



# PHOENIX

ENVIRONMENTAL SCIENCES

## Long-term migratory shorebird monitoring program for the Optimised Mardie Project

Prepared for Mardie Minerals Pty Ltd

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Final



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Phoenix Environmental Sciences Pty Ltd  
2/3 King Edward Road OSBORNE PARK WA 6017  
P: 08 6323 5410  
E: [admin@phoenixenv.com.au](mailto:admin@phoenixenv.com.au)  
Project code:1355-MSP-BCI-VER

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## 1 INTRODUCTION

Mardie Minerals Pty Ltd (Mardie Minerals) is developing the Optimised Mardie Project (Optimised Proposal), an evaporative solar salt project that utilises seawater to produce raw salts as a feedstock for processing high purity salt, fertiliser grade sulphate of potash (SoP), and potentially other commercial by-products. The Optimised Proposal is located approximately 80 km south-west of Karratha, in the Pilbara region of Western Australia (WA).

Environmental approval for the Original Mardie Project was granted under the Environmental Protection Act 1986 (EP Act) on 24 November 2021 via Ministerial Statement (MS) 1175. The Optimised Proposal involves the expansion and realignment of concentrator and crystalliser ponds and an increased salt and SoP production rate following the addition of newly acquired tenements.

This Project currently has ten other management plans associated with it, that are in various stages of development at the time of completing this monitoring program. Development and implementation of this monitoring program is subject to the overarching adaptive management approach adopted by Mardie Minerals documented in the Monitoring and Adaptive Management Plan (MAMP; required under Ministerial Statement No. 1175 [MS 1175]). As new management plans are developed and implemented, data from those plans will be considered in future revisions of this monitoring program. See Table 1-1 for details on the status of the other ten management plans associated with the Optimised Mardie Project.

**Table 1-1 Associated management plan status for the Mardie Minerals salt project.**

Management plan	Status	Latest version	Last updated	Linkages with this monitoring program
Construction Environmental Management Plan (CEMP)	Approved (EPBC)	2	10-08-2022	<p>The CEMP includes management actions for the mitigation of potential impacts to the environment. Impacts relevant to this monitoring program addressed in the CEMP include:</p> <ul style="list-style-type: none"> <li>• Unapproved disturbance of fauna habitat;</li> <li>• Fauna injury or mortality through vehicle strike or entrapment;</li> <li>• Loss of BCH, Mangrove or Marine ecosystem function due to loss of light or smothering from sediment;</li> <li>• Contamination of soils, surface waters and marine environment (acid sulphate soils);</li> <li>• Attraction of feral animals (waste); and</li> <li>• Injury or death to local fauna (hydrocarbons)</li> </ul> <p>Review of survey data gathered from implementing this monitoring program will consider compliance with the management actions of the CEMP to determine if there is a correlation.</p> <p>Key discoveries from this monitoring program that require additional management (i.e., identification of additional habitats critical to migratory shorebirds) may be considered in future revisions of the CEMP.</p>
Dredge Management Plan	Approved (EPBC and EP Act)	Rev 3	12-08-2022	<p>The DMP includes management actions for mitigation of potential impacts from dredging on the environment. Impacts relevant to this monitoring program addressed in the DMP include:</p>

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Management plan	Status	Latest version	Last updated	Linkages with this monitoring program
				<ul style="list-style-type: none"> <li>Disturbance of contaminants and Potential Acid Sulphate Soils during marine construction activities (dredging and disposal); and</li> <li>Indirect impacts on marine fauna habitat through decreased water quality.</li> </ul> <p>Review of survey data gathered from implementing this monitoring program will consider compliance with the management actions of the DMP to determine if there is a correlation.</p> <p>Key discoveries from this monitoring program that require additional management (i.e., identification of additional habitats critical to migratory seabirds) may be considered in future revisions of the DMP.</p>
Marine Environmental Quality Monitoring & Management Plan	Approved (EPBC and EP Act)	Rev 5	15-08-2022	No clear/significant linkages identified.
Heritage Management Plan	Approved (EP Act)			No clear/significant linkages identified.
Benthic Communities and Habitat Monitoring and Management Plan (BCHMMP)	Drafted	A	16-08-2022	<p>The BCHMMP includes management actions, controls, monitoring and reporting commitments to mitigate potential impacts of the Proposal on Benthic Communities and Habitat (BCH) some of which is habitat for migratory shorebirds.</p> <p>Monitoring and reporting outcomes (including changes to the extent and health of migratory shorebird habitat) from the BCHMMP will be considered in the evaluation of the monitoring data gathered for this program.</p> <p>Key discoveries from this monitoring program that require additional management (i.e., identification of additional habitat or habitat preference for migratory shorebirds) may be considered in future revisions of the BCHMMP.</p>
Groundwater Monitoring and Management Plan (GMMP)	Drafted	C	11-10-2022	<p>No significant direct linkages between ground water and migratory shore birds have been identified.</p> <p>Groundwater may indirectly impact migratory shorebirds through changes to the BCH (intertidal) extent and health. BCH is identified as critical habitat for migratory shorebirds.</p> <p>Impacts to groundwater levels and quality may have impact on coastal ecosystems, specifically algal mat which is migratory shorebird habitat. Changes to groundwater levels and quality, and subsequently BCH health and extent will be considered in evaluating results from surveys identified in this program.</p>

Management plan	Status	Latest version	Last updated	Linkages with this monitoring program
				Key discoveries from this monitoring program that require additional management (i.e., identification of additional habitats critical to migratory shorebirds) may be considered in future revisions of the GMMP.
Illumination Plan	In development. Modelling underway	0.2	02-02-2022	An illumination plan is in development to provide management actions and controls to mitigate impacts associated with the artificial light emissions from the Proposal on fauna behaviour. Monitoring of shorebirds from this program may be considered in the preparation of the illumination plan.
Turtle Monitoring Program	Ready for submission	Rev C	02-04-2019	No clear/significant linkages identified.
Mesquite Management Plan	EPBC Act only. Not commenced	N/A	N/A	No clear/significant linkages identified.
MAMP	In development	Rev A	N/A	This monitoring program will incorporate Mardie Minerals' overarching adaptive management approach detailed within the MAMP.

Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned to develop a migratory shorebird monitoring program for the Original Mardie Project, Figure 1-1. This monitoring program expands the program in consideration of the Optimised Proposal. The monitoring program follows an initial desktop study and reconnaissance survey in 2017 (Phoenix 2017), a Level 2 targeted terrestrial fauna survey over 2017-2018 (Phoenix 2020) and supplementary survey work in 2019 and 2020 (Phoenix 2021).

Globally, shorebird populations are in decline, and a major contributing factor to these declines is habitat loss (Clemens *et al.* 2009). This presents a considerable conservation challenge as their movement patterns take them across international boundaries that span much of the globe (Bamford *et al.* 2008). The identification and management of important sites for migratory species is therefore a complicated task that is managed with considerable scrutiny. There are 37 migratory shorebird species listed under the EPBC Act Policy Statement 3.21 (DoEE 2017), which are also protected under the following international agreements;

- the Convention on Conservation of Migratory Species of Wild Animals (CMS or Bonn Convention),
- bilateral agreements for the conservation of migratory birds between the Government of Japan (JAMBA), the Government of China (CAMBA), and the Government of the Republic of Korea (ROKAMBA), and
- the Convention on Wetlands of International Importance (also known as the Ramsar Convention).

Of the 37 species of migratory shorebirds listed under the EPBC Act, 20 were recorded during the surveys completed by Phoenix during the baseline surveys. While the vast majority (93.1%) of the birds recorded during the baseline surveys were outside the proposed development areas, compliance with Commonwealth and State legislation as well as the agreements listed above, requires that the proposed works do not negatively impact any of the EPBC listed species. As such, it is necessary to adequately monitor the population in the vicinity of the proposed Project. If a decline is detected, which is attributable to the Project, mitigation procedures will need to be implemented to reverse any negative effects the Project has had on said species.

In developing this management plan, a focus has been made through discussions with BirdLife Australia to maximise the value of the data gathered for improving our understanding of the migratory shorebird population that uses the Pilbara coast each year. Filling knowledge gaps in the migratory shorebird ecology in Australia is objective 4a of the Wildlife Conservation Plan for Migratory Shorebirds (DoEE 2015). This large area of the Australian coast is not currently being surveyed by any other monitoring programs, and so presents an opportunity to fill a knowledge gap through partnership with Mardie Minerals as they complete their monitoring program obligations. All migratory shorebird data gathered through the implementation of this monitoring program will be made available to the Department of Climate Change, Energy, the Environment and Water (DCCEEW), the Department of Biodiversity, Conservation and Attractions (DBCA), and BirdLife Australia's National Shorebird Monitoring Program ('Shorebird 2020').

As part of the project's marine and intertidal research offsets program required by MS 1175, data collected throughout the project will be shared with relevant scientific bodies to fill knowledge gaps relating to the marine and intertidal zones impacted. Utilising this data the offset program will aim to:

- map the original and current extent of Samphire and Algal mat on the west Pilbara coast
- identify and quantify the potential effects of sea level rise on the values of mangroves, samphire, and algal mat on the west Pilbara coast, and identify the significance of salt projects in preventing the adaptation of intertidal BCH to sea-level rise
- identify the ecological roles, values and functions of intertidal benthic communities and habitat
- identify the ecological roles, values and functions of intertidal benthic communities and habitat, to be paid in the event that loss of intertidal benthic communities and habitat, or loss of health, percent cover or diversity of intertidal benthic habitat and communities is identified by the Benthic communities and habitat monitoring and management plans

Within 6 months of commencement of the project, Mardie minerals will be required to submit a detailed research project proposal to the DCCEEW for approval by the minister which will meet the marine research requirements. Details on the contents of this proposal can be found in the EPBC 2018/8236 Decision Notice section 29c.

The Wildlife Conservation Plan for Migratory Shorebirds lists coastal development in Australia, anthropogenic disturbance, and altered hydrological regimes as threats that are to be mitigated (DoEE 2015). While the Project has the potential to impact shorebirds through such mechanisms, there is considerable evidence that saltworks in the region and other comparable regions provide valuable feeding habitat for a range of migratory shorebird species (e.g., Bennelongia 2011; Bertzeletos *et al.* 2012; Clemens *et al.* 2009; Estrella *et al.* 2016; Houston *et al.* 2012; Johnstone *et al.* 2013). The saltworks at Lake MacLeod and Port Hedland have both been shown to provide internationally important feeding habitat for migratory shorebirds (Bertzeletos *et al.* 2012; Estrella *et al.* 2016; Johnstone *et al.* 2013). Given the evidence of the value these land uses can have for migratory species (specifically the initial intake ponds where invertebrate density is very high), it is likely that this project will have a net positive outcome on migratory shorebirds, with the creation of new foraging habitat.

This report outlines the results of the baseline work completed by Phoenix associated with the Project and details the proposed monitoring program. The aim of the program is to ensure that a robust dataset is collected and can be analysed to provide evidence of changes to the migratory shorebird population at the Project site.

In addition, in accordance with MS 1175 condition 8-2(4), this monitoring program includes triggers and management actions to be implemented in the event that impacts to migratory shorebirds are observed at Mardie. However, useful triggers and thresholds and their associated management actions will be developed when 5-years of monitoring data has been collected.

## 1.1 BASELINE SURVEYS

Phoenix undertook a desktop study and site reconnaissance to inform the Pre-Feasibility Study (PFS) for the Project in 2017 (Phoenix 2017). The key findings of the desktop study and site reconnaissance with respect to migratory shorebirds was that migratory shorebirds are certain to occur and therefore needed to be assessed in terms of individual and collective numbers with respect to Important Bird Areas (IBA's) and East Asian-Australasian Flyway (EAAF) population criteria.

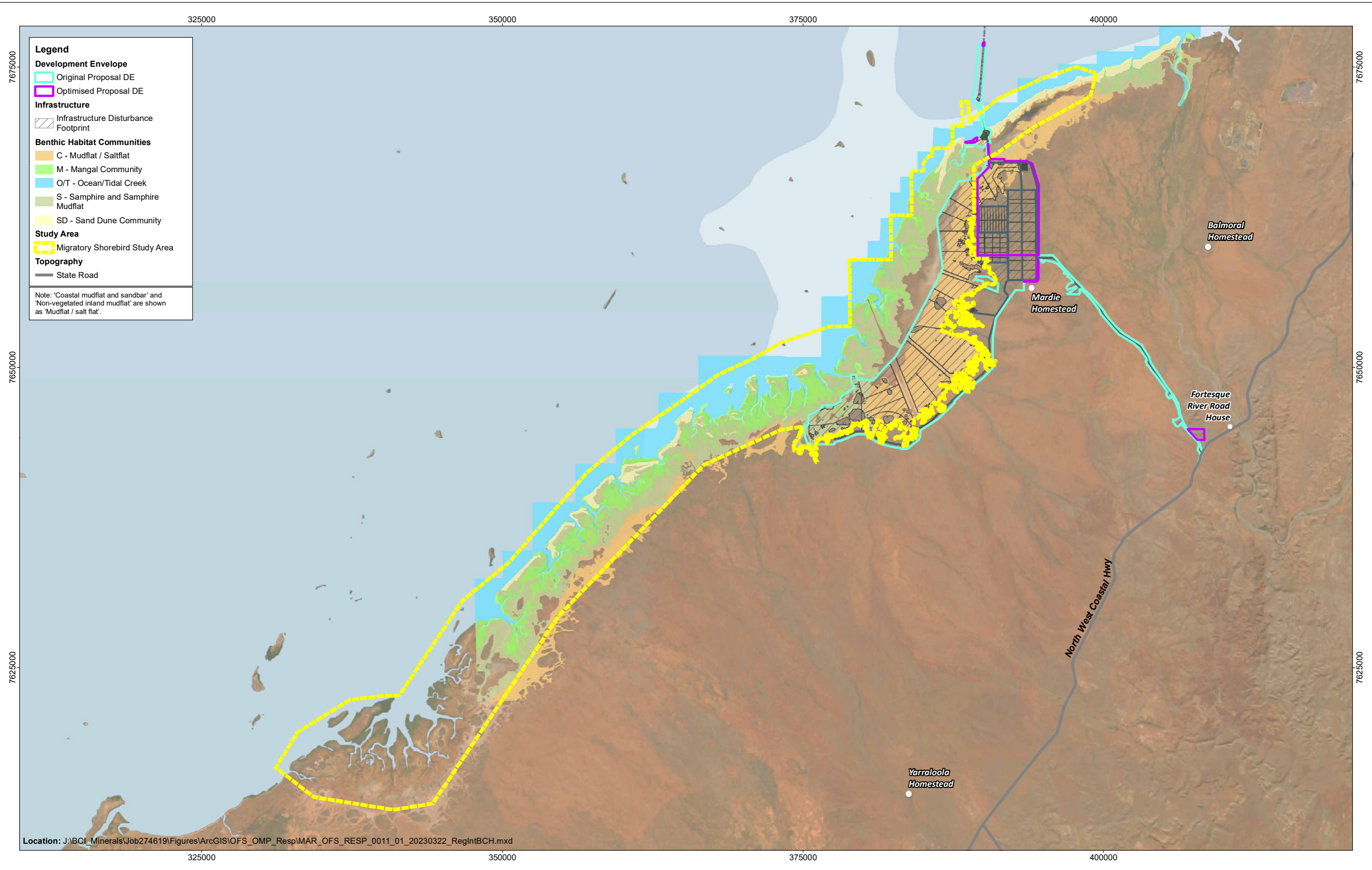
Based on the desktop and reconnaissance findings, as well as the requirements of the Original Mardie Project Environmental Scoping Document (ESD) (BCI Minerals & Preston Consulting 2018) Phoenix undertook a targeted Level 2 survey for vertebrate fauna, including migratory shorebirds. The migratory shorebird surveys included a portion of the area of the Optimised Proposal. The surveys took place over the period 2017-2019 (Phoenix 2020), with the local shorebird surveys occurring over the summer of 2018-2019 and winter 2019.

The shorebird sampling took place within the Migratory Shorebird Study Area (MSSA) associated with the coast and coastal habitats. The sampling comprised of a 'local program' and a 'regional program' where the local program was adjacent to the Project Development Envelope (DE) and the regional program was south of the DE within the MSSA (Figure 1-1). Similar habitats were sampled in the local and regional programs; these habitats (described in Phoenix 2020) (Figure 1-2) included;

- samphire wetland
- coastal mudflat and sandbar
- mangal forest stand
- mangal forest fringing tidal creeks
- non-vegetated inland mudflat, and
- beach.

Figure 1-1 shows migratory shorebirds habitat mapping within the approved and proposed Mardie Project Development Envelopes.





**Legend**

**Development Envelope**

- Original Proposal DE
- Optimised Proposal DE

**Infrastructure**

- Infrastructure Disturbance Footprint

**Benthic Habitat Communities**

- C - Mudflat / Saltflat
- M - Mangal Community
- O/T - Ocean/Tidal Creek
- S - Samphire and Samphire Mudflat
- SD - Sand Dune Community

**Study Area**

- Migratory Shorebird Study Area

**Topography**

- State Road

Note: 'Coastal mudflat and sandbar' and 'Non-vegetated inland mudflat' are shown as 'Mudflat / salt flat'.

Location: J:\BCL\_Minerals\Job274619\Figures\ArcGIS\OFS\_OMP\_Resp\MAR\_OFS\_RESP\_0011\_01\_20230322\_RegIntBCH.mxd

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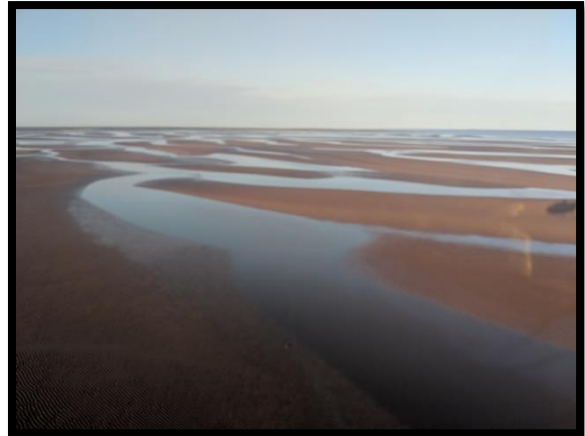
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**Mardie Project**  
**Migratory Shorebird Baseline Study Area**

Figure:  
**1-1**



a) Samphire wetland



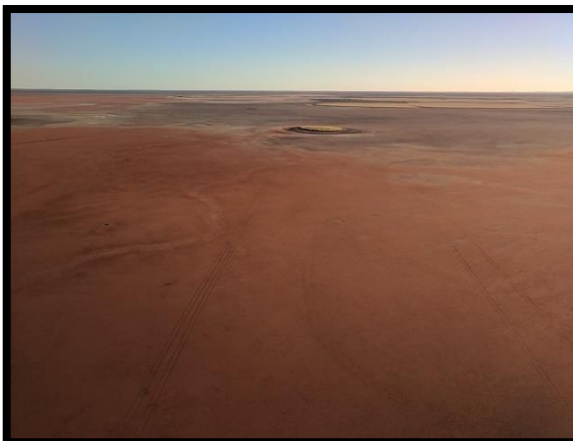
b) Coastal mudflat and sandbar



c) Mangal forest stand



d) Mangal forest fringing tidal creeks



e) Non-vegetated inland mudflat



f) Beach

**Figure 1-2 Typical migratory shorebird habitats in the area**

## 1.2 BASELINE SURVEY RESULTS

Phoenix completed the baseline migratory shorebird surveys over four phases. These surveys were conducted aerially with the use of a helicopter. The dates those phases were carried out over are presented in Table 1-2, and the flightpath transects for one phase of the survey as an example of the coverage achieved by each phase are presented in Figure 1-3.

The highest numbers of migratory shorebirds were recorded during Phases 2 and Phase 4 which occurred during January and February. A total of 20 of the 37 species listed under EPBC Act Policy Statement 3.21 (DoEE 2017) were recorded during the surveys, 19 of which were also recorded exclusively in the local program (see Figure 1-4). All 20 species were recorded in the summer sample events, and 18 were recorded overwintering; no species were confined to the overwintering survey (Phase 3).

The highest densities of birds were detected along the coast directly to the west of the DE and at the southern extent of the MSSA. Full details of the baseline survey results and extrapolations of populations across the survey areas is provided in the final survey report (Phoenix 2020).

**Table 1-2 Baseline survey details and results**

Phase	Survey dates	Number of replicates	Median number of migratory shorebirds recorded	Total number of migratory shorebird species
Phase 1	5-7 Dec. 2017	6	322	18
Phase 2	13-15 Jan. 2018	6	737	17
Phase 3	24-26 Jul. 2018	10	436	18
Phase 4	21-25 Feb. 2019	4	731	20

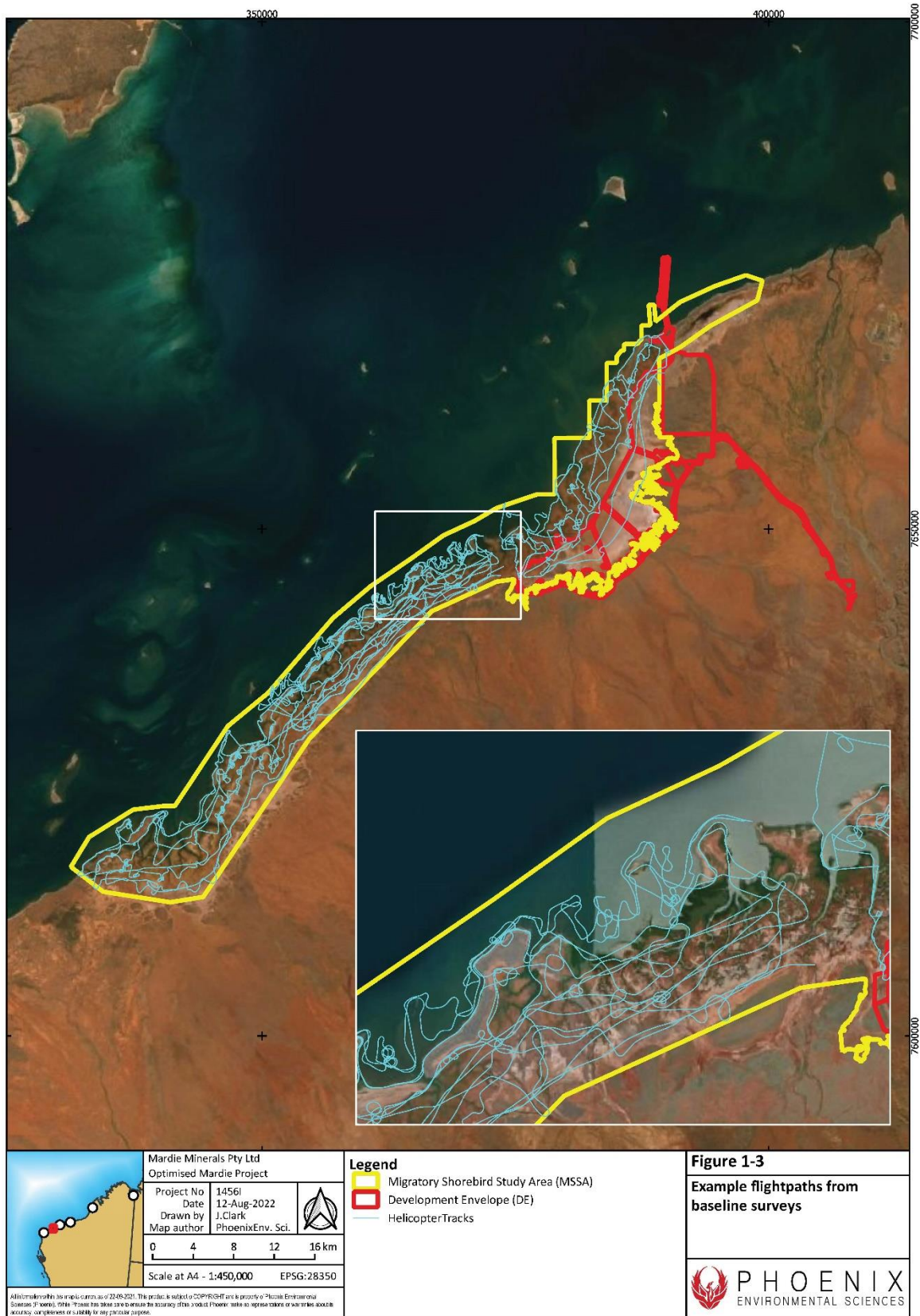


Figure 1-3 Example flightpaths from baseline surveys



Figure 1-4 Location of all migratory shorebird records from baseline surveys

### 1.3 SIGNIFICANCE OF THE MARDIE AREA TO MIGRATORY SHOREBIRDS

The EPBC Act provides protection for 105 Migratory species (not including sub-species) listed under numerous international agreements that Australia is a signatory to (section 1). Of these, 37 Migratory shorebird species (Table 3-3) are given special consideration through recently updated guidelines: *Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed Migratory shorebird species* (DoEE 2017).

Australia is geographically and ecologically an important location for Migratory shorebirds within the EAAF ('the flyway'). A total of 36 of the 37 Australian Migratory shorebird species breed in the northern hemisphere and migrate annually to southern non-breeding areas including Australia. Double-banded plovers migrate between Australia and breeding grounds in New Zealand, rather than north-south through the flyway. The flyway stretches from Siberia and Alaska, southwards through east and south-east Asia, to Australia and New Zealand.

Under the EPBC Act, 'important habitat' is a key concept for Migratory species (DoEE 2013; 2017). Important habitats in Australia for Migratory shorebirds under the EPBC Act include those recognised as nationally or internationally important. The accepted and applied approach to identifying internationally important shorebird habitat has been through the use of criteria adopted under the Ramsar Convention on Wetlands (DoEE 2017).

According to that approach:

1. Internationally important habitat regularly supports
  - a. 1% of the individuals in a population of one species or sub-species of waterbird or
  - b. a total abundance of at least 20,000 waterbirds
2. Nationally important habitat regularly supports:
  - a. 0.1% of the flyway population of a single species of Migratory shorebird or
  - b. a total abundance of at least 2,000 Migratory shorebirds or
  - c. at least 15 Migratory shorebird species.

The MSSA met the criteria for 1a, 2a, 2b and 2c. Within the regional program area, the area is likely to also meet criteria 1b. The Level 2 migratory shorebird survey recorded 20 of the 37 species listed under *EPBC Act Policy Statement 3.21* (DoEE 2017) and therefore the MSSA meets the diversity criterion for 'nationally important shorebird habitat' as it supports at least 15 migratory shorebird species (during the summer months) (Phoenix 2020).

The results indicated the MSSA is likely to regularly support at least 2,000 birds and therefore is likely to meet the threshold criterion of 'total abundance of at least 2,000 Migratory shorebirds' for nationally significant shorebird habitat.

Six species were recorded in nationally significant numbers (i.e., >0.1% of the EAAF population estimates) in any one sample event:

- Bar-tailed Godwit
- Eastern Curlew (CR)
- Grey-tailed Tattler (P4)
- Ruddy Turnstone
- Sanderling
- Whimbrel.

Accordingly, the MSSA appears to meet the individual species abundance criterion for nationally important habitat, i.e., regularly supports >0.1% of the flyway population of a single species of

Migratory shorebird. An additional eight species (Common Greenshank, Curlew Sandpiper (CR), Greater Sand Plover (VU), Oriental Plover, Pacific Golden Plover, Red Knot (EN), Red-necked Stint and Terek Sandpiper) were deemed to be likely to also occur in nationally significant numbers in the MSSA.

Based on extrapolated data, a further three species are likely to occur in internationally significant numbers (i.e., >1% of the EAAF population) in the MSSA – Grey-tailed Tattler (P4), Ruddy Turnstone and Whimbrel (all of which were evenly distributed across the MSSA).

## 2 SCOPE OF WORK

The scope of work for the Optimised Mardie Project: Migratory Bird Monitoring Program is to develop and implement a long-term migratory shorebird monitoring program that principally aims to:

1. monitor and track any changes in the migratory shorebird population at the impact sites (inside and adjacent to the development footprint), as well as at both the control and regional sites (described in 2.1).
2. determine whether the trends in number of migratory species detected each year at the impact sites are consistent with those at the control and regional sites.
3. record any threats to shorebirds in impact and control areas (e.g., feral or native predators, human influences).
4. in the event that there is:
  - a. a decline in numbers of any migratory bird species is detected, or
  - b. an increase in threats to migratory birds, such as presence of predators or human influences.

Then additional works will be actioned to identify the threatening process and reverse or mitigate the declines or threatening processes. This will require an adaptive management approach, as the nature of the disturbance will need to be identified before a management plan can be implemented as per MS 1175 and EPBC 2018/8236 Decision Notice.

A series of other environmental management plans are in the process of being developed for this project as listed in Table 1-1. As these documents are developed and approved, information gathered will be incorporated into other environmental management plans as part of the overarching adaptive management approach (defined in the proposed Adaptive Management Plan).

### 2.1 STUDY AREA

The three study areas are defined as follows (Figure 3-1):

- Impact Area (IA) – areas inside and adjacent to the DE. These areas include the evaporation ponds and the trestle jetty, and are a maximum of 5 km from the DE
- Control Area (CA) – areas to the southwest of the impact areas away from the DE that are of similar habitat to those found in the IA. These sites fall within a distance of 10 km to 40 km from the DE
- Regional Area (RA) – areas within the Pilbara of similar habitat that are more than 40 km from the DE.

## 3 METHODS

### 3.1 OVERVIEW

Accurately measuring changes in migratory shorebird communities between years is a complicated task. The methods outlined below were developed in consultation with BirdLife Australia with consideration for the following factors:

- tidal variation – birds use different habitats at different times of day in accordance with the tides
- seasonality – number of birds present varies dramatically throughout the year
- annual variability – number of birds varies between years depending on weather events and other factors, including international events and development
- remote/difficult to access areas – birds occur in areas with poor access and use a range of habitats where they can be difficult to observe
- detectability – many migratory species can be difficult to identify/detect.

The goal of the methods outlined below is to provide a robust, spatially explicit dataset that will show whether a change in the migratory shorebird population occurs inside the IA and identify whether that change is attributable to the developments associated with the Project. Consideration has been made to assess changes in the numbers of migratory shorebird species at the local scale (comparing trends involving the IA and CA), the regional scale (trends involving the CA and RA) and national scale (trends involved in national count data collated by BirdLife Australia (BirdData)). If a decline measured at the IA is greater than the trend measured at the CA, or RA, then it will be considered a decline attributable to the Project and the threatening process will need to be identified and managed. If declines measured at the IA are less than those measured at the CA or RA, then they will be considered a reflection of changes in the migratory bird species populations caused by factors other than the Project.

The monitoring program incorporates both aerial (helicopter) and ground-based bird counts (Table 3-1). Aerial surveys were used in the baseline survey as they provide the greatest coverage, get around limitation caused by tides and can be used to survey a range of habitat types that are otherwise inaccessible. Ground-surveys are an effective way of providing additional data at key sites and can also provide a more accurate count of species that occur in mixed flocks of birds that can be difficult to accurately identify.

By using a combination of the two survey methods, and surveying at various spatial scales, it will be possible to assess whether the diversity and number of birds at the IA is increasing, decreasing, or static. In the event that a change is detected, the annual habitat monitoring assessments (BCI and Phoenix 2021) and finer scale location data will be useful in identifying the cause(s). These methods were developed using the baseline data (Phoenix 2020), the *Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species* (DoEE 2017), and consultation with Dr. J. Ringma, the WA shorebird project coordinator at BirdLife Australia.

### 3.2 AERIAL SURVEYS

The baseline surveys for the Proposal that Phoenix completed between 2017-2020 all used an aerial survey technique. Aerial surveys, using a helicopter, are the recommended method for surveying migratory shorebirds in large remote regions where access is a limiting factor (DoEE 2017). Aerial surveys provide a cost-effective and efficient method for sampling large numbers of birds quickly (Kingsford *et al.* 2020). The survey method used for the monitoring program will be a modified version



of the method used during the baseline survey. Adjustments were made to maximise the repeatability of the survey between years, which will aid in the statistical analysis of changes in migratory shorebird occurrence at the IA and CA.

A series of 18 transects across the MSSA have been selected to be sampled systematically each year. The transects are made up of 1x10 grids that are 500 m by 500 m squares. Sites were placed so that nine are located in the IA and nine are in the CA. The transects are aligned along paths flown during the baseline surveys and thus target the range of potential shorebird habitats, taking into account the habitat-tidal sequence, from ocean mud/sand flats, through beaches, mangrove stands, samphire wetlands and finally bare mudflats that are barely inundated at the limit of the tide.

Each transect will be surveyed systematically by flying slowly at a low height through the middle of the grid, and recording all birds observed. A team of two people will be used to complete these surveys with at least one member being an ornithologist with experience conducting aerial surveys of shorebirds. These surveys will be repeated at both high and low tide over four consecutive days in late January or early February when shorebird numbers are at their highest.

### **3.3 GROUND-SURVEYS**

The baseline surveys recorded 6.94% of the total number of migratory shorebirds recorded in the MSSA inside the DE, despite the DE being 32% of the size of the MSSA. This is largely due to the habitat inside the DE being less suitable habitat than the adjacent tidal areas where most of the birds were detected.

The purpose of the ground-surveys at the ponds is to provide information on any changes to habitat use by migratory birds in response to the development. Numerous studies have shown that salt works such as this one along the north-western and north-eastern coasts can provide suitable foraging habitat for migratory shorebirds (e.g., Bennelongia 2011; Bertzeletos *et al.* 2012; Clemens *et al.* 2009; Estrella *et al.* 2016; Houston *et al.* 2012; Storr 1984). As such, it is likely that the first few stages of the evaporation ponds will see an increase in usage once the development has been completed. This may result in an apparent decline in some species in the surrounding area, as they move into the newly created foraging habitat. To account for this, the birds inside the areas expected to see the greatest increase in numbers will be monitored.

Systematic counts across the first two evaporation ponds (these most closely resemble seawater) will be carried out by the same team that complete the aerial surveys, and either during the days leading up to or after the aerial surveys have been completed. This survey will be done using a car to move around the site and with a spotting scope to locate and identify birds. These counts will only be done once at high tide and once at low tide as tidal variation in the surrounding area will likely influence the birds. While completing these surveys, any evidence of predation pressure from cats and/or dogs or disturbances caused by humans will also be recorded.

Additional ground-based surveys may also be completed around Karratha, approximately 100 km east of the DE, to provide regional data to be used to calibrate for annual variation in migratory shorebird numbers. Alternatively, a data-sharing agreement may be made with other salt projects in the region that can be used to provide regional context for annual variation in migratory shorebird numbers.

**Table 3-1 Summary of long-term monitoring program coverage**

<b>Method</b>	<b>Location</b>	<b>No. of replicates</b>	<b>Total area of coverage (ha)</b>
Aerial Survey (Figure 3-1)	Impact Area	9	2,250
	Control Area	9	2,250
<b>Subtotal</b>		<b>18</b>	<b>4,500</b>
Ground Survey (Figure 3-2)	Evaporation ponds 1 and 2	1	2,953
<b>Total</b>		<b>19</b>	

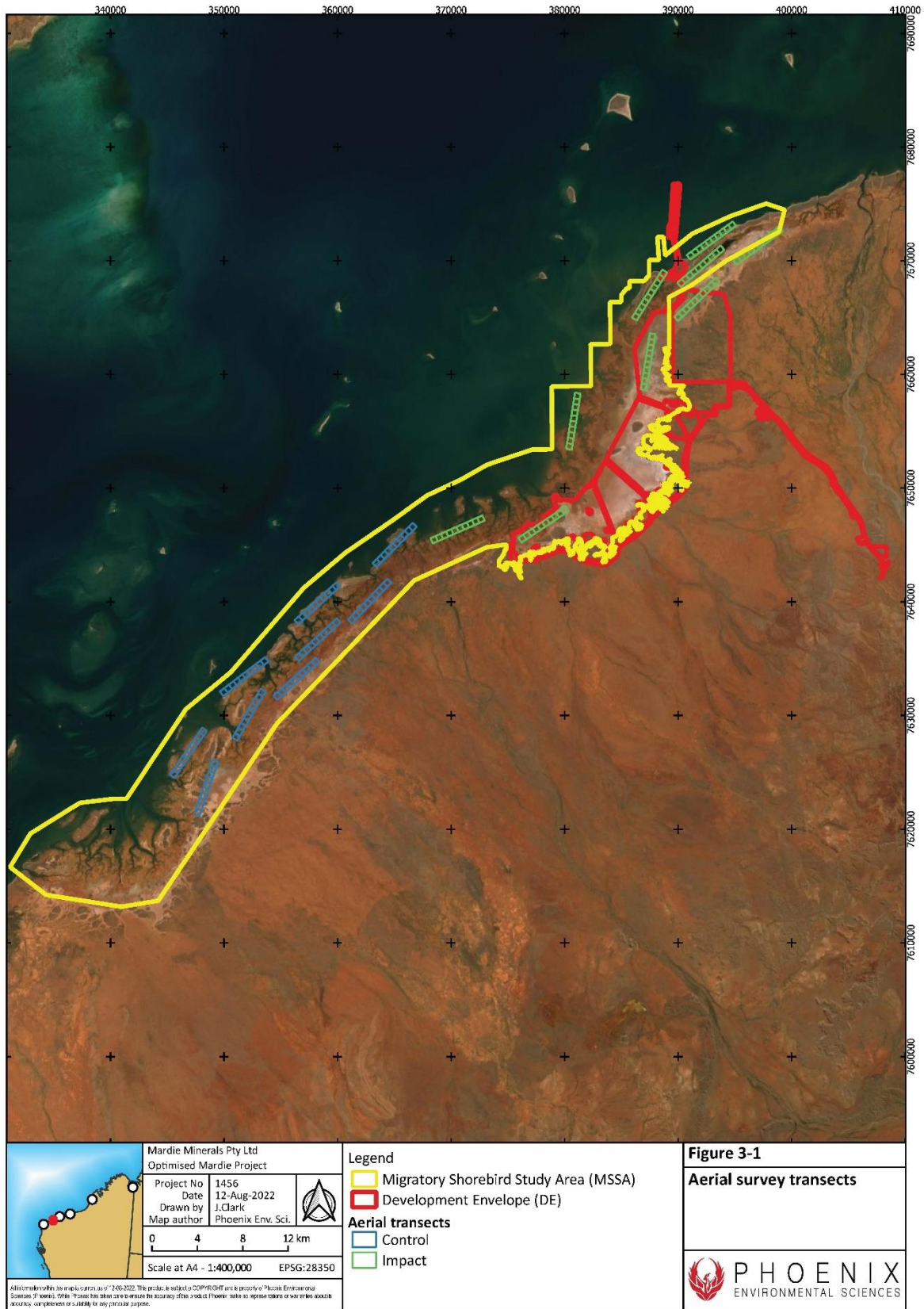


Figure 3-1 Aerial survey transects

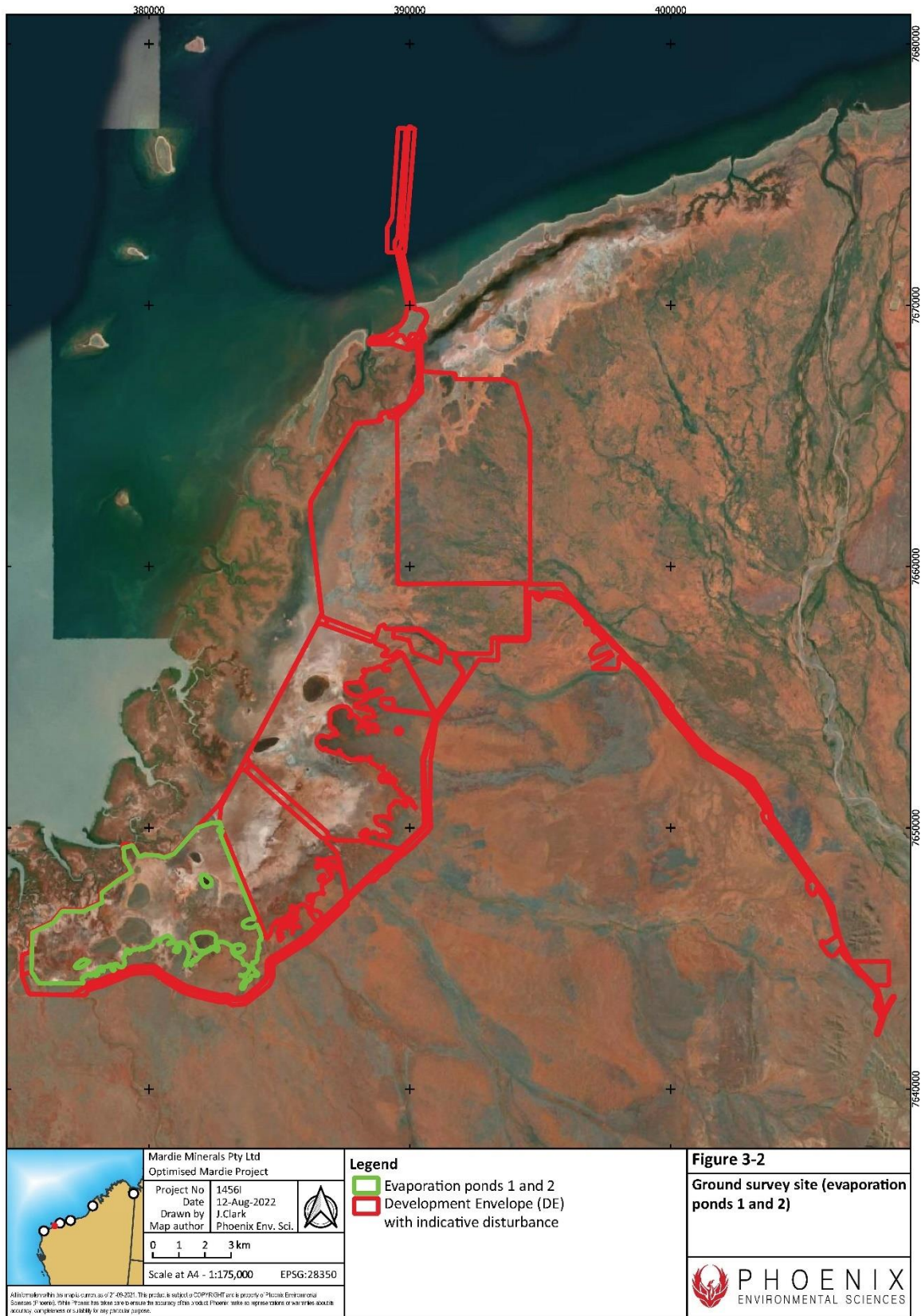


Figure 3-2 Ground survey sites

### 3.4 DATA ANALYSIS

Changes in the migratory shorebird population over time will be estimated using General Linear Modelling techniques. Model type and fit will be assessed for each species with specific model formats used for each taxon to best fit population trends, for example, logistic regressions for species undergoing regional decline or zero inflated models for species only encountered periodically. By modelling populations, we can better estimate how improbable unusually high or low counts are with respect to previous counts which allows for greater confidence when accounting for the high level of variability expected between counts.

For any species where data is insufficient (encounter rates too low), suitable surrogate species will be selected. This will be done by pairing up rare and common birds of similar size that occupy similar habitats and employ similar feeding methods. The trend of the commonly detected bird can be considered a surrogate indication for the rarely detected bird. An example of this is the Godwits. Only One Black-tailed Godwit was encountered during the four baseline phases, but almost 4400 Bar-tailed Godwits were recorded. As such, the trend of the Bar-tailed Godwit will be used to assess the trend for the Black-tailed Godwit.

Data will need to be collected annually; however, it will take some time before a trend can be determined with any confidence as the number of birds is likely to continue to fluctuate. We are anticipating that it will take at least five years before we can establish trigger and threshold criteria and begin to properly evaluate whether a change is occurring. In the meantime, i.e. until 5 years of data has been obtained, data from IA can be compared to data from CA, RA and global data sources to assess for Project-related changes. In addition, trends in bird usage of habitat types can be assessed by drilling down into data recorded in each 500m x 500m square in transects.

The longer the monitoring program runs, the greater our confidence in the data will become. However, habitat monitoring of mangrove, *Tecticornia*/samphire shrublands and algal mat communities conducted in accordance with the Benthic Communities and Habitat Monitoring and Management Plan will provide an 'early warning system' regarding habitat changes that would be expected to impact shorebird usage.

Maximum count was used for the analysis of baseline data in the Phoenix (2020) report as it is used as a measure of the importance of the area, however, it is more susceptible to outliers which is problematic for monitoring over longer time frames. Hence, we will be moving to a modelled average (using General Linear Modelling) as it is a better measure of trend.

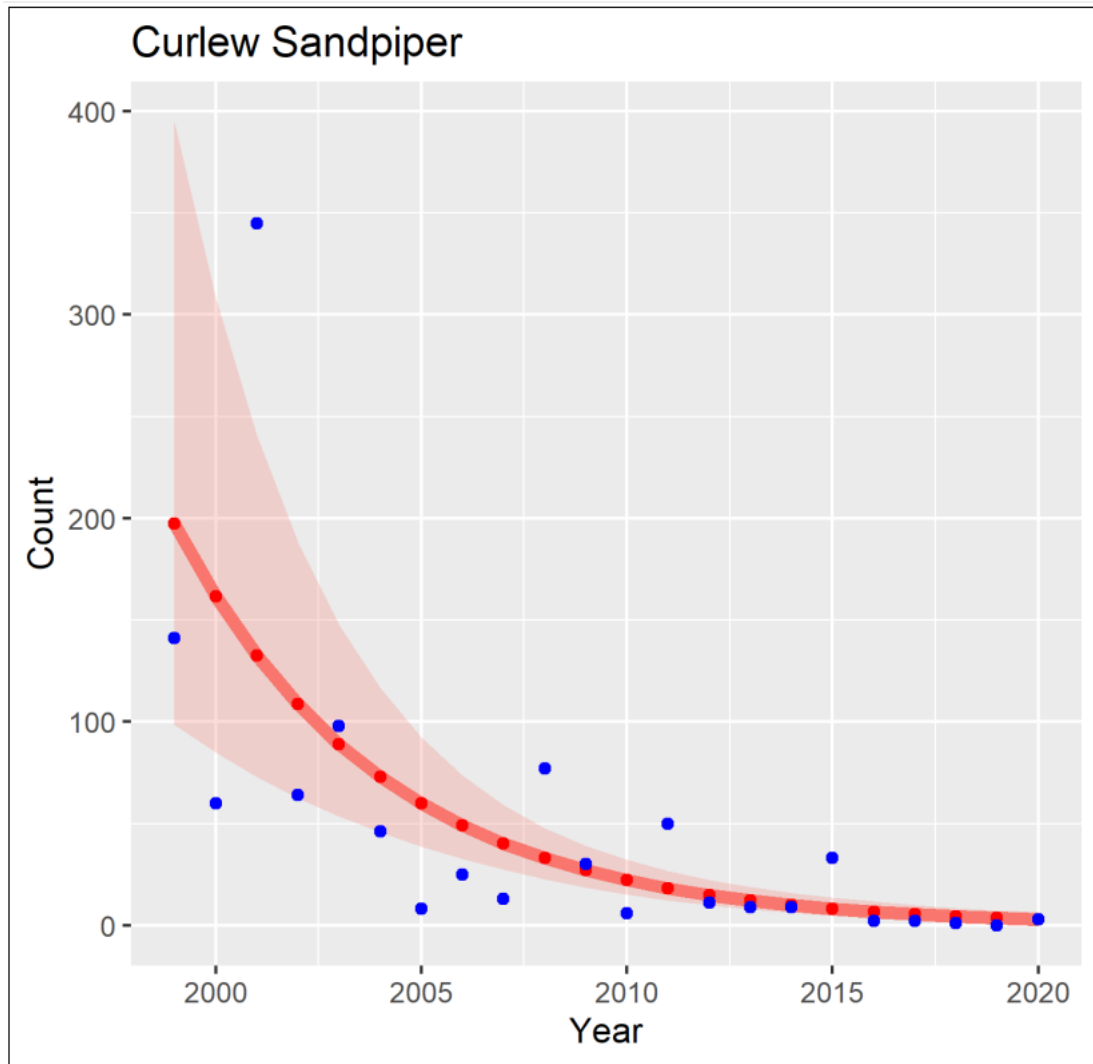
Shorebird populations are under a state of decline due to numerous threats throughout the flyway. Hence, populations trends at the assessment site may be affected by external influences, potentially misrepresenting the impacts of at a local scale due to flyway wide declines or vice versa. In order to distinguish between site level and flyway levels changes in population, monitoring must take place at both a local scale (between IA and CA) and at the regional scale. Regional data will consist of annual counts during the same time period at 3-5 sites (using either data collected at Karratha by the Phoenix team or data from Rio Tinto Karratha saltworks and Port Hedland, assuming we can organise a data-sharing agreement). We will also factor in global changes in the population size in the event that a change in the total population size of the flyway occurs. By comparing trends at the local scale to the larger scales it will be possible to gauge whether any changes are attributable to the Project.

The baseline data (Phoenix 2020) will be incorporated into the model as the sites selected for the aerial surveys all intersect helicopter transect lines. The detection rate of species across the whole of the MSSA and the proposed transect sites are displayed in Table 3-2. For species with a low chance of being suitable for trend analysis, surrogate species may provide an indication of whether a change is likely to have occurred.

An example generalised logistical model fitted to changes in numbers of a shorebird species (Curlew Sandpiper) in a different region (Rottneest Island) is presented in Figure 3-3. Similar trends will be generated for all species where sufficient data is available for this monitoring program.

**Table 3-2**      **Detection rates of species during baseline surveys inside the MSSA and proposed transects**

Species	Detection rate over whole MSSA (%)	Detection rate over proposed transects (%)	Likelihood to be suitable for trend analysis
Bar-tailed Godwit	92	38	High
Black-tailed Godwit	4	0	Low
Common Greenshank	100	58	High
Common Sandpiper	85	35	High
Curlew Sandpiper	23	4	Low
Eastern Curlew	88	38	High
Great Knot	23	4	Low
Greater Sand Plover	58	8	Medium
Grey Plover	15	0	Low
Grey-tailed Tattler	100	54	High
Lesser Sand Plover	12	0	Low
Oriental Plover	31	12	Medium
Oriental Pratincole	27	8	Medium
Pacific Golden Plover	19	0	Low
Red Knot	38	4	Low
Red-necked Stint	96	42	High
Ruddy Turnstone	81	38	High
Sanderling	15	4	Low
Terek Sandpiper	73	19	Medium
Whimbrel	88	65	High



**Figure 3-3** Example generalised logistic model fitted to changes in Curlew Sandpiper numbers from Rottnest Island. Blue dots depict individual counts, the redline is the averaged trend, and the pinkish fill is one standard deviation from the mean.

### 3.5 REVIEW AND REPORTING

The results of the long-term migratory shorebird monitoring program will be reviewed every five years by a consultant with suitable expertise in migratory shorebirds. This review will also consider the program efficacy and recommend changes, if suitable.

In addition to annual survey data review, any encounter with, or observation of, a dead, injured or visibly unhealthy/distressed shorebird will be recorded in the ESMS as a fauna sighting. A similar process will be followed for the reporting of feral animals, including cats and foxes, particularly when observed in known shorebird habitat, including ponds and infrastructure. All personnel conducting activities on the Project site will be made aware of this requirement as part of their site inductions.

Where the encounter has resulted in an injury, e.g. vehicle strike, entrapment, etc that is attributable to the Project, then it will be entered as an environmental incident. The site environmental advisor will manage the incident in accordance with the BCI Incident Reporting and Management Procedure. See also interim triggers and management actions for on-ground incidents in Section 4.

## 4 UTILISATION OF RESULTS

In addition to making results available to DCCEEW, DBCA, the Birdlife Shorebird2020 program, and any other relevant community stakeholders, Mardie Minerals will use the outputs of the long-term monitoring program to:

- compare to the outputs of the Mardie Benthic Communities & Habitats Monitoring and Management Plan
- inform regular reviews of its environmental risk profile, specifically in relation to migratory shorebirds, and adjust if necessary
- initiate specific research if declining utilisation of the area by migratory shorebirds is observed
- review its operational and environmental management controls relevant to migratory shorebirds, if necessary.
- inform other environmental management plans for this project with consideration of the proposed Monitoring and Adaptive Management Plan to meet the requirements of MS 1175 and EPBC 2018/8236 Decision Notice.

The long-term monitoring program will also provide valuable information for closure planning, ensuring that closure impacts to migratory shorebirds are minimised.

As mentioned in Section 1, a minimum of 5-years of annual survey data will be collected before trigger and threshold criteria and related management actions can be developed (refer to MS 1175 condition 8-2(4), estimated to be in 2026. Until this time, the triggers and management actions presented in Table 4-1 will be implemented for the Mardie Project, with the aim of achieving the outcome of MS 1175 condition 8-1(1):

*“...no reduction in the richness and abundance of migratory shorebirds and other shorebirds in the proposal area, attributable to the proposal.”*

**Table 4-1. Interim triggers and management actions.**

Trigger	Management Response
Annual survey data triggers	
The change in diversity and abundance of shorebirds in Control Areas(CA) is statistically significantly higher (P <0.05) than in the Impact Areas (IA).	Investigate reasons for the difference. Respond as appropriate to the findings so that the objectives of the Shorebird MMP are achieved. If the survey results are not adequate to determine a cause, refine the survey methodology to ensure the opportunity to identify the contributing factor/s is maximised in future surveys.  Note this result will be expected during construction and perhaps in the season following.
As above, but specific to certain migratory shorebird habitat types.	Test correlation between shorebird monitoring results with BCHMMP monitoring data.  Review BCHMMP if project-attributable changes to BCH health appear to contribute to reduced richness or abundance of migratory shorebirds.
Ground surveys observe large congregations of shorebirds foraging, roosting or nesting within the Project .	Investigate reason/s for high utilisation and review operations and other management options to continue to encourage the behaviour pattern if it is consistent with the outcome of MS 1175 condition 8-1(1).

Trigger	Management Response
Results from surveys conducted under this Program demonstrate impact or changes to migratory shorebird populations	In accordance with EPBC 2018/8236 implement actions required by EPBC 2018/8236 condition 22.d (relates to management actions, investigation and reporting to DCCEEW).
<b>On-ground incident triggers</b>	
Dead or injured shorebirds in Project Development Envelope	<ul style="list-style-type: none"> <li>• Collect photographic evidence with view to determining cause and timing of injury/death.</li> <li>• Check for predation, visible ingestion of plastics, entanglement, etc.</li> <li>• Injured fauna to be managed by authorised Fauna Handler.</li> <li>• Record and manage as environmental incident in accordance with Corporate – BCI Incident Reporting and Management Procedure.</li> </ul>
Introduced vertebrate fauna observed near or in shorebird habitat areas.	<ul style="list-style-type: none"> <li>• Record fauna sightings in fauna sighting register.</li> <li>• Manage introduced species in accordance with EPBC 2018/8236 condition 15b.</li> <li>• Fauna management implemented in accordance with Construction Environmental Management Plan required by EPBC 2018/8236 condition 15a.</li> </ul>
Shorebirds nesting in operational areas.	<ul style="list-style-type: none"> <li>• Record fauna sightings in fauna sighting register.</li> <li>• Examine options to isolate area from Project activities (e.g. implement temporary restricted access zones).</li> <li>• Consider bird-scaring devices to discourage shorebirds from areas where they may be at risk and/or where their presence prevents normal Project activities.</li> </ul>
Site personnel are observed feeding, harassing or otherwise disturbing shorebirds.	<ul style="list-style-type: none"> <li>• Record and manage as environmental incident or near miss in accordance with Corporate – BCI Incident Reporting and Management Procedure.</li> </ul>



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