estimates (mean or median), dotted lines = ±1 SE (or 1 MAD), small dashed lines = ±2 SE (or 2 MAD), long dashed lines = ±3 SE (or 3 MAD). Error bars indicate 95% CI.*

Monitoring Program: Flatback Turtle Incubation Success	
Objective:	• To measure and detect changes to Flatback Turtle incubation success.
Methodology:	• Monitoring marked nests to estimate these parameters: – egg hatching probability – hatchling emergence probability – incubation duration – incubation temperature – clutch fate – clutch size. • Only key demographic parameters are control-charted; these include egg hatching probability and hatchling emergence probability.
Changes to Program:	• In the 2016–2017 Reporting Period, additional analyses were applied to all locations, and involved calculating the hatch success for all marked clutches, including those clutches that were incomplete at excavation (i.e. disturbed or lost due to turtle interference or predation), and those lost to observers. Previous seasons have not included these clutches as part of the hatch success rate, and only utilised information from clutches that were complete at excavation. • From the 2017–2018 Reporting Period to the 2019-2020 Reporting Period, RTK GPS was used to record the locations of all marked nests at Inga, Bivalve, Terminal, and Mushroom beaches. This involved using a known survey point for a base station (or in the case of Mushroom Beach, a control logger marker post) to derive positions with an accuracy of <5 cm. • The amended LTMTMP (Ref. 7), which was approved in July 2018 (see Section 4.5), does not include a requirement for monitoring egg and hatchling morphometrics (size and mass) from marked Flatback Turtle nests at Barrow Island and MDA.
Results: (Ref. 43; Ref. 42; Ref. 21; Ref. 22; Ref. 34)	*Egg Hatching Probability*[3] • The egg hatching probability at Barrow Island (complete clutches), exceeded the +1 MAD control limit during the 2016–2017 Reporting Period (Figure 4-7). There were no other control limit exceedances during the 2015–2020 Reporting Period. • For complete clutches, the mean overall egg hatching probability on Barrow Island was 88.6 ± 12.0% during the 2019-2020 Reporting Period, which was similar to the 2017-2018 and 2018-2019 Reporting Periods and significantly higher compared to the baseline (Bivalve and Terminal beaches combined). Egg hatching probability was not significantly different at Inga, Bivalve, Terminal, or Mushroom beaches when compared to the 2018–2019 Reporting Period nor was it significantly different between beaches. Egg hatching probability was lowest at Mushroom Beach (86.4 ± 14.0%) and highest at Inga Beach (90.1 ± 8.7%) during the 2019–2020 Reporting Period. • Egg hatching probability measurements at MDA were not available during the 2019-2020 Reporting Period due to restricted access following impact from Tropical Cyclone Blake. Egg hatchling probability (complete clutches) at MDA was 82.1 ± 22.8% during the 2018–2019 Reporting Period which was lower than the 2015-2016 Reporting Period (86.6 ± 12.6 %), higher than the 2016-2017 Reporting Period (79.2 ± 15.3 %) and similar to the 2017-2018 Reporting Period (83.9 ± 16.5 %).

Monitoring Program: Flatback Turtle Incubation Success

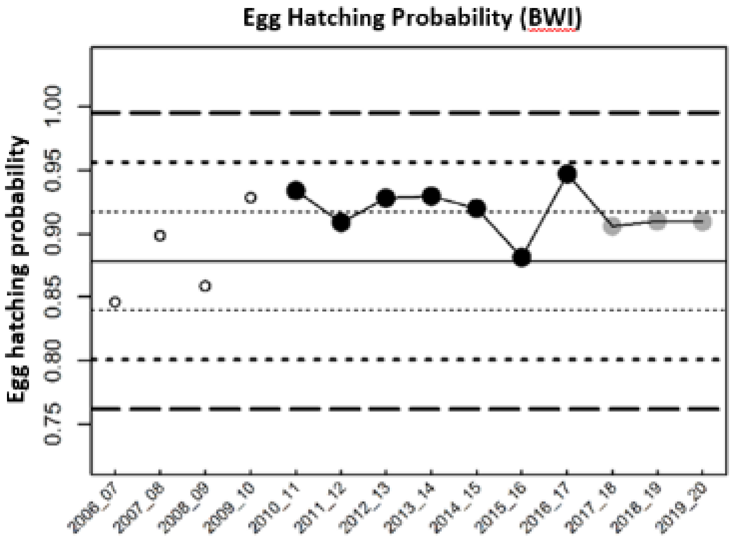


Figure 4-7: Control Chart for Egg Hatching Probability for Complete Clutches at Barrow Island (all monitored beaches [Bivalve, Terminal, Inga, and Mushroom] combined)[1, 2]

Hatchling Emergence Probability[3]

- The egg hatching emergence probability (complete clutches) at Barrow Island was 87.3 ± 13.1% during the 2019–2020 Reporting Period, which was similar to the 2018–2019 Reporting Period and significantly higher than the baseline (Bivalve and Terminal beaches combined). Hatchling emergence probability was not significantly different at Inga, Bivalve, Terminal, or Mushroom beaches when compared to the 2019–2020 Reporting Period, nor was it significantly different between beaches.
- The egg hatchling emergence probability at Barrow Island exceeded the +1 MAD control limit during the 2016–2017 Reporting Period (Figure 4-8).

  Hatching emergence probability at MDA was 81 ± 22% during the 2018–2019 Reporting Period. Hatching emergence probability was not available for the 2019-2020 Reporting Period due to restricted access following Tropical Cyclone Blake. Hatching emergence probability at MDA could also not be calculated during the 2017-2018 Reporting Period due to the advanced decomposition of dead hatchlings at the time of the excavation field survey. Hatchling emergence probability at MDA was 85.8 ± 12.3 during the 2015-2016 Reporting Period and 76.3 ± 18.0 % during the 2016-2017 Reporting Period.

Monitoring Program: Flatback Turtle Incubation Success

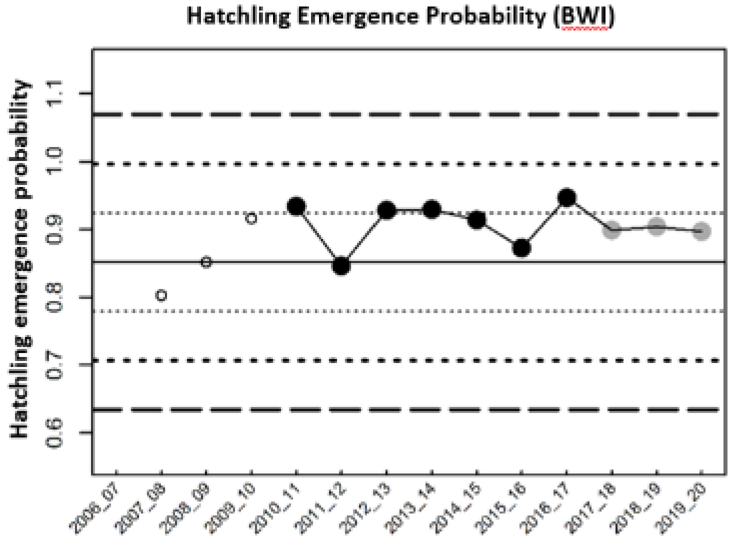


Figure 4-8: Control Chart for Hatchling Emergence Probability for Complete Clutches at Barrow Island (all monitored beaches [Bivalve, Terminal, Inga and Mushroom] combined)[1, 2]

Incubation Duration

- The mean incubation duration on Barrow Island was longest during the 2018–2019 Reporting Period at 53 ± 4 days, which was significantly longer than MDA, previous Reporting Periods, and the baseline. The mean incubation duration on Barrow Island was 47.2 ± 2.0 days during the 2019-2020 Reporting Period, which was significantly lower than the 2018-2019 Reporting Period and similar to the baseline.

Incubation Temperature

- The mean daily clutch temperature was 31.6 ± 1.6 °C at Inga Beach, 31.6 ± 1.8 °C at Bivalve Beach, 31.1 ± 1.6 °C at Terminal Beach, and 31.2 ± 1.6 °C at Mushroom Beach during the 2019–2020 Reporting Period. Mean daily clutch temperatures were significantly warmer at Bivalve and Inga beaches when compared to Terminal and Mushroom beaches. Mean daily clutch temperatures at all individual routine monitoring beaches on Barrow Island were significantly warmer compared to the 2018–2019 Reporting Period, and significantly cooler compared to the baseline (Bivalve and Terminal beaches).
- From 2015–2019 all Reporting Periods recorded significantly warmer temperatures at MDA than at all Barrow Island beaches. Incubation temperature data was not available for MDA during the 2019–2020 Reporting Period due to restricted access to the main beach following Tropical Cyclone Blake.

Clutch Fate

- Of the 89 marked clutches in the 2019–2020 Reporting Period, (Inga = 25; Bivalve = 22; Terminal = 22; and Mushroom = 20), 63 were considered complete (71%) and 26 were incomplete (29%). Of the 26 incomplete clutches, eight were disturbed/predated (31%), eight were lost (31%), six were inundated (23%), and four were mixed with another clutch (15%). All disturbance events were deemed to have occurred during the incubation period prior to hatching (as identified from temperature logger profiles).
- At MDA, marked clutches were unable to be excavated during the 2019–2020 Reporting Period due to restricted access to the main beach following Tropical Cyclone Blake.
- Of the 90 marked clutches in the 2018–2019 Reporting Period (Inga = 17; Bivalve = 26; Terminal = 27; and Mushroom = 20), 58 were considered complete (64%) and 32 were incomplete (36%). Of the 32 incomplete clutches, 24 were disturbed/predated (75%), two were lost to observers (6%), two were inundated (6%), and four were mixed with another clutch (13%). At MDA during the 2018–2019 Reporting Period, 35

Monitoring Program: Flatback Turtle Incubation Success	
	of the 36 marked clutches (97%) were complete and one was incomplete (3%; disturbed due to turtle interference/predation). *Clutch Size* • There were no significant differences in clutch sizes at Barrow Island or MDA when compared to the baseline and the 2015–2020 Reporting Periods. • Clutch sizes on Barrow Island during the 2015–2020 Reporting Period ranged from a minimum of 46.4 ± 7.7 eggs (2017–2018 Reporting Period) to a maximum of 48.2 ± 9.4 eggs (2019–2020 Reporting Period). • Clutch sizes on MDA during the 2015–2020 Reporting Period ranged from a minimum of 45.7 ± 7.9 eggs (2017–2018 Reporting Period) to a maximum of 49.7 ± 8.4 eggs (2016–2017 Reporting Period).

1 *Open dots = baseline estimate derived from empirical data, black dots = construction parameter estimate, grey dots = operations parameter estimate, solid horizontal line = long-term expected estimate derived from baseline estimates (mean or median), dotted lines = ±1 SE (or 1 MAD), small dashed lines = ±2 SE (or 2 MAD), long dashed lines = ±3 SE (or 3 MAD).*

2 *Note: The control chart estimates for 2016–2017 and 2017–2018 include the Inga Beach incubation success study data (see Section 4.2.2).*

3 *Note: Marked clutches at MDA were unable to be excavated during the 2019–2020 Reporting Period due to restricted access to the main beach, and therefore no incubation success data is available. Instead, incubation success data for MDA has been provided for the 2018–2019 Reporting Period.*

Monitoring Program: Marine Turtle Track Census	
Objectives:	• Assess Barrow Island-wide distribution of marine turtle nesting activity as indicated by species-specific track counts. • Monitor Hawksbill Turtle track abundance on selected key beaches, as indicated by track counts.
Methodology:	• Survey marine turtle track counts on beaches to collect data on species presence, nesting distribution, and abundance. Track count data are control-charted for Bivalve and Terminal beaches.
Changes to Program:	• This program was removed from the LTMTMP in 2018, and a close-out report was submitted to regulators.
Results: (Ref. 43; Ref. 42; Ref. 21; Ref. 22)	*Flatback Turtles* • Nesting activity was recorded on between 20 and 25 of the 47 beaches (43–53%) on Barrow Island during the 2017–2018 Reporting Period. • Flatback Turtle nesting activity has been documented on 37 of the 47 beaches monitored since 2008–2009, with the total number of beaches used by this species ranging annually from 19 to 26. In 2017–2018, all 20 beaches where Flatback Turtle nesting activity was observed had records of Flatback Turtle nesting activity from previous Barrow Island-wide census surveys. • The percentage of Flatback Turtle nesting activity on beaches within a 2 km radius of Gorgon Gas Development facilities (i.e. Flatback Turtle emergences on beaches within 2 km of Gorgon Gas Development facilities as a percentage of the Flatback Turtle emergences on all beaches) has not changed significantly over the last ten seasons. • The daily track count at Terminal Beach exceeded the +1 MAD control limit (management review) during the 2016–2017 Reporting Period and exceeded the +2 MAD control limit (management review) during the 2017–2018 Reporting Period. • The track count at Bivalve Beach exceeded the −2 MAD control limit (management review) during the 2016–2017 Reporting Period and exceeded the −1 MAD control limit (management review) during the 2017–2018 Reporting Period. The track count displays a declining trend since 2011–2012. *Green Turtles*

Monitoring Program: Marine Turtle Track Census	
	• Nesting activity was recorded on 24 of the 47 beaches (51%) on Barrow Island during the 2015–2016 Reporting Period, and on 32 of the 47 beaches (68%) during the 2016–2017 and 2017–2018 Reporting Periods. • Overall, Green Turtle nesting activity during the 2016–2017 and 2017–2018 Reporting Periods was significantly higher than the 2009–2010, 2014–2015, and 2015–2016 Reporting Periods, significantly lower than the 2011–2012 and 2013–2014 Reporting Periods, and similar to all other Reporting Periods. The pattern of nesting on index beaches continued to follow a long-term oscillating trend. • The percentage of Green Turtle nesting activity on beaches within a 2 km radius of Gorgon Gas Development facilities has not changed significantly over the last ten seasons. *Hawksbill Turtles* • Low levels of nesting activity were consistent for the 2015–2018 Reporting Periods, as well as all previous Reporting Periods • In 2017–2018 one track was recorded at Ant Beach South, a nesting beach within a 2 km radius of the Gorgon Gas Development facilities. Nesting activity was only previously recorded on beaches within this radius in the 2011–2012, 2013–2014, and 2016–2017 (four tracks) seasons.

Monitoring Program: Flatback Turtle Satellite Tracking	
Objectives:	• Identify the spatial behaviour of adult female Flatback Turtles using satellite telemetry and geographic information system data/software. • Record time-depth behaviour for adult female Flatback Turtles. • Assist with identifying and delineating internesting habitat.
Methodology:	• GPS tracking units were attached to adult female Flatback Turtles to collect data on internesting and time-depth behaviour.
Changes to Program:	• Nesting Flatback Turtles were fitted with GPS tracking units for the first time at MDA in the 2015–2016 Reporting Period. • This program was removed from the LTMTMP in 2018, and a close-out report was submitted to regulators.
Results: (Ref. 43; Ref. 42; Ref. 21; Ref. 22)	*Barrow Island* • Movement patterns and distribution were consistent throughout the 2015–2018 Reporting Periods, with tracked turtles either remaining within the nearshore area of Barrow Island (<10 km) or moving to an area close to the WA mainland. • The tracked turtles spent time within an area ~2 km south of the end of the LNG Jetty during the 2017–2018 Reporting Period. One turtle spent 32.1% of its time within the boundary of the LNG Jetty dredged area, with this use of the area consistent with activity recorded during some previous seasons (notably 2010–2011, 2014–2015, and 2016–2017). Overall, the tracked turtles consistently spent most of their time within areas >1 km away from the end of the LNG Jetty each Reporting Period. *Mundabullangana* • During 2015 and 2016, two turtles (M1 and M3) migrated in a north-east direction from MDA towards the Kimberley region, while the other two tracked turtles (M2 and M4) almost immediately undertook movements consistent with a foraging behavioural state. The mean bathymetric depth for turtles M1 and M3 when migrating was 23.2 ± 11.3 m (range = 2–47, n = 103, M1) and 15.5 ± 10.6 m (range = 0–56, n = 81, M3). • The foraging areas used by turtles M1, M3, and M4 overlapped with areas used by post-nesting Flatback Turtles previously tracked from Barrow Island. • No MDA-specific turtles were tagged during the 2017–2018 Reporting Period.

Monitoring Program: Beach Sand Temperature	
Objectives:	• Record data on sand temperature at nest depth for various Flatback Turtle nesting beaches. • Use these data to facilitate monitoring of short- and long-term construction and operational impacts of the Gorgon Gas Development on the marine turtle populations of Barrow Island.
Methodology:	• Monitoring beach sand temperature at nest depth (50 cm) for selected Flatback Turtle nesting beaches on Barrow Island, and at MDA, using temperature data loggers.
Changes to Program:	• This program was removed from the LTMTMP in 2018, and a close-out report was submitted to regulators.
Results: (Ref. 43; Ref. 42; Ref. 21; Ref. 22)	• Daily mean sand temperature at Barrow Island during the 2015–2016 Flatback Turtle nesting season was 31.8 ± 1.2 °C, similar to the previous two seasons and significantly warmer than baseline seasons. The daily mean sand temperature at Barrow Island was highly correlated with daily maximum air temperature ($r^2 = 0.892$). However, in 2017–2018 the correlation was only moderate ($r^2 = 0.465$). • Daily mean sand temperature at Barrow Island during the 2016–2017 Flatback Turtle nesting/hatching season (November–April) was 31.7 ± 1.3 °C. The temperature was significantly cooler than the previous two seasons and significantly warmer than baseline seasons. • Daily mean sand temperature at Barrow Island during the 2017–2018 Flatback Turtle nesting/hatching season (November to April) was 32.0 ± 1.3 °C. The temperature was significantly warmer than in the 2016–2017 season and the baseline.

Monitoring Program: Strandings	
Objectives:	• Routinely inspect and report on beach strandings of marine fauna (turtles) on east coast beaches on Barrow Island, and maintain data in a strandings database. • Use these data to facilitate monitoring of short- and long-term construction and operational impacts of the Gorgon Gas Development on the marine turtle populations of Barrow Island.
Methodology:	• Record data on beach strandings of marine turtles during the Flatback Turtle Tagging Program.
Changes to Program:	• This program was removed from the LTMTMP in 2018.
Results: (Ref. 43; Ref. 42; Ref. 21; Ref. 22)	• All events recorded during the 2015–2018 Reporting Periods were entered into the CAPL Wildlife Database. • Reportable incidents recorded during the Reporting Period are listed in Section 4.3. No evidence from the strandings data indicate that activities associated with the Gorgon Gas Development adversely affected the marine turtle populations of Barrow Island during the Reporting Period.

4.2 Studies

4.2.1 Flatback Turtle Abundance and Distribution – Additional Beaches

A pilot study was initiated during the 2016–2017 Reporting Period to provide information on the abundance and distribution of nesting adult Flatback Turtles on two nesting beaches (A07 and Junction), which were not routinely monitored during the Flatback Turtle Abundance and Distribution Monitoring Program. The study was expanded to cover the full nesting season during the 2017–2018 Reporting Period to better understand the spatial and temporal variation in nesting beach usage and beach fidelity for those turtles encountered at A07, Junction, and Camp beaches. The study was continued during the 2018–2019 and 2019–2020 Reporting Periods, however Camp Beach was discontinued due to logistical reasons and the small number of turtles encountered.

During the 2016–2017 Reporting Period an additional 108 new turtles were tagged across both beaches, and 240 remigrant turtles were encountered. These turtles showed a strong fidelity to both these beaches; 72.9% of turtles sighted at least once on A07 Beach were sighted again on both beaches, and 80.9% of turtles sighted at least once on Junction Beach were sighted again on both beaches (Ref. 21).

During the 2017–2018 Reporting Period, 611 turtles were encountered at the three beaches (74% remigrant and 26% new turtles). These turtles generally showed a strong fidelity to the three beaches, with 83.4%, 82.4%, and 55.3% of the turtles sighted at least once on A07, Junction, and Camp beaches, respectively, being sighted again on one of these same three beaches (Ref. 22).

During the 2018–2019 Reporting Period, 597 Flatback Turtles (78% remigrant and 22% new) were encountered at A07 and Junction beaches. These turtles continued to show a strong fidelity to the two beaches, with 87.0% and 86.1% of the turtles sighted at least once on A07 and Junction beaches, respectively, and then sighted again on one of these same two beaches during the 2018–2019 Reporting Period (Ref. 34).

During the 2019–2020 Reporting Period, 612 Flatback Turtles (87% remigrant and 13% new) were encountered at A07 and Junction beaches. For turtles sighted at least once at A07 beach, 54.4% of their sightings during the entire season were recorded at A07 beach which was lower than the 2018–2019 Reporting Period (58.6%). For turtles sighted at least once on Junction Beach, 65.3% of all of their sightings during the entire season were recorded at Junction Beach, which was similar to the 2018–2019 Reporting Period (65.5%) (Ref. 43).

The remigrant turtles sighted at least once at A07/Junction beaches in the 2019–2020 Reporting Period show an increasing trend in their use of YCS/YCN beaches. Their use of the beaches north of the MOF/Causeway also show a reduction, with the combined percentage of sightings of the A07/Junction turtles at Terminal and Mushroom beaches lower during each season since construction began (with the exception of the 2010-2011 Reporting Period) (Ref. 43).

4.2.2 Incubation Success – Additional Beaches

During the 2016–2017 Reporting Period, a study was conducted to determine incubation success for the first time on Inga Beach. This study was initiated primarily in response to analyses of nesting data, which suggest that, like Terminal and Bivalve beaches, the distribution of Flatback Turtle nesting activity on Inga Beach had also shifted further towards the direction of the MOF.

To better understand the hatch/emergence success and incubation environment of Flatback Turtles clutches on A07, Junction, Camp, YCS, and YCN beaches, CAPL initiated a study using the same methodology as the routine Incubation Success Program. Both studies continued through the final two years of the 2015–2020 Reporting Period.

Of the 15 clutches marked during the 2016–2017 Reporting Period, three were found to be incomplete (two were disturbed by other nesting turtles or natural predation and one was inundated). For complete clutches (n=12), hatch (85.6 ± 20.2%) and hatchling emergence (84.4 ± 20.9%) success, clutch size

(48.8 ± 9.4 eggs) and egg size and weight, on Inga Beach were similar to that recorded for beaches routinely monitored for the Flatback Turtle Incubation Success Program; however, the incubation period was shorter (45.5 ± 1.9 days) than marked clutches on other monitored beaches. This corresponded with significantly warmer clutch temperatures (31.8 ± 1.3 °C) when compared to Terminal and Bivalve beaches (Ref. 21).

Of the 83 clutches marked during the 2017–2018 Reporting Period, 80% were found to be undisturbed, and of the 17 incomplete clutches, five were disturbed by other nesters or natural predators, seven could not be found, four were mixed with another clutch, and one was inundated (by tidal or wave action). For all clutches, mean overall hatch success was high, ranging from 67.2 ± 37.4% at A07 Beach to 80.3 ± 26.9% at YCN Beach, and the mean incubation period was not significantly different between any of the beaches (Ref. 22).

Of the 60 clutches marked during the 2018–2019 Reporting Period, 70% were found to be undisturbed; of the 18 incomplete clutches, 11 were disturbed by other nesters or natural predators, three could not be found, three were mixed with another clutch, and one was inundated (by tidal or wave action). For all clutches, mean overall egg hatching probability continued to be high, ranging from 53 ± 34% at Junction Beach to 83 ± 14% at YCN Beach, and the mean incubation period was not significantly different between any of the beaches (Ref. 34).

Of the 49 clutches marked during the 2019–2020 Reporting Period, 41 were complete (84%) and eight were incomplete (16%). Of the eight incomplete clutches, five were disturbed/predated, two were lost, and one was inundated. For all clutches, mean overall egg hatching probability continued to be high, ranging from 79.3 ± 15.4% at YCN Beach to 89.3 ± 14.9% at Junction Beach, and the mean incubation period was not significantly different between any of the beaches (Ref. 43).

With regard to incubation environment during both Reporting Periods, the results of the study showed that while marked clutches on A07, Junction, Camp, YCS, and YCN beaches were significantly warmer than marked clutches on beaches routinely monitored for incubation success (except for Bivalve Beach), these beaches (except Junction) provide an incubation environment for Flatback Turtle nests that is comparable to the routinely monitored beaches on Barrow Island and at MDA (Ref. 43).

4.2.3 Flatback Turtle Hatchling Dispersal and Survivorship

A study was initiated during the 2018–2019 Reporting Period to monitor how Flatback Turtle hatchling in-water dispersal from select east coast beaches of Barrow Island are impacted by the physical presence of infrastructure associated with the Gorgon Gas Development causeway, MOF, and LNG Jetty, and sources of offshore artificial light (including the LNG/condensate vessels). For the 2018–2019 season, vessels were used to manually track Flatback Turtle hatchlings at night from three primary release beaches (YCS, YCN, and Mushroom), and three secondary release beaches (Junction, Inga, and Terminal).

A total of 106 Flatback Turtle hatchlings were tracked from the release beaches during 21 survey nights. Most hatchlings were released at YCS and YCN beaches (n = 59; 55%), followed by Mushroom (n = 26; 25%), Inga (n = 15; 14%), Terminal (n = 4; 4%), and Junction (n = 2; 2%) beaches. The mean tracking duration for each hatchling was 103 ± 100 minutes, and the longest was 356 minutes (Ref. 34).

Modelling results indicated that the hatchlings' orientation towards the LNG Jetty head did not change according to the amount of moonlight, the presence of the LNG/condensate vessel, or the wind or wave direction. However, the closer a hatchling was to the LNG Jetty, the more it oriented towards it, an effect that was more pronounced during strong tidal change rates on an ebb tide (Ref. 34).

Flatback Turtle hatchling in-water dispersal (as represented by the hatchlings' travel speed) was found to be influenced by the presence of the LNG/condensate vessel at the LNG Jetty, with the hatchlings' travel speed slowing down as they approached closer to the jetty. The slower travel speed was considered to be due to hatchlings' attraction to artificial light, which was shown to increase more as hatchlings approached the jetty when an LNG/condensate vessel was present. Despite the increased exposure to predation from the longer transit time to open water, the hatchlings' slower speed did not appear to affect their overall survivorship, with the greatest risk of predation occurring within the intertidal area <500 m from the Barrow Island coastline and away from infrastructure (Ref. 23).

4.3 Event Data

Incidents involving harm to marine turtles reported during the Reporting Period are summarised in the following table.

Event Data: Harm to Marine Turtles	
Reporting Requirement:	• Reportable incidents[1] involving harm to marine turtles.
Results:	A total of 12 reportable incidents[1] were recorded over the 2015–2020 Reporting Period. • Two incidents were considered Project-attributable. These involved the temporary entanglement of an unidentified species of adult marine turtle and the temporary entanglement of an adult Green Turtle, both within the Port of Barrow Island. • There were two incidents of injured adult female Flatback Turtles and one deceased Flatback Turtle hatchling where the cause of injury or death could not be determined. • There was one incident of a deceased adult Green Turtle which was observed to have a severe laceration across the carapace. The likely cause was thought to be from natural expansion and splitting of the decaying animal. However, DPaW was unable to inspect the carcass to confirm prior to the tide removing it from the beach, so the final classification remained as Unknown. • There were four incidents of deceased Green Turtles (found on several Barrow Island beaches) and one unidentifiable (due to its decomposed state) turtle (found on Bivalve Beach) where the cause of injury or death could not be determined. • One deceased Green Turtle was found with what appeared to be an injured neck. DPaW and Chevron were unable to determine the cause of death. *1. Harm or mortality to listed marine turtles attributable to the Gorgon Gas Development, and significant impacts detected by the monitoring program on matters of NES relevant to this Plan (Ref. 7).* *Note: Review of all marine fauna events was conducted during the compilation of the Five-year EPR. The following events were reported with a cause of injury or death that was unable to be conclusively determined as anthropogenic. Review of the event information confirmed that these events were incorrectly reported; therefore the following modifications have been made.* • *2015-2016 Reporting Period: One injured adult female Flatback Turtle has been excluded as it was deemed likely a natural stranding event. One deceased Flatback Turtle hatchling has been included, where the cause of death could not be determined.* • *2016-2017 Reporting Period: Seven deceased adult Green Turtles have been excluded as they were deemed likely natural stranding events.* • *2018-2019 Reporting Period: One deceased Green Turtle and one stranded but alive Green Turtle have been excluded as they were deemed likely natural stranding events. One deceased Flatback Turtle hatchling has been excluded as this was deemed likely a natural event.*

4.4 Audit and Review

Findings of the annual audit and review of lighting design features, management measures, and operating controls, including details of light management initiatives and activities undertaken during the Reporting Period, are summarised in the following table.

Stressor: Light	
Audit Results:	CAPL completed five audits of the LTMTMP during the Reporting Period. The audits included verifying compliance with lighting design features, management measures, and operating controls, as described in the LTMTMP (Ref. 7). The requirements specified in the LTMTMP were fulfilled except for these audit findings: • Operations Control Building (OCB) window blinds were not operational therefore windows did not have treatments to minimise light spill from the building. – Action: Maintain window treatment design features to reduce night-time light spill from the OCB (Complete). • Temporary Lighting Towers (TLTs), observed at 10 locations out of 30 sighted on the GTP areas, pointed outwards, or created light spill towards the coastline, rather than being as low as practicable/downward facing. – Action: Adjust/move the observed TLTs and identify and adjust any other TLTs as necessary (Complete). – Action: Provide contractors and CAPL personnel with awareness training and material that identifies the lighting requirements for Barrow Island in preparation for the 2017–2018 turtle season (Complete). • Reviews of on-site lighting identified areas where task lighting was observed to be permanently on. – Action: Corrective actions, including a review of area task lighting on site, were implemented to address this finding (Complete). • No direct impacts to marine turtles were identified during the audits.
Light Management Initiatives, Activities and Reasonably Practicable Lighting Improvements:	• The lighting requirements specified in the LTMTMP (Ref. 7) were fulfilled except for the audit findings identified above. • The following lighting management initiatives and activities were implemented during the 2015–2020 Reporting Period: **Lighting Management Initiatives** • Site planning sessions continued for activities with the potential to affect marine turtle behaviour before and during the marine turtle nesting season. • Marine turtle awareness, highlighting the relationships between lighting management and impacts to marine turtles, were incorporated into routine prestart and contractor meetings, Injury Free Observation/Health and Safety Representative committee meetings, and site notices. Hatchling response equipment (used to retrieve hatchlings dropped into operational areas by birds) was distributed at prestart meetings. • Personnel engagement continued via marine turtle nesting and turtle hatchling tours to raise awareness of the environmental commitments associated with marine turtles. Environmental Stewardship / Reward and Recognition Tours were conducted every fortnight, with prospective participants being nominated to the Gorgon Leadership Team. Additional information was also disseminated through the accommodation TVs on the marine turtle nesting season, monitoring programs, and lighting management. • A specialist consultant conducted facility lighting on-site inspections over the GTP and associated facilities, and compare the output of diesel- versus solar-powered lighting towers. • Lighting inspections of offshore vessels and reviews of contractor vessel lighting management plans were conducted to ensure compliance requirements were met. Where actions were identified, improvements were implemented to vessel lighting design and management. • Lighting inspections of onshore facilities, including the GTP, MOF, Tug Pen, Toll Abutment, and TLTs were conducted to ensure compliance requirements were

Stressor: Light	
	met. A common observation was missing or broken window blinds, which is being addressed via maintenance orders and a refresh of workforce awareness to turn off lights and close blinds that are functional. • Temporary lighting levels were assessed in LNG Train 1 and in Acid Gas Removal Unit (AGRU) 1 at numerous locations between mid-September 2019 and mid-October 2019 for the Turnaround. **Reasonably Practicable Lighting Improvements** *Sitewide* • A digital Lighting Inspection Checklist mobile application was developed and will be implemented on site during future marine turtle monitoring seasons. • Mobile solar-powered lighting towers were trialled in January 2020. These towers have been programmed to meet optimal turtle-friendly lighting requirements for wavelength and light intensity. Following a further trial of next-generation towers, these solar units are planned to replace the mobile diesel towers, where practicable. • Specific light management measures were implemented during the 2019–2020 Reporting Period that reduced light from certain directions at some monitoring sites. This included lowering and redirecting a TLT at the MOF, which reduced its visibility from YCN, Inga, and Bivalve beaches, and a change to a TLT at the western end of the causeway, which completely removed its visibility when viewed from Bivalve Beach. • The solar-powered towers have no short wavelength (blue/green) light present in the spectral output, with only a narrow band peaking at ~590 nanometres. Combined with the lower illumination levels, they have the potential to further reduce ambient light levels provided these same operational constraints are followed: – only target the work area required – keep tower to the minimum height required – tower should not be directly visible from any marine turtle nesting beaches during the nesting season (Ref. 36). *Associated Terrestrial Infrastructure (Camps, OCB, etc.)* • A management decision was made to permanently close Main Camp in July 2020. All personnel will now be accommodated at Butler Park. This action will reduce the light spill near east coast beaches, as only minimal safety and security lights will be left in place.
Conclusions on the Effectiveness of Lighting Design Features, Management Measures, and Operating Controls:	• CAPL considers lighting design features, management measures, and operating controls are 'effective' if they meet the environmental objectives of the LTMTMP (Ref. 7), and if they reduce potential adverse lighting impacts to Barrow Island marine turtle populations. • There were no internal audit findings for lighting that represented Material or Serious Environmental Harm to the marine turtle populations on Barrow Island. • Sources of night-time light emissions were similar during the 2015–2020 Reporting Period. • Overall light levels have dropped each year since the start of Gorgon Gas Development operations, and in general, are very low and well managed. • Artificial light levels varied across monitored marine turtle nesting beaches, and there was evidence of localised misorientation in 2017–2018 at Bivalve Beach with an exceedance of +2 SD control limit for dispersion offset (misorientation) for the first and only time since the start of baseline monitoring. During the 2018–2019 and 2019–2020 Reporting Periods exceedances of +1 SD and +2 SD management alert triggers, respectively, were recorded at Terminal Beach. • During the Reporting Periods from 2015–2016 to 2017–2018 modelled hatchling post-emergence dispersion spread (disorientation) at Bivalve Beach fluctuated between exceeding the +1 SD and +2 SD management triggers. • Control chart outputs for modelled parameters during the 2015–2020 Reporting Period indicate that the Flatback Turtle population nesting on Barrow Island remains stable and demographically healthy.

Stressor: Light	
	• Localised changes in the spatial distribution of Flatback Turtle beach usage observed at Terminal, Bivalve, and Inga beaches during the 2015–2020 Reporting Period were a behavioural response to localised sediment redistribution due to the presence of the causeway and MOF and were not linked to artificial light at those locations. • Overall, there were no indications of adverse impacts to the marine turtle populations that use the east coast beaches of Barrow Island during the 2015–2020 Reporting Period for nesting and hatching due to artificial lighting.

4.5 Changes to the Long-term Marine Turtle Management Plan

The LTMTMP (Ref. 7) was revised twice during the Reporting Period.

Revision 3 Amendment 1 of the LTMTMP (Ref. 27) was developed over 2014–2015. It was approved by the then OEPA (now DWER) in October 2015 and by the then DotEE (now DAWE) in February 2016. The key changes made in this revision included:

- clarifying the role of the Gorgon Marine Turtle Expert Panel
- adding a risk assessment for operating the DomGas pipeline
- updating management measures.

As an outcome of the Five-year EPR (August 2010–August 2015; Ref. 6) and commissioning, start-up, and operation of the Gorgon Gas Development, the LTMTMP (Ref. 7) was also updated between 2015 and 2018.

The document was transferred to the Gorgon Operations EMP template and allocated a new document number (GOR-COP-01728), and was issued as Revision 1.0 once approved.

The key changes made in this revision included:

- adding commissioning, start-up, and operations activities and risks
- adding the outcomes of a turtle risk review undertaken by CAPL in 2015
- updating design features and management measures
- updating the marine turtle monitoring program (see Section 4.1)
- clarifying the Scope of Studies section (see Section 4.2).

Revision 1.0 of the LTMTMP (Ref. 7) was approved by DWER and DotEE in July 2018.

4.6 Conclusion

Taken as a whole, the marine turtle monitoring program results from the 2015–2020 Reporting Period indicate that the Gorgon Gas Development did not impact the nesting population of Flatback Turtles at Barrow Island. There is evidence to suggest that the presence of the causeway/MOF may be causing localised density-dependent effects at some beaches (Ref. 43).

Over the last eight consecutive seasons the + MAD control limit was exceeded at Barrow Island for the estimated annual abundance. The annual abundance at Barrow Island for the 2019–2020 season did not follow a similar trend to the regional Reference site at MDA when compared to the previous season. However, the EWMA control chart that shows the 3-year smoothed LRR of the rookery-specific MSORD-based abundance estimates, remained within control limits indicating that the high abundance at Barrow Island during the 2019-2020 Reporting Period likely reflects natural interannual variation known to occur for this species (Ref. 43).

The breeding omission probability has exceeded the +1 MAD control limit at Barrow Island for six consecutive years. This parameter was again lower at MDA than at Barrow Island during the 2019–2020 Reporting Period, indicating a lower likelihood that a turtle would skip a nesting season if it had nested the previous season. Investigation into patterns of increased breeding omission indicate that a sustained elevation in breeding omission rate over consecutive seasons is likely driven by a combination of varying conditions at, and long migration distances to, remote foraging grounds used between breeding cycles. High energy demands for large migration distances and reproduction, coupled with fluctuations in food supply, have been demonstrated to influence breeding omission probability for other marine turtle species. Flatback Turtles tracked from the Barrow Island and MDA rookeries in previous seasons confirm these nesting populations forage in widely distributed foraging grounds across the North West Shelf. This suggests that the interannual fluctuation in Flatback Turtle breeding omission rate at Barrow Island is likely a function of natural variables, not Gorgon Gas Development activities (Ref. 43).

The levels of visible light from monitored Barrow Island beaches has varied each season since monitoring began in 2009–2010, with the light level dependent on temporal and spatial variation in Gorgon Gas Development activities and natural environmental variables at the time of monitoring. The whole-sky brightness has decreased over the 2015–2020 Reporting Period. Therefore, it is unlikely that artificial light levels contributed to the + SD control limit exceedance for the modelled hatchling post-emergence dispersion offsets. In the 2019–2020 Reporting Period, there was an increase in light from the direction of Main Camp at Bivalve Beach. However, when compared to the intensity of other existing light sources, the increase was not considered substantial enough to cause the misorientation exceedance. A new source of light, the tanker mooring site, was visible from Terminal Beach, but this remote point source is spatially small and of low intensity and considered unlikely to cause an impact. One potential cause for the exceedance in fan offset was the narrower spatial distribution of the hatchling emergence points across the beach in comparison to the baseline (Ref. 43).

In the case of Bivalve Beach, beach usage (as indicated by the percentage of sightings and individuals) has decreased nearly every season since construction of the causeway was completed in 2011, to the lowest ever percentage reported in 2019–2020 (Ref. 43). This decrease supports the findings of a study that used a modelling approach to account for imperfect detection and estimated annual beach-specific movement rates and nesting beach fidelity at Barrow Island between 2005–2006 and 2016–2017. The study found that Flatback Turtles that previously nested at Bivalve Beach tended to be ‘movers’ (low fidelity) to other beaches in their next nesting season (predominantly to Terminal Beach); however, caution was advised in drawing a strong conclusion due to concerns about sampling effort at all beaches (Ref. 52).

Outcomes of the monitoring programs, investigations into observed deviations in demographic parameters, and nesting behaviour, indicate that the Flatback Turtle population nesting on Barrow Island remains stable and demographically healthy, with consistently high survival rates observed for nesting females.

As required by the LTMTMP (Ref. 7), CAPL will continue to routinely monitor key marine turtle demographic parameters to detect and evaluate potential implications for marine turtle nesting. If exceedances of LTMTMP management triggers or performance standards are detected, these will be assessed in accordance with the requirements identified in the LTMTMP and relevant Ministerial conditions.

4.7 Five-year Overview of Environmental Performance

The 2015–2020 outcome for marine turtles is summarised in the table below.

Objectives[1]	Outcome
Address the long-term management of the marine turtles that utilise the east coast beaches and waters where there are Proposal-related stressors to marine turtles.	Monitoring of marine turtles and stressors, as per the requirements of the approved LTMTMP (Ref. 7), throughout the five-year Reporting Period did not detect any adverse changes to the population of Flatback Turtles that can be attributed to the Gorgon Gas Development.
Establish baseline information on the populations of marine turtles that utilise the beaches adjacent to the east coast facilities identified in Conditions 6.3 and 14.3;	
Establish a monitoring program to measure and detect changes to the Flatback Turtle population in accordance with Condition 16.4(ii); and	Section 3 of the approved LTMTMP (Ref. 7) provides baseline information on marine turtle populations at Barrow Island.
Specify design features, management measures, and operating controls to manage, and where practicable, avoid adverse impacts to marine turtles, with specific reference to reducing light and noise emissions as far as practicable.	Section 6 of the approved LTMTMP (Ref. 7) describes the management strategies and measures for lighting control. These are updated (if required) after the annual lighting effectiveness reviews.

1 As defined in Condition 16.3 of MS 800, and Condition 12.3 of EPBC 2003/1294 and 2008/4178.

4.8 Proposed Environmental Management Improvements

No management improvements related to the LTMTMP (Ref. 7) are proposed as part of this Five-year EPR.

5 Short-range Endemics and Subterranean Fauna

Table 5-1: EPR Reporting Requirements for Short-range Endemics and Subterranean Fauna

Item	Source	Section in this EPR
Results of survey and studies to locate outside the GTP footprint and Additional Support Area (ASA) those remaining short-range endemics (SRE) and subterranean fauna species previously found only within the GTP footprint and ASA	MS 800, Schedule 3(4i)	5.1
A five-year overview of environmental performance	MS 800, Condition 5.3(iii) EPBC 2003/1294 and 2008/4178, Condition 4.2(iii)	5.2
Proposed environmental management improvements	MS 800, Condition 5.3(iv) EPBC 2003/1294 and 2008/4178, Condition 4.2(iv)	5.3

5.1 Monitoring Results

The Short-Range Endemics and Subterranean Fauna Monitoring Plan (SRESFMP; Ref. 9) focuses on surveys to locate and identify those SREs and subterranean fauna species that had only previously been located within the GTP footprint and the ASA. Several of these species were confirmed outside the GTP footprint and ASA before construction commenced, and a further two subterranean fauna species were identified during construction (Ref. 9). Therefore, the ongoing focus of the SRESFMP is to locate these four taxa: *Idiommata* sp., *Oniscidea* sp. nov. 1., *Pilbaracandona* sp. nov. 1., and *Symphyla* sp.

The SRESFMP was amended in the 2018–2019 Reporting Period, in consultation with relevant regulatory agencies, to reduce the monitoring frequency for subterranean fauna from yearly to 5-yearly.

The 2015–2020 results for the surveillance and study of SRE fauna species are summarised in the following table.

Monitoring Program: Short-range Endemics	
Objective:	• Survey for, and identify, those SREs that had previously only been located within the GTP footprint and ASA.
Methodology:	• Targeted surveillance of *Idiommata* sp. using various techniques, including trapping (pitfall), night-time searches, and burrow searches. • The survey effort for *Idiommata* sp. during the 2015–2020 Reporting Period occurred as part of the vertebrate NIS surveillance program, where pitfall traps were used for sampling. • Relevant trapping effort totalled 6,220 pitfall trapping nights. • In addition, 492 hours of night visual surveillance searches were carried out during the 2018–2019 and 2019–2020 Reporting Periods. • During the 2015–2016 Reporting Period, an additional 1234 funnel trapping nights occurred.
Result:	• *Idiommata* sp. was not detected outside the GTP footprint or ASA during the vertebrate NIS surveillance program and night visual surveillance searches.
Conclusion:	• *Idiommata* sp. was not detected outside the GTP footprint or ASA during the Reporting Period.

Subterranean Fauna	
Objective:	• Survey for, and identify, those subterranean fauna that had previously only been located within the GTP footprint and ASA.
Methodology:	• Targeted sampling of subterranean fauna using haul nets for stygofauna and habitat traps for troglofauna.
Result:	• Three targeted surveys were undertaken during the 2016–2017 Reporting Period. These involved sampling 21 sites over a total of 10 days and deploying 295 haul nets and litter traps (litter traps were collected after a minimum of six weeks). • Three targeted surveys were undertaken during the 2017–2018 Reporting Period. These involved sampling 21 sites over a total of 11 days, and deploying 405 haul nets and litter traps. • *Oniscidea* sp. nov. 1., *Pilbaracandona* sp. nov.1., and *Symphyla* sp. were not detected outside the GTP footprint and ASA during the 2016–2017 and 2017–2018 Reporting Periods.
Conclusion:	• *Oniscidea* sp. nov. 1., *Pilbaracandona* sp. nov.1., and *Symphyla* sp. were not detected outside the GTP footprint and ASA during the 2015–2020 Reporting Period.

5.2 Five-year Overview of Environmental Performance

The 2015–2020 outcome for SREs and subterranean fauna is summarised in the table below.

Objectives[1]	Outcome
To locate those SRE and subterranean fauna species that have only previously been located on the GTP site and Additional Support Area.	Targeted monitoring, as per the requirements of the approved SRESFMP (Ref. 9), throughout the five-year Reporting Period identified two of the four target taxa (*Bogidomma* sp. 1 and *Trinemura* sp. nov. 1) outside the GTP footprint and ASA. One SRE taxa (*Idiommata* sp.) and three subterranean taxa (*Oniscidea* sp. 1, *Pilbaracandona* sp. nov. 1, and *Symphyla* sp.), remain unidentified outside the GTP footprint and ASA.

1 As defined in Condition 11.1 of MS 800.

5.3 Proposed Environmental Management Improvements

No management improvements related to the SRESFMP (Ref. 9) are proposed as part of this Five-year EPR.

6 Fire Management

Table 6-1: EPR Reporting Requirements for Fire Management

Item	Source	Section in this EPR
Incidence of fires caused by the Proposal, and fires that impact on the Proponent's facilities, including details of cause, lessons learnt, and recommended actions	MS 800, Schedule 3(5i) MS 769, Schedule 3(2i) EPBC 2003/1294 and 2008/4178, Schedule 3(4i)	6.1
Material or Serious Environmental Harm caused by fire directly attributable to the Proposal	MS 800, Schedule 3(5ii) MS 769, Schedule 3(2ii) EPBC 2003/1294 and 2008/4178, Schedule 3(4ii)	N/A[1]
Any changes to the Gorgon Gas Development Fire Management Plan (Ref. 10) including: • management responses to address Material or Serious Environmental Harm caused by fire directly attributable to the Proposal • improvement to fire management practices.	MS 800, Schedule 3(5iii) MS 769, Schedule 3(2iii) EPBC 2003/1294 and 2008/4178, Schedule 3(4iii)	6.2
A five-year overview of environmental performance	MS 800, Condition 5.3(iii) MS 769, Condition 5.3(ii) EPBC 2003/1294 and 2008/4178, Condition 4.2(iii)	6.3
Proposed environmental management improvements	MS 800, Condition 5.3(iv) MS 769, Condition 5.3(iii) EPBC 2003/1294 and 2008/4178, Condition 4.2(iv)	6.4

1. *No Material or Serious Environmental Harm caused by fire was recorded during the Reporting Period.*

6.1 Event Data

Incidences of fire caused by the Gorgon Gas Development, or fires that impacted on Gorgon Gas Development facilities during the Reporting Period, including details of cause, lessons learnt, and recommended actions, are provided in the following table.

Event Data: Fires	
Results:	• No fire events occurred during the Reporting Period that caused Material or Serious Environmental Harm outside the TDF. • No fires impacted Gorgon Gas Development facilities. • Table 6-2 summarises the event cause, completed actions, and lessons learnt for fire events attributable to Gorgon Gas Development activities during the Reporting Period.

Table 6-2: Causes, Completed Actions, and Lessons Learnt for Fire Events Attributable to Gorgon Gas Development Activities during the Reporting Period

Date	Event Cause	Completed Actions[1]	Lessons Learnt
28 Oct 2015	Hot slag from welding made contact with a concrete joint recently sealed with primer,	• On-the-job training for spark encapsulation. • Mentor relevant worker.	• Ensure appropriate controls and preventive systems are in place

Date	Event Cause	Completed Actions[1]	Lessons Learnt
	causing the primer vapour to ignite. No impact on vegetation.	• One week period of daily inspections.	before starting any welding activity.
19 Nov 2015	Grinding sparks caused vegetation to ignite within the TDF.	• Conduct risk assessment for weather conditions to ensure these conditions are adequately assessed. • Issue HES alert at prestart meetings. • Amend Work Method Statement to include further relevant controls. • Amend Job Hazard Analysis (JHA) to include further relevant controls.	• Reinforce to the workforce the potential risks and required controls for grinding activities.
7 Dec 2015	Discarded cigarette butt likely caused ignition of cardboard boxes in a laydown area of an accommodation barge. No impact on vegetation.	• Conduct toolbox talk on fire prevention for all relevant marine crew. • Close two designated smoking areas to manage the risk of potential fires.	• Reinforce to the workforce that cigarette butts need to be properly extinguished and placed in correct disposal bins.
5 Jan 2016	Discarded cigarette butt likely caused ignition of cardboard boxes in a laydown area of an accommodation barge. No impact on vegetation.	• Move the designated smoking area to a more enclosed location. • Issue notices to contractors on board the barge. • Relocate cardboard boxes and water bottles to a safe area.	• Reinforce to the workforce that cigarette butts need to be properly extinguished and placed in correct disposal bins.
26 Feb 2016	The vibration of a water pump being used for dewatering caused the surface of the pump to contact with plywood, causing the plywood to ignite. No impact on vegetation.	• Develop a JHA for the dewatering activity. • Remove plywood from work area. • Construct a windrow around the pumps to restrict pump movements.	• The dewatering task requires a JHA that recognises the potential movement of equipment as a result of vibration.
21 Mar 2016	The rubber seal on a compressor oil filler cap was damaged, causing it to come off and allow the release of oil. The oil ignited on the hot surface of the compressor.	• Inspect all compressors to ensure that their oil filler caps were correctly secured in place. • Replace all damaged filler caps with new original equipment manufacturer-approved filler caps. • Discuss lessons learnt from the incident in toolbox/prestart talks. • Install new insulation lagging on compressors where required. • Update prestart inspection checklist for compressors.	• Engine maintenance and inspection to include inspection of oil filler caps for wear and tear.
5 Jun 2016	A capacitor in the duct fan failed due to an electrical fault, which then created a heat source that ignited the fan.	• Issue a prestart notice to recall all similar duct fans for inspection. • Electrical experts to inspect the damaged duct fan and issue report. • Develop and distribute a sitewide safety notice for recalling, inspecting, and testing similar duct fans.	• Duct fans require inspection and testing to confirm that they do not have the potential of becoming an ignition source if capacitor fails. This testing is required even if the manufacturer has specified the fan for continuous use.

Date	Event Cause	Completed Actions[1]	Lessons Learnt
24 Apr 2018	Water pump starter motor overheated due to friction and caught fire. A fire extinguisher was used to extinguish fire. No impact on vegetation.	• Review routine maintenance for engine starter motors and start contactors. • Install signs that clearly identify the emergency start and stop controls that are located on engines. • Train production technicians in how to stop engines in runaway conditions. • Repair the engine start system, replace starting coils, and test run pump to confirm correct operation from all start and stop locations. • Install battery isolators to allow power to be isolated locally.	• Appropriate maintenance, signage, and training must be in place for engines. • Always ensure that emergency start / stop controls on equipment are clearly identified. • Routine preventive maintenance programs should consider including water pump starter motors. • Consider installing a battery isolation system for water system pumps to isolate power from the engine if a fault causes continual cranking.
7 May 2018	Trailer-mounted diesel compressor caught fire due to ignition of paint on acoustic insulation fitted to the inside face of the exhaust chamber doors. A fire extinguisher was used to extinguish fire. No impact on vegetation.	• Inspect diesel compressors to remove any painted acoustic panels. • Review and update JHAs to include periodic temperature monitoring of exhaust manifold and compartment. • Review and update premobilisation checklist to include foam condition verification and painting of internal foam panels. • Amend compressor premobilisation function test. • Inspect other relevant compressors on Barrow Island to confirm all potential causes of fire have been eliminated. • Share lessons learnt from the event with the workforce via a Post-Investigation Alert.	• Install and treat noise attenuation insulation according to design and operational requirements. • Install mechanical bracing on insulation to stop insulation falling onto hot surfaces. • Ensure exhaust flaps are not obstructed and are functioning as per design.
4 Jan 2019	While changing a liquid filter cartridge, static build-up caused a small flammable gas cloud to ignite during bagging of the spent filter. A fire extinguisher was used to extinguish the fire. There was no impact on vegetation.	• Conduct a hazard identification (HAZID) study to identify risks and safeguards for managing hydrocarbon gas and static build-up during filter change-out. • Incorporate static bonding/earthing hazards and safeguards from the HAZID into relevant documentation, and update procedures and work standards as required. • Identify maintenance activities where a static bonding/earthing hazard exists that has the potential to ignite a gaseous hydrocarbon atmosphere and requires additional mitigations.	• Static electricity hazards must be identified, and safeguards confirmed to be in place prior to any potential exposure to flammable gas, such as breaking containment.

Date	Event Cause	Completed Actions[1]	Lessons Learnt
		• Identify and implement methods to earth the filter basket during the filter change-out activity. • Communicate outcomes of the HAZID regarding the additional requirements to relevant personnel. • Update personal protective equipment (PPE) procedure to include static bonding and earthing hazards and safeguards. • Review PPE / consumables used for activities where a static bonding/earthing hazard exists that has the potential to ignite a gaseous hydrocarbon atmosphere, and procure antistatic alternatives where possible.	

1 *Schedule 3(5i) of MS 800, Schedule 3(2i) of MS 769, and Schedule 3(4i) of EPBC 2003/1294 and 2008/4178, requires 'Recommended Actions' to be reported; this was changed to 'Completed Actions' because the actions from the fire event have been completed.*

6.2 Changes to the Fire Management Plan

The Gorgon Gas Development Fire Management Plan (FMP; Ref. 10) was revised once during the Reporting Period.

As an outcome of the Five-year EPR (August 2010–August 2015; Ref. 6) and commissioning, start-up, and operation of the Gorgon Gas Development, the FMP was updated between 2015 and 2016.

The document was transferred to the Gorgon Operations EMP template and allocated a new document number (GOR-COP-01238), and was issued as Revision 1.0 once approved.

The key changes made in this revision included:

- adding commissioning, start-up, and operations activities and risks
- adding a fire TDF
- adding the outcomes of a fire risk review undertaken by CAPL in 2015
- updating management measures.

Revision 1.0 of the FMP (Ref. 10) was approved by OEPA and DotEE in October 2015.

6.3 Five-year Overview of Environmental Performance

The 2015–2020 outcome for fire management is summarised in the table below.

Objectives[1]	Outcome
Ensure that the Proposal does not cause Material or Serious Environmental Harm outside the Terrestrial Disturbance Footprint due to fire	Fire risk-reduction and management measures have been implemented, as per the approved FMP (Ref. 10), throughout the five-year Reporting Period. No fires attributable to Gorgon Gas Development activities on Barrow Island have resulted in Material or Serious Environmental Harm outside the TDF.
Fire risk reduction measures are built into the design of the facilities to protect the Proponent's assets from the impact from fire on Barrow Island.	

1 As defined in Condition 12.4 of MS 800, Condition 11.4 of MS 769, and Condition 9.4 of EPBC 2003/1294 and 2008/4178.

6.4 Proposed Environmental Management Improvements

No management improvements related to the FMP (Ref. 10) are proposed as part of this Five-year EPR.

7 Carbon Dioxide Injection Project

The Carbon Dioxide Injection Project is the largest of its kind in the world and represents the largest greenhouse gas abatement project undertaken by industry to date.

The Project plans to inject between 3.4 and 4 million tonnes of reservoir carbon dioxide each year. This will reduce greenhouse gas emissions from the Gorgon Project by approximately 40 percent.

To date, the Gorgon Joint Venture Participants have invested more than AU$2.5 billion in the Carbon Dioxide Injection Project and remain committed to safely reducing the Gorgon Gas Development's greenhouse gas emissions.

Table 7-1: EPR Reporting Requirements for Carbon Dioxide Injection Project

Item	Source	Section in this EPR
Volume of reservoir carbon dioxide and other acid gases removed from the incoming natural gas stream and available for injection	MS 800, Schedule 3(6i) EPBC 2003/1294 and 2008/4178, Schedule 3(5i)	7.1
Volume of reservoir carbon dioxide and other acid gases injected	MS 800, Schedule 3(6ii) EPBC 2003/1294 and 2008/4178, Schedule 3(5ii)	7.2
Results of environmental monitoring and identified Material or Serious Environmental Harm, if any, resulting from the seepage of injected carbon dioxide to the surface or near-surface environments including those which may support subterranean fauna (including the Blind Gudgeon [*Milyeringa veritas*])	MS 800, Schedule 3(6iii) EPBC 2003/1294 and 2008/4178, Schedule 3(5iii)	7.3
Reasons for shortfall between the volume of reservoir carbon dioxide extracted and injected	MS 800, Schedule 3(6iv) EPBC 2003/1294 and 2008/4178, Schedule 3(5iv)	7.4
In the event the amount of carbon dioxide injected falls significantly below the target levels specified in Condition 26.2 Chevron Australia shall report on: • measures that could be implemented that would ensure the target level is met or, if injection is not considered feasible for all or some of the gas, measures to otherwise offset • which if any of these measures the Proponent intents to implement	MS 800, Schedule 3(6v) EPBC 2003/1294 and 2008/4178, Schedule 3(5v)	7.5
In the event that monitoring shows there is an elevated risk of Material or Serious Environmental Harm and/or risk to human health associated with the injection of reservoir carbon dioxide, the Proponent shall report to the Minister on the efficacy of continuing to geo-sequester and alternative offsets considered instead of continuing injection of reservoir carbon dioxide	MS 800, Schedule 3(6vi) EPBC 2003/1294 and 2008/4178, Schedule 3(5vi)	N/A
A five-year overview of environmental performance	MS 800, Condition 5.3(iii) EPBC 2003/1294 and 2008/4178, Condition 4.2(iii)	7.6
Proposed environmental management improvements	MS 800, Condition 5.3(iv) EPBC 2003/1294 and 2008/4178, Condition 4.2(iv)	7.7

7.1 Volume of Reservoir Carbon Dioxide Removed

The Commonwealth *National Greenhouse and Energy Reporting Act 2007* (NGER Act) contains provisions on the reporting of emissions from the transport, injection, and underground storage of GHGs. To comply with NGER Act reporting requirements, CAPL is required to determine the volume of reservoir carbon dioxide removed from the incoming natural gas stream that is available for injection. This EPR includes data on the volumes of reservoir carbon dioxide extracted for the financial years over the 2015–2020 Reporting Period; these data align with CAPL's NGER Act reporting obligations. This enables the processes and procedures (including quality assurance, audit, and sign-off checks) developed for NGER Act compliance to be applied to these data. The volume of reservoir carbon dioxide separated from the natural gas stream is calculated daily. The separated reservoir carbon dioxide stream is sampled for compositional analysis, as required.

Volume of Reservoir Carbon Dioxide Removed and Available for Injection
• 1,408 standard cubic metres of reservoir carbon dioxide was removed from the incoming natural gas stream in the 2015–2016 financial year.
• 449,456,860 standard cubic metres of reservoir carbon dioxide was removed from the incoming natural gas stream during the 2016–2017 financial year. This equates to 1,049,532 tonnes carbon dioxide equivalent (CO_2e).
• 1,686,885,590 standard cubic metres of reservoir carbon dioxide was removed from the incoming natural gas stream during the 2017–2018 financial year. This equates to 3,531,581 tonnes carbon dioxide equivalent (CO_2e).
• 1,716,831,444 standard cubic metres of reservoir carbon dioxide was removed from the incoming natural gas stream during the 2018–2019 financial year. This equates to 3,741,777 tonnes CO_2e.
• 1,482,134,010 standard cubic metres of reservoir carbon dioxide was removed from the incoming natural gas stream during the 2019–2020 financial year. This equates to 3,856,511 tonnes CO_2e.
Note: The volumes of reservoir carbon dioxide reported in previous EPRs as having been removed and available for injection were calculated prior to the Minister's determination of the commencement date of Condition 26.2, of Ministerial Statement 800 as amended by Ministerial Statement 1136 (see Section 7.5).

7.2 Volume of Reservoir Carbon Dioxide Injected

This EPR includes data on the volumes of reservoir carbon dioxide injected for the 2015–2020 Reporting Period; these data align with CAPL's NGER Act reporting obligations. The carbon dioxide injection system commenced on 6 August 2019, as such 2019-2020 is the first year of data for volume of reservoir carbon dioxide injected.

Volume of Reservoir Carbon Dioxide Injected
• 851,324,939 standard cubic metres of reservoir carbon dioxide was injected during the 2019–2020 financial year. This equates to 2,707,092 tonnes CO_2e.

7.3 Monitoring Results

During the Reporting Period there was no evidence of seepage of injected reservoir carbon dioxide to the surface or near-surface environments.

7.4 Reasons for Shortfall Between Volume Extracted and Injected

As reported in the 2017 and 2018 EPRs (Ref. 21; Ref. 22), technical issues associated with the Carbon Dioxide Injection Project were identified during the pre-commissioning and start-up checks.

Once these issues were resolved, the safe start-up and operation of the carbon dioxide injection system began on 6 August 2019.

The key reasons for the shortfall between the volume of reservoir carbon dioxide extracted and injected are as follows:

- In order to ensure the safe start-up and operation of the injection system, the three CO_2 compressor modules and the nine CO_2 injection wells were progressively brought online between August 2019 and February 2020.
  - Injection from Train 3 compressor commenced on 6 August 2019;
  - The Train 2 compressor commenced start-up on 10 October 2019. Technical issues with the compressor resulted in curtailment of injection from this compressor from 11 October until 22 October 2019;
  - The Train 1 compressor commenced injection on 26 February 2020.
- In early February 2020, compressors were turned off for approximately five days as a result of Cyclone Damian.

Injectivity tests have been conducted on each injection well, with injection performance exceeding pre-drill estimates during the reporting period.

7.5 Measures Being Implemented

On 18 June 2018, the Chair of the WA EPA wrote to CAPL advising that the Minister for the Environment had requested ‘an inquiry into the reservoir carbon dioxide injection system conditions for the Gorgon Gas Development under section 46 of the *Environmental Protection Act 1986* (WA)’ (EP Act). The Chair of the EPA stated that ‘the inquiry was initiated in view of the release of the annual Environmental Performance Reporting for the Gorgon Gas Development and the need to have a clearly defined starting point for the commencement of the carbon dioxide injection system’.

On 25 September 2019 the EPA published its report (Report 1649) (Ref. 47) and made these recommendations to the Minister:

1. It is appropriate to change implementation Condition 26, by amending Condition 26.2 to contain the term ‘Commencement of Gas Processing Operations’ of the Gas Treatment Plant and to define this term.
2. For the purposes of Condition 26.2, Gas Processing Operations of the Gas Treatment Plant are taken to have begun from the date of the first grant of the licence to operate under Part V of the *Environmental Protection Act 1986*, being 14 July 2016.
3. From 14 July 2016 to 30 July 2018, reservoir carbon dioxide removed during gas processing operations pursuant to the 14 July 2016 Licence would be calculated for the purposes of the condition. From 30 July 2018 reservoir carbon dioxide removed during gas processing operations pursuant to the 30 July 2018 Licence would be calculated for the purposes of this condition.
4. After complying with section 46(8) of the EP Act, the Minister may issue a statement of decision to change Condition 26.2 of MS 800.

On 29 May 2020, consistent with the recommendations of the EPA in Report 1649 (Ref. 47), the Minister determined the commencement date of Condition 26.2 as follows:

Condition 26.2 of Ministerial Statement 800 is deleted and replaced with:

26.2 The Proponent must:
(1) implement all practicable means to inject underground all reservoir carbon dioxide removed during Gas Processing Operations of the Gas Treatment Plant; and
(2) ensure that, calculated on a 5 year rolling average commencing on 18 July 2016, at least 80 per cent of reservoir carbon dioxide removed during Gas Processing Operations of the Gas Treatment Plant that would otherwise be vented to the atmosphere is injected underground.

Gas Processing Operations of the Gas Treatment Plant: For the purposes of condition 26.2, Gas Processing Operations of the Gas Treatment Plant comprise:
(a) the gas processing operations that are carried out at LNG Train 1 on and after the commencement date of the first grant of the licence to operate that Train under Part V, Division 3 of the EP Act, being 18 July 2016; and
(b) the gas processing operations that are carried out at LNG Trains 2 and 3 on and after the date of the first grant of the licence to operate those Trains under Part V, Division 3 of the EP Act, being 30 July 2018.

Following the Minister's determination of the commencement date for Condition 26.2, the first five year rolling average period will end on 14 July 2021. In accordance with Schedule 3, 6v of Ministerial Statement 800, in the 2021 Environmental Performance Report, CAPL will report on:

- measures that could be implemented that would ensure that target level set in Condition 26.2 is met or, if injection is not considered feasible for all or some of the gas, measures to otherwise offset
- which, if any, of these measures the Proponent intends to implement

Note: The volumes of reservoir carbon dioxide reported in previous EPRs as having been removed and available for injection were calculated prior to the Minister's determination of the commencement date of Condition 26.2 of Ministerial Statement 800 as amended by Ministerial Statement 1649.

7.6 Five-year Overview of Environmental Performance

The safe start-up and operation of the CO_2 injection system commenced on 6 August 2019.

Following a staged commissioning and start-up of all three compressor modules, the system was injecting at full injection rates by the end of February 2020.

In the 2019–2020 Reporting Period, >2.7 million tonnes of CO_2e was injected, thus confirming the Carbon Dioxide Injection Project as one of the world's largest GHG abatement projects to be undertaken by industry.

Refer to Section 2.3 for the five-year overview of environmental performance.

7.7 Proposed Environmental Management Improvements

Although the CO_2 injection system has operated reliably during the 2019–2020 Reporting Period, CAPL is taking the necessary time to safely address system performance, with a focus on long-term reliable operation over the life of the Gorgon Gas Development.

Refer to Section 2.4 for the key proposed management improvements.

8 Air Quality

Table 8-1: EPR Reporting Requirements for Air Quality

Item	Source	Section in this EPR
Air quality monitoring results, with a discussion on the success (or otherwise) in meeting emissions targets	MS 800, Schedule 3(7i)	8.1
A five-year overview of environmental performance	MS 800, Condition 5.3(iii)	8.2
Proposed environmental management improvements	MS 800, Condition 5.3(iv)	8.3

8.1 Monitoring Results

The objectives of the Gorgon Gas Development Air Quality Management Plan (AQMP; Ref. 11), as defined by Ministerial conditions, are to:

- ensure air quality meets the appropriate standards for human health in the workplace
- ensure air emissions from GTP operations do not pose a risk of Material or Serious Environmental Harm to the flora, vegetation communities, terrestrial fauna, and subterranean fauna of Barrow Island.

The air quality monitoring program measures both ambient air quality and point source air quality at major emission sources (stack monitoring).

Ambient air quality monitoring measures select atmospheric pollutants and air toxics emissions associated with the commissioning, start-up, and operation of the GTP, and then compares these data against the applicable assessment (ambient) criteria defined in the AQMP (Ref. 11).

Stack air quality monitoring measures select atmospheric pollutants and air toxics at the point of discharge from major GTP emission sources (Frame 9 Gas Turbine Generators [GTGs] and Frame 7 Liquefaction Compressor Gas Turbines [LCGTs]). These emissions are assessed against the targets specified in the AQMP (Ref. 11).

The monitoring program completed during the Five-year Reporting Period is summarised in Table 8-2, Figure 8-1, and Figure 8-2 below.

Table 8-2: Summary of Ambient Air Quality and Stack Air Quality Monitoring Completed during the Five-year Reporting Period

	Ambient Air Quality	Stack Air Quality (Major Emission Sources)
Locations:	• Butler Park (workforce accommodation) Air Quality Monitoring Station (AQMS) • Terminal Tanks (TT)[1] / Communications Tower (CT) AQMS (close to the GTP) • other locations beyond the GTP	• 5 x GTGs • 6 x LCGT
Frequency:	• Continuous	• Quarterly
Parameters	Varied per location, but includes: • NO, NO_x, NO_2 • PM_{10} • H_2S, SO_2 • NMVOC (non-methane volatile organic compounds)	• NO_x • CO • NMVOC

	Ambient Air Quality	Stack Air Quality (Major Emission Sources)
	• CO • O_3 • weather	

1 *The AQMS at TT was relocated to CT in August 2016, which is ~600 m south-west of TT and thus is closer to the GTP.*

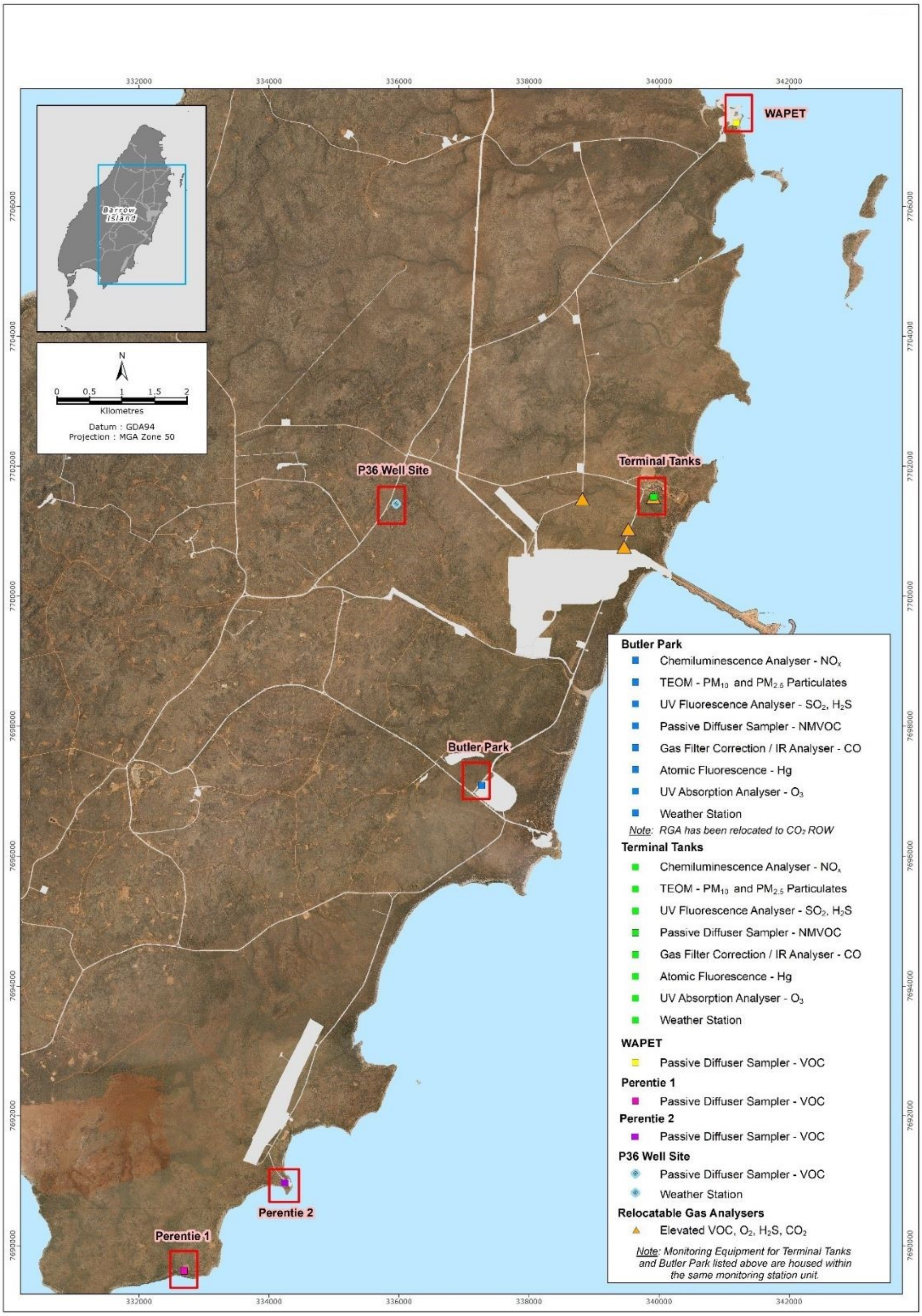


Figure 8-1: Ambient Air Quality Monitoring Locations and Parameters August 2015 to August 2016

Figure 8-2: Ambient Air Quality Monitoring Locations and Parameters August 2016 to August 2020

Air quality monitoring results, including assessment of exceedances, are summarised in the tables below; data is presented for the 2015–2020 Reporting Period and for the 2019–2020 Reporting Period. Note: The assessment of whether a test result exceeds a given guideline is based solely on the numeric value and does not take in to account the measurement uncertainty associated with the numeric value or values. Inherent within this approach is a risk of a false positive when the test result minus the measurement uncertainty is less than or equal to the guideline.

Monitoring Program: Ambient Air Quality

Results:

- There were no recorded exceedances for ozone (O_3), sulphur dioxide (SO_2), carbon monoxide (CO), or aromatic hydrocarbons (benzene, toluene, and xylene) against the relevant National Environmental Protection Measure (NEPM) guidelines (Ref. 48).
- There were five PM_{10} exceedances against the NEPM guideline at the TT location for the 2015-2016 Reporting Period. This was lower than previous years (78 exceedances in the 2013-2014 Reporting Period and 7 in the 2014-2015 Reporting Period), reflecting the transition from construction to operation. From August 2016, the AQMS was relocated from TT to the CT location, closer to the GTP and immediately adjacent an unsealed road. The PM_{10} exceedances against the NEPM guideline at the CT location are likely due to dust lift-off caused by vehicle movements directly impacting the AQMS. The PM_{10} exceedances against the NEPM guideline at the Butler Park AQMS are likely due to localised particulate sources, including resuspended road dust, construction/demolition work, and emissions from vehicles transporting personnel to and from Butler Park.
- Hydrogen sulphide (H_2S) exceedances at CT occurred from March 2017 and continued throughout 2018, with maximum readings obtained in late 2017. AGRUs were commissioned with the LNG trains from 2016 to 2017 and were the most likely source of H_2S emissions. Although elevated readings were recorded in 2019 and 2020, there has been a decline in the number of occasions this has occurred with fewer in 2020 than 2019. Prior to operation of the CO_2 injection infrastructure, all acid gases removed from the feed gas by the AGRUs were vented instead of being injected. The CO_2 injection system was progressively commissioned from August 2019 to February 2020, marking the start of CO_2 injection (which includes H_2S). The H_2S measurements taken at CT reflect this process change. The H_2S exceedance at BP was associated with south-easterly winds, which indicated that the source was local and not derived from GTP sources – Butler Park is approximately 4 km north-east of the GTP.
- During August 2016 and September 2016 at CT there were 16 exceedances of nitrogen dioxide (NO_2) against the 1-hour NEPM guideline, all of which were associated with south-west winds. A power generator south-west of the AQMS and close to it provided power to CT during the transition to mains power. The generator was decommissioned at the end of September 2016 and there have been no recorded exceedances since that period.

Table 8-3: Summary of Exceedances against Guideline Values during the Five-year Reporting Period

Guideline Value				No. of Exceedances		
Parameter	Guideline	Concentration	Averaging Period	TT[1]	CT[2]	BP[3]
PM_{10}[4]	NEPM[5]	50 µg/m³	1 day	5	166	69[13]
		25 µg/m³	1 year[6]	0[8]	4[13]	3[9,13]
NO_2[4]	NEPM[5]	0.12 ppm	1 hour	0	16	0
		0.03 ppm	1 year[6]	0	0	0
O_3[4]	NEPM[5]	0.10 ppm	1 hour	0	0	0
		0.08 ppm	4 hours	0	0	0
SO_2[4]	NEPM[5]	0.20 ppm	1 hour	0	0	0

Monitoring Program: Ambient Air Quality

		0.08 ppm	1 day	0	0	0
		0.02 ppm	1 year[6]	0	0	0
H_2S[4]	WHO[7]	7 $\mu g/m^3$	30 minutes	0	1469[13]	1[13]
CO[4]	NEPM[5]	9 ppm	8 hours	0	0	0
Benzene	NEPM[5]	0.003 ppm	1 year[6]	0	0[10]	0[10]
Toluene	NEPM[5]	1 ppm	1 day	0[11]	0[11] (0[12])	0[11]
		0.1 ppm	1 year[6]	0	0[10]	0[10]
Xylene	NEPM[5]	0.25 ppm	1 day	0[11]	0[11] (0[12])	0[11]
		0.20 ppm	1 year[6]	0	0[10]	0[10]

Table 8-4: Summary of Exceedances against Guideline Values during the 2019–2020 Reporting Period

Guideline Value				No. of Exceedances 2019–2020	
Parameter	**Guideline**	**Concentration**	**Averaging Period**	**CT[2]**	**BP[3]**
PM_{10}[4]	NEPM[5]	50 $\mu g/m^3$	1 day	37	19
		25 $\mu g/m^3$	1 year[6]	1	1
NO_2[4]	NEPM[5]	0.12 ppm	1 hour	0	0
		0.03 ppm	1 year[6]	0	0
O_3[4]	NEPM[5]	0.10 ppm	1 hour	0	0
		0.08 ppm	4 hours	0	0
SO_2[4]	NEPM[5]	0.20 ppm	1 hour	0	0
		0.08 ppm	1 day	0	0
		0.02 ppm	1 year[6]	0	0
H_2S[4]	WHO[7]	7 $\mu g/m^3$	30 minutes	152	0
CO[4]	NEPM[5]	9 ppm	8 hours	0	0
Benzene	NEPM[5]	0.003 ppm	1 year[6]	0	0
Toluene	NEPM[5]	1 ppm	1 day	0	0
		0.1 ppm	1 year[6]	0	0
Xylene	NEPM[5]	0.25 ppm	1 day	0	0
		0.20 ppm	1 year[6]	0	0

1. *TT is Terminal Tanks AQMS. TT was relocated to CT in August 2016.*
2. *CT is Communications Tower AQMS.*
3. *BP is Butler Park AQMS.*
4. *The following parameter abbreviations are used in this table: PM_{10} = particulate matter with an aero-equivalent diameter of less than 10 microns; NO_2 = nitrogen dioxide; O_3 = ozone; SO_2 = sulphur dioxide; H_2S = hydrogen sulphide; and CO = carbon monoxide.*
5. *NEPM is the National Environmental Protection Measure.*
6. *In NEPM, the annual averaging period is based on a calendar year. For the purposes of this report, the period 10 August to 9 August of the following year is used as the yearly averaging period.*
7. *WHO is the World Health Organisation.*
8. *To calculate a valid annual average, it is a NEPM requirement that there is a minimum data capture of 75% for each quarter. From 10 November 2015 to 9 February 2016, the data capture rate did not meet this requirement. Based on the available data, the average PM_{10} for the 2015-2016 Reporting Period was below the NEPM guideline.*

Monitoring Program: Ambient Air Quality	
	9. *To calculate a valid annual average, it is a NEPM requirement that there is a minimum data capture of 75 % for each quarter. From 10 November 2017 to 9 February 2018, the data capture rate did not meet this requirement. Based on the available data, the average PM_{10} for the 2017-2018 Reporting Period was above the NEPM guideline. This has been included in the number of exceedances shown in the table.* 10. *No passive diffusive samplers (PDSs) were deployed at CT between 29 October 2018 and 6 December 2018, and 14 March 2020 and 24 May 2020. Because of this, the minimum quarterly requirements were not met for the 2018-2019 and 2019-2020 Reporting Periods. Based on the available data, the averages were below the NEPM guidelines for benzene, toluene, and xylene.* 11. *This is based on a conservative estimate where it is assumed that the pollutant concentration measured over the sampling period (nominally 14 days) was due to a single event lasting one day.* 12. *Since November 2018, a continuous instrumental VOC analyser has been deployed at CT AQMS. The value in brackets is the number of daily exceedances recorded by this analyser.* 13. *Cumulative total for five-year Reporting Period has been revised to correct typographical error within previous reports.*
Conclusions:	• Although exceedances occurred for PM_{10}, NO_x and H_2S, these came from localised sources. • The exceedances of PM_{10} are not considered attributable to GTP emission sources, but from local sources of dust from vehicle movements, short-term construction/demolition activities, or regional weather events that generated dust. The GTGs have stacks that are ~50 m tall. It is unlikely that any particulate emissions from the stacks would impact the CT or BP AQMSs. • The exceedances of NO_x were considered attributed to the generator used to power the CT prior to transition to mains power. The generator was decommissioned at the end of September 2016 and there have been no recorded exceedances since that period. • The AGRUs' vents, located ~1 km south-west of CT, are the most likely source of the H_2S exceedances of the World Health Organization's (WHO) 30-minute guideline (Ref. 50). The exceedances were associated with south-westerly to westerly winds, which are more frequent between September and March. The number of exceedances has decreased each reporting year since 2017, reflecting optimisation of plant operating conditions to minimise emissions, including start-up of CO_2 injection. Although exceedances against the WHO guideline for H_2S occurred, this guideline is only for nuisance effects (odour/annoyance to a local population that would typically result in complaints). It is not a concentration level that, if exceeded, would result in an actual impact to human health and is three orders of magnitude below the National Occupational Health Exposure Standards (NOHES) guidelines (Ref. 51). The exceedance of H_2S at BP was not considered attributable to GTP emission sources, but from a localised source. • Overall, results of the ambient air quality monitoring demonstrated that air quality fell below the relevant NEPM guidelines during the 2015–2020 Reporting Period, indicating that air quality is below NOHES guidelines. This indicates that air emissions were within appropriate standards for human health in the workplace, and that GTP operations did not pose a risk of Material or Serious Environmental Harm to the flora, vegetation communities, terrestrial fauna, and subterranean fauna of Barrow Island.

Monitoring Program: Stack Air Quality (Major Emission Sources)

Results:

- All air quality parameters, except nitrogen oxides (NO_x) and CO, were below the relevant emission targets in the Reporting Period for the emission sources considered (Table 8-5).
- There were no exceedances of the target emissions for the Frame 7 LCGT during the Reporting Period (Ref. 12).

Table 8-5: Summary of Exceedances against Stationary Source Emissions Targets during the Five-year Reporting Period

Emission Source	Emission Targets [1]		No. of Exceedances
	Parameter	Concentration (mg/m^3) [2]	
GTG 1	NO_x [3]	70	12[6]
	CO	125	0
	NMVOC	40	0
GTG 2	NO_x [3]	70	11[6]
	CO	125	2[6]
	NMVOC	40	0
GTG 3	NO_x [3]	70	10[6]
	CO	125	0[4]
	NMVOC	40	0
GTG 4	NO_x [3]	70	6[5,6]
	CO	125	1[6]
	NMVOC	40	0
GTG 5	NO_x [3]	70	6[6]
	CO	125	0
	NMVOC	40	0
LCGTs	NO_x [3]	350	0
	CO	125	1
	NMVOC	40	0

1 *Emission targets apply at the point of discharge to the environment.*

2 *The concentrations are at standard temperature and pressure (0 °C and 1013.25 hectopascals), dry and referenced to 15% oxygen.*

3 *NO_x is oxides of nitrogen calculated as NO_2.*

4 *Includes one CO result at 125 mg/m^3, which was equal to the emission target.*

5 *In May 2017 and July 2017, GTG4 was tested and then retested the following day. The number of exceedances includes results from both the initial test and the retest.*

6 *Cumulative total for five-year Reporting Period has been revised to correct typographical error within previous reports.*

Conclusions:

- Overall, results of the stack air quality monitoring demonstrated that all measured parameters remained within emission targets during the 2015–2020 Reporting Period, except for some exceedances for NO_x and isolated exceedances of CO.
- The NO_x exceedances on the GTGs were typically associated with, and due to, the GTGs operating under low loads (typically <50% capacity). When GTGs are operating at low load, the dry low NO_x (DLN) equipment within the GTG is not operational—the efficiency of the machine declines and emissions concentrations increase (particularly NO_x, but also CO due to incomplete combustion). Therefore, higher emissions profiles are recorded during such periods. In November 2019, an exceedance of the NO_x target was noted on GTG1 whilst the DLN equipment was operational. The GTG load was approximately 59% at the time of sampling, which suggests that the DLN equipment was not operating optimally at the time of sampling.

8.2 Five-year Overview of Environmental Performance

The 2015–2020 outcome for air quality is summarised in the table below.

Objectives[1]	Outcome
Ensure air quality meets appropriate standards for human health in the workplace Ensure air emissions from the GTP operations do not pose a risk of Material or Serious Environmental Harm to the flora, vegetation communities, fauna, and subterranean fauna of Barrow Island.	*Ambient air quality* The PM_{10} profile for CT and BP was similar across each year of the 2015–2020 Reporting Period indicating that the sources have remained consistent. All exceedances were attributed to local sources such as vehicle activity near the AQMS, or regional weather events, rather than from GTP emission sources. Aside from the exceedances at CT in August–September 2016 that were related to the nearby power generator, no exceedances of criteria have been recorded at either CT or BP, indicating sustained performance of ambient NO_2 concentrations. At BP, except for the single exceedance due to a localised source at the beginning of the Reporting Period, measured concentrations of H_2S have been consistently low. At CT, the number of H_2S exceedances (WHO guideline for nuisance level) have decreased each reporting year since 2017, reflecting optimisation of plant operating conditions to minimise emissions, including start-up of CO_2 injection. PDSs for monitoring VOCs (including BTEX) were deployed throughout the 2015–2020 Reporting Period. There have been no exceedances of NEPM annual criteria or 1-day NEPM guidelines at any monitoring location during the Reporting Period using PDSs. However, because conservative estimates from PDSs in 2017 met the criteria for an escalation in VOC monitoring methods, CAPL instigated continuous monitoring of VOCs at the CT AQMS in November 2018. Since commissioning the continuous measurement equipment at CT, no exceedances of the NEPM 1-day or 1-year guidelines for VOCs have been recorded. Ambient air quality for O_3, SO_2, and CO were below the criteria for the 2015–2020 Reporting Period. *Stack air quality* All exceedances of NO_x emissions targets for GTGs have occurred when the load on the GTG was below the range where DLN burners are active; similarly, the small number of exceedances of CO targets also occurred during periods where GTGs were operating at low loads (with no exceedances since February 2017). There has only been one exceedance of CO emissions targets for LCGTs, and none since 2016.

1 *As defined in Condition 29.2 of MS 800.*

8.3 Proposed Environmental Management Improvements

The key proposed management improvements for the AQMP (Ref. 11) are summarised in the table below.

Proposed environmental management improvement	Justification
Remove PM_{10} monitoring at all locations	Exceedances are strongly related to regional weather events, local dust, and not GTP emissions. PM_{10} monitoring is not required per Licence L/9102/2017/1 (S10.1.1; (Ref. 26).
Remove Passive Diffuse Samplers (NMVOC) at all locations	Monitoring data has demonstrated that ambient concentration of NMVOCs are negligible and monitoring via PDSs is not required.
Remove SO_x, O_3, and CO monitoring at all locations	Monitoring data has demonstrated that ambient concentration of these parameters are below the relevant criteria.

9 Coastal Stability

Table 9-1: EPR Reporting Requirements for Coastal Stability

Item	Source	Section in this EPR
Results of beach and sediment monitoring	MS 800, Schedule 3(8i) EPBC 2003/1294 and 2008/4178, Schedule 3(6i)	9.1, 9.2
Any mitigation measures applied in response to action-related impacts of beach profile	MS 800, Schedule 3(8ii) EPBC 2003/1294 and 2008/4178, Schedule 3(6ii)	N/A[1]
All exceedances of management triggers	Approval letter from the former WA Department of Environment and Conservation to CAPL (Ref. 13)	9.1, 9.2
A five-year overview of environmental performance	MS 800, Condition 5.3(iii) EPBC 2003/1294 and 2008/4178, Condition 4.2(iii)	9.3
Proposed environmental management improvements	MS 800, Condition 5.3(iv) EPBC 2003/1294 and 2008/4178, Condition 4.2(iv)	9.4

1 *No mitigation measures as required under Condition 25.6(iii) of MS 800 and Condition 18.6(iii) of EPBC 2003/1294 and 2008/4178 were implemented during the 2015–2020 Reporting Period; therefore, reporting is not applicable at this time.*

9.1 Monitoring Results

The objectives of the Gorgon Gas Development Coastal Stability Management and Monitoring Plan (CSMMP; Ref. 14), as defined by Ministerial conditions, are to:

- ensure that the MOF and LNG Jetty do not cause significant adverse impacts to the beaches adjacent to those facilities
- establish a monitoring program to detect adverse changes to the beach structure and beach sediments that could have implications for marine turtles nesting on the beaches adjacent to the MOF and LNG Jetty.

The CSMMP has been revised twice from the original, which was published in September 2009, with one of the revisions coming into effect during the 2015–2020 Reporting Period. Updates to the monitoring program were designed to improve beach structure monitoring, and to quantitatively track changes in the availability of suitable nesting habitat for marine turtles, based on the physical characteristics of each beach. Revision 1 of the CSMMP was implemented between October 2014 and May 2016 (Ref. 30); and Revision 2 of the CSMMP (Ref. 14) and Revision 1 of the CSMMP Supplement (Ref. 15) were implemented from May 2016. Key changes to the monitoring programs are summarised in Table 9-2.

Table 9-2: Summary of Coastal Stability Monitoring Programs

	Monitoring Program		
	Jul 2008 to Apr 2014	**Oct 2014 to May 2016**	**May 2016 onward**
Location	• *Potential impact beaches*: Terminal and Bivalve • *Reference beaches:* Inga, YCN, YCS		
Frequency	• Four times a year • After a major event	• Twice a year • After a major event	

	Monitoring Program		
	Jul 2008 to Apr 2014	Oct 2014 to May 2016	May 2016 onward
Beach Structure	*Beach Morphology* RTK GPS beach profiles measured along 25 transects on Terminal, 24 transects on Bivalve, and two transects each on Inga, YCN, and YCS beaches	*Beach Morphology* Remote sensing surveys to generate digital surface elevation models over entire beach	
Beach Sediments	*Sediment Sampling* Four locations (CBF, FA, BD, PD[1]) and at four depths (0.0 m, 0.3 m, 0.6 m, 1.0 m) along selected transects (seven on Terminal, six on Bivalve, two each on Inga, YCN, and YCS beaches) analysed for: • particle size distribution (PSD) • moisture content	Sediment Sampling Two locations (CBF, FA) and up to two depths[2] (0.0 m, 0.6 m) along selected transects (seven on Terminal, six on Bivalve, two each on Inga, YCN, and YCS beaches) analysed for PSD	
	In Situ Sediment Characteristics Profile of vertical compaction collected at four locations (CBF, FA, BD, PD[1]) along selected transects (seven on Terminal, six on Bivalve, two each on Inga, YCN, and YCS beaches)	N/A	
Visual Record	*In Situ Photography* • Photographs taken looking north, south, east, and west from each CBF sediment sampling site on all five beaches. • Alongshore photographs taken from elevated views along Terminal and Bivalve beaches.	*In Situ Photography* • Photographs taken looking north and south from each CBF sediment sampling site on Inga, YCN, and YCS beaches. • Alongshore photographs taken from elevated views along Terminal and Bivalve beaches.	
	N/A	*Aerial Photography* Aerial imagery collected annually extending over full length of coastline from north of Terminal Beach to south of YCS Beach	
Marine Turtle Nesting Habitat	N/A		*Turtle Nesting Zones* Turtle nesting zones on Terminal, Bivalve, Inga, YCN, and YCS beaches are defined and categorised as 'optimal', 'suboptimal' or 'unsuitable' based on physical beach characteristics

1. *CBF = Crest of Beach Face; FA – Foredune Area; BD = Base of Primary Dune; PD = Primary Dune. Note: PD location only sampled annually*
2. *0.6 m depth sampled at FA location only*

Coastal stability management triggers have been established for beach volume, beach slope, and sediment particle size, and data from each monitoring event are compared against the management triggers. The actions required if a management trigger exceedance occurs are set out in the CSMMP Supplement: Management Triggers (Ref. 15). Management triggers specific to changes in turtle nesting habitat, based on the amount of suitable area quantified through habitat mapping, have also been defined. These marine turtle nesting habitat management triggers only apply to the beaches adjacent to the MOF and LNG Jetty (Terminal and Bivalve), and only to data collected during the end of dry season monitoring event (Ref. 14; Ref. 15).

The 2015–2020 monitoring results, including any detected exceedances and major event monitoring, are summarised in the following tables.

Monitoring Program: Beach Structure

Objective:

- Detect changes to the beaches adjacent to the marine facilities that may affect the stability of those beaches by measuring beach profile, beach volume, and quantifying the extent of any erosion or accretion of sediment over time.

Methodology:

- Remote sensing surveys are completed twice each year (at the end of the dry and wet seasons where practicable, typically October and April). These surveys capture horizontal (x,y-plane) and vertical (z-plane) data to generate digital surface models over the entire beach (landward of the primary dune to the waterline) at Terminal, Bivalve, Inga, YCN, and YCS beaches.
- Topographic surveys (using remote sensing or RTK GPS methods) to record beach morphology are also undertaken, where practicable, after a major event.

Survey Timing

- Beach structure was monitored by routine twice-yearly surveys using remote sensing (LiDAR) during the 2015–2020 Reporting Period (Table 9-3), in accordance with Revisions 1 and 2 of the CSMMP (Ref. 30; Ref. 14). There were two exceedances of the major event trigger and one near-exceedance event, which also resulted in remote sensing survey mobilisation during the Reporting Period (August 2015, June 2017, and July 2019; Table 9-5).
- Further to the formal surveys summarised in Table 9-3, ad hoc photo monitoring and beach inspections were completed in response to notable weather events. These surveys were voluntary; remote sensing was not mobilised for these events because meteorological conditions did not exceed the major event[1] criteria. Further details are provided in Table 9-5.

Table 9-3: Coastal Stability Monitoring Program: Beach Structure Surveys (Aug 2015–Aug 2020)

Reporting Period[1]	Routine Monitoring	Major Event Monitoring
	Remote Sensing[2]	Remote Sensing[2]
2015–2016	Nov 2015, Apr 2016	Aug 2015[3]
2016–2017	Oct 2016, May 2017	Jun 2017[4]
2017–2018	Oct 2017, May 2018	
2018–2019	Oct 2018, April 2019[5]	Jul 2019[3]
2019–2020	Nov 2019, May 2020	

1. *Annual EPR period includes those surveys undertaken between 10 August–9 August each year.*
2. *Revision 1 and 2 of the CSMMP (October 2014–May 2016 and May 2016 onwards, respectively) required remote sensing surveys be undertaken at monitoring beaches (Ref. 14; Ref. 30). This was a change from Revision 0 of the CSMMP, which required RTK GPS transects (July 2008–October 2014, Ref. 31).*
3. *The trigger for major event monitoring was reached on 17 July 2015 and 8 July 2019, and remote sensing surveys were subsequently mobilised. Although the July 2015 storm occurred outside of this 2015–2020 Reporting Period, the survey was undertaken after 10 August 2015 and therefore is included in this report.*

1 Major event: a sustained period (four days or longer) of winds with an easterly component (NNE to SSE), during which the total duration of winds >18 knots is ≥96 hours recorded at Barrow Island (Ref. 14).

<table>
<tr><th colspan="2">Monitoring Program: Beach Structure</th></tr>
<tr><td></td><td>
4. The trigger for major event monitoring was almost exceeded in June 2017 (10 hours short of exceeding the trigger; Ref. 35) and a remote sensing survey was voluntarily mobilised.
5. The April 2019 post-wet season survey occurred immediately after Tropical Cyclone (TC) Veronica. Although TC Veronica did not exceed the major event trigger, it was considered notable due to simultaneous timing with an astronomical high tide, and additional analyses were undertaken to quantify the impact of this event on the east coast beaches (Ref. 16).
</td></tr>
<tr><td>Results:</td><td>
Surface Elevation – Patterns of Erosion and Accretion

Measurements of surface elevation are presented using data from the post-dry season surveys (typically captured in October each year). The results represent changes between the most recent post-dry season survey and:

baseline conditions (October 2009–November 2019)
the beginning of this Reporting Period (October 2015–November 2019)
the previous year (October 2018–November 2019).

Surface elevation changes can highlight areas where erosion and accretion have occurred on the beaches between two time periods and are presented for all Impact and Reference beaches. Results indicate a realignment of sediment towards the MOF at Terminal, Bivalve, and Inga beaches, with a similar pattern evolving at YCN Beach over the Reporting Period.

Terminal Beach

Between October 2009 and November 2019, Terminal Beach eroded at the northern end of the beach and accreted at the southern end, adjacent to the MOF, with some accretion also evident in the creek bed (approximately halfway along the beach; (Figure 9-1).
Between October 2015 and November 2019, the trend at Terminal Beach was similar to that observed for the baseline comparison; however, most of the overall change occurred before 2015. Accretion was recorded at the southern end of Terminal Beach on the lower beach face and also in the creek bed (Figure 9-1). Erosion was recorded at the northern section of the beach, immediately north of the pipeline, and in a pocket at the southern end of the beach, possibly indicating a redistribution of sediments to the lower beach face in this area (Figure 9-1).
Between October 2018 and November 2019, erosion occurred at the southern end of Terminal Beach and accretion in the creek bed (Figure 9-1).

Bivalve Beach

Between October 2009 and November 2019, Bivalve Beach accreted at the northern end of the beach, adjacent to the MOF, and eroded at the southern end, with erosion particularly localised in the creek bed at the southern end of the beach (Figure 9-2).
Between October 2015 and November 2019, Bivalve Beach accreted at the northern end, similar to the baseline comparison (Figure 9-2). Erosion was also recorded in the northern third of the beach, corresponding to the northern boundary of exposed bedrock. Most of the overall change at Bivalve Beach occurred before 2015.
Between October 2018 and November 2019, elevation differences indicated erosion had occurred along the length of the beach at the base of the FA (Figure 9-2).

Inga Beach

Between October 2009 and November 2019, Inga Beach exhibited similar trends to Bivalve Beach, with accretion at its northern end, predominantly on the beach face. Erosion at Inga Beach starts approximately one-third of the way south along the beach and extends to the northern boundary of the natural subaerial[2] rock platform (Figure 9-3).
Between October 2015 and November 2019, Inga Beach has accreted at the northern end of the beach and eroded through the central area of the beach (Figure 9-3). The erosion is consistent with the progressive exposure of intertidal rock observed in this area.
Between October 2018 and November 2019, erosion was recorded along the central section of the Inga Beach (Figure 9-3), which is consistent with the trends observed since baseline, and over the Reporting Period.

</td></tr>
</table>

[2] A rock platform permanently exposed to the air

Monitoring Program: Beach Structure	
	YCN Beach • Between October 2009 and November 2019, YCN Beach mainly exhibited erosion at the southern end and accretion at the northern end (Figure 9-4), which may also be linked to construction of the MOF. YCN Beach is highly variable at the northern boundary, where the Terminal Creek sandbar is frequently redistributed by wave action and creek flows. • Between October 2015 and November 2019, YCN Beach recorded accretion on the active beach face over the northern half of the beach (Figure 9-4). A small area of erosion occurred on the lower beach face in the southern half of the beach. Elevation differences indicate that the erosion recorded over the southern half of the beach occurred prior to 2015, whilst the accretion in the north has occurred more recently. • Between October 2018 and November 2019, YCN Beach remained relatively stable (Figure 9-4). A small area of accretion was observed at the Terminal Creek mouth, at the northern end of the beach. *YCS Beach* • Between October 2009 and November 2019, YCS Beach exhibited accretion at the base of the foredune and erosion on the active beach face, predominantly north of the mid-point (Figure 9-5). This erosion is linked to the erosion at the southern end of YCN Beach, with the outcropping rock located around the mid-point of YCS Beach acting as a sediment cell boundary forming a southern limit to shoreline rotation. • Between October 2015 and November 2019, YCS Beach recorded predominantly erosion in pockets along the active beach zone. In the north, erosion occurred north of the outcropping rock, similar to the trend observed in the baseline comparison. In the south, erosion was also associated with sediment redistribution around intertidal rock. • Between October 2018 and November 2019, the trend at YCS Beach was similar to that observed over the Reporting Period. Elongated pockets of erosion occurred on the active beach face, adjacent to intertidal rock.

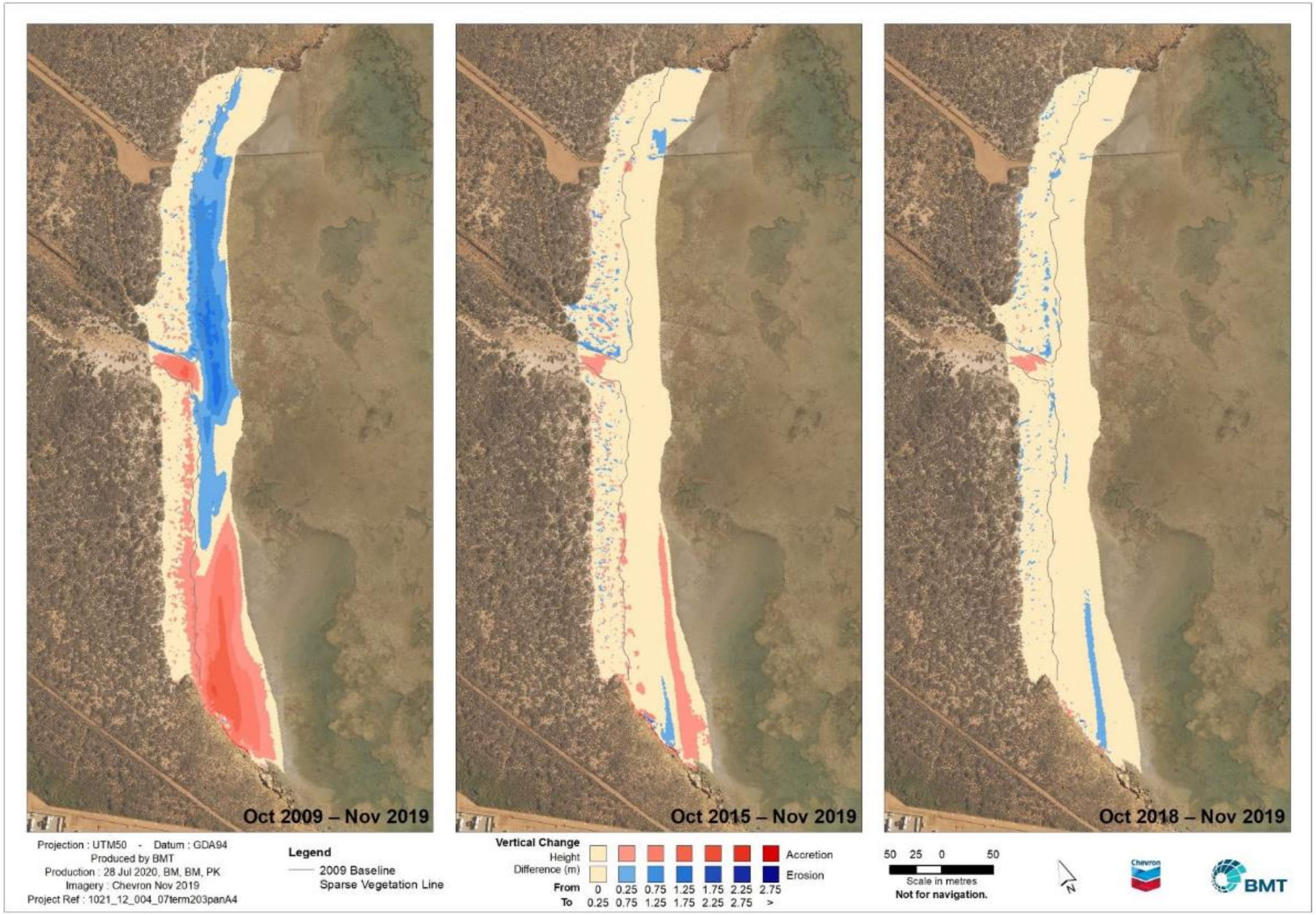


Figure 9-1: Surface Elevation Changes at Terminal Beach

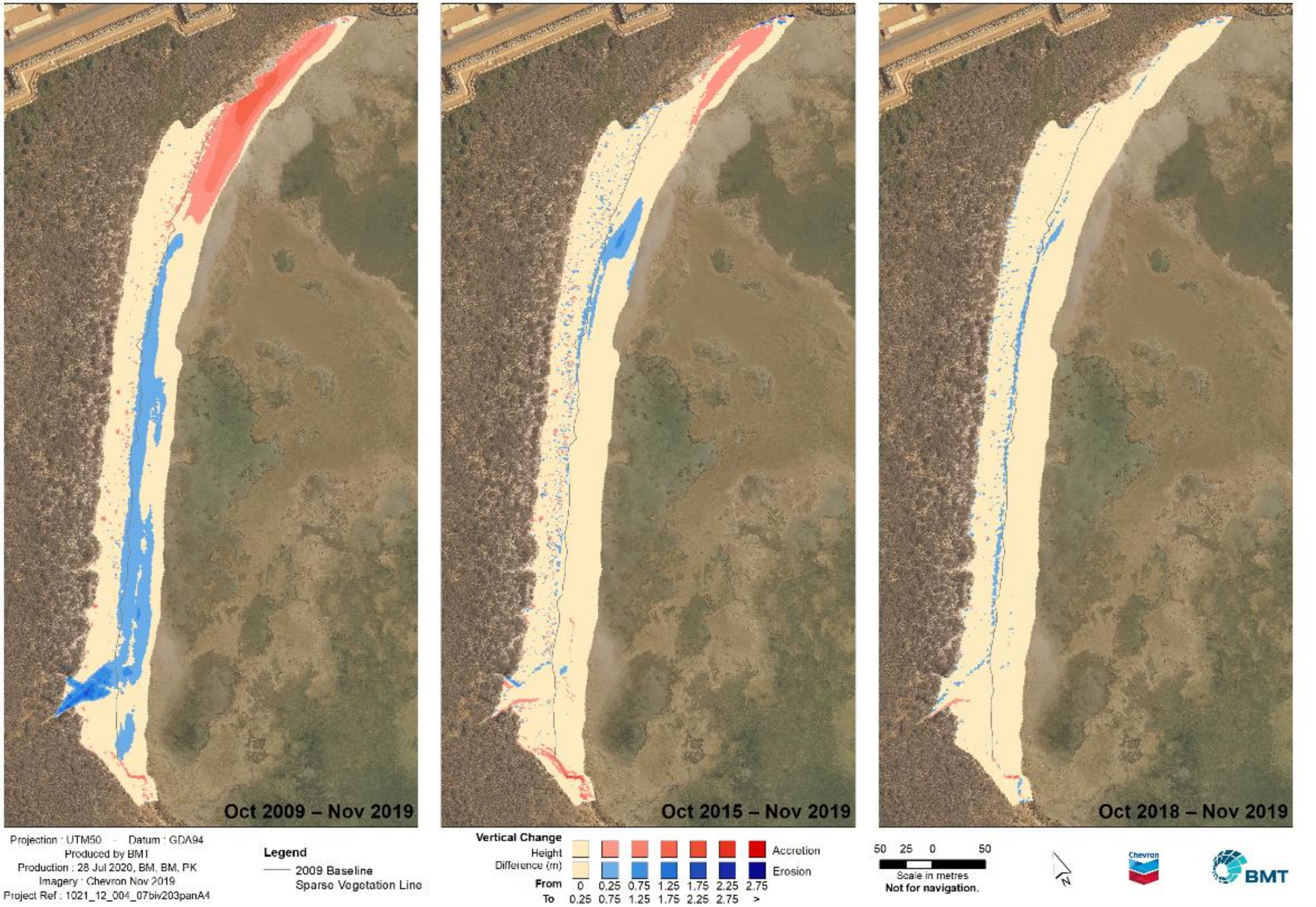


Figure 9-2: Surface Elevation Changes at Bivalve Beach

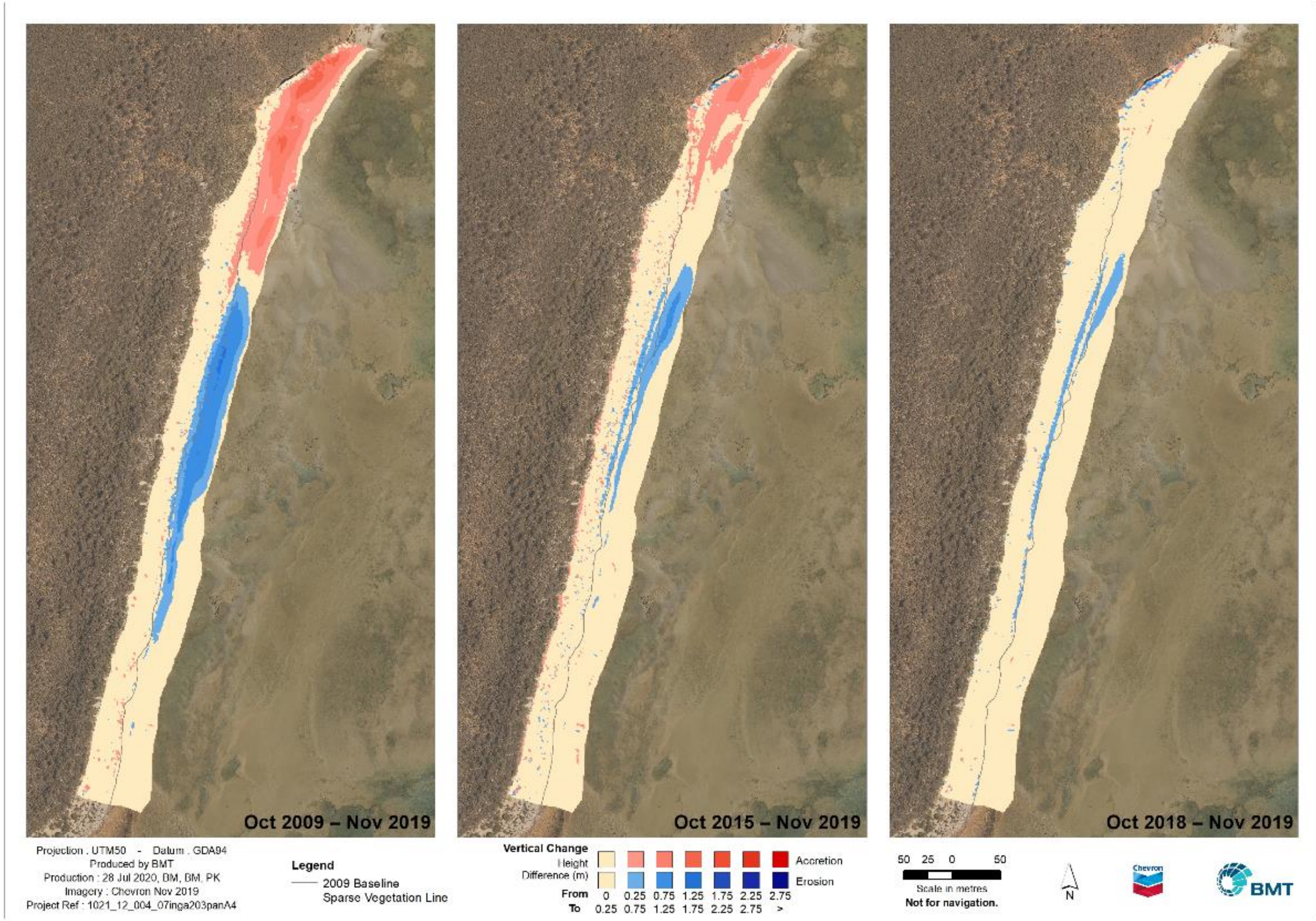


Figure 9-3: Surface Elevation Changes at Inga Beach

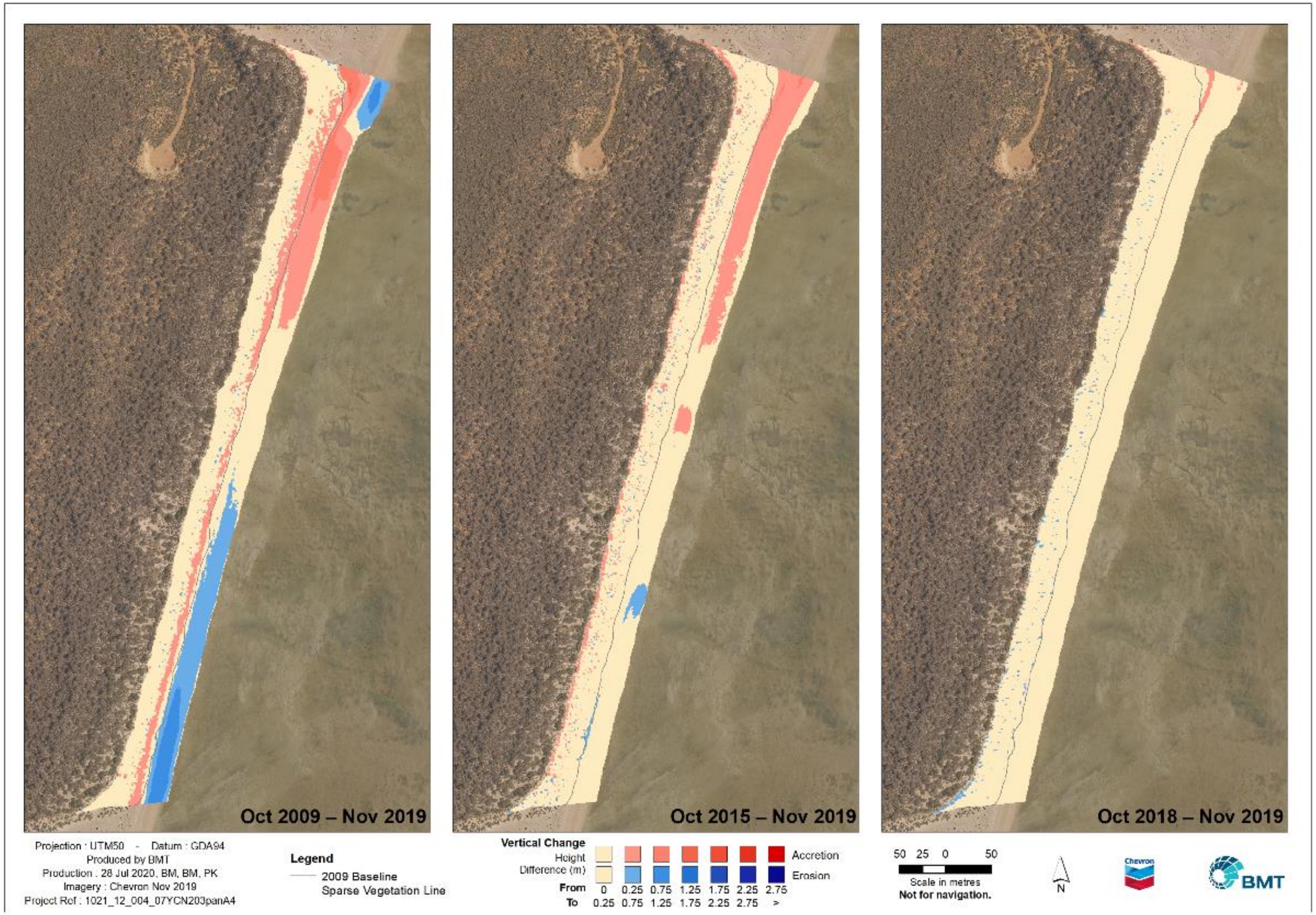


Figure 9-4: Surface Elevation Changes at YCN Beach

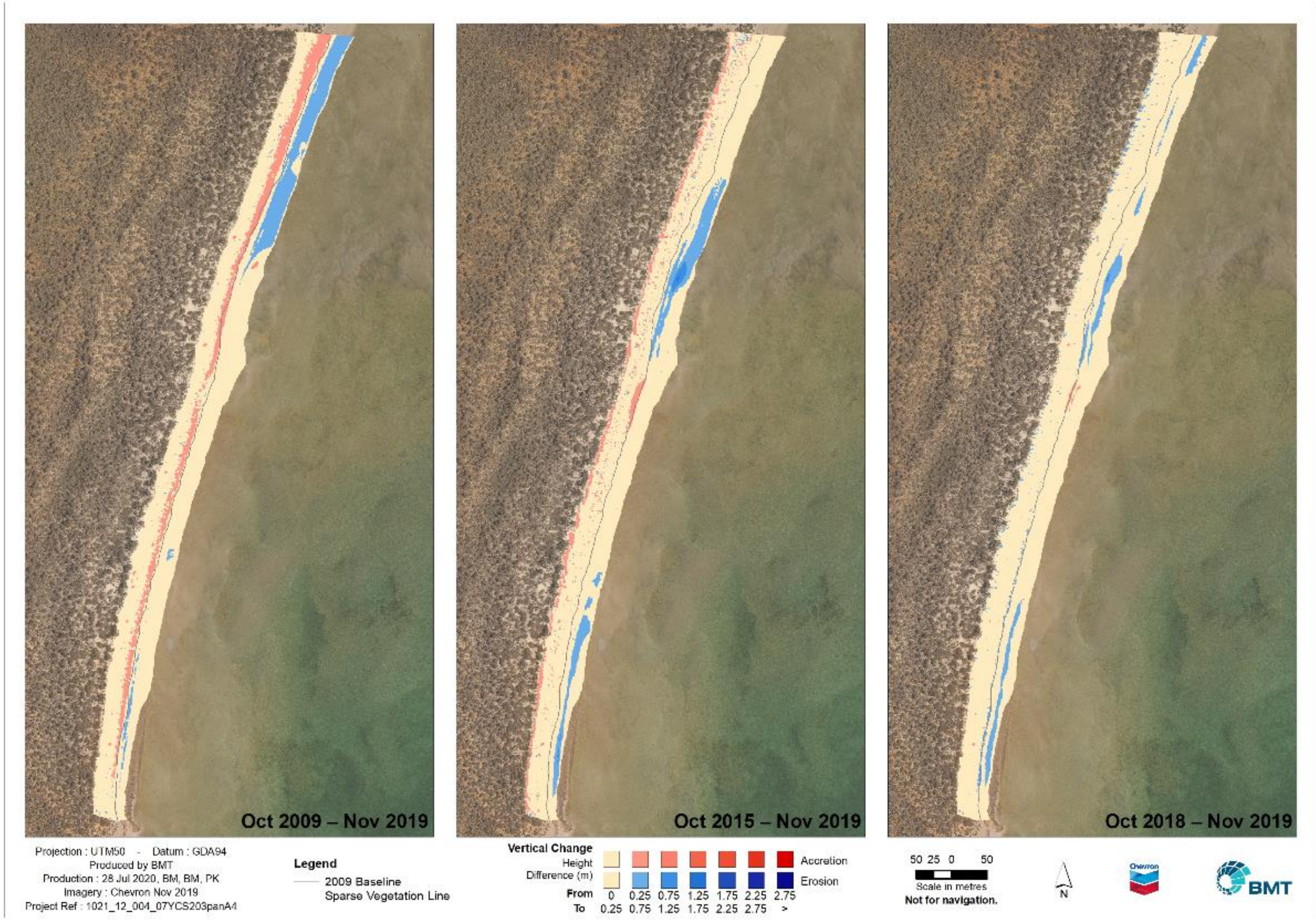


Figure 9-5: Surface Elevation Changes at YCS Beach

Monitoring Program: Beach Structure

Results:

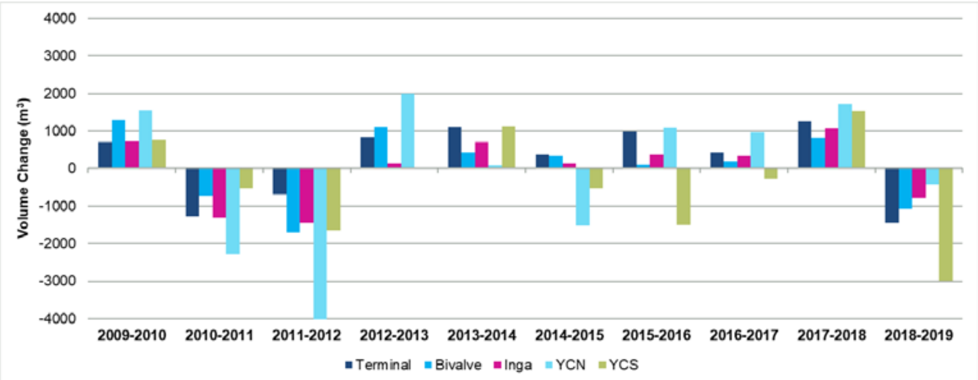
Net Volume Change

- Net sand volumes on the beaches fluctuate as a result of seasonal and interannual cycles, or significant weather events such as tropical cyclones (Ref. 32). Seasonal changes are linked to wind patterns and wave climate, whereas interannual changes can be linked to regional influences, such as water-level fluctuations (e.g. caused by the El Niño Southern Oscillation) and other metocean variables.
- Since baseline (October 2009) to November 2019, a net reduction has occurred over the active zone (i.e. below the sparse vegetation line) of all Reference beaches and a net gain has occurred on both Terminal Beach (2307 m^3) and Bivalve Beach (779 m^3; Table 9-4). This trend was the same for baseline to May 2020, where both Terminal and Bivalve beaches recorded further volume gains, and the Reference beaches recorded further volume reductions (Table 9-4). Terminal and Bivalve beaches have a greater capacity to retain sediment in the study area because sediment is captured in the shelter of the MOF, whereas Inga, YCN, and YCS beaches have more open study area boundaries.
- Over the Reporting Period, a trend of sediment gain over the active zone of the beach was recorded between 2015–2018 for all beaches except YCS (Figure 9-6, Table 9-4). A reduction in sediment volume was recorded for all beaches over 2018–2019, likely resulting from changes due to strong storm activity (Table 9-5) at Barrow Island during this period.
- Annual changes in sediment volume in the active zone of the beach has varied between years but has mostly been consistent across all beaches (i.e. all gains for the year or all losses, noting some exceptions; Figure 9-6). Annual changes suggest the sediment transport processes contribute to net sediment losses and gains occur on a regional scale.

Table 9-4: Net Volume Changes (m^3) across the Active Zone[1] of the Beach at Monitored Beaches

Beach	Length (m)	Change since Baseline		Change since Oct 2015		Annual change	
		Oct 09–Nov 19	Oct 09–May 20	Oct 15–Nov 19	Oct 15–May 20	Oct 18–Nov 19	May 19–May 20
Terminal	700	2307	2645	1243	1580	-1442	1305
Bivalve	785	779	1317	34	572	-1074	836
Inga	818	-3	-286	1030	747	-785	1084
YCN	832	-1004	-1016	3349	3338	-428	1693
YCS	1175	-4042	-4913	-3245	-4116	-3000	1070

1 *Active Zone = the beach face, defined as the area below the sparse vegetation line.*

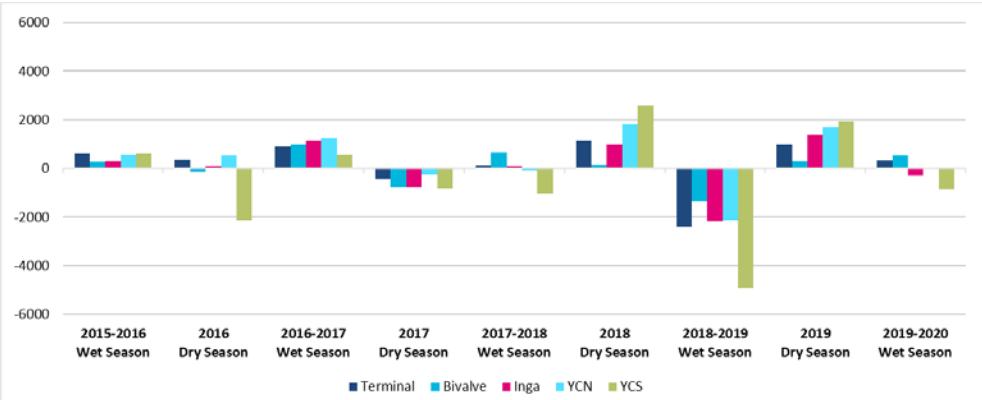


Note: Dry season: April–October; Wet season: October–April

Figure 9-6: Annual Net Volume Change of the Active Zone of the Beach (below the Sparse Vegetation Line) at Monitored Beaches, October to October, 2009–2019

Seasonal Change

- Similar to annual results (Figure 9-6), seasonal volume changes varied for seasons between different years, but typically the response for all beaches within a season was the same (i.e. all gains or all losses, with some exceptions, Figure 9-7).
- The largest volume reductions for the Reporting Period were recorded following the 2018–2019 wet season. During this wet season, the east coast beaches were inundated by a large storm surge generated by TC Veronica (Table 9-5), which caused large-scale erosion across all beaches.
- The largest volume gains were recorded following the 2018 and 2019 dry seasons. Both dry seasons featured prolonged periods of easterly winds, with an exceedance of the major event trigger occurring in June 2019 (Table 9-5). However, a prolonged period of strong easterly winds also occurred during the 2017 dry season, and volume reductions were recorded for all beaches (Table 9-5), indicating that beaches respond differently to variations in the metocean conditions produced by individual storm events.



Note: Dry season: April–October; Wet season: October–April

Figure 9-7: Seasonal Net Volume Change of the Active Zone of the Beach (below the Sparse Vegetation Line) at Monitored Beaches over the Five-year Reporting Period

Major Event Monitoring

- During the 2015–2020 Reporting Period, major event monitoring was completed for two storm events that exceeded the major event wind trigger, occurring in July 2015 and June 2019. Additional monitoring was voluntarily completed following other significant storm events to assess morphological changes under different meteorological conditions (Table 9-5).
- The greatest recorded changes resulting from a single storm event during the Reporting Period (as indicated by changes in beach volume and surface elevation) occurred following TC Veronica. Volume reductions were recorded at all beaches (Figure 9-7), and elevation changes indicated that erosion was widespread across the FA of all beaches (Ref. 16). The combination of metocean conditions (wind, wave, and tide) generated by TC Veronica resulted in a storm surge that inundated the FA, and redistributed sediment both alongshore and offshore over the intertidal platform (Ref. 16; Table 9-5).
- Results of post-storm monitoring undertaken over the Reporting Period indicate that beach response is variable and dependent upon the metocean conditions produced by each individual storm event. Waves and elevated water levels generated by infrequent, high-energy events, such as TC Veronica, are the most likely conditions to cause significant changes in beach morphology. Despite this, TC Veronica did not trigger major event monitoring, as the major event trigger is wind-driven and does not take into account wave height or tidal state. In contrast, results of events that did trigger major event monitoring were variable, but overall beach change (as indicated by net volume reductions) was minimal, and in some cases, net volume gains were identified after major events.

Table 9-5: Summary of Monitoring Completed in Response to Major Weather Events over the Reporting Period

Event	Monitoring	Results
July 2015 major event[1] (11–18 July 2015)	Remote sensing survey (19 August 2015), post-storm inspection and photographs of all monitoring beaches (2–5 August 2015), review of wind data.	• Easterly wind speeds had diurnal peaks of 25–30 knots over the storm period. • August 2015 surface elevation and volume data were assessed; results indicated the post-storm event erosion and accretion impacts were small. • All beaches except Bivalve Beach had a net loss of sediment when compared to the previous post-wet season survey (May 2015). Localised accretion was also recorded over the beach face of Bivalve, Terminal, and YCS beaches. • Between August and October 2015, all beaches except Bivalve Beach showed a net volume gain of sediment, indicating accretion had occurred over the beach face in the months following the major event. Despite the net volume reduction, Bivalve Beach also recorded localised accretion over the northern section of the beach during this time period.
Tropical Low 14U (25–30 January 2017)	Post-storm inspection and photographs of Terminal, Bivalve, and YCS beaches (6–7 February 2017), review of metocean data	• Actual tidal height exceeded the predicted astronomical tidal height by up to 0.87 m, and significant wave height peaked at 2.76 m. This coincided with wind speeds reaching ~43 knots on 28 January 2017. Winds were predominantly north-easterly during peak metocean conditions. • Despite the metocean conditions having the potential to cause beach morphology changes, no significant changes were noted during the post-storm inspection at any of the beaches inspected.
June 2017 storm (9–13 June 2017)	Remote sensing survey, post-storm inspection and photographs of all monitoring beaches (5–7 July 2017), review of metocean data	• Actual tidal height exceeded the predicted astronomical tidal height by up to 0.55 m and the maximum significant wave height peaked at 1.99 m. Easterly wind speeds had diurnal peaks of 25–30 knots over the storm period. • Metocean conditions were not as strong as Tropical Low 14U, but conditions were sustained for longer. • Net volume reductions were observed for all monitoring beaches when compared to the previous post-wet season survey (May 2017). The largest changes at Bivalve and Terminal beaches occurred adjacent to the MOF. Erosion scarps were noted at the northern ends of Bivalve and Inga beaches and profile deflation was observed at the southern end of Terminal Beach. • Beach recovery immediately following the storm was not assessed; however, volume changes for the period May 2017–October 2017 indicated there had been small volume gains following the major event at all beaches.
May 2018 storm (13–21 May 2018)	Post-storm inspection and photographs of Terminal Beach (26 May 2018), review of wind data	• Easterly wind speeds had diurnal peaks of 25–30 knots over the storm period. • Photographs taken of Terminal Beach in May 2018 were compared to photos from April 2018. The lower beach face had a steeper slope, and wrack was visible higher up the beach in May 2018. • There was no visual record of vegetation loss or dune deflation following this event.
TC Riley (24–29 January 2019)	Pre- and post-cyclone inspections and photographs of Terminal and Bivalve beaches (25 January and	• Actual tidal height exceeded the predicted astronomical tidal height by up to 0.7 m and the maximum significant wave height peaked at 1.47 m. This coincided with north-easterly winds peaking at 32 knots on 27 January 2019. Winds were predominantly north-easterly and south-westerly for the period.

Monitoring Program: Beach Structure

		3 February 2019), review of metocean data	• Photographs taken of Terminal and Bivalve beaches before and after TC Riley showed profile deflation at the southern end of Terminal Beach and at the northern end of Bivalve Beach. • There was no visual record of vegetation loss following this event.
	TC Veronica (20–27 March 2019)	Pre-, during, and post-cyclone inspections and photographs of Terminal and Bivalve beaches, review of metocean data	• Actual tidal height exceeded the predicted astronomical tidal height by up to 0.7 m and significant wave height peaked at 1.8 m. Winds peaked at 35 knots on 24 March 2019 from a north-easterly direction; however, winds were predominantly southerly and south-easterly for the period. Peak wind and wave height conditions coincided with annual highest astronomical tide causing a notable storm surge. • Photographs of Terminal Beach showed the FA was inundated during the peak storm surge, with water exceeding the high tide mark. • Terminal Creek (between Inga and YCN beaches) was flooded during the peak storm surge. • Large-scale volume reductions were recorded for all beaches following TC Veronica. Key spatial changes included erosion at the southern end of Terminal Beach, erosion along the sparse vegetation lines at Terminal, Bivalve, and Inga beaches, and beach face erosion on Yacht Club Beaches. • Greatest changes in sediment coverage occurred over the active zone of the beach, at the extremities of existing outcropping rock. • Notable reductions in foredune volume were also observed at Terminal, Bivalve, and Inga beaches; however, >90% of the baseline foredune volume remained at these beaches.
	June 2019 major event[1] (3–8 June 2019)	Remote sensing survey (8–11 July 2019), review of metocean data	• Actual tidal height exceeded the predicted astronomical tidal height by up to 0.5 m and significant wave height peaked at 2.2 m. Easterly winds peaked at 38 knots on 3 June 2019. • Net accretion was recorded for all beaches, relative to the most recent post-wet season survey (May 2019). Volume gains indicated some recovery from the erosion caused by TC Veronica. Most accretion occurred on the lower beach face, likely resulting from alongshore sediment redistribution. • Despite the widespread accretion recorded, the FA at the northern end of Terminal Beach recorded erosion, but >90% of the baseline foredune volume remained. • Accretion in July 2019 did not typically occur in the same location on the beaches as the erosion in May 2019, with the exception of YCS Beach, which may signify a limited potential for beaches to recover following large storm events. • When comparing the effects of TC Veronica to the June major event, patterns of erosion and accretion were variable, showing the beaches respond differently to variations in metocean conditions, which are specific to each storm.
	TC Damien (3–9 February 2020)	Pre- and post-cyclone inspections and photographs (7 February and 14 February 2020), review of metocean data	• Winds were predominantly from the south-west and peaked at 40 knots, and significant wave height reached 2.7 m. Actual tidal height exceeded the predicted astronomical tidal height by 0.6 m. • Structural beach changes were visible in photographs from before and after the cyclone, including steeper beach face profiles at Bivalve and Terminal beaches after the storm.

Monitoring Program: Beach Structure

		• Photographs from the post-storm inspection showed that sediment had been moved offshore at Terminal Beach after the cyclone and distributed over the intertidal platform. A large accumulation of wrack was noted at the northern end of Bivalve Beach.

1. Major event: a sustained period (four days or longer) of winds with an easterly component (NNE to SSE), during which the total duration of winds >18 knots is ≥96 hours recorded at Barrow Island (Ref. 14).

Management Trigger Exceedances

- Exceedances of Management Triggers at Terminal and Bivalve beaches have been detected since July 2010. Investigations of these exceedances attributed the cause to both natural variability and beach realignment due to the presence of the MOF.

Terminal Beach

- During the Reporting Period, management trigger exceedances were recorded for both volume and slope at monitored transects on Terminal Beach (T11 and T22); however, the number of exceedances recorded varied between surveys (Table 9-6).
- Key observations include:
  - Volume exceedances at T11 at both the CBF and FA for all surveys over the Reporting Period, corresponding to an increase in volume across the profile.
  - Slope exceedances at T11 FA for all surveys, corresponding to a decrease in the angle of the slope (i.e. flattening) at the FA.
  - Volume exceedances at T22 CBF and FA for all surveys over the Reporting Period, corresponding to a decrease in volume at the CBF, and an increase in volume at the FA.

Table 9-6: Management Trigger Exceedances at Terminal Beach During the Five-year Reporting Period

Transect	Survey Date		Volume Trigger				Slope Trigger			
			1	2	3	4	1	2	3	4
11	Nov 2015	CBF	X	X	X	X	-	-	-	-
		FA	X	X	X	X	X	X	X	X
	Apr 2016	CBF	X	X	X	X	-	-	-	-
		FA	X	X	X	X	-	X	X	X
	Oct 2016	CBF	X	X	X	X	-	-	-	-
		FA	X	X	X	X	X	X	X	X
	May 2017	CBF	X	X	X	X	-	-	-	-
		FA	X	X	X	X	-	X	X	X
	Oct 2017	CBF	X	X	X	X	-	-	-	-
		FA	X	X	X	X	X	X	X	X
	May 2018	CBF	X	X	X	X	-	-	-	-
		FA	X	X	X	X	X	X	X	X
	Oct 2018	CBF	X	X	X	X	-	-	-	-
		FA	X	X	X	X	X	X	X	X
	Apr 2019	CBF	X	X	X	X	X	-	-	-
		FA	X	X	X	X	X	X	X	X
	Nov 2019	CBF	X	X	X	X	-	X	-	-
		FA	X	X	X	X	X	X	X	X
	May 2020	CBF	X	X	X	X	-	X	-	-
		FA	X	X	X	X	X	X	X	X

Monitoring Program: Beach Structure

22	Nov 2015	CBF	X	X	X	X	-	-	-	-
		FA	-	X	-	-	-	X	-	-
	Apr 2016	CBF	X	X	X	X	-	-	-	-
		FA	-	X	-	-	-	X	-	-
	Oct 2016	CBF	X	X	X	X	-	-	-	-
		FA	-	X	X	-	-	X	X	-
	May 2017	CBF	X	X	X	X	-	-	-	-
		FA	-	X	X	-	-	-	-	-
	Oct 2017	CBF	X	X	X	X	-	-	-	-
		FA	-	X	X	-	-	-	-	-
	May 2018	CBF	X	X	X	X	-	-	-	-
		FA	-	X	X	-	-	-	-	-
	Oct 2018	CBF	X	X	X	X	-	-	-	-
		FA	-	X	X	X	X	X	-	-
	Apr 2019	CBF	X	X	X	X	-	-	-	-
		FA	-	X	X	X	-	X	-	-
	Nov 2019	CBF	X	X	X	X	-	-	-	-
		FA	-	-	X	X	X	X	-	-
	May 2020	CBF	X	X	X	X	-	-	-	-
		FA	-	-	-	X	X	X	X	-

1 *Trigger 1 = single point ±3 SD from the baseline mean; Trigger 2 = two out of three consecutive points ±2 SD from the baseline mean; Trigger 3 = four out of five consecutive points ±1 SD from the baseline mean; Trigger 4 = eight consecutive points on the same side of the baseline mean.*

2 *'X' = exceedance, increase from baseline; 'X' = exceedance, decrease from baseline; '-' = no exceedance.*

Bivalve Beach

- During the Reporting Period, management trigger exceedances were recorded for both volume and slope at monitored transects on Bivalve Beach (B11 and B22); however, the number of exceedances recorded varied between surveys (Table 9-7).
- Key results include:
  - Volume exceedances at B11 CBF for all surveys over the Reporting Period, corresponding to an increase in volume in the active zone of the beach.
  - Volume exceedances at B22 CBF for all surveys over the Reporting Period, corresponding to a decrease in volume in the active zone of the beach.
  - Slope exceedances at B22 CBF for all surveys over the Reporting Period, corresponding to an increase in the angle of the slope (i.e. steepening) at the CBF.

Table 9-7: Management Trigger Exceedances at Bivalve Beach During the Five-year Reporting Period

Transect	Survey Date		Volume Trigger				Slope Trigger			
			1	2	3	4	1	2	3	4
11	Nov 2015	CBF	X	X	X	X	-	-	-	X
		FA	-	-	X	-	-	-	-	-
	Apr 2016	CBF	X	X	X	X	-	-	-	X
		FA	-	-	-	-	-	-	-	-
	Oct 2016	CBF	X	X	X	X	X	X	-	X

Monitoring Program: Beach Structure

		FA	-	-	-	-	-	-	-	-
	May 2017	CBF	X	X	X	X	X	X	-	X
		FA	-	-	-	-	X	-	-	-
	Oct 2017	CBF	X	X	X	X	-	X	X	-
		FA	-	-	-	-	-	-	-	-
	May 2018	CBF	X	X	X	X	-	X	X	X
		FA	-	-	-	-	-	-	-	-
	Oct 2018	CBF	X	X	X	X	X	X	X	X
		FA	-	-	-	-	-	-	-	-
	Apr 2019	CBF	X	X	X	X	-	X	X	-
		FA	-	-	-	-	-	-	-	-
	Nov 2019	CBF	X	X	X	X	-	-	-	-
		FA	-	-	-	-	-	-	-	-
	May 2020	CBF	X	X	X	X	-	-	-	-
		FA	-	-	-	-	-	-	-	-
22	Nov 2015	CBF	X	X	X	X	-	-	-	X
		FA	-	-	-	-	-	-	-	-
	Apr 2016	CBF	X	X	X	X	-	-	-	X
		FA	-	-	-	-	-	-	-	-
	Oct 2016	CBF	X	X	X	X	-	-	-	X
		FA	-	-	X	-	X	-	-	-
	May 2017	CBF	X	X	X	X	-	-	-	X
		FA	-	-	X	-	-	-	-	-
	Oct 2017	CBF	X	X	X	X	-	-	-	X
		FA	-	X	X	-	-	-	-	-
	May 2018	CBF	X	X	X	X	-	-	X	X
		FA	-	X	X	-	-	-	-	-
	Oct 2018	CBF	X	X	X	X	-	X	X	X
		FA	-	X	X	X	-	-	-	-
	Apr 2019	CBF	X	X	X	X	-	X	X	X
		FA	-	-	X	-	X	-	-	-
	Nov 2019	CBF	X	X	X	X	-	-	-	X
		FA	-	-	-	-	X	X	-	-
	May 2020	CBF	X	X	X	X	-	-	-	X
		FA	-	-	-	-	X	X	-	-

1 *Trigger 1 = single point ±3 SD from the baseline mean; Trigger 2 = two out of three consecutive points ±2 SD from the baseline mean; Trigger 3 = four out of five consecutive points ±1 SD from the baseline mean; Trigger 4 = eight consecutive points on the same side of the baseline mean.*

2 *'X' = exceedance, increase from baseline; 'X' = exceedance, decrease from baseline; '-' = no exceedance.*

Monitoring Program: Beach Sediments	
Objective:	• Detect changes to beach sediments as a result of the presence of the MOF and LNG Jetty.
Methodology:	• Sediment sampling is completed twice a year (at the end of the dry and wet seasons where practicable, typically October and April) at two locations (CBF and FA), and up to three depths (0.0 m, 0.3 m, 0.6 m) along selected transects (seven on Terminal, six on Bivalve, and two each on Inga, YCN, and YCS beaches). Samples are analysed to measure changes in PSD over time. • Beach sediment sampling is also undertaken after a major (weather) event, where practicable.
Results:	• Changes in sediment sample PSDs can indicate transport dynamics on the monitored beaches. Changes observed at Barrow Island since baseline and over the Reporting Period indicate that longshore[3] transport far exceeds the rate of cross-shore[4] transport, particularly as the greatest changes were observed at sites in the active zone of the beach (CBF sites), with fewer changes occurring at FA sites, where turtles nest. Over the Reporting Period, finer sediments (i.e. fines and sand) have been transported towards the MOF on Terminal and Bivalve beaches, with coarser, heavier sediments (i.e. gravel) remaining in situ. This has increased the gravel fraction in surface samples from eroding sections of the beach furthest from the MOF—a change that is typical of longshore sediment redistribution • PSDs of surface samples (0.0 m) are displayed in Figure 9-8 to Figure 9-11 for monitoring transects at Terminal Beach (T11, T22) and Bivalve Beach (B11, B22) to demonstrate sediment composition changes occurring at the southern and northern sections of each beach over the Reporting Period. Summaries of sediment composition changes at Inga, YCN, and YCS beaches are also provided, and additional graphs are displayed in Figure 9-12 to Figure 9-17. • Sediment samples collected at FA 0.6 m sites are used to inform the placement of nesting zones in the marine turtle nesting habitat maps (see Figure 9-19 to Figure 9-23). **Seasonal Monitoring** *Terminal Beach* • Over the Reporting Period, sediment coverage at Terminal Beach has decreased and sediments have coarsened within CBF sediments at the northern end of the beach, such that bedrock has been exposed at the most northern CBF sites, including T22, which has had no sediment coverage since May 2018 (Figure 9-9). Minor variations in PSD have been observed at T11 CBF (southern end of Terminal Beach), with fines and gravel portions contributing <5% to the distribution for each survey in the Reporting Period (Figure 9-8). • At the southern end of Terminal Beach (T11), no notable changes in PSD have occurred in FA samples (Figure 9-8). At the northern end (T22), the amount of gravel in FA samples has decreased since November 2015 (Figure 9-9).

[3] The process of sediments being transported along a coast parallel to the shoreline
[4] The process of sediments being transported across a beach, perpendicular to the shoreline

Monitoring Program: Beach Sediments

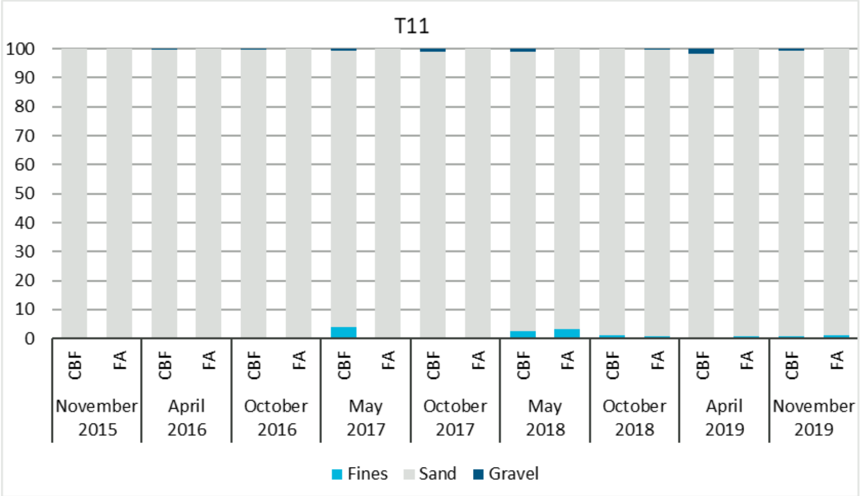
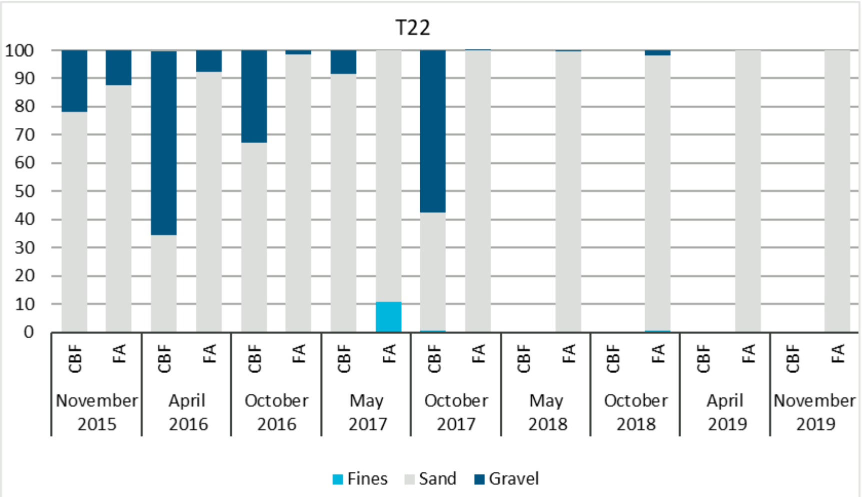


Figure 9-8: PSD of Sediment Samples at T11 (southern end of Terminal Beach) for Routine Biannual Surveys, November 2015–November 2019



Note: Blank values = sediment sample could not be collected due to insufficient sediment coverage

Figure 9-9: PSD of Sediment Samples at T22 (northern end of Terminal Beach) for Routine Biannual Surveys, November 2015–November 2019

Bivalve Beach

- At Bivalve Beach, a decrease in the gravel component of CBF sediments at the northern end of the beach has been recorded over the Reporting Period (B11, Figure 9-10), indicating a fining of CBF sediments close to the MOF. At the southern end of the beach, CBF sediments have been variable and generally indicate coarsening in this area (Figure 9-11). A sediment sample was unable to be collected at B22 CBF in November 2019, as there was insufficient sediment coverage at this site.
- No notable trends have occurred at B11 and B22 FA sites on Bivalve Beach in the Reporting Period (Figure 9-10 and Figure 9-11).

Monitoring Program: Beach Sediments

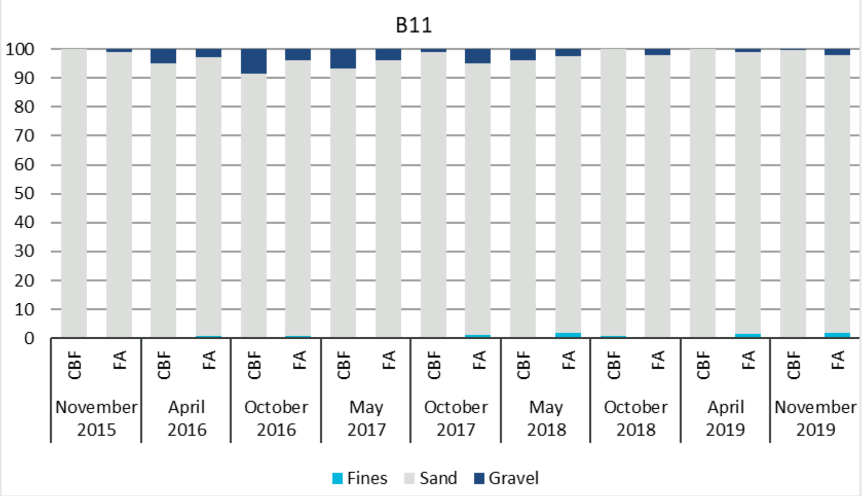
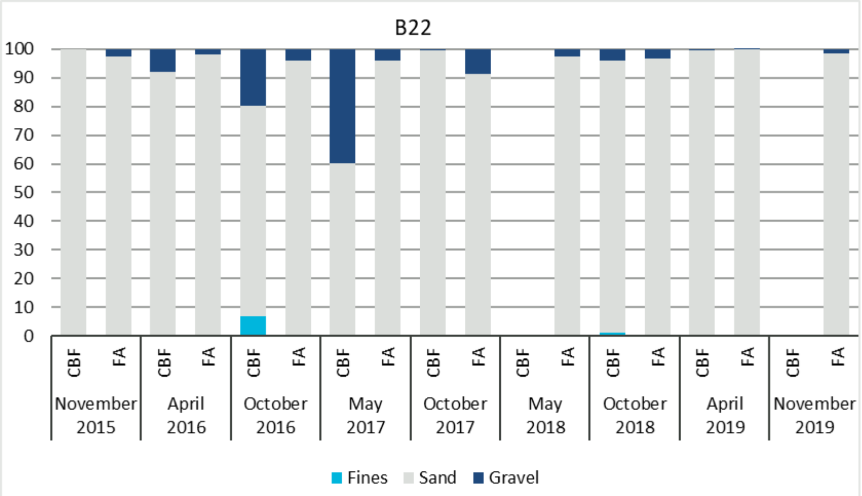


Figure 9-10: PSD of Sediment Samples at B11 (northern end of Bivalve Beach) for Routine Biannual Surveys, November 2015–November 2019



Note: Blank = sediment sample could not be collected due to insufficient sediment coverage

Figure 9-11: PSD of Sediment Samples at B22 (southern end of Bivalve Beach) for Routine Biannual Surveys, November 2015–November 2019

Inga, YCN, and YCS Beaches

- At the northern transect at Inga Beach (I1), the gravel portion in CBF sediments has gradually decreased, with negligible gravel recorded in the most recent three surveys at this location (Figure 9-12). FA sediments in the north have recorded small variations in the portions of fines and gravel, but no longer-term trend is evident. There has been no notable change in PSD at the southern transect (I2) for both CBF and FA sediments over the Reporting Period; however, a sample was unable to be collected during the April 2019 survey due to insufficient sediment coverage (Figure 9-13).
- At YCN and YCS beaches there has been little notable change in PSD over the Reporting Period, with minor fluctuations in composition observed annually and seasonally (Figure 9-14 to Figure 9-17).

Monitoring Program: Beach Sediments

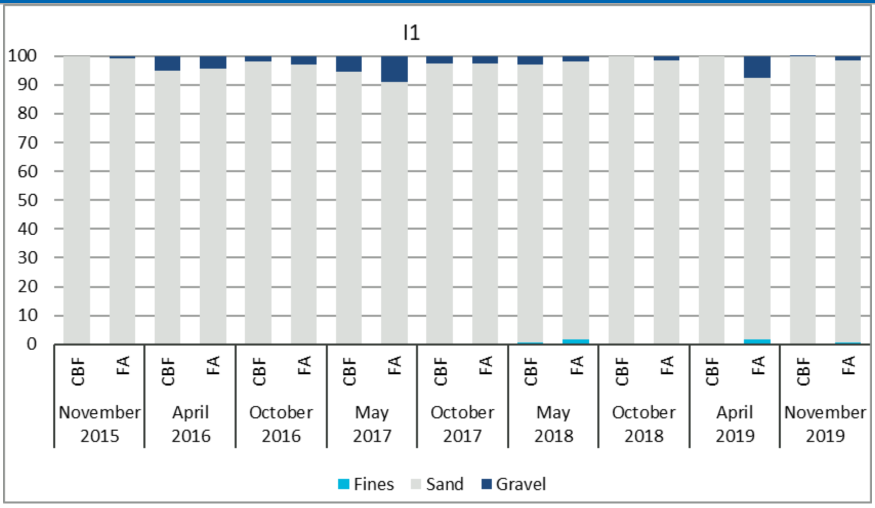
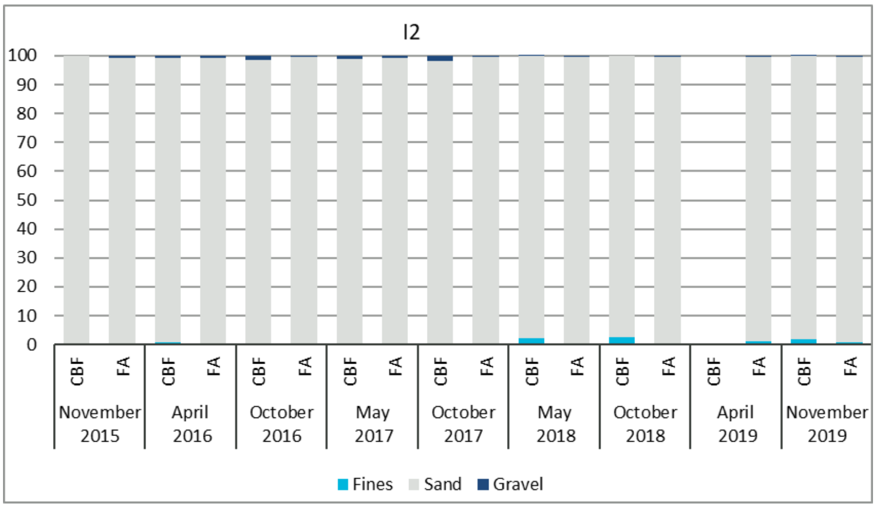


Figure 9-12: PSD of Sediment Samples at I1 (northern end of Inga Beach) for Routine Biannual Surveys, November 2015–November 2019



Note: Blank = sediment sample could not be collected due to insufficient sediment coverage

Figure 9-13: PSD of Sediment Samples at I2 (northern end of Inga Beach) for Routine Biannual Surveys, November 2015–November 2019

Monitoring Program: Beach Sediments

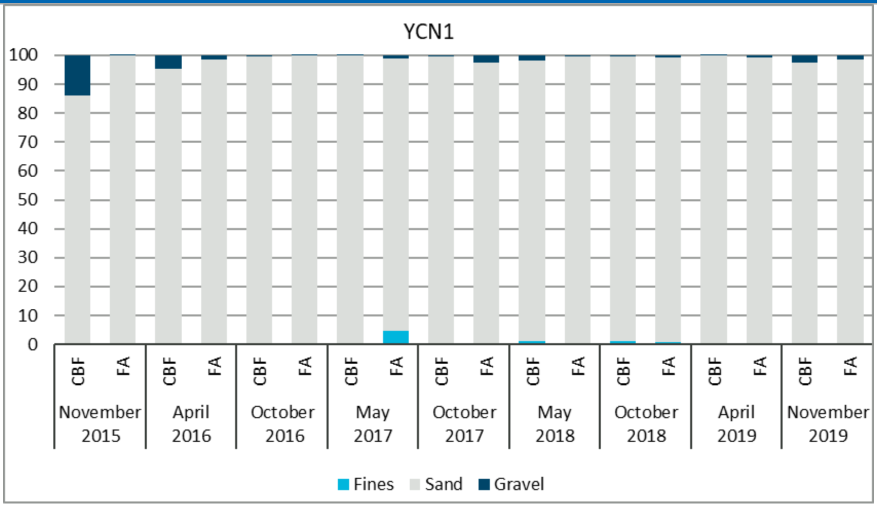


Figure 9-14: PSD of Sediment Samples at YCN1 (northern end of YCN Beach) for Routine Biannual Surveys, November 2015–November 2019

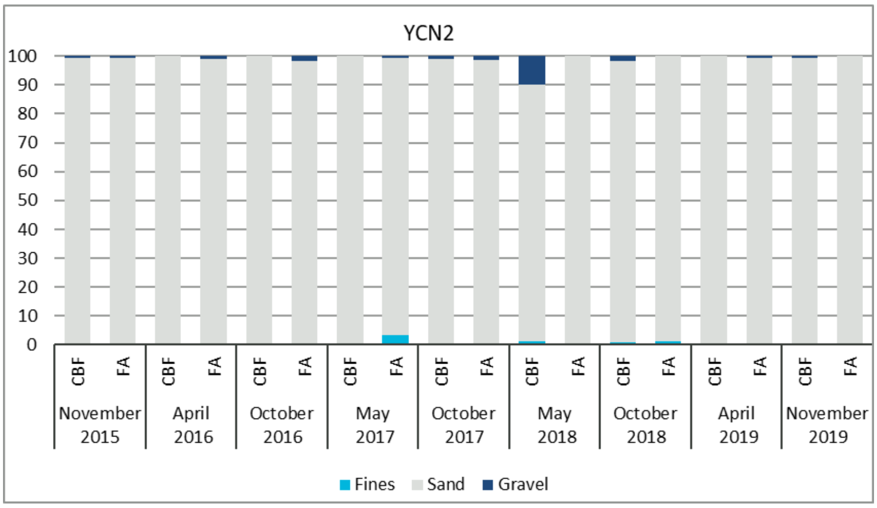
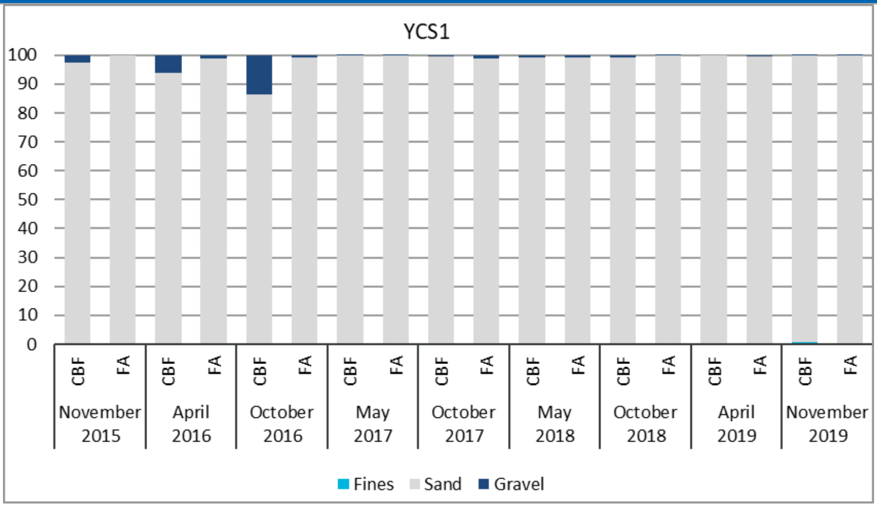
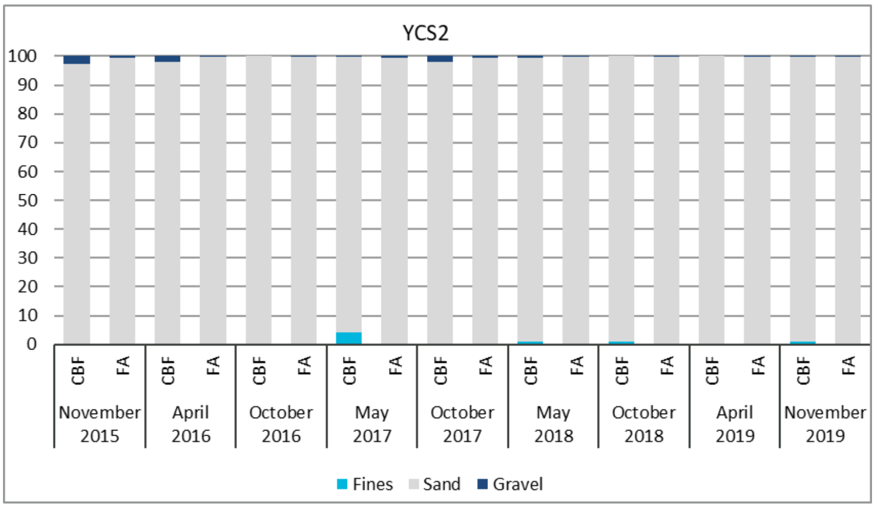


Figure 9-15: PSD of Sediment Samples at YCN2 (southern end of YCN Beach) for Routine Biannual Surveys, November 2015–November 2019

Monitoring Program: Beach Sediments	
	 **Figure 9-16: PSD of Sediment Samples at YCS1 (northern end of YCS Beach) for Routine Biannual Surveys, November 2015–November 2019**  **Figure 9-17: PSD of Sediment Samples at YCS2 (southern end of Yacht Club South Beach) for Routine Biannual Surveys, November 2015–November 2019**
Management Trigger Exceedances:	• The beach sediment management trigger is qualitative and based on a change from baseline sediment characteristics. At some sites, the management trigger can no longer be assessed due to erosion. Due to this, and the qualitative nature of the management trigger, no exceedances of management triggers for sediment PSD were identified during the Reporting Period.

Monitoring Program: Marine Turtle Nesting Habitat	
Objective:	• Detect adverse changes to the beach structure and beach sediments (as a result of the presence of the MOF and LNG Jetty) that could have implications for marine turtle nesting on the beaches adjacent to these marine facilities.
Methodology:	• Multiple physical beach characteristics were used to categorise and map the suitability of areas on each beach for marine turtle nesting. Areas were categorised as one of three zones: – Optimal Nesting Zone: characteristics of the measured physical parameters within the study area are considered ideal for marine turtle nesting

Monitoring Program: Marine Turtle Nesting Habitat	
	– Suboptimal Nesting Zone: characteristics of the measured physical parameters within the study area are considered less than ideal but may still allow successful marine turtle nesting – Unsuitable Nesting Zone: characteristics of the measured physical parameters within the study area are unlikely to allow successful marine turtle nesting. • Physical characteristics used to classify the nesting habitat zones include: landward and seaward boundaries, presence of rock (e.g. intertidal rock, subaerial rock), sediment composition, sand depth, and other (e.g. presence of infrastructure, discontinuous nesting areas within otherwise unsuitable area).
Results:	• The total available (defined as optimal + suboptimal) nesting zone for the mapped Barrow Island beaches in October 2009 was 14.7 ha (89% was optimal nesting zone); this decreased to 11.6 ha (73% optimal nesting zone) by November 2019 (Ref. 32). • The changes in nesting zone classifications varied between individual beaches, with the greatest changes observed on Terminal, Bivalve, and Inga beaches (Figure 9-18 to Figure 9-23). These changes were primarily related to an increase in the amount of intertidal rock exposed on the beaches over time, resulting in optimal nesting habitat being reclassified as either suboptimal or unsuitable as sandy access pathways to the foredunes were eroded. • Exposure of intertidal rock over time is due to the progressive realignment (due to longshore sediment redistribution) of Terminal, Bivalve, and Inga beaches towards the MOF, causing a gain in optimal nesting area at the beach end closest to the MOF (northern end for Bivalve and Inga beaches, southern end for Terminal Beach); and a loss in optimal nesting area at the opposite end. *Terminal Beach* • The area of optimal nesting zone at Terminal Beach has progressively decreased between 2009 (2.25 ha) and 2019 (0.77 ha). The northern two-thirds of the beach have undergone the greatest change, due to exposed intertidal rock restricting turtle access to nesting habitat (Figure 9-19). The southern third of the beach is mostly optimal habitat, with some areas of shallow sand depth to bedrock restricting nesting adjacent to the limestone headland at Town Point (Figure 9-19). • Since 2015, further exposure of the subaerial rock platform at the northern section of Terminal Beach has caused the small remnant sections of optimal and suboptimal nesting zones to be reclassified as unsuitable; however, the reduction in optimal nesting area at Terminal Beach has been small over the Reporting Period (−2.8% of study area; Figure 9-18, Figure 9-19). *Bivalve Beach* • At Bivalve Beach, the intertidal rock has been progressively exposed since 2009, and in 2019 had restricted turtle access to the southern two-thirds of the beach (Figure 9-20). The total area of optimal nesting zone at Bivalve Beach has reduced from 2.10 ha in 2009 to 0.68 ha in 2019. The northern end of Bivalve Beach has recorded an increase in optimal nesting habitat in recent years, where there was previously unsuitable habitat in 2009 due to inadequate sediment depth adjacent to the limestone headland at Town Point (Figure 9-20). • Since 2015, sediment deposition at the northern end of Bivalve Beach has continued such that further optimal nesting area has become available adjacent to the MOF, and the decrease in the amount of optimal nesting area has been small over the Reporting Period (−1.6% of study area; Figure 9-18, Figure 9-20). At the southern end of the beach, ongoing exposure of the subaerial rock platform has recategorised the remaining suboptimal nesting area to unsuitable nesting habitat. *Inga Beach* • Inga Beach has undergone similar changes to those observed at Bivalve Beach, such that the intertidal rock along the southern section of Inga Beach has been progressively exposed since 2009 (Figure 9-21). As a result, the total area of optimal nesting zone has decreased from 1.86 ha in 2009 to 0.72 ha in 2019. However, the area of optimal nesting habitat at the northern end of the beach has expanded further north as beach sediments have accreted in this area to cover previously exposed intertidal rock. • Since 2015, the amount of intertidal rock exposed has approximately doubled in the southern two-thirds of Inga Beach, halving the amount of optimal nesting zone area

Monitoring Program: Marine Turtle Nesting Habitat

(Figure 9-21, Figure 9-18). It appears the rate of change in optimal nesting habitat at Inga Beach has been greater for the period 2015–2019 (−12.4% of study area) when compared to the period 2009–2015 (−5.4% of study area; Figure 9-18).

YCN Beach

- At YCN Beach, the entire length of the beach is suitable for nesting and no major changes to the area of optimal nesting have occurred since 2009 (Figure 9-18, Figure 9-22). A small circular area was classified as suboptimal in 2015 due to suboptimal sediment grain size characteristics, but has reverted to an optimal sediment composition in subsequent years (Figure 9-22).

YCS Beach

- Minimal changes to turtle nesting areas at YCS Beach have occurred since 2009, with small losses in optimal and suboptimal nesting areas occurring between 2015 and 2019 as a result of intertidal rock exposure along the central and southern sections of the beach (Figure 9-18, Figure 9-23).

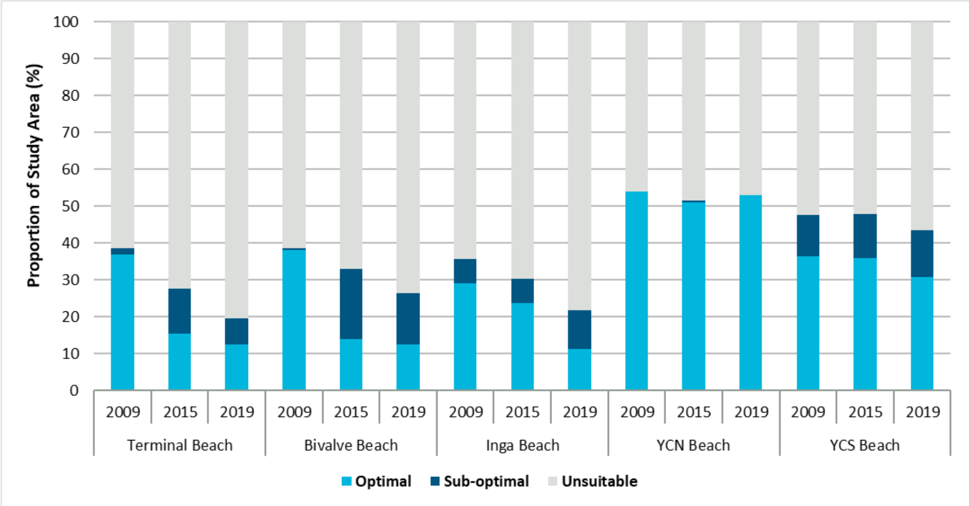


Figure 9-18: Proportions (%) of Marine Turtle Nesting Habitat Zones for Monitored Beaches in October 2009 (Baseline), October 2015, and November 2019

Management Trigger Exceedances:

- No exceedances of the marine turtle nesting habitat management triggers occurred during the Reporting Period at Terminal or Bivalve beaches.

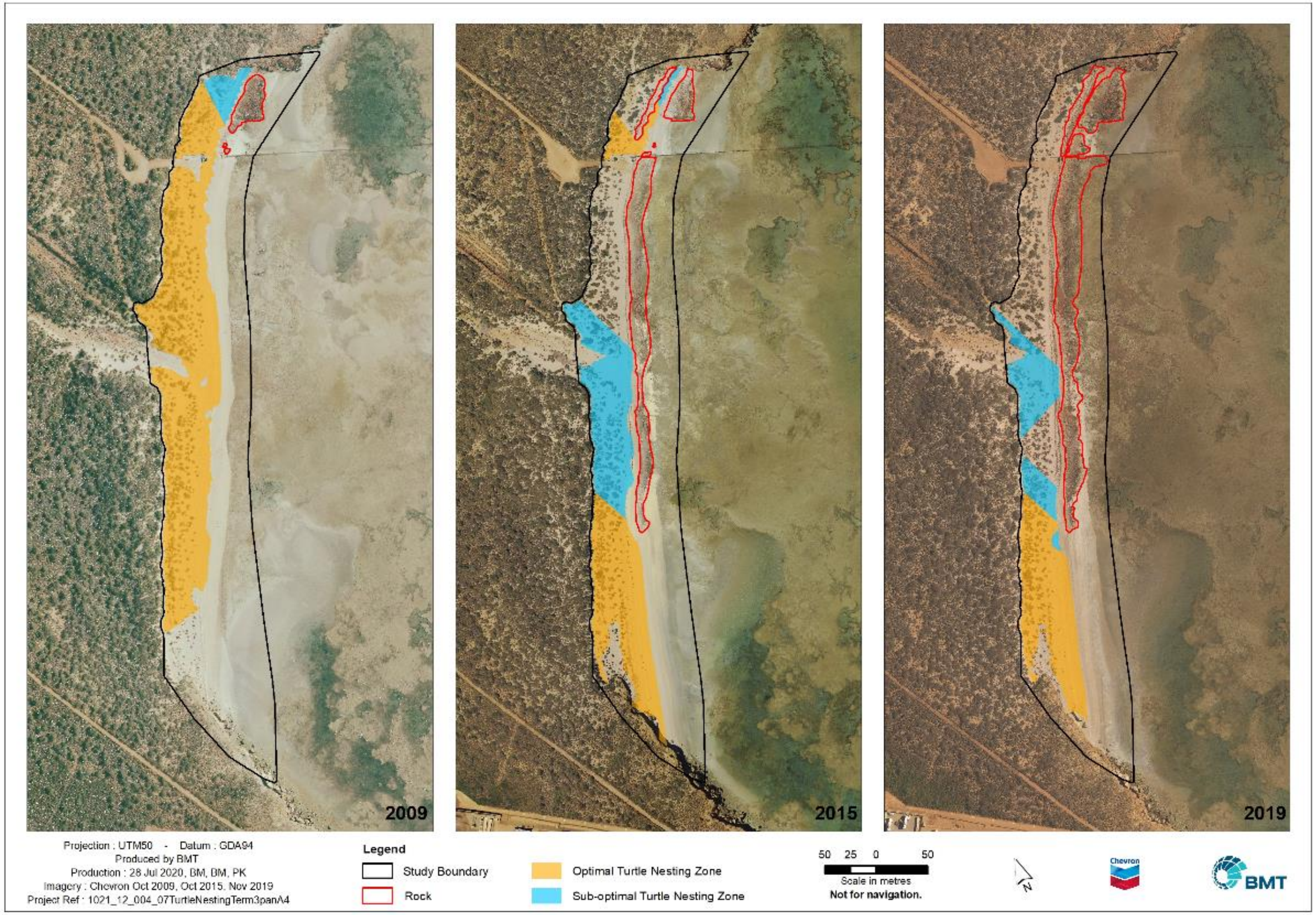


Figure 9-19: Marine Turtle Nesting Habitat Zones for Terminal Beach

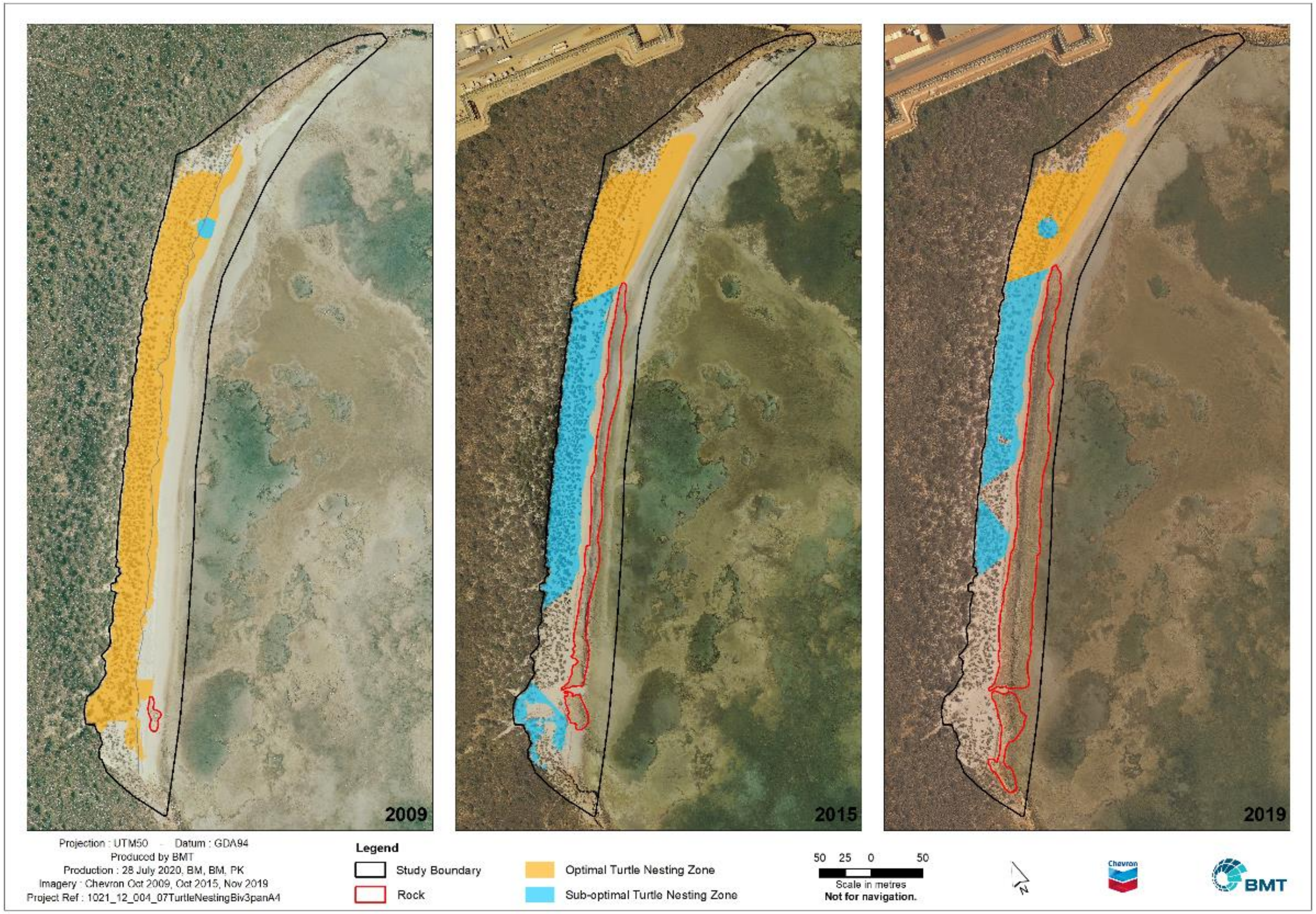


Figure 9-20: Marine Turtle Nesting Habitat Zones for Bivalve Beach

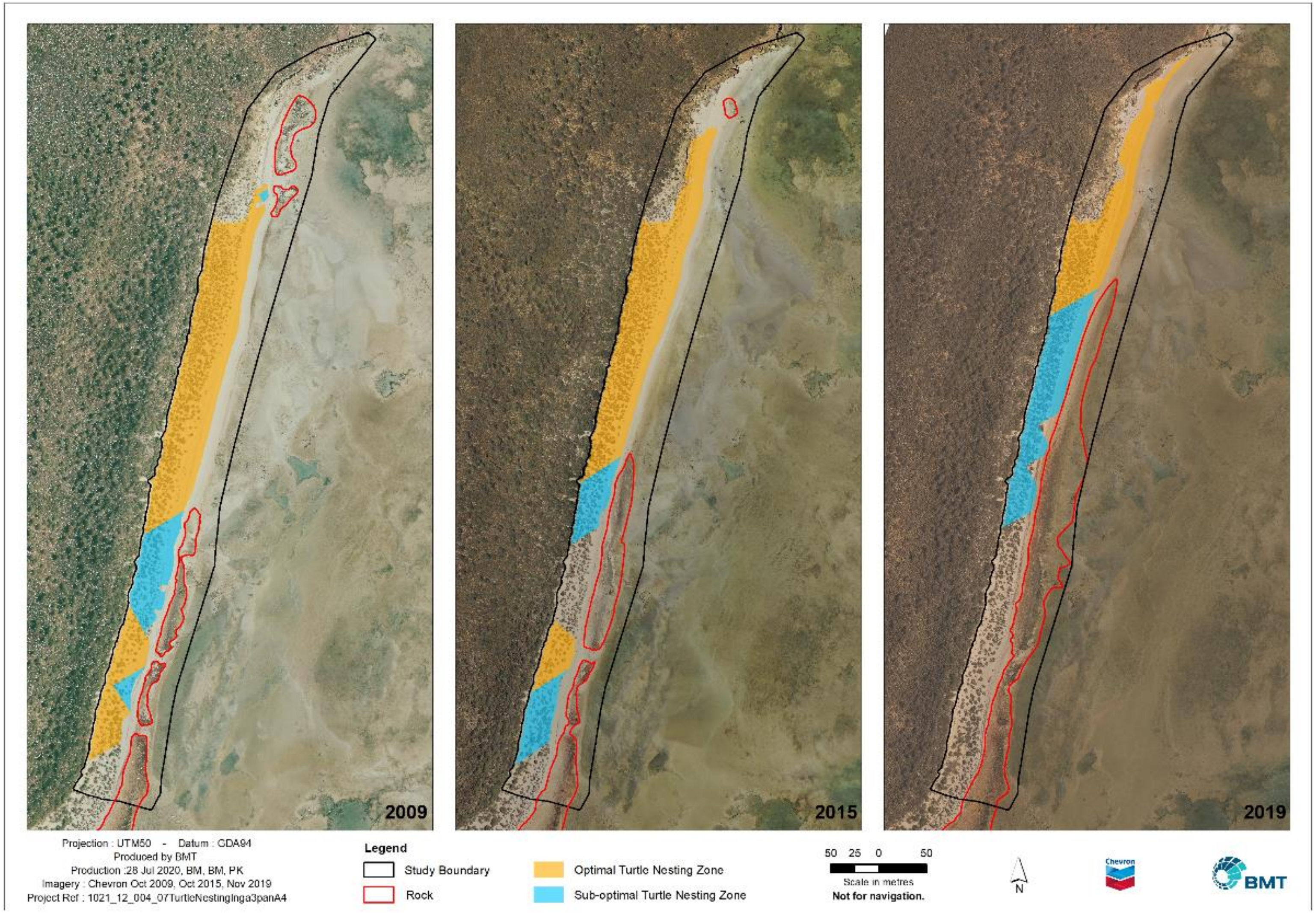


Figure 9-21: Marine Turtle Nesting Habitat Zones for Inga Beach

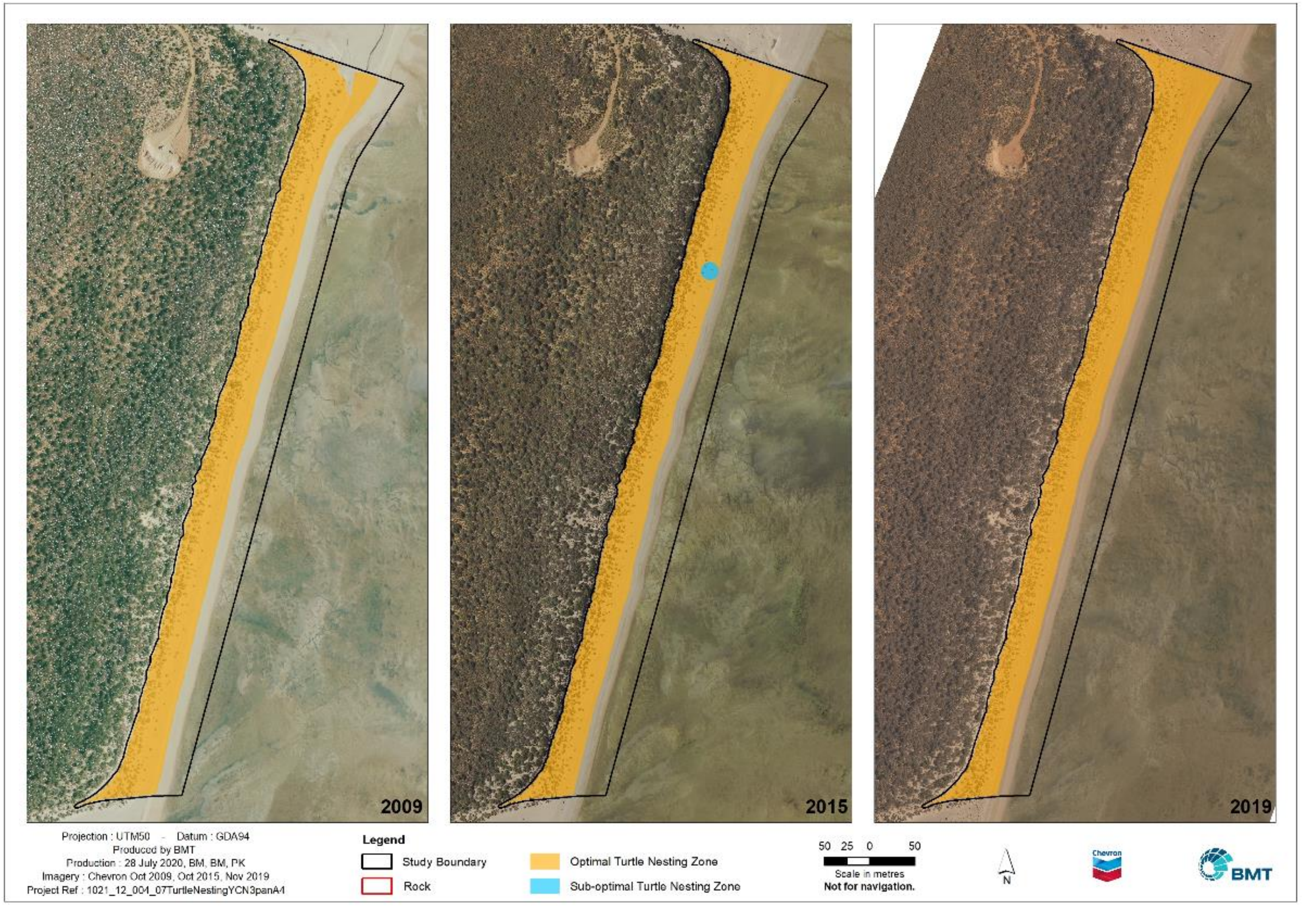


Figure 9-22: Marine Turtle Nesting Habitat Zones for YCN Beach

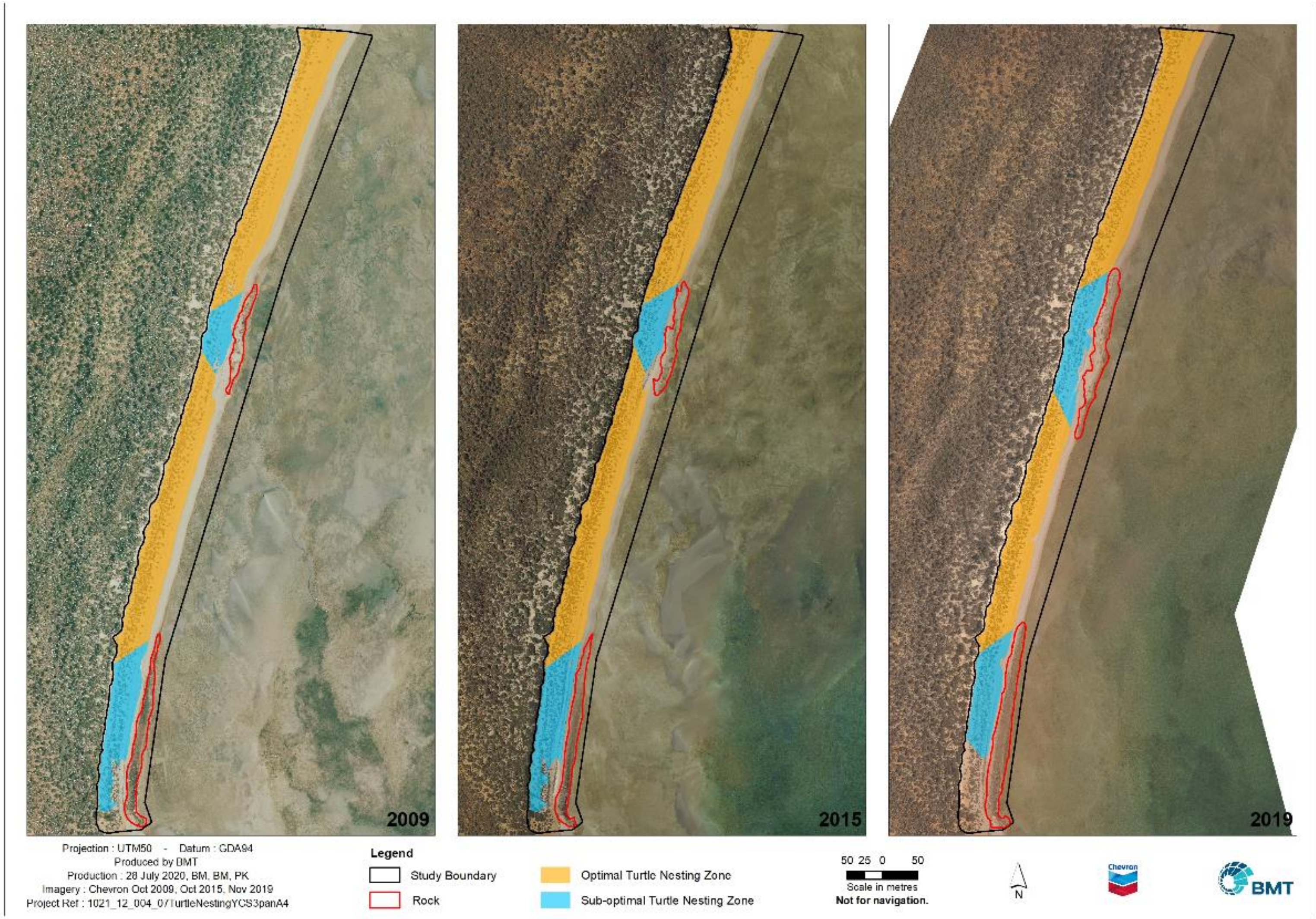


Figure 9-23: Marine Turtle Nesting Habitat Zones for YCS Beach

9.2 Conclusion

During the Reporting Period, exceedances of the slope and volume management triggers were detected for all sites at monitored transects on Terminal and Bivalve beaches, with the exception of the FA at T22, which did not record a slope exceedance for any survey. Despite exceeding management triggers for beach volume and beach slope, it is considered unlikely that the shoreline changes occurring on Terminal and Bivalve beaches are currently having significant adverse impacts on the stability of these beaches.

Coastal instability is caused by erosion of the beach face and berm of a beach, allowing wave action to begin influencing the backshore and sand dunes. A stable beach may be changing in the active zone (beach face) but should remain relatively static in the backshore and sand dunes.

Terminal and Bivalve beaches are inherently stable through geological control; that is, they are underpinned by rock, and bounded at each end by rock headlands. Changes to these beaches has been generally limited to the beach face. Most of the FA on Terminal and Bivalve beaches have accreted or remained the same, although erosion has encroached into the seaward edge of the foredune in some sections of those beaches over the Reporting Period, causing some vegetation loss (Ref. 16). Although currently stable, these changes may increase the vulnerability of the FA and PDs to extreme metocean conditions, and the presence of the MOF will likely restrict the capacity for natural recovery after such events.

Inga, YCN, and YCS beaches are bounded by rock headlands at the northern end of Inga Beach and the southern end of YCS Beach, and are intersected by subaerial and intertidal rock outcrops and creeks. These features have a greater capacity for sediment exchange into and out of the study area boundaries, which results in lower capacity for trapping sediments than on Terminal and Bivalve beaches.

In addition to routine twice-yearly surveys, three significant weather events prompted remote sensing surveys during the Reporting Period (July 2015, June 2017, June 2019), with data on other notable weather events also being collected and analysed on an ad hoc basis (e.g. photographs, beach inspections, metocean variables). Results from the storm analysis indicated that morphological change varied with each event, and that the largest volume reductions were observed when peak wind and wave conditions coincided with the highest spring tide (TC Veronica, Table 9-5).

Alongshore sand redistribution at the beach face has exposed sections of the underlying rock platform on Terminal, Bivalve, and Inga beaches since construction of the MOF. This has reduced beach accessibility for marine turtles, by eroding sandy access pathways to the foredune nesting areas. Over the Reporting Period, the largest reductions in suitable nesting habitat have occurred at Terminal, Bivalve, and Inga beaches, which have seen an increase in optimal nesting area closest to the MOF (northern ends of Bivalve and Inga beaches, southern end of Terminal Beach), and a decrease furthest from the MOF. However, no management triggers for marine turtle nesting habitat (which apply to Terminal and Bivalve beaches only) were exceeded during the Reporting Period as a result of the changes. Note: The current management triggers for marine turtle nesting habitat were designed to detect large changes from year to year and do not adequately detect progressive smaller changes at Impact Beaches. Revised, more suitable, and sensitive management triggers for marine turtle nesting habitat have been proposed in the revised CSMMP, submitted to State and Commonwealth regulators in March 2019.

The redistribution of sand towards the MOF on these beaches has shifted nesting distribution and reduced the area used for nesting, reflecting a preference for those areas of beach where access to nesting habitat remains unimpeded. New areas of beach (created through accretion) have formed that were previously inaccessible or unsuitable for nesting.

Results of the CSMMP since construction of the MOF have indicated that changes to Terminal, Bivalve, and Inga beaches have been greater than predicted, prompting the last five-year EPR to recommend a revision of the coastal stability management triggers (Ref. 6). In March 2019, a new revision (Revision 3) of the CSMMP was submitted to the WA Department of Water and Environmental Regulation and Commonwealth Department of Agriculture, Water and the Environment, which proposed new management triggers for coastal stability and marine turtle nesting habitat. The plan is currently (late 2020) awaiting approval.

As required by the CSMMP (Ref. 14), CAPL will continue to monitor changes in beach morphology to detect and evaluate any potential implications for marine turtle nesting. If exceedances of CSMMP management triggers or performance standards are detected, they will be assessed in accordance with the requirements identified in the current approved CSMMP and relevant Ministerial Conditions.

9.3 Five-year Overview of Environmental Performance

The 2015–2020 outcome for coastal stability is summarised in the table below.

Table 9-8: Summary of the Environmental Performance for Coastal Stability during the Five-year Reporting Period

Objectives[1]	Outcome
Ensure that the MOF and LNG Jetty do not cause significant adverse impacts to the beaches adjacent to those facilities	Monitoring of beach structure and beach sediment, as per the requirements of Revision 1 and 2 of the CSMMP (October 2014–May 2016 and May 2016–present, respectively), throughout the five-year Reporting Period did not detect a significant adverse impact on the stability of Impact beaches (Terminal and Bivalve) either side of the MOF and LNG Jetty.
Establish a monitoring program to detect adverse changes to the beach structure and beach sediments that could have implications for marine turtles nesting on the beaches adjacent to the MOF and LNG Jetty on Barrow Island	An approved monitoring program (as part of the CSMMP) for beach structure and beach sediments has been in place since 2009. The monitoring program was revised in October 2014 (Revision 1) and again in May 2016 (Revision 2) to quantitively track changes in the availability of suitable nesting habitat based on the physical characteristics of the beach. Data collected over the 2015–2020 Reporting Period has informed a new revision of the CSMMP and Supplement[2] which proposes coastal stability and marine turtle nesting habitat management triggers better placed to meet the objectives to the CSMMP. The proposed changes also aim to better identify major weather events that are likely to cause significant change to the beaches, and to assess coastal stability in a more accurate and meaningful way, using updated management triggers based on changes in foredune volume.

1 *As defined in Condition 25.3 of MS 800, and Condition 18.3 of EPBC 2003/1294 and 2008/4178*

2 *The separate document 'Coastal Stability Management and Monitoring Plan Supplement: Management Triggers' has been incorporated into the new revision of the CSMMP (awaiting approval, as at late 2020). Therefore, the whole coastal stability condition (Condition 24 for State, Condition 18 for Commonwealth) is addressed in one document.*

9.4 Proposed Environmental Management Improvements

Since construction of the MOF, monitoring has shown that changes to beach structure through longshore and cross-shore sediment redistribution on Terminal, Bivalve, and Inga beaches have surpassed the predictions made before construction commenced. As a result, the previous five-year EPR recommended revising the coastal stability management triggers to better meet the objectives of the CSMMP. Data from routine and contingency monitoring has subsequently been used to develop new coastal stability and marine turtle nesting management triggers. These triggers are detailed in a new revision of the CSMMP, which was submitted to State and Commonwealth regulators in March 2019 and is awaiting approval (as at late 2020). Under this new revision, Inga Beach has been reclassified as an 'Impact' beach, and Mushroom Beach (to the north of Terminal Beach) has been added as a 'Reference' beach. As with the current triggers, the new management triggers only apply to Impact beaches.

The new coastal stability management triggers (yet to be approved) have been developed for detecting changes under ambient conditions, and following significant weather events. Under ambient conditions, beach volume in the FA is the primary indicator of stability and is quantitatively assessed relative to pre-construction volumes (October 2009). Management triggers relating to significant weather events are qualitative, and focus on assessing the impacts of weather events (e.g. storms and tropical cyclones) and monitoring subsequent recovery.

Similarly, revised management triggers and new performance standards have been proposed for marine turtle nesting habitat in the revised CSMMP (yet to be approved); the parameters used to map marine turtle nesting habitat have not changed. The revised management structure provides quantitative limits of change in optimal nesting habitat compared to baseline levels, at both an individual beach level and cumulative change across the monitored beaches. Additionally, the new management structure aims to assess the impact of reductions in optimal nesting area on measures of Flatback Turtle productivity (using monitoring data from the LTMTMP) to determine whether the Gorgon Gas Development represents a significant threat to the viability of the Barrow Island Flatback Turtle population.

Supported by the monitoring data presented in Section 9.1, CAPL has identified improvements to and streamlining of the routine monitoring program, as summarised in Table 9-9. Some of these changes are already proposed under the new revised CSMMP, while others will be proposed in future revisions. The key changes are listed below.

Proposed environmental management improvement	Justification
Reducing the frequency of routine monitoring to once a year	Seasonal influences on the volume and distribution of sand on beaches are now well-understood (Figure 9-7); however, interpretation of important trends in coastal changes, and any decisions on required management, are made at the interannual scale. Specific seasonal events that cause relevant changes to beaches will still be captured through significant weather event monitoring.
Removing management triggers specific to sediment particle size (sand grain size)	Sediment particle size (sand grain size) is relevant to turtle nesting site characteristics, but has little bearing on coastal stability. Sediment particle size is already incorporated into the parameters for annual mapping of marine turtle nesting habitat (in conjunction with topographic data and aerial imagery) and there is no value in a stand-alone management trigger for sand grain size.

Proposed environmental management improvement	Justification
Change how significant weather events are identified	Weather events are assessed via multiple metocean variables, not solely wind, to determine the potential risk to Impact beaches. The importance of changing the significant weather event definition (formerly termed a 'major event') was illustrated by TC Veronica, which caused the greatest recorded changes to beach morphology over the Reporting Period (Figure 9-7, Table 9-5). Although TC Veronica did not exceed the major event trigger, the combination of wind, tide, and wave conditions caused a significant storm surge and regional-scale erosion across the east coast beaches of Barrow Island. In contrast, only small volume reductions were observed following the July 2015 major event; conversely, volume gains were observed following the June 2019 major event (Table 9-5). These observations indicate that beaches respond differently to individual storm events, and the potential impact of a significant weather event should be assessed via multiple metocean variables.

Table 9-9: Proposed Routine Monitoring Program

Monitoring Aim	Monitoring Objectives	Monitoring Parameters	Monitoring Methods	Monitoring Frequency	Environmental Performance Standard
Detect changes to beach structure, including beach profiles and erosion or accretion of sand	• Detect erosion and accretion • Detect loss of foredune • Quantify storm-induced change	• Beach profile (includes surface elevation) • Beach planform • Beach volume • Vegetation lines • Water lines	Topographic survey and imagery via remote sensing or suitable alternative	Once a year, at the end of the dry season where practicable	P1; P2; P3; P4
	Identify features associated with beach instability	Feature identification	Visual assessment and photographic record	Once a year, at the end of the dry season where practicable	P1
	Identify significant weather events	• Wind speed and direction • Water level • Wave characteristics	Deployed metocean instruments	Continuous	P1; P2; P3; P4
Detect changes to beach sediments	Detect changes in sediment particle (sand grain) size	• Sediment particle size distribution	Sediment samples at selected depths at points of interest for laboratory analysis of particle size	Once a year, at the end of the dry season where practicable	P2; P3; P4
Detect adverse changes that may have implications for nesting marine turtles	Detect changes in beach sediments that may impact suitability for nesting Detect changes that may affect access to available nesting habitat	• Sediment particle size distribution • Sediment depth • Water lines	Marine turtle nesting habitat mapping, collating data from remote sensing, and on-ground sampling	Once a year, at the end of the dry season where practicable	P2; P3; P4

Monitoring Aim	Monitoring Objectives	Monitoring Parameters	Monitoring Methods	Monitoring Frequency	Environmental Performance Standard
	Detect changes in extent of available nesting habitat	• Bedrock exposure and infrastructure			

10 Terrestrial Rehabilitation

Table 10-1: EPR Reporting Requirements for Terrestrial Rehabilitation

Item	Source	Section in this EPR
A description of any rehabilitation activities undertaken	MS 800, Schedule 3(9i)	10.1
Results of the rehabilitation monitoring program including performance against completion criteria targets	MS 800, Schedule 3(9ii)	10.2
Results of any studies to address knowledge gaps as referenced in Condition 32.5(x) and proposals for further studies (if any)	MS 800, Schedule 3(9iii)	10.3
Recommended changes, if any, to the Gorgon Gas Development Post-Construction Rehabilitation Plan (PCRP) (Ref. 17)	MS 800, Schedule 3(9iv)	10.6
Topsoil usage and topsoil balances	Gorgon Gas Development Topsoil Management Plan (TMP) (Ref. 18, Section 3.3)	10.4
Changes to volume of soil stockpiled as a result of rehabilitation or clearing activities	TMP (Ref. 18, Section 3.3)	10.4
Results of the Topsoil Monitoring Program, topsoil performance reviews, and topsoil volume reconciliation	TMP (Ref. 18, Section 5.0)	10.5
Progress against rehabilitation objectives in Table 5–2 of the PCRP (Ref. 17)	PCRP (Ref. 17, Table 5–2)	10.1, 10.2, 10.3, 10.4, 10.5
A five-year overview of environmental performance	MS 800, Condition 5.3(iii)	10.7
Proposed environmental management improvements	MS 800, Condition 5.3(iv)	10.8

10.1 Rehabilitation Activities

Rehabilitation activities undertaken during the Reporting Period are summarised in the following table. Areas rehabilitated from inception to the 2019-2020 Reporting Period for the Gorgon Gas Development are shown in Figure 10-1.

Rehabilitation Activities
• Rehabilitation activities were completed at the horizontal directional drilling (HDD) crossing in November 2015, with the installation of jute dune matting, secured by plastic pins. • The former Operations Workforce Accommodation site was decommissioned and rehabilitated during the Reporting Period. Works were completed in October 2018. • Approximately 30% of the installed pins at the HDD Crossing site were removed in two separate scopes in 2019. Pin removal is required due to UV degradation of the plastic pins. Biodegradable jute matting was left in situ.

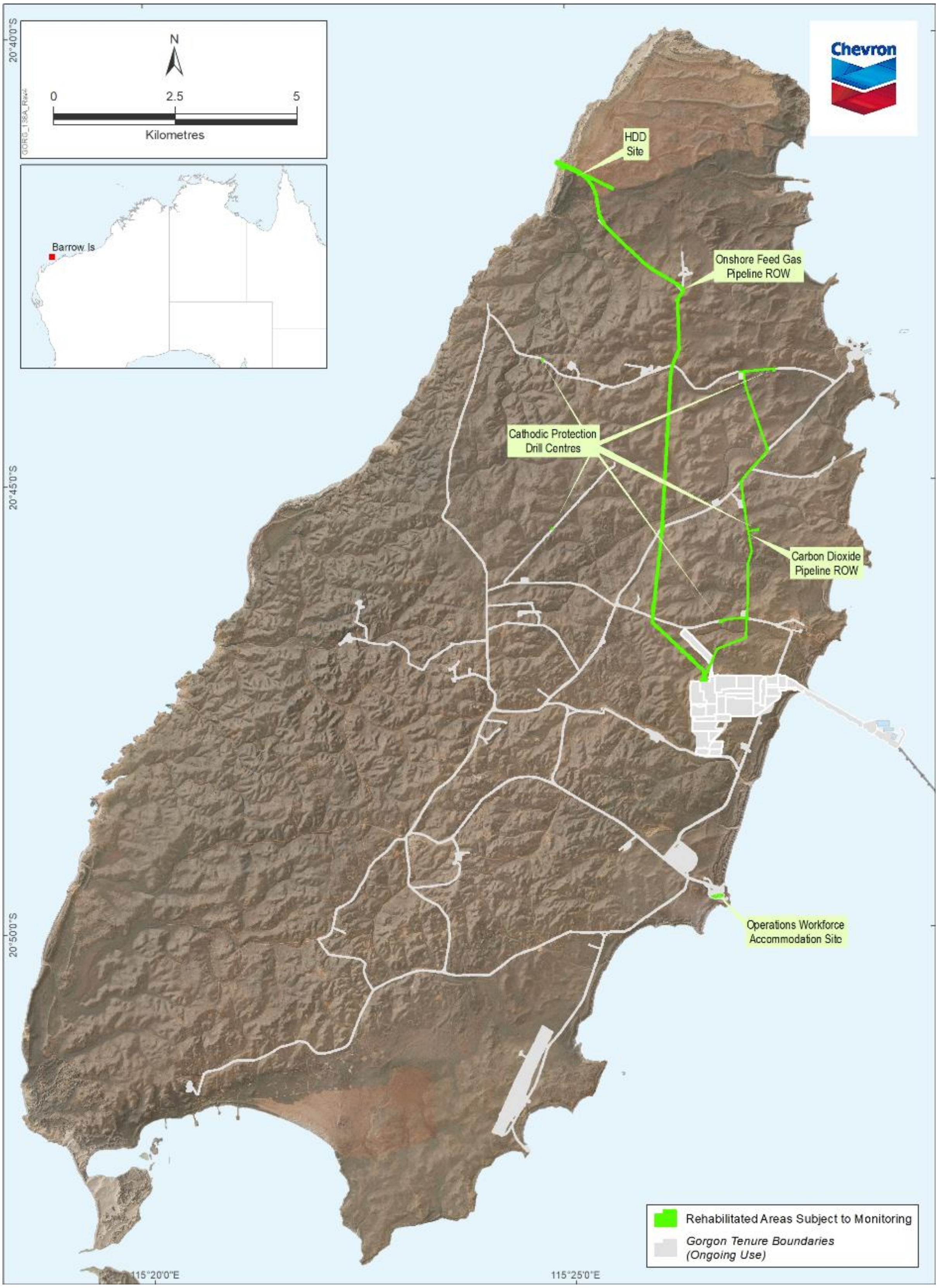


Figure 10-1: Areas Rehabilitated for the Gorgon Gas Development

10.2 Rehabilitation Monitoring

The PCRP (Ref. 17) details the rehabilitation methodology and completion criteria for rehabilitating temporarily disturbed lands on the Gorgon Gas Development. The rehabilitation monitoring methodology is Ecosystem Function Analysis (EFA), a method that has been used on Barrow Island since 2004.

The rehabilitation monitoring methodology and results are summarised in the following table.

Monitoring Program: Rehabilitation	
Objectives:	• To meet the intent of the Ministerial objectives for rehabilitation, the PCRP (Table 5–2 in Ref. 17) further defines specific objectives for the rehabilitation of temporarily disturbed areas: – The rehabilitated land surface and soil properties are appropriate to support the target ecosystem. – Vegetation in rehabilitated areas will have equivalent values as surrounding natural ecosystems. – The rehabilitated ecosystem has equivalent functions and resilience as the target ecosystem. – Rehabilitated areas provide appropriate habitat for fauna and fauna recruitment including EPBC Act listed species. – The rehabilitated area should be able to be managed in the same way as surrounding land.
Methodology:	• EFA, which was originally described as Landscape Function Analysis (LFA), is a methodology developed by the Commonwealth Scientific and Industrial Research Organisation that uses indicators to assess and determine functional status of the landscape. EFA differs from LFA in that ecosystem components such as vegetation composition, cover, and habitat complexity are also recorded and assessed to provide a quantitative measure of the ecological functionality of the site. LFA is a core component of EFA and primarily focuses on stability, water infiltration, and nutrient indices. For arid environments, permanent EFA transects are set up to follow a line of resource flow, typically up to 50 m long. • A new methodology, Object-based Image Analysis (OBIA), was added to the existing monitoring methods in 2018 to estimate vegetation cover at each rehabilitated and analogue site. Aerial images of the sites were processed using PCI Geomatica® software and estimates of vegetation cover were made using OBIA in eCognition® software. This method was implemented to obtain vegetation cover estimates for the area of an entire site, rather than a single transect. As the OBIA technique is relatively new, the level of accuracy that this software provides is still being demonstrated in the Barrow Island context. • Typically, >20 rehabilitation Impact sites and 8–14 Reference sites in equivalent vegetation associations were monitored during the annual Reporting Periods. Broadly, the monitoring gathered data on these attributes: – landscape function (stability, infiltration, and nutrient cycling) – vegetation (*Triodia* cover, species diversity, density, vegetation cover and height, floristic composition, and functional structure) – erosion and visual amenity.
Results:	• Rehabilitation of temporarily disturbed areas during the Reporting Period has partly returned some of the aesthetic values and ecological function that was present in rehabilitated areas prior to the disturbance associated with the Gorgon Gas Development. • Annual rehabilitation monitoring conducted since 2016 has demonstrated that rehabilitated areas are fundamentally stable, with limited evidence of erosion, poor infiltration, or issues related to rehabilitation earthworks: – Results from the 2019 monitoring demonstrate that the landscape function indices of soil stability, infiltration, and nutrient cycling have stabilised since 2016, but are at lower levels than those of comparable Reference sites

Monitoring Program: Rehabilitation	
	– Infiltration and nutrient cycling indices are strongly influenced by plant and litter cover, which has been constrained through prolonged periods of below-average rainfall (Ref. 19). • Early-colonising species that were present in 2016 continue to dominate rehabilitated areas. The keystone genus *Triodia* (representative of successional processes) was present in 21 of 22 Impact transects: – Although *Triodia* spp. were present in 2019, density and cover metrics are significantly below completion criteria and Reference site thresholds. – Low *Triodia* densities such as those observed in 2019 (year 4) may be associated with inadequate vegetation cover at maturity. • The value of the rehabilitated areas as faunal habitat has improved since 2016.In 2019 all but one Impact transect did not have the *Triodia* cover and mid-story plant stratum required to provide suitable habitat for native fauna. • No impact monitoring site has attained all the completion criteria as detailed in the PCRP, as observed in any of the annual monitoring events during the Reporting Period. This is not unexpected given the prolonged period of below-average rainfall during initial vegetation establishment (June 2015 to July 2016) (Ref. 34).
Conclusions:	• Rehabilitated areas have not yet met all relevant completion criteria as detailed in the PCRP. • Most sites have stabilised since inception; however, progress toward landscape function criteria has been impacted by a lack of vegetation and litter cover due to prolonged periods of below-average rainfall. • The presence of the keystone genus *Triodia* suggests rehabilitated areas are undergoing anticipated successional changes; however, the low density of plants and lack of maturity suggest that the system is not yet self-sustaining. • Rehabilitated areas are performing well with respect to lack of erosion and visual amenity.

10.3 Studies

No studies to address knowledge gaps were carried out during the Reporting Period; however, the low *Triodia* density at most sites has necessitated a one-off examination of soil-stored seed within the rehabilitation areas. The Gorgon Gas Development has an established methodology for evaluating this aspect of soil biology that was developed for the Topsoil Monitoring Program (see Section 10.4). A total of 30 soil samples will be taken during the 2020 monitoring event scheduled for October.

An additional knowledge gap relates to the presence of invertebrates in rehabilitated areas. Learnings from the Topsoil Monitoring Program suggest that invertebrates will recolonise disturbed soils, so it is assumed that this process will occur within the rehabilitation areas. A total of eight emergent traps will be installed during the 2020 monitoring event scheduled for October.

This additional work will be separately reported in the 2021 EPR and the next five-year EPR. Results of the 2020 soil-stored seed analysis will determine the need for further monitoring or remedial activities.

10.4 Topsoil Activities

Topsoil activities undertaken during the Reporting Period and topsoil stockpile volumes are summarised in the following table.

Topsoil Activities	
Activities:	**Monitored Topsoil Stockpile Volume Summary (2015–2020)**

Topsoil Stockpile	Original Topsoil Source Location	Changes to Volume Stockpiled During the Reporting Period (m^3)	Total Volume Stockpiled (m^3)
A28	GTP Site	None	7,483
Q31	GTP Site	None	7,984
X62J	GTP Site	−1915	17,655[1]
R Station	GTP Site	None	3,481
P13	CO_2 pipeline right-of-way (ROW)	−5880	9,453[1]
ASA Stage 3	ASA Stages 3 and 4	None	2,272
ASA Stage 2	ASA Stages 1 and 2	None	3,550
Perentie II	GTP Site and ASA	None	8,884

1 *The total volume stockpiled for X62J was updated following completion of the stockpile survey in November 2015. The total volume stockpiled for P13 was updated to include topsoil activities conducted after completion of the stockpile survey in October 2017.*

10.5 Monitoring Results

The TMP (Ref. 18) complements the PCRP (Ref. 17), and describes the stripping, transport, and re-use of recovered topsoil. The TMP also includes a monitoring program to measure topsoil viability.

The topsoil monitoring results[5] are summarised in the following table.

Monitoring Program: Topsoil	
Objectives:	• Measure and record the physical, chemical, and biological attributes, and the overall integrity, of the stored topsoil from the Gorgon Gas Development. • Provide assurance that the topsoil remains viable and stable.
Results:	• Overall, topsoil stockpiles have stabilised during the Reporting Period, with most landscape function indices trending toward Reference site levels since inception. • Vegetation cover has steadily declined at all monitored stockpiles, from record high levels in 2017, through to 2019 (Ref. 20): – Vegetation cover at any given topsoil monitoring event is strongly contingent on the timing and volume of rainfall in the preceding months, – Most stockpiles have perennial grasses, such as those in the keystone genus *Triodia*, providing the bulk of cover, or are trending toward this, in line with expected ecosystem successional processes. – Cover provided by perennial shrubs on stockpiles has remained constant, or has increased. – As the stockpile ages, the composition of species providing cover between stockpiles is progressively trending toward similarity with reference sites. • In 2019, the number of monocot germinant numbers in laboratory germination of soil-stored seed was almost the lowest on record and consistent with levels at inception of the stockpiles: – Monocot germinant genera includes the keystone genus, *Triodia*. – Low numbers of germinant monocots observed in stockpiles in 2019 indicate a short seed viability cycle, following the exponential increase after the 2017 mast seeding event.

[5] Note: These results are based on data collected in April–June 2019, which was analysed and reported in the 2015–2020 Reporting Period. The 2020 monitoring results will be reported in the 2021 EPR.

Monitoring Program: Topsoil	
	– In contrast, germinant dicot numbers have remained consistent throughout nine monitoring events, which were conducted from October to November of each calendar year. • Invertebrate abundance and diversity of high-order taxa has been relatively consistent across monitoring events, except for the lower than average numbers observed in 2016.
Conclusion:	• The Topsoil Monitoring Program has met its key objectives, whilst improving CAPL's understanding of soil biology and vegetation establishment. • As the commitment for five years of field-based monitoring has now been met, the program will pivot toward assessing vegetation cover, using aerial imagery and remote sensing.

10.6 Changes to the Post-Construction Rehabilitation Plan

An amendment was made to the PCRP (Ref. 17) during the Reporting Period in consultation with relevant regulatory agencies, to allow for the retention of subsurface fixtures, such as rock anchors or concrete footings—excavating these has the potential to damage areas of limestone or calcrete caprock. The PCRP now allows these fixtures to be retained where a Net Environmental Benefit Analysis demonstrates their removal has the potential to cause a greater environmental impact than leaving them in place.

10.7 Five-year Overview of Environmental Performance

The 2015–2020 outcome for terrestrial rehabilitation is summarised in the table below.

Objectives[1]	Outcome
Ensure that the rehabilitation of terrestrial areas following construction is properly planned in a manner that promotes self-sustaining ecosystems able to be managed as part of their surroundings consistent with the conservation objectives of a Class A Nature Reserve.	Rehabilitation requirements (including monitoring) for disturbed areas within the TDF that are no longer required for the ongoing construction or operation of the Gorgon Gas Development are described in the approved PCRP and TMP (Ref. 17; Ref. 18). Rehabilitation of the temporary disturbance areas has resulted in a surface that can be managed consistent with the surrounding Class A Nature Reserve. Initial vegetation assemblages are on a trajectory toward self-sufficiency and are fundamentally stable; however. it is not likely that vegetation is currently self-sustaining, primarily due to low levels of soil-stored seed and low *Triodia* spp. density. Therefore, monitoring of temporary disturbance areas will continue to inform future rehabilitation and potential remedial actions if required. A novel remote-sensing methodology has been applied to rehabilitation areas and has contributed towards CAPL's understanding of Barrow Island vegetation establishment and vegetation cover measurements. It is likely that this method will be used in future to predict the likelihood of rehabilitation success and identify minor problems prior to annual monitoring.
Design rehabilitation of native vegetation to ultimately develop into viable ecological systems that are comparable and compatible with surrounding native vegetation and its land uses, and restore as closely as practicable the pre-disturbance biodiversity and ecosystem functional values.	
Ensure planning, implementation, monitoring, and reporting on rehabilitation is carried out consistent with industry best practice.	
Ensure management of rehabilitation continues until affected areas are self-sustaining.	Management, monitoring, and potential remedial works will be ongoing in rehabilitated areas until the completion criteria in the PCRP are met.
Better inform any ongoing rehabilitation and post-closure rehabilitation.	

1 *As defined in Condition 32.4 of MS 800.*

10.8 Proposed Environmental Management Improvements

The key proposed management improvements for the PCRP and TMP are summarised in the table below.

Proposed Management Improvement	Justification
Investigate soil-stored seed within rehabilitation areas	Information from the topsoil program has identified constraints on seed production in Barrow Island *Triodia* spp. The assumption that viable soil-stored seed was transferred from stockpiles to rehabilitated areas needs to be tested, in the absence of in situ seed production.
Initiate an initial investigation into invertebrate abundance and diversity within rehabilitation areas	Invertebrate diversity and abundance in rehabilitated areas likely follows a similar trajectory as per topsoil stockpiles (i.e.: invertebrates return to disturbed areas, with abundance linked to environmental factors); however, this needs to be verified.
Review the literature related to the recalcitrant species *Triodia wiseana*	The topsoil stockpiles harvested from limestone upland sites feature *Triodia wiseana* density and cover metrics that have been lower than Reference site levels, indicating a complex seed dormancy mechanism in the species.

11 Greenhouse Gas Abatement

Table 11-1: EPR Reporting Requirements for Greenhouse Gas Abatement

Item	Source	Section in this EPR
Data on greenhouse gas (GHG) emission intensity (defined as GHG emissions per tonne of LNG produced) averaged over one year, and describe the methodology used	MS 800, Schedule 3(10i)	11.1
Trend of annually averaged GHG emission intensity and explain the reasons for any change	MS 800, Schedule 3(10ii)	11.1
Recent advances in technology and/or operation processes for LNG processing facilities	MS 800, Schedule 3(10iii)	11.2
Justification for the adoption or otherwise of the recent advances referred to in Schedule 3, Item 10iii	MS 800, Schedule 3(10iv)	11.2
The actual energy efficiency[1] of gas turbines in the GTP	MS 800, Schedule 3(10v)	11.1
A five-year overview of environmental performance	MS 800, Condition 5.3(iii)	11.3
Proposed environmental management improvements	MS 800, Condition 5.3(iv)	11.4

1 Although MS 800 refers to 'energy efficiency', 'thermal efficiency' is the appropriate term for the calculation of this metric, and is used below.

11.1 Monitoring Results

The 2015–2020 results for GHG emission intensity and thermal efficiency are summarised in the following tables.

GHG Emission Intensity	
Methodology:	• GHG emissions are determined in accordance with the methods specified under the NGER Act. GHG emissions intensity and energy efficiency are prepared for the financial year (1 July to 30 June) so as to align with the data prepared for compliance with the NGER Act[1]. • GHG emissions intensity is expressed as the total 'Scope 1' GHG emissions (expressed as tonnes of CO_2e) divided by the amount of saleable LNG[2] (expressed in tonnes of LNG). The emissions intensity value includes emissions associated with processing DomGas and condensate, and the provision of all Barrow Island utilities and support services, in addition to emissions associated with processing of saleable LNG. Care should be exercised when comparing this metric with similar metrics from other facilities to ensure a like-for-like comparison.
Results:	GHG emissions intensity for each financial year: • 2015–2016: 19.6 tonnes CO_2e per tonne of saleable LNG. Note: This does not represent steady state operations because the GTP was still being commissioned. • 2016–2017: 1.14 tonnes CO_2e per tonne of saleable LNG. Note: This does not represent steady state operations because the GTP was still being commissioned. • 2017–2018: 0.63 tonnes CO_2e per tonne of saleable LNG. • 2018–2019: 0.57 tonnes CO_2e per tonne of saleable LNG. • 2019–2020: 0.43 tonnes CO_2e per tonne of saleable LNG. From 2017 to 2020 the average greenhouse gas emission intensity decreased significantly in line with operations. From 2017 to 2020 incremental improvements have been realised through initiatives such as Advanced Process Control (APC) systems and through CO2 injection.

1 Emissions/production during the Reporting Period that fall in the 2020–2021 financial year will be reported in the 2021 EPR.

2 'Saleable LNG' is the LNG produced and loaded into the LNG storage tanks.

Gas Turbine Generator Thermal Efficiency	
Methodology:	• The thermal efficiency of the GTGs is determined by dividing the amount of electricity generated (expressed in Joules) by the energy content of the fuel used to power the turbines (also expressed in Joules). Thermal efficiency of the GTGs is calculated daily and averaged over the Reporting Period for the GTGs in operation.
Results:	The energy efficiency of the operational Frame 9 GTGs for each financial year was: • 2015–2016: 10.3%. Note: This does not represent steady state operations efficiency because the GTP was still being commissioned. • 2016–2017: 17.6%. Note: This does not represent steady state operations because the GTP was still being commissioned. The thermal efficiency of the GTGs over each financial year was: • 2017–2018: 21.2% • 2018–2019: 22.2% • 2019–2020: 23.7%

11.2 Recent Advances in Technology and/or Operational Processes

As part of Chevron Corporation's Operational Excellence Management System (OEMS) and global processes, CAPL undertakes reviews to determine opportunities to reduce GHG emissions per tonne of LNG produced, which includes reviewing recent advances in technology and/or operational processes for LNG facilities. Section 7 details the Carbon Dioxide Injection Project. Other examples include:

- Gas Turbine Performance Improvement – Performance improvement packages (PIPs) were installed on the gas turbines within LNG Trains 1 and 2 during their respective turnarounds. The PIP improves the engine efficiency by reducing losses across seals, improved aero performance, and increasing the firing temperature.
- Advanced Process Control (APC) systems – These control processes at the LNG facility more precisely, resulting in energy efficiency gains. APC systems use computer algorithms to make incremental changes that allow facilities to operate closer to their design limits and increase performance, thus helping reduce energy use. An APC installed on portions of the LNG facility has improved process stability and reduced flaring. As this technology develops, more opportunities may become available to refine operations to reduce GHG emissions.
- MEG Regeneration Flash Gas Vapours – As per Works Approval W6354/2020/1, construction has commenced on infrastructure to capture and reroute flash gas vapours. MEG regeneration flash gas vapours will be routed to the condensate stabilisation compressors from where they will be directed to the GTP inlet, to allow processing via the mercury removal units, AGRUs, and sequestration of captured CO_2. Operation of the proposed infrastructure will result in no routine MEG regeneration flash gas vapour emissions to air during normal operations.

Other opportunities to reduce GHG emissions per tonne of LNG produced include the following procedure which will be assessed for application in future turnaround and train restarts:

- A revised Warm Restart Main Cryogenic Heat Exchanger cooldown procedure has been developed. This procedure eliminates the pre-cooldown step from the start-up sequence, resulting in less flaring and more consistent start-ups.

11.3 Five-year Overview of Environmental Performance

The 2015–2020 outcome for GHG abatement is summarised in the table below.

Objectives[1]	Outcome
Demonstrate that currently applied best practice in terms of greenhouse gas emissions have been adopted in the design and operations of the Gas Treatment Plant. The greenhouse gas emissions per tonne of LNG produced should be normalised to the standard conditions and benchmarked against publicly available data for other national and overseas LNG processing facilities.	Best practice measures adopted to reduce GHG emissions from the GTP have been implemented as per the approved Greenhouse Gas Abatement Program (Ref. 49), throughout the five-year Reporting Period. As per the approved Greenhouse Gas Abatement Program, the GHG emissions per tonne of LNG produced was normalised to the standard conditions and benchmarked against publicly available data for other national and overseas LNG processing facilities.
Periodically review and, where practicable, adopt advances in technology and operational processes aimed at reducing greenhouse gas emissions per tonne of LNG produced.	In accordance with Chevron Corporation's OEMS, CAPL undertakes reviews to determine opportunities to reduce GHG emissions per tonne of LNG produced. Once identified, these opportunities are then assessed for inclusion into business planning.

1. *As defined in Condition 27.2 of MS 800.*

11.4 Proposed Environmental Management Improvements

No management improvements related to the Greenhouse Gas Abatement Program are proposed as part of this Five-year EPR.

12 Spill Management

Table 12-1: EPR Reporting Requirements for Spill Management

Item	Source	Section in this EPR
Incidence of spills caused by the Proposal, and spills that impact on the Proponent's facilities including details of cause and recommended actions	MS 769, Schedule 3(3i)	12.1
A five-year overview of environmental performance	MS 800, Condition 5.3(iii) MS 769, Condition 5.3(ii)	12.2
Proposed environmental management improvements	MS 800, Condition 5.3(iv) MS 769, Condition 5.3(iii)	12.3

12.1 Event Data

Incidences of spills caused by the Jansz Feed Gas Pipeline, or spills that impacted on Jansz Feed Gas Pipeline facilities during the 2015–2020 Reporting Period, including details of cause and recommended actions are summarised in Table 12-2.

Table 12-2: Causes and Completed Actions for Spills Associated with the Jansz Feed Gas Pipeline Facilities during the Five-year Reporting Period

Date	Event Description	Event Cause	Completed Actions[1]
10 Oct 2015	Approximately 1 litre of hydraulic fluid released subsea from ROV hydraulic line.	Loss of hydraulic fluid subsea caused by retrofitting a solid handle to the torque tool of an ROV, which became stuck in the tooling drawer.	• The retrofitted solid handle was removed from the ROV. • The damaged hydraulic fluid hose was replaced, then function tested.

1 *Schedule 3(3i) of MS 769 requires 'Recommended Actions' to be reported; this was changed to 'Completed Actions' because the actions from the spill event have now been completed.*

12.2 Five-year Overview of Environmental Performance

One spill event occurred during the 2015–2020 Reporting Period. No environmental impact was observed as a result of the event.

12.3 Proposed Environmental Management Improvements

No further improvements to spill management are proposed as part of this Five-year EPR.

13 Terminology

Table 13-1 defines the acronyms, abbreviations, and terminology used in this document.

Table 13-1: Terminology

Acronym/ Abbreviation/Term	Definition
~	Approximately
<	Less/fewer than
>	Greater/more than
°C	Degrees Celsius
µg	Microgram
ABU	Australian Business Unit
Action trigger	Measured parameter deviates outside a 3 SD limit
Adult female breeding omission probability	Annual probability estimate of skipped breeding for adult female marine turtle nesters in a nesting population
Adult female survival probability	Annual estimated survival rate for adult female marine turtle nesters in a nesting population
AGRU	Acid Gas Removal Unit
Alert trigger	Measured parameter deviates towards (but remains within) one SD for two consecutive years, or deviates outside a 1 SD limit
aMDEA	Activated methyl diethanolamine
Annual nester abundance	Estimate of total female marine turtle nesters per season at a rookery
ANZECC	Australian and New Zealand Environment and Conservation Council
APC	Advanced Process Control
AQMP	Air Quality Management Plan
AQMS	Air Quality Monitoring Station
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ASA	Additional Support Area
At Risk	Being at risk of Material Environmental Harm or Serious Environmental Harm and/or, for the purposes of the EPBC Act relevant listed threatened species, threatened ecological communities, and listed migratory species, at risk of Material Environmental Harm or Serious Environmental Harm
At Risk zone/site/island/well	An area where potential impacts are predicted to occur
BD	Base of Primary Dune; sampling site located at the base of the Primary Dune
BP	Butler Park (monitoring site)
BTEX	Benzene, toluene, ethylbenzene, and xylene compounds
Butler Park	Barrow Island accommodation village (formerly known as the Construction Village)
CAPL	Chevron Australia Pty Ltd
CBF	Crest of Beach Face; sampling site located at the change in slope at the transition between the beach face and foredune area
CDS	Conventional Distance Sampling

Acronym/ Abbreviation/Term	Definition
CI	Confidence Interval; an interval that is likely to contain the true value of a population parameter, but reflects the inherent uncertainty in estimating this parameter from a sample. The level of confidence reflects the likelihood that the constructed interval contains the true parameter value, so a 95% Confidence Interval is an interval that will include the true parameter value 95% of the time. By convention, 95% Confidence Intervals are usually used to define reasonably upper and lower bounds for parameter estimates.
Clutch frequency	The mean number of clutches laid per female marine turtle nester per season
cm	Centimetre
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
COPC	Chemicals of Potential Concern
CSMMP	Coastal Stability Management and Monitoring Plan
CT	Communications Tower
DLN	Dry Low NO_x
DNA	Deoxyribonucleic Acid
DO	Dissolved oxygen
DOC	Dissolved organic carbon
DomGas	Domestic Gas
DotEE	Former Commonwealth Department of the Environment and Energy (now the Department of Agriculture, Water and the Environment; DotEE dates: from 19 Jul 2016 to 31 Jan 2020)
DPaW	Former Western Australian Department of Parks and Wildlife (now part of Western Australian Department of Biodiversity, Conservation, and Attractions [from 1 July 2017])
DSM	Density Surface Modelling
EC	Electrical Conductivity (of groundwater)
eDNA	Environmental DNA; DNA that can be extracted from environmental samples
EFA	Ecosystem Function Analysis
EMP	Environmental Management Plan
Environmental Harm	Has the meaning given by Part 3A of the *Environmental Protection Act 1986* (WA)
EP Act	Western Australian *Environmental Protection Act 1986*
EPA	Western Australian Environmental Protection Authority
EPBC 2003/1294	Commonwealth Ministerial Approval (for the Gorgon Gas Development) as amended or replaced from time to time.
EPBC 2008/4178	Commonwealth Ministerial Approval (for the Revised Gorgon Gas Development) as amended or replaced from time to time
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
EPR	Environmental Performance Report
EWMA	Exponentially Weighted Moving Average

Acronym/ Abbreviation/Term	Definition
FA	Foredune Area; area between the beach face and the primary dune, which is populated by scattered vegetative hummocks and marine turtle body holes
First Response	Quarantine activities that occur immediately after the detection of a suspect NIS or Marine Pest. The aim is to contain, control, and eliminate.
FMP	Fire Management Plan
GHG	Greenhouse Gas
Gorgon Gas Development	Gorgon Gas Development and Jansz Feed Gas Pipeline
GPS	Global Positioning System
GTG	Gas Turbine Generator
GTP	Gas Treatment Plant
H_2S	Hydrogen sulphide
ha	Hectare
Hatchling	Newly hatched marine turtle
Hatchling Disorientation	The range of dispersion (nest fan spread angle) of marine turtle hatchling tracks from the emergence point
Hatchling Misorientation	The degree of deflection (nest fan offset angle) of marine turtle hatchling tracks from the most direct line to the ocean
HAZID	Hazard Identification
HDD	Horizontal Directional Drilling
HES	Health, Environment, and Safety (now known as HSE)
Hg	Mercury
HSE	Health, Safety, and Environment (was HES)
Incursion Response	Coordinated quarantine activities that aim to delineate, delimit, and eliminate positively identified NIS and Marine Pests.
Index beach	Key beach that is used as an index for monitoring
Internesting interval	Period between a successful nest and subsequent nest or nesting attempt in a single breeding season. The females move to offshore internesting grounds while they form the next clutch of eggs. Internesting grounds may be close to or remote from the nesting beach.
IR	Infrared
JHA	Job Hazard Analysis
km	Kilometre
km^2	Square kilometre
L	Litre
LCGT	Liquefaction Compressor Gas Turbine
LFA	Landscape Function Analysis
LiDAR	Light Detecting and Ranging
LNG	Liquefied Natural Gas
LOR	Limit of Reporting (also known as the detection limit)
LRR	Log Response Ratio

Acronym/ Abbreviation/Term	Definition
LTMTMP	Long-term Marine Turtle Management Plan
m	Metre
m^2	Square metre
m^3	Cubic metre
MAD	Median Absolute Deviation
MAH	Monocyclic Aromatic Hydrocarbon
Management triggers	Quantitative, or where this is demonstrated to be not practicable, qualitative matters above or below which relevant additional management measures must be considered
Marine Pest	Species other than the native species known or those likely to occur in the waters of the Indo–West Pacific region and the Pilbara Offshore marine bioregion
Mast seeding	Mass, synchronous seed production by a plant species every two or more years on a regional scale
Material Environmental Harm	Environmental Harm that is neither trivial nor negligible
MDA	Mundabullangana (Reference site on the WA mainland)
MEG	Monoethylene glycol; used as a hydrate inhibitor
Metocean	Meteorological and oceanographic conditions
mg	Milligram
mm	Millimetre
MOF	Materials Offloading Facility
MS	(Western Australian) Ministerial Statement
MS 769	Western Australian Ministerial Statement 769 (for the Jansz Feed Gas Pipeline) as amended from time to time
MS 800	Western Australian Ministerial Statement 800 (for the Gorgon Gas Development) as amended from time to time
MS 965	Western Australian Ministerial Statement 965, issued for the Additional Support Area, as amended from time to time
MSORD	Multi-state Open Robust Design
N/A	Not Applicable
NEPM	National Environmental Protection Measure
NGER Act	Commonwealth *National Greenhouse and Energy Reporting Act 2007*
NIS	Non-indigenous Terrestrial Species; any species of plant, animal, or microorganism not native to Barrow Island
NMVOC	Non-methane Volatile Organic Compound
NO	Nitrogen oxide, nitric oxide
NO_2	Nitrogen dioxide
NOHES	National Occupational Health Exposure Standards
NO_x	Nitrogen oxides (NO and NO_2)
O_3	Ozone
O_2	Oxygen

Acronym/ Abbreviation/Term	Definition
OBIA	Object-based Image Analysis
OCB	Operations Centre Building
OEMS	Operational Excellence Management System
OEPA	Former Office of the (Western Australian) Environmental Protection Authority (now Department of Water and Environmental Regulation [DWER] [from 1 July 2017])
ORP	Oxidation-reduction Potential (also known as redox)
PAH	Polycyclic Aromatic Hydrocarbon
PCRP	Post-Construction Rehabilitation Plan
PD	Primary Dune; sampling site located on the primary dune beyond the permanent vegetation line
PDS	Passive Diffusive Sampler
PFC	Percentage foliage cover
pH	Measure of acidity or basicity of a solution
PIP	Performance Improvement Package
$PM_{2.5}$	Particulate matter less than 2.5 microns
PM_{10}	Particulate matter less than 10 microns
PPE	Personal Protective Equipment
ppm	Parts per million
Project	Gorgon Gas Development
Proliferation	Increase of a species, attributable to the Gorgon Gas Development, by frequent and repeated reproduction: • NIS plants (excluding those considered to be naturalised) proliferation: an increase in the distribution of NIS plants producing propagules outside existing Weed Hygiene Zones. • NIS animals' proliferation: an increase in reproductively capable offspring dispersing outside the known distribution. • Marine Pest proliferation: an increase in reproductively capable offspring dispersing outside the known distribution in the waters surrounding Barrow Island.
PSD	Particle Size Distribution
Q1, Q2, etc.	Three-month quarter of a calendar year
QEP	Quarantine Expert Panel
QMS	Quarantine Management System
Quarantine Incident	A quarantine incident is declared (declaration is subject to positive identification*) by the CAPL Quarantine Manager following: • a detection of NIS or Marine Pest on Barrow Island after Final Quarantine Clearance, or • the proliferation of a NIS population on Barrow Island or Marine Pest in the waters surrounding Barrow Island. **Level 1 Quarantine Incident** • A confirmed detection of NIS on Barrow Island, after Final Quarantine Clearance, where the risk of the species to the biodiversity of Barrow Island is considered by CAPL, on advice of the Quarantine Expert Panel (QEP), to be low, or

<table>
<tr><th>Acronym/ Abbreviation/Term</th><th>Definition</th></tr>
<tr><td></td><td>
A proliferation of existing NIS on Barrow Island as a consequence of Gorgon Gas Development activities.
Level 2 Quarantine Incident
A confirmed detection of NIS on Barrow Island, after Final Quarantine Clearance, where:
uncertainty exists (as determined by CAPL on advice of the QEP) as to the risk of the species to the biodiversity of Barrow Island due to a range of factors (e.g. the ability of the species to survive on Barrow Island, availability of suitable habitats), or
the risk to the biodiversity of Barrow Island is considered to be high (as determined by CAPL, on advice of the QEP), but the ability to detect and eradicate is considered readily achievable (due to factors such as visibility, fecundity, slow dispersal etc.).
Level 3 Quarantine Incident
Terrestrial NIS: A confirmed detection of NIS on Barrow Island, after Final Quarantine Clearance, where:
the risk to the biodiversity of Barrow Island is considered to be high and the ability to detect and eradicate is difficult (as determined by CAPL, on advice of the QEP), and/or
the consequence of eradication/control actions on the biodiversity of Barrow Island is considered to be high (as determined by CAPL, on advice of the QEP).
Marine Pests: A confirmed detection of a Marine Pest on marine infrastructure or in the waters surrounding Barrow Island. Note: A Marine Pest that has only been detected on the wetsides of a vessel and not on marine infrastructure and/or in the waters surrounding Barrow Island is not considered an incident (see Quarantine Intercept).
* Positive identification is taxonomic (morphologic or molecular) confirmation in every instance except where there is high certainty of species identification in the expert judgement of the CAPL Quarantine Manager.
Note: An introduction of a Marine Pest is classified as a Level 3 Incident only.
</td></tr>
<tr><td>Quarantine Intercept</td><td>Terrestrial NIS: The detection, containment, and removal of suspected NIS prior to Final Clearance.
Marine Pest: The detection, containment, and removal of a Marine Pest on a vessel (including barges etc.) wetsides after Final Quarantine Clearance is granted and when the vessel is within the limited access zone or controlled access zone.</td></tr>
<tr><td>Quarantine Introduction</td><td>The presence of viable NIS on Barrow Island, or of a Marine Pest in the waters surrounding Barrow Island (excluding on vessel wetsides—see Quarantine Intercept).
In both instances, the species will be considered introduced if the species has survived First Response and Incursion Response.</td></tr>
<tr><td>Quarantine Near Miss</td><td>Terrestrial NIS: The detection, containment, and removal of suspected NIS prior to Final Clearance.
Marine Pest: The detection, containment, and removal of a Marine Pest on a vessel (including barges etc.) wetsides after Final Quarantine Clearance is granted and when the vessel is within the limited access zone or controlled access zone.</td></tr>
</table>

Acronym/ Abbreviation/Term	Definition
Quarantine Procedural Breach	Any case where a quarantine observation, inspection, or audit detects a failure to comply with Barrow Island quarantine procedures, standards, or concessions. **Level 1 Quarantine Procedural Deviation** • Upon arrival of a vessel or material at Barrow Island, it is determined that a quarantine procedure, or part thereof, has not been followed and the potential impact of the deviation has low risk to the biodiversity of Barrow Island and surrounding waters. **Level 2 Quarantine Procedural Deviation** • Upon arrival of a vessel or material at Barrow Island, it is determined that a quarantine procedure, or part thereof, has not been followed and the potential impact of the deviation has high risk to the biodiversity of Barrow Island and surrounding waters.
Redox	*See* ORP
Reference zone/site/island/well	Specific areas of the environment that are not at risk of being affected by the Project or existing developments, that can be used to determine the natural state, including natural variability, of environmental attributes.
Rehabilitation Impact Site	A transect or other monitoring method located within an area that has been subject to anthropogenic disturbance and has since been rehabilitated according to the methodology in the PCRP (Ref. 17)
Rehabilitation Reference Site	A transect or other monitoring method located within an area that has not been subject to recent anthropogenic disturbance
Remigration interval	The frequency (in years) between breeding seasons at which marine turtles return to the nesting ground to reproduce
Reporting Period	The period from 10 August 2015 to 9 August 2020 covered by this EPR
ROV	Remotely Operated Vehicle
ROW	Right-of-way
RTK	Real-time Kinematic
SAP	Sampling and Analysis Plan
SAQP	Sampling and Analysis Quality Plan
Scope 1	Defined under the Greenhouse Gas Protocol (a Corporate Accounting and Reporting Standard) as 'all direct GHG emissions, where direct GHG emissions are emissions from sources that are owned or controlled by the reporting entity'
SD	Standard deviation (statistical variation); a measure used to quantify the amount of variation or dispersion of a set of data values
SE	Standard error (statistical variation); a measure used to quantify the accuracy with which a sample mean represents a population mean
Serious Environmental Harm	Environmental harm that is: a) irreversible, of a high impact or on a wide scale; or b) significant or in an area of high conservation value or special significance and is neither trivial nor negligible.
SO_2	Sulfur dioxide
SRE	Short-range Endemics; taxonomic group of invertebrates that are unique to an area, found nowhere else, and have naturally small distributions (i.e. <10 000 km^2).
SRESFMP	Short-range Endemics and Subterranean Fauna Monitoring Plan
SSC	Surveillance System Components
TAPL	Texaco Australia Pty Ltd

Acronym/ Abbreviation/Term	Definition
TC	Tropical cyclone
TDF	Terrestrial Disturbance Footprint The area to be disturbed by construction or operations activities associated with the Terrestrial Facilities listed in Condition 6.3 of MS 800, Condition 6.3 of MS 769, and Condition 5.2 of EPBC 2003/1294 and 2008/4178, and set out in the Terrestrial and Subterranean Baseline State and Environmental Impact Report required under Condition 6.1 of MS 800, Condition 6.1 of MS 769, and Condition 5.1 of EPBC 2003/1294 and 2008/4178.
TEOM	Tapered Element Oscillating Microbalance
Threatened Species	Species listed as extinct, extinct in the wild, critically endangered, endangered, vulnerable or conservation dependent under section 178 of the Commonwealth EPBC Act.
TLT	Temporary Lighting Tower
TMP	Topsoil Management Plan
Topsoil	The top layer of soil that stores seed and acts as the growth medium in which vegetation can establish itself
Transect	The path along which a researcher moves, counts, and records observations
TRH	Total Recoverable Hydrocarbons
TSEMP	Terrestrial and Subterranean Environment Monitoring Program
TT	Terminal Tanks (monitoring site)
UPL	Upper Percentile Limit
UV	Ultraviolet
VOC	Volatile Organic Compound
WA	Western Australia
WAPET Landing	Proper name referring to the site of the barge landing existing on the east coast of Barrow Island prior to the date of MS 800.
Waters surrounding Barrow Island	Refers to the waters of the Barrow Island Marine Park and Barrow Island Marine Management Area (~4169 ha and 114 693 ha respectively), as well as the Port of Barrow Island representing the Pilbara Offshore Marine Bioregion.
Weed	Non-indigenous plant species; a plant that establishes in natural ecosystems, subsequently adversely affecting natural processes and ultimately resulting in the decline of the native vegetation community
Weed Hygiene Zone	An area within which non-indigenous plant species, assessed to be high-risk species, have established populations and/or where a seedbank of a high-risk species is present.
WHO	World Health Organization
YCN	Yacht Club North (beach)
YCS	Yacht Club South (beach)

14 References

Table 14-1 lists the documentation referenced in this EPR.

Table 14-1: References

Ref. No.	Description	Document ID
1.	Chevron Australia. 2016. *Gorgon Gas Development and Jansz Feed Gas Pipeline: Terrestrial and Subterranean Environment Monitoring Program*. Rev. 1.0. Chevron Australia, Perth, Western Australia. Available from: https://australia.chevron.com/-/media/australia/our-businesses/documents/gorgon-terrestrial-and-subterranean-environment-monitoring-program.pdf [Accessed 11 Sep 2019]	GOR-COP-01696
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3.	Biota Environmental Sciences. 2019. *Gorgon Gas Development: Barrow Island Terrestrial Vertebrate Fauna 2018 Monitoring Report*. Unpublished report for Chevron Australia, Perth, Western Australia.	ABU180401770
4.	Golder Associates Pty Ltd. 2017. *Gorgon GTP Groundwater Monitoring Operational Sampling and Analysis Quality Plan*. Unpublished report for Chevron Australia, Perth, Western Australia.	ABU170700438
5.	Chevron Australia. 2017. *Gorgon Gas Development and Jansz Feed Gas Pipeline: Terrestrial and Marine Quarantine Management System*. Rev. 1.0. Chevron Australia, Perth, Western Australia. Available from: https://australia.chevron.com/-/media/australia/our-businesses/documents/terrestrial-and-marine-quarantine-management-system.pdf [Accessed 11 Sep 2019]	GOR-COP-01854
6.	Chevron Australia. 2015. *Gorgon Gas Development and Jansz Feed Gas Pipeline: Five-year Environmental Performance Report (August 2010–August 2015)*. Rev. 0. Chevron Australia, Perth, Western Australia. Available from: https://australia.chevron.com/-/media/australia/our-businesses/documents/gorgon-and-jansz-feed-gas-pipeline-5-year-environmental-performance-report-2010-2015.pdf [Accessed 11 Sep 2019]	G1-NT-REPX0007517
7.	Chevron Australia. 2018. *Gorgon Gas Development and Jansz Feed Gas Pipeline: Long-term Marine Turtle Management Plan*. Rev. 1.0. Chevron Australia, Perth, Western Australia. Available from: https://australia.chevron.com/-/media/australia/our-businesses/documents/gorgon-emp-long-term-marine-turtle-management-plan.pdf [Accessed 11 Sep 2019]	GOR-COP-01728
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