walker

TOONDAH HARBOUR

CHAPTER 17
MIGRATORY SHOREBIRDS

saunders havill group

17. Migratory Shorebirds

17.1. Introduction

The Migratory and Threatened Shorebirds technical studies were completed by BAAM. Details of the key personnel involved in the study are provided in Appendix 1-F. The full technical report is provided in Appendix 2-N.

17.1.1 Scope of Study

This chapter describes migratory and listed threatened shorebird species that are likely to occur within or adjacent to the Project footprint, legislative context, desktop and field survey methods, potential impacts of the Project on shorebirds, and the proposed avoidance and mitigation measures to prevent, minimise or compensate for significant residual impacts on migratory and threatened shorebirds. Shorebirds are defined as bird species in the order Charadriiformes (Colwell 2010).

The scope of the assessment is to:

- Provide a description of shorebird species, including listed threatened and migratory shorebird species that are likely to be present in the vicinity of the site, including the following details:
  - The scope, timing (survey season/s) and methodology for studies or surveys used to provide information on shorebirds and their habitats at the site (and in areas that may be impacted by the Project);
  - How studies or surveys are consistent with (or a justification of divergence from) relevant guidelines or policy statements, or are in accordance with best practice studies or surveys;
  - The past and projected trends and existing threats to the condition of habitat for shorebird species;
  - Those aspects of the environment considered critical to the continued presence and functioning of threatened and migratory shorebird species identified as likely to be directly or indirectly impacted (including, but not limited to, roosting and foraging habitat);
  - A habitat assessment for each relevant threatened and migratory shorebird species, informed by a desktop assessment of relevant commonwealth and state government databases and the outcomes of field surveys or studies and including details of the habitat area (in hectares), quality, location and use specifications of known and potential suitable habitat in relation to the Project disturbance area;
  - Discussion of the value of suitable habitat present within the Project site and how it may be impacted by the Project; and
  - An analysis of the strengths, limitations and expected effectiveness of methodologies used to identify the threatened and migratory shorebird species and their habitats and identify any key information gaps, further studies needed and any proposals to address critical information needs.
- Provide a description of all the relevant impacts of the Project on threatened and migratory shorebird species during both the construction and operational phases of the Project and the handover of management of the development, including the following information:
  - A detailed assessment of the nature and extent of the likely short-term and long-term relevant impacts;
  - A statement about whether any relevant impacts are likely to be unknown, unpredictable or irreversible;
  - Analysis of the significance of the relevant impacts; and
  - Any technical data and other information used or needed to make a detailed assessment of the relevant impacts.
- Provide information on proposed avoidance and mitigation measures to deal with the relevant direct and indirect impacts of the Project on threatened and migratory shorebird species that are substantiated and based on best available practices, including the following elements:
  - A description of each proposed avoidance or mitigation measure in relation to the likely impacts;

  - An assessment of the expected or predicted effectiveness and achievability of each proposed avoidance or mitigation measure including timeframes for achieving effectiveness;
  - Measures to identify and avoid areas of high conservation or biodiversity value as far as possible; and
  - Details of any baseline data or proposed monitoring to support an adaptive management approach that will demonstrate progress towards achieving the proposed outcomes and determine the effectiveness of the measures proposed.
- Provide an assessment of the significance of the residual impacts of the Project on threatened and migratory shorebird species.

17.1.2 Relevant Legislation, Policy, and Planning Instruments

17.1.2.1 *Ramsar Convention*

The Ramsar Convention's broad aims are to halt the worldwide loss of wetlands and to conserve, through wise use and management, those that remain. In designating a wetland as a Ramsar site, countries agree to establish and oversee a management framework aimed at conserving the wetland and ensuring its wise use. Wise use under the Convention is broadly defined as maintaining the ecological character of a wetland through implementation of ecosystem approaches, in the context of sustainable development.

Criteria 5 and 6 for listing of a Ramsar site are a wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds and a wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird. The MBRS fulfils both criteria.

An assessment of impacts to the ecological character of the MBRS is provided in Chapter 27 of the Draft EIS.

17.1.2.2 *Bilateral migratory bird agreements with Japan (JAMBA), China (CAMBA) and the Republic of Korea (ROKAMBA)*

These agreements aim to conserve migratory birds in the East Asian - Australasian Flyway (EAAF). Each of these agreements provides for the protection and conservation of migratory birds and their important habitats, protection from take or trade except under limited circumstances, the exchange of information, and building cooperative relationships. Birds listed under these three agreements must also be placed on the migratory species list under the EPBC Act.

17.1.2.3 *The Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)*

The Bonn Convention aims to improve the status of threatened migratory species through national actions and international agreements. Species listed under this agreement must also be placed on the migratory species list under the EPBC Act.

Potential impacts to migratory shorebirds must be assessed at the site, regional and international levels. In particular, the assessment must address the potential for the Project to impact on species or subspecies of birds that are in danger of extinction. These impacts are addressed through assessment against significant impact criteria from EPBC Act Policy Statement 1.1 (refer to Chapter 25).

17.1.2.4 *Wildlife Conservation Plan for Migratory Shorebirds*

The Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia 2015) provides a framework to guide the conservation of migratory shorebirds and their habitat in Australia and, in recognition of their migratory habits, outlines national activities to support their appreciation and conservation throughout the EAAF.

The conservation plan outlines actions to be implemented by Australian and State Governments to protect migratory shorebirds at the national and international levels. Key objectives and actions identified by the plan include:

1. Protection of important habitats for migratory shorebirds has occurred throughout the EAAF:
   a. Maintain, and where possible, improve existing international obligations that concern migratory shorebird conservation;
   b. Seek the support of the Chinese and South Korean governments to protect remaining tidal flats in the Yellow Sea;
   c. Support the East Asian-Australasian Flyway Partnership (EAAFP) Implementation Strategy;
   d. Make available, via the EAAFP website, Australian Government standards and case studies for assessing development proposals that may impact on important migratory shorebird habitats.

2. Wetland habitats in Australia, on which migratory shorebirds depend, are protected and conserved:
   a. Identify key areas for shorebird species and improve legal site protection and management using international, national and state mechanisms;
   b. Update a directory of important habitat for migratory shorebirds.

3. Anthropogenic threats to migratory shorebirds in Australia are minimised or, where possible, eliminated:
   a. Develop and implement a community education and awareness program to reduce the effective of recreational disturbance on migratory shorebirds;
   b. Investigate the impacts of climate change on migratory shorebird habitat and populations;
   c. Investigate the significance of cumulative impacts on migratory shorebird habitat and populations in Australia;
   d. Investigate the impacts of hunting and shorebird prey harvesting on migratory shorebirds in Australia and the EAAF;
   e. Develop guidelines for wetland rehabilitation and the creation of artificial wetlands to support populations of migratory shorebirds;
   f. Ensure all areas important to migratory shorebirds in Australia continue to be considered in development assessment processes.

4. Knowledge gaps in migratory shorebird ecology in Australia are identified and addressed to inform decision makers, land managers and the public:
   a. Identify and prioritise knowledge gaps that are required to support the conservation and management of migratory shorebirds and their habitats;
   b. Identify important stop-over and staging areas for migratory shorebirds in the EAAF;
   c. Survey northern and inland Australia for migratory shorebird populations and identify important habitats;
   d. Maintain Shorebirds 2020 as Australia's national shorebird monitoring programme;
   e. Complete a review of the conservation status of all migratory shorebirds in Australia;
   f. Promote conservation of migratory shorebirds through strategic programmes and educational products;
   g. Promote exchange of shorebird conservation information between governments, NGOs and communities through use of networks, publications and web sites.

A key action of the plan was to ensure assessments of future developments are undertaken in accordance with the EPBC Act and the associated guidelines and policy documents and take account of information included in the wildlife conservation plan for migratory shorebirds and other sources of information. This action is addressed by *EPBC Act Policy Statement 3.21 Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species*.

17.1.2.5 *EPBC Act Policy Statement 3.21 Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species*

EPBC Act Policy Statement 3.21 assists proponents in avoiding, assessing and mitigating significant impacts on migratory shorebirds listed under the EPBC Act. The policy statement has been addressed throughout the migratory shorebird assessment for the Project, including:

- All surveys were carried out in accordance with the guidelines with survey effort significant exceeding the guideline requirements;
- Assessment of potential important shorebird habitat within and adjacent the Project footprint has been assessed in accordance with the guideline;
- Significant impacts for migratory and threatened shorebirds have been assessed against significant impact guidelines 1.1 (refer to Chapters 24 and 25); and
- Avoidance and mitigation strategies recommended by the guidelines have been incorporated into Project management strategies.

EPBC Act Policy Statement 3.21 provides guidance with respect to the degree of importance of sites within complexes or areas, noting, for example, that a large area may be considered internationally or nationally important, but within that area there may be particular sites that are more valuable than others, such as regular roosting and feeding sites. In promoting the wise use of wetlands consistent with Australia's obligations under the Ramsar Convention, it may be pertinent to strongly protect such sites from development and recreational activities that may disturb shorebirds, but allow these activities within the boundary of the broader area (Commonwealth of Australia 2015b).

The Project's design principles (refer to Section 2.3.2) have resulted in the avoidance and minimisation of direct impacts on migratory shorebird habitat and management actions will be put in place to mitigate indirect and facilitated impacts on the Cassim Island roost site, a key roosting site adjacent to the Project footprint. As outlined in detail under Section 17.3, there is strong spatial variation in shorebird use of tidal flat feeding habitat across Moreton Bay, and the tidal flats within the Project footprint support amongst the lowest densities of migratory shorebirds when compared with tidal flats elsewhere in Moreton Bay.

17.1.2.6 *National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds*

These Guidelines provide users with the theoretical, technical and practical information required to assess if artificial lighting is likely to affect wildlife and the management tools to minimise and mitigate that affect. The lighting strategy for the Project (Simpson 2022b) has incorporated measures outlined in the National Light Pollution Guidelines. Measures relevant to the Project are outlined in Section 13.6. Specific measures that will be implemented include:

- Lighting during construction phases will have luminaire design which directs light downwards and not horizontally or vertically;
- Construction lighting towers are typically low and aimed to almost horizontally to achieve desired coverage of the worksite. Where possible these work towers will be located to the east of the worksite and with the illumination directed to the west. This will avoid light spill towards roost sites. Where lighting must face eastward, they will be fitted with appropriate shrouds to avoid adverse impacts;
- Lighting during operational phases will have luminaire design which directs light downwards and not horizontally or vertically;
- Residential towers will not feature large prominent illuminated areas on vertical surfaces. Rather illumination will mostly be directed downwards onto footpaths and other public areas; and
- Luminaires selected for the public areas will be Dark Sky Compliant LED lights. These are "amber" lights which are specifically designed to protect turtles and other fauna from the adverse aspects of urban lighting.

17.1.2.7 *Species Conservation Advice*

Commonwealth conservation advice has been addressed where relevant for species potentially impacted by the Project in Chapters 23 and 24 of the EIS.

17.1.2.8 *Nature Conservation Act 1992*

The *Nature Conservation Act 1992* (NC Act) is the principal legislation for the conservation and management of Queensland's native flora and fauna species and is administered by the Queensland Department of Environment and Science (DES). The key goal of the NC Act is the protection of endangered, vulnerable and near threatened (EVNT) species of flora and fauna as listed under the *Nature Conservation (Wildlife) Regulation 1994*.

Under section 332 of the *Nature Conservation (Wildlife) Regulation 1994*, an approved species management program is required for tampering with an animal breeding place that is being used by a protected animal (including least concern native species) to incubate or rear the animal's offspring.

17.1.3 Activities that May Result in Impacts

Migratory and threatened shorebirds may be impacted by a range of Project activities. These include:

Reclamation and Maritime Construction Works:

- Disturbance from the excavation of mud, sheet piling and placement of rock to construct the bund walls;
- Creation of ambient and underwater noise and vibration during construction activities such as pile driving and excavation; and
- Short term increases in artificial lighting around the temporary unloading dock during dredging activities.

Dredging:

- Suspension in the water column of any contaminants and nutrients, including ASS, from the dredge sediment which may impact on nearby habitats;
- Potential for spills of fuel and other chemicals;
- Creation of ambient and underwater noise and vibration during the dredging process; and
- Disturbance from increased vessel movement during dredging including the dredger, barges and support vessels.

Ongoing Use of the Ferry Terminal, Marina and Urban Area:

- Disturbance from increased human use of the foreshore parks, walking tracks and open space including increase in domestic pets present in these facilities;
- Disturbance from boat movements in Toondah Harbour;
- A general increase in ambient light and noise resulting from new uses; and
- Potential for spills of fuel and other chemicals.

17.2. Assessment Methodology

The assessment approach combined a desktop review of threatened and migratory shorebird species known and likely to occur in the Project footprint or surrounds with the results of a series of targeted field surveys for shorebirds and their habitats.

17.2.1 Desktop Methods

The purpose of the desktop assessment was to undertake searches of biodiversity databases and review previous studies near the Project footprint and any relevant literature to summarise all existing information on threatened and migratory shorebirds for the Project footprint and surrounds.

Consequently, the desktop assessment involved the following:

- A search of the Protected Matters Online Search Tool database to identify migratory shorebird species, including listed threatened species that have potential to occur (Appendix 2-N);

- A search of the Queensland Government's Wildlife Online database within a 3 km radius of the study area (Appendix 2-N), to identify migratory shorebird species, including listed threatened species that have previously been identified within the local area;
- A review and analysis of database records managed by the Queensland Wader Study Group (QWSG). The QWSG is a special interest group within Birds Queensland that monitors shorebird populations and conducts regular shorebird surveys where there are known large shorebird populations;
- A review of the conservation advice statements for listed threatened species in the Commonwealth species profile and threats database;
- A review of current and historical aerial imagery; and
- A review of relevant survey and assessment guidelines and any relevant literature relating to the ecology of the shorebirds of the area.

The published literature, particularly that dealing with the population ecology, habitat requirements and sensitivity to habitat change and disturbance of threatened and migratory shorebird species assessed as known or likely to occur in the study area was reviewed to inform the assessment.

17.2.2 Field Methods

To assess shorebird use of the Project footprint and surrounds, a series of targeted field surveys were undertaken in accordance with best practice survey guidelines as outlined in the following sections. All shorebird surveys were led by Dr Penn Lloyd, an ornithologist with more than 25 years' field experience, extensive experience in surveying shorebirds including as an active member of the QWSG, and 62 peer-reviewed publications in ecology, including several on shorebirds. Survey activities were conducted in accordance with Scientific Purposes permit WISP16206615 and Animal Ethics Committee approval number CA 2018/01/1143.

17.2.2.1 *Shorebird Surveys*

Surveys were carried out in accordance with EPBC Act Policy Statement 3.21: Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species (Commonwealth of Australia 2015b).

The guidelines outline the minimum survey requirements for assessing migratory shorebird use of a study area. The guidelines specify that the minimum survey effort and timing in tidal areas should include:

- Four surveys for roosting shorebirds and four surveys for foraging shorebirds (including two surveys at spring low tide and two surveys at neap low tide) during the period when the majority of shorebirds are present in the area (i.e., within the period late September to March for Moreton Bay);
- One survey during the northern hemisphere breeding season to capture data on birds that remain in Australia during the breeding season, as well as the double-banded plover (i.e., within the period late April to August for Moreton Bay) which migrates to Australia for the winter;
- Surveys for roosting shorebirds conducted as close to the time of high tide as practicable and at a maximum of no more than two hours either side of high tide;
- Surveys for foraging shorebirds conducted as close to the time of low tide as practicable and at a maximum of no more than two hours either side of low tide; and
- Surveys not to be undertaken during periods of high rainfall or strong winds or when activities are taking place which cause shorebird disturbance.

The guidelines specify that the minimum data requirements for the survey report should include:

- Shorebird statistics relating to roosting areas, including total abundance (total number of birds present across all species), species richness (number of species observed) and species abundance (number of birds of each species present);
- Shorebird behaviour, including activity (roosting, foraging) and foraging location (spatial data of the area used by shorebirds for feeding to enable mapping of foraging habitat);
- Survey conditions, including date, time of day, tide height, weather conditions (precipitation, wind speed and direction);
- Number of observers and experience level; and
- Method used to conduct the survey.

17.2.2.2 *Surveys for Roosting Shorebirds at High Tide*

No high tide roost sites occur within the Project footprint. Two roost sites, Cassim Island and Nandeebie Claypan, occur adjacent to the Project footprint. A third roost site occurs on the mainland shoreline 400 m south-west of the proposed dredge channel at Oyster Point and a fourth roost site occurs on an offshore sandbank more than 2 km east of the Project footprint (see Figure 17-1).

Surveys of shorebirds roosting at the high tide roost sites were conducted in full accordance with EPBC Act survey guidelines. The total survey effort and temporal coverage at each roost site was as follows:

- Cassim Island (18 surveys)
  - four surveys within the period November 2014 to March 2015 and one survey in June 2015;
  - four surveys within the period January to March 2019 and one survey in June 2019;
  - four surveys within the period December 2019 to February 2020 and one survey in June 2020; and
  - three surveys within the period October to December 2021.

- Nandeebie Claypan (52 surveys)
  - 15 surveys within the period October 2014 to March 2015 and one survey in June 2015
  - Six surveys within the period January to March 2019 and one survey in June 2019;
  - Ten surveys within the period December 2019 to February 2020 and one survey in June 2020; and
  - 18 surveys within the period September to December 2021.

- Oyster Point (34 surveys)
  - Seven surveys within the period January to March 2019 and one survey in June 2019; and
  - 12 surveys within the period December 2019 to February 2020 and one survey in June 2020; and
  - 13 surveys within the period September to December 2021.
- Offshore sandbank (eight surveys within the period October to December 2021); while this site is located outside the potential area of Project impact, it was surveyed to provide additional information about the use of roost sites in south-western Moreton Bay.

Survey effort at each of the roost sites substantially exceeded the minimum survey effort guidelines with the exception of the offshore sandbank roost site, where the minimum survey effort of four surveys during the period when the majority of shorebirds are present in the area (i.e., within the period late September to March for Moreton Bay) was achieved.

17.2.2.3 *Surveys for Foraging Shorebirds at Low Tide within the Project footprint*

Surveys of shorebirds foraging on the tidal flats at low tide within and immediately adjacent to the Project footprint (see Figure 17-1 for the low tide survey area) were conducted in full accordance with survey guidelines.

The total survey effort and temporal coverage was as follows:

- 2014/15 season: 13 surveys within the period October 2014 to March 2015 and one survey in June 2015;
- 2018/19 season: eight surveys within the period January to March 2019 and three surveys in June 2019;
- 2019/20 season: 12 surveys within the period December 2019 to February 2020 and four surveys in June 2020; and
- 2021/22 season: 11 surveys within the period October to December 2021.

Survey effort for shorebirds foraging at low tide within and immediately adjacent to the Project footprint substantially exceeded the minimum survey effort guidelines.

17.2.2.4 *Surveys for Foraging Shorebirds at Low Tide across South-western Moreton Bay*

To assess the relative importance of foraging habitat at Toondah Harbour in the context of representative foraging habitats elsewhere in south-western Moreton Bay, surveys of shorebirds foraging at low tide were conducted across an additional 567 ha of tidal flat foraging habitat along the mainland coastline north and south of Toondah Harbour. The locations of these additional survey areas, which stretched along approximately 34 km of coastline between Thorneside in the north and Redland Bay in the south are shown in Figure 17-2. All tidal flat foraging habitat within 1.3 km north of Toondah Harbour, within 2.3 km south of Toondah Harbour and to the east of Toondah Harbour was surveyed, an area totalling 185 ha.

The total survey effort and temporal coverage was as follows:

- 2018/19 season: four surveys within the period January to February 2019 and one survey in June 2019; and
- 2019/20 season: four surveys within the period December 2019 to February 2020 and one survey in June 2020.

Survey effort for these context surveys exceeded the minimum survey effort guidelines.

17.2.2.5 *Mapping the Extent of Intertidal Foraging Habitat*

The seaward edge of the tidal flat in the vicinity of the Project footprint was mapped by traversing the edge of the tidal flat exposed during the lowest astronomical tide of 2020 - a spring low tide of 0.23 m on 11 February 2020 - and recording the edge to sub-metre precision. To enable a comparison of shorebird foraging densities across tidal flat areas in south-western Moreton Bay, the perimeters of all tidal flat areas subject to the foraging shorebird surveys were mapped based on aerial imagery from 16 July 2009 on a spring low tide of 0.49 m. The resulting tidal flat seaward boundaries were compared with those mapped by Dhanjal-Adams *et al*. (2016).

Figure 17-1: Shorebird Survey Areas

Legend

- Toondah Harbour PDA (Project Area)
- Low tide survey areas
- Cassim Island roost site
- Nandeebie claypan roost site
- Oyster Point roost site
- Sandbank roost

TOONDAH HARBOUR

walker

0 50 100 150 200 250 300 m

GDA 1994 MGA zone 56

Scale (A3): 1:10,000

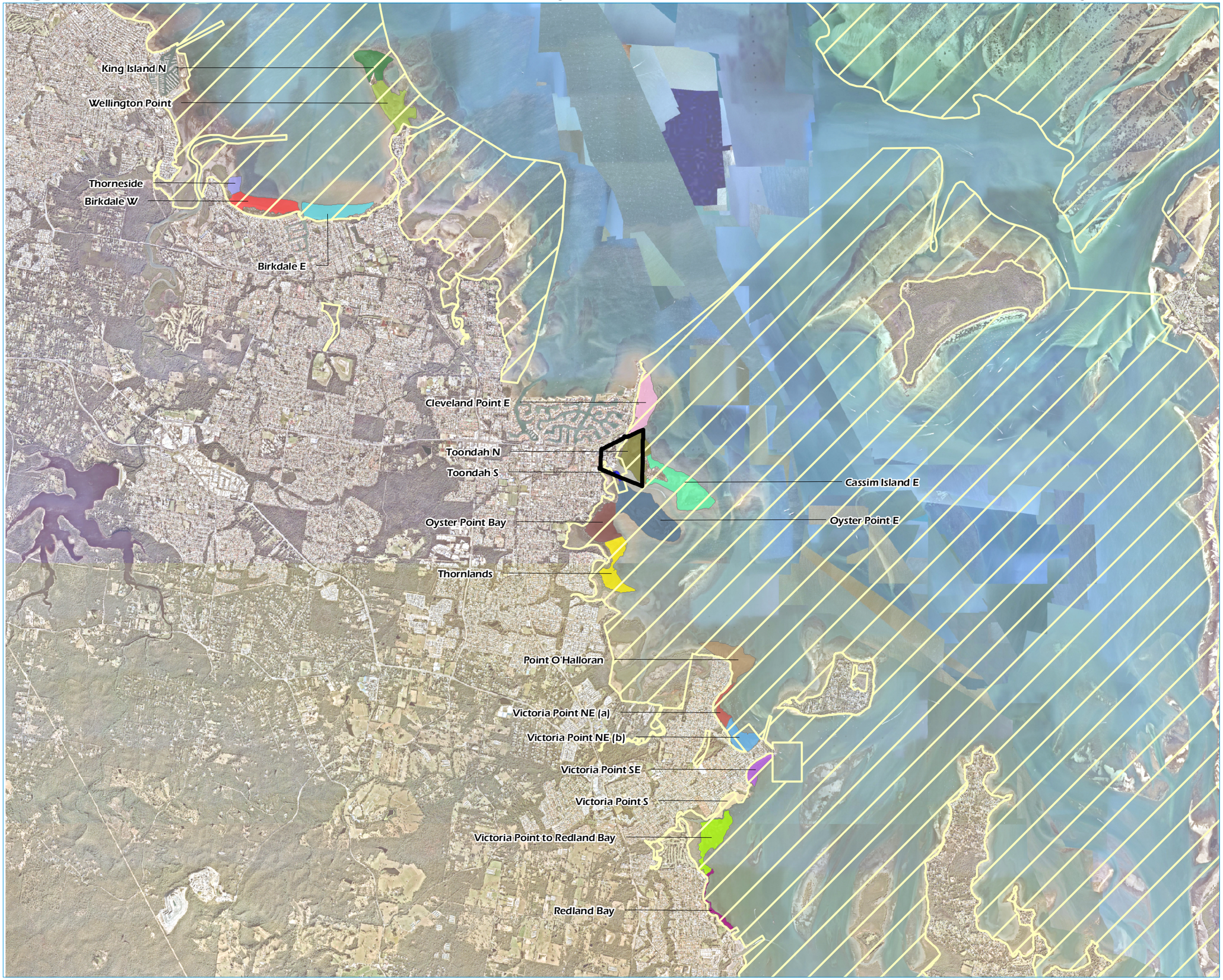
N

DATE: 22/12/2021

FILE REF. 9858 E 03 1 Shorebird suvery areas C

Layer Source: © State of Queensland Datasets (Department of Natural Resources, Mines and Energy 2020), Aerial Imagery (Nearmap.com 2020)

Figure 17-2: Shorebird Low Tide Survey Areas - South-western Moreton Bay



Legend

- Toondah Harbour PDA (Project Area)
- Moreton Bay Ramsar site
- Birkdale E
- Birkdale W
- Cassim Island E
- Cleveland Point E
- Victoria Point SE
- King Island N
- Oyster Point Bay
- Oyster Point E
- Point O'Halloran
- Redland Bay
- Thorneside
- Thornlands
- Toondah N
- Toondah S
- Victoria Point to Redland Bay
- Victoria Point NE (a)
- Victoria Point NE (b)
- Victoria Point S
- Wellington Point

TOONDAH HARBOUR

walker

0 1 2 3 km

GDA 1994 MGA zone 56

Scale (A3): 1:75,000

N

DATE: 27/05/2022

FILE REF. 9858 E 17 2 Shorebird low tide suvery areas A

Layer Source: © State of Queensland Datasets (Department of Natural Resources, Mines and Energy 2020), Aerial Imagery (Nearmap.com 2020)

Toondah Harbour EIS

17.2.3 Analysis of Methodological Approach

The approach used for the assessment of shorebird use of the Project footprint and surrounding areas combines a desktop review of available information on shorebird use of the area with a series of field surveys over four seasons (2014/15, 2018/19, 2019/20 and 2021/22) across a six-year period. Field surveys have substantially exceeded the minimum survey requirements outlined in Commonwealth of Australia (2015b). The integration of the field survey data with substantial shorebird monitoring datasets managed by the QWSG provided extensive data over a 26-year period to enable a detailed analysis of temporal variation in the use of important roost sites in the vicinity of the Project footprint. Furthermore, two seasons of surveys of migratory shorebird use of an additional 567 ha of tidal flat feeding habitat along a 34 km stretch of mainland coastline north and south of the Project footprint have been completed. When combined with other published information, these surveys provide a substantial dataset to assess the relative importance of tidal flat feeding habitat in the Project footprint to shorebird species in the region. Consequently, there is high confidence that the methodological approach has effectively identified the threatened and migratory shorebird species using feeding and roosting habitats within and adjacent to the Project footprint, and the relative importance of these habitats to threatened and migratory shorebird species in the broader context of the MBRS.

The surveys undertaken for the Project, particularly the broader surveys of shorebird use of low tide feeding habitat in south-western Moreton Bay, have contributed to priorities identified in the conservation action statements for threatened migratory shorebird species (TSSC 2015a,b, 2016a,b,c,d,e), the Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia 2015a) and a recent review of managing threats to migratory shorebirds in Moreton Bay (Fuller *et al*. 2021). These include enhancing existing migratory shorebird population monitoring and improving knowledge of shorebird use of tidal flat feeding habitat areas across Moreton Bay.

17.2.4 Assessment of Migratory Shorebird Habitat Importance

The Commonwealth guidelines for assessing impacts on migratory shorebird species (Commonwealth of Australia 2015b) outline the process to be followed for assessing whether 'important habitat' for migratory shorebirds under the EPBC Act occurs at a site (Figure 17-3).

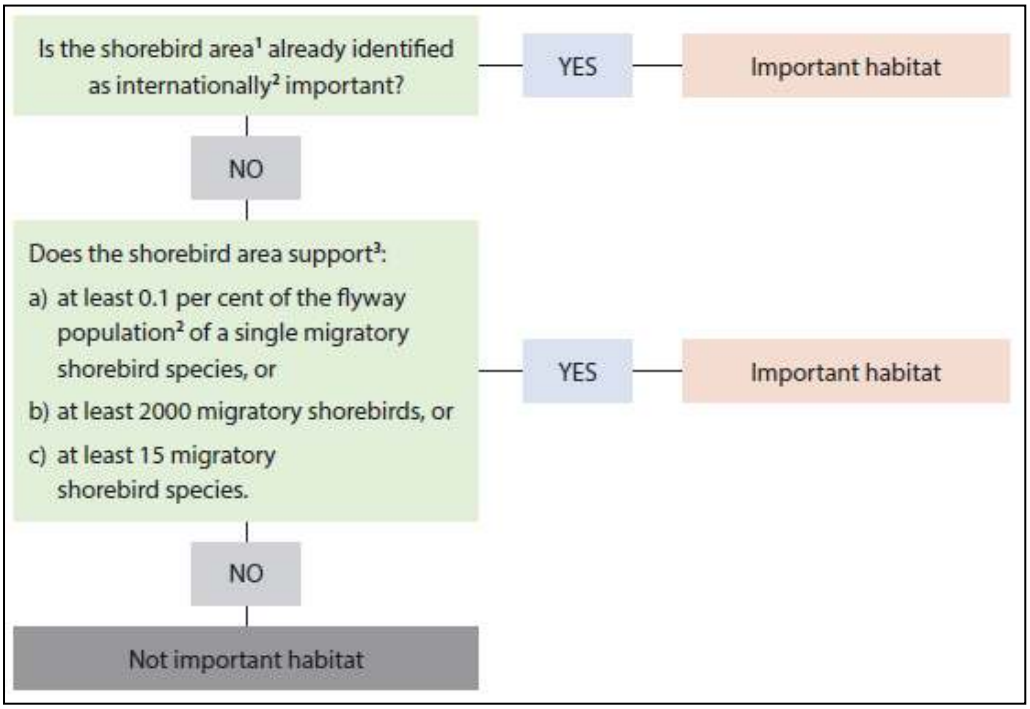


Figure 17-3: Process for Identifying Important Habitat for Migratory Shorebirds (excluding Latham's Snipe) under the EPBC Act (from Commonwealth of Australia 2015b).

A shorebird area is defined as: *the geographic area that had been used by the same group of shorebirds over the main non-breeding period, which is effectively the home range of the local population when present* (Commonwealth of Australia 2015b). Shorebird areas may include multiple roosting and feeding habitats. Migratory shorebird areas may therefore extend beyond the boundaries of a property or Project footprint and may also extend beyond Ramsar boundaries for internationally important areas (Commonwealth of Australia 2015b).

Shorebird habitat within a shorebird area is considered internationally important if it regularly supports[3] (Commonwealth of Australia 2015b):

- 1% of the individuals in a population of one species or subspecies of waterbird; or
- a total abundance of at least 20,000 waterbirds.

Habitat areas used by shorebirds within a listed Ramsar site are considered internationally important regardless of the number of shorebirds that use the habitat area.

Shorebird habitat within a shorebird area is considered nationally important if it regularly supports (Commonwealth of Australia 2015b):

- 0.1% of the flyway population of a single species of migratory shorebird; or
- 2,000 migratory shorebirds; or
- 15 migratory shorebird species.

17.3. Existing Values

17.3.1 Migratory Shorebird Ecology

Most shorebirds live on or near the coast, on beaches, reefs and tidal mudflats, though some also frequent, or are largely confined to, freshwater habitats (Colwell 2010). Most coastal species feed on flat, tidal shores with extensive muddy or sandy intertidal areas (hereafter referred to as tidal flats). Most species are gregarious, wary and fly strongly and swiftly (Geering *et al*. 2007; Colwell 2010).

A large proportion of Australia's shorebird species are migratory, spending their non-breeding season (the Austral summer) in Australia and migrating up to 13,000 km north along the EAFF to breeding grounds in eastern Siberia and western Alaska (Bamford *et al*. 2008) or, in the case of the double-banded plover (*Charadrius bicinctus*), south to New Zealand (Pierce 1999). They are highly dependent on a relatively small number of key feeding grounds at stop-over sites on their migration routes and on their non-breeding grounds in order to replenish their fat reserves for migration. If their feeding rates are reduced and they do not manage to lay down sufficient reserves of fat, their subsequent survival on migration can be severely compromised (Baker *et al*. 2004).

Coastal migratory shorebirds also depend on roosting areas near their feeding areas that allow them to rest (during times when their feeding habitat is inundated at high tide) without losing too much energy to disturbance (Colwell 2010). The roosting sites of coastal migratory shorebirds are typically located in the upper reaches of intertidal areas or bordering the high-water mark, and include sand bars, sandy beaches, rocky coastlines, saltmarsh, clay pans, shallow lagoons, mangrove trees and a variety of artificial sites such as dredge spoil ponds, salt works ponds, rocky seawalls, floating

[3] For permanent wetlands, 'support' is defined as: *migratory shorebirds are recorded during surveys and/or known to have occurred within the area during the previous five years* (Commonwealth of Australia 2015b).

platforms and purpose-built artificial roosts. Migratory shorebirds select roost sites based on (Rogers *et al*. 2006a, Ryeland *et al*. 2020):

- Distance from feeding areas, preferring sites close to feeding areas since that reduces their energy expenditure flying between roosting and feeding sites;
- Distance from tall cover, preferring sites with little cover to ensure a clear view of approaching predators;
- Climate, preferring sites at the water's edge or with a wet substrate to stay cool;
- Height of the tide (whether the site will be inundated); and
- Background colour of the roost site, preferring sites that provide camouflage against predators.

There is also some evidence that feeding site selection is influenced by distance from available roost sites (Rogers *et al*. 2006a), since energy expended flying between feeding and roosting sites reduces the birds' ability to store fat for migration (Rogers 2003). As a result of these requirements, both feeding and roosting habitats are essential to migratory shorebirds.

Migratory shorebirds generally show high site fidelity to both roost sites and feeding habitat areas. Grey-tailed tattlers and bar-tailed godwits using Moreton Bay show strong roost site fidelity, repeatedly using the same roost site and only occasionally being observed at roosts several kilometres away (Coleman and Milton 2012). Satellite tracking of the movements of eastern curlew within Moreton Bay over several years (Lilleyman *et al*. 2020) has shown that they move through locations within their home range within the bay and travel from 1 - 20 km between roosting and feeding areas but showed high site fidelity, returning to the same roosting and feeding areas between years.

Studies have shown that site fidelity may be mediated by resource distribution, and that while they may be site faithful in certain situations, behavioural flexibility allows shorebirds to respond to spatial and temporal changes in resource distribution (Oudman *et al*. 2018), including by moving to alternative sites (Chan 2021), and to switch diets in response to collapse in preferred prey (Zhang *et al*. 2018, Chan 2021). Yet, the ability of shorebirds to respond to habitat loss by moving to alternative habitat areas may vary within and between species. In an experimental trial, great knots that displayed more explorative behaviours in an enclosure before release responded quicker to the collapse of their prey stock at their main staging site in the Yellow Sea by moving to other sites earlier than less explorative individuals (Chan 2021).

17.3.1.1 *Threats to Migratory Shorebirds and Population Trends*

Many of the key feeding and roosting sites for migratory shorebirds are coastal wetlands that are increasingly threatened by development for aquaculture, industry and housing (Yang *et al*. 2011; MacKinnon *et al*. 2012; Murray *et al*. 2014), particularly at key stop-over sites on their migration routes through east Asia. This makes migratory shorebirds particularly susceptible to habitat loss, disturbance and environmental change (Gill *et al*. 2001; Piersma and Baker 2000; Baker *et al*. 2004; Wilson *et al*. 2011; Melville *et al*. 2016; Moores *et al*. 2016; Piersma *et al*. 2016). Consequently, migratory shorebirds are in decline around the world (Pierce-Higgins *et al*. 2017; Nilsson 2018), including in Australia (Close & Newman 1982; Nebel *et al*. 2008; Wilson *et al*. 2011; Clemens *et al*. 2016).

An analysis of shorebird population trends in Moreton Bay over 15 years (1992-2008) found that the abundances of at least seven migratory shorebird species declined significantly by between 43% and 79% over this period, whereas the abundances of resident shorebird species showed no significant trends. The primary cause of the population declines of migratory shorebirds in Moreton Bay was attributed to habitat loss at key migration stopover sites in the Yellow Sea region (Wilson *et al*. 2011). Similarly, a more recent analysis revealed significant Australia-wide decreases in abundance in 12 of 19 migratory shorebird species, with estimated annual rates of decline of between 1.98% and 9.53% (Clemens *et al*. 2016). Migratory shorebird species with the greatest reliance on the Yellow Sea as a stopover site have experienced the greatest population declines, whereas those that stop primarily in other regions have had slowly declining or stable

populations (Studds *et al*. 2017). Other threats, including in Australia, include human disturbance at feeding and roosting sites, habitat loss and degradation from pollution, changes to the water regime and invasion of mudflats and coastal saltmarshes from the spread of mangroves (Fuller *et al*. 2021).

17.3.2 Database Search Results

The Protected Matters Search Tool (PMST) database search identified 32 migratory shorebird species that are known or predicted to occur in the Project footprint and surrounds. The Wildlife Online database search identified records for 21 migratory shorebird species within 3 km of the Project footprint since 1980. Table 17-1 summarises the threatened and migratory shorebird species identified in the desktop searches that are known or have a realistic likelihood of occurring within or adjacent to the Project footprint, their status under the EPBC Act and NC Act, and their preferred habitat requirements. The full likelihood of occurrence assessment is included in Appendix 2-N.

The following data were sourced from the QWSG for inclusion in this assessment:

- Seven winter (June-July) low tide counts of shorebirds foraging in the Project footprint in 2014/15;
- Five summer (October) low tide counts of shorebirds foraging in the Project footprint in 2014/15;
- Six summer low tide counts of shorebirds foraging in the Project footprint in 2016/17 presented in Bush (2017);
- 266 high tide counts of shorebirds roosting at the Nandeebie Claypan roost site over the period 1996 to 2021;
- 390 high tide counts of shorebirds roosting at the Oyster Point roost site over the period 2000 to 2020, including one earlier count in 1992;
- One high tide count of shorebirds roosting at the Cassim Island roost site in February 2021; and
- 22 high tide counts of shorebirds roosting at the offshore sandbank.

Analysis of the QWSG data is addressed in the field results sections (17.3.3 to 17.3.5).

Table 17-1: Threatened and Migratory Shorebird Species Identified in the Protected Matters Search Tool (PM) and Wildlife Online (WO) Desktop Searches and Assessed as Known, Likely or to Have Potential to Occur in the Project footprint and Immediate Surrounds, their Status under the EPBC Act (EPBC) and NC Act (NC), and their Preferred Habitat Requirements.

Species	Common Name	Status EPBC[4]	NC[5]	Preferred Habitat	Likelihood of Occurrence
Calidris ferruginea	Curlew Sandpiper	CE, M	E	Feeds on tidal flats, roosts on beaches, rocky shores, sandbars, claypans and saltmarshes near the high tide mark (Higgins & Davies 1996).	Known. Feeds on tidal flats over 5 km distant from the Project footprint and has roosted (very rarely, last record over ten years ago) at shoreline roost sites adjacent to the Project footprint. There are no records of this species using habitats within or adjacent to the Project footprint within the past five years.
Calidris canutus	Red Knot	E, M	S	Feeds on tidal flats, roosts on beaches, sandbars, claypans and saltmarshes near the high tide mark (Higgins & Davies 1996).	Known. While it has not been recorded within the Project footprint, the species has been recorded within 3 km, it has potential to feed on tidal flats within (very rarely) or adjacent to the Project footprint and it has been recorded roosting (very rarely) at adjacent shoreline roost sites.
Calidris tenuirostris	Great Knot	CE, M	E	Feeds on tidal flats, roosts on beaches, sandbars, claypans and saltmarshes near the high tide mark (Higgins & Davies 1996).	Known. Feeds (rarely) on tidal flats within and adjacent to the Project footprint and roosts occasionally in small numbers at adjacent shoreline roost sites.
Charadrius leschenaultii	Greater Sand Plover	V, M	S	Feeds on tidal flats, roosts on beaches, rocky shores, sandbars, claypans and saltmarshes near the high tide mark (Marchant & Higgins 1993).	Known. While it has not been recorded within the Project footprint, the species is known to feed on tidal flats in the local region, it has potential to feed on tidal flats within or adjacent to the Project footprint (rarely) and it has been recorded roosting (very rarely, in 1992) at adjacent shoreline roost sites. There are no records of this species using habitats within or adjacent to the Project footprint within the past five years.

[4] Status under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*: CE = critically endangered; E = endangered; M = migratory; V = vulnerable.
[5] Status under the Queensland *Nature Conservation Act 1992*: C = least concern; E = endangered; V = vulnerable; S = special least concern (migratory).

Species	Common Name	Status EPBC[4]	Status NC[5]	Preferred Habitat	Likelihood of Occurrence
Charadrius mongolus	Lesser Sand Plover	E, M	E	Feeds on tidal flats, roosts on beaches, rocky shores, sandbars, claypans and saltmarshes near the high tide mark (Marchant & Higgins 1993).	Known. Feeds on tidal flats within (rarely) and adjacent to the Project footprint and it has been recorded roosting (very rarely, in 1992) at adjacent shoreline roost sites.
Limosa lapponica baueri	Bar-tailed Godwit (Western Alaskan)	V, M	V	Feeds on tidal flats, roosts on beaches, sandbars, claypans and saltmarshes near the high tide mark (Higgins & Davies 1996).	Known. Feeds on tidal flats within and adjacent to the Project footprint and roosts at adjacent roost sites.
Numenius madagascariensis	Eastern Curlew	CE, M	E	Feeds on tidal flats, roosts on beaches, sandbars, claypans and saltmarshes near the high tide mark (Higgins & Davies 1996).	Known. Feeds on tidal flats within and adjacent to the Project footprint and roosts at adjacent shoreline roost sites.
Esacus magnirostris	Beach Stone-curlew		V	Open, undisturbed sandy beaches, reefs and lagoons and nearby tidal flats (Marchant & Higgins 1993).	Potential. While it has not been recorded within or adjacent to the Project footprint, the species is known to feed on tidal flats in the local region and has potential to feed (rarely) on tidal flats within or adjacent to the Project footprint.
Arenaria interpres	Ruddy Turnstone	M	S	Feeds on tidal flats, roosts on mangrove trees, beaches, rocky shores, sandbars, claypans and saltmarshes near the high tide mark (Higgins & Davies 1996).	Known. Feeds on tidal flats adjacent to the Project footprint and roosts in small numbers at adjacent mangrove and shoreline roosts.
Calidris acuminata	Sharp-tailed Sandpiper	M	S	Coastal and inland areas, preferring non-tidal fresh or brackish wetlands, or mudflats near river mouths (Higgins & Davies 1996).	Known. Feeds on tidal flats distant to the Project footprint and roosts occasionally in small numbers at adjacent shoreline roosts.
Calidris ruficollis	Red-necked Stint	M	S	Feeds on tidal flats, roosts on beaches, rocky shores, sandbars, claypans and saltmarshes near the high tide mark (Higgins & Davies 1996).	Known. Feeds on tidal flats within (rarely) and adjacent to the Project footprint and roosts at adjacent shoreline roost sites (rarely).

Species	Common Name	Status EPBC[4]	Status NC[5]	Preferred Habitat	Likelihood of Occurrence
Charadrius bicinctus	Double-banded Plover	M	S	Feeds on intertidal mudflats and sandflats, roosts on beaches, sandbars, claypans and saltmarshes near the high tide mark (Marchant & Higgins 1993).	Known. While it has not been recorded within the Project footprint, the species is known to feed on intertidal mudflats in the local region. It has potential to feed on intertidal mudflats within or adjacent to the Project footprint and it has been recorded roosting (very rarely, in 1992) at adjacent shoreline roost sites. There are no records of this species using habitats within or adjacent to the Project footprint within the past five years.
Limosa limosa	Black-tailed Godwit	M	S	Feeds in shallow saltwater and freshwater wetlands, roosts on beaches, sandbars, claypans and saltmarshes near the high tide mark (Higgins & Davies 1996).	Known. Recorded roosting (very rarely) at shoreline roost sites adjacent to the Project footprint. There are no records of this species using habitats within or adjacent to the Project footprint within the past five years.
Numenius phaeopus	Whimbrel	M	S	Feeds on tidal flats, roosts on mangrove trees, beaches, rocky shores, sandbars, claypans and saltmarshes near the high tide mark (Higgins & Davies 1996).	Known. Feeds on tidal flats within and adjacent to the Project footprint and roosts at adjacent mangrove and shoreline roost sites.
Numenius minutus	Little Curlew	M	S	Short, dry grasslands and sedgelands, including artificial areas, and on the grassy edges of freshwater wetlands (Higgins & Davies 1996).	Known. Two birds recorded roosting at Nandeebie Claypan in 2000; a vagrant to the local area. There are no records of this species using habitats within or adjacent to the adjacent within the past 21 years.
Pluvialis fulva	Pacific Golden Plover	M	S	Feeds on tidal flats, roosts on beaches, rocky shores, sandbars, claypans, saltmarshes and short, open grassy areas near the coast (Marchant & Higgins 1993).	Known. Feeds on tidal flats adjacent to the Project footprint and roosts occasionally in small numbers at adjacent shoreline roost sites.
Pluvialis squatarola	Grey Plover	M	S	Feeds on intertidal mudflats and sandflats, roosts on beaches, sandbars, claypans and saltmarshes near the high tide mark (Marchant & Higgins 1993).	Known. While it has not been recorded within the Project footprint, it feeds occasionally on adjacent intertidal mudflats, has potential to feed within the Project footprint and has potential to roost (very rarely) at adjacent shoreline roost sites.

Species	Common Name	Status EPBC[4]	Status NC[5]	Preferred Habitat	Likelihood of Occurrence
Tringa brevipes	Grey-tailed Tattler	M	S	Feeds on tidal flats, roosts on mangrove trees, beaches, rocky shores, sandbars, claypans and saltmarshes near the high tide mark (Higgins & Davies 1996).	Known. Feeds on tidal flats within and adjacent to the Project footprint and roosts at adjacent mangrove and shoreline roost sites.
Tringa nebularia	Common Greenshank	M	S	Feeds on tidal flats, roosts on beaches, sandbars, claypans and saltmarshes near the high tide mark (Higgins & Davies 1996).	Known. Feeds on tidal flats within (rarely) and adjacent to the Project footprint and roosts (rarely) at adjacent mangrove and shoreline roost sites.
Xenus cinereus	Terek Sandpiper	M	S	Feeds on tidal flats, roosts on mangrove trees, beaches, rocky shores, sandbars, claypans and saltmarshes near the high tide mark (Higgins & Davies 1996).	Known. Feeds on tidal flats within and adjacent to the Project footprint and roosts at adjacent mangrove and shoreline roost sites.
Actitis hypoleucos	Common Sandpiper	M	S	Mangrove inlets, rocky shores and creeks, channels and dams (Higgins & Davies 1996).	Potential. While it has not been recorded within or adjacent to the Project footprint, the species is known from the local area and has potential to feed on tidal flats within (rarely) or adjacent to the Project footprint and roost at adjacent shoreline roost sites (rarely).
Tringa stagnatilis	Marsh Sandpiper	M	S	Feeds in the shallows of brackish and freshwater wetlands (Higgins & Davies 1996).	Potential. While it has not been recorded within or adjacent to the Project footprint, the species is known from the local region and has potential to feed on tidal flats within (very rarely) or adjacent to the Project footprint and roost (very rarely) at adjacent shoreline roost sites.

17.3.3 Shorebirds Roosting at High Tide Sites at Toondah Harbour

No high tide roost sites occur within the Project footprint. Shorebirds were observed roosting at two roost sites adjacent to the Project footprint during the field surveys: Cassim Island mangrove roost; and Nandeebie Claypan saltmarsh roost. Shorebirds were also observed roosting at the Oyster Point shoreline roost and the offshore sandbank roost site.

17.3.3.1 *Cassim Island*

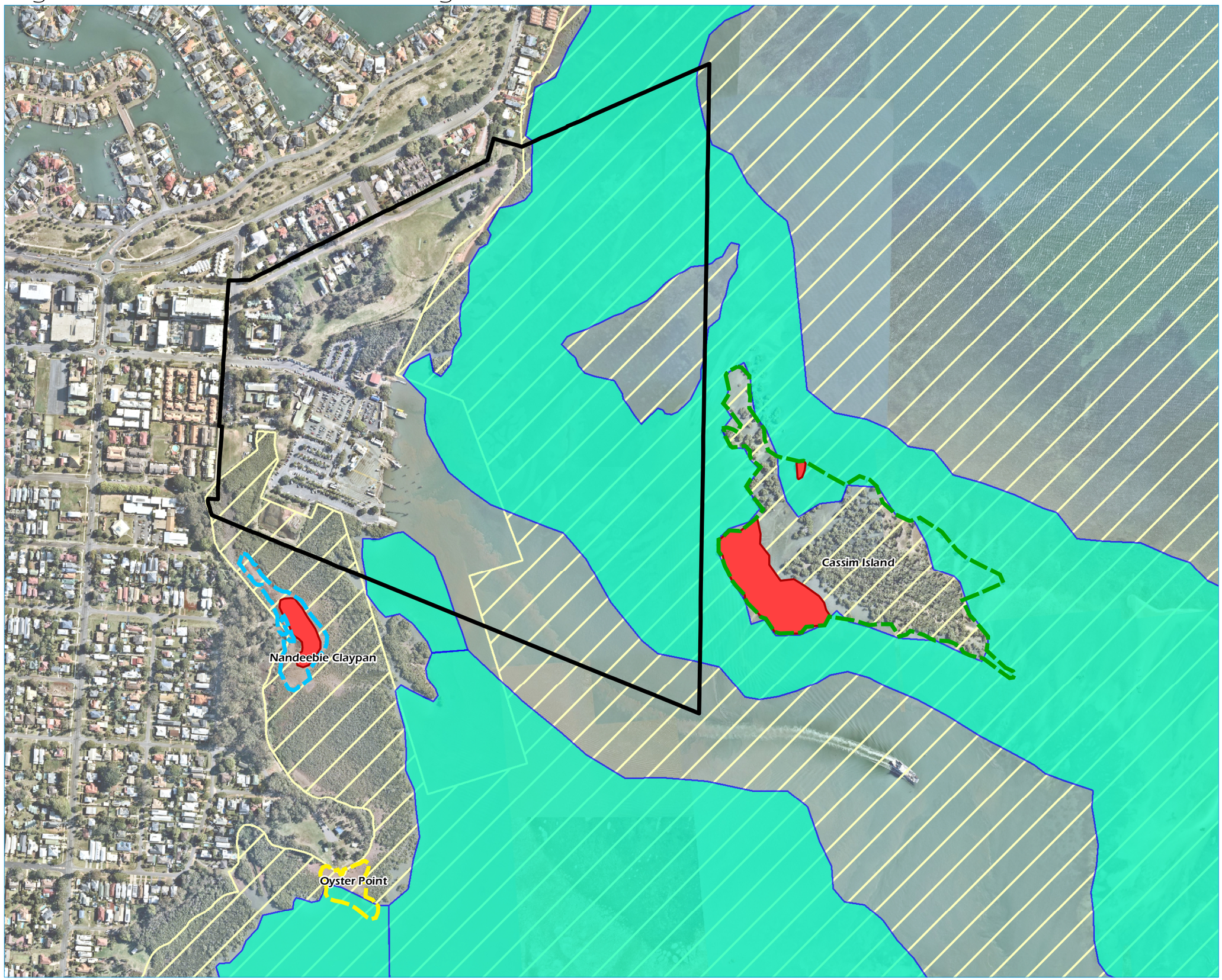
Cassim Island is not a true island but instead comprises a large and dispersed area of mangrove trees, dominated by grey mangrove (*Avicennia marina*), that grow on and around an intertidal sand bar near the eastern boundary of the Project footprint (Figure 17-4, Plate 17-1). These mangrove trees were used as a roost site by an average of 839 and maximum of 1,300 migratory shorebirds during the summer months, mostly grey-tailed tattler but also whimbrel (Plate 17-2), terek sandpiper, ruddy turnstone and occasionally bar-tailed godwit and several common greenshank (Table 17-2). During the three winter season surveys, no migratory shorebirds were present on two of the surveys, but 44 whimbrel were present in the June 2020 survey (Table 17-2). These are the first recorded shorebird roost data for the Cassim Island roost site. The QWSG had no prior roosting records for Cassim Island. This suggests that the significant shorebird roosting at Cassim Island may be a relatively recent occurrence.

Table 17-2: Average (and Maximum) Counts of Migratory Shorebird Species Roosting at Cassim Island.

Species	**Common Name**	**Status**		**Summer**				**Winter**		
		EPBC	NC	2014/15	2018/19	2019/20	2021/22	2014/15	2018/19	2019/20
Tringa brevipes	Grey-tailed Tattler	M	S	461 (600)	1000 (1100)	633 (870)	357 (570)	0	0	0
Numenius phaeopus	Whimbrel	M	S	189 (270)	145 (190)	170 (280)	87 (150)	0	0	44
Xenus cinereus	Terek Sandpiper	M	S	23 (30)	45 (50)	26 (35)	25 (35)	0	0	0
Arenaria interpres	Ruddy Turnstone	M	S	27 (50)	45 (50)	12 (20)	7 (10)	0	0	0
Limosa lapponica	Bar-tailed Godwit (Western Alaskan)	M, V	V	0	0	2 (7)	15 (25)	0	0	0
Tringa nebularia	Common Greenshank	M	S	0	0	<1 (1)	1 (4)	0	0	0

The highest roosting densities occurred in the south-western portion of the roost, particularly in the mangrove trees along the outer edge of this area, where most grey-tailed tattler, terek sandpiper and ruddy turnstone roosted, and in a small, isolated patch of tall mangroves in the central north where most whimbrel roosted on most surveys (Figure 17-4). Fewer birds roosted as small groups or scattered individuals in the north-western and north-eastern portions of the roost. When disturbed out of the trees during the surveys, birds moved around to settle again in different portions of the roost.

Figure 17-4: Shorebird Feeding Habitat and Roost Sites at Toondah Harbour



Legend

- Toondah Harbour PDA (Project Area)
- Tidal flat shorebird feeding habitat
- High roosting density
- Cassim Island roost site
- Nandeebie claypan roost site
- Oyster Point roost site
- Moreton Bay RAMSAR

TOONDAH HARBOUR

walker

0 100 200 300 m

GDA 1994 MGA zone 56 Scale (A3): 1:6,500

DATE: 27/05/2022

FILE REF. 9858 E 17 4 Shorebird feeding habitat C

Layer Source: © State of Queensland Datasets (Department of Natural Resources, Mines and Energy 2020), Aerial Imagery (Nearmap.com 2020)

Toondah Harbour EIS

Plate 17-1: Mangrove Tree Roost at Cassim Island.

Plate 17-2: Whimbrel Roosting in Mangrove Tree.

Cassim Island also supports a mid-tide roost site in the form of a rocky sandbank located amongst the mangrove trees in the centre of the high-density roosting area (see Figure 17-4 for location). This sandbank is used by migratory shorebirds as a high tide roost site on the occasional lowest neap tides or as a mid-tide roost site before they move to either the adjacent mangrove trees or alternative roost sites at Oyster Point or Geoff Skinner Reserve. Up to 50 bar-tailed godwit were observed using this sandbank as a mid-tide roost and up to 25 bar-tailed godwit were observed using it on a low neap high tide.

Disturbance to birds roosting at Cassim Island by watercraft was not observed during any survey; however, kayaks were observed moving between the roost site and the mainland shoreline on one survey, including by a person fishing and recreational kayakers travelling parallel to the mainland shoreline between Cleveland Point and Victoria Point. Roosting birds flew up in response to overflight of the roost by a white-bellied sea-eagle on one occasion, but the birds settled back on the roost once it had passed.

A single QWSG survey in February 2021 recorded similar numbers of birds to the Project surveys: 500 grey-tailed tattler, 200 whimbrel, 15 ruddy turnstone, four terek sandpiper and two bar-tailed godwit. There is no evidence that the Cassim Island roost has unique properties such as providing refuge during extreme high tides or inclement weather conditions. The mangrove trees provide suitable roosting habitat on all tides to the species that use the roost. However, the suitability of trees throughout the perimeter of the roost provides the opportunity for the birds to move to seek shelter from strong winds or in response to disturbance.

17.3.3.2 *Nandeebie Claypan*

Nandeebie Claypan is a mainland shoreline roost located on the eastern edge of Nandeebie Park, approximately 100 m from the southern boundary of the Project footprint (Figure 17-4). It comprises a relatively small area of low, sparse saltmarsh bordered by mangroves along the eastern edge and tall parkland trees along the western boundary (Plate 17-3). A concrete public footpath and cycleway built in 2004 traverses the shoreline approximately 50-70 m from the roost area (Plate 17-4), which means that migratory shorebirds roosting at Nandeebie Claypan, including eastern curlew, great knot, bar-tailed godwit and whimbrel were doing so within 50-70 m of people using the footpath/cycleway. While trees and shrubs provide a partial visual screen between the roost site and the footpath/cycleway, the roosting birds are still visible from the footpath/cycleway. A 100 m wide band of mangrove trees provides a buffer between the roost site and the southern boundary of the Project footprint.

Plate 17-3: Saltmarsh Roost Site at Nandeebie Claypan.

Plate 17-4: Public Footpath and Cycleway on the Western Boundary of the Nandeebie Claypan Roost.

Four migratory shorebird species were recorded using the Nandeebie Claypan for roosting during field surveys: bar-tailed godwit, whimbrel, eastern curlew and great knot (Table 17-3). However, no migratory shorebirds were observed using the roost during 29 surveys through the 2019/20 and 2021/22 seasons.

Eastern curlew was present on 87% of summer high tide surveys during 2014/15 but was absent during all subsequent surveys. When eastern curlew was present in 2014/15, the average and maximum number of individuals present was 12 and 45 respectively. The frequency with which bar-tailed godwit was present at high tide declined from 26% of surveys in 2014/15 to 17% in 2018/19 and 0% in 2019/20 and 2021/22. No migratory shorebirds were recorded roosting at Nandeebie Claypan during any of the three winter surveys (one survey per season).

Table 17-3: Average (and Maximum) Counts of Shorebird Species (when Present) Roosting at Nandeebie Claypan.

Species	**Common Name**	**Status**		**Average (and maximum) birds recorded**			
		EPBC	NC	2014/15 15 surveys	2018/19 6 surveys	2019/20 11 surveys	2021/22 18 surveys
Limosa lapponica baueri	Bar-tailed Godwit (Western Alaskan)	M, V	V	660 (1026)	640 (640)	0	0
Numenius phaeopus	Whimbrel	M	S	43 (124)	7 (10)	0	0
Numenius madagascariensis	Eastern Curlew	CE, M	V	12 (45)	0	0	0
Calidris tenuirostris	Great Knot	CE, M	E	3 (5)	2 (2)	0	0

Based on a combined analysis of the project survey data and QWSG count data, nine migratory shorebird species have been recorded roosting at Nandeebie Claypan during the summer months (October to February) over the 26-year period since 1995. One additional species was recorded roosting during the winter months (May to August) - a flock of 35 red-necked stint in August 2016. One additional species was recorded in other months - a single flock of 60 red knot in September 1997. These two species have not been recorded at Nandeebie Claypan outside of these periods.

The last recorded use of the Nandeebie Claypan roost by any migratory shorebird was in January 2020, when a group of three whimbrel were recorded on a QWSG survey. No migratory shorebirds have been recorded on 45 surveys since then,

including 36 surveys over the months September to March. These data indicate that the Nandeebie Claypan has now been abandoned as a roost site by migratory shorebirds. The decline in shorebird use of the claypan is likely linked to mangrove encroachment that has reduced the open area of this relatively small roost site (Fuller *et al*. 2021). The landward side of the roost is bordered by 10-15 m tall swamp she-oak trees that restrict the field of view of the roosting birds, which causes them to, for example, react immediately to any alarm calls from passerine land birds such as noisy miners by taking flight and leaving the roost.

Disturbance to shorebirds roosting at Nandeebie Claypan by people or dogs was not observed to occur; however, birds were once disturbed by the alarm calls of passerine birds responding to the presence of raptors in the area and left the roost, flying north.

There is no evidence that the Nandeebie Claypan roost has unique properties such as providing refuge during extreme high tides or inclement weather conditions; the roost was used historically on all tides. In fact, the available evidence shows that the roost has now been abandoned, most likely due to mangrove encroachment combined with the small available area for roosting and closely adjacent tall trees that reduce the field of view for the roosting birds.

17.3.3.3 *Oyster Point*

Oyster Point is a mainland shoreline roost located on the southern edge of the Oyster Point public recreation park, approximately 400 m south-west of the southern extent of the Project footprint and 450 m south of the Nandeebie Claypan roost (Figure 17-4). It comprises an open area of shoreline with mangrove vegetation on either side. The public recreation park, which includes exercise equipment, a children's playground, barbeque facilities and picnic tables, extends right to the edge of the roost (Plate 17-5).

Oyster Point is a neap tide or spring mid-tide roost. Shorebirds are able to use the roost throughout neap high tides, but on spring high tides the rising tide completely covers the roost. This forces the roosting shorebirds to relocate to an alternative roost site as the rising tide pushes them closer to the shoreline bank and the adjoining public park (Plate 17-6). During most surveys on a rising tide, a large proportion of the birds using Oyster Point were seen to arrive from a mid-tide roost at Thornlands (visible across the bay from Oyster Point) that the birds left once the tide rose to approximately 1.8 m AHD. If not disturbed, shorebirds remained on the Oyster Point roost until they were pushed within 3-5 m of the shoreline bank, once the tide reached a height of approximately 2.2 m AHD. Historically, shorebirds would relocate from Oyster Point to Nandeebie Claypan during rising spring tides, and this was observed to occur on some surveys in 2014/15 and 2018/19. However, during the 2019/20 and 2020/21 seasons, shorebirds leaving Oyster Point usually flew north, bypassing Nandeebie Claypan, presumably to the next major roost site at Geoff Skinner Reserve 7 km further north, or occasionally flew south across the bay to land at one of two roost sites in Thornlands. During the 2019/20 surveys, flocks of migratory shorebirds flying in from feeding areas to the south that would normally stop at Oyster Point were increasingly observed flying past Oyster Point as they commuted further north towards Geoff Skinner Reserve.

During the 2018/19 to 2021/22 summer surveys, nine migratory shorebird species were recorded roosting at Oyster Point, the most frequently occurring species being bar-tailed godwit (maximum of 825 birds) and eastern curlew (maximum of 45 birds) (Table 17-4).

Table 17-4: Average (and maximum) Counts of Shorebird Species (when Present) Roosting at Oyster Point.

Species	Common Name	Status		Average (and maximum) birds when present		
		EPBC	NC	2018/19 7 surveys	2019/20 12 surveys	2021/22 13 surveys
Limosa lapponica	Bar-tailed Godwit (Western Alaskan)	V, M	V	454 (825)	461 (618)	485 (596)
Numenius madagascariensis	Eastern Curlew	CE, M	E	22 (45)	9 (11)	12 (12)
Numenius phaeopus	Whimbrel	M	S	1 (1)	0	0
Calidris acuminata	Sharp-tailed Sandpiper	M	S	5 (5)	28 (28)	5 (5)
Calidris ruficollis	Red-necked Stint	M	S	8 (8)	2 (2)	0
Calidris tenuirostris	Great Knot	CE, M	E	1 (2)	2 (3)	0
Tringa brevipes	Grey-tailed Tattler	M	S	0	1 (1)	1 (1)
Tringa nebularia	Common Greenshank	M	S	1 (1)	4 (4)	0
Arenaria interpres	Ruddy Turnstone	M	S	0	0	1 (1)

Plate 17-5: View over the Oyster Point roost showing proximity to public recreational park infrastructure.

Plate 17-6: Roosting shorebirds pushed towards the edge of the park at Oyster Point by rising spring tide.

Based on a combined analysis of the project survey data and QWSG count data, 12 migratory shorebird species have been recorded roosting at Oyster Point during the summer months (October to February) over the 20-year period since 2000. Over that period, up to 1,656 migratory shorebirds have roosted at Oyster Point, including maximum counts of 1,645 bar-tailed godwit, 70 whimbrel, 130 eastern curlew, 22 great knot, 26 red knot, 20 curlew sandpiper, 36 sharp-tailed sandpiper, 45 terek sandpiper, 116 grey-tailed tattler, 4 common greenshank, 3 ruddy turnstone and 2 red-necked stint. A similar complement of species has been recorded roosting at Oyster Point during the winter months (May to August).

The average numbers of migratory shorebirds on surveys when at least one migratory shorebird was present has ranged between 184 and 408 in summer and 33 and 82 in winter. The average migratory shorebird numbers and frequency of use show no obvious change over time in summer, but the frequency of use of Oyster Point during winter appears to have declined in recent years.

The area of the Oyster Point roost site used by roosting shorebirds is within 120 m of the public park infrastructure that has a high frequency of public use. Disturbance to shorebirds roosting at Oyster Point by people walking to the shoreline edge or onto the intertidal area was frequently observed, particularly once birds were pushed relatively close to the shoreline edge on higher tides. Eastern curlews observed roosting at Oyster Point during the field surveys permitted human approach to within 75-100 m but flushed once people approached to within 70 m of the roosting birds (see Plates 17-7 and 17-8). No disturbance by unleashed dogs was observed during any survey. When birds left the roost in response to disturbance, flocks frequently circled around and attempted to return if the disturbance agent moved away again, otherwise they left the roost to fly to an alternative roost site.

Plate 17-7: Flock of Eastern Curlew Roosting at Oyster Point Roost.

Plate 17-8: Roosting Eastern Curlew flushed by person approaching to the edge of the shoreline at Oyster Point, 70m from the birds.

During surveys of birds roosting at Oyster Point and the neighbouring Nandeebie Claypan, many migratory shorebirds with individually unique flags on their legs were observed. Unique flags were recorded on 134 bar-tailed godwit, two grey-tailed tattler, two great knot and one eastern curlew (Appendix 2-N). Approximately 83% of a sample of 58 flagged bar-tailed godwit observed at Oyster Point have also been recorded using the roost site at Manly Marina, 15 km north-west of Oyster Point. Observations of godwits flying north from Oyster Point also confirm that most godwits that use Oyster Point are most likely to use the roost at Geoff Skinner Reserve when they are unable to continue roosting at Oyster Point. During the low-tide surveys, two flagged bar-tailed godwit that have used Oyster Point for roosting were observed feeding on tidal flats at Victoria Point, 4 km and 7 km south of Oyster Point.

17.3.3.4 *Sandbank East of Cassim Island*

An offshore sandbank roost site is located more than 2 km east of the Project footprint (see Figure 17-1). It comprises a narrow, 30 m-wide strip of unvegetated sand up to 270 m long that remains exposed on most high tides, becoming completely covered in water only on the highest spring tides. Migratory shorebirds were found roosting on the sandbank on three of eight surveys conducted in October-December 2021, including up to 230 eastern curlew and up to 17 bar-tailed godwit (Table 17-5). Based on combined survey data from the QWSG (July 2014 to October 2021) and surveys conducted for the Project (October to December 2021), migratory shorebirds were recorded using the sandbank on 58% of summer (October-February) surveys, on 67% of winter (May-August) surveys, and on all surveys during migration periods, demonstrating regular use of the roost site throughout the year. The maximum number of migratory shorebirds recorded on any survey was 259, and the most frequently recorded species were eastern curlew (maximum count 230) and bar-tailed godwit (maximum count 186). There has been no significant change in the use of the roost site by migratory shorebirds within the period of available data.

During the high tide surveys October-December 2021, the only potential disturbance observed was a person fishing from the sandbank at high tide on one occasion, having accessed the location in a kayak that was pulled up on the sandbank. The person was observed on the sandbank at the start of the survey, with no birds present. Had any birds been present on the roost prior to the arrival of the fisher, they would have been disturbed off the roost.

Table 17-5: Average (and maximum) Counts of Shorebird Species (when present) Roosting on the Offshore sandbank.

Species	Common Name	Status		BAAM			QWSG +BAAM		
		EPBC	NC	17/10/21	03/12/21	13/12/21	Summer 19 surveys	Winter 6 surveys	Other 5 surveys
Limosa lapponica	Bar-tailed Godwit	V, M	V	17	0	10	65 (186)	60 (110)	44 (71)
Numenius madagascariensis	Eastern Curlew	CE, M	E	174	0	230	61 (230)	24 (40)	26 (58)
Numenius phaeopus	Whimbrel	M	S	6	4	0	24 (64)	4 (10)	10 (34)
Calidris ruficollis	Red-necked Stint	M	S	0	0	0	0	0	29 (29)
Calidris canutus	Red Knot	M, E	E	0	0	0	0	0	2 (2)
Calidris tenuirostris	Great Knot	CE, M	E	0	0	0	1 (1)	0	0
Pluvialis fulva	Pacific Golden Plover	M	S	10	0	0	6 (10)	0	17 (17)
Arenaria interpres	Ruddy Turnstone	M	S	0	0	0	0	0	2 (2)
Haematopus longirostris	Australian Pied Oystercatcher		LC	70	0	6	73 (220)	45 (105)	41 (128)

17.3.4 Shorebirds Foraging at Low Tide at Toondah Harbour

At low tide, a broad expanse of tidal flat is exposed between the mainland shoreline at GJ Walter Park and the Cassim Island mangroves to the north of the ferry channel, as well as a small area of tidal flat within the Project footprint to the south of the ferry channel (Figure 17-4). The low-tide surveys for foraging shorebirds covered a total area of approximately 41.3 ha of tidal flat within and immediately adjacent to the Project footprint. The main tidal flat area encloses a 4.6 ha subtidal area that is excluded from the tidal flat area calculation since it remains submerged and is not used for foraging by shorebirds.

Table 17-6 summarises the average and maximum number of each shorebird species recorded feeding on the tidal flats within the Toondah Harbour survey area during each summer season. The figures for migratory shorebirds are restricted to surveys in the months October to February when migratory shorebird numbers are most stable in Moreton Bay.

Five migratory shorebird species regularly used Toondah Harbour for feeding at low tide during the summer months (October-February): grey-tailed tattler (present on 75% of surveys over the past five years), bar-tailed godwit (present on all surveys; Plate 17-9), whimbrel (present on all surveys), eastern curlew (present on 97% of surveys over the past five years; Plate 17-10) and terek sandpiper (present on 36% of surveys over the past five years). A further four species were

rarely recorded in small numbers: red-necked stint, common greenshank, lesser sand plover and great knot. A single great knot was recorded on a single survey in 2014/15 and two lesser sand plovers were recorded on a single survey in 2019/20. Total migratory shorebirds varied substantially between years, between an average of 98 in 2014/15 and an average of 29 in 2021/22, largely due to variation in the numbers of grey-tailed tattler and bar-tailed godwit (Table 17-6). Numbers of whimbrel and eastern curlew were relatively constant between years. Only two migratory shorebird species were recorded feeding on tidal flats at Toondah Harbour during the winter surveys (June-August): grey-tailed tattler and whimbrel.

Plate 17-9: Bar-tailed Godwit.

Plate 17-10: Eastern Curlew.

Disturbance to shorebirds foraging on the Toondah Harbour mudflats at low tide was infrequently observed. An unleashed dog ran out approximately 30 m onto the mudflat during one survey and a single person collecting marine species along the waterline edge was observed on several surveys. Although GJ Walter Park is well used for recreational activities, and people were present in the park on nearly all surveys, people only very infrequently walk into the intertidal zone, likely due to the rocky and muddy nature of the substrate and fringing mangroves.

Table 17-6: Summary of the Average (and Maximum) Number of Shorebirds Recorded Feeding at Toondah Harbour Each Summer Season.

Species	Status		Average (and maximum) birds recorded					Overall 49 surveys	Last 5 years 32 surveys
	EPBC	NC	2014/15 12 surveys	2016/17[1] 5 surveys	2018/19 8 surveys	2019/20 13 surveys	2021/22 11 surveys		
Migratory Shorebirds									
Grey-tailed Tattler	M	S	49 (92)	10 (32)	7 (25)	23 (78)	5 (15)	21 (92)	12 (78)
Bar-tailed Godwit	V, M	V	24 (36)	9 (15)	13 (19)	17 (24)	9 (18)	15 (36)	13 (24)
Whimbrel	M	S	12 (19)	10 (18)	10 (14)	8 (11)	6 (9)	9 (19)	8 (14)
Eastern Curlew	CE, M	E	5 (7)	3 (6)	4 (5)	4 (5)	3 (4)	4 (7)	3 (5)
Terek Sandpiper	M	S	8 (42)	1 (7)	0	7 (16)	6 (36)	5 (42)	5 (36)
Red-necked Stint	M	S	<1 (1)	0	<1 (2)	<1 (3)	0	<1 (3)	<1 (3)
Common Greenshank	M	S	0	1 (4)	0	0	0	1 (4)	0
Lesser Sand Plover	E, M	E	0	0	0	<1 (2)	0	<1 (2)	<1 (2)
Great Knot	CE, M	E	<1 (1)	0	0	0	0	<1 (1)	0
Resident Shorebirds									
Summer surveys (Oct-Mar)			13	6	8	13	11	40	32
Australian Pied Oystercatcher		LC	9 (43)	5 (18)	32 (61)	36 (105)	7 (24)	21 (105)	24 (105)
Masked Lapwing		LC	5 (17)	<1 (2)	5 (10)	2 (5)	2 (6)	3 (17)	3 (10)

1: QWSG data from Bush (2017)

17.3.5 Migratory Shorebird Habitat Importance within and adjacent to the Project footprint

As previously identified, shorebird habitats within or adjacent to the Project footprint occur within the MBRS and are therefore automatically considered to be important habitat for migratory shorebirds under the EPBC Act. Table 17-7 assesses the shorebird habitat within and adjacent to the Project footprint in isolation of the rest of the MBRS that they are part of against the other EPBC Act criteria that are based on the proportion of flyway population, and the number and species richness of shorebirds. These criteria are:

- Supports at least 0.1% of the flyway population of a single migratory shorebird species;
- Supports at least 2,000 migratory shorebirds; or
- Supports at least 15 migratory shorebird species.

Each site has been assessed as a discrete location as they have different characteristics (i.e., mangrove roost vs shoreline roost vs tidal flat foraging habitat vs sandbank roost) that provide habitat for different shorebird species.

Table 17-7: Assessment of the Importance of Migratory Shorebird Habitats in their Own Right.

Shorebird habitat	Assessment of shorebird habitat importance
Tidal flat foraging habitat in the Project footprint	The tidal flat foraging habitat within the Project footprint has supported seven migratory shorebird species, including up to a maximum of 0.11% of the EAAF population of grey-tailed tattler within the past five years. This habitat meets the criterion of national significance for grey-tailed tattler since it has supported over 0.1% of the EAAF population.
Cassim Island roost site	The roost site supported six migratory shorebird species, including up to 1.6% of the EAAF population of grey-tailed tattler, up to 0.3% of the EAAF population of whimbrel and up to 0.1% of the EAAF population of terek sandpiper within the past five years. The roost site is internationally significant for grey-tailed tattler, supporting more than 1% of the EAAF population, and nationally significant for whimbrel and terek sandpiper, supporting more than 0.1% of their EAAF populations.
Nandeebie Claypan roost site	The roost site supported four migratory shorebird species within the past five years, but not at nationally or internationally significant numbers for any species and it has now been abandoned as a roost site.
Oyster Point roost site	The roost site supported 10 migratory shorebird species within the past five years, including up to 0.1% of the estimated flyway population of eastern curlew and up to 0.5% of the estimated flyway population of bar-tailed godwit. The roost site is nationally significant for eastern curlew and bar-tailed godwit, supporting more than 0.1% of their EAAF populations.
Sandbank roost site	The roost site supported six migratory shorebird species within the past five years, including up to 0.7% of the estimated flyway population of eastern curlew. The roost site is nationally significant for eastern curlew, supporting more than 0.1% of its EAAF population.

17.3.5.1 *Shorebirds Foraging at Low Tide in South-western Moreton Bay*

The surveys of foraging shorebird densities found substantial variation in the shorebird species composition and foraging densities across the different tidal flat areas sampled at low tide in south-western Moreton Bay. Tidal flats in the Project footprint had the lowest total migratory shorebird summer foraging density of all the areas sampled– an average of 10.0 birds per 10 ha over the past five years compared with the average densities of 13.9 to 116.6 birds per 10 ha recorded

across other tidal flat areas both north and south of the Project footprint in south-western Moreton Bay. The highest total migratory shorebird summer foraging densities were recorded at the more northerly tidal flats from Wellington Point to Thorneside; these northern tidal flats also supported relatively high summer foraging densities of several species that were either absent from or occurred at low densities at the more southerly locations, such as curlew and broad-billed sandpipers, red-necked stint and lesser and greater sand plovers. Consequently, the average migratory shorebird species richness per survey was greatest on the tidal flats from Wellington Point to Thorneside. Similarly, the northern tidal flats from Wellington Point to Thorneside supported substantially greater total migratory shorebird foraging densities during the winter months than the other areas sampled.

As a further comparison of the migratory shorebird foraging densities at Toondah Harbour compared with other parts of Moreton Bay, Figure 17-5 compares the average foraging densities for the most common species (and total migratory shorebirds) at Toondah Harbour to the average foraging densities across the rest of south-western Moreton Bay sampled in this study, as well as the average foraging densities recorded within the months October to February over 11 years of monthly surveys from 2014 to 2020 on 79 ha of tidal flats in the central western portion of Moreton Bay on the western edge of Bramble Bay, north of the Brisbane River alongside Brisbane Airport (Lloyd *et al*. 2021). This comparison confirms that the tidal flats at Toondah Harbour support a low total migratory shorebird foraging density, an average density of eastern curlew and terek sandpiper, and relatively low densities of bar-tailed godwit, whimbrel and grey-tailed tattler—the five most common migratory shorebird species using the Toondah Harbour tidal flats.

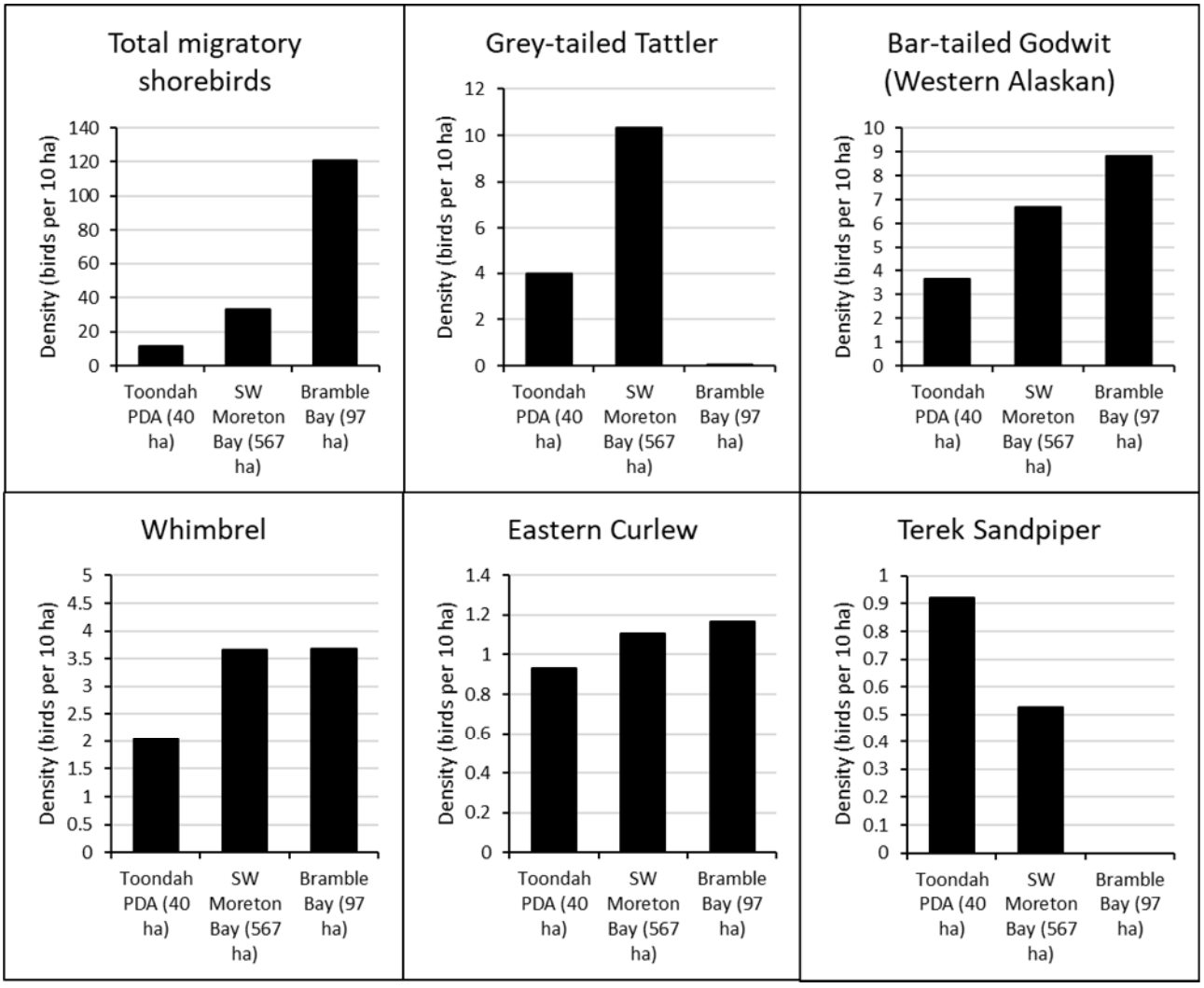


Figure 17-5: Average Migratory Shorebird Summer Foraging Densities.

17.3.6 Threats and Trends in Shorebird Habitat Condition

There is little information available on past and projected trends and existing threats to the condition of habitat, particularly feeding habitat for shorebird species within the Project footprint and surrounds. Two of the five known roost sites in Cleveland have been lost to development and two others including Nandeebie Claypan are impacted by mangrove encroachment (Fuller *et al*. 2021). Development of the Raby Bay marina in 1994 resulted in the loss of one of the larger roosts in the Cleveland area that was used by up to 4,500 roosting shorebirds (Fuller *et al*. 2021). Although a small roosting area was eventually constructed nearby at Empire Point in an attempt to accommodate the birds displaced by the Raby Bay development (Lawler 1995), it never supported large numbers of birds (Harding *et al*. 1999). In the absence of active management it became overgrown with vegetation and abandoned as a roost site (Fuller *et al*. 2021). A mangrove roost site used by large numbers of grey-tailed tattler, terek sandpiper and ruddy turnstone on King Island north of Wellington Point in 2014, following storm damage to the Manly Marina roost site, was abandoned after illegal cutting of mangroves (Redland City Bulletin 2016) resulting in increased visual disturbance to roosting birds from recreational walkers (BAAM, unpublished). In Moreton Bay as a whole, 15 migratory shorebird roosting sites have been identified as destroyed (11 to development, three to mangrove overgrowth and one to erosion) and 95% of roost sites are, or have been, impacted by one or more threats, particularly human disturbance (67 sites), development (43 sites), mangrove encroachment (25 sites), erosion (14 sites) and land management (four sites) (Fuller *et al*. 2021).

The key current threat to tidal flat feeding habitat in Moreton Bay is human disturbance of foraging shorebirds, particularly from unleashed dogs being walked on tidal flats at low tide (Fuller *et al*. 2021). In the local Cleveland area, unleashed dogs are an increasing disturbance to shorebirds feeding on the tidal flats at Wellington Point, a popular recreational walking destination that also supports high densities of foraging migratory shorebirds. At Wellington Point, pressure from a special interest group has led to relaxation of laws restricting dog access (Redland City Bulletin 2020). Although local laws require dogs to be on-leash, dog walkers frequently ignore this law due to insufficient compliance action, a problem experienced elsewhere in Moreton Bay (Stigner *et al*. 2016, Fuller *et al*. 2021). Other threats to feeding habitat include loss of tidal flat to mangrove encroachment and sea level rise resulting from global climate change (Iwamura *et al*. 2013, Saintilan *et al*. 2019).

Whereas approximately 50% of Australia's non-tidal wetlands have been converted to other uses (Commonwealth of Australia 2015b), there has been limited loss of tidal flats to development across Australia. Australia supports 8,866 km^2 of tidal flats, the third largest area of tidal flats of any country in the world (Murray *et al*. 2019). Of far greater consequence for the trajectory of migratory shorebird populations that use tidal flat habitats in Australia has been the loss and degradation of tidal flats at key migration stopover sites in the Yellow Sea region (Wilson *et al*. 2011; Studds *et al*. 2017). The Yellow Sea supports critical stop-over feeding habitats for many migratory shorebirds on the EAAF. In the mid-1950s, tidal flats occupied 11,200 km^2 in the Yellow Sea, but this had reduced to 5,450 km^2 by the 1980s and 3,890 km^2 by the 2000s, representing a loss of up to 65%, or 7,310 km^2 over 50 years (Murray *et al*. 2014). This loss of tidal feeding habitat has largely resulted from extensive land reclamation for agriculture, aquaculture, urban and industrial development, and is ongoing (Murray *et al*. 2014, Moores *et al*. 2016). The largest single reclamation project has been at Saemangeum, South Korea, where approximately 29,000 ha of tidal flats were impounded behind a 33-km long sea wall in 2006. The Saemangeum tidal flats supported at least 330,000 migratory shorebirds prior to the reclamation, including 30% of the world population of great knot. Following the completion of the impoundment, an estimated 130,000 migratory shorebirds disappeared from the flyway population within the first two years and 300,000 had disappeared by 2013, including an estimated 104,000 great knots. These missing birds are presumed to have died following the loss of habitat (Moores *et al*. 2016). These studies highlight why past and ongoing feeding habitat loss at key staging sites in the Yellow Sea is the single biggest threat to migratory shorebirds on the EAAF. China recently announced a moratorium on approving new land reclamation projects (BirdLife International 2018, Xinhua 2018), which may reduce the future extent of tidal flat loss in the Yellow Sea.

17.3.7 Key Assessment Outcomes

The Project footprint is located close to three important migratory shorebird roost sites in the MBRS:

1. Cassim Island is a large and dispersed area of mangrove trees, is located east of the Project footprint. These mangrove trees were used as a roost site by an average of 926 and maximum of 1,300 migratory shorebirds during the summer months, mostly grey-tailed tattler but also whimbrel, terek sandpiper, ruddy turnstone and occasionally bar-tailed godwit and common greenshank. During the three winter season surveys, no migratory shorebirds were present on two of the surveys, but 44 whimbrel were present in the June 2020 survey. The roost site supported up to 1.6% of the estimated flyway population of grey-tailed tattler (internationally significant), up to 0.3% of the estimated flyway population of whimbrel (nationally significant) and up to 0.1% of the estimated flyway population of terek sandpiper (nationally significant) within the past five years.

2. Nandeebie Claypan is a mainland shoreline roost located on the eastern edge of Nandeebie Park, approximately 100 m from the southern boundary of the Project footprint. Based on a combined analysis of the project survey data and QWSG count data, 11 migratory shorebird species have historically been recorded roosting at Nandeebie Claypan. The most abundant species roosting at Nandeebie was bar-tailed godwit, with eastern curlew and whimbrel also frequently present in lower numbers. The frequency of use of the roost site declined from 96-100% of summer high tides over 5-year intervals in the period 1995-2004 to 28% of summer high tides over the most recent 5-year interval 2015-2019, and from 88% of winter high tides over the 5-year interval 1995-1999 to 4% of winter high tides over the most recent 5-year interval 2015-2019. The abundance of migratory shorebirds using the roost site when migratory shorebirds were present in summer has similarly declined from an average of 680 and maximum of 2,560 over the 5-year interval 1995-1999 to an average of 28 and maximum of 102 over the most recent 5-year interval 2015-2019, but a maximum of 652 migratory shorebirds were recorded roosting in March 2019. The declining use of the roost site by migratory shorebirds is attributed to mangrove encroachment. The roost site has supported four migratory shorebird species within the past five years, but not at internationally or nationally significant numbers, and has now been abandoned as a roost site.

3. Oyster Point is a mainland shoreline roost located on the southern edge of the Oyster Point public recreation park, approximately 400 m south-west of the southern boundary of the Project footprint. Oyster Point is a neap tide or mid-tide roost. Shorebirds are able to use the roost throughout neap high tides, but on most other high tides the rising tide completely covers the roost and forces the roosting shorebirds to relocate to an alternative roost site as the rising tide pushes them closer to the shoreline bank and the adjoining public park. Based on a combined analysis of the project survey data and QWSG count data, 15 migratory shorebird species have been recorded roosting at Oyster Point. The most frequent and abundant species roosting at Oyster Point is bar-tailed godwit, with eastern curlew and whimbrel also frequently present in lower numbers. The average and maximum numbers of migratory shorebirds on surveys when at least one migratory shorebird was present has ranged between an average of 184-527 and maximum of 408-1,656 in summer and an average of 33-100 and maximum of 82-405 in winter. The average migratory shorebird numbers and frequency of use show no obvious change over time in summer, but the frequency of use of Oyster Point during winter appears to have declined in recent years. The roost site supported up to 0.1% of the estimated flyway population of eastern curlew (nationally significant) and up to 0.5% of the estimated flyway population of bar-tailed godwit (nationally significant) within the past five years.

The Project footprint incorporates approximately 28.9 ha of tidal flat that is used as feeding habitat by migratory and resident shorebirds, 25.6 ha of which occurs within the MBRS. Tidal flat feeding habitat within the Project footprint is characterised as important habitat for migratory shorebirds under the EPBC Act since it occurs within the MBRS, a shorebird area that supports internationally significant numbers of migratory shorebirds. When considered in isolation of the rest of the MBRS, the Project footprint and immediately adjacent area of approximately 40 ha of tidal flats has

supported up to a maximum of 0.11% of the estimated flyway population of grey-tailed tattler (nationally significant) within the past five years.

Five migratory shorebird species regularly used the tidal flats for feeding at low tide during the summer months (October-February) over the past five years (2017-2021): grey-tailed tattler (present on 75% of surveys; average of 12.5, maximum of 78 birds), bar-tailed godwit (present on all surveys; average of 12.9, maximum of 24 birds), whimbrel (present on all surveys; average of 7.6, maximum of 14 birds), eastern curlew (present on 97% of surveys; average of 4, maximum of 7 birds) and terek sandpiper (present on 36% of surveys; average of 4.6, maximum of 36 birds). A further four species were rarely recorded in small numbers: red-necked stint, common greenshank, lesser sand plover and great knot.

Total migratory shorebirds varied substantially between years, between an average of 98 in 2014/15 and an average of 29 in 2021/22, largely due to variation in the numbers of grey-tailed tattler and bar-tailed godwit. Numbers of whimbrel and eastern curlew were relatively constant between years. Only two migratory shorebird species were recorded feeding on tidal flats at Toondah Harbour during winter: grey-tailed tattler, which was present on 47% of winter surveys with an average of 9 and a maximum of 52 birds; and whimbrel, a single bird recorded on a single survey. The average density of migratory shorebirds using the Toondah Harbour tidal flats over the summer months (13.3 birds per 10 ha) was lower than the average densities of 13.9 to 116.6 birds per 10 ha recorded across other tidal flat areas both north and south of the Project footprint in south-western Moreton Bay.

17.4. Potential Impacts

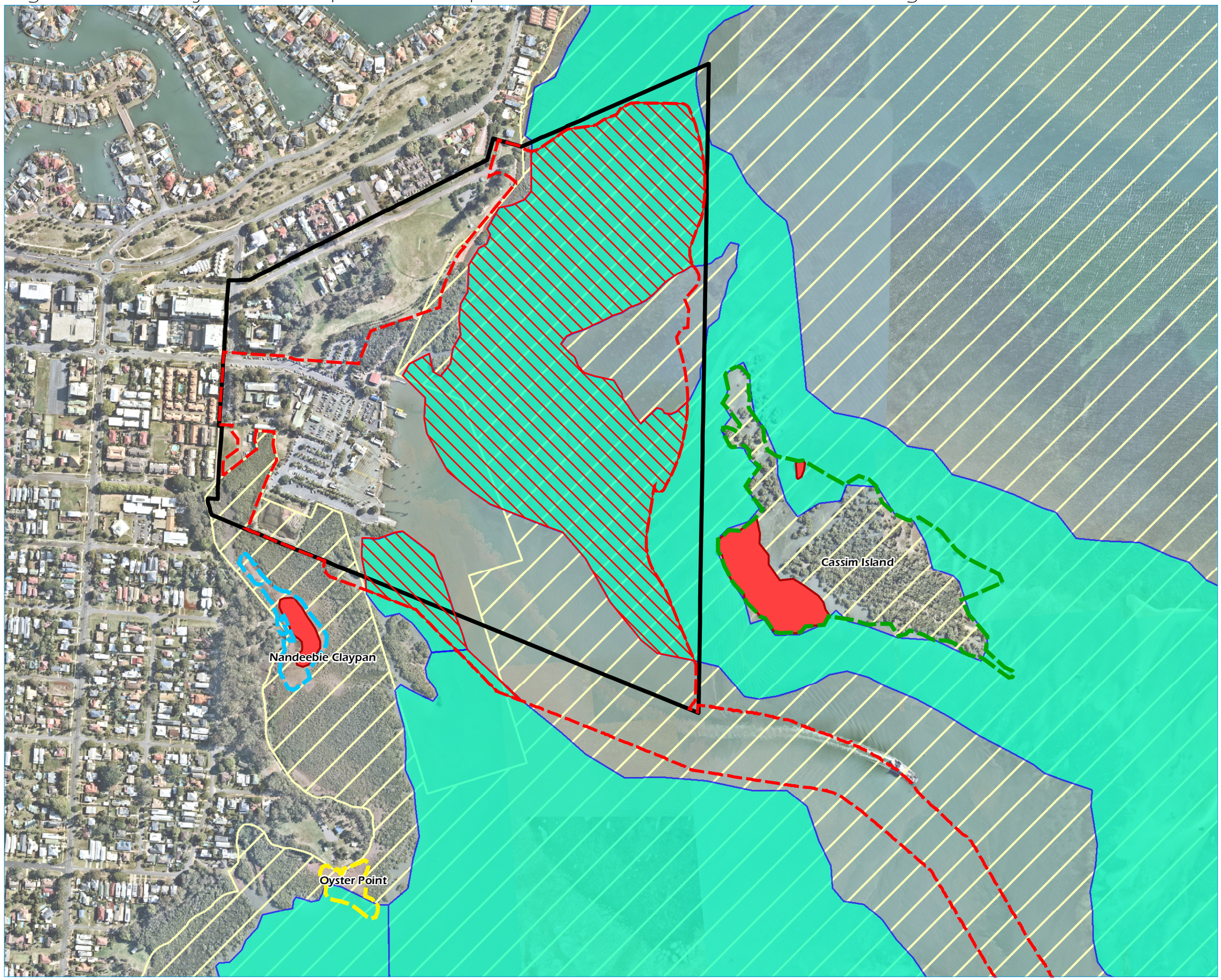
The Project has the potential to have both direct and indirect impacts on migratory and threatened shorebird species. Potential impacts are addressed according to the overarching activities being undertaken on site:

- Dredging and reclamation;
- Civil, tidal and building works; and
- Ongoing uses and operations.

As these activities will at times occur concurrently during the development process (i.e., dredging and reclamation works for the southern reclamation area will commence while buildings are still being constructed in the northern reclamation area), key mechanisms for disturbance of shorebirds are also addressed. These include activities resulting in disturbance from human interactions, noise and lighting. The assessment includes a discussion of expected peaks and general use over the life of the Project.

Figure 17-6 shows the Project development footprint in relation to the locations of migratory and threatened shorebird habitats. The potential direct and indirect impacts of the dredging and reclamation activities, civil works, and ongoing use and operations on migratory and threatened shorebirds are discussed further in the sections below.

Figure 17-6: Project Development Footprint in Relation to Shorebird Feeding Habitat and Roost Sites at Toondah Harbour



Legend

- Toondah Harbour PDA (Project Area)
- Development footprint
- Moreton Bay RAMSAR
- Tidal flat shorebird feeding habitat
- High roosting density
- Shorebird feeding habitat impacted by the Project footprint (28.9 ha)
- Cassim Island roost site
- Nandeebie claypan roost site
- Oyster Point roost site

TOONDAH HARBOUR

walker

0 100 200 300 m

GDA 1994 MGA zone 56

Scale (A3): 1:6,500

N

DATE: 27/05/2022

FILE REF. 9858 E 17 6 Project Footprint Shorebird feed

Layer Source: © State of Queensland Datasets (Department of Natural Resources, Mines and Energy 2020), Aerial Imagery (Nearmap.com 2020)

Toondah Harbour EIS

17.4.1 Dredging, Reclamation and Civil Works

The dredging and reclamation works will occur in both stages 1 and 2 of the development.

Dredging and reclamation in stage 1 entails enclosing the northern reclamation area with sheet piling and, in most areas, placing rock on either side of the sheet piling to create a stable revetment. Reclamation activities will also include excavation of the northern marina and use of excavated material to create the northern landform, as well as dredging of the turning basin and Fison Channel. A barge unloading facility and temporary internal road will be constructed by the Proponent for the purpose of unloading the dredged material. Dredging and reclamation works are expected to be ongoing over a five-year period, although for much of this time works will be restricted to excavators moving sediments around to dry them out and create a stable landform. The dredging activity is expected to last only three to four months, while installation of the sheet piling and rock bunding will take three to six months.

Dredging and reclamation in stage 2 will commence after the completion of stage 1 and entails construction of the southern reclamation containment bund, and creation of the southern landform. The barge unloading facility constructed in stage 1 will be moved to a new location to support construction of the containment bund. Excavation within the bunded area will deliver the internal waterway connecting the marina to Fison Channel. Dredging will be carried out in the outer sections of the Fison Channel with material transferred to the unloading facility by barge. Timeframes for the various activities are expected to be similar to stage 1, with reclamation works generally restricted to the use of excavators once the bund walls are installed and the second stage of dredging is completed.

Potential impacts on migratory and threatened shorebird species during the dredging, reclamation and civil works phases include:

- The loss of 28.9 ha of tidal flat feeding habitat, which is characterised as important habitat under the EPBC Act; a direct impact;
- Disturbance to migratory shorebirds roosting in mangrove trees at the Cassim Island roost site, which is characterised as important habitat under the EPBC Act; an indirect impact that may result from noise, activity and proximity of workers and machinery; and
- Disturbance to migratory shorebirds roosting at the Nandeebie Claypan roost site associated with civil, tidal and building works.

Construction activities will occur throughout both Stages 1 and 2 of construction and will include civil works (i.e., subdivision works and provision of services for residential, recreational, commercial and retail uses), tidal works and building works.

Works will commence in the northern reclamation area approximately two years after the start of dredging and reclamation activities and will be carried out intermittently for a period of up to 20 years. Civil and building works will generally progress from north to south. Importantly, ferry terminal works will also commence approximately two years after the start of construction.

Potential impacts on migratory and threatened shorebird species during construction include:

- Disturbance to migratory shorebirds roosting in mangrove trees at the Cassim Island roost site, which is characterised as important habitat under the EPBC Act; an indirect impact that may result from noise, light, activity and proximity of workers and machinery;
- Disturbance to migratory shorebirds roosting at the Nandeebie Claypan roost site, which is characterised as important habitat under the EPBC Act; an indirect impact that may result from noise, activity and proximity of workers and machinery;

- Disturbance and displacement of migratory shorebirds feeding on tidal flats adjacent to the Project footprint, which are characterised as important habitat under the EPBC Act; an indirect impact that may result from noise, light, activity and proximity of workers and machinery; and
- A reduction in benthic invertebrate abundance (migratory shorebird food) in tidal flats adjacent to the Project footprint; an indirect impact that may occur through changes in water quality resulting from storm water discharge to tidal flats.

17.4.2 Ongoing Use and Operations

Ongoing use and operations include the actual construction of buildings and other features on lands for which all civil works are complete, as well as the gradual occupation of the residential dwellings and use of commercial, retail and recreational elements over the 18-year development schedule.

Potential impacts on migratory and threatened shorebird species during ongoing use and operations include:

- Increased disturbance to migratory shorebirds roosting in mangrove trees at the Cassim Island roost site, which is characterised as important habitat under the EPBC Act; an indirect impact that may result from noise, light, activity and proximity of workers and machinery, and increased frequency of motorised and non-motorised watercraft moving close to or through the roost site;
- Increased disturbance to migratory shorebirds roosting at the Nandeebie Claypan roost site, which is characterised as important habitat under the EPBC Act; an indirect impact that may result from noise, light and increased use of the public footpath and cycleway adjacent to the roost site from more people living in the local area;
- Increased disturbance to migratory shorebirds roosting at the Oyster Point roost site, which is characterised as important habitat under the EPBC Act; an indirect impact that may result from increased use of the Oyster Point public park facilities from more people living in the local area;
- Disturbance and displacement of migratory shorebirds feeding on tidal flats adjacent to the Project footprint, which are characterised as important habitat under the EPBC Act; an indirect impact that may result from noise, light, activity and proximity of people, and increased accessibility of tidal flat habitats to people and dogs; and
- A reduction in benthic invertebrate abundance (migratory shorebird food) in tidal flats adjacent to the Project footprint; an indirect impact that may occur through changes in water quality resulting from storm water discharge to tidal flats.

17.4.3 Review of Key Impacts on Shorebirds

Human disturbance can be a major threat to shorebirds and can have a significant impact on the quality of habitat available to shorebirds (Commonwealth of Australia 2015b, Fuller *et al*. 2021). This section reviews published knowledge of disturbance impacts on feeding and roosting shorebirds to inform mitigation and management measures.

17.4.3.1 *Disturbance from Recreational and Other Activity*

During the approach of a disturbance agent, foraging and roosting shorebirds reduce their foraging or resting activity to become more vigilant and will typically begin to walk away from the approach. If the approach continues, the birds will eventually take flight to a new location. Disturbance causes birds to spend energy flying away and to lose feeding time while relocating to different feeding areas where the increased bird densities may intensify competition from interference and, if of sufficient duration, from prey depletion (Goss-Custard *et al*. 2006).

There is little published information on critical thresholds of disturbance. In France, modelling shows that foraging oystercatcher *Haematopus ostralegus* experience reduced survival and breeding success if they are put to flight more than 1.0-1.5 times per hour in winters with good feeding conditions, or more than 0.2-0.5 times per hour when feeding conditions are poor (Goss-Custard *et al*. 2006). At Roebuck Bay in Western Australia, great knot spent an average of 30

minutes per high tide in alarm flights from disturbance by raptors and humans at the most disturbed roost site, yet still preferred to use this site than an alternative site 25 km away (Rogers *et al*. 2006c). At a disturbed roost site in Moreton Bay up to 400 shorebirds continued to use the roost during spring high tides despite a median number of flights per hour of 0.7, with a total time in flight of less than five minutes (Milton *et al*. 2011).

Birds taking flight are the most obvious result of disturbance, and different shorebird species have different sensitivities, taking flight at different distances from disturbance agents. Flight initiation distances in response to a variety of disturbance agents have been reviewed in available literature and are summarised in Table 17-8.

Table 17-8: Flight Initiation Distance (FID) of a Variety of Migratory Shorebird Species in Response to Disturbance Agents.

Species	Agent	Bird Activity	FID avg (m)	FID range (m)	Ref.*
Australian Studies					
Eastern Curlew *Numenius madagascariensis*	Walker	Mixed	126	81-196	1
Whimbrel *N. phaeopus*	Walker	Mixed	90		1
Pacific Golden Plover *Pluvialis dominica*	Walker	Mixed	49	40-60	1
Grey Plover *P. squatarola*	Walker	Mixed	44		1
Sand Plovers (Lesser Sand Plover (*Charadrius mongolus* and Greater Sand Plover *Charadrius leschenaultii*)	Walker	Roosting	44		9
Latham's Snipe *Gallinago harwickii*	Walker	Mixed	19	9-45	1
Black-tailed Godwit *Limosa limosa*	Walker	Mixed	31	27-35	1
Bar-tailed Godwit *L. lapponica*	Walker Walker	Mixed Foraging	60	45-69 18-38	1 2
Common Sandpiper *Tringa hypoleucos*	Walker	Mixed	43		1
Grey-tailed Tattler *T. brevipes*	Walker	Mixed	23		1
Common Greenshank *T. nebularia*	Walker	Mixed	55	25-145	1
Marsh Sandpiper *T. stagnatilis*	Walker	Mixed	44	20-99	1
Ruddy Turnstone *Arenaria interpres*	Walker	Mixed	30	17-54	1
Knots (Red Knot *Calidris canutus* and Great Knot *Calidris tenuirostris*)	Walker	Roosting	74		9
Sanderling *Caldris alba*	Walker	Mixed	32	22-39	1
Red-necked Stint *C. ruficollis*	Walker	Mixed	19	9-41	1
Pectoral Sandpiper *C. melanotos*	Walker	Mixed	23	16-30	1
Sharp-tailed Sandpiper *C. acuminata*	Walker	Mixed	20	4-44	1
Curlew Sandpiper *C. ferruginea*	Walker	Mixed	25	14-35	1
Shorebirds and terns	Plane Boat Walker Dog	Roosting Roosting Roosting Roosting	170 75 25 30		7 7 7 7

Species	Agent	Bird Activity	FID avg (m)	FID range (m)	Ref.*
Studies Elsewhere					
Bar-tailed Godwit *L. lapponica*	Walker	Foraging	107		4
	Walker	Foraging	219	88-127	5
	Walker	Foraging	101-138	150-225	3
	Walker	Foraging	45		8
	Kayak	Roosting	210	25-83	6
	Windsurfer	Roosting	240		6
Grey Plover *P. squatarola*	Walker	Foraging	124	106-142	4
	Walker	Foraging	64	31-85	8
Ruddy Turnstone *Arenaria interpres*	Walker	Foraging	47	31-53	4
	Walker	Foraging	25	3-87	8

* References: (1) Glover *et al*. 2011; (2) Blumstein *et al*. 2003; (3) Glimmerveen and Went 1984 in Smit and Visser 1993; (4) van der Meer in Smit and Visser 1993; (5) Wolff *et al*. 1982 in Smit and Visser 1993; (6) Koepff and Dietrich 1986 in Smit and Visser 1993; (7) Milton *et al*. 2011; (8) Collop *et al*. 2016; (10) Lilleyman *et al*. 2016.

Larger species such as eastern curlew and whimbrel tend to be 'flighty', meaning they are more sensitive to disturbance and tend to take flight at greater distances from disturbance agents than most other shorebirds (Smit and Visser 1993, Glover *et al*. 2011). Joggers and walkers with a leashed dog are more disturbing than a walker alone (Lafferty 2001, Glover *et al*. 2011) and unleashed dogs are substantially more disturbing (Pfister and Harrington 1992, Kyne 2010, Stigner *et al*. 2016). The presence of off-leash dogs reduced the number of foraging shorebirds feeding on tidal flat habitat in Moreton Bay by about 20%, an impact that does not factor in the long-term avoidance of an area that may be subject to sustained high levels of disturbance (Stigner *et al*. 2016).

Other more disturbing sources of disturbance are watercraft, particularly jet-skis (Smit and Visser 1993, Collins *et al*. 2000, Rodgers and Schwikert 2003). Jet-skis are more disturbing than most other watercraft because of their generally faster travelling speeds and sharp turning abilities.

Shorebird responses to disturbance often depend on the context in which the disturbance takes place. Individuals in larger flocks tend to be more sensitive to disturbance, particularly when they are in large, mixed species flocks, such as occurs at shorebird roosting sites (Rogers *et al*. 2006b, Glover *et al*. 2011). The relationship between flock size and disturbance does not appear to be linear; rather, disturbance levels climbed abruptly if bird numbers exceeded 50-100 (Rogers *et al*. 2006b). Therefore, flight initiation distances for individual species may be larger than those reported in Table 17-8 when these species are roosting in large, mixed-species flocks.

Shorebirds living in environments that are heavily used by humans and exposed to repetitive, non-lethal disturbance stimuli experience energetic costs associated with their responses to disturbance (West *et al*. 2002, Goss-Custard *et al*. 2006). To reduce these costs, shorebirds are expected to habituate to repetitive stimuli that do not present a direct mortality risk (Deniz *et al*. 2003). Many studies have demonstrated the ability of many shorebird species to habituate to many forms of repetitive disturbance (Smit and Visser 1993, West *et al*. 2002, Baudains and Lloyd 2007), although the process of habituation may require lengthy exposure to repetitive disturbance stimuli (Komenda-Zehnder *et al*. 2003).

Potential Project Impacts

Construction activities including reclamation sheet piling and the rockwall breakwater are proposed to be undertaken at distances of 70-130 m from the closest mangrove trees around Cassim Island. The rockwall breakwater will be

constructed in the winter months and will be gated and not open to the public once completed. No buildings will be constructed within 250 m of the Cassim Island roost site.

Nandeebie Claypan is approximately 100 m south-west of the closest project feature, which is the extended car parking for the ferry terminal. On ground surveys show this roost site has been abandoned for the last two years. The 100 m buffer between the Project footprint and roost site is dominated by mangrove forest which provides a visual and sound barrier to the roost site. No buildings will be located within 250 m of the roost site. The new ferry terminal will be near its current location.

Construction activities including the installation of sheet piling and placement of rock armouring will occur within the flight initiation distances for some shorebird species as outlined in Table 17-8. These activities will be short term (2-4 months) and will be carried out during breeding season in the northern hemisphere (April – August), when few shorebirds will be using the Cassim Island roost site, thereby minimising the risk of disturbance roosting shorebirds.

While no dwellings or retail areas will be located within 250 m of the roost sites, the completed development will house up to 5,800 new residents, which is expected to increase public use of the public walkway/cycleway and Oyster Point Park recreational facilities that are located within 50-70 m of the Nandeebie Claypan and Oyster Point roost sites. These areas are already public spaces used by residents in an area that continues to experience population growth from ongoing residential housing development. As a contributor to this population growth, there is potential for the Project to increase the risk of disturbance to shorebird species using these roost sites. Migratory shorebirds roosting at Oyster Point have habituated to public use of the recreational facilities. Potential impacts may be mitigated through the use of educational signage and other measures within Nandeebie and Oyster Point Parks.

The offshore sandbank 2 km east of the Project footprint is sufficiently far removed that shorebird use of the roost is very unlikely to be impacted by noise, light and construction or operational activity associated with the Project. The only potential source of increased impact is small recreational boat traffic, which is already present at Toondah Harbour. While the Project includes a marina with up to 200 wet berths, the existing public boat ramp will be decommissioned, resulting in no net change to the quantity of small recreational boat traffic in the harbour. The boat traffic lanes are well marked either side of the sandbank and are located sufficiently far from the sandbank that passing boats do not cause disturbance to the birds. Realignment of the Fison Channel to the south of the existing channel will further reduce potential impacts. Accordingly, recreational boat traffic is unlikely to result in a significant impact on shorebird use of the offshore sandbank roost site. During the high tide surveys, a person was observed fishing on the sandbank on one occasion, having accessed it in a kayak. The risk of such disturbance may increase slightly as the Project includes a boat ramp for non-motorised recreational vessels, although it is noted that GJ Walter Park is already considered a canoe and kayak launch point by RCC. This risk may be mitigated by information signage at the boat ramp.

17.4.3.2 *Disturbance from Noise*

Seabirds exhibit alert behaviours to most levels of noise exposure, but begin to take flight in response to noise exposure levels greater than 85 dB(A) (Brown 1990), consistent with observations that sound levels of 43-87 dB(A) have limited effects on foraging shorebirds, but sound levels of 84-100 dB(A) cause most shorebirds in a habituated population to leave the area of disturbance (Smit and Visser 1993). A study examining the responses of shorebirds roosting at a site close to several industrial power plants to experimentally generated impulse noise found that the probability of birds taking flight but returning to the roost increased in response to noise levels of 60-70 dB(A) while the probability of all birds taking flight and leaving the roost site increased exponentially from a probability of approximately 10% at 65 dB(A) to 30% at 70 dB(A) and 100% at 90 dB(A) (Wright *et al*. 2013). Disturbance reactions are generally stronger when disturbing sounds are combined with visual disturbance (Smit and Visser 1993). Also, intermittent bursts of noise are generally more disturbing than continuous noise; birds are expected to habituate more readily to the latter (Smit and Visser 1993).

Potential Project Impacts

Project activities with the most potential to cause high noise levels at Cassim Island are bund wall construction, including the establishment of the sheet piling and placement of rock armouring for the eastern edge of the northern reclamation, and sheet piling and creation of the rockwall breakwater, which will be carried out as part of the southern reclamation. Noise modelling carried out for the Project (refer to Chapter 12) shows maximum noise levels at Cassim Island of 65-70 dB(A) during these construction periods. Creation of the sheet pile bunds and rock walls will be short-lived, taking 2-4 months for each of the reclamation areas to be fully enclosed. Noise levels will be highest when the works are adjacent the roost site, which will likely take less than one month. Once the outer perimeter is complete, works within the reclamation area and other construction activities such as the use of excavators or construction of buildings are not expected to result in noise levels above 60 dB(A) at Cassim Island.

While most construction works will be carried out during the day, dredging operations will be ongoing 24 hours a day, six days per week. The narrower dredging sections in the Fison Channel and central parts of the turning basin must be dredged at night whilst there is no ferry traffic. Modelling indicated maximum noise levels at Cassim Island from the dredging activities are not expected to exceed 60 dB(A).

Considering that noise generated during the dredging, reclamation and construction phases of the Project will also be accompanied by visual disturbance of moving people and machinery that may approach within 80 m of the north-western portion and 120-130 m of the south-western portion of the Cassim Island roost, it is likely that noise disturbance exceeding 60 dB(A) in the receiving environment during some construction activities would cause shorebirds roosting along the western edges of the roost site to take flight from time to time. To mitigate the risk of this impact, works that will result in noise levels exceeding 60 dB(A) in the receiving environment of the higher density roosting areas at the Cassim Island roost will be restricted to the winter months (mid-April to August) when few migratory shorebirds are present.

Given that the mangrove roost site is up to 700 m long and 300 m wide, it is expected that birds taking flight in response to disturbance will move to portions of the roost site more distant from the source of the disturbance in the first instance, as they have been observed to do in response to disturbance during field surveys. The extent to which migratory shorebirds will abandon the roost site in response to repeated disturbance from their currently preferred roosting areas in the roost site is difficult to predict, but based on existing behaviour it is more likely that the birds would shift their preferred roosting locations within the roost rather than abandon the roost.

The staged dredging and reclamation program, with stage 1 dredging and reclamation occurring at least 240 m from the preferred south-western roosting area provides an opportunity to monitor the impacts of dredging and reclamation on the responses of roosting birds to noise and visual disturbance and adaptively manage mitigation measures before stage 2 dredging and reclamation occurs. This staging also allows time for birds using preferred areas of the roost to habituate to increased non-lethal noise and activity disturbance in proximity to the roost site.

Modelling (Simpson Engineering 2022a) shows maximum noise levels at the abandoned Nandeebie Claypan roost site are predicted to be 65–70 dB(A) and will occur during works on the southern car park area of the ferry terminal. These works are expected to last 2–4 months, with high noise-generating activities such as placement of rock armouring accounting for a smaller portion of this period. During most works, noise levels at Nandeebie Claypan are not expected to exceed 55 dB(A).

In the unlikely event that migratory shorebirds resume roosting at Nandeebie Claypan, they may occasionally take flight in response to noise disturbance during the high noise activities but can be expected to habituate to the lower noise levels during subsequent phases. Previous observed behaviour suggests that migratory shorebirds that take flight in

response to disturbance at Nandeebie Claypan typically leave the roost site immediately to move to an alternative roost site. To mitigate the risk of this impact, works that will result in noise levels exceeding 60 dB(A) in the receiving environment of the Nandeebie Claypan roost site will be restricted to the winter months (mid-April to August), when migratory shorebirds are generally absent from Moreton Bay. Noise impacts after the completion of the ferry terminal car park are not likely, due to the reduced predicted noise levels.

17.4.3.3 *Disturbance from Lighting*

Migratory shorebirds have good nocturnal vision and are active during both the day and at night. Many shorebird species have the ability to switch between visual foraging techniques and tactile (touch) foraging techniques with little loss in foraging efficiency (Robert and McNeil 1989), yet artificial illumination of feeding habitat may also assist the foraging efficiency of species with a predominantly visual foraging strategy. One study of the influence of artificial illumination from street lighting on shorebird foraging efficiency found that artificial illumination of between 0.18 lux to 0.74 lux had a positive effect on the nocturnal foraging of shorebirds, increasing both their feeding rates and food intake rates, but on the other hand may draw them to degraded habitat areas close to the sources of illumination, and potentially raises their exposure to predators (Santos *et al*. 2009). Similarly, a second study found that artificial light generated from a large industrial site allowed Common Redshanks to extend their visual foraging strategy and increase their foraging efficiency within an estuary (Dwyer *et al* 2013).

At Roebuck Bay in Western Australia, shorebirds avoid roosting at shoreline roost sites where they are exposed to artificial lighting such as streetlights or traffic; possibly such lighting makes roosting shorebirds too easily detected by predators (Rogers *et al*. 2006c).

Potential Project Impacts

The Project lighting strategy is expected to minimise light spill to 1 Lux within the Project footprint and therefore ensure that light levels in the receiving environment of the tidal flats and Cassim Island roost site are substantially less than 1 Lux (refer to Chapter 13). Consequently, there is low potential for Project lighting to impact on migratory shorebird use of roosting and feeding habitats adjacent to the Project footprint, noting that full moon under clear conditions provides light levels of 0.1-0.3 Lux (Gaston *et al*. 2013).

17.4.3.4 *Loss of Feeding Habitat in the Context of Carrying Capacity of Moreton Bay for Migratory Shorebird Species*

Population size is a balance between birth rate and death rate in a population. Under natural conditions, the population sizes of most bird species, including shorebirds, are regulated by density dependent factors that increase or decrease birth rates and/or death rates in proportion to the density of the population (Shepherd and Boates 1999). Put simply, the size of a species' population fluctuates around the carrying capacity of the habitat it occupies such that: (1) an increase in population density above the carrying capacity leads to an increase in mortality and/or a decrease in breeding productivity until population size decreases below the carrying capacity again; or (2) a decrease in population density below the carrying capacity leads to a decrease in mortality rates and/or an increase in breeding success until the population size increases above the carrying capacity again. The regulation of population size in migratory shorebirds is complicated by the spatial separation between habitats used at different stages of the annual cycle, namely breeding habitat in the northern hemisphere, staging or refuelling habitat during migration, and non-breeding habitat in the southern hemisphere.

A key question for the assessment of the impact of the loss of a small area of tidal flat feeding habitat on the non-breeding grounds of a migratory shorebird species in Moreton Bay is the extent to which migratory shorebird numbers in Moreton Bay are currently regulated by local density dependent factors, such as food availability, that set a ceiling on the carrying capacity of Moreton Bay for migratory shorebirds. If Moreton Bay was currently operating at carrying capacity, then the loss of an area of feeding habitat is predicted to result in a reduction in the numbers of migratory shorebirds in direct proportion to the area of habitat lost. This is illustrated in a simplified manner by the upper panel of Figure 17-7, a

situation where the population is at the carrying capacity of 100 birds distributed evenly across the habitat; loss of 10% of the habitat results in loss of 10% of the birds. While the birds displaced from the lost habitat move into the remaining habitat, the increased bird density leads to increased competition for limited food resources with birds already using that habitat, which eventually results in a proportionate loss of birds from the area due to density dependent factors. The bottom panel of Figure 17-7 illustrates the same situation but following a 30% reduction in the size of the population to 70 birds, with no change to the carrying capacity of the habitat. In this scenario, loss of 10% of the habitat does not result in the loss of any birds since the total number of birds following displacement remains below the carrying capacity of 90 birds after habitat loss.

Several migratory shorebird species are known to have suffered severe population declines, including within Moreton Bay, due to factors operating outside of Australia. The declines are mostly related to loss of key staging habitat in south-east Asia as a result of large-scale land reclamation and aquaculture, hunting pressure on the breeding grounds and on migration, and habitat loss due to expanding agriculture on the breeding grounds (Wilson *et al*. 2011, Yang *et al*. 2011, Murray *et al*. 2014, Melville *et al*. 2016, Moores *et al*. 2016, Studds *et al*. 2017, Morrick *et al*. 2021). The reduction in migratory shorebird numbers is likely to have reduced feeding densities in suitable habitat across Moreton Bay to the point where their current populations are below the original carrying capacity of Moreton Bay. There are few published data to test this hypothesis. Thompson (1990) conducted a single survey on 10 February 1990 of all migratory shorebirds foraging along the mainland coastline from Eprapah Creek to Redland Bay. This survey area incorporated the length of mainland coastline from Point O'Halloran to Redland Bay surveyed during the EIS surveys as well as an additional 38 ha of tidal flats between Eprapah Creek and Point O'Halloran and between the boat ramp and ferry terminal at Victoria Point.

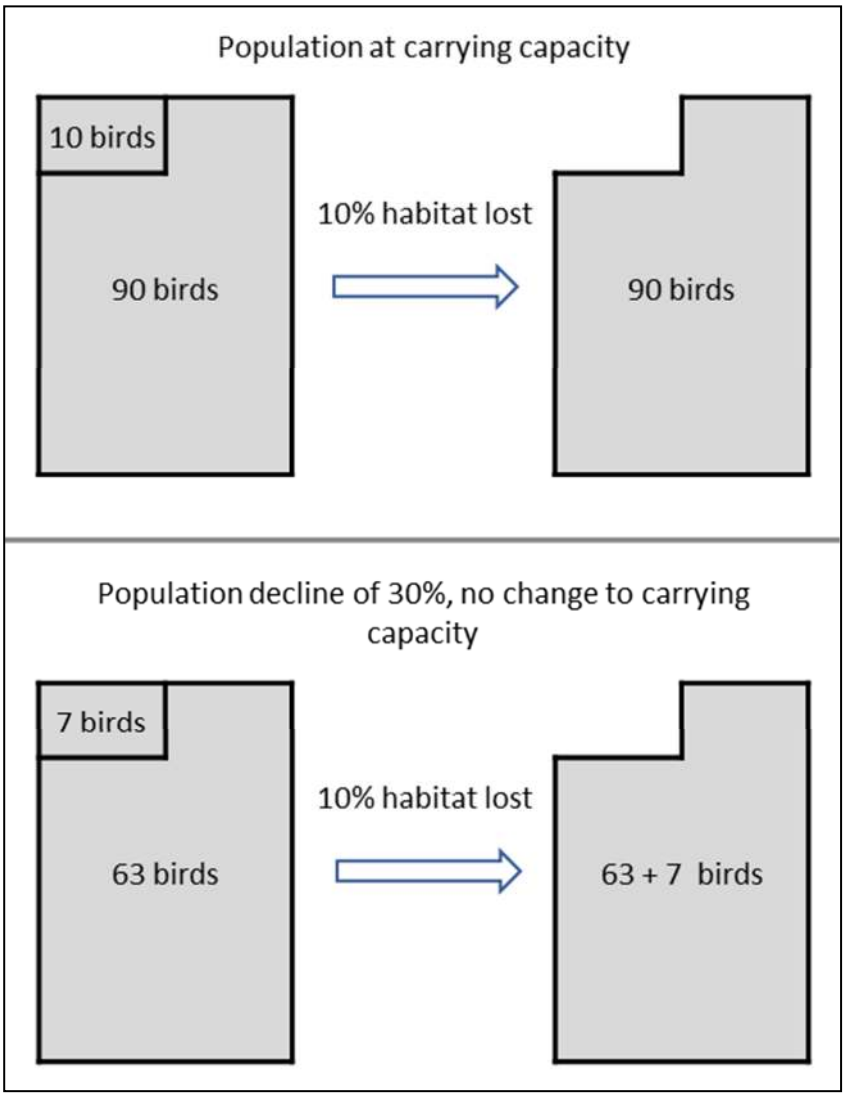


Figure 17-7: Schematic Illustrating the Operation of Density Dependence in Regulating Population Size after Habitat Loss.

Table 17-9 provides a comparison between the survey results of Thompson (1990) and surveys carried out for the Project 30 years later, including comparison of feeding densities to account for the small difference in survey area between the two studies. This comparison shows that there has been a substantial reduction in the density of eastern curlew in particular foraging in this area from a density of 6.2 birds per 10 ha 30 years ago to an average density of 1.7 birds per 10 ha currently (Table 17-9). Furthermore, the overall feeding density for all declining species has similarly decreased from an observed density of 26.2 birds per 10 ha 30 years ago to an average density of 9.7 birds per 10 ha today. The overall feeding density for all species that have not declined showed little change (17.8 birds per 10 ha 30 years ago versus an average of 17.2 birds per 10 ha currently).

Table 17-9: Comparison of Migratory Shorebirds Feeding at Low Tide between 1990 (Thompson 1990) and 2018-2020 (this study).

Common Name / Survey Area	**Eprapah Ck to Redland Bay, 10 February 1990 – 1 summer survey**		**Point O'Halloran to Redland Bay, 2018/19 to 2019/20 – 8 summer surveys**	
Tidal Flat Area	**193 ha**		**155 ha**	
	Number	**Density (per 10 ha)**	**Average number**	**Average density (per 10 ha))**
Eastern Curlew*	119	6.2	27	1.7
Bar-tailed Godwit*	354	18.3	125	8.0
Black-tailed Godwit	14	0.7	0	0
Whimbrel	42	2.2	53	3.4
Grey-tailed Tattler	222	11.5	122	7.9
Pacific Golden Plover	2	0.1	58	3.8
Lesser Sand Plover*	4	0.2	0	<0.1
Greater Sand Plover*	6	0.3	0	0
Terek Sandpiper	28	1.5	0	0
Ruddy Turnstone	4	0.2	0	0
Great Knot*	20	1.0	0	0
Red-necked Stint	32	1.7	8	0.5
Sharp-tailed Sandpiper	0	0.0	31	2.0
Curlew Sandpiper*	2	0.1	0	0
Total migratory shorebirds	**849**	**44.0**	**424**	**27.3**
Total declining species*	505	26.2	151	9.7
Total non-declining species	344	17.8	272	17.2

* Species reported to have declined substantially across Australia since the 1990's, resulting in them being listed as threatened species under the EPBC Act (see Section 17.3 for further detail).

Potential Project Impacts

The data presented in Table 17-9 supports the prediction that the current foraging densities of declining species such as eastern curlew and bar-tailed godwit in south-western Moreton Bay are likely to be substantially lower than the carrying capacity for the area. Consequently, the loss of a relatively small area of feeding habitat in south-western Moreton Bay as a result of the Project is unlikely to result in a proportionate reduction in the population sizes of declining species such as eastern curlew and bar-tailed godwit in Moreton Bay, if there has been no change to the carrying capacity of the remaining feeding habitat.

The apparent stability in the overall feeding density of species that have not declined to the point of being listed as threatened species provides some evidence to support that the carrying capacity of the area has not decreased. This is despite the increasing impacts of disturbance in tidal flat feeding habitats, noting that the 2018-2020 low tide surveys of this area recorded minimal disturbance to foraging shorebirds. Whether the loss of a relatively small area of feeding habitat in south-western Moreton Bay will result in a proportionate reduction in the population sizes of migratory

shorebird species such as grey-tailed tattler and whimbrel, whose populations have not declined, will likely depend on: (1) the extent of dietary overlap with species whose populations have declined, which remains uncertain; and (2) whether the species population size is regulated by density dependent factors on the non-breeding grounds. If the species population is regulated by factors operating on the breeding grounds and/or on migration, then the potential for an impact of the Project in reducing population size in proportion to the loss of feeding habitat in Moreton Bay is reduced. Evidence to date suggests that the population sizes of migratory shorebird species on the EAAF that use tidal flat habitats for feeding on the non-breeding grounds are regulated by either breeding success on their breeding grounds in the northern hemisphere or the rate of mortality during migration through south-east Asia that is related to staging habitat loss and/or hunting pressure in that region (Wilson *et al*. 2011, Yang *et al*. 2011, Murray *et al*. 2014, Melville *et al*. 2016, Moores *et al*. 2016, Studds *et al*. 2017, Morrick *et al*. 2021).

17.5. Adaptive Management and Monitoring Measures

17.5.1 National Guidelines

A range of guidelines provide information on management measures that can be implemented to mitigate impacts of developments or human activities on feeding and roosting shorebirds to inform mitigation and management measures recommended to be implemented for the Project.

EPBC Act Policy Statement 3.21—Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species

EPBC Act Policy Statement 3.21 identifies options for mitigating impacts from disturbance to shorebirds. Recommended measures from policy statement 3.21 relevant to the Project include:

<u>Options for mitigating the risk of disturbance from recreational and other activities</u>

- The use of buffer zones around important areas for shorebirds—Appropriate buffers depend on local circumstances, including the species present, type of habitat (ephemeral or permanent), habitat use (roosting or foraging) and scale of disturbance. Studies have recommended buffer zones with widths ranging from 100-255 m (Rodgers *et al*. 1997, Glover *et al*. 2011);
- The construction of appropriate barriers, such as fences around important areas for shorebirds to restrict access—Ideally, there should be no public access (by humans and/or domestic animals) to areas identified as important to migratory shorebirds. Where this is not feasible, particular recreational activities may need to be excluded or it may be necessary to limit the number of people using an area at one time and/or limit activities during the period between October and March (when the majority of shorebirds will be present);
- Landscape and urban design, including vegetation screening to screen shorebirds from activities; and
- Increased community education through mechanisms such as interpretive signs at access points to shorebird habitats.

The effectiveness of buffers, exclusion zones and interpretive signage to manage disturbance to shorebirds depends critically on the extent and regularity of enforcement (Fuller *et al*. 2021). In the absence of enforcement, 68% of dogs were walked off leash within a shorebird buffer zone in Altona, Victoria despite the area having interpretive and regulatory signs that require dogs on leash, and a variety of education and extension programs having been conducted in the area (Weston *et al*. 2009). Similarly, more than 80% of dogs were observed being walked off-leash on important tidal flat shorebird feeding habitat in the Moreton Bay Ramsar site where off-leash dogs were prohibited (Fuller *et al*. 2021).

<u>Options for mitigating impacts from noise</u>

- Landscape and urban design, including vegetation screening to assist with sound attenuation (Commonwealth of Australia 2015b); and

- Timing of particularly noisy construction activities to occur during the winter months (mid-April to August inclusive), when fewer migratory shorebirds are present in Moreton Bay.

National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds
The National Light Pollution Guidelines (Commonwealth of Australia 2020) outline options for mitigating impacts from light on shorebirds as including:

- Lighting design should start from a point of natural darkness and artificial light should only be added for specific and defined purposes and only in the required location and for the specified duration of human use;
- Landscape and urban design, including vegetation screening to assist with light screening to ensure that: (a) no light source is directly visible from foraging or nocturnal roost habitats, or from flight pathways; (b) no fixed light source is installed in nocturnal foraging or roost areas; (c) a dark zone is maintained between nocturnal foraging and roost habitats and sources of artificial light; (d) mobile light sources such as vehicle headlights are prevented from shining into nocturnal foraging and roost habitat; and (e) artificial light on jetties and breakwaters are managed to allow dark areas in places that may provide a safe area for shorebirds to roost;
- Ensuring all light fittings are located, directed or shielded to avoid lighting anything but the target object or area, and particularly avoiding light spill to nocturnal foraging and roost areas;
- Using adaptive controls for light management including motion sensors to turn lights on only when needed in the vicinity of nocturnal foraging and roost areas;
- Using fixed window screens or window tinting on fixed windows and skylights to contain light inside buildings in the vicinity of nocturnal foraging and roost areas;
- Keeping light intensity as low as possible and using lights with reduced or filtered blue, violet and ultra-violet wavelengths in the vicinity of nocturnal foraging and roost areas; and
- Using non-reflective, dark-coloured surfaces to minimise light reflectance in the vicinity of nocturnal foraging and roost areas.

17.5.2 Management through Design

The design of the Project has been revised several times to reduce the risk of significant impacts from disturbance on migratory shorebirds using the Cassim Island roost site.

Firstly, the south-eastern boundary of the Project footprint, which is located adjacent to the south-western portion of the Cassim Island roost site that is used by the highest density of migratory shorebirds for roosting, has been moved further west. Consequently, there is a 250 m buffer to potential disturbances from ongoing uses such as such as lighting and noise from urban development.

Secondly, the design of the south-eastern boundary of the Project footprint has been changed since the referral from parkland to a rockwall breakwater up to 30 m in width. The rockwall breakwater will be gated and inaccessible to the public. This change reduces the potential for human disturbance to the Cassim Island roost site, while the rockwall breakwater provides potentially suitable roosting habitat site for species such as grey-tailed tattler, terek sandpiper, ruddy turnstone and plovers.

Thirdly, the boat ramp for non-motorised recreational vessels has been moved to the north of the PDA. This will reduce the risk of non-motorised vessels moving through or closely adjacent to the roost site mangroves if their pre-dominant direction of travel will be to the north and/or east, not to the south. Signage will also be installed at the boat ramp identifying the high ecological value of Cassim Island and directing users away from the area.

17.5.3 Project Specific Management Measures

Dredging and reclamation

Management measures during the dredging, reclamation and civil construction phase will include the following:

- Water quality monitoring including an adaptive management program will be implemented during dredging and various stages of construction for the Project (refer to Chapter 9). This will minimise impacts of dredging and reclamation on sedimentation and water quality that may have downstream impacts on the benthic invertebrates that shorebirds feed on in tidal flats adjacent to the Project footprint.
- To minimise physical disturbance to the intertidal habitat adjacent to the Project footprint during dredging activities, the spatial boundaries to the disturbance area will be clearly identified and communicated to workers undertaking the dredging and reclamation activities.
- To minimise disturbance to feeding or roosting shorebirds adjacent to the Project footprint, no access by workers or machinery will occur to intertidal areas beyond the disturbance boundary, using appropriate barriers if necessary.
- To minimise disturbance to roosting shorebirds adjacent to the Project footprint, noise levels will be regularly monitored at roost sites to ensure they do not exceed 60 dB(A) from September to mid-April inclusive. Furthermore, activities that have a higher risk of disturbance will be restricted to the winter months mid-April to August when fewer migratory shorebirds are present in Moreton Bay. These include dredging and activities producing noise levels greater than 60 dB(A) to the receiving environment (particularly the mangroves of the higher density roosting areas of Cassim Island). Should such activities be required to extend into the period September to mid-April, they will only be undertaken if monitoring prior to and during the operation of such activities demonstrates that either: (a) migratory shorebirds are not using the relevant roost site(s) at the time; or (b) the realised noise levels do not cause roosting migratory shorebirds to take flight in response to Project activity disturbance at any point during their operation.
- To reduce the risk of noise disturbance to feeding or roosting shorebirds adjacent to the Project footprint, sheet piling will be vibrated into place. Where pile driving is required to ensure sheet piles are installed in the underlying hard clays, activities will be minimised to reduce disturbance timeframes.
- To minimise noise disturbance to feeding or roosting shorebirds adjacent to the Project footprint, all equipment will be maintained in good working condition and fitted with high performance mufflers in good condition.

Civil, tidal and building works

Management measures during the civil, tidal and building works phases will include:

- To minimise disturbance to feeding or roosting shorebirds adjacent to the Project footprint, appropriate barriers will be used and clearly communicated to ensure no access by workers or machinery occurs to intertidal areas outside the construction area.
- To minimise light disturbance to intertidal habitats adjacent to the Project footprint, the lighting strategy outlined in Chapter 13 will be implemented. Specific actions include:
  - Lighting during construction phases will have luminaire design that directs light downwards and not horizontally or vertically.
  - Construction lighting towers are typically low and aimed to limit light coverage to the worksite. Where possible these work towers will be located to the east of the worksite and with the illumination directed to the west. This will avoid light spill towards roost sites. Where lighting must face eastward, they will be fitted with appropriate shrouds to avoid adverse impacts.
- To minimise disturbance to roosting shorebirds adjacent to the Project footprint, noise levels will be regularly monitored at roost sites to ensure they do not exceed 60 dB(A) from September to mid-April inclusive. Furthermore, activities that have a higher risk of disturbance such as dredging and activities producing noise levels greater than 60 dB(A) to the receiving environment (particularly the mangroves of the higher density roosting areas of Cassim Island) will be restricted to the winter months mid-April to August when fewer

migratory shorebirds are present in Moreton Bay. Should such activities be required to extend into the period September to mid-April, they will only be undertaken if monitoring prior to and during the operation of such activities demonstrates that either: (a) migratory shorebirds are not using the relevant roost site(s) at the time; or (b) the realised noise levels do not cause roosting migratory shorebirds to take flight in response to Project activity disturbance at any point during their operation.

- To minimise noise disturbance to feeding or roosting shorebirds adjacent to the Project footprint, all construction equipment will be maintained in good working condition and fitted with high performance mufflers in good condition.
- To minimise the potential impact of storm water runoff on the benthic invertebrates that shorebirds feed on in tidal flats adjacent to the Project footprint, the Project stormwater management plan (refer to Chapter 9) will be implemented.

Ongoing use and operations

Recommended management measures during the ongoing use and operations phase of the Project include the following:

- To minimise light disturbance to intertidal habitats adjacent to the Project footprint, the lighting strategy outlined in Chapter 13 will be implemented. Specific actions include:
  - Lighting during construction and operational phases will have luminaire design that directs light downwards and not horizontally or vertically.
  - Residential towers will not feature large prominent illuminated areas on vertical surfaces. Rather illumination will mostly be directed downwards onto footpaths and other public areas.
  - Luminaires selected for the public areas will be Dark Sky Compliant LED lights. These are "amber" lights which are specifically designed to protect turtles and other fauna from the adverse aspects of urban lighting.
- To minimise disturbance to shorebirds roosting in the Cassim Island mangroves, the area within 100 m of the outer edge of the mangroves surrounding Cassim Island will be designated as a sensitive shorebird habitat area, prominent information signage to this effect will be erected at the boat ramp for non-motorised vessels and entry of watercraft into the Cassim Island sensitive shorebird habitat area during high tide will be discouraged.
- To minimise disturbance to shorebirds roosting in the Cassim Island mangroves, and to facilitate the use of the rockwall as an alternative high tide roost site for species that favour this type of roost (e.g. grey-tailed tattler, terek sandpiper, ruddy turnstone, plovers): (a) an appropriate barrier such as a fence and informative signage will be used to prevent access of people to the rockwall during high tide; and (b) any artificial lighting on the rockwall for navigation purposes will be managed to allow dark areas in places that may provide a safe area for shorebirds to roost.
- To minimise the potential impact of stormwater runoff on the benthic invertebrates that shorebirds feed on in tidal flats adjacent to the Project footprint, the Project stormwater management plan (refer to Chapter 9) will be implemented.

In addition to the above measures, the Proponent commits to the following actions to further minimise risk of impacts on migratory birds during ongoing use of Toondah Harbour:

- Engage with RCC and the Queensland Government to implement a prohibition area for watercraft at Cassim Island and the offshore sandbar roost site;
- Endeavour to obtain agreement from RCC to implement measures to rehabilitate Nandeebie Claypan (no migratory birds have been observed using the Nandeebie Claypan roost site for more than two years) and reduce the risk of disturbance to shorebirds roosting at Nandeebie Claypan from increased public use of the footpath/cycleway adjacent to the roost site; and

- Endeavour to obtain agreement from RCC to put in place measures to protect shorebirds roosting at Oyster Point from increased public use of the recreational facilities adjoining the roost and install prominent site-specific information signage about migratory shorebird use of the roost site and their sensitivity to disturbance.

17.5.4 Summary of Management Measures

Where an activity is anticipated to have an impact on migratory and threatened shorebird species, mitigation measures are proposed in Table 17-10.

Table 17-10: Migratory and Threatened Shorebirds Management Measures.

Potential Impacts	Mitigation Measure	Desired outcomes and effectiveness
Disturbance and loss of habitat as a result of dredging and reclamation	▪ Carry out water quality monitoring in accordance with Chapter 9. ▪ Implement lighting strategy during construction periods as outlined in Chapter 13. ▪ Clearly identify and delineate Project spatial boundaries to minimise physical disturbance of intertidal areas outside the Project footprint. ▪ No access allowed beyond the Project boundary. Use appropriate physical barriers if necessary. ▪ Implement educational programs for all construction workers highlighting the importance of roosting sites and ways shorebirds can be impacted. ▪ Carry out noise monitoring at sensitive areas including high tide roost sites during high noise generating activities such as pile driving. ▪ Activities that have a higher risk of disturbance (noise levels greater than 60 dBA) will be restricted to mid-April to August when fewer migratory shorebirds are present in Moreton Bay, unless monitoring shows no birds are present or noise levels are lower than expected. ▪ Use vibration piling to install sheet piling where possible and minimise pile driving. ▪ All construction equipment will be maintained in good working condition and fitted with high performance mufflers in good condition.	▪ Minimise disturbance of shorebirds outside the Project footprint, in particular at the adjacent roost sites. ▪ Management measures have been developed in accordance with a range of government guidelines and published ecological studies, therefore are expected to effectively reduce the potential to disturb.
Disturbance to roost sites and adjacent habitat from civil, marine and building works	▪ Appropriate barriers will be used and clearly communicated to ensure no access by workers or machinery to intertidal areas outside the Project footprint. ▪ Implement lighting strategy during construction periods as outlined in Chapter 13. ▪ Activities that have a higher risk of disturbance (noise levels greater than 60 dBA) will be restricted to mid-April to August when fewer migratory shorebirds are present in Moreton Bay, unless monitoring shows no birds are present or noise levels are lower than expected.	▪ Minimise disturbance of shorebirds outside the Project footprint, in particular at the adjacent roost sites. ▪ Management measures have been developed in accordance with a range of government guidelines and published ecological studies, therefore are expected to effectively reduce the potential to disturb.

Potential Impacts	Mitigation Measure	Desired outcomes and effectiveness
	▪ All construction equipment will be maintained in good working condition and fitted with high performance mufflers in good condition. ▪ Implement stormwater management and treatment in accordance with Chapter 9.	
Disturbance to roost sites during ongoing operations	▪ Implement lighting strategy into detailed design of open space and public areas as outlined in Chapter 13. ▪ Cassim Island will be designated as a sensitive shorebird habitat area with educational signage erected at the boat ramp for non-motorised vessels. Entry of watercraft within the Cassim Island sensitive shorebird habitat area during high tide will be discouraged. ▪ Install a barrier fence to prevent access to the rockwall breakwater to allow undisturbed use by shorebirds. ▪ Implement stormwater management and treatment in accordance with Chapter 9 of the EIS.	▪ Minimise disturbance of shorebirds outside the Project footprint, in particular at the adjacent roost sites. ▪ Management measures have been developed in accordance with a range of government guidelines and published ecological studies, therefore are expected to effectively reduce the potential to disturb.

17.5.5 Draft Shorebird Monitoring Plan

Dredging and Reclamation

The monitoring program for dredging and reclamation activities will be undertaken for at least five years after commencement of works and must be carried out in years when any dredging operations or sheet piling occurs. Monitoring will include:

- Monthly monitoring of potential disturbance and migratory shorebird use of the Cassim Island and Nandeebie Claypan roost sites during high tide over the period September to April inclusive to determine if changes in migratory shorebird use of the roost sites occur by comparison with the baseline;
- Monthly monitoring of migratory shorebird responses to disturbance (from dredging and reclamation activities) at the Cassim Island and Nandeebie Claypan roost sites at high tide and tidal flat feeding habitat adjacent to the Project footprint at low tide during the period September to April inclusive;
- Seasonal monitoring of benthic invertebrate community structure and abundance in tidal flat shorebird feeding areas adjacent to the Project footprint and within the potential zone of influence of the dredging and reclamation activities, and at comparable control sites outside the zone of influence to determine if changes to benthic invertebrate community structure and abundance occur by comparison with the baseline in a before-after-control-impact (BACI) design; and
- Monthly monitoring of migratory shorebird use of tidal flats adjacent to the Project footprint within the potential zone of influence of the dredging and reclamation activities and at comparable control sites outside the zone of influence of dredging and reclamation activities to determine if changes to migratory shorebird feeding densities occur by comparison with the baseline in a before-after-control-impact (BACI) design.

Civil, Tidal and Building Works

On completion of the dredging and reclamation program, monitoring will continue for another five-year period to identify any changes in migratory shorebird use as a result of construction activities. Monitoring will include:

- Monthly monitoring of potential disturbance and migratory shorebird use of the Cassim Island and Nandeebie Claypan roost sites during high tide over the period September to April inclusive to determine if changes in migratory shorebird use of the roost sites occur by comparison with the baseline;

- Monthly monitoring of migratory shorebird responses to disturbance (from civil construction activities) at the Cassim Island and Nandeebie Claypan roost sites at high tide and tidal flat feeding habitat adjacent to the Project footprint at low tide during the period September to April inclusive; and
- Monthly monitoring of migratory shorebird use of tidal flats adjacent to the Project footprint and within the potential zone of influence of the civil construction activities, and at comparable control sites outside the zone of influence of civil construction activities to determine if changes to migratory shorebird feeding densities occur by comparison with the baseline in a before-after-control-impact (BACI) design.

Monitoring will cease if results show that works are having no impact on shorebird usage of the roost sites and adjacent mudflats for a period of at least three years.

Ongoing Use and Operations

The monitoring plan during the ongoing use and operations phase should include the following components to monitor the impacts of the Project on migratory shorebirds for two years after the completion of the Project:

- Monthly monitoring of potential disturbance and migratory shorebird use of the Cassim Island, Nandeebie Claypan and Oyster Point roost sites during high tide during the period September to April inclusive to determine if changes in migratory shorebird use of the roost sites occur by comparison with the baseline;
- Monthly monitoring of migratory shorebird responses to disturbance (from ongoing use and operational activities) at the Cassim Island and Nandeebie Claypan roost sites at high tide and tidal flat feeding habitat adjacent to the Project footprint at low tide over the period September to April inclusive, bearing in mind that Nandeebie Claypan is currently abandoned as a roost site;
- Monthly monitoring of migratory shorebird use of tidal flats that are adjacent to the Project footprint and within the potential zone of influence of the ongoing use and operational activities, and at comparable control sites outside the zone of influence of ongoing use and operational activities over the period September to April inclusive to determine if changes to migratory shorebird feeding densities occur by comparison with the baseline in a before-after-control-impact (BACI) design; and
- Monitoring frequency will be reviewed each year and will cease once it is demonstrated shorebird use has not deviated from baseline conditions.

17.6. Residual Risk of Impact

The risk of significant residual impacts to the noise environment has been assessed following the methodology outlined in Chapter 6.

The assessment of the risk of significant residual impacts of the Project on shorebirds listed as migratory shorebirds or threatened species under the EPBC Act before and after implementation of the recommended management measures outlined in Section 6 is summarised in Table 17-11. This assessment is informed by the detailed assessment of potential residual significant impacts to shorebirds presented in Section 17.4.

Table 17-11: Migratory and Threatened Shorebirds Risk Assessment of Key Activities.

Activity	Initial risk assessment					Mitigated risk assessment				
	Scale	Duration	Impact	Likelihood	Risk	Scale	Duration	Impact	Likelihood	Residual risk
Disturbance and loss of habitat as a result of dredging and reclamation	Local	Permanent	High	Certain	High	Local	Permanent	High	Certain	High
Disturbance to roost sites and adjacent habitat from civil, marine and building works	Regional	Short Term	Medium	Likely	High	Regional	Short Term	Medium	Not likely	Low
Disturbance to roost sites during ongoing operations	Regional	Long Term	High	Possible	High	Regional	Long Term	High	Not likely	Medium