Contents

9 Nature conservation

9.1 Chapter content

The Project impact assessment for nature conservation was provided in Chapter 9 of the Project EIS.

This chapter provides additional information to address the submissions received during the statutory public display period of the Project EIS. The key issues raised from the Project EIS submission process, relevant to the nature conservation chapter are summarised in Table 9.1.

Table 9.1 Summary of submission issues received in relation to the Project EIS nature conservation chapter

Submitter ID number (refer Appendices A and B)	Summary of submission issue raised	Project EIS section (public notification version)	AEIS section containing information to address submission comments	Complete replacement section for Project EIS	Supplements the Project EIS information
2.02	Describe how the Project Offset Framework address the re-establishment of seagrass and other benthic habitats within the Port	Section 9.28	Appendix E4	✓	
3.01	Include waterway providing for fish passage as an MSES	Section 9.3.4	Sections 9.6.2 and 9.15.3		✓
3.02	Include any potential indirect impacts to marine plants (including mangroves, seagrass, macroalgae, samphires and saltmarsh) into the summary of expected significant residual impact (SRI)	Section 9.26, Table 9.86	Section 9.2.2		✓
			Sections 9.4.4 and 9.4.6	✓	
3.03	All marine plants are MSES (not just seagrass) and the table should be updated to include the whole area of direct loss of seagrass and potential impacts to other marine plants as a result of the works	Section 9.26, Table 9.88	Section 9.2.2		✓
			Section 9.4.4	✓	
12.03	The impact assessment for each MSES and MNES, including the significant residual impact assessment should be revised to account for the cumulative and potentially synergistic impacts of all proposed project activities	Chapter 9	Sections 9.2.5, 9.3.2, 9.4.2, 9.5.2, 9.6.4, 9.7.1, 9.8.2, 9.10.6, 9.11.4		✓
12.07	This section does not refer to all the species listed under the NC Act, but only makes reference to the Water mouse (*Xeromys myoides*). It is unclear why other NC Act listed species are not listed here Amend the draft EIS to list all NC Act listed species relevant to the proposed Project.	Section 1.9.2.11	Sections 9.2.1 and 9.3.1		✓
12.09	Describe any environmental windows during which dredging and bund construction are proposed to be suspended. Include these in the list of commitments for the proposed Project	Section 2.5.6	Section 9.14		✓
12.25	Discuss the appropriateness of the impact assessment considering increased turbidity over a year of dredging as a short-term impact on fauna.	Section 9.13.2.3	Section 9.15.2		✓
12.49	Clearly describe how the proposed Project has sought to avoid impacts to MSES. Describe why the level of adverse impact to a range of environmental values and MSES is considered an acceptable environmental impact.	Appendix Q3	Section 9.15.1		✓

Submitter ID number (refer Appendices A and B)	Summary of submission issue raised	Project EIS section (public notification version)	AEIS section containing information to address submission comments	Complete replacement section for Project EIS	Supplements the Project EIS information
12.51	Clearly identify how the multiple identified potential impacts overlap both spatially and temporally. Clearly describe the cumulative and synergistic impacts of the proposed Project on each of the identified ecological values listed in Table 9.1. The revised assessment should inform a revised SRI assessment	Chapter 9	Sections 9.2.5, 9.3.2, 9.4.2, 9.5.2, 9.6.4, 9.7.1, 9.8.2, 9.10.6 and 9.11.4		✓
12.52	Consider and commit to the avoidance of sensitive environmental windows to avoid and minimise potential impact of the proposed Project	Chapter 9	Section 9.14		✓
12.53	Provide an estimate of the impact of the proposed Project on seagrass based on the historic distribution of seagrass meadows in the Port	Section 9.8.2	Section 9.4.2		✓
12.54	Review all macroalgae data available for the Port and amend Figure 9.20 to include full distribution of macroalgae in the Port and amend the impact assessment to reflect any changes in macroalgae distribution	Section 9.9	Sections 9.4.3 and 9.4.4		✓
12.56	Indicate on a map where indirect impacts to seagrass are predicted to occur. Describe the criteria used to identify where indirect impacts are predicted to occur.	Section 9.9.2.1	Section 9.4.2 Figures 9.9a and 9.9b		✓
12.57	Update Section 9.9.8 to ensure it includes a definitive statement regarding whether a SRI is predicted or not for marine plants	Section 9.9.8	Section 9.2.6 Section 9.4.6		✓
12.58	Describe in detail the predicted impacts of dredge plumes and sedimentation on reef communities, including the different taxa present in reef communities (e.g. corals and sponges). Describe whether these impacts are expected to be sub-lethal or lethal impacts. If impacts are predicted to be lethal, include a prediction of the percentage of coral and other taxa that are predicted to die.	Section 9.10.2	Sections 9.5.1 and 9.5.2		✓
12.59	Clarify what permanent impacts to reef habitat are likely	Section 9.11.8	Sections 9.5.1 and 9.5.2		✓
12.60	Include a detailed description of fish communities that utilise the Port, in particular the species that utilise the areas proposed to be occupied by the WBE reclamation area and the dredge channel Describe effective mitigation measures that would be implemented during the construction of the WBE reclamation area to ensure fish are not entrapped within the reclamation area	Section 9.12.1.1	Section 9.6.1		✓
12.61	Include additional detailed information regarding the distribution and abundance of the estuarine stingray to support the conclusions of the impact assessment and SRI	Section 9.13.2	Sections 9.6.1, 9.6.3 and 9.6.4		✓

Submitter ID number (refer Appendices A and B)	Summary of submission issue raised	Project EIS section (public notification version)	AEIS section containing information to address submission comments	Complete replacement section for Project EIS	Supplements the Project EIS information
12.62	Acknowledge that impacts from the construction of the proposed WBE reclamation area would result in immediate impacts to fish habitat availability and short-term impacts to those individuals entrapped within the reclamation area	Section 9.17.2.4	Section 9.6.1		✓
12.63	Include an assessment of the total extent of the potential indirect impact area on migratory shorebirds, including the foraging area and adjacent roosting area. The total indirect disturbance area should be calculated in hectares, provided in a table and depicted in a figure at a suitable scale. This additional area should inform a revised SRI assessment that includes both direct and indirect impacts to migratory shorebirds.	Section 9.17.2.4	Sections 9.8.1, 9.8.2 and 9.8.3		✓
12.64	Provide a draft Offset Strategy for review and assessment. The strategy must addresses both the State and Commonwealth offsets framework requirements.	Section 9.28	Appendix E4	✓	
12.65	Update the background and baseline information on marine turtles in the Port in the EIS and address the detailed comments below	Section 9.18	Section 9.9	✓	
12.66	Acknowledge that marine turtle surveys in the Port to date have focused on shallow water feeding green turtles. Note the absence of surveys focused on deeper water feeding species/populations and describe the gaps in knowledge of these species in the Port in the draft EIS. Ensure this lack of knowledge regarding deeper water feeding turtle species is adequately considered and addressed in the impact assessment.	Section 9.18.2.1	Section 9.9.1	✓	

Submitter ID number (refer Appendices A and B)	Summary of submission issue raised	Project EIS section (public notification version)	AEIS section containing information to address submission comments	Complete replacement section for Project EIS	Supplements the Project EIS information
12.67	Address these comments and take account of the vulnerability of the less common turtle species to additional losses of habitat and individuals via indirect and direct mortality. ■ The SW Pacific loggerhead genetic stock experienced major decline in breeding numbers in eastern Australia (attributed to drowning in Prawn Trawls) since the 1970s. By 2000, the annual nesting population in Queensland was estimated at approximately 500 females for the year (equivalent to an 86% decline in numbers). In the past 18 years, the population recovery have been minimal: the current size of the annual nesting loggerhead population in Queensland is at approximately 75% of the population level of the mid-1970s. The reduction in the area of available habitat and the mortality of even small numbers of large immature and adult loggerheads within the population within Port Curtis should not be dismiss as not significant. It should be noted that the recent IUCN RED-LISTING has classified the SW Pacific Loggerhead genetic stock as critically endangered. ■ The Olive ridley nesting population within Queensland is a unique and endemic genetic stock to Queensland. The annual nesting population is currently estimated at a few hundred adult females annually and with an annual recruitment of new females into the breeding population approaching zero. The Olive ridley turtles that have been recorded within Port Curtis and the immediately adjacent waters have not been genetically assessed to identify their stock. Any reduction in the area of available habitat and the mortality of even a small numbers of large immature and adult Olive ridleys within the population within Port Curtis should not be dismissed as not significant. ■ The multiple genetic stocks of hawksbill turtle populations nesting within north Queensland and the eastern Coral Sea region are all severely depleted and the mixed stocks of hawksbill turtles foraging within the GBRWHA are in decline. A reduction in the area of available habitat and the mortality of even a small numbers of immature and adult hawksbills within the population within Port Curtis should not be dismissed as not significant.	Section 9.18.2.1	Section 9.9.2	✓	

Submitter ID number (refer Appendices A and B)	Summary of submission issue raised	Project EIS section (public notification version)	AEIS section containing information to address submission comments	Complete replacement section for Project EIS	Supplements the Project EIS information
12.68	Amend Table 9.66 to acknowledge the following information. ■ The presence of a foraging flatback population within the deeper subtidal waters of the Port, including existing dredged channels (foraging on soft bodied benthic invertebrates). ■ Foraging by pelagic post hatchling flatback turtles (foraging on plankton in the entrances to Port Alma & Port Curtis). ■ Presence of a foraging loggerhead population within the deeper subtidal waters of the Port, including existing dredged channels (foraging on mollusc, crustacean and echinoderm benthic invertebrates). ■ Known foraging hawksbill population utilising coral and rocky reefs and some soft bottom habitats within the shallow and deeper subtidal waters of the Port (foraging on encrusting invertebrates and algae). ■ Known foraging olive ridley population within the deeper subtidal waters of the Port, including existing dredged channels (foraging on mollusc and crustacean benthic invertebrates).	Section 9.18.2.1	Section 9.9.2	✓	
12.69	Correctly refer to areas of the Port that are used for inter-nesting by each turtle species. Account for potential impacts of proposed project activities on the reproductive output and survival of inter-nesting flatback turtles.	Section 9.18.2.2	Sections 9.9.2 and 9.10	✓	
12.70	Correct reference to leatherback nesting at Curtis, Peak and Avoid Islands in the 2017-2018 breeding season and the incorrect reference to Limpus et al. 2018	Section 9.18.2.2	Section 9.9.2	✓	
12.71	Correct reference to leatherback nesting at Curtis, Peak and Avoid Islands in the 2017-2018 breeding season and the incorrect reference to Limpus et al. 2018 Amend Table 9.69 to include seagrass, macroalage and mangroves in the calculation of green turtle habitat in the Port. Reanalyse the potential impact of the proposed project based on this wider range of habitat use by green turtles	Section 9.18.	Sections 9.9.2 and 9.10.2.1	✓	

Submitter ID number (refer Appendices A and B)	Summary of submission issue raised	Project EIS section (public notification version)	AEIS section containing information to address submission comments	Complete replacement section for Project EIS	Supplements the Project EIS information
12.72	The impact assessment of flatback turtles must take account of: ■ The loss of benthic foraging habitat for flatback turtles ■ The potential for dredging related death or injury of foraging flatback turtles ■ The impact of subsequent maintenance dredging which would prevent or impede recovery of available food resources in the channel. Revise the impact statement to reflect these matters.	Section 9.18.2.4	Section 9.9.2	✓	
12.73	Provide information regarding resident foraging population of resident foraging hawksbill and loggerhead turtles within the Port from the GPC funded marine turtle monitoring team. Based on this information, amend the impact statement and risk assessment for these species to take account of: ■ The loss of benthic foraging habitat ■ The potential for dredging related death or injury of foraging turtles ■ The impact of subsequent maintenance dredging which will prevent or impede the recovery of available food resources within the proposed dredging footprint.	Section 9.18.2.5	Section 9.10	✓	
12.74	Amend Table 9.68 to reference loggerhead, hawksbill and olive ridley turtles as expected to occur. Amend the table footnote to read: “All marine turtle species are listed as Species of conservation significance.” Amend the impact assessment for these species to address that they are expected to occur in the Port.	Section 9.19.1.2	Sections 9.9 and 9.10	✓	
12.75	The assessment should acknowledge and take account or the longer-term impact of this permanent loss of habitat on marine turtles	Section 9.19.2.5	Section 9.10	✓	

Submitter ID number (refer Appendices A and B)	Summary of submission issue raised	Project EIS section (public notification version)	AEIS section containing information to address submission comments	Complete replacement section for Project EIS	Supplements the Project EIS information
12.76	Acknowledge that the addition of light into an environment already impacting marine turtle behaviour will likely impact on marine turtles. Describe the potential impacts and likely changes in turtle behaviour and population. There is no currently demonstrated turtle friendly light that is non-disruptive to marine turtles, therefore mitigation measures must be implemented to ensure that: ■ Only amber LED aeroscreen lighting is used outside of buildings on the reclamation area ■ Using shading, to ensure that no light source within the area is directly visible from outside the perimeter of the area (excluding lighting required for navigation and safety).	Section 9.19.2.5	Section 9.10.2.5 and Appendices G and I	✓	
12.77	Ensure the impact assessment includes the entire dredge footprint in calculations of habitat loss for all four turtle species and dolphin species	Sections 9.19.3 and 9.19.3.2	Section 9.10.3.2	✓	
12.78	Acknowledge and address the potential for the direct mortality of marine turtles during dredging	Sections 9.19.3.4 and 9.19.3.5	Sections 9.10.3.4 and 9.10.3.5	✓	
12.79	Describe the potential negative impact of dredging on the behaviour of inter-nesting female flatback turtles and their egg production Describe the potential implications of an increasing proportion of the inter-nesting flatback turtle population utilising a deeper shipping channel Incorporate the risk of direct mortality and the disruption of egg production in these inter-nesting females into the risk assessment for this species	Section 9.19.3.5	Sections 9.10.3.2 and 9.10.7	✓	
12.80	Include an assessment of the potential impact of short-term declines in water quality during dredging on benthic macroinvertebrates	Section 9.19.3.6	Section 9.10.3.6	✓	

Submitter ID number (refer Appendices A and B)	Summary of submission issue raised	Project EIS section (public notification version)	AEIS section containing information to address submission comments	Complete replacement section for Project EIS	Supplements the Project EIS information
12.81	Assess fully the potential impacts of lighting on marine turtles. The department does not consider the potential impacts as negligible. The EIS should consider the potential impact of lighting and the potential for hatchling aggregations near dredge vessels that would likely result in increased turtle hatchling mortality. There are no currently demonstrated turtle friendly light that is non-disruptive to marine turtles. Therefore mitigation measures must be implemented to ensure (with the exception of required navigation lighting) that: ■ Only amber LED aeroscreen lighting is used for lighting outside of cabins ■ Cabin portholes on all vessels to be blacked out at night to prevent light spill ■ With the use of shading, no light source within the area is directly visible from outside the vessel perimeter.	Section 9.19.3.7	Sections 9.10.2.5 and 9.10.3.7 and Appendices F and I	✓	
12.82	Address the preceding comments regarding marine turtles, including the SRI assessment	Section 9.19.7	Sections 9.10.6 and 9.10.8	✓	
12.83	Include a comprehensive and detailed assessment of the potential cumulative impacts of all project activities on each marine turtle species	Section 9.18	Sections 9.10.6 and 9.10.8	✓	
12.84	Describe the cumulative impact of all direct and indirect impacts of the proposed project on seagrass meadows and foraging habitat on dugongs. Include the historic extent of seagrass habitat in the assessment of the potential impact of the proposed project on seagrass and dugongs. The disturbance area should be calculated in hectares, provided in a table, depicted in a figure at a suitable scale and inform the revised SRI assessment.	Sections 9.20.2.3 and 9.21.7 and Table 9.79	Sections 9.11.4.3 and 9.11.5.2		✓
12.85	Make reference to the findings of the Meager and Limpus 2014 and Weijs et al 2016 studies of contaminants in humpback dolphins, noting that the impacts of the contaminants on dolphin health are not well understood. Reference the potential impacts of the avoidance of turbid plumes by fish and the resultant impacts on dolphins.	Section 9.21.3.3	Section 9.11.3.1		✓
12.86	Amend the piling soft-start mitigation measure to ensure that a soft-start is always implemented before piling	Section 9.21.4.1	Appendix G	✓	

Submitter ID number (refer Appendices A and B)	Summary of submission issue raised	Project EIS section (public notification version)	AEIS section containing information to address submission comments	Complete replacement section for Project EIS	Supplements the Project EIS information
12.87	Amend likelihood of dolphin species to account for the following information: ■ Indo-Pacific bottlenose dolphins should be included as "confirmed in the area" ■ Common bottlenose dolphins, spinner dolphins and false killer whales should be recorded as having "a low likelihood of occurring" in the outer channel ■ Long-nosed fur seals have also been confirmed relatively close at Pancake Creek ■ Acknowledge the single record of a southern right whales at Rock Cod Shoals in 2018.	Appendix K2, Table 2	Sections 9.11.4 and 9.11.5	✓	
12.88	Amend Section 9.20, Tables 9.72 and 9.73 to correct the background information and the impact assessment regarding whales: ■ Table 9.72 should refer to Queensland waters only and should also note that long-nosed fur seals often visit the Gladstone area during winter (e.g. Pancake Creek in 2018, DES unpublished data)	Section 9.20.2	Sections 9.11.2.1, 9.11.4 and 9.11.5	✓	
	Amend Table 9.73 to correct the following information: ■ The common minke whales have not been confirmed in Queensland waters (only dwarf minkes and Antarctic minkes. Omura's and fin whales have been recorded in Queensland waters (Eye on the Reef data)). ■ Southern right whales have been confirmed in the Gladstone region (DES data) ■ Other than humpback whales, all species should be recorded as having a low likelihood of occurrence in the area.	Table 9.73	Section 9.11.2.1, Table 9.41	✓	
	■ Humpback whales: As the size of the humpback population increases, the number of humpback whales visiting the Port is expected to increase. The migration season is also lengthening, with migrants now expected from May to October (with low numbers also reported in April and November). The draft EIS should be amended to note this information.	Section 9.20.2	Section 9.11.2	✓	

Submitter ID number (refer Appendices A and B)	Summary of submission issue raised	Project EIS section (public notification version)	AEIS section containing information to address submission comments	Complete replacement section for Project EIS	Supplements the Project EIS information
12.89	Amend Sections 9.20 and Table 9.74 to correct the information below, regarding marine mammals-dolphins, particularly: ■ Only the Australian humpback dolphin is frequently found in the Port. Indo-Pacific bottlenose dolphins have also been reported in the Port. Within the seaward areas of the dredging works, spinner dolphins, common bottlenose dolphins and false killer whales may be encountered (but are rare in the area)	Section 9.20.2.2	Section 9.11.2.3	✓	
	■ Table 9.74: remove the common dolphin from this table, which have not been confirmed north of Fraser Island. Either remove Risso's dolphins or include the other pelagic dolphins (e.g. Fraser's and Pan tropical spotted dolphin).	Table 9.74	Table 9.39	✓	
	■ Humpback dolphins: The discussion of this species is incomplete. Update the draft EIS with more recent information on population size and structure in the region (e.g. Cagnazzi 2017, Parra et al 2018, Parra and Cagnazzi 2016, Meager et al 2018).	Section 9.20.2.2	Section 9.11.3.3	✓	
	■ Snubfin dolphins: Only one snubfin dolphin has been reported in the Port (D. Cagnazzi, pers. comm.)		Section 9.11.3.3	✓	
	■ Coastal bottlenose dolphin and Indian Ocean bottlenose dolphin: revise and use the standard names for these species from the scientific literature, which is the Indo Pacific bottlenose dolphin, *Tursiops aduncus* and the common bottlenose dolphin, *Tursiops truncatus*. It is the former species that is associated with inshore habitats in Queensland (locally referred to as the 'inshore bottlenose dolphin'), whereas common bottlenose dolphins are pelagic and are larger. There are many scientific articles on *Tursiops aduncus* that should also be referred to in the draft EIS.		Section 9.11.3.3	✓	
12.90	Reference the findings of a study of hearing thresholds measured for the Humpback dolphins sibling species *Sousa chinensis* (Li et al. 2012)	Section 13.4.2.2	Section 9.11.3.2		✓
12.91	Include a rigorous, evidence based assessment of the cumulative impact of historic port development (by GPC and others) on the environmental values of the Port. Include a table that lists the hectare area of each habitat lost as a result of historic development in the Port. Discuss the potential impacts of this current project in relation to historic impacts to these values. Discuss whether the additional impacts from this project are acceptable in terms of the cumulative historic impacts.	Section 9.29.13	Section 9.12		✓

Submitter ID number (refer Appendices A and B)	Summary of submission issue raised	Project EIS section (public notification version)	AEIS section containing information to address submission comments	Complete replacement section for Project EIS	Supplements the Project EIS information
12.92	Provide a detailed assessment of the impacts to MSES (and MNES) that relate to the offsite and indirect impacts of proposed Project activities. The assessment should take into account the definition of indirect impacts in the SRI guidelines by the Department of State Development, Infrastructure and Planning (2014) and the Significant impact guidelines 1.1, Commonwealth of Australia 2013 available at: http://www.dlgrma.qld.gov.au/resources/guideline/planning/dsdip-significant-residual-impact-guideline.pdf. and http://www.environment.gov.au/system/files/resources/42f84df4-720b-4dcf-b262-48679a3aba58/files/nes-guidelines_1.pdf Clarify the extent of impacts for MSES and MNES by adequately accounting for and combining the indirect impact areas to the direct impact areas. This additional indirect impact area should inform a revised SRI assessment and any potential offset obligation. Ensure the draft EIS consistently refers to both direct and indirect areas of impact.	Sections 9.26 and 9.29	Sections 9.2.6, 9.3.3, 9.4.6, 9.5.3, 9.6.4, 9.7.2, 9.8.3, 9.10.6, 9.11.5 and 9.15.3	✓	
E1.02, E2.02, E3.02, E4.02, E5.02, E6.02, E7.02, E8.02, E9.02, E9.04 and E9.10	The Project will cause the loss of hundreds of hectares of seagrass and shorebird habitat, this is unacceptable in a World Heritage Area. The continued economic expansion of Gladstone Port is incompatible with the World Heritage Values of Gladstone harbour.	Sections 9.9 and 917	Sections 9.4.2 to 9.4.7 and 9.8.1 to 9.8.4.		✓
E1.03, E2.03, E3.03, E4.03, E5.03, E6.03, E7.03, E8.03, E9.05, E9.06 and E9.11	Details of the proposed offsets must be provided prior to Project approval, so that decision makers can be certain that the proposed offsets are achievable before approving the Project.	Section 9.28	Appendix E4	✓	
E9.04 and E9.14	Implement environmental windows as part of avoiding impacts on seagrass meadows.	Appendices Q1 and Q2	Appendices F and G	✓	
			Section 9.14		✓

Table notes:

1 Submitter ID number commencing with 'E' are submissions received under the EPBC Act public notification process (refer AEIS Appendix B for details)
2 Other ID numbers are submissions received under the SDPWO Act public notification process (refer AEIS Appendix A for details)

9.2 Terrestrial and intertidal flora and wetlands

9.2.1 Other Nature Conservation Act 1992 flora species potentially impacted by the Project

This section supplements the Project EIS Section 9.4 (terrestrial and intertidal flora and wetlands – existing environment) and Appendix I1 (Sections 3 and 4).

To determine the potential flora present within the Project direct impact areas and potential indirect impact areas (Project impact areas) information was obtained from the following general sources:

- Database searches, including:
  - EPBC Act Protected Matters Search Tool
  - WildNet database (*Nature Conservation Act 1992* (NC Act))
- Field investigations.

The assessment of the likelihood of occurrence of conservation significant species listed under the EPBC Act and NC Act to occur within the Project impact areas was determined based on the database searches and field investigations. Appendix I1, Appendix B of the Project EIS provides the assessment of the likelihood of occurrence.

The NC Act listed flora species that have a moderate and confirmed likelihood of occurrence to be potentially impacted (direct and/or indirect) by the Project are provided in Table 9.2.

Impact assessments for these listed species have been undertaken in the relevant ecological values sections of the Project EIS and AEIS (refer the Project EIS Sections 9.5 and 9.8 and the AEIS Section 9.2).

Table 9.2 NC Act listed flora species that have a moderate and confirmed likelihood of occurrence to be potentially impacted (direct and/or indirect) by the Project

Scientific name	Common name	EPBC Act listing	NC Act listing
Flora			
Bertya opponens	NCN	Vulnerable	Least concern
Cycas megacarpa	NCN	Endangered	Endangered
Cycas ophiolitica	Marlborough blue	Endangered	Endangered
Dichanthium setosum	Bluegrass	Vulnerable	Least concern
Germainia capitata	NCN	Vulnerable	Vulnerable
Myrsine serpenticola	NCN	-	Endangered
Xylosma ovata	NCN	-	Near threatened

Table notes:

NCN = No common name
- = species is not listed under the EPBC Act

9.2.2 Marine plants

This section supplements the Project EIS Sections 9.4 and 9.8 (terrestrial and intertidal flora and wetlands values and seagrass meadows).

Under the *Fisheries Act 1994* (Fisheries Act), the definition of a marine plant includes the following:

- *A plant (a tidal plant) that usually grows on, or adjacent to tidal land, whether it is living, dead, standing or fallen*

- *Material of a tidal plant, or other plant material on tidal land*
- *A plant or material of a plant, prescribed by regulation to be a marine plant.*

The definition of marine plants is broad, and includes macro and micro marine plants as well as the material of tidal or other plants on tidal land (Couchmand and Beumer 2007). Marine plants include mangroves, seagrass, samphires, saltcouch and saltmarsh plants, algae and other tidal plants growing adjacent to the tidal zone, landward and seaward. All marine plants are protected under the Fisheries Act, regardless of their status under the NC Act and the *Vegetation Management Act 1999* (VM Act).

The Project EIS Section 9.4 (terrestrial and intertidal flora and wetlands existing environment) identified a number of Regional Ecosystems (REs) analogous to intertidal vegetation that are considered to be marine plants mapped within the Project indirect impact areas (i.e. RE 11.1.2a, 11.1.4a, 11.1.4c, 12.1.2 and 12.1.3).

It has been identified that fourteen different mangrove species have been recorded to occur along the Port Curtis coastline (refer Table 9.3).

Table 9.3 Mangrove species recorded as occurring along the Port Curtis coastline

Mangrove species recorded along the Port Curtis Coast	
Acanthus ilicifolius (Holly leaf mangrove)	*Ceriops tagal* (Yellow mangrove)
Acrostichum speciosum (Mangrove fern)	*Excoecaria agallocha* (Milky mangrove)
Aegialitis annulata (Club mangrove)	*Lumnitzera racemosa* (Black mangrove)
Aegiceras corniculatum (River mangrove)	*Osbornia octodonta* (Myrtle mangrove)
Avicennia marina (Grey mangrove)	*Rhizophora stylosa* (Red mangrove)
Bruguiera exaristata (Orange mangrove)	*Xylocarpus granatum* (Cannonball mangrove)
Bruguiera gymnorrhiza (Large-leaved orange mangrove)	*Xylocarpus moluccensis* (Cedar mangrove)

Source: GPC (2012)

Other marine plants such as saltmarsh flora species that have been identified within Port Curtis (on Facing Island), include *Enchylaena tomentosa* (Ruby saltbush), *E. agallocha, Sarcocornia quinqueflora* (Bead weed)*, Sarcocornia viminale, Sesuvium portulacastrum* (shoreline purslane), *Sporobolus virginicus* (Marine couch), *Suaeda australis* (Austral seablite)*, Tecticornia halocnemoides* (Glasswort), *Tecticornia indica* and *Tecticornia pergranulata* (Ecosure 2017).

During the Project EIS field investigations, it was identified that the Coastal Saltmarsh threatened ecological community (TEC) and mangrove communities within the WBE reclamation area and BUF were absent. Consequently, the establishment of the WBE reclamation area and BUF will not result in the direct loss of these values.

Seagrass and epibenthic macroalgae are the only marine plants mapped within the Project direct impact areas. Sections 9.4.5 and 9.4.6 provides an assessment of the Project direct and indirect impacts on all marine plants, including the potential cumulative and synergistic impact, and significant residual adverse impact assessment.

9.2.3 Project impacts on terrestrial and intertidal flora values

This section supplements the Project EIS Sections 9.5 (terrestrial and intertidal flora and wetlands values – potential impacts and risk assessment).

No terrestrial and intertidal flora or the Coastal Saltmarsh TEC are known to occur within the WBE reclamation area and BUF, as discussed in the Project EIS Section 9.4.2 and 9.4.3. However the Project has the potential to result in indirect impacts to terrestrial and intertidal flora values. The potential indirect impact areas are defined as the terrestrial and intertidal environments within a 500m buffer surrounding the direct impact areas (i.e. the WBE reclamation area, BUF and barge access channel), to ensure that impacts associated with edge effects on adjacent communities can be adequately addressed.

Potential indirect impact areas encompass 23.68ha of mapped remnant vegetation analogous with terrestrial communities and 94.5ha of mapped remnant vegetation analogous with intertidal communities. Section 9.4.4 provides further detail on the impacts to marine plants (i.e. intertidal flora values).

The dredging activities are located within a marine zone, and do not extend into areas of terrestrial vegetation, mangroves or coastal saltmarshes.

9.2.4 Project impacts on wetland values

This section supplements the Project EIS Section 9.5 (terrestrial and intertidal flora and wetlands values – potential impacts and risk assessment).

The construction of the WBE reclamation area and BUF bund walls will result in the permanent loss of wetland areas from within the Port Curtis directory of important wetlands (DIWA) and overlapping high ecological significant (HES) wetland (refer Figure 9.1).

The HES wetlands are considered a matter of state environmental significance (MSES). The Project activity has the potential to result in a lag time impact where indirect Project impacts such as change in tidal flows and patterns and the accumulation of sediment build up over time may occur. These impacts may not be noticeable at the time but have the potential to result in a significant synergistic impact on wetland values and subsequently other values that depend on these wetlands (refer AEIS Sections 9.4.5, 9.6.3, 9.10.6, 9.11.4 and 9.15.3).

The direct impact on wetland values are defined as the areas that the Project directly impacts upon (i.e. the establishment of the WBE reclamation area and BUF and the areas to be dredged). The potential Project indirect impact areas of wetland values include the areas that are adjacent to the Project activities that have the potential to result in the degradation of wetland values, thus resulting in potential adverse impacts on native flora and fauna species that rely on these wetland areas as potential habitat. Table 9.4 provides a summary of the impacted wetland values (MSES) relevant to the Project activities.

Table 9.4 Estimate of Project impact (direct and indirect) area based on MSES wetland values

Project activity	Area of direct impact to MSES wetland values	Area of indirect impact to MSES wetland values
WBE reclamation area (southern area)	47.47ha	24.98ha[1]
WBE reclamation area (northern area)	1.16ha	
BUF	0ha	0ha
Areas to be dredged	0ha	0ha
Total	**48.63ha**	**24.98ha**

Table notes:

1 The Project potential indirect impact area for the establishment of the WBE reclamation area has been combined for the southern and northern area. The Project potential indirect impact area is based on Project activities that result in the changes in tidal flow and increase in sedimentation resulting in the degradation of the wetland area

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Western Basin Expansion Reclamation Area

Northern Reclamation Area

Southern Reclamation Area

Existing Western Basin Reclamation Area

Fisherman's Landing

Legend

- Project direct impact areas on high ecological significance wetlands
- Potential Project indirect impact areas on high ecological significance wetlands
- MSES – High ecological significance wetlands
- Western Basin Expansion reclamation area
- Initial dredging works for barge access channel
- Barge unloading facility
- Existing shipping channels
- Port of Gladstone Port limits

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
MSES – High ecological significance wetlands: Department of Environment and Science (2017)

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0 255 510 Metres

Date: 08/08/2019 Version: 1 Job No: 237374

Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 9.1: Potential Project impacts to wetland values

9.2.5 Potential cumulative and synergistic impacts from Project activities

9.2.5.1 Context of potential impacts

This section supplements the Project EIS Section 9.5 (terrestrial and intertidal flora and wetland values – potential impacts and risk assessment) which provides an assessment of the potential impacts of the various Project activities on terrestrial and intertidal flora and wetland values.

The cumulative impact assessment that is applicable to the Project, considering foreseeable 'significant' projects and exogenous factors such as flood events and climate change is provided in the Project EIS (Chapter 21 – cumulative impact assessment and Appendix P). As such this section provides the cumulative assessment of the Project activities (i.e. the establishment of the WBE reclamation area and BUF, dredging activities, installation and removal of navigational aids and operation and maintenance activities) as a whole.

To identify potential synergistic impacts on terrestrial and intertidal flora and wetland values, this section provides an assessment of the potential cumulative Project impacts that were previously addressed individually as discrete Project activities on terrestrial and intertidal flora and wetland values (refer Project EIS Sections 9.5.2 to 9.5.5).

The Project activities can be described as occurring in discrete spatial areas although there is some temporal overlap of Project activities. The spatial categories are described below and their location (i.e. area of direct impact) is provided in Figure 9.2.

- Establishment of the WBE reclamation area and BUF
- Dredging activities
- Removal and installation of navigational aids
- Stabilisation and maintenance activities.

The Project dredging works will be undertaken as either a staged dredging campaign (i.e. over two stages) or as a singular campaign. Figure 9.3 illustrates the Project activity timeframes and dredging campaign options.

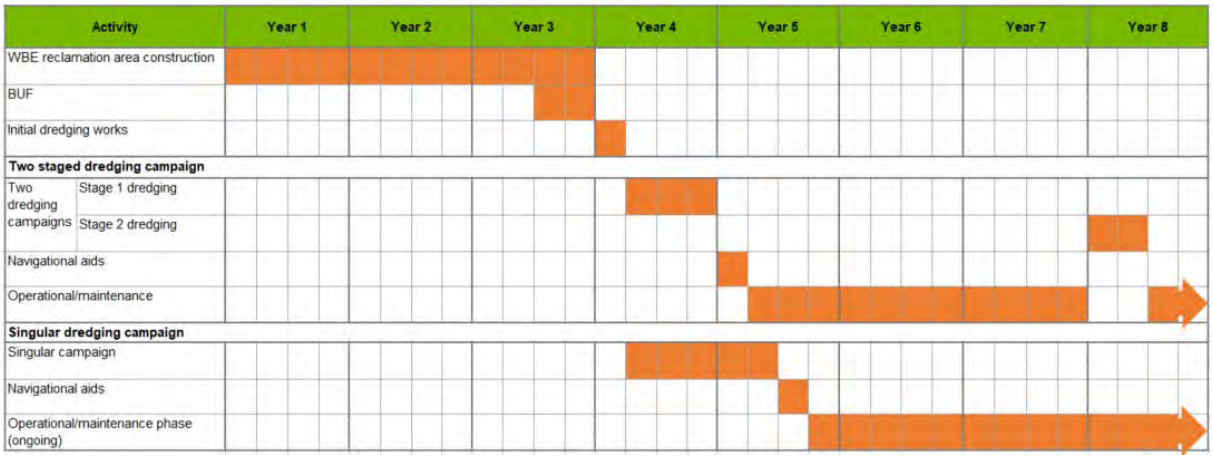

Figure 9.3 Indicative Project activity timeframes

Whilst the location of direct impacts is discrete, it is acknowledged that indirect impacts arising from the discrete Project locations (e.g. silt plumes, alterations to water quality and increased vessel movement) have the potential to result in impacts that overlap in a spatial and temporal context. Given this overlap, synergistic interactions resulting from multiple Project related impacts have the potential to impact upon terrestrial and intertidal flora and wetlands, with the results being greater than the sum of any of the single stressors alone.

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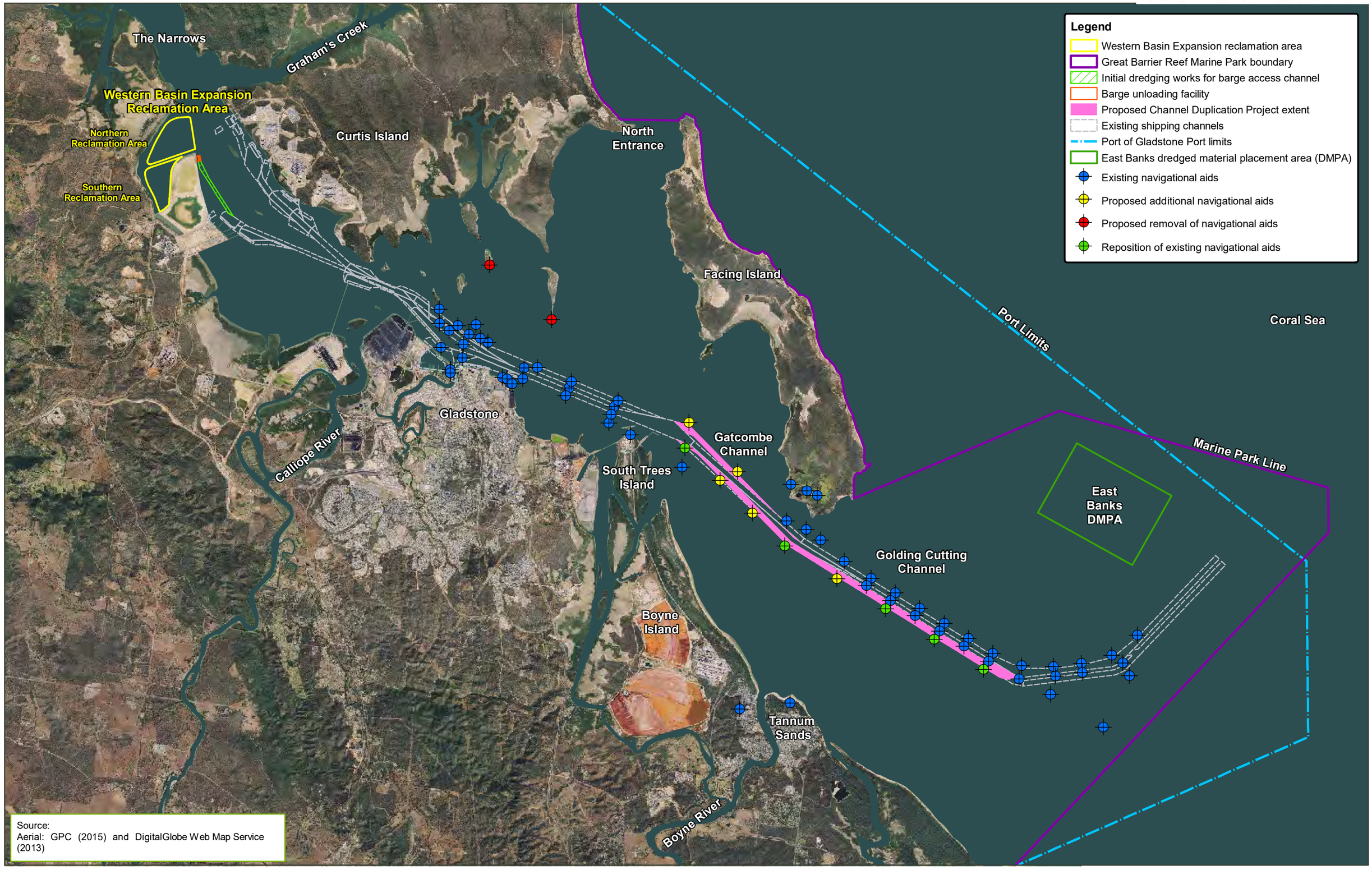

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)

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Date: 08/08/2019 Version: 2 Job No: 237374

Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 9.2: Location of Project activities

Potential cumulative impacts were assessed in conjunction with potential synergistic impacts from Project activities. Cumulative impacts were defined as an accumulation of impact from all Project activities. These were considered to be independent of temporal constraints and constituted of a contributing factor driving synergistic processes. Accordingly, cumulative impacts were not assessed *per se* but rather, were assessed within the synergistic impact assessment and were incorporated into the significant residual adverse impact assessment.

Synergistic impacts result from multiple processes which act simultaneously upon a particular value. The magnitude of impact would be a function of the initial direct impact and further direct impacts (as an accumulation) and/or a function of the initial direct impact with potentiation from further indirect impacts (as a synergy), with consideration for any amplification associated with the multiple factors acting simultaneously.

To identify potential Project synergistic impacts upon terrestrial and intertidal flora and wetland values, the Project EIS impact assessment outcomes (as a whole of program rather than discrete Project activities) were assessed (refer Project EIS Sections 9.5.2 to 9.5.5 and AEIS Appendices E1, E2 and E3). This enabled potential Project direct impacts (and indirect impacts) to be identified and the potential for contribution towards synergistic processes upon key threatening process to be considered. This approach acknowledged the potential scale of the Project related impacts on the value and its potential to impact upon the value's capacity for recovery from the impact, by contributing to a recognised threatening process.

Significant synergistic impacts were defined as potential synergistic impacts that had the capacity to contribute towards threatening processes that are recognised for a value (e.g. terrestrial and intertidal flora and wetlands). The resulting likelihood of risk identified the likely contribution of synergistic pathways upon the residual adverse impact of that value.

The synergistic assessment utilised a qualitative risk approach to determine the potential risk of a significant synergistic impact. Noting that a quantitative analysis was not possible as data related to synergistic processes is traditionally non-tractable to analysis, a risk-based assessment was utilised.

The synergistic impact assessment for intertidal and terrestrial flora and wetland values was conducted for MSES/MNES values only.

Potential Project related impacts assessed as potentially significant (post implementation of Project impact mitigation measures) were identified as potential pathways for significant synergistic impacts and consisted of:

- Permanent loss of habitat
- Loss of connectivity
- Introduction and spread of weed and/or pest species
- Erosion and sedimentation
- Potential short term decline in water quality.

The framework of the synergistic assessment focussed on:

- The potential Project activity impacts
- The synergistic pathways associated with the Project activities
- How the potentiated impacts contribute to key threatening processes, and
- The likelihood of risk of significant impact (refer Table 9.5) from the synergistic impact contribution to key threatening process.

Table 9.5 Likelihood definitions for potential impacts occurring over the life of the Project

Description	Frequency
Unlikely	Unlikely but not trivial. May occur during construction/life of the Project but probability < 50%
Potential	Less likely than not, but still considerable; probability of about 50% chance of occurring over the life of the Project
Likely	Likely to occur during construction/life of the Project or during a 12 month timeframe; probability up to 90% chance of occurring

Potential impacts to threatening processes (across all Project activities) have been identified in the Project EIS Sections 9.5.2 to 9.5.5. These sections outline the initial Project impact which contribute to the synergies with other potential Project impacts. For further detail, refer to applicable potential Project activity impacts within the Project EIS Sections 9.5.2 to 9.5.5.

Increased impact associated with competition, resource accumulation, reproductive opportunity loss and a reduction in biological fitness were assessed as pathways for the potential to contribute to key threatening processes as potential indirect synergistic impacts. Potential indirect synergistic impacts were typically associated with potential to reduce a value's life history parameters (e.g. reduced growth, reproduction, resource accumulation), through to the potential reduction in population resilience as a contributing factor towards key threatening processes. Increased competition has been considered to initially derive from Project potential impacts, including permanent removal of habitat, short term decline in water quality, reduced light availability and short term increase in sedimentation.

Reductions in biological fitness has been considered to derive from all of the initial impacts, as potential reproductive opportunities were considered to be contributing factors to this synergistic pathway. Synergistic impacts which act upon resilience were considered to result in potential reduction in individual and population biological fitness.

The sections below provide the synergistic impact assessment for terrestrial and intertidal flora and wetland values separately.

9.2.5.2 Terrestrial and intertidal flora values

The potential Project synergistic impacts (includes both direct and indirect impacts) on terrestrial and intertidal flora values have the potential to derive from the following impacts:

- Direct and/or permanent loss of flora values
- Loss of connectivity
- Introduction of weeds and/or pests
- Erosion and sedimentation
- Short term declines in water quality.

However the potential Project indirect impacts also have the potential to result in a synergistic impact to terrestrial and intertidal flora values. Potential Project indirect impacts that could result in a synergistic impact to terrestrial and intertidal flora values if combined together include:

- Introduction and spread of weed and/or pest species into terrestrial and intertidal vegetation communities adjoining the Western Basin and WBE reclamation areas and vehicle routes may occur due to vehicular movements associated with the transport of bund wall material
- Alterations to hydrodynamics within the WBE reclamation area
- Potential for some erosion to occur in the channels surrounding the WBE reclamation area. This erosion would continue (provided the bed material is erodible) until the channel reaches a new equilibrium depth

- Potential damage to the adjacent intertidal and terrestrial vegetation communities (including potential habitat for flora species of conservation significance) may occur as a result of elevated dust levels due to increased truck movements associated with the transport of reclamation bund wall material and during the placement of core, and armour material, and geotextile fabric at the WBE reclamation area and BUF.

Table 9.6 provides a summary of the potential synergistic impacts from the Project as a whole on terrestrial and intertidal flora MSES/MNES values. For the purposes of determination of the risk assessment with significant synergistic impact, Project direct impacts were contained in concert with synergistic pathways to determine the potential of synergistic impacts, that will contribute to key threatening processes. The likelihood of risk was determined based on Table 9.5 definitions.

Table 9.6 Risk of significant synergistic impact from identified Project impacts on terrestrial and intertidal flora values

Terrestrial and intertidal flora MNES/MSE values	Species threats identified in relevant conservation advices, recovery plans and threat abatement plans	Project direct impact (as result of whole program)	Potential Project pathways acting in synergy with Project impact	Potential indirect synergistic impact contributing to key threatening process	Likelihood of risk of significant impact (refer Table 9.5)
Endangered and vulnerable flora values under the EPBC Act and NC Act, and important habitat Vulnerable subtropical and temperate coastal saltmarsh TEC under the EPBC Act	■ **Clearing** ■ **Direct removal of seedlings and seedling cues** ■ Inappropriate fire regime ■ **Destruction of habitat and individuals due to clearing** ■ **Loss of genetic variation and insect pollinators** ■ Legal harvesting and commercial salvage ■ **Altered hydrology/tidal restriction** ■ Climate change ■ Changes to hydrology, including from flood mitigation and drainage works ■ **Land claim/infilling** ■ **Acid sulfate soils** ■ **Mangrove encroachment** ■ **Recreation** ■ **Pollution/litter** ■ **Invasive species** ■ Loss of connectivity ■ **Invasive weeds, particularly exotic grasses** ■ **Fragmentation**	Permanent removal of flora values	■ Permanent change of habitat ■ Temporary decline in water quality ■ Increased sedimentation and erosion	■ Reduction in individual and population resilience ■ Compounding impact on individual resource partitioning (compromised physiology) from reduction of foraging resource and water quality degradation (all Project activities) ■ Minor reduction of life-history parameters	Unlikely
		Permanent or irreversible fragmentation or loss of connectivity values	■ Permanent change of habitat ■ Temporary decline in water quality ■ Increased sedimentation and erosion	■ Reduction in individual and population resilience ■ Minor reduction of life-history parameters	Unlikely
		Potential hydrodynamic impacts and short term declines in water quality	■ Permanent change of habitat ■ Temporary decline in water quality	■ Reduction in individual and population resilience ■ Minor reduction of life-history parameters	Unlikely
		Introduction and spread of weeds and/or pests and increased edge effects	■ Permanent change of habitat ■ Temporary decline in water quality	■ Introduction of competition resulting in reduction in individual and population resilience ■ Minor reduction of life-history parameters	Unlikely
		Potential release of contaminants into adjacent environments	■ Permanent change of habitat ■ Temporary decline in water quality ■ Increase in dust	■ Reduction in population resilience	Unlikely

Table note:

Bold identifies threats acknowledged in relevant conservation advices, recovery plans and threat abatement plans which are potentially impacted by Project activities

The assessment identified that the Project has an unlikely risk of significant synergistic impact for terrestrial and intertidal flora values due to:

- No direct or permanent loss of terrestrial and intertidal flora values
- No loss of connectivity of values

The implementation of mitigation measures provided in the Dredging EMP and Project EMP (refer AEIS Appendices F and G, respectively) and associated management plans to reduce the likelihood and magnitude of potential Project impacts on flora values.

9.2.5.3 Wetlands

The potential Project synergistic impacts (includes both direct and indirect impacts) on wetland values have the potential to derive from the following impacts:

- Direct or permanent loss of wetland values
- Loss of connectivity
- Introduction of weeds and/or pests
- Erosion and sedimentation
- Potential short term decline in water quality.

In addition, the Project indirect impacts such as the introduction and spread of weed and pest species may result in the degradation of adjacent wetland habitats, decline in the suitability of available habitat for wetland fauna species, introduction of disease that may adversely impact native flora and/or fauna species, and other potential adverse impacts on native flora and fauna (i.e. invasive species have the potential to be toxic to native fauna, and compete for available resources). These potential Project indirect impacts are considered to have a low synergistic impact due to the impacts occurring in the short term within a contained extent.

Table 9.7 provides a summary of the potential synergistic impacts from the Project as a whole on MSES wetland values. For the purposes of determination of the risk assessment with significant synergistic impact, Project direct impacts were contained in concert with synergistic pathways to determine the potential of synergistic impacts, that will contribute to threatening processes. The likelihood of risk was determined based on Table 9.5 definitions.

Table 9.7 Risk of significant synergistic impact from identified Project impacts on MSES wetland values

Wetland values	Threats to wetland values#	Project direct impact (as result of whole program)	Potential Project pathways acting in synergy with Project impact	Potential indirect synergistic impact contributing to key threatening process	Likelihood of risk of significant impact (refer Table 9.5)
MSES wetland values	■ Clearing of Melaleuca wetland habitat ■ Inappropriate agricultural practices in Melaleuca wetland habitat ■ Modification of water flows in Melaleuca wetland habitat ■ **Loss of habitat** ■ **Coastal development** ■ **Deteriorating water quality** ■ **Habitat or lifecycle of native species dependent on the wetland are affected** ■ **Change in hydrodynamic regime of the wetland** ■ **Introduction of invasive species being established in the wetland**	Permanent removal of wetlands	■ Permanent change of habitat ■ Loss of habitat for native species ■ Temporary decline in water quality	■ Reduction in individual and population resilience ■ Compounding impact on individual resource partitioning (compromised physiology) from reduction of foraging resource and water quality degradation (all Project activities) ■ Minor reduction of life-history parameters	Potential
		Short term decline in water quality	■ Permanent change of habitat ■ Temporary decline in water quality	■ Reduction in population recruitment through increased vessel interaction and predation on potential hatchlings	Potential
		Vessel and vehicle movement	■ Permanent change of habitat ■ Loss of habitat for native species ■ Temporary decline in water quality	■ Habitat degradation and modification, alterations to the behaviour of native fauna species ■ Introduction of disease that may adversely impact native fauna ■ Predation and competition pressures ■ Minor reduction in life-history parameters ■ Reduction in population resilience	Potential

Table note:

Bold identifies threats acknowledged in relevant conservation advices, recovery plans and threat abatement plans which are potentially impacted by Project activities

The assessment identified that the Project has the potential risk of significant synergistic impact for wetland values, due to the direct and permanent loss of MSES wetland values.

The Project will implement mitigation measures provided in the Dredging EMP and Project EMP (refer AEIS Appendices F and G) and associated management plans to reduce the likelihood and magnitude of potential Project impacts on wetland values.

9.2.6 Significant residual adverse impact assessment

This section supplements the Project EIS Section 9.5.7 (significant residual adverse impact assessment).

The analysis presented in the AEIS Appendix E2 did not identify any flora values for which potential Project impacts are considered to have a residual impact on a threatening process which may lead to the progressive loss of the species or ecologically significant habitat (refer AEIS Appendix E2, Items 1.1 to 1.7). With respect to the nature of the Project activities and the implementation of appropriate mitigation measures, the Project is not anticipated to have a residual impact on flora values that are considered a MNES or MSES. Consequently, a significant residual adverse impact assessment on flora values has not been conducted for the Project.

The Coastal Saltmarsh TEC was confirmed during Project EIS field investigations as being analogous with RE 12.1.2 and within areas mapped as RE 11.1.4. No Coastal Saltmarsh TEC was observed within the WBE reclamation area and BUF during Project EIS field investigations; however areas of Coastal Saltmarsh TEC occur in areas adjacent to the WBE reclamation area and the haul route between the Western Basin and WBE reclamation areas and the Targinnie/Yarwun quarry.

The Project EIS provided a significant residual adverse impact assessment to identify if the Project will, or is considered likely to have, a significant residual adverse impact on terrestrial and intertidal flora values (refer Project EIS Section 9.5.7). The significant residual adverse impact assessment concluded that the proposed Project activities will not have a significant residual adverse impact on terrestrial and intertidal flora values. The Project cumulative and synergistic impact assessment (refer Section 9.2.3) did not change the Project EIS finding for the significant residual adverse impact assessment on terrestrial and intertidal flora values and as such the significant residual adverse impact assessment has not been reassessed as part of the AEIS.

The Project will implement mitigation measures provided in the Dredging EMP and Project EMP (refer AEIS Appendices F and G, respectively), and associated management plans to reduce the likelihood and magnitude of potential Project impacts on flora values.

A HES wetland is considered a MSES and subject to significant impact assessment in accordance with the *Queensland Environmental Offsets Policy Significant Residual Impact Guideline* (EHP 2014a). The Project impact areas (i.e. the establishment of the WBE reclamation area) include HES wetlands. As such, a significant residual adverse impact assessment for MSES wetlands has been conducted for the Project (refer Project EIS Section 9.5.7). The Project EIS concluded that the Project activities will have a significant residual adverse impact on MSES wetlands, including:

- The establishment of the WBE reclamation area will result in the direct disturbance of approximately 48.63ha of mapped HES wetlands
- The establishment of the WBE reclamation area will result in the indirect impact (i.e. sedimentation and erosion from changes to tidal velocities adjoining the proposed WBE reclamation area) of approximately 24.98ha of mapped HES wetlands.

The Project EIS Section 9.5.7.2 (summary of wetland values requiring assessment) provides the significant residual adverse impact assessment for the MSES wetland. It was determined that a reassessment was not required as part of the AEIS as the Project activities and impacts have not changed due to the potential cumulative Project activity synergistic impacts assessed in Section 9.2.5.

9.2.7 Summary

This section supplements the Project EIS Section 9.5.8 (assessment summary).

Based on the Project EIS Section 9.5.7 (significant residual adverse impact assessment) and the above supplementary assessment, all Project activities are likely to have no significant residual adverse impact on terrestrial and intertidal flora values. The Project has the potential to have an indirect impact of approximately 94.50ha on terrestrial and intertidal flora (based on 500m within the Project activities). The Project will implement mitigation measures provided in the Dredging EMP and Project EMP (refer AEIS Appendices F and G) and associated management plans to reduce the likelihood and magnitude of potential Project impacts on terrestrial and intertidal flora values.

Based on the Project EIS Section 9.5.7 (significant residual adverse impact assessment) and the above supplementary assessment, the Project activities below are likely to have a significant residual adverse impact on the MSES wetland values (HES wetlands):

- Direct disturbance from the establishment of the WBE reclamation area on MSES wetland values (i.e. direct impact area of 48.63ha)
- Indirect impacts from the establishment of the WBE reclamation area (i.e. potential habitat alteration due to potential hydrological and water quality impacts) on wetland values (i.e. predicted indirect impact area of 24.98ha (MSES wetlands)).

The potential Project significant residual adverse impact on MSES wetland values will be offset by implementing the Channel Duplication Project Offset Strategy (refer AEIS Appendix E4 for the draft strategy).

9.3 Intertidal and terrestrial fauna

This section supplements the Project EIS Section 9.7 (terrestrial and intertidal fauna values – potential impacts and risk assessment) which provides an assessment of the potential impacts of the various Project activities on terrestrial and intertidal fauna values. Also note Sections 9.6, 9.7, 9.8, 9.10 and 9.11 provide assessments on additional fauna values (e.g. fish and marine reptiles, benthic macroinvertebrates, migratory birds, marine turtles, marine mammals).

9.3.1 Other Nature Conservation Act 1992 fauna species potentially impacted by the Project

This section supplements the Project EIS Section 9.4 (terrestrial and intertidal fauna – existing environment) and Appendix I1 (Section 13).

To determine the potential fauna present within the Project direct impact areas and potential indirect impact areas (Project impact areas) information was obtained from the following general sources:

- Database searches, including:
  - EPBC Act Protected Matters Search Tool
  - WildNet database (NC Act)
- Field investigations.

The assessment of the likelihood of occurrence of conservation significant species listed under the EPBC Act and NC Act to occur within the Project impact areas was determined based on the database searches and field investigations. Appendix I1, Appendix B of the Project EIS provides the assessment of the likelihood of occurrence.

The NC Act listed fauna species that have a moderate and confirmed likelihood of occurrence to be potentially impacted (direct and/or indirect) by the Project are provided in Table 9.2.

Impact assessments for these listed species have been undertaken in the relevant ecological values sections of the Project EIS and AEIS (refer the Project EIS Sections 9.7, 9.13, 9.17, 9.19 and 9.21 and the AEIS Sections 9.6, 9.8, 9.10 and 9.11).

Table 9.8 NC Act listed fauna species that have a moderate and confirmed likelihood of occurrence to be potentially impacted (direct and/or indirect) by the Project

Scientific name	Common name	EPBC Act listing	NC Act listing
Fauna			
Acanthophis antarcticus	Common death adder	-	Vulnerable
Ardenna pacifica	Wedge-tailed shearwater	Migratory	Vulnerable
Calidris canutus	Red knot	Endangered and Migratory	Endangered
Calidris ferruginea	Curlew sandpiper	Critically endangered	Endangered
Calidris tenuirostris	Great knot	Critically endangered	Endangered
Caretta caretta	Loggerhead turtle	Endangered	Endangered
Charadrius leschenaultii	Greater sand plover	Vulnerable	Vulnerable
Charadrius mongolus	Lesser sand plover	Endangered	Endangered
Chelonia mydas	Green turtle	Vulnerable	Vulnerable
Crocodylus porosus	Saltwater crocodile	Marine and Migratory	Vulnerable
Dasyatis fluviorum	Estuary stingray	-	Near threatened
Dugong dugon	Dugong	Migratory	Vulnerable
Eretmochelys imbricata	Hawksbill turtle	Vulnerable	Endangered
Esacus magnirostris	Beach stone-curlew	Marine species	Vulnerable
Fregetta grallaria grallaria	White-bellied storm-petrel	Vulnerable	Least concern
Lepidochelys olivacea	Olive ridley turtle	Endangered	Endangered
Limosa lapponica baueri	Western Alaskan bar-tailed godwit	Vulnerable	Vulnerable
Limosa lapponica menzbieri	Northern Siberian bar-tailed godwit	Critically endangered	Endangered
Macronectes giganteus	Southern giant-petrel	Endangered	Endangered
Manta alfredi	Reef manta ray	Migratory	Vulnerable
Megaptera novae-angliae	Humpback whale	Vulnerable	Vulnerable
Natator depressus	Flatback turtle	Vulnerable	Vulnerable
Ninox strenua	Powerful owl	-	Vulnerable
Numenius madagascariensis	Eastern curlew	Critically endangered	Endangered
Phaethon rubricauda	Red-tailed tropicbird	Migratory	Vulnerable
Phoebetria fusca	Sooty albatross	Vulnerable	Vulnerable
Pterodroma neglecta neglecta	Kermadec petrel western	Vulnerable	Least concern
Sousa sahulensis	Australian humpback dolphin	Migratory	Vulnerable
Taphozous australis	Coastal sheathtail bat	-	Near threatened
Thalassarche cauta cauta	Shy albatross	Vulnerable	Vulnerable
Thalassarche cauta steadi	White-capped albatross	Vulnerable	Vulnerable
Thalassarche eremita	Chatham albatross	Endangered	Special least concern

Scientific name	Common name	EPBC Act listing	NC Act listing
Thalassarche melanophris	Black-browed albatross	Vulnerable	Special least concern
Thalassarche salvini	Salvin's albatross	Vulnerable	Special least concern
Xeromys myoides	Water mouse	Vulnerable	Vulnerable

Table notes:

NCN = No common name
- = species is not listed under the EPBC Act

9.3.2 Potential cumulative and synergistic impacts from Project activities

The cumulative impact assessment that is applicable to the Project, considering foreseeable 'significant' projects and exogenous factors such as flood events and climate change is provided in the Project EIS (Chapter 21 – cumulative impact assessment and Appendix P). As such this section provides the cumulative assessment of the Project activities (i.e. the establishment of the WBE reclamation area and BUF, dredging activities, installation and removal of navigational aids, and operation and maintenance) as a whole.

To identify potential synergistic impacts on terrestrial and intertidal fauna MNES/MSES values, this section provides an assessment of the potential cumulative Project impacts that were previously addressed individually as discrete Project activities on terrestrial and intertidal fauna values (refer Project EIS Sections 9.7.2 to 9.7.5).

The Project activities can be described as occurring in discrete spatial areas although there is some temporal overlap of Project activities. The spatial categories are described below and their location (i.e. area of direct impact) is provided in Figure 9.2.

- Establishment of the WBE reclamation area and BUF
- Dredging activities
- Removal and installation of navigational aids
- Stabilisation and maintenance activities.

The Project dredging works will be undertaken as either a staged dredging campaign (i.e. over two stages) or as a singular campaign. Figure 9.4 illustrates the Project activity timeframes and dredging campaign options.

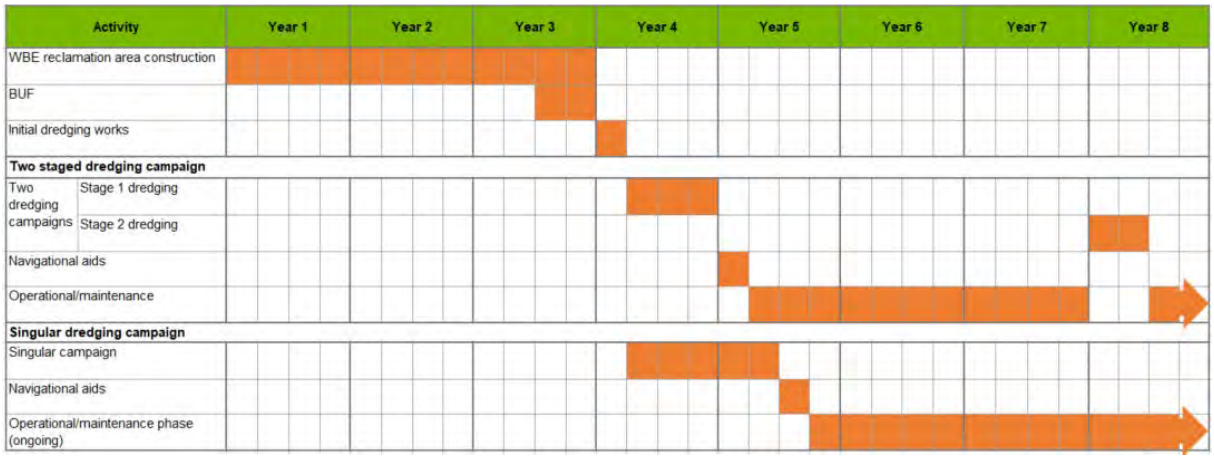

Figure 9.4 Indicative Project activity timeframes

Whilst the location of direct impacts is discrete, it is acknowledged that indirect impacts arising from the discrete Project locations (e.g. silt plumes, alterations to water quality and increased vessel movement) have the potential to result in impacts that overlap in a spatial and temporal context. Given this overlap, synergistic interactions resulting from multiple Project related impacts have the potential to impact upon intertidal and terrestrial fauna, with the results being greater than the sum of any of the single stressors alone.

Potential cumulative impacts were assessed in conjunction with potential synergistic impacts from Project activities. Cumulative impacts were defined as an accumulation of impact from all Project activities. These were considered to be independent of temporal constraints and constituted a contributing factor driving synergistic processes. Accordingly, cumulative impacts were not assessed *per se* but rather, were assessed within the synergistic impact assessment and were incorporated into the significant residual adverse impact assessment.

Synergistic impacts result from multiple processes which act simultaneously upon a particular value. The magnitude of impact would be a function of the initial direct impact and further direct impacts (as an accumulation) and/or a function of the initial direct impact with potentiation from further indirect impacts (as a synergy) with consideration for any amplification associated with the multiple factors acting simultaneously.

To identify potential Project synergistic impacts upon terrestrial and intertidal fauna values, the Project EIS impact assessment outcomes (as a whole of program rather than discrete Project activities) were assessed (refer Project EIS Sections 9.7.2 to 9.7.5 and AEIS Appendices E1, E2 and E3). This enabled potential Project direct impacts (and indirect impacts) to be identified and the potential for contribution towards synergistic processes upon key threatening process to be considered. This approach acknowledged the potential scale of the Project related impacts on the value and its potential to impact upon the value's capacity for recovery from the impact by contributing to a recognised threatening process.

Significant synergistic impacts were defined as potential synergistic impacts that had the capacity to contribute towards threatening processes that are recognised for a value (e.g. intertidal and terrestrial fauna). The resulting likelihood of risk identified the likely contribution of synergistic pathways upon the residual adverse impact of that value.

The synergistic assessment utilised a qualitative risk approach to determine the potential risk of a significant synergistic impact. Noting that a quantitative analysis was not possible as data related to synergistic processes is traditionally non-tractable to analysis, a risk-based assessment was utilised.

The synergistic impact assessment for intertidal and terrestrial fauna species was conducted for MSES/MNES values only.

Potential Project related impacts assessed as potentially significant (post implementation of Project impact mitigation measures) were identified as potential pathways for significant synergistic impacts and consisted of:

- Permanent loss of habitat
- Direct mortality and injury of fauna
- Potential displacement of fauna due to noise, vibration, dust and artificial lighting.

The framework of the synergistic assessment focussed on:

- The potential Project activity impacts
- The synergistic pathways associated with the Project activities
- How the potentiated impacts contribute to key threatening processes
- The likelihood of risk of significant impact (refer Table 9.9) from the synergistic impact contribution to key threatening process.

Table 9.9 Likelihood definitions for potential impacts occurring over the life of the Project

Description	Frequency
Unlikely	Unlikely but not trivial. May occur during construction/life of the Project but probability < 50%
Potential	Less likely than not, but still considerable; probability of about 50% chance of occurring over the life of the Project
Likely	Likely to occur during construction/life of the Project or during a 12 month timeframe; probability up to 90% chance of occurring

Potential impacts to threatening processes (across all Project activities) have been identified in the Project EIS Sections 9.7.2 to 9.7.5. These sections outline the initial Project impacts which contribute to the synergies with other potential Project impacts. For further detail, refer to applicable potential Project activity impacts within the Project EIS Sections 9.7.2 to 9.7.5.

Increased impact associated with competition, resource accumulation, reproductive opportunity loss and a reduction in biological fitness were assessed as pathways for the potential to contribute to key threatening processes as potential indirect synergistic impacts. Potential indirect synergistic impacts were typically associated with a potential to reduce a value's life history parameters (e.g. reduced growth, reproduction, resource accumulation), through to the potential reduction in population resilience as a contributing factor towards key threatening processes. Increased competition has been considered to initially derive from Project potential impacts, including permanent removal of habitat, and short term decline in water quality.

Reductions in biological fitness has been considered to derive from all of the initial impacts, as potential reproductive opportunities were considered to be contributing factors to this synergistic pathway. Synergistic impacts which act upon resilience were considered to result in potential reduction in individual and population biological fitness.

Synergistic impacts to intertidal and terrestrial fauna have the potential to derive from the following impacts:

- Permanent loss of habitat area and connectivity
- Direct mortality and injury of fauna
- Potential impact of hydrological changes on fauna habitat
- Introduction and spread of weeds and/or pest species.

Table 9.10 provides a summary of the potential synergistic impacts from the Project as a whole on terrestrial and intertidal fauna. For the purposes of determination of the risk assessment with significant synergistic impact, Project direct impacts were contained in concert with synergistic pathways to determine the potential of synergistic impacts that will contribute to key threatening processes. The likelihood of risk was determined based on Table 9.9 definitions.

Table 9.10 Risk of significant synergistic impact from identified Project impacts on terrestrial and intertidal fauna values

Terrestrial and intertidal fauna value (MNES/MSES values)	Species threats identified in relevant conservation advices, recovery plans and threat abatement plans[#]	Project direct impact (as result of whole program)	Potential Project pathways acting in synergy with Project impact	Potential indirect synergistic impact contributing to key threatening process	Likelihood of risk of significant impact (refer Table 9.9)
Vulnerable Water mouse (*Xeromys myoides*) under the EPBC Act and NC Act, and important habitat Near threatened Coastal sheathtail bat (*Taphozous australis*) under the NC Act, and important habitat Migratory Salt water crocodile (*Crocodylus porosus*) under the EPBC Act	▪ Habitat loss and degradation, including impacts from pollution ▪ Anthropogenic disturbances including walking dogs through habitat areas, boating, use of off-road vehicles and beach combing ▪ Inappropriate grazing and fire regimes, which can degrade and destroy habitat and food sources ▪ **Clearing of vegetation including loss of habitat through coastal development** ▪ Predation by feral cats, dogs and pigs ▪ **Loss of foraging habitat** ▪ **Predation pressure on eggs** ▪ **Flooding pressure on eggs** ▪ **Loss, degradation and fragmentation of freshwater and inter-tidal wetland communities utilised by the species** ▪ **Reclamation of inter-tidal and terrestrial habitats as a result of deposition of dredge spoil** ▪ **Changes in soil chemistry, for instance the development of acid sulphate soils as a result of disturbance and exposure to air of 'at risk' soils, may disrupt mangrove habitat**	Permanent loss of habitat area and connectivity	▪ Permanent change of habitat ▪ Temporary decline in water quality ▪ Contaminant and sediment releases ▪ Introduction and spread of weed and pest species	▪ Reduction in individual and population resilience ▪ Displacement of fauna ▪ Compounding impact on individual resource partitioning (compromised physiology) from reduction of foraging resource and water quality degradation (all Project activities) ▪ Minor reduction of life-history parameters	Unlikely
		Direct mortality and injury of fauna	▪ Permanent change of habitat ▪ Temporary decline in water quality	▪ Reduction in population resilience ▪ Increase in potential mortality from contact with dredging equipment from modification of habitat use ▪ Reduction in recruitment from loss of gravid females	Unlikely
		Potential impact of hydrological changes on fauna habitat	▪ Permanent change of habitat ▪ Temporary decline in water quality	▪ Reduction in population resilience ▪ Displacement of fauna	Unlikely
		Introduction and spread of pest and/or weed species	▪ Permanent change of habitat ▪ Temporary decline in water quality	▪ Introduction of competition resulting in reduction in individual and population resilience ▪ Minor reduction of life-history parameters ▪ Displacement of fauna	Unlikely

Terrestrial and intertidal fauna value (MNES/MSES values)	Species threats identified in relevant conservation advices, recovery plans and threat abatement plans[#]	Project direct impact (as result of whole program)	Potential Project pathways acting in synergy with Project impact	Potential indirect synergistic impact contributing to key threatening process	Likelihood of risk of significant impact (refer Table 9.9)
	▪ **Physical changes to saltmarsh such as runnelling or bund wall construction that modify tidal amplitude and frequency of inundation** ▪ Changes in hydrology, including increased freshwater inflows and sedimentation from stormwater runoff as a result of adjacent residential development ▪ **Drainage of coastal and terrestrial wetlands for urban and industrial developments** ▪ **Modified water levels and salinity in tidal waterways resulting from installation of flow control gates for flood mitigation** ▪ Use of recreational vehicles in inter-tidal areas due to the long-lasting damage they cause through destruction and degradation of habitat ▪ **Predation pressures from native and introduced fauna, competition for food resources and modification of suitable habitat by feral and hard-hoofed animals such as pigs** ▪ Inappropriate burning of sedgeland, grassland and adjacent Melaleuca wetland communities				

Table note:

Bold identifies threats acknowledged in relevant conservation advices, recovery plans and threat abatement plans which are those potentially impacted by Project activities

The assessment identified that the Project has an unlikely risk of significant synergistic impact for terrestrial and intertidal fauna values.

The Project will implement mitigation measures provided in the Dredging EMP and Project EMP (refer AEIS Appendices F and G, respectively) and associated management plans to reduce the likelihood and magnitude of potential Project impacts on terrestrial and intertidal fauna values.

9.3.3 Significant residual adverse impact assessment

It was determined that a reassessment of the significant residual adverse impact assessment for intertidal and terrestrial fauna was not required as part of the AEIS as the Project activities and impacts have not changed due to the potential cumulative Project activity synergistic impacts assessed in Section 9.3.1.

The significant residual adverse impact assessment concluded that the Project will not have a significant residual adverse impact on the Water mouse (*Xeromys myoides*). The significant residual adverse impact assessment concluded that the proposed Project activities at the Western Basin and WBE reclamation areas will not have a significant residual adverse impact on the Saltwater crocodile (*Crocodylus porosus*), or Protected Wildlife Habitat for the Coastal sheathtail bat (*Taphozous australis*). It is noted that the Project is considered to potentially have a significant impact on the Beach Stone Curlew (refer Project EIS and Section 9.15 of this document). Project EIS Section 9.7.7 provides the significant residual adverse impact assessment for MNES and MSES terrestrial and intertidal fauna.

9.3.4 Summary

Based on the Project EIS Section 9.7.7 and the above supplementary assessment, all Project activities are likely to have no significant residual adverse impact assessment on terrestrial and intertidal fauna values.

The Project will implement mitigation measures provided in the Dredging EMP and Project EMP (refer AEIS Appendices F and G, respectively) and associated management plans to reduce the likelihood and magnitude of potential Project impacts on terrestrial and intertidal fauna values.

9.4 Seagrass meadows and epibenthic macroalgae

9.4.1 Seagrass values

9.4.1.1 Findings of the Port Curtis seagrass monitoring survey (Chartrand et al. 2019)

This section supplements the Project EIS Section 9.8 (seagrass meadows and epibenthic macroalgae – existing environment) and Appendix I1 (Section 7.3).

The annual seagrass survey was conducted on Port Curtis and Rodds Bay seagrass meadows during November 2018. A total of 1,507 sites were surveyed using methods that followed the established techniques for the TropWATER Queensland-wide ports seagrass monitoring program (Chartrand et al. 2019). This methodology included the sampling of intertidal areas with helicopter surveys and shallow subtidal areas using boat-based free diving.

Five seagrass species from three families were observed during the survey. A total area of coastal seagrass mapped in Port Curtis was 3,558 ± 466ha in 2018, approximately 700ha above the long term average and 374 ± 16ha in Rodds Bay (Chartrand et al. 2019). Dugong feeding trails were observed throughout the Port Curtis and Rodds Bay survey areas, with the exception of Graham's Creek (Chartrand et al. 2019).

The overall condition score for seagrass meadows within Port Curtis and Rodds Bay was satisfactory, an improvement following three years of consistently poor conditions (Chartrand et al. 2019). Ten monitoring meadows were in very good to satisfactory condition, and only four remained in poor or very poor condition. South Trees, Inner and Mid Harbour monitoring meadow condition remained the same. Western Basin and The Narrows meadows either improved or remained unchanged, with several meadows improving more than one grade (Chartrand et al. 2019). The Rodds Bay meadow condition improved substantially following a number of years of poor to very poor condition.

There was no relationship between proximity of port and anthropogenic activities and change or improvement within meadows indicating regional environmental conditions rather than anthropogenic activity were the driver of observed seagrass changes in 2018 (Chartrand et al. 2019). The total gain in seagrass extent in 2018 and recovery in some meadows was likely due to a lack of major rainfall and flooding events in 2018 (Chartrand et al. 2019). The subtidal monitoring meadow in the Western Basin zone returned with a substantial footprint, and with the highest biomass for this meadow recorded since monitoring began. In 2018, seagrasses in the Western Basin area covered 943 ± 73ha which is similar to the previous year (Chartrand et al. 2019). *Halophila ovalis* continued to dominate most meadows and increased from light to moderate biomass across the zone.

Figure 9.5 shows the total area of coastal seagrass mapped within the survey extent in Port Curtis (excluding Rodds Bay). Seagrass condition in 2018 was satisfactory, an improvement following several years of poor condition (Chartrand et al. 2019).

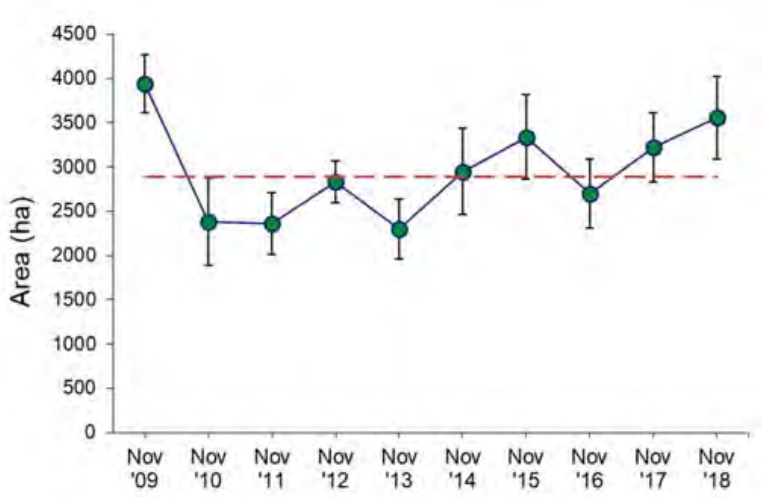

Figure 9.5 **Annual changes in total coastal seagrass area in Port Curtis, excluding Rodds Bay (2009 to 2018)**

Figure note:

Red dashed line represents the long term average of seagrass meadow area mapped (2009 to 2018)

Source: Chartrand et al. (2019)

The extent of seagrass meadows surveyed in Port Curtis in 2018 is shown in Figure 9.6a (Outer Harbour) and Figure 9.6b (Inner Harbour). The historical (cumulative) extent of seagrass meadows in Port Curtis and Rodds Bay from 2002 to 2018 is shown in Figure 9.7.

9.4.2 Project impact on historic extent of seagrass meadows

This section supplements the Project EIS Section 9.9 (seagrass meadows and epibenthic macroalgae – potential impacts and risk assessment).

Seagrass meadows are known to occur within the Project impact areas and have been mapped within Port Curtis since 2002 (Rasheed et al. 2003). The Project EIS identified direct impacts as a result of the Project on seagrass meadows which includes the physical removal and/or burial of seagrass and/or potential seagrass habitat. Potential indirect impacts from the Project, include:

- A reduction of benthic light through increased suspended sediments (i.e. high turbidity)

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Gatcombe Channel
Facing Island
South Trees Island
Boyne Island
Tannum Sands
Boyne River
Golding Cutting Channel
East Banks DMPA
Not surveyed
Marine Park Line
Wild Cattle Island
Colosseum Inlet
Hummock Hill Island
Rodds Peninsula
Rodds Bay

Legend

- Proposed additional navigational aids
- Reposition of existing navigational aids
- Great Barrier Reef Marine Park boundary
- Proposed Channel Duplication Project extent
- Existing shipping channels
- Port of Gladstone Port limits
- East Banks dredged material placement area (DMPA)
- Area not surveyed
- November 2018 seagrass mapping extent

Seagrass meadow zones

- Colosseum Inlet
- Inner Harbour
- Lower Boyne Estuary
- Mid Boyne Estuary
- Mid Harbour
- Outer Harbour
- Rodds Bay
- South Trees Inlet (Lower)
- South Trees Inlet (Upper)

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Seagrass mapping extent: Chartrand et al. (2019)
Navigational aids: GPC (2014)

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0 1,250 2,500 Metres

Date: 08/08/2019 Version: 7 Job No: 237374

Coordinate system: GDA_1994_MGA_Zone_56

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Figure 9.6a: Extent of seagrass meadows in Outer Harbour in 2018

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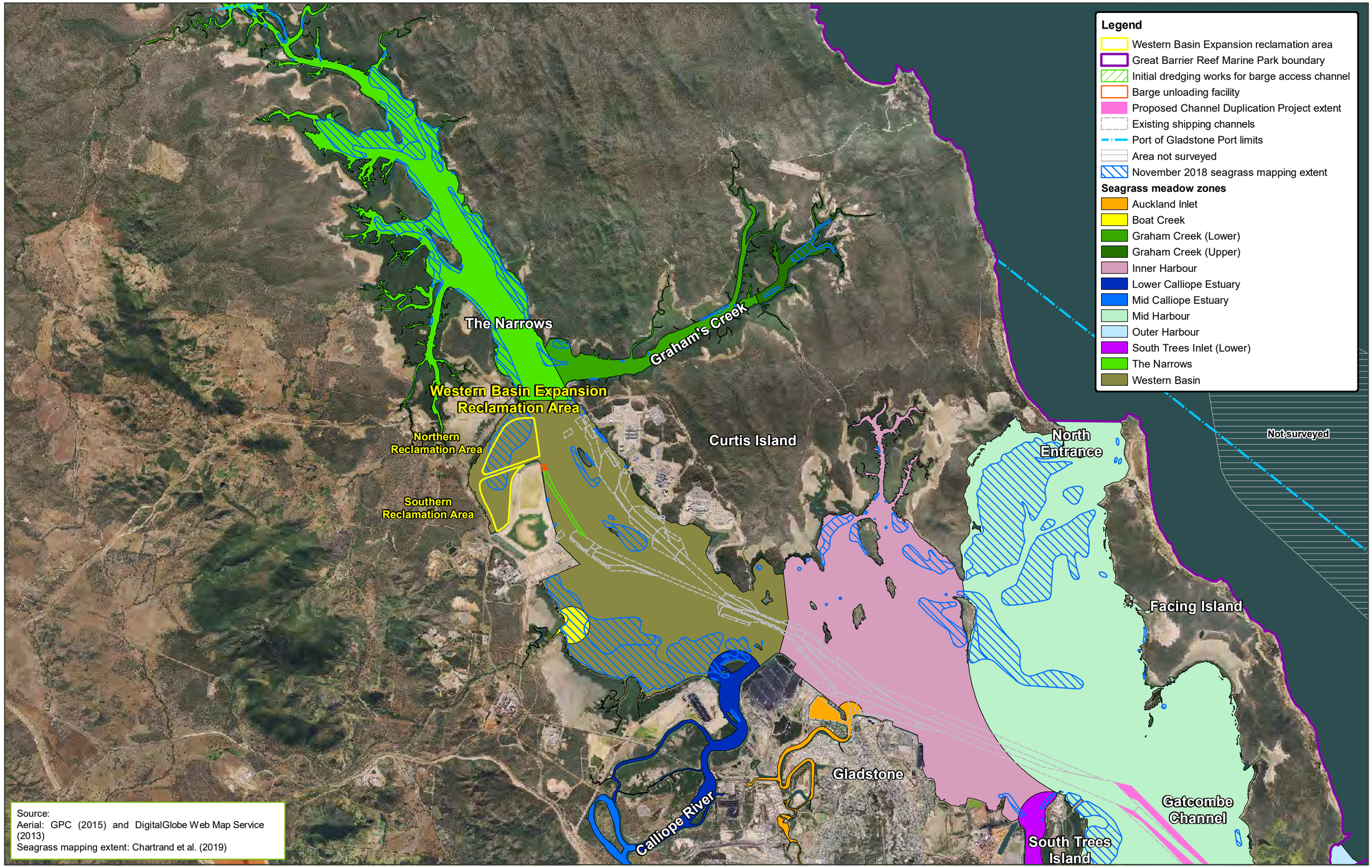

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Seagrass mapping extent: Chartrand et al. (2019)

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Coordinate system: GDA_1994_MGA_Zone_56

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Figure 9.6b: Extent of seagrass meadows in Inner Harbour in 2018

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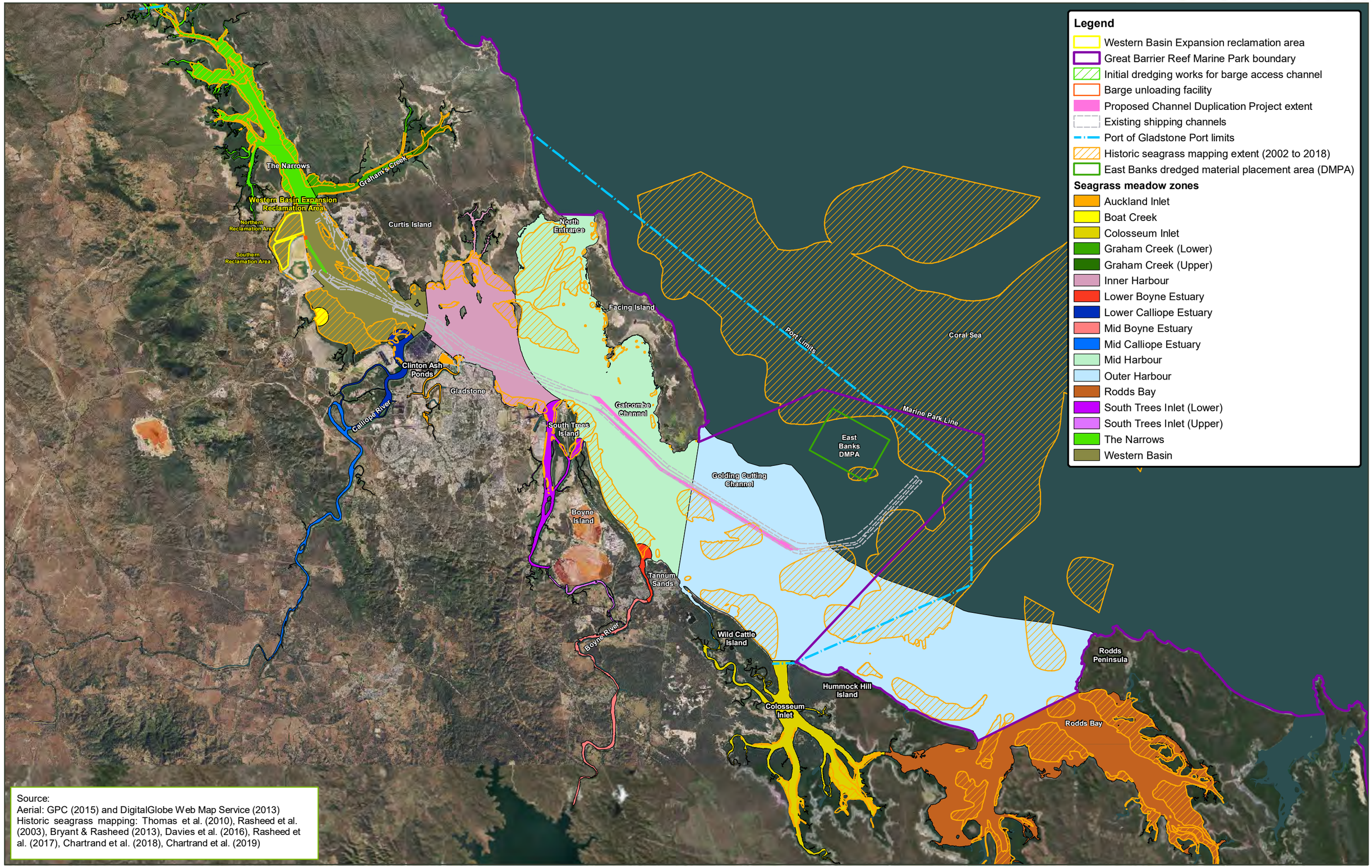

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Historic seagrass mapping: Thomas et al. (2010), Rasheed et al. (2003), Bryant & Rasheed (2013), Davies et al. (2016), Rasheed et al. (2017), Chartrand et al. (2018), Chartrand et al. (2019)

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0 2,550 5,100 Metres

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Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 9.7: Historical extent of seagrass meadows in Port Curtis and Rodds Bay (2002 to 2018)

- Increased sedimentation leading to ‘smothering’ seagrass
- Changing existing bathymetry and seabed depth (e.g. erosion)
- Altering existing hydrodynamics such as sediment resuspension and siltation rates (York and Smith 2013).

It has been recognised that the potential for seagrass species to recover from natural and anthropogenic disturbances can vary between species (Davies et al. 2015). Seagrass meadows in Port Curtis have shown a capacity to recover from natural and anthropogenic impacts (Davies et al. 2015). Therefore, the seasonal and long term variation in the quality and extent of seagrass meadows should be considered when determining the Project impacts on seagrass.

The direct impact areas on seagrass meadows are defined as the areas that the Project directly impacts upon (i.e. the establishment of the WBE reclamation area and BUF, barge access channel, and the channel duplication area to be dredged). The potential Project indirect impact areas on seagrass meadows at the WBE reclamation area is based on erosion and sedimentation impacts due to changes in tidal velocities adjacent to the WBE reclamation area. The potential indirect impacts areas at the channel duplication area to be dredged includes the seagrass meadows that are located within the zone of high impact, where existing light levels will drop below biological tolerances of seagrass communities (BMT WBM 2019). The seagrass meadows located within the zone of high impact, moderate impact, low impact and influence will be managed through the Project Dredging EMP, Project EMP and Environmental Monitoring Procedure (refer AEIS Appendices F to H, respectively). The zones of impact from the dredging activities and the seagrass meadows identified from 2002 to 2018, likely to be affected are shown in Figure 9.8. The zones of impact from the dredging activities and the seagrass meadows identified in the November 2018 survey are shown in Figure 9.9.

As part of a Project commitment, pre-dredging surveys of the deep water seagrass meadows will occur to determine the level of direct impact to the seagrass meadows located within the channel. Where there will be a direct permanent loss of deep water seagrass meadows as a result of the Project, offsets will be provided under the Project’s offset strategy (refer AEIS Appendix E4).

Based on the historic distribution of seagrass meadows from survey data between 2002 and 2018, the potential Project direct impact on seagrass meadows at the WBE reclamation area is approximately 275.23ha and at the channel duplication area to be dredged is 35.65ha. The potential Project indirect impact on seagrass meadows at the channel duplication area to be dredged is approximately 976.39ha. The permanent loss of deep water seagrass within the Project zone of high impact (i.e. indirect impact area) is unlikely due to the implementation of adaptive management measures contained in the Environmental Monitoring Procedure (refer AEIS Appendix H). Table 9.11 and Table 9.12 provides a summary of the potentially impacted seagrass meadows relevant to the Project impact areas. The impacts are discussed in more detail in the significant residual adverse impact assessment (refer Section 9.4.6).

Figure 9.10a and Figure 9.10b provides the location of seagrass meadows that are considered to be potentially directly and indirectly impacted as a result of the Project.

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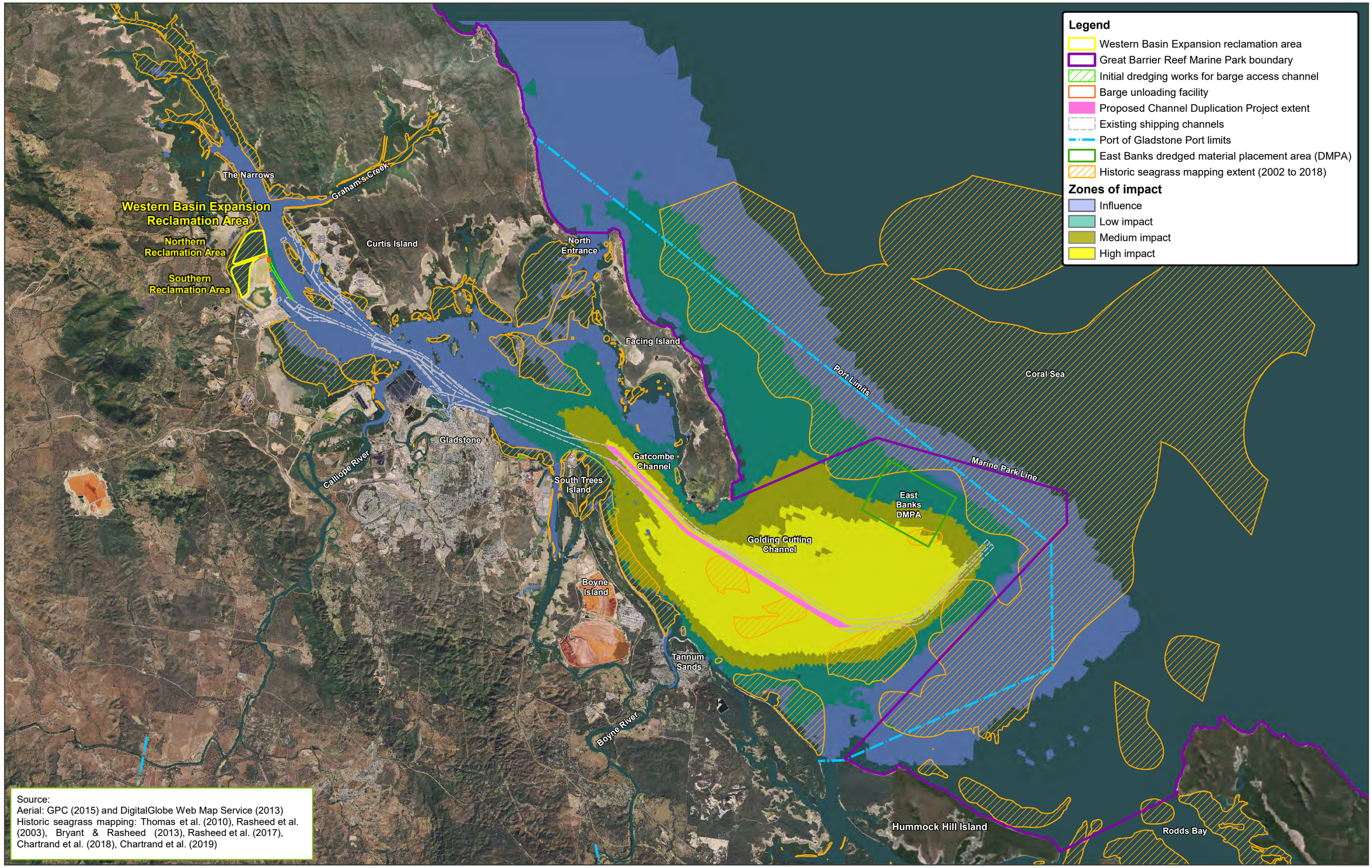

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Historic seagrass mapping: Thomas et al. (2010), Rasheed et al. (2003), Bryant & Rasheed (2013), Rasheed et al. (2017), Chartrand et al. (2018), Chartrand et al. (2019)

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Date: 08/08/2019 Version: 11 Job No: 237374

Coordinate system: GDA_1994_MGA_Zone_56

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Figure 9.8: Seagrass meadows (historical extent) within the zones of impact (Stages 1 and 2 dredging)

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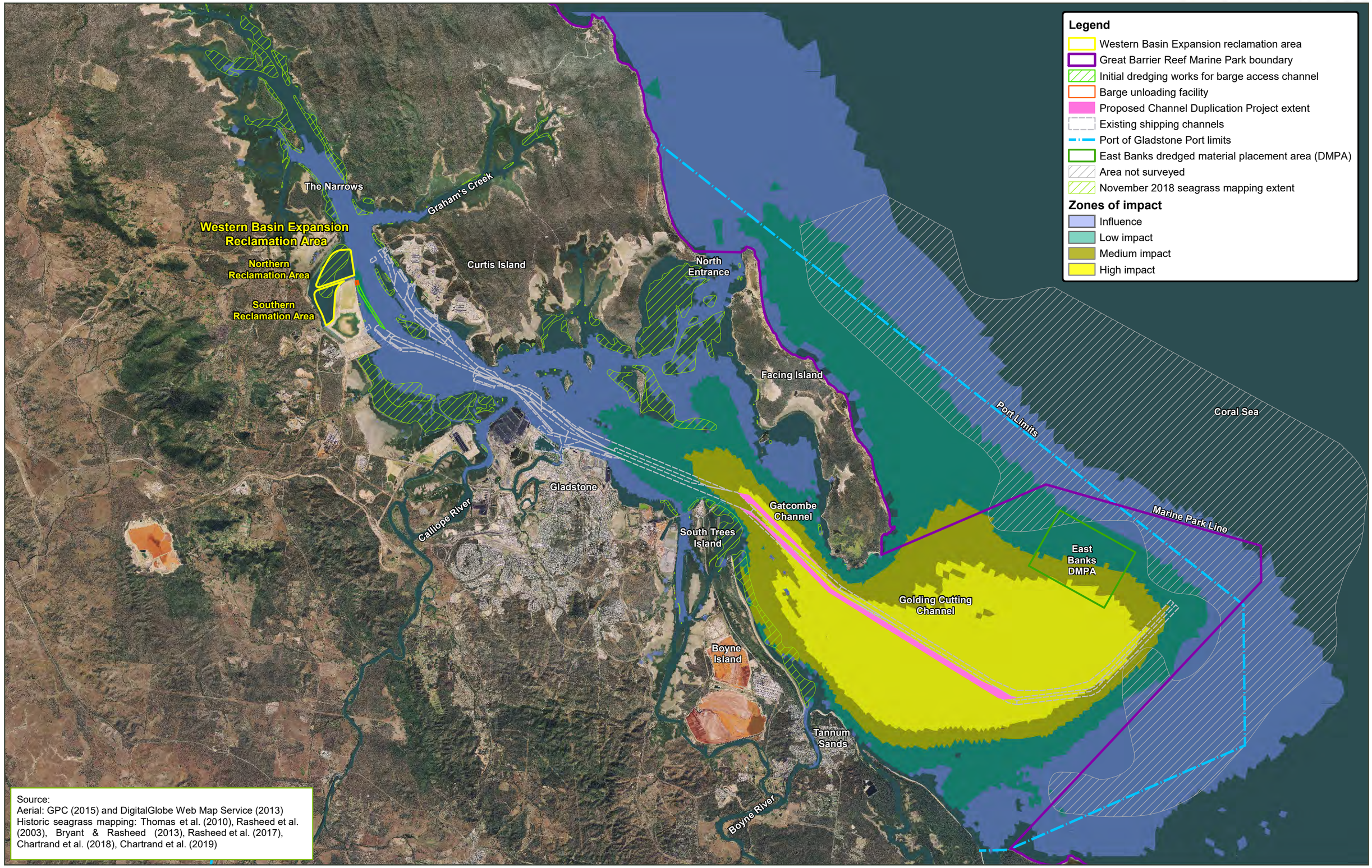

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Historic seagrass mapping: Thomas et al. (2010), Rasheed et al. (2003), Bryant & Rasheed (2013), Rasheed et al. (2017), Chartrand et al. (2018), Chartrand et al. (2019)

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0 1,900 3,800 Metres

Date: 08/08/2019 Version: 9 Job No: 237374

Coordinate system: GDA_1994_MGA_Zone_56

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Figure 9.9: Seagrass meadows (November 2018) within the zones of impact (Stages 1 and 2 dredging)

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Western Basin Expansion Reclamation Area

Northern Reclamation Area

Southern Reclamation Area

Existing Western Basin Reclamation Area

Fisherman's Landing

Legend

- Project direct impact on seagrass meadows
- Potential Project indirect impact areas on seagrass meadows
- Historic seagrass mapping extent (2002 to 2018)
- Western Basin Expansion reclamation area
- Initial dredging works for barge access channel
- Barge unloading facility
- Existing shipping channels

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)

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0 255 510 Metres

Date: 08/08/2019 Version: 5 Job No: 237374

Coordinate system: GDA_1994_MGA_Zone_56

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Figure 9.10a: Potential Project direct and indirect impact areas on seagrass meadows at the WBE reclamation area

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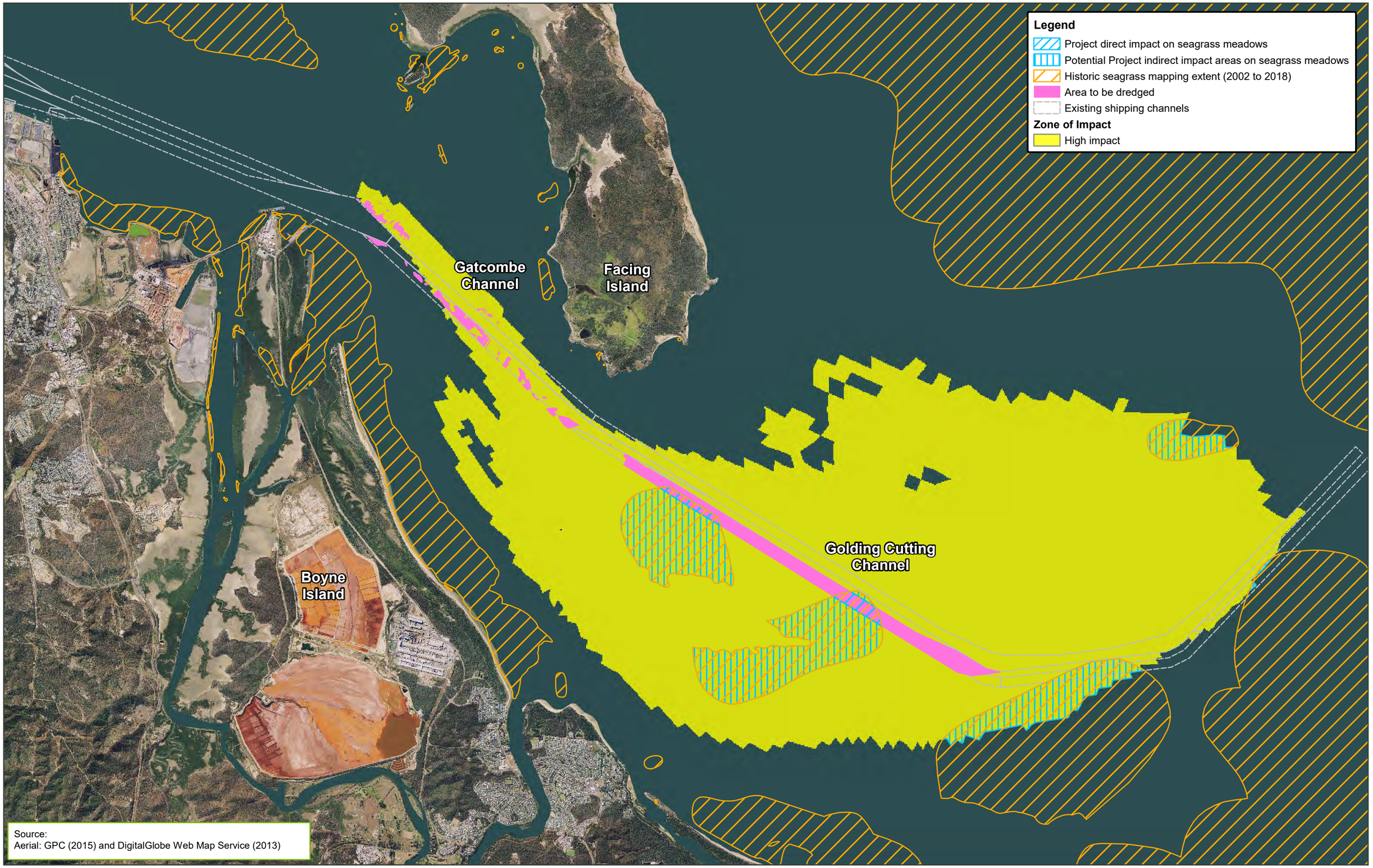

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0 800 1,600 Metres

Date: 09/08/2019 Version: 6 Job No: 237374

Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 9.10b: Potential Project direct and indirect impact areas on seagrass meadows at the channel duplication area to be dredged

Table 9.11 Estimate of potential Project direct impact area based on historic mapping of seagrass meadows

Project activity	Potential direct impact area on historic mapping of seagrass meadows	Total
WBE reclamation area (southern area)	110.48ha	275.23ha
WBE reclamation area (northern area)	164.75ha	
BUF	0ha[1]	0ha
Barge access channel	0ha[1]	0ha
Area to be dredged (Stage 1 and Stage 2 combined)	35.65ha	35.65ha
Total		**310.88ha**

Table note:

1 The Project direct impact is considered to be negligible after consideration of existing indirect impact from the existing Western Basin reclamation area and is therefore excluded from the Project impact assessment.

Table 9.12 Estimate of potential Project indirect impact area based on historic mapping of seagrass meadows

Project activity	Potential indirect impact area on historic mapping of seagrass meadows	Total
WBE reclamation area (southern area)	99.41ha[1]	99.41ha[1]
WBE reclamation area (northern area)		
BUF	0ha[2]	0ha
Barge access channel	0ha[2]	0ha
Area to be dredged (Stage 1 and Stage 2 combined)	876.98ha[3]	876.98ha[3]
Total		**976.39ha**

Table notes:

1 The Project potential indirect impact area for the establishment of the WBE reclamation area has been combined for the southern and northern area. The Project indirect impact area is based on erosion and sedimentation impacts due to changes in tidal velocities adjacent to the WBE reclamation area

2 The Project indirect impact is considered to be associated from the existing Western Basin reclamation area and is therefore excluded from the Project impact assessment.

3 Project indirect impact area is based on the predicted zone of high impact for the channel duplication dredging activities

The overall Project hydrodynamic model results indicate that some short term impacts to turbidity levels are expected throughout the Port area, with the highest increases in turbidity levels expected to occur in areas outside of the Port where wave activity can resuspend existing sediment and dredged sediment after initial deposition. It is important to note that the ambient (background) turbidity level is high throughout the Project impact areas. The model results indicate minor sustained impacts to the turbidity level within the Port, and higher sustained (but temporary) effects in the vicinity of the area to be dredged and further offshore (due to resuspension activity).

Modelling results also indicated a short term increase in the deposition rate in a number of areas within the Port and also along the coastline to the north. Minor sustained (but temporary) increases in the deposition rate are noted within the Port, with larger increases in the outer part of the shipping channel (refer Project EIS Chapter 8). Figure 9.11 and Figure 9.12 give an overall indication of the spatial distribution of the predicted Project dredging activities impacts.

9.4.3 Macroalgae values within the Port

This section supplements the Project EIS Section 9.8.3 (epibenthic macroalgae values) and Appendix I1 (Section 7.3).

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The Narrows
Graham's Creek
Western Basin Expansion Reclamation Area
Northern Reclamation Area
Southern Reclamation Area
Curtis Island
North Entrance
Facing Island
Port Limits
Coral Sea
Gladstone
Gallitope River
South Trees Island
Gatcombe Channel
Marine Park Line
East Banks DMPA
Golding Cutting Channel
Boyne Island
Tannum Sands
Boyne River

Legend

- Western Basin Expansion reclamation area
- Initial dredging works for barge access channel
- Barge unloading facility
- Great Barrier Reef Marine Park boundary
- Proposed Channel Duplication Project extent
- Existing shipping channels
- Port of Gladstone Port limits
- East Banks dredged material placement (DMPA)
- Historic seagrass mapping extent (2002 to 2018)

Impact of dredging on the 50th percentile of turbidity

Turbidity (NTU)

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Historic seagrass mapping: Thomas et al. (2010), Rasheed et al. (2003), Bryant & Rasheed (2013), Davies et al. (2016), Rasheed et al. (2017), Chartrand et al. (2018), Chartrand et al. (2019)

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0 1,700 3,400 Metres

Date: 08/08/2019 Version: 11 Job No: 237374

Coordinate system: GDA_1994_MGA_Zone_56

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Figure 9.11: 50th percentile of depth averaged turbidity (above background) impact of overall dredging campaign

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The Narrows
Graham's Creek
Western Basin Expansion Reclamation Area
Northern Reclamation Area
Southern Reclamation Area
Curtis Island
North Entrance
Facing Island
Port Limits
Coral Sea
Gladstone
Gallitope River
Gatcombe Channel
South Trees Island
Marine Park Line
East Banks DMPA
Golding Cutting Channel
Boyne Island
Tannum Sands
Boyne River

Legend

- Western Basin Expansion reclamation area
- Great Barrier Reef Marine Park boundary
- Initial dredging works for barge access channel
- Barge unloading facility
- Proposed Channel Duplication Project extent
- Existing shipping channels
- Port of Gladstone Port limits
- East Banks dredged material placement area (DMPA)
- Historic seagrass mapping extent (2002 to 2018)

Impact of dredging on the 95th percentile of turbidity

Turbidity (NTU)

- 0 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 25
- 25 - 30
- 30 - 35
- 35 - 40

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Historic seagrass mapping: Thomas et al. (2010), Rasheed et al. (2003), Bryant & Rasheed (2013), Davies et al. (2016), Rasheed et al. (2017), Chartrand et al. (2018), Chartrand et al. (2019)

Map by: RB P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_264.mxd 08/08/2019 10:20

0 1,700 3,400 Metres

Date: 08/08/2019 Version: 10 Job No: 237374

Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 9.12: 95th percentile of depth averaged turbidity (above background) impact of overall dredging campaign

The Project EIS Section 9.8.3 (epibenthic macroalgae values) identified a number of epibenthic macroalgae species within the database search area. Further benthic macroalgae surveys were undertaken as part of deep water surveys in 2002 and 2013 (Rasheed et al. 2003; McKenna et al. 2014). It was identified that most of the algal communities in the 2002 and 2013 surveys occur within proximity to shipping channels, port facilities and the existing East Banks dredged material placement area. Figure 9.13 identifies the location, density and distribution of benthic macroalgae within the Port Curtis region from the November 2013 survey. The 2002 macroalgae survey identified low coverage and did not form distinct community regions and was therefore not mapped (Rasheed et al. 2003; McKenna et al. 2014).

Benthic macroalgal communities, as surveyed and mapped in November 2013 in Port Curtis, occurred in aggregated patches throughout the survey area and covered approximately 26,008ha (i.e. 28.7%).

Recent discussions in June and July 2019 with DES identified that there is new intertidal and subtidal ecosystem mapping being created as part of the Queensland Wetlands Program. This mapping is currently in the user testing stage and has not been released for public view as of 5 August 2019. It is understood that this mapping provides detailed assessments of benthic macroalgae which have been completed utilising field verified and modelled predictions of the distribution of benthic macroalgae within the Port Curtis region. Therefore as this new mapping system is yet to be publicly released, current publicly available data for macroalgae has been reviewed for the AEIS and no update has been made from the existing information provided in the Project EIS (refer Project EIS Sections 9.8 and 9.9).

Table 9.13 identifies the recorded macroalgae that will be potentially directly and indirectly impacted by the Project (Rasheed et al. 2003 and McKenna et al. 2014) (refer Figure 9.14). It should be noted that macroalgae can occupy a variety of habitats, including seagrass meadows (Diaz-Pulido and McCook 2008), therefore the Project impacts on seagrass meadows also includes macroalgae.

The indirect impacts to macroalgae within the Project zone of high impact (i.e. indirect impact area) is unlikely due to the implementation of adaptive management measures contained in the Environmental Monitoring Procedure (refer AEIS Appendix H). The impacts are discussed in more detail in the significant residual adverse impact assessment (refer Section 9.4.6).

Table 9.13 Recorded macroalgae within the potential Project impact areas

Project activity	Area within the Project potential direct impact area	Area within the Project potential indirect impact area
WBE reclamation area (southern area)	0ha	0ha
WBE reclamation area (northern area)	0ha	0ha
BUF	0ha	0ha
Barge access channel	0ha	0ha
Area to be dredged (Stage 1 and Stage 2 combined)	49.68ha	787.05ha[1]
Total	**49.68ha**	**787.05ha[1]**

Table note:

1 Project indirect impact area is based on the predicted zone of high impact for the channel duplication dredging activities

9.4.4 Potential direct and indirect impacts on marine plants

This section supplements the Project EIS Sections 9.5 and 9.9 (terrestrial and intertidal flora and wetlands and seagrass).

All marine plants in Queensland (including mangroves, seagrass, saltcouch and samphires) are protected. The protection applies over all tenures, including unallocated State land and privately owned land. Section 9.2.2 provides examples of marine plants.

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Curtis Island
North Entrance
Facing Island
Clinton Ash Ponds
Gladstone
Calliope River
Gatcombe Channel
South Trees Island
East Banks DMPA
Golding Cutting Channel
Port Limits
Marine Park Line
Coral Sea
Boyne Island
Tannum Sands
Boyne River
Wild Cattle Island
Colosseum Inlet
Hummock Hill Island
Rodds Peninsula
Rodds Bay

0 3 0 4 1 3 2 0 3 0 10 9 4 0 7 7 8 7 0 5 6

Legend

- Bustard Bay benthic habitat sites
- Western Basin Expansion reclamation area
- Great Barrier Reef Marine Park boundary
- Initial dredging works for barge access channel
- Barge unloading facility
- Proposed Channel Duplication Project extent
- Existing shipping channels
- Port of Gladstone Port limits
- East Banks dredged material placement area (DMPA)
- Benthic macroalgae habitat regions
- Deep water benthic habitat survey extent
- Medium cover density cover
- Low/Medium density cover
- Low density cover
- 7 Region ID (refer Table 3.17)

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Benthic macroalgae habitat regions and density cover: McKenna et al. (2014)

Map by: RB
P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_375.mxd 08/08/2019 10:23

Metres
0 1,900 3,800

Date: 08/08/2019 Version: 2 Job No: 237374
Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 9.13: Location, density and distribution of benthic macroalgae within the Port Curtis region (November 2013)

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Legend

- Benthic macroalgae habitat regions
- Project indirect impact areas on macroalgae
- Project direct impact areas on macroalgae
- Great Barrier Reef Marine Park boundary
- Proposed Channel Duplication Project extent
- Existing shipping channels
- Port of Gladstone Port limits
- East Banks dredged material placement area (DMPA)

Zone of Impact

- High impact

Gatcombe Channel

Facing Island

East Banks DMPA

Golding Cutting Channel

Boyne Island

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Benthic macroalgae habitat regions: McKenna et al. (2014)

Map by: RB P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_423.mxd 08/08/2019 11:27

0 800 1,600 Metres

Date: 08/08/2019 Version: 0 Job No: 237374

Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 9.14: Potential Project direct and indirect impact area on macroalgae

Project direct impact areas are defined as the areas that will result in the direct and permanent loss of marine plants. Indirect impact areas are the areas that have the potential to be affected by Project activities for example, via changes in water quality, noise and dust levels, erosion and sedimentation and other edge effects.

The Project EIS Section 9.5 (terrestrial and intertidal flora and wetlands – potential impacts and risk assessment) and Section 9.2.2 of the AEIS identified that the Project has the potential to have an indirect impact on mangrove and saltmarsh marine plants. Section 9.4.2 and 9.4.3 identified that the Project will have a potential direct and indirect impact on seagrass meadows and macroalgae. Table 9.14 identifies the marine plants that will be potentially directly and indirectly impacted by the Project. Marine plants located within the potential Project indirect impact will be managed (i.e. minimising potential impacts) through the implementation of the Dredging EMP, Project EMP and Project Environmental Monitoring Procedure (refer AEIS Appendices F to H). The impacts are discussed in more detail in the significant residual adverse impact assessment (refer Section 9.4.6). Figure 9.15 identifies the location of marine plants in respect to the Project impact areas.

Table 9.14 Area of marine plants within the Project potential impact areas

Marine plant	Area within the Project potential direct impact areas	Area within the Project potential indirect impact areas
Seagrass meadows	310.88ha	976.39ha[1]
Samphire forbland on marine clay plains	0ha	33.52ha[2]
Mangrove low open forest and/or woodland on marine clay plains	0ha	23.51ha[2]
Saltpan vegetation including grassland, herbland and sedgeland on marine clay plains	0ha	19.70ha[2]
Mangrove shrubland to low closed forest on marine clay plains and estuaries	0ha	17.77ha[2]
Macroalgae	49.68ha	787.05ha[3]
Total	**360.56ha**	**1,857.94ha**

Table notes:

1 The Project indirect impact area is based on erosion and sedimentation impacts due to changes in tidal velocities adjacent to the WBE reclamation area and the zone of high impact for the channel duplication dredging activities
2 The Project indirect impact area is based on 500m buffer surrounding the WBE reclamation area direct impact area to ensure associated edge effects on adjacent ecological values have been addressed
3 The Project indirect impact area is based on the zone of high impact for the channel duplication dredging activities

9.4.5 Potential cumulative and synergistic impacts from Project activities

This section supplements the Project EIS Section 9.9 (seagrass meadows and epibenthic macroalgae – potential impacts and risk assessment) which provides an assessment of the potential impacts of the various Project activities on marine plants, including seagrass, mangroves and macroalgae.

The cumulative impact assessment that is applicable to the Project, considering foreseeable significant' projects and exogenous factors such as flood events and climate change is provided in the Project EIS (Chapter 21 – cumulative impact assessment and Appendix P). This section provides the cumulative assessment of the Project activities (i.e. the establishment of the WBE reclamation area and BUF, dredging activities, installation and removal of navigational aids, and operation and maintenance) as a whole.

To identify potential synergistic impacts on marine plants, this section provides an assessment of the potential cumulative Project impacts that were previously addressed individually as discrete Project activities on marine plants (refer Project EIS Sections 9.9.2 to 9.9.5).

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Gatcombe Channel
South Trees Island
Marine Park Line
East Banks DMPA
Golding Cutting Channel
Boyne Island
Tannum Sands
Rodds Bay

11.1.4a
11.1.2a
11.1.4c
12.1.3
12.1.2

Legend

- Historical seagrass mapping extent (2002-2018)

Regional Ecosystems V11

- Category A or B area that is least concern
- Category C or R area that is of least concern
- Western Basin Expansion reclamation area
- Great Barrier Reef Marine Park boundary
- Initial dredging works for barge access channel
- Barge unloading facility
- Proposed Channel Duplication Project extent
- Existing shipping channels
- Port of Gladstone Port limits
- East Banks dredged material placement area (DMPA)
- Benthic macroalgae habitat regions
- Deep water benthic habitat survey extent
- Medium cover density cover
- Low/Medium density cover
- Low density cover

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Benthic macroalgae habitat regions and density cover: McKenna et al. (2014)
Vegetation management regional ecosystem map - version 11.0:

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Map by: RB

0 1,900 3,800 Metres

Date: 09/08/2019 Version: 4 Job No: 237374
Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 9.15: Location of marine plants within the Project impact areas

The Project activities can be described as occurring in discrete spatial areas although there is some temporal overlap of Project activities. The spatial categories are described below and their location (i.e. area of direct impact) is provided in Figure 9.2.

- Establishment of the WBE reclamation area and BUF
- Dredging activities
- Removal and installation of navigational aids
- Stabilisation and maintenance activities.

The Project dredging works will be undertaken as either a staged dredging campaign (i.e. over two stages) or as a singular campaign. Figure 9.16 illustrates the Project activity timeframes and dredging campaign options.

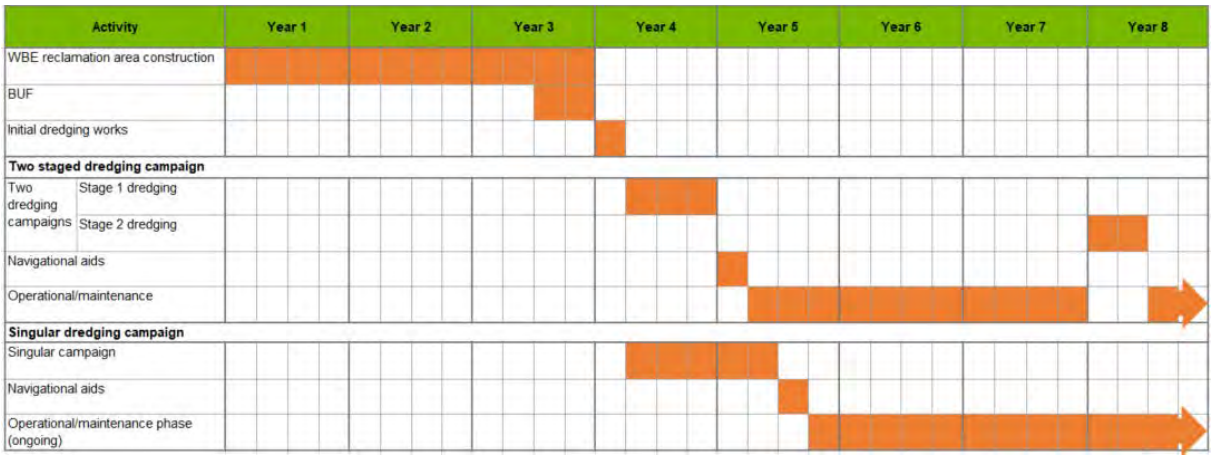

Figure 9.16 Indicative Project activity timeframes

Whilst the location of direct impacts is discrete, it is acknowledged that indirect impacts arising from the discrete Project locations (e.g. silt plumes, alterations to water quality and increased vessel movement) have the potential to result in impacts that overlap in a spatial and temporal context. Given this overlap, synergistic interactions resulting from multiple Project related impacts have the potential to impact upon marine plants, with the results being greater than the sum of any of the single stressors alone.

Potential cumulative impacts were assessed in conjunction with potential synergistic impacts from Project activities. Cumulative impacts were defined as an accumulation of impact from all Project activities. These were considered to be independent of temporal constraints and constituted a contributing factor driving synergistic processes. Accordingly, cumulative impacts were not assessed *per se* but rather, were assessed within the synergistic impact assessment and were incorporated into the significant residual adverse impact assessment.

Synergistic impacts result from multiple processes which act simultaneously upon a particular value. The magnitude of impact would be a function of the initial direct impact and further direct impacts (as an accumulation) and/or a function of the initial direct impact with potentiation from further indirect impacts (as a synergy) with consideration for any amplification associated with the multiple factors acting simultaneously.

To identify potential Project synergistic impacts upon marine plants, the Project EIS impact assessment outcomes (as a whole of program rather than discrete Project activities) were assessed (refer Project EIS sections 9.9.2 to 9.9.5 and AEIS Appendices E1, E2 and E3). This enabled potential Project direct impacts (and indirect impacts) to be identified and the potential for contribution towards synergistic processes upon threatening process to be considered. This approach acknowledged the potential scale of the Project related impacts on the value and its potential to impact upon the value's capacity for recovery from the impact by contributing to a recognised threatening process.

Significant synergistic impacts were defined as potential synergistic impacts that had the capacity to contribute towards threatening processes that are recognised for a value (e.g. seagrass/marine plants). The resulting likelihood of risk identified the likely contribution of synergistic pathways upon the residual adverse impact of that value.

The synergistic assessment utilised a qualitative risk approach to determine the potential risk of a significant synergistic impact. Noting that a quantitative analysis was not possible as data related to synergistic processes is traditionally non-tractable to analysis, a risk-based assessment was utilised.

The synergistic impact assessment for marine plants was conducted for MSES/MNES values only.

Potential Project related impacts assessed as potentially significant (post implementation of impact mitigation measures) were identified as potential pathways for significant synergistic impacts and consisted of:

- Permanent loss and alteration of habitat
- Hydrology impacts
- Erosion and sedimentation
- Potential short term decline in water quality.

The framework of assessment focussed on:

- The potential Project activity impacts
- The synergistic pathways associated with the Project activities
- How the potentiated impacts contribute to threatening processes, and
- The likelihood of risk of significant impact (refer Table 9.15) from the synergistic impact contribution to threatening processes.

Table 9.15 Likelihood definitions for potential impacts occurring over the life of the Project

Description	Frequency
Unlikely	Unlikely but not trivial. May occur during construction/life of the Project but probability < 50%
Potential	Less likely than not, but still considerable; probability of about 50% chance of occurring over the life of the Project
Likely	Likely to occur during construction/life of the Project or during a 12 month timeframe; probability up to 90% chance of occurring

Potential impacts to threatening processes (across all Project activities) have been identified in the Project EIS Sections 9.9.2 to 9.9.5. These sections outline the initial Project impact which contribute to the synergies with other potential Project impacts. For further detail, refer to applicable potential Project activity impacts within the Project EIS Sections 9.9.2 to 9.9.5.

Increased impact associated with competition, resource accumulation, reproductive opportunity loss and a reduction in biological fitness were assessed as pathways for the potential to contribute to threatening processes as potential indirect synergistic impacts. Potential indirect synergistic impacts were typically associated with potential to reduce a value's life history parameters (e.g. reduced growth, reproduction, resource accumulation), through to the potential reduction in population resilience as a contributing factor towards threatening processes. Increased competition has been considered to initially derive from Project potential impacts, including permanent removal of habitat, short term decline in water quality, reduced light availability and short term increase in sedimentation.

Reproductive opportunity has been considered to initially derive from Project potential impacts, including permanent removal of habitat and altered hydrology and velocity flows which have the potential to result in the failure of flowers to pollinate in soft sediment habitats with reduced seed-set.

Reductions in biological fitness of marine plant communities has been considered to derive from all of the initial Project potential impacts, as potential reproductive opportunities were considered to be contributing factors to this synergistic pathway. Synergistic impacts which act upon resilience were considered to result in potential reduction in individual and population biological fitness.

The potential Project synergistic impacts (includes both direct and indirect impacts) on marine plant values include:

- Direct and/or permanent loss of marine plants
- Alteration of habitat
- Short term increase in sedimentation
- Hydrodynamic impacts
- Short term declines in water quality.

Table 9.16 provides a summary of the potential synergistic impacts from the Project as a whole on marine plants. For the purposes of determination of the risk assessment with significant synergistic impact, Project direct impacts were contained in concert with synergistic pathways to determine the potential of synergistic impacts that will contribute towards threatening processes. The likelihood of risk was determined based on Table 9.15 definitions.

Table 9.16 Risk of significant synergistic impact from identified Project impacts on marine plants

Marine plant value (MNES/MSES)	Species threats identified in relevant research articles, and MSES criteria[#]	Project direct impact (as result of whole program)	Potential Project pathways acting in synergy with Project impact	Potential indirect synergistic impact contributing to threatening processes	Likelihood of risk of significant impact (refer Table 9.15)
MSES marine plant values (seagrass) under the Fisheries Act	■ **Loss of habitat** ■ **Alteration of habitat** ■ **Poor water quality** ■ **Reduced light** ■ **Disease** ■ **Introduction of invasive seaweed** ■ **Increased nutrient runoff** ■ Increased intensity of storms, floods and cyclones ■ Sea surface temperature and sea level rise ■ **Fragmentation or increased fragmentation of marine plant** ■ **Adverse changes affecting survival of marine plants through modifying or destroying abiotic factors necessary for a marine plant's survival** ■ **Alteration in the species composition or marine plants in an ecological community**	Permanent loss of habitat	■ Permanent change of habitat ■ Temporary decline in water quality ■ Increased vessel movement ■ Reduced light availability	■ Increase in potential mortality from contact with dredging equipment from modification of habitat use ■ Reduction in individual and population resilience ■ Minor reduction of life-history parameters ■ Fragmentation of habitat	Likely
		Alteration of habitat	■ Permanent change of habitat ■ Temporary decline in water quality	■ Reduction in individual and population resilience ■ Minor reduction of life-history parameters ■ Fragmentation of habitat	Potential
		Short term increase in sedimentation	■ Potential vessel interaction ■ Temporary decline in water quality ■ Increased turbidity ■ Smothering ■ Reduced light availability	■ Reduction in individual and population resilience ■ Minor reduction of life-history parameters	Unlikely
		Hydrodynamic impacts	■ Permanent change of habitat ■ Temporary decline in water quality ■ Increased turbidity ■ Reduced light availability	■ Minor reduction in life-history parameters ■ Reduction in population resilience	Potential

Marine plant value (MNES/MSES)	Species threats identified in relevant research articles, and MSES criteria[#]	Project direct impact (as result of whole program)	Potential Project pathways acting in synergy with Project impact	Potential indirect synergistic impact contributing to threatening processes	Likelihood of risk of significant impact (refer Table 9.15)
	■ **Interference with the natural recovery of marine plants**	Short term declines in water quality	■ Permanent change of habitat ■ Increase turbidity ■ Reduced light availability	■ Increase in potential mortality from contact with dredging equipment from modification of habitat use ■ Reduction in population resilience	Potential
MSES marine plant values (macroalgae) under the Fisheries Act	■ **Loss of habitat** ■ **Alteration of habitat** ■ **Poor water quality** ■ Increased intensity of storms, floods and cyclones ■ **Introduction of invasive species** ■ Sea surface temperature and sea level rise ■ **Fragmentation or increased fragmentation of marine plant** ■ **Adverse changes affecting survival of marine plants through modifying or destroying abiotic factors necessary for a marine plant's survival** ■ **Alteration in the species composition or marine plants in an ecological community** ■ **Interference with the natural recovery of marine plants**	Permanent loss of habitat	■ Permanent change of habitat ■ Temporary decline in water quality ■ Increased vessel movement	■ Reduction in individual and population resilience ■ Minor reduction of life-history parameters ■ Fragmentation of habitat	Likely
		Alteration of habitat	■ Permanent change of habitat ■ Temporary decline in water quality	■ Reduction in individual and population resilience ■ Minor reduction of life-history parameters	Potential
		Short term increase in sedimentation	■ Potential vessel interaction ■ Temporary decline in water quality	■ Reduction in individual and population resilience ■ Minor reduction of life-history parameters	Unlikely
		Hydrodynamic impacts	■ Permanent change of habitat ■ Temporary decline in water quality ■ Increased turbidity	■ Minor reduction in life-history parameters ■ Reduction in population resilience	Potential
		Short term declines in water quality	■ Permanent change of habitat ■ Increase turbidity	■ Increase in potential mortality from contact with dredging equipment from modification of habitat use ■ Reduction in population resilience	Potential

Marine plant value (MNES/MSES)	Species threats identified in relevant research articles, and MSES criteria[#]	Project direct impact (as result of whole program)	Potential Project pathways acting in synergy with Project impact	Potential indirect synergistic impact contributing to threatening processes	Likelihood of risk of significant impact (refer Table 9.15)
MSES marine plant values (mangroves and saltmarshes) under the Fisheries Act	■ **Loss of habitat** ■ **Alteration of habitat** ■ **Poor water quality** ■ Increased intensity of storms, floods and cyclones ■ **Introduction of invasive species** ■ Sea surface temperature and sea level rise ■ **Fragmentation or increased fragmentation of marine plant** ■ **Adverse changes affecting survival of marine plants through modifying or destroying abiotic factors necessary for a marine plant's survival** ■ **Alteration in the species composition or marine plants in an ecological community** ■ **Interference with the natural recovery of marine plants**	Permanent loss of habitat	■ Permanent change of habitat ■ Temporary decline in water quality ■ Increased vessel movement	■ Reduction in individual and population resilience ■ Minor reduction of life-history parameters	Unlikely
		Alteration of habitat	■ Permanent change of habitat ■ Temporary decline in water quality	■ Reduction in individual and population resilience ■ Minor reduction of life-history parameters ■ Displacement of foraging species	Unlikely
		Short term increase in sedimentation	■ Potential vessel interaction ■ Temporary decline in water quality	■ Reduction in individual and population resilience ■ Minor reduction of life-history parameters	Unlikely
		Hydrodynamic impacts	■ Permanent change of habitat ■ Temporary decline in water quality ■ Increased turbidity	■ Minor reduction in life-history parameters ■ Reduction in population resilience	Potential
		Short term declines in water quality	■ Permanent change of habitat ■ Increase turbidity	■ Reduction in population resilience ■ Minor reduction in life-history parameters	Potential

Table note:

Bold identifies threats acknowledged in relevant research papers and MSES self assessment criteria which are those potentially impacted by Project activities

The assessment identified that the Project has the potential risk of significant synergistic impact for seagrass meadows and macroalgae values due to:

- Permanent and direct loss of seagrass meadows and macroalgae
- Potential habitat alteration due to potential hydrological and water quality impacts.

The significance of any potential synergistic impact on mangroves, saltmarshes and other marine plants is considered to be low.

The Project will implement mitigation measures provided in the Dredging EMP and Project EMP (refer AEIS Appendices F and G, respectively) and associated management plans to reduce the risk of potential Project impacts on marine plant values.

A significant residual adverse impact assessment has been conducted for marine plant values (i.e. seagrass meadows and macroalgae) as the Project was identified as potentially having a residual sequential impact on the value. The significant residual adverse impact assessment for marine plant values is provided in Section 9.4.6.

9.4.6 Significant residual adverse impact assessment

This section replaces the Project EIS Section 9.9.7 (seagrass – significant residual adverse impact assessment).

The Project EIS significant residual adverse impact assessment for marine plant values has been reviewed as part of the AEIS to ensure that the Project activities have been assessed at their broadest scope (i.e. the cumulative impact of all Project activities have been assessed) and that potential offsite and indirect Project impacts have been included in the significance assessment. This assessment has considered indirect Project impacts as per the definition of 'offsite and indirect' impacts provided in the *Queensland Environmental Offsets Policy Significant Residual Impact Guideline* (EHP 2014a).

Offsite and indirect impacts are identified via the Project impact magnitude assessment. The magnitude of a potential Project impact is a product of the temporal duration of the potential impact and the spatial scale of the impact. For each impact the estimated duration of the impact is identified (i.e. its anticipated temporal extent) and classified as temporary, short term, medium term, long term or permanent. The anticipated spatial extent of the potential impact is classified as undetectable, contained extent, local area or extensive. The consequence of the potential Project impact is determined by combining the impacts temporal and spatial extents in the magnitude matrix. AEIS Appendix E1 provides further information and definitions regarding Project assessment of magnitude.

For the purposes of this significance assessment of offsite and indirect impacts, the magnitude assessments of the potential Project residual impacts relative to the significant impact criteria assessed were considered. The consequence assessments for each relative Project residual impact were considered with respect to the potential combined, cumulative Project impact to ensure that the impact assessment was conducted with respect to the Project's broadest scope (i.e. all Project activities).

The Significant Residual Impact Guideline (EHP 2014b) outlines the criteria for identifying when an impact on prescribed environmental matters (i.e. MSES) has the potential to be significant. The significant impact criteria provides a trigger for considering the need for implementing offsets for a project.

The significant residual adverse impact assessment provided in Table 9.18 has been prepared for MNES and/or MSES marine plant values which are considered to have a moderate or high likelihood of occurrence within the Project impact areas (refer Project EIS Appendix I2 (Appendix B)).

This assessment of significant residual adverse impacts considers the significance of potential Project impacts after the implementation of the Project mitigation measures included in the Dredging EMP and Project EMP (refer AEIS Appendices F and G, respectively).

Marine plants are protected under the Fisheries Act and are defined as the following:

a) *A plant (a tidal plant) that usually grows on, or adjacent to tidal land, whether it is living, dead, standing or fallen*

b) *Material of a tidal plant, or other plant material on tidal land*

c) *A plant, or material of a plant, prescribed by regulation to be a marine plant.*

Table 9.17 includes the marine plants which are subject to this significant residual adverse impact assessment, due to Project impacts having the potential to result in:

- Very high or high consequence (post mitigation measures) on a species (refer AEIS Appendix E3), and/or
- A residual impact to a threatening process (refer AEIS Appendix E2 (Item Q3.1)).

Table 9.17 Marine plant Matters of National Environmental Significance and Matters of State Environmental Significance subject to significance residual adverse impact assessment

Marine plant type (conservation significance)	MNES	MSES	Significance assessment
Coastal seagrass meadows (Protected (Fisheries Act))	N/A	Yes	Table 9.18
Deep water seagrass meadows (Protected (Fisheries Act))	N/A	Yes	
Macroalgae (Protected (Fisheries Act))	N/A	Yes	
Mangroves (Protected (Fisheries Act))	N/A	Yes	

The significant impact assessment criteria for marine plants (EHP 2014b) has been used for the significant residual adverse impact assessment (refer Table 9.18). The significant residual adverse impact assessment concluded that the proposed Project activities will have a significant residual adverse impact on marine plants (i.e. seagrass meadows and macroalgae).

Note that MNES which relate to seagrass meadows such as threatened species habitat (e.g. turtles and marine mammals) and Outstanding Universal Value (OUV) of the GBRWHA, are addressed under their respective sections within the Project EIS and AEIS.

Table 9.18 Significant residual adverse impact assessment for MSES marine plant values

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
MSES – Marine plant ■ Private infrastructure works impacting more than 17m^2 of fish habitat or public infrastructure works impacting more than 25m^2 of fish habitat	**MSES seagrass:** Potentially significant impact **MSES macroalgae:** Potentially significant impact **MSES mangroves:** Unlikely to have a significant impact **MSES other marine plants:** Unlikely to have a significant impact	Fish habitat includes marine plants, with the definition of marine plants, including seagrass communities, algae, mangroves, samphires and saltmarsh. The historic seagrass mapping indicates all of the locations where seagrass has been previously recorded (i.e. not necessarily all at one point in time). It is also noted that macroalgae can occupy habitats such as seagrass meadows, and as such impacts to macroalgae within the WBE reclamation area have been addressed in the assessment of potential seagrass meadow impacts. Project impacts have been identified which have the potential to adversely impact the marine plant values detailed in this significant impact assessment criteria. The potential for these impacts to extend to offsite and indirect impact areas has been evaluated via the Project activity's magnitude assessment. The results are summarised below. ■ Permanent loss and alteration of seagrass and macroalgae habitat during the establishment of the WBE reclamation area and dredging activities – Moderate magnitude: Potential residual impact considered to be permanent in duration (temporal) and contained in extent (spatial) ■ Hydrodynamic and water quality impacts resulting in habitat alteration during the establishment of the WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be permanent in duration (temporal) and contained in extent (spatial) ■ Contaminant and sediment releases resulting in impacts on habitat during the establishment of the WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be medium in duration (temporal) and contained in extent (spatial) The Project activities cumulative and synergistic impacts have been incorporated into the significant residual adverse impact assessment for this significant impact assessment criteria. The Project involves the permanent loss of seagrass meadows and macroalgae from establishment of the WBE reclamation area. This includes the direct and indirect disturbance of seagrass communities recorded from all seagrass surveys (2002 to 2018 historic mapping), including: ■ Approximately 110.48ha within the WBE reclamation area (southern area) ■ Approximately 164.75ha within the WBE reclamation area (northern area) ■ Approximately 99.41ha within the areas adjoining WBE reclamation area (indirect impacts from erosion and sedimentation due to changes in tidal velocities adjoining the WBE reclamation area).

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
		The cumulative and synergistic impact assessment identified that the Project has the potential risk of significant synergistic impact for seagrass and macroalgae values due to: ■ Permanent and direct loss of seagrass and macroalgae meadows ■ Potential habitat alteration due to potential hydrological and water quality impacts. The historic extent of seagrass meadows and macroalgae within the area to be dredged for the channel duplication is 85.33ha (comprising 35.65ha of deep water seagrass and 49.68ha of macroalgae), however no seagrass has been recorded in the channel duplication footprint since 2002. Baseline surveys of this area will be undertaken prior to the commencement of dredging to determine the extent of seagrass that will be directly impacted within the area to be dredged and indirectly impacted in the zone of high impact for the channel duplication. Further the Project dredging has the potential to have indirect impacts on seagrass meadows that are mapped within the Project dredging zone of high impact which is approximately 1,664.03ha (comprising 876.98ha of seagrass and 787.05ha of macroalgae) mapped from historic extent (i.e. 2002 to 2018). However the permanent loss of deep water seagrass and macroalgae within the Project zone of high impact (i.e. indirect impact area) is unlikely due to the implementation of adaptive management measures contained in the Environmental Monitoring Procedure (refer AEIS Appendix H). The historic seagrass within the BUF and barge access channel is considered to be negligible. The Project indirect impact to the historically mapped seagrass adjoining the BUF has been removed by the existing WBDDP reclamation area and therefore this seagrass is excluded from the Project impact assessment. Other marine plants such as mangroves, samphires and saltmarshes are not directly impacted by the Project. Therefore the significance of any potential cumulative and synergistic impacts on mangroves, saltmarshes and other marine plants is considered to be low. With the implementation of mitigation measures outlined in the Dredging EMP (refer AEIS Appendix F) and the Project EMP (refer AEIS Appendix G), it is unlikely that the Project will result in impacts on the mangrove and saltmarsh communities on the coastline adjacent to the WBE reclamation area. Under this significant impact assessment criteria there is likely to be significant residual adverse impact to marine plants due to: ■ Permanent loss of 374.64ha of seagrass meadows and macroalgae (fish habitat) as a result of the establishment of WBE reclamation area, including: – 110.48ha from the establishment of the WBE reclamation area (southern area) – 164.75ha from the establishment of the WBE reclamation area (northern area) – 99.41ha from indirect impacts from the establishment of the WBE reclamation area. ■ Permanent loss of 85.33ha of seagrass meadows and macroalgae (fish habitat) at the channel duplication area to be dredged.

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
MSES – Marine plant ■ Temporary impacts are expected to take five years or more for the impact area to be restored to its predevelopment condition	**MSES seagrass:** Unlikely to have a significant impact **MSES macroalgae:** Unlikely to have a significant impact **MSES mangroves:** Unlikely to have a significant impact **MSES other marine plants:** Unlikely to have a significant impact	**Unlikely to have a significant impact** Project impacts have been identified which have the potential to adversely impact the marine plant values detailed in this significant impact assessment criteria. The potential for these impacts to extend to offsite and indirect impact areas has been evaluated via the Project activity's magnitude assessment. The results are summarised below. ■ Potential decline in water quality during the establishment of the WBE reclamation area and BUF and dredging activities – Moderate magnitude: Potential residual impact considered to be medium term in duration (temporal) and contained in extent (spatial) The Project activities cumulative and synergistic impacts have been incorporated into the significant residual adverse impact assessment for this significant impact assessment criteria. The Project has the potential to result in short term (as defined in the risk assessment timeframe definition (refer AEIS Appendix E1)) declines in water quality as a result of dredging activities. Given the short and ephemeral lifecycle of deep water seagrass meadows and macroalgae within the high or moderate zones of impact, the temporary nature of the dredge plume, and the ability to modify dredging locations/durations to reduce the impacts to small areas of seagrass meadows within the high and moderate zones of impact, it is expected that the water quality impacts are unlikely to impact the seagrass meadows and macroalgae in the area in the long term. With the implementation of mitigation measures outlined in the Dredging EMP (refer AEIS Appendix F) and the Project EMP (refer AEIS Appendix G), it is unlikely that temporary impacts associated with short term declines in water quality would have a significant impact on seagrass meadows and macroalgae adjacent to the Project direct impact areas. Therefore, it is unlikely that the restoration of Project indirect impact areas will take more than five years. With consideration to the sequential timing and discrete locations of the Project activities and the aforementioned magnitude levels of any potential residual impact, the Project is not considered likely to have a significant residual adverse impact on this significant impact assessment criteria. Other marine plants such as mangroves, samphires and saltmarshes on the coastline adjacent to the WBE reclamation area are unlikely to be impacted as a result of Project activities. The Project includes the implementation of mitigation measures outlined in the Dredging EMP (refer AEIS Appendix F) and the Project EMP (refer AEIS Appendix G), which will manage any potential Project indirect impacts to other marine plants.

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
MSES – Marine plant ■ A proposed reduction in the extent of marine plants through removal, destruction or damage of marine plants	**MSES seagrass:** Potentially significant impact **MSES macroalgae:** Potentially significant impact **MSES mangroves:** Unlikely to have a significant impact **MSES other marine plants:** Unlikely to have a significant impact	**Potentially significant impact** The proposed disturbance to marine plants will include permanent damage through direct marine plant (e.g. seagrass and macroalgae) removal and destruction, as outlined in the response to the first criteria of this table. The Project does not result in the removal, destruction or damage to other marine plants such as mangroves, samphires and saltmarshes that are located on the coastline adjacent to the WBE reclamation area, which is outlined in the response to the first criteria of this table.
MSES – Marine plant ■ Fragmentation or increased fragmentation of a marine ecological community	**MSES seagrass:** Potentially significant impact **MSES macroalgae:** Potentially significant impact **MSES mangroves:** Unlikely to have a significant impact **MSES other marine plants:** Unlikely to have a significant impact	**Potentially significant impact** Project impacts have been identified which have the potential to fragment seagrass meadows and macroalgae. The potential for these impacts to extend to offsite and indirect impact areas has been evaluated via the Project activity's magnitude assessment. The results are summarised below. ■ Permanent and direct loss of seagrass and macroalgae during the establishment of the WBE reclamation area and BUF and dredging activities – Moderate magnitude: Potential residual impact considered to be medium term in duration (temporal) and contained in extent (spatial) ■ Potential decline in water quality during the establishment of the WBE reclamation area and BUF and dredging activities – Moderate magnitude: Potential residual impact considered to be medium term in duration (temporal) and contained in extent (spatial) ■ Hydrodynamic and water quality impacts resulting in habitat alteration during the establishment of the WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be permanent in duration (temporal) and contained in extent (spatial) ■ Contaminant and sediment releases resulting in impacts on habitat during the establishment of the WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be medium in duration (temporal) and contained in extent (spatial) The Project activities cumulative and synergistic impacts have been incorporated into the significant residual adverse impact assessment for this significant impact assessment criteria.

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
		There has been no macroalgae mapped within the WBE reclamation area (Rasheed et al. 2003; McKenna et al. 2014). Therefore, the establishment of the WBE reclamation area is unlikely to result in the fragmentation of macroalgae. However it is noted that macroalgae can occupy multiple habitats, including seagrass meadows (Diaz-Pulido and McCook 2008) as such this fragmentation has been covered as part of the seagrass meadow fragmentation assessment. The establishment of the WBE reclamation area has the potential to result in indirect impacts from erosion and sedimentation due to changes in tidal velocities adjoining the WBE reclamation area. These indirect impacts have the potential to result in the fragmentation of approximately 99.41ha of seagrass meadows mapped in the area between the northern and southern WBE reclamation areas and between the WBE reclamation area and the mainland (i.e. based on the 2002 to 2018 historic seagrass surveys). This seagrass meadow area has been included within the Project's permanent loss of fish habitat (i.e. 374.64ha) assessed under the first significant impact assessment criteria. Baseline surveys will be undertaken prior to commencement of the Project to map areas of marine plants that are likely to be impacted by Project activities. This will further inform the assessment of fragmentation of marine communities, including seagrass meadows, especially deep water seagrass. Seagrass adjacent to the Western Basin and WBE reclamation areas will be monitored following construction to identify actual impacts, or to determine if it persists following construction. There is potential for indirect fragmentation of seagrass and macroalgae within the channel duplication area to be dredged. However the permanent loss of deep water seagrass and macroalgae within the Project zone of high impact (i.e. indirect impact area) is unlikely due to the implementation of adaptive management measures contained in the Environmental Monitoring Procedure (refer AEIS Appendix H). No fragmentation impacts are expected to occur for the mangrove and coastal saltmarsh communities on the coastline adjacent to the Western Basin and WBE reclamation areas (i.e. no clearing is required). With the implementation of mitigation measures outlined in the Dredging EMP (refer AEIS Appendix F) and the Project EMP (refer AEIS Appendix G), it is unlikely that the Project will result in impacts on the mangrove and saltmarsh communities on the coastline adjacent to the WBE reclamation area.
MSES – Marine plant Adverse changes affecting survival of marine plants through modifying or destroying abiotic (non-living) factors (such as water, nutrients, or soil) necessary for a marine plant's survival	**MSES seagrass:** Unlikely to have a significant impact **MSES macroalgae:** Unlikely to have a significant impact **MSES mangroves:** Unlikely to have a significant impact **MSES other marine plants:** Unlikely to have a significant impact	**Unlikely to have a significant impact** Project impacts have been identified which have the potential to adversely impact the marine plant values detailed in this significant impact assessment criteria. The potential for these impacts to extend to offsite and indirect impact areas has been evaluated via the Project activity's magnitude assessment. The results are summarised below. ■ Potential decline in water quality during the establishment of the WBE reclamation area and BUF and dredging activities – Moderate magnitude: Potential residual impact considered to be medium term in duration (temporal) and contained in extent (spatial)

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
		The Project activities cumulative and synergistic impacts have been incorporated into the significant residual adverse impact assessment for this significant impact assessment criteria. The Project has the potential to result in short term declines in water quality as a result of Project dredging activities. Given the short and ephemeral lifecycle of the deep water seagrass and macroalgae within the high or moderate zones of impact, the temporary nature of the dredge plume, and the ability to modify dredging locations/durations to reduce the impacts to areas of seagrass meadows within the high and moderate zones of impact, it is expected that the potential Project water quality impacts are unlikely to impact the seagrass meadows and macroalgae in the area in the long term. Indirect impacts have the potential to occur to the seagrass meadows and macroalgae located within the zone of high impact. However the permanent loss of deep water seagrass and macroalgae within the Project zone of high impact (i.e. indirect impact area) is unlikely due to the implementation of adaptive management measures contained in the Environmental Monitoring Procedure (refer AEIS Appendix H). Further baseline surveys will be undertaken prior to commencement of the Project to map areas of marine plants that are likely to be impacted by Project activities. This will further inform the assessment of fragmentation of marine communities, including seagrass meadows. Other marine plants such as mangroves, samphires and saltmarshes are located 200m away from the WBE reclamation and are not located within the high or moderate zones of impact. It is unlikely that the dredge plume will impact on these other marine plants. With the implementation of mitigation measures outlined in the Dredging EMP (refer AEIS Appendix F) and the Project EMP (refer AEIS Appendix G), it is unlikely that temporary impacts and Project indirect impacts associated with short term declines in water quality would have a significant impact on seagrass meadows and macroalgae adjacent to the Project direct impact areas. With consideration to the sequential timing and discrete locations of the Project activities and the aforementioned magnitude levels of any potential residual impact, the Project is not considered likely to have a significant residual adverse impact on this significant impact assessment criteria.
MSES – Marine plant Alteration in the species composition of marine plants in an ecological community, that causes a decline or loss of functionally important species	**MSES seagrass:** Unlikely to have a significant impact **MSES macroalgae:** Unlikely to have a significant impact **MSES mangroves:** Unlikely to have a significant impact **MSES other marine plants:** Unlikely to have a significant impact	**Unlikely to have a significant impact** Project impacts have been identified which have the potential to adversely impact the marine plant values detailed in this significant impact assessment criteria. The potential for these impacts to extend to offsite and indirect impact areas has been evaluated via the Project activity's magnitude assessment. The results are summarised below. ■ Permanent and direct loss of seagrass and macroalgae during the establishment of the WBE reclamation area and BUF and dredging activities – Moderate magnitude: Potential residual impact considered to be medium term in duration (temporal) and contained in extent (spatial)

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
■		■ Potential decline in water quality during the establishment of the WBE reclamation area and BUF and dredging activities – Moderate magnitude: Potential residual impact considered to be medium term in duration (temporal) and contained in extent (spatial) The Project activities cumulative and synergistic impacts have been incorporated into the significant residual adverse impact assessment for this significant impact assessment criteria. The Project is not likely to result in a notable alteration in marine plant species composition or result in the loss of a functionally important species. The seagrass meadows (which includes macroalgae) within the Project impact areas support seagrass and macroalgae species which are not unique to the impact area, with several surrounding meadows within Port Curtis supporting the same species. Furthermore, the species types found in the intertidal areas of Port Curtis are also represented in the wider Natural Resource Management (NRM) region of Fitzroy under the Queensland Government's Reef Water Quality Protection Plan at Shoalwater Bay, Keppel Islands, Rodds Bay and Hervey Bay (McKenzie et al. 2014). With consideration to the sequential timing and discrete locations of the Project activities and the aforementioned magnitude levels of any potential residual impact, the Project is not considered likely to have a significant residual adverse impact on this significant impact assessment criteria.
MSES – Marine plant ■ Interference with the natural recovery of marine plant communities.	**MSES Seagrass:** Potentially significant impact **MSES macroalgae:** Potentially significant impact **MSES mangroves:** Unlikely to have a significant impact **MSES other marine plants:** Unlikely to have a significant impact	**Potentially significant impact** Project impacts have been identified which have the potential to adversely impact the marine plant values detailed in this significant impact assessment criteria. The potential for these impacts to extend to offsite and indirect impact areas has been evaluated via the Project activity's magnitude assessment. The results are summarised below. ■ Permanent and direct loss of seagrass and macroalgae during the establishment of the WBE reclamation area and BUF and dredging activities – Moderate magnitude: Potential residual impact considered to be medium term in duration (temporal) and contained in extent (spatial) ■ Potential decline in water quality during the establishment of the WBE reclamation area and BUF and dredging activities – Moderate magnitude: Potential residual impact considered to be medium term in duration (temporal) and contained in extent (spatial)

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
		The Project activities cumulative and synergistic impacts have been incorporated into the significant residual adverse impact assessment for this significant impact assessment criteria. The potential for seagrass meadows and macroalgae to recover from declines are highly dependent on the availability of propagules (viable seeds), the species present, and a return to favourable growing conditions (Jarvis et al. 2015). The construction of the WBE reclamation area and dredging activities over existing and historical seagrass and macroalgae habitat will result in the permanent loss of potentially viable seagrass seed banks seeds contained with intertidal sediments. The loss of potentially viable seed banks has the potential to impact on the capacity for surrounding seagrass meadows in Port Curtis to recover from widespread losses. However, it is noted that there are seagrass meadows containing the same seagrass species in the areas surrounding the Western Basin and WBE reclamation areas that will not be significantly impacted by the Project. Therefore, these meadows are likely to provide a source of seed/propagules for the recovery of local marine plant communities in Port Curtis. The Project is considered likely to have a significant residual adverse impact on this assessment criteria for Project direct and indirect impacts associated with the establishment of the WBE reclamation area as discussed in the first significant impact assessment criteria. The Project is not expected to directly impact on other marine plants (i.e. as no clearing is required for mangroves or saltmarshes). With the implementation of mitigation measures outlined in the Dredging EMP (refer AEIS Appendix F) and the Project EMP (refer AEIS Appendix G), it is unlikely that the Project will result in impacts on the mangrove and saltmarsh communities on the coastline adjacent to the WBE reclamation area.

Table note:

** Includes the identification of potential Project impacts on significant impact assessment criteria, spatial and temporal assessment (i.e. magnitude assessment) of the potential Project residual impact on offsite and indirect impact areas and cumulative Project impact assessment

9.4.7 Summary

This section supplements the Project EIS Section 9.9.8 (seagrass meadows and epibenthic macroalgae – assessment summary).

Based on the Project EIS Section 9.17.7 and the above supplementary assessment, the Project activities below are likely to have a significant residual adverse impact on the marine plant values (i.e. seagrass meadows and macroalgae).

- Direct disturbance of 374.64ha of seagrass meadows and macroalgae as a result of the establishment of WBE reclamation area
  - 110.48ha from the establishment of the WBE reclamation area (southern area)
  - 164.75ha from the establishment of the WBE reclamation area (northern area)
  - 99.41ha from indirect impacts for the establishment of the WBE reclamation area.
- Direct disturbance of 85.33ha of seagrass meadows and macroalgae at the channel duplication area to be dredged (refer Figure 9.10a and Figure 9.10b)

The Project will implement mitigation measures provided in the Dredging EMP and Project EMP (refer AEIS Appendices F and G, respectively), and associated management plans to reduce the likelihood and magnitude of potential Project impacts on marine plants.

The potential Project significant residual adverse impact on marine plant values will be offset by implementing the Channel Duplication Project Offset Strategy (refer AEIS Appendix E4 for the draft strategy).

9.5 Reef communities

This section supplements the Project EIS Section 9.11 (reef communities – potential impact and risk assessment) which provides an assessment of the potential impacts of the various Project activities on reef communities.

9.5.1 Direct and indirect impacts on reef communities

The predominant potential indirect impact on reef communities from Project dredging activities will be short term declines in water quality from an increase in turbidity and sedimentation, including the suspension and resuspension of fine sediments. The potential impacts of Project dredging activities on reef communities are represented by zones of impact from the Project hydrodynamic model. The Project hydrodynamic modelling predicted that the reef communities mapped within the region fall within the Project zone of low impact or within the Project zone of influence, therefore indicating that Project dredging activities will not result in any long term decline in reef communities. The Project hydrodynamic modelling also predicted that the deposition rates during Project dredging activities will be low at coral reef locations (refer Figure 9.17).

There are no reef communities located within the WBE reclamation area. There are two reefs at East Banks mapped on the GBRMPA spatial layer (2009b) in the vicinity of the area to be dredged for the duplication of the existing shipping channels, however these do not appear to exist as coral reefs (BMT WBM 2014). The East Banks (East) reef is located within the existing shipping channel, however these shipping channels are subject to regular Port maintenance dredging. Therefore, the Project activities (i.e. the establishment of the WBE reclamation area and the Project dredging activities) will not result in the permanent or direct loss of reef communities, and therefore sub-lethal or lethal impacts to reef communities are not expected from Project activities.

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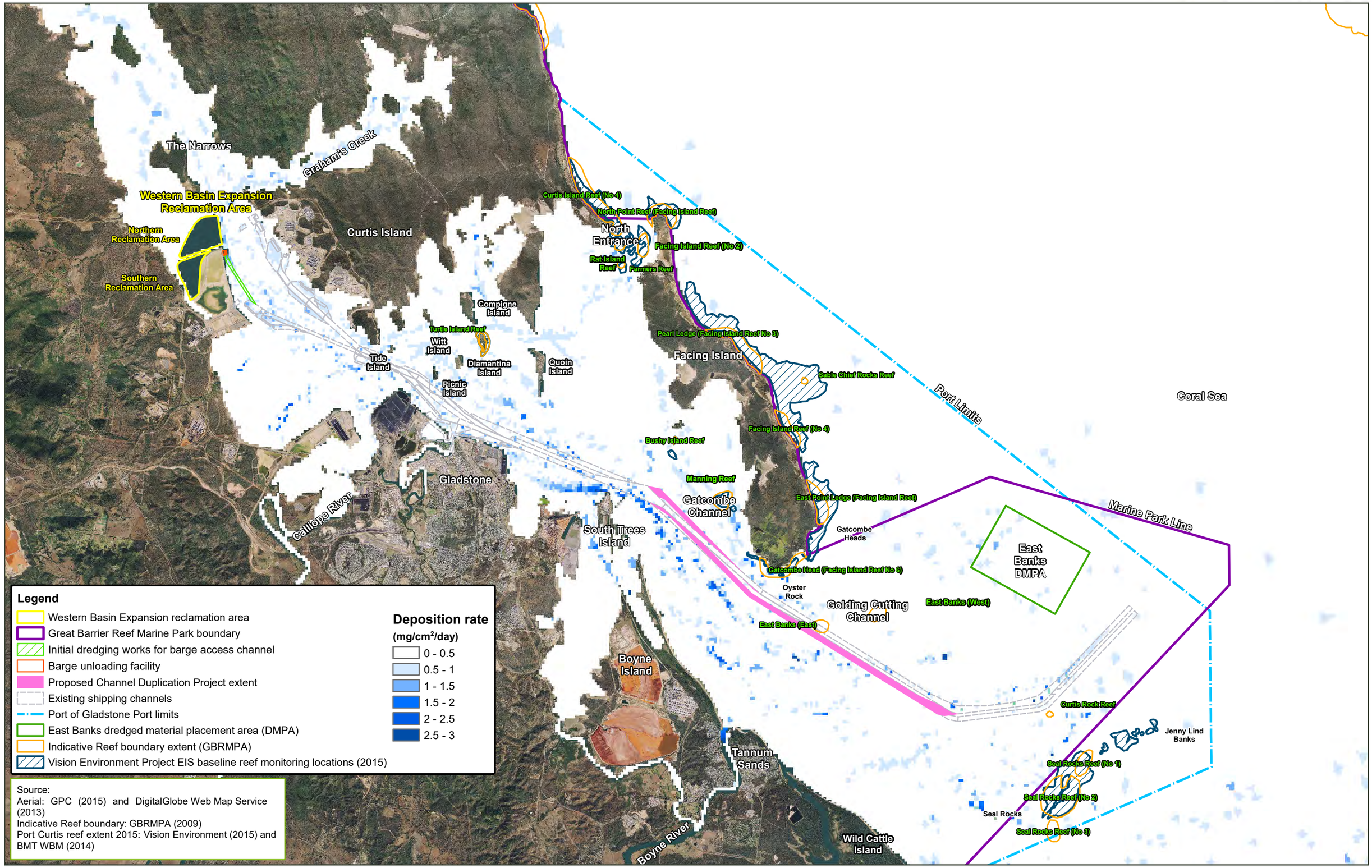

Legend

- Western Basin Expansion reclamation area
- Great Barrier Reef Marine Park boundary
- Initial dredging works for barge access channel
- Barge unloading facility
- Proposed Channel Duplication Project extent
- Existing shipping channels
- Port of Gladstone Port limits
- East Banks dredged material placement area (DMPA)
- Indicative Reef boundary extent (GBRMPA)
- Vision Environment Project EIS baseline reef monitoring locations (2015)

Deposition rate
(mg/cm²/day)

- 0 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Indicative Reef boundary: GBRMPA (2009)
Port Curtis reef extent 2015: Vision Environment (2015) and BMT WBM (2014)

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Map by: RB

0 1,700 3,400 Metres

Date: 09/08/2019 Version: 1 Job No: 237374
Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 9.17: 50th percentile of the deposition rate ambient and total overall dredging campaign

9.5.2 Potential cumulative and synergistic impacts from Project activities

This section supplements the Project EIS Section 9.11 (reef communities – potential impacts and risk assessment) which provides an assessment of the potential impacts of the various Project activities on reef communities.

The cumulative impact assessment that is applicable to the Project, considering foreseeable 'significant' projects and exogenous factors such as flood events and climate change is provided in the Project EIS (Chapter 21 – cumulative impact assessment and Appendix P). This section provides the cumulative assessment of the Project activities (i.e. the establishment of the WBE reclamation area and BUF, dredging activities, installation and removal of navigational aids, and operation and maintenance) as a whole.

To identify potential synergistic impacts on reef communities, this section provides an assessment of the potential cumulative Project impacts that were previously addressed individually as discrete Project activities on reef communities (refer Project EIS Sections 9.11.2 to 9.11.5).

The Project activities can be described as occurring in discrete spatial areas although there is some temporal overlap of Project activities. The spatial categories are described below and their location (i.e. area of direct impact) is provided in Figure 9.2.

- Establishment of the WBE reclamation area and BUF
- Dredging activities
- Removal and installation of navigational aids
- Stabilisation and maintenance activities.

The Project dredging works will be undertaken as either a staged dredging campaign (i.e. over two stages) or as a singular campaign. Figure 9.18 illustrates the Project activity timeframes and dredging campaign options.

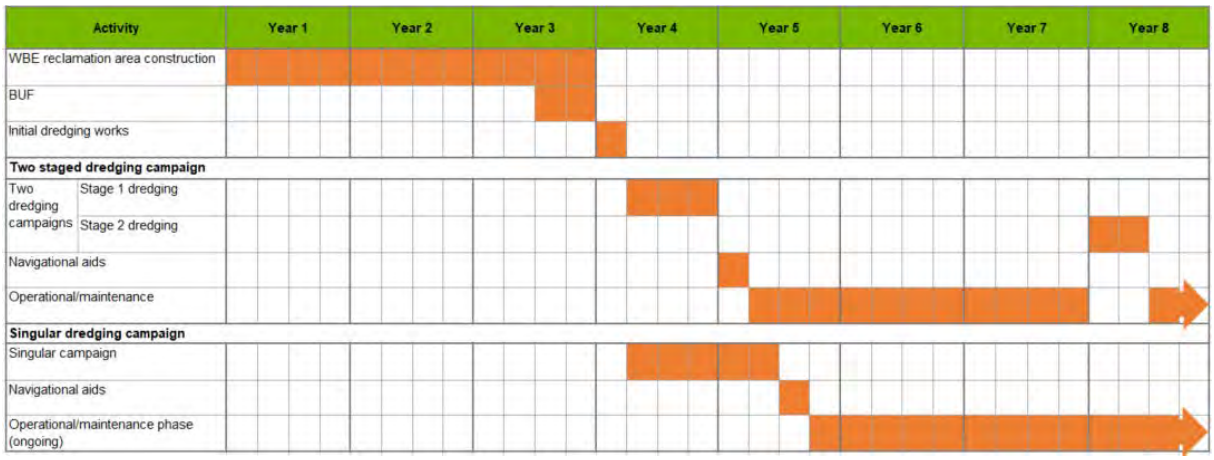

Figure 9.18 Indicative Project activity timeframes

Whilst the location of direct impacts is discrete, it is acknowledged that indirect impacts arising from the discrete Project locations (e.g. silt plumes, alterations to water quality and increased vessel movement) have the potential to result in impacts that overlap in a spatial and temporal context. Given this overlap, synergistic interactions resulting from multiple Project related impacts have the potential to impact upon reef communities, with the results being greater than the sum of any of the single stressors alone.

Potential cumulative impacts were assessed in conjunction with potential synergistic impacts from Project activities. Cumulative impacts were defined as an accumulation of impact from all Project activities. These were considered to be independent of temporal constraints and constituted a contributing factor driving synergistic processes. Accordingly, cumulative impacts were not assessed *per se* but rather, were assessed within the synergistic impact assessment and were incorporated into the significant residual adverse impact assessment.

Synergistic impacts result from multiple processes which act simultaneously upon a particular value. The magnitude of impact would be a function of the initial direct impact and further direct impacts (as an accumulation) and/or a function of the initial direct impact with potentiation from further indirect impacts (as a synergy) with consideration for any amplification associated with the multiple factors acting simultaneously.

To identify potential Project synergistic impacts upon reef communities, the Project EIS impact assessment outcomes (as a whole of program rather than discrete Project activities) were assessed (refer Project EIS Sections 9.5.2 to 9.5.5 and AEIS Appendices E1, E2 and E3). This enabled potential Project direct impacts (and indirect impacts) to be identified and the potential for contribution towards synergistic processes upon threatening processes to be considered. This approach acknowledged the potential scale of the Project related impacts on the value and its potential to impact upon the value's capacity for recovery from the impact by contributing to a recognised threatening process.

Significant synergistic impacts were defined as potential synergistic impacts that had the capacity to contribute towards threatening processes that are recognised for a value (e.g. reef communities). The resulting likelihood of risk identified the likely contribution of synergistic pathways upon the residual adverse impact of that value.

The synergistic assessment utilised a qualitative risk approach to determine the potential risk of a significant synergistic impact. Noting that a quantitative analysis was not possible as data related to synergistic processes is traditionally non-tractable to analysis, a risk-based assessment was utilised.

Potential Project related impacts assessed as potentially significant (post implementation of impact mitigation measures) were identified as potential pathways for significant synergistic impacts and consisted of:

- Permanent loss of habitat
- Potential short term decline in water quality.

The framework of assessment focussed on:

- The potential Project activity impacts
- The synergistic pathways associated with the Project activities
- How the potentiated impacts contribute to threatening processes, and
- The likelihood of risk of significant impact (refer Table 9.19) from the synergistic impact contribution to threatening process.

Table 9.19 Likelihood definitions for potential impacts occurring over the life of the Project

Description	Frequency
Unlikely	Unlikely but not trivial. May occur during construction/life of the Project but probability < 50%
Potential	Less likely than not, but still considerable; probability of about 50% chance of occurring over the life of the Project
Likely	Likely to occur during construction/life of the Project or during a 12 month timeframe; probability up to 90% chance of occurring

Potential impacts to threatening processes (across all Project activities) have been identified in the Project EIS Sections 9.11.2 to 9.11.5. These sections outline the initial Project impact which contribute to the synergies with other potential Project impacts. For further detail, refer to applicable potential Project activity impacts within the Project EIS Sections 9.11.2 to 9.11.5.

Increased impact associated with competition, resource accumulation, reproductive opportunity loss and a reduction in biological fitness were assessed as pathways for the potential to contribute to threatening processes as potential indirect synergistic impacts. Potential indirect synergistic impacts were typically associated with potential to reduce a value's life history parameters (e.g. reduced growth, reproduction, resource accumulation), through to the potential reduction in population resilience as a contributing factor towards threatening processes. Increased competition has been considered to initially derive from Project potential impacts, including permanent removal of habitat, short term decline in water quality, and short term increase in sedimentation.

Resource accumulation opportunity has been considered to initially derive from Project potential impacts, including permanent removal of habitat, changes in hydrology and velocity flows.

The potential Project synergistic impacts (includes both direct and indirect impacts) on reef communities include:

- Permanent loss and alteration to habitat
- Short term decline in water quality.

Table 9.20 provides a summary of the synergistic impacts from the Project as a whole on reef communities. For the purposes of determination of the risk assessment with significant synergist impact, Project direct impacts were contained in concert with synergistic pathways to determine the potential of synergistic impacts, that will contribute to threatening processes. The likelihood of risk was determined based on Table 9.19 definitions.

Table 9.20 Risk of significant synergistic impact from identified Project impacts on reef communities

Reef communities	Threats to reef communities#	Project direct impact (as result of whole program)	Potential Project pathways acting in synergy with Project impact	Potential indirect synergistic impact contributing to key threatening process	Likelihood of risk of significant impact (refer Table 9.19)
Reef communities	■ **Habitat loss** ■ Climate change ■ **Poor water quality from runoff** ■ **Coastal development** ■ Impacts form fishing ■ **Sediment and nutrient pollution**	Permanent loss and/or alteration of habitat	■ Permanent change of habitat ■ Temporary decline in water quality ■ Contaminant and sediment releases ■ Increased contact with vessel and dredging equipment	■ Reduction in individual and population resilience ■ Compounding impact on individual resource partitioning (compromised physiology) from water quality degradation (all Project activities) ■ Minor reduction of life-history parameters	Unlikely
		Short term decline in water quality	■ Permanent change of habitat ■ Introduction and spread or pest and/or weed species ■ Increased contact with vessel and dredging equipment ■ Soil and erosion runoff	■ Reduction in population resilience ■ Minor reduction of life-history parameters ■	Unlikely

Table note:

Bold identifies threats acknowledged within research papers that are potentially impacted by Project activities

The assessment identified that the Project does not have the potential risk of significant synergistic impact for reef communities due to:

- No permanent loss or alteration to habitat.

The potential impacts to water quality and reef communities through a release of sediment laden runoff and/or contaminants during the establishment of the WBE reclamation area and BUF will be generally restricted to a contained area and occur within the short term. The Project dredging activity changes in water quality will be generally within the local area and temporary in nature. Further the predicted zones of impact from the Project hydrodynamic modelling model indicate that Port Curtis and Facing Island coral reefs will not be impacted by this increase in turbidity.

The Project will implement mitigation measures provided in the Dredging EMP (refer AEIS Appendix F), the Project EMP (refer AEIS Appendix G) and associated management plans to reduce the likelihood and magnitude of potential Project impacts on reef communities. The implementation of mitigation measures contained in these EMPs will reduce potential residual Project impacts upon reef communities.

9.5.3 Significant residual adverse impact assessment

No reef communities are listed as a MNES under the provisions of the EPBC Act or are listed as a MSES under the provisions of the *Environmental Offsets Regulation 2014*. As such, a significant residual adverse impact assessment has not been conducted for the value.

9.5.4 Summary

This section supplements the Project EIS Section 9.11.8 (reef communities – assessment summary).

Based on the Project EIS Section 9.11.1 to 9.11.5 and the above supplementary assessment, the Project activities are not likely to have a significant residual adverse impact on the reef communities.

The Project will implement mitigation measures provided in the Dredging EMP and Project EMP (refer AEIS Appendices F and G, respectively), and associated management plans to reduce the likelihood and magnitude of potential Project impacts on reef communities.

9.6 Fish and marine reptiles (excluding marine turtles)

9.6.1 Fish species utilising the Port and potential impacts

9.6.1.1 Fish species utilising the Port and WBE reclamation area

This section supplements the Project EIS Section 9.12.2 (fish and marine reptile values (excluding marine turtles)).

The Project EIS Section 9.12.2 and Appendix I1 (Section 9 and Appendix J) provides a detailed description of the fish species that utilise the Port of Gladstone and potential Project impact areas. A summary of fish species surveys conducted within the Port of Gladstone is provided below.

A total of 6,037 reef fish from 59 species were encountered throughout the four monitoring locations during the 2014 dry season (37% of individuals recorded) and the 2015 wet season (63% of individuals recorded) (Vision Environment 2015) (refer Project EIS Appendix I1, Appendix L (Table 2)). The most common fish species observed consisted of the Yellowtail demoiselle (*Neopomacentrus azysron*) (41%), followed by the Spotted-tail wrasse (*Coris caudimacula*) (11%), and Wards damsel (*Pomacentrus wardi*) (10%). The most common fish families throughout the monitoring program included Pomacentridae (Damsel fish) (73%), followed by Labridae (Wrasse) (21%), and Apogonidae (Cardinal fishes) (2%) (Vision Environment 2015).

A total of 2,936 estuarine and coastal fish representing 34 species were encountered during the 2014 dry season (58.7%) and the 2015 wet season 2015 (41.3%) surveys (Vision Environment 2015). The most common estuarine and coastal species occurring in most locations irrespective of season, was the Southern herring, (*Herklotsichthys castelnaui*) (39%), followed by the Estuary glassfish (*Ambassis marianus*) (21%) and the Spottyface anchovy (*Stolephorus waitei*) (14%). Banana prawns (*Fenneropenaeus merguiensis*) were also common among catches (7%) (Vision Environment 2015). Lilleys Inlet, South Trees Inlet, Boat Creek South and The Narrows/Targinnie Creek recorded the highest numbers of fish.

Based on the results of database searches, there are five fish species (i.e. cartilaginous fish) of conservation significance, which have the potential to occur within the Project impact areas (i.e. low and moderate likelihood only), includes: *Dasyatis fluviorum* (Estuarine stingray), *Carcharodon carcharias* (Great white shark), *Rhincodon typus* (Whale shark), *Pristis zijsron* (Green sawfish) and *Manta alfredi* (Reef manta ray).

Analysis of environmental databases indicates that 13 sea snake species are known, or are predicted to occur, within Port Curtis and adjoining waters (refer Project EIS Appendix I1 (Section 10.3.2)). However, none of these sea snake species are listed as having conservation significance under the provisions of the NC Act or the EPBC Act.

9.6.1.2 Estuary stingray

This section supplements the Project EIS Section 9.13.2 (fish and marine reptile – potential impact and risk assessment, establishment of the dredged material placement area and barge unloading facility).

The Estuary stingray is known to occur in rivers, estuaries and adjacent coastal waters along the eastern Australia coastline from central New South Wales northwards to central Queensland (Pierce and Bennett 2010). The Estuary stingray has been commonly recorded in shallow coastal waters, particularly over mangrove-fringed sand/mud intertidal flats (Pierce and Bennett 2010). Connolly et al. (2006) recorded the Estuary stingray within Port Curtis with a total abundance of 0.07%. It is therefore, considered that the Estuary stingray has a low total abundance within Port Curtis.

While potentially occurring in low total abundance, the establishment of the WBE reclamation area has the potential to impact habitat (as a loss of habitat) that may be utilised by the Estuary stingray. Although the Project impact areas support habitat for the Estuary stingray, this habitat is not unique to the Project impact area, with several surrounding meadows within Port Curtis supporting habitat for the Estuary stingray. Therefore there are substantial areas of suitable potential habitat in adjacent areas, and as such the WBE reclamation area is not likely to be key habitat for this species. The loss of this potential habitat will be permanent and irreversible and restricted to a contained area, therefore moderate in magnitude.

Adaptive design measures will be implemented during the Project detailed design phase to reduce the direct and indirect impacts of Estuary stingray habitat loss at the WBE reclamation area (refer Project AEIS Appendix I). Other relevant Project mitigation measures are provided in the Dredging EMP and Project EMP (refer AEIS Appendices F and G, respectively).

9.6.1.3 Project potential impacts on fish species from the establishment of the WBE reclamation area

This section supplements the Project EIS Section 9.13.2 (establishment of the dredged material placement area and barge unloading facility).

Construction equipment required for the establishment of the WBE reclamation area bund walls includes trucks and a small number of excavators and/or dozers required to assist in the placement of material. Core material will be placed directly over the existing sediments and bund material will then be shaped by bulldozer, grader or long arm excavator depending on location and required bund profile. Armour material will then be placed along the seaward exposed face.

Construction of the WBE reclamation area bund walls is to be undertaken over a three year period and has the potential to entrap fish and marine reptiles without appropriate design or mitigation measures (i.e. sudden entrapment of species without use of appropriate dewatering methodologies). Once dredging commences there is potential for fish and marine reptiles to be entrapped within the bund wall during construction. Entrapped fish and marine reptile species have the potential to be injured (including mortal injuries) as a result of the placement of dredged material into the reclamation area, or due to the dewatering process (i.e. via asphyxiation of fish).

To minimise the potential impacts on fish species and marine reptiles during the construction of the WBE reclamation area and bund wall close, the Project EMP (refer AEIS Appendix G) and bund wall closure plan will be implemented. The bund wall closure plan will include:

- When construction of the WBE reclamation area and BUF reaches the stage where the bund/sheet piling wall is to be closed, a suitably qualified and experienced marine spotter will be present to minimise the risk of marine fauna being stranded within the WBE reclamation area and BUF
- If there are any instances of overflow into the reclamation area or BUF once it has been closed, the area within the reclamation area or BUF bund will be immediately inspected for any stranded fauna
- Fish capture/salvage techniques will be implemented, as provided in the Fish Salvage Guidelines (DAF 2018b), if required
- All personnel involved in the capture and salvage of fauna will be appropriately inducted and trained
- Fauna exclusion measures will be installed on the seaward facing side of all discharge points to prevent fauna entering into the reclamation area via the discharge points. Exclusion measures will allow fauna within the reclamation area to leave and re-enter the marine environment (e.g. one-way gates).

The post mitigation risk ratings associated with the potential impact associated with entrapment of fish and marine reptile species during the construction of the WBE reclamation area is low. These potential impacts are expected to be temporary and are expected to be contained in extent, and are therefore low in magnitude.

The AEIS Appendix E3 provides detail on the assessment of this potential impact and the resultant risk rating.

9.6.2 Western Basin Expansion reclamation area impact on fish passage and intertidal area

This section supplements the Project EIS Section 9.26.2 (matters of state environmental significance).

There are many structures which are considered waterway barriers to fish movement. Structures such as dams, weirs and culverts have been constructed on Queensland waterways and can impede fish movement upstream or downstream of these structures (DAF 2018a). Loss of access to habitat has caused a decline in distribution of native fish populations. It is for this reason that any new waterway barriers that are constructed within waterways must provide adequate fish passage. Waterway barrier works require approvals under Queensland legislation (e.g. Fisheries Act) (DAF 2018a).

The Fisheries Act defines waterway barrier works as ‘a dam, weir or other barrier across a waterway if the barrier limits fish stock access and movement along a waterway.’

Barriers not considered to be waterway barrier works include:

- *Bank revetment or other bank stabilisation works are not waterway barrier works when they:*
  - *Fill minor erosion pockets to regularise the bank of the waterway;*
  - *In waterways less than 50m wide at the main channel width, do not extend into the waterway beyond the toe of the bank, or raise the bed level of the waterway above its natural profile*

- *In waterways greater than 50m wide at the main channel width, do not extend beyond 10% of the width of the waterway (main channel width), or raise the bed level of the waterway above its natural profile, (both maintenance and new works)* (DAF 2017).

However, if the barrier extends further than the above distances into the waterway, then they are considered waterway barrier works.

The *Environmental Offsets Regulation 2014* identifies MSES, which includes:

> *Any part of a waterway providing for passage of fish is a matter of State environmental significance only if the construction, installation or medication of waterway barrier works carried out under an authority will limit the passage of fish along the waterway.*

Figure 9.19 shows the location of waterways as defined on DAF's ArcGIS spatial layer. The proposed WBE reclamation area is not located within a defined waterway therefore the establishment of the WBE reclamation area will not be a waterway barrier for fish passage.

There is an identified amber waterway located to the west of the WBE reclamation area, however the distance between the reclamation works and the mouth of this waterway is 206m. Tidal flow into the waterway will be continually maintained during construction and operation, and will not impede fish passage into this waterway in anyway.

The Port of Gladstone may potentially be considered an 'inlet of the sea'. The WBE reclamation area provides an intertidal area for fish habitat. The WBE reclamation area, however does not inhibit marine fauna species (e.g. fish) moving between the mainland waterways and Port Curtis marine waters nor limiting fish stock access and movement.

The establishment of the WBE reclamation area and BUF will result in the loss of intertidal and subtidal habitat, with 276.10ha for the WBE reclamation area (northern and southern areas) and 1.89ha for the BUF. These intertidal and subtidal habitats provide potential habitat for a range of fish species, other marine reptiles, and fisheries values. The construction of the WBE reclamation area has the potential to indirectly affect higher-order predators (i.e. shorebirds and dolphins) through a realised loss of foraging resources by a direct loss of fish foraging habitat.

Whilst the loss of fish foraging habitat area is noted as a direct impact, the prevalence of unimpacted fish foraging areas (including mapped fish habitat areas, seagrass meadows, mangrove communities and other inshore areas identified as having fisheries importance) within adjacent areas within Port Curtis is considered to mitigate the indirect impacts on higher-order predators.

Adaptive design measures (i.e. use of rock within the bund wall) will be implemented during the Project detailed design phase to reduce the impact of potential habitat loss at the WBE reclamation area.

The potential impacts of the removal of habitat are permanent, but are expected to be contained in extent and are therefore considered moderate in magnitude.

Post mitigation risk ratings associated with potential impact associated with an intertidal area barrier for fish passage resulting from the construction of the WBE reclamation area is low (refer Table 9.21). The AEIS Appendix E3 provides detail on the assessment of this potential impact and the resultant risk rating

Section 9.6.4 provides an identification of significant residual adverse impacts for the intertidal area for fish passage.

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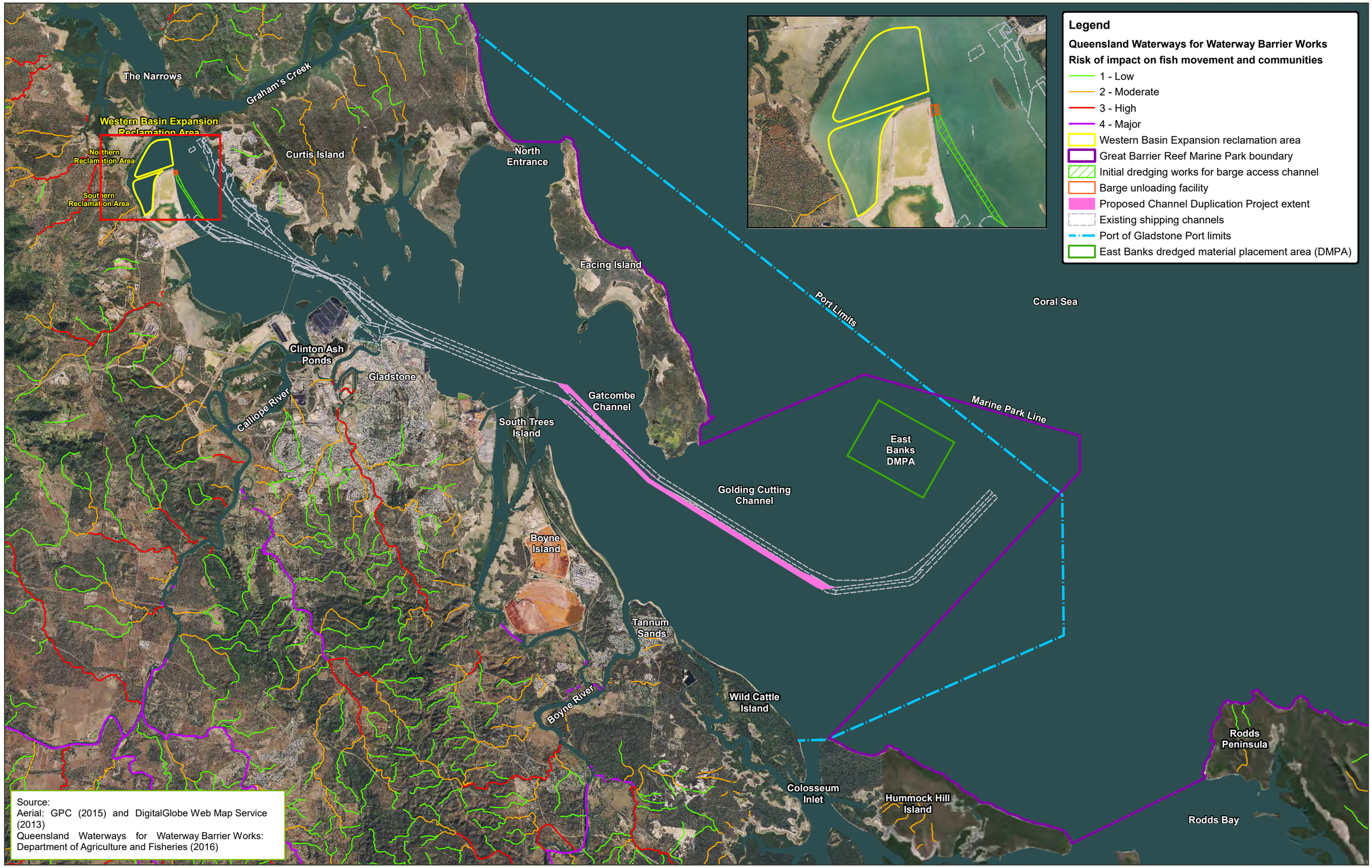

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Date: 08/08/2019 Version: 1 Job No: 237374

Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 9.19: Waterways providing for fish passage

Table 9.21 Summary of consequence and risk ratings for intertidal area barrier works during the establishment of the Western Basin Expansion reclamation area and BUF

Sensitive receptor	Consequence rating (sensitivity x magnitude)	Likelihood of impact	Risk rating	Potential to contribute to key threatening process
Species of conservation significance and/or migratory species				
Species of conservation significance and/or migratory fauna species listed under the EPBC Act and/or the NC Act	**Moderate** (high x moderate)	Unlikely	**Low**	No
Other marine reptiles				
Species not listed as having conservation significance under the EPBC Act and/or the NC Act (including Sea snakes and kraits)	**Low** (low x moderate)	Unlikely	**Low**	No
Estuarine and coastal fish communities				
Estuarine and coastal fish communities	**Moderate** (moderate x moderate)	Unlikely	**Low**	No

9.6.3 Potential cumulative and synergistic impacts from Project activities

This section supplements the Project EIS Section 9.13 (fish and marine reptiles – potential impacts and risk assessment) which provides an assessment of the potential impacts of the various Project activities on fish and marine reptiles (excluding marine turtles).

The cumulative impact assessment that is applicable to the Project, considering foreseeable 'significant' projects and exogenous factors such as flood events and climate change, is provided in the Project EIS (Chapter 21 – cumulative impact assessment and Appendix P). As such this section provides the cumulative assessment of the Project activities (i.e. the establishment of the WBE reclamation area and BUF, dredging activities, installation and removal of navigational aids, and operation and maintenance) as a whole.

To identify potential synergistic impacts on fish and marine reptiles, this section provides an assessment of the potential cumulative Project impacts that were previously addressed individually as discrete Project activities on fish and marine reptiles (refer Project EIS Sections 9.13.2 to 9.13.5).

The Project activities can be described as occurring in discrete spatial areas although there is some temporal overlap of Project activities. The spatial categories are described below and their location (i.e. area of direct impact) is provided in Figure 9.2.

- Establishment of the WBE reclamation area and BUF
- Dredging activities
- Removal and installation of navigational aids
- Stabilisation and maintenance activities.

The Project dredging works will be undertaken as either a staged dredging campaign (i.e. over two stages) or as a singular campaign. Figure 9.20 illustrates the Project activity timeframes and dredging campaign options.

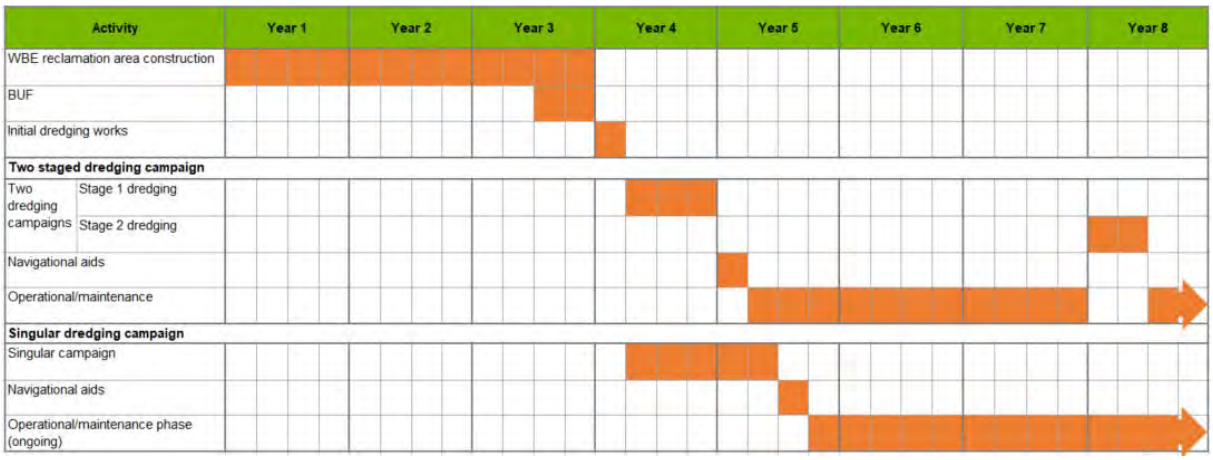

Figure 9.20 Indicative Project activity timeframes

Whilst the location of direct impacts is discrete, it is acknowledged that indirect impacts arising from the discrete Project locations (e.g. silt plumes, alterations to water quality and increased vessel movement) have the potential to result in impacts that overlap in a spatial and temporal context. Given this overlap, synergistic interactions resulting from multiple Project related impacts have the potential to impact upon fish and marine reptiles (excluding marine turtles), with the results being greater than the sum of any of the single stressors alone.

Potential cumulative impacts were assessed in conjunction with potential synergistic impacts from Project activities. Cumulative impacts were defined as an accumulation of impact from all Project activities. These were considered to be independent of temporal constraint and constituted a contributing factor driving synergistic processes. Accordingly, cumulative impacts were not assessed *per se* but rather, were assessed within the synergistic impact assessment and were incorporated into the significant residual adverse impact assessment.

Synergistic impacts result from multiple processes which act simultaneously upon a particular value. The magnitude of impact would be a function of the initial direct impact and further direct impacts (as an accumulation) and/or a function of the initial direct impact with potentiation from further indirect impacts (as a synergy) with consideration for any amplification associated with the multiple factors acting simultaneously.

To identify potential Project synergistic impacts upon fish and marine reptiles, the Project EIS impact assessment outcomes (as a whole of program rather than discrete Project activities) were assessed (refer Project EIS Sections 9.13.2 to 9.13.5 and AEIS Appendices E1, E2 and E3). This enabled potential Project direct impacts (and indirect impacts) to be identified and the potential for contribution towards synergistic processes upon key threatening process to be considered. This approach acknowledged the potential scale of the Project related impacts on the value and its potential to impact upon the value's capacity for recovery from the impact, by contributing to a recognised threatening process.

Significant synergistic impacts were defined as potential synergistic impacts that had the capacity to contribute towards threatening processes that are recognised for a value (e.g. fish and marine reptiles). The resulting likelihood of risk identified the likely contribution of synergistic pathways upon the residual adverse impact of that value.

The synergistic impact assessment utilised a qualitative risk approach to determine the potential risk of a significant synergistic impact. Noting that a quantitative analysis was not possible as data related to synergistic processes is traditionally non-tractable to analysis, a risk-based assessment was utilised.

The synergistic impact assessment for fish and marine reptiles (excluding turtles) was conducted for MSES/MNES values only.

Potential Project related impacts assessed as potentially significant (post implementation of impact mitigation measures) were identified as potential pathways for significant synergistic impacts and consisted of:

- Permanent loss and alteration to habitat
- Direct contact with dredging vessels
- Entrapment and direct contact
- Increased noise and vibration
- Potential short term decline in water quality.

The framework of assessment focussed on:

- The potential Project activity impacts
- The synergistic pathways associated with the Project activities
- How the potentiated impacts contribute to key threatening processes
- The likelihood of risk of significant impact (refer Table 9.22) from the synergistic impact contribution to key threatening processes.

Table 9.22 Likelihood definitions for potential impacts occurring over the life of the Project

Description	Frequency
Unlikely	Unlikely but not trivial. May occur during construction/life of the Project but probability < 50%
Potential	Less likely than not, but still considerable; probability of about 50% chance of occurring over the life of the Project
Likely	Likely to occur during construction/life of the Project or during a 12 month timeframe; probability up to 90% chance of occurring

Potential impacts to threatening processes (across all Project activities) have been identified in the Project EIS Sections 9.13.2 to 9.13.5. These sections outline the initial Project impact which contribute to the synergies with other potential Project impacts. For further detail, refer to applicable potential Project activity impacts within the Project EIS Sections 9.13.2 to 9.13.5.

Increased impact associated with competition, resource accumulation, reproductive opportunity loss and a reduction in biological fitness were assessed as pathways for the potential to contribute to key threatening processes as potential indirect synergistic impacts. Potential indirect synergistic impacts were typically associated with potential to reduce a value's life history parameters (e.g. reduced growth, reproduction, resource accumulation), through to the potential reduction in population resilience as a contributing factor towards key threatening processes. Increased competition has been considered to initially derive from Project potential impacts, including permanent removal of habitat, short term decline in water quality, reduced light availability and short term increase in sedimentation.

Reproductive opportunity has been considered to initially derive from Project potential impacts, including permanent removal of habitat, declines in water quality, direct contact with dredging equipment and an increase in noise and vibration.

Reductions in biological fitness has been considered to derive from all of the initial impacts, as potential reproductive opportunities were considered to be contributing factors to this synergistic pathway. Synergistic impacts which act upon resilience were considered to result in potential reduction in individual and population biological fitness.

The potential Project synergistic impacts (includes both direct and indirect impacts) on fish and marine reptiles (excluding marine turtles) include:

- Permanent loss and alteration to habitat
- Short term declines in water quality

- Direct contact with dredged equipment
- Increase in noise and vibration.

No synergistic impacts have the potential to derive from entrapment during the construction of the WBE reclamation area and bund wall close. Any impact on an entrapped fish or marine reptiles (excluding turtles) will be a direct impact rather than a combination impact. In the instance of a release from entrapment synergistic impacts would likely follow those of permanent loss of habitat.

Exogenous factors (such as extreme flood events) may increase vulnerability of fish to external stressors. These are expected to affect their habitat, principally through a loss of foraging resource (including but not limited to, seagrass meadows). Whilst foraging-site fidelity is considered within this impact, the true impact from extreme flood events is not achievable, and therefore is considered, but not included as a specific impact in the synergistic impact assessment. The Project EMP (refer AEIS Appendix G) will provide mitigation/management measures to be implemented during serve extreme events to limit active dredging sediment suspension. This is considered to limit active dredging suspension occurring in addition to natural resuspension occurrence associated with high-energy climatic conditions.

Table 9.23 provides a summary of the synergistic impacts from the Project as a whole on fish and marine reptiles (excluding marine turtles). For the purposes of determination of the risk assessment with significant synergistic impact, Project direct impacts were contained in concert with synergistic pathways to determine the potential of synergistic impacts, that will contribute to key threatening processes. The likelihood of risk was determined based on Table 9.22 definitions.

Table 9.23 Risk of significant synergistic impact from identified Project impacts on fish and marine reptiles (excluding marine turtles)

Fish and Marine reptile values	Threats to fish and marine reptiles#	Project direct impact (as result of whole program)	Potential Project impact pathways acting in synergy with Project impact	Potential indirect synergistic impact contributing to key threatening process	Likelihood of risk of significant impact (refer Table 9.22)
Near Threatened Fish (Estuary stingray) under the NC Act, and important habitat	■ **Loss of estuarine wetland** ■ **Coastal development** ■ **Habitat modification** ■ Bycatch in commercial fisheries ■ Persecution by shellfish farmers ■ Commercial fishing ■ Declining water quality due to catchment run-off ■ Mortality related to being caught accidentally (bycatch) or illegally (targeted) by commercial and recreational fisheries ■ Ecotourism ■ Bycatch in fisheries ■ Boat strike from large vessels ■ Habitat disruption from mineral exploration, production and transportation ■ Marine debris ■ Disturbance from domestic tourism operation	Permanent removal of foraging resource	■ Permanent change of habitat ■ Temporary decline in water quality ■ Contaminant and sediment releases ■ Potential increase in noise and vibration	■ Reduction in individual and population resilience ■ Displacement of fauna ■ Compounding impact on individual resource partitioning (compromised physiology) from reduction of water quality degradation (all Project activities) ■ Minor reduction of life-history parameters	Potential
		Decline in water quality	■ Permanent change of habitat	■ Reduction in population resilience	Unlikely
		Direct contact with vessel and dredging equipment	■ Permanent change of foraging habitat	■ Reduction in population resilience ■ Displacement of fauna	Unlikely
		Increase in noise and vibration	■ Temporary change of habitat	■ Displacement of fauna ■ Introduction in competition from avoidance behaviour resulting in reduction in individual and population resilience ■ Compounding impact on individual resource partitioning (compromised physiology) from reduction of water quality degradation (all Project activities) ■ Minor reduction of life-history parameters	Unlikely

Fish and Marine reptile values	Threats to fish and marine reptiles#	Project direct impact (as result of whole program)	Potential Project impact pathways acting in synergy with Project impact	Potential indirect synergistic impact contributing to key threatening process	Likelihood of risk of significant impact (refer Table 9.22)
Migratory fish (Giant manta ray, Longfin mako, Porbeagle and Shortfin mako) under the EPBC Act, and important habitat Vulnerable, Migratory fish (Great white shark) under the EPBC Act, and important habitat Migratory fish (Reef manta ray) under the EPBC Act and Vulnerable under the NC Act, and habitat other than important habitat Vulnerable and Migratory fish (Whale shark) under the EPBC Act, and important habitat	■ **Loss of estuarine wetland** ■ **Coastal development** ■ **Habitat modification** ■ Bycatch in commercial fisheries ■ Persecution by shellfish farmers ■ Commercial fishing ■ Declining water quality due to catchment run-off ■ Mortality related to being caught accidentally (bycatch) or illegally (targeted) by commercial and recreational fisheries ■ Ecotourism ■ Bycatch in fisheries ■ Boat strike from large vessels ■ Habitat disruption from mineral exploration, production and transportation ■ Marine debris ■ Disturbance from domestic tourism operation	Decline in water quality	■ Permanent change of foraging habitat	■ Reduction in population resilience	Unlikely
		Direct contact with vessel and dredging equipment	■ Permanent change of foraging habitat	■ Reduction in population resilience ■ Displacement of fauna	Unlikely
		Increase in noise and vibration	■ Temporary change of habitat	■ Displacement of fauna ■ Introduction in competition from avoidance behaviour resulting in reduction in individual and population resilience ■ Compounding impact on individual resource partitioning (compromised physiology) from reduction of water quality degradation (all Project activities) ■ Minor reduction of life-history parameters	Unlikely

Fish and Marine reptile values	Threats to fish and marine reptiles#	Project direct impact (as result of whole program)	Potential Project impact pathways acting in synergy with Project impact	Potential indirect synergistic impact contributing to key threatening process	Likelihood of risk of significant impact (refer Table 9.22)
Sea kraits and other marine reptiles not listed under the EPBC Act and NC Act as species of conservation significance	■ **Coastal development** ■ Commercial fishing ■ **Habitat modification** ■ Bycatch in fisheries	Permanent removal of foraging resource	■ Permanent change of habitat ■ Temporary decline in water quality ■ Contaminant and sediment releases ■ Potential increase in noise and vibration	■ Minor reduction of life-history parameters ■ Reduction in individual and population resilience	Unlikely
		Decline in water quality	■ Permanent change of habitat	■ Minor reduction of life-history parameters	Unlikely
		Direct contact with vessel and dredging equipment	■ Permanent change of habitat	■ Minor reduction of life-history parameters	Unlikely
		Increase in noise and vibration	■ Temporary change of habitat	■ Minor reduction of life-history parameters	Unlikely

Table note:

Bold identifies threats acknowledged in relevant conservation advices, recovery plans and threat abatement plans which are those potentially impacted by Project activities

The assessment identified that the Project has the potential risk of significant synergistic impact for fish due to the permanent removal of foraging resources. No other risk of significant synergistic impact for fish and marine reptiles (excluding marine turtles) from Project activities has been identified.

The Project will implement mitigation measures provided in the Dredging EMP and Project EMP (refer AEIS Appendices F and G, respectively) and associated management plans to reduce the risk of potential Project impacts on fish and marine reptiles.

A significant residual adverse impact assessment has been conducted for significant fish values to incorporate the findings of the cumulative and synergistic impacts on the value. The significant residual adverse impact assessment for the fish and marine reptile (excluding marine turtle) values is provided in Section 9.6.4.

9.6.4 Significant residual adverse impact assessment

This section replaces the Project EIS Section 9.13.7 (fish and marine reptiles – significant residual adverse impact assessment).

The Project EIS significant residual adverse impact assessment for fish or other marine reptile (excluding marine turtle) values has been reviewed as part of the AEIS to ensure that the Project activities have been assessed at their broadest scope (i.e. the cumulative impact of all Project activities have been assessed) and that potential offsite and indirect Project impacts have been included in the significance assessment. This assessment has considered indirect Project impacts as per the definition of 'offsite and indirect' impacts provided in the *Matters of National Environmental Significance Significant Impact Guidelines, Version 1.1* (DoE 2013) and the *Queensland Environmental Offsets Policy Significant Residual Impact Guideline* (EHP 2014a).

Offsite and indirect impacts are identified via the Project impact magnitude assessment. The magnitude of a potential Project impact is a product of the temporal duration of the potential impact and the spatial scale of the impact. For each impact the estimated duration of the impact is identified (i.e. its anticipated temporal extent) and classified as temporary, short term, medium term, long term or permanent. The anticipated spatial extent of the potential impact is classified as undetectable, contained extent, local area or extensive. The consequence of the potential Project impact is determined by combining the impacts temporal and spatial extents in the magnitude matrix. AEIS Appendix E1 provides further information and definitions regarding Project assessment of magnitude.

For the purposes of this significance assessment of offsite and indirect impacts, the magnitude assessments of the potential Project residual impacts relative to the significant impact criteria assessed were considered. The consequence assessments for each relative Project residual impact were considered with respect to the potential combined, cumulative Project impact to ensure that the impact assessment was conducted with respect to the Project's broadest scope (i.e. all Project activities).

A significant residual adverse impact assessment has been conducted for MNES and/or MSES fish or other marine reptile (excluding marine turtle) species which are considered to have a moderate or high likelihood of occurrence within the Project impact areas (refer Project EIS Appendix I1 (Appendix B)).

This assessment of significant residual adverse impacts considers the significance of potential Project impacts after the implementation of the Project mitigation measures the Dredging EMP and Project EMP (refer AEIS Appendix F and G, respectively).

Table 9.24 includes the fish or other marine reptile (excluding marine turtle) species which are subject to this significant residual adverse impact assessment, due to Project impacts having the potential to result in:

- Very high or high risk (post mitigation measures) on a species (refer Project EIS Sections 9.13.2 to 9.13.5), and/or
- A residual impact to a key threatening process (refer AEIS Appendix E3 (Item 2.0)).

The MNES significant impact assessment criteria for listed and migratory species (DoE 2013) and the significant impact assessment criteria for protected wildlife habitat (EHP 2014b) has been used for the significant residual adverse impact assessment (refer Table 9.24). For the purposes of the significant residual adverse impact assessment, the species listed in Project EIS Section 9.13.1.2 have been considered together as 'Chondrichthyan species', as all species are all contained within this broader scientific classification (i.e. class containing cartilaginous fish).

The significant residual adverse impact assessment concluded that the proposed Project activities will not have a significant residual adverse impact on fish or other marine reptile (excluding marine turtle) species.

Table 9.24 Significant residual adverse impact assessment – Fish and marine reptiles (excluding marine turtles) species

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
MNES significant impact assessment criteria – Endangered, vulnerable, migratory species: ■ Lead to a long term decrease in the size of a population of a species ■ Reduce the area of occupancy of the species ■ Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline ■ Adversely affect habitat critical to the survival of a species ■ Substantially modify (including by fragmentation, altering fire regimes, alerting nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species **MSES significant impact assessment criteria – Protected wildlife habitat:** ■ Lead to a long term decrease in the size of a local population ■ Reduce the extent of occurrence of the species ■ Cause disruption to ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species	**Unlikely to have a significant impact**	The Chondrichthyan species subject to this assessment are pelagic, mobile species which are widely distributed in Australian waters. Project impacts have been identified which have the potential to fragment fish and marine reptile populations. The potential for these impacts to extend to offsite and indirect impact areas has been evaluated via the Project activity's magnitude assessment. The results are summarised below. ■ Permanent loss and alteration of foraging habitat during the establishment of the WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be permanent in duration (temporal) and contained in extent (spatial) ■ Direct mortality and injury of fish and marine reptiles during the establishment of the WBE reclamation area and BUF – Low magnitude: Potential residual impact considered to be medium in duration (temporal) and contained in extent (spatial) ■ Potential noise, vibration and dust impacts during the establishment of the WBE reclamation area and BUF and dredging activities – Moderate magnitude: Potential residual impact considered to be medium term in duration (temporal) and contained in extent (spatial) ■ Contaminant and sediment releases resulting in impacts on habitat during the establishment of the WBE reclamation area and BUF – Low magnitude: Potential residual impact considered to be medium in duration (temporal) and contained in extent (spatial) ■ Short term decline in water quality during dredging activities – Low magnitude: Potential residual impact considered to be short term in duration (temporal) and contained in extent (spatial) The Project activities cumulative and synergistic impacts have been incorporated into the significant residual adverse impact assessment for this significant impact assessment criteria. The inshore region of Port Curtis provides potential habitat for juvenile, sub-adult and adult Chondrichthyan species in the form of nursery grounds and foraging habitat.

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
		The establishment of the WBE reclamation area will result in the permanent loss of potential habitat for the Estuary stingray. Although the Project impact areas support habitat for the Estuary stingray this habitat is not unique to the Project impact area, with several surrounding meadows within Port Curtis supporting habitat for the Estuary stingray. Therefore there are substantial areas of suitable potential habitat in adjacent areas, and as such the WBE reclamation area is not likely to be key habitat for this species. The WBE reclamation area is unlikely to be potential habitat for other Chondrichthyan species known or likely to occur in the Project impact areas. Dredging activities will result in the temporary loss of potential habitat for Chondrichthyan species associated with the shipping channels and the barge access channel. This temporary loss is not expected to result in significant impacts on these species as the areas to be dredged are not known to be ecologically significant or important habitat. The Project activities may also result in underwater noise impacts and short term declines in water quality, however, with the implementation of the Dredging EMP (refer AEIS Appendix F) and the Project EMP (refer AEIS Appendix G), these potential impacts are not likely to impact on the size of a population, area of occupancy or important habitat for Chondrichthyan species. The primary foraging resources for the Chondrichthyan species included in this assessment are defined by common and widespread species, including zooplankton, benthic macroinvertebrates, crustaceans and fish. The Project will have a potential impact on intertidal foraging resources within the WBE reclamation area and BUF, however with respect to the non-specific nature of the foraging resources, the mobility of the Chondrichthyan species subject to this assessment and that the works will not isolate species movement, the Project is not anticipated to have a significant impact on the foraging resources for the species. It is important to note that no part of Port Cutis is listed as an area of identified habitat critical to the survival of the Chondrichthyan species included in this assessment, as per any applicable recovery plans or conservation advice documents. Proposed works within the Project impact areas are not anticipated to cause disruption to ecologically significant locations for the Chondrichthyan species included in this assessment. Consequently, the removal of potential species habitat is not considered likely to reduce the viability of local species assemblages, impacting on their extent of occurrence or leading to a long term population decrease in the local region. With consideration to the sequential timing and discrete locations of the Project activities and the aforementioned magnitude levels of any potential residual impact, the Project is not considered likely to have a significant residual adverse impact on this significant impact assessment criteria.

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
MNES significant impact assessment criteria – Endangered, vulnerable, migratory species: ■ Fragment an existing population into two or more populations **MSES significant impact assessment criteria – Protected wildlife habitat:** ■ Fragment an existing population ■ Result in genetically distinct populations forming as a result of habitat isolation	**Unlikely to have a significant impact**	Project impacts have been identified which have the potential to fragment fish and marine reptile populations. The potential for these impacts to extend to offsite and indirect impact areas has been evaluated via the Project activity's magnitude assessment. The results are summarised below. ■ Permanent loss and alteration of foraging habitat during the establishment of the WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be permanent in duration (temporal) and contained in extent (spatial) ■ Potential noise, vibration and dust impacts during dredging activities and the establishment of the WBE reclamation area and dredging activities – Low magnitude: Potential residual impact considered to be short term in duration (temporal) and contained in extent (spatial) The Project activities cumulative and synergistic impacts have been incorporated into the significant residual adverse impact assessment for this significant impact assessment criteria. Chondrichthyan species are considered to be highly mobile species which do not require the provision of specific shelter or microhabitat resources to facilitate movement across the landscape. The Project is considered unlikely to create a significant barrier to species movement through the marine environment or fragment cartilaginous fish populations. The Project activities are not anticipated to result in genetically distinct populations forming as a result of habitat isolation. With consideration to the sequential timing and discrete locations of the Project activities and the aforementioned magnitude levels of any potential residual impact, the Project is not considered likely to have a significant residual adverse impact on this significant impact assessment criteria.

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
MNES significant impact assessment criteria – Endangered, vulnerable, migratory species: ■ Disrupt the breeding cycle of a population ■ Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species	**Unlikely to have a significant impact**	Project impacts have been identified which have the potential to fragment fish and marine reptile populations. The potential for these impacts to extend to offsite and indirect impact areas has been evaluated via the Project activity's magnitude assessment. The results are summarised below. ■ Permanent loss and alteration of foraging habitat during the establishment of the WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be permanent in duration (temporal) and contained in extent (spatial) ■ Potential increase in artificial lighting increase during dredging activities – Low magnitude: Potential residual impact considered to be short term in duration (temporal) and contained in extent (spatial) ■ Potential noise, vibration and dust impacts during dredging activities and the establishment of the WBE reclamation area and dredging activities – Low magnitude: Potential residual impact considered to be short term in duration (temporal) and contained in extent (spatial) The Project activities cumulative and synergistic impacts have been incorporated into the significant residual adverse impact assessment for this significant impact assessment criteria. The Chondrichthyan fish species included in this assessment are pelagic and mobile species which give birth to live young. As such, the species do not require specific microhabitat features to facilitate breeding activities. The proposed works within the Project impact areas are not considered to result in a significant impact on areas critical to species breeding. As such, the Project is not anticipated to have a significant impact on the breeding cycle of species populations. The establishment of the WBE reclamation area and BUF and Project dredging activities have the potential to result in underwater noise impacts. These potential noise impacts may alter the behaviour patterns of fish and result in modification of fish behaviour, however, these impacts will be temporary to short term in nature and within a contained extent. Given the mobile nature of these species, and the absence of ecologically significant or important habitat within the Project impact areas, it is expected that Chondrichthyan fish species will temporarily avoid the Project impact areas during periods of peak underwater noise production.

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
		Underwater noise impacts will be managed with the implementation of the appropriate mitigation measures contained in the Dredging EMP (refer AEIS Appendix F) and the Project EMP (refer AEIS Appendix G). As such, potential impacts are unlikely to have a significant impact on Chondrichthyan fish species. With consideration to the sequential timing and discrete locations of the Project activities and the aforementioned magnitude levels of any potential residual impact, the Project is not considered likely to have a significant residual adverse impact on this significant impact assessment criteria.
MNES significant impact assessment criteria – Endangered, vulnerable, migratory species: ■ Result in invasive species that are harmful to an endangered, vulnerable or migratory species becoming established in the species' habitat **MSES significant impact assessment criteria – Protected wildlife habitat:** ■ Result in invasive species that are harmful to an endangered or vulnerable species becoming established in the endangered or vulnerable species' habitat	**Unlikely to have a significant impact**	Project impacts have been identified which have the potential to fragment fish and marine reptile populations. The potential for these impacts to extend to offsite and indirect impact areas has been evaluated via the Project activity's magnitude assessment. The results are summarised below. ■ Introduction and/or spread of invasive species during the stabilisation and maintenance activities of the final Project landform in the WBE reclamation area – Low magnitude: Potential residual impact considered to be short term in duration (temporal) and contained in extent (spatial) The Project activities cumulative and synergistic impacts have been incorporated into the significant residual adverse impact assessment for this significant impact assessment criteria. Invasive species have not been identified as a key threatening process for the Chondrichthyan species subject to this assessment (DES 2017a; DSEWPC 2013; GBRMPA 2012a). However, the introduction and/or spread of invasive species have the potential to adversely impact Chondrichthyan species via increased competition for resources or predation pressures. With the implementation of the mitigation measures included in the Dredging EMP (refer AEIS Appendix F) and the Project EMP (refer AEIS Appendix G), it is unlikely that Project activities will result in the introduction or spread of invasive species harmful to Chondrichthyan species. With consideration to the sequential timing and discrete locations of the Project activities and the aforementioned magnitude levels of any potential residual impact, the Project is not considered likely to have a significant residual adverse impact on this significant impact assessment criteria.

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
MNES significant impact assessment criteria – Endangered, vulnerable, migratory species: ■ Introduce disease that may cause the species to decline **MSES significant impact assessment criteria – Protected wildlife habitat:** ■ Introduce disease that may cause the species to decline	**Unlikely to have a significant impact**	Project impacts have been identified which have the potential to introduce disease that may cause the decline of fish and marine reptile species and populations. The potential for these impacts to extend to offsite and indirect impact areas has been evaluated via the Project activity's magnitude assessment. The results are summarised below. ■ Potential increase in waste material and marine debris during the establishment of the WBE reclamation area and BUF – Low magnitude: Potential residual impact considered to be short term in duration (temporal) and contained in extent (spatial) ■ Contaminant and sediment release during dredging activities – Low magnitude: Potential residual impact considered to be short term in duration (temporal) and contained in extent (spatial) The Project activities cumulative and synergistic impacts have been incorporated into the significant residual adverse impact assessment for this significant impact assessment criteria. The nature of the Project activities is considered unlikely to introduce disease that may cause species decline. The Dredging EMP (refer AEIS Appendix F) and Project EMP (refer AEIS Appendix G) will be implemented to minimise the potential introduction of disease to the area which have the potential to cause species decline. With consideration to the sequential timing and discrete locations of the Project activities and the aforementioned magnitude levels of any potential residual impact, the Project is not considered likely to have a significant residual adverse impact on this significant impact assessment criteria.
MNES significant impact assessment criteria – Endangered, vulnerable, migratory species: ■ Interfere with the recovery of the species **MSES significant impact assessment criteria – Protected wildlife habitat:** ■ Interfere with the recovery of the species	**Unlikely to have a significant impact**	Project impacts have been identified which have the potential to introduce disease that may cause the decline of fish and marine reptile species and populations. The potential for these impacts to extend to offsite and indirect impact areas has been evaluated via the Project activity's magnitude assessment. The results are summarised below. ■ Contaminant and sediment release during dredging activities – Low magnitude: Potential residual impact considered to be short term in duration (temporal) and contained in extent (spatial)

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
		The Project activities cumulative and synergistic impacts have been incorporated into the significant residual adverse impact assessment for this significant impact assessment criteria. Following review of the relevant conservation advices, recovery plans and threat abatement plans for the Chondrichthyan species subject to this assessment, injury and mortality as a result of bycatch in recreational and commercial fishing operations has been identified as a key threatening process to the species (DES 2017a; DSEWPC 2013; GBRMPA 2012a). The Project will not contribute to this threatening process. Declining water quality is another key threatening process common to the Chondrichthyan species subject to this impact assessment DES 2017a; DSEWPC 2013; GBRMPA 2012a). Short term declines in water quality are likely to occur as a result of Project activities. These potential impacts will be minimised through the implementation of mitigation measures on the Dredging EMP (refer AEIS Appendix F) and Project EMP (refer AEIS Appendix G). Therefore, potential impacts as a result of declines in water quality are not likely to interfere with the recovery of Chondrichthyan species subject to this assessment. Desktop and field geochemical investigations undertaken for the Project concluded that the marine sediments to be removed from the areas to be dredged are considered 'clean' as per NAGD (Commonwealth of Australia 2009) and the potential for contaminants to be mobilised into the water column during dredging activities is considered to be low (refer Project EIS Section 6.5 and Appendices E4 and E6). Adaptive design measures will be implemented during the Project detailed design phase to reduce the potential impacts to water quality (refer AEIS Appendix F and G, respectively). Project design of the WBE reclamation area and BUF will incorporate geotextile material to be placed within the inner face of the seaward bund wall reclamation area in order to minimise the migration of dredged material fines through the bund wall to the marine waters of Port Curtis. The release of dredging decant waters will be controlled by a licenced discharge point and weir box with conditions which will dictate the water quality criteria to be met prior to discharge. With consideration to the sequential timing and discrete locations of the Project activities and the aforementioned magnitude levels of any potential residual impact, the Project is not considered likely to have a significant residual adverse impact on this significant impact assessment criteria.

Table note:

** Includes the identification of potential Project impacts on significant impact assessment criteria, spatial and temporal assessment (i.e. magnitude assessment) of the potential Project residual impact on offsite and indirect impact areas and cumulative Project impact assessment

9.6.5 Summary

This section supplements the Project EIS Section 9.13.8 (fish and marine reptiles (excluding marine turtles) – assessment summary).

Based on the Project EIS Section 9.13 and the above supplementary assessment, all Project activities are unlikely to have a significant residual adverse impact on the fish and marine reptile values (excluding marine turtles).

The Project will implement mitigation measures provided in the Dredging EMP and Project EMP (refer AEIS Appendices F and G, respectively), and associated management plans to reduce the likelihood and magnitude of potential Project impacts on fish and marine reptiles (excluding marine turtles).

9.7 Soft sediment habitats and benthic macroinvertebrates

9.7.1 Potential cumulative and synergistic impacts from Project activities

This section supplements the Project EIS Section 9.15 (soft sediment habitats and benthic macroinvertebrates – potential impacts and risk assessment) which provides an assessment of the potential impacts of the various Project activities on soft sediment habitats and benthic macroinvertebrates.

The cumulative impact assessment that is applicable to the Project, considering foreseeable 'significant' projects and exogenous factors such as flood events and climate change is provided in the Project EIS (Chapter 21 – cumulative impact assessment and Appendix P). As such this section provides the cumulative assessment of the Project activities (i.e. the establishment of the WBE reclamation area and BUF, dredging activities, installation and removal of navigational aids, and operation and maintenance) as a whole.

To identify potential synergistic impacts on soft sediment habitats and benthic macroinvertebrates, this section provides an assessment of the potential cumulative Project impacts that were previously addressed individually as discrete Project activities on soft sediment habitats and benthic macroinvertebrates (refer Project EIS Sections 9.15.2 to 9.15.5).

The Project activities can be described as occurring in discrete spatial areas although there is some temporal overlap of Project activities. The spatial categories are described below and their location (i.e. area of direct impacts) is provided in Figure 9.2.

- Establishment of the WBE reclamation area and BUF
- Dredging activities
- Removal and installation of navigational aids
- Stabilisation and maintenance activities.

The Project dredging works will be undertaken as either a staged dredging campaign (i.e. over two stages) or as a singular campaign. Figure 9.21 illustrates the Project activity timeframes and dredging campaign options.

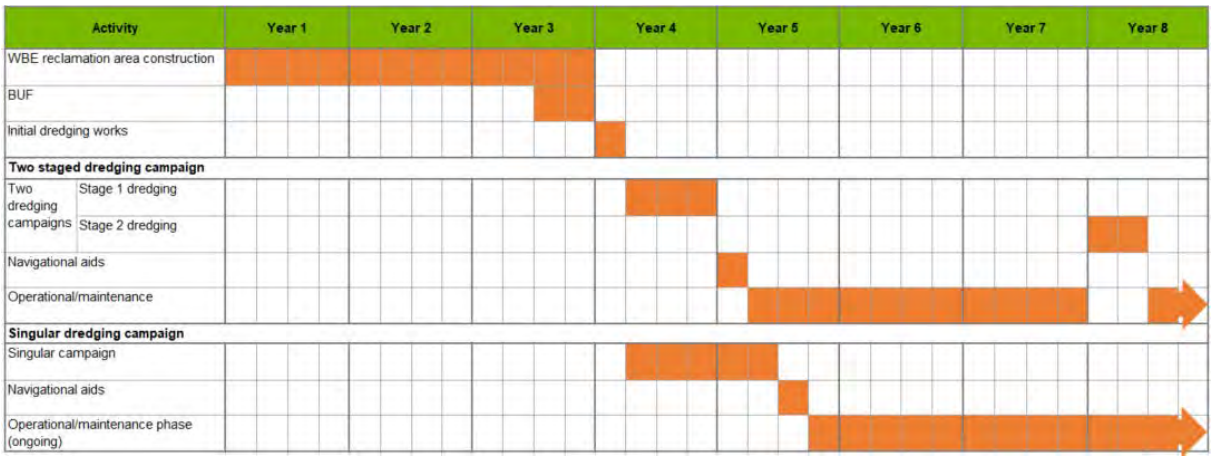

Figure 9.21 Indicative Project activity timeframes

Whilst the location of direct impacts is discrete, it is acknowledged that indirect impacts arising from the discrete Project locations (e.g. silt plumes, alterations to water quality and increased vessel movement) have the potential to result in impacts that overlap in a spatial and temporal context. Given this overlap, synergistic interactions resulting from multiple Project related impacts have the potential to impact upon soft sediment and benthic macroinvertebrates, with the results being greater than the sum of any of the single stressors alone.

Potential cumulative impacts were assessed in conjunction with potential synergistic impacts from Project activities. Cumulative impacts were defined as an accumulation of impact from all Project activities. These were considered to be independent of temporal constraints and constituted of a contributing factor driving synergistic processes. Accordingly, cumulative impacts were not assessed *per se* but rather, were assessed within the synergistic impact assessment and were incorporated into the significant residual adverse impact assessment.

Synergistic impacts result from multiple processes which act simultaneously upon a particular value. The magnitude of impact would be a function of the initial direct impact and further direct impacts (as an accumulation) and/or a function of the initial direct impact with potentiation from further indirect impacts (as a synergy) with consideration for any amplification associated with the multiple factors acting simultaneously.

To identify potential Project synergistic impacts upon soft sediment habitats and benthic macroinvertebrates, the Project EIS impact assessment outcomes (as a whole of program rather than discrete Project activities) were assessed (refer Project EIS Sections 9.15.2 to 9.15.5 and AEIS Appendices E1, E2 and E3). This enabled potential Project direct impacts (and indirect impacts) to be identified and the potential for contribution towards synergistic processes upon threatening processes to the value to be considered. This approach acknowledged the potential scale of the Project related impacts on the value and its potential to impact upon the value's capacity for recovery from the impact by contributing to a recognised threatening process.

Significant synergistic impacts were defined as potential synergistic impacts that had the capacity to contribute towards threatening processes that are recognised for a value (e.g. soft sediment habitats and benthic macroinvertebrates). The resulting likelihood of risk identified the likely contribution of synergistic pathways upon the residual adverse impact of that value.

The synergistic assessment utilised a qualitative risk approach to determine the potential risk of a significant synergistic impact. Noting that a quantitative analysis was not possible as data related to synergistic processes is traditionally non-tractable to analysis, a risk-based assessment was utilised.

Potential Project related impacts assessed as potentially significant (post implementation of impact mitigation measures) were identified as potential pathways for significant synergistic impacts and consisted of:

- Permanent loss of habitat

- Displacement of macroinvertebrates
- Potential short term decline in water quality.

The framework of assessment focussed on:

- The potential Project activity impacts
- The synergistic pathways associated with the Project activities
- How the potentiated impacts contribute to threatening processes
- The likelihood of risk of significant impact (refer Table 9.25) from the synergistic impact contribution to threatening processes.

Table 9.25 Likelihood definitions for potential impacts occurring over the life of the Project

Description	Frequency
Unlikely	Unlikely but not trivial. May occur during construction/life of the Project but probability < 50%
Potential	Less likely than not, but still considerable; probability of about 50% chance of occurring over the life of the Project
Likely	Likely to occur during construction/life of the Project or during a 12 month timeframe; probability up to 90% chance of occurring

Potential impacts to threatening processes (across all Project activities) have been identified in the Project EIS Sections 9.15.2 to 9.15.5. These sections outline the initial Project impacts which contribute to the synergies with other potential Project impacts. For further detail, refer to applicable potential Project activity impacts within the Project EIS Sections 9.15.2 to 9.15.5.

Increased impact associated with competition, resource accumulation, reproductive opportunity loss and a reduction in biological fitness were assessed as pathways for the potential to contribute to threatening processes as potential indirect synergistic impacts. Potential indirect synergistic impacts were typically associated with potential to reduce a value's life history parameters (e.g. reduced growth, reproduction, resource accumulation), through to the potential reduction in population resilience as a contributing factor towards threatening processes. Increased competition has been considered to initially derive from Project potential impacts, including permanent removal of habitat, short term decline in water quality, reduced light availability and short term increase in sedimentation.

Reductions in biological fitness of benthic macroinvertebrates has been considered to derive from all of the initial Project potential impacts, as potential reproductive opportunities were considered to be contributing factors to this synergistic pathway. Synergistic impacts which act upon resilience were considered to result in potential reduction in individual and population biological fitness.

The potential Project synergistic impacts (includes both direct and indirect impacts) on soft sediment habitats and benthic macroinvertebrates include:

- Permanent loss and alteration to habitat
- Displacement of macroinvertebrates
- Short term declines in water quality
- Increase contamination
- Increase sedimentation.

Table 9.26 provides a summary of the potential synergistic impacts from the Project as a whole on soft sediment habitats and benthic macroinvertebrates. For the purposes of determination of the risk assessment with significant synergistic impact, Project direct impacts were contained in concert with synergistic pathways to determine the potential of synergistic impacts, that will contribute to threatening processes. The likelihood of risk was determined based on Table 9.25 definitions.

Table 9.26 Risk of significant synergistic impact from identified Project impacts on soft sediment habitat and benthic and macroinvertebrates

Soft sediment habitat and benthic and macroinvertebrates	Threats to soft sediment habitat and benthic macroinvertebrates #	Project direct impact (as result of whole program)	Potential Project pathways acting in synergy with Project impact	Potential indirect synergistic impact contributing to key threatening process	Likelihood of risk of significant impact (refer Table 9.25)
Soft sediment habitat and benthic macroinvertebrates	■ **Habitat loss** ■ **Poor water quality from run-off** ■ **Sediment and nutrient pollution**	Permanent loss and/or alteration of habitat	■ Permanent change of habitat ■ Temporary decline in water quality ■ Contaminant and sediment releases	■ Reduction in individual and population resilience ■ Displacement of fauna ■ Minor reduction of life-history parameters	Likely
		Decline in water quality	■ Permanent change of habitat ■ Temporary decline in water quality	■ Reduction in population resilience	Unlikely
		Introduction and spread of pest and/or weed species	■ Permanent change of habitat ■ Temporary decline in water quality	■ Minor reduction of life-history parameters	Unlikely
		Increase contaminant and sediment releases	■ Permanent change of habitat ■ Temporary decline in water quality	■ Minor reduction of life-history parameters	Unlikely

Table note:

Bold identifies threats acknowledged within research papers that are potentially impacted by Project activities

The assessment identified that the Project has a low potential risk of significant synergistic impact for soft sediment habitats and benthic macroinvertebrates. Although the Project activities result in the permanent loss and/or alternation of soft sediment habitat and benthic macroinvertebrate species the soft sediment habitat and benthic macroinvertebrate species recorded within the Project impact areas are not considered unique to the Project impact areas and are representative of those species which have been recorded in the wider Port Curtis area. Based on habitat assessments and benthic macroinvertebrate community surveys, the WBE reclamation area and BUF is not considered to support unique benthic macroinvertebrate or benthic habitats, nor are the benthic macroinvertebrate communities present considered to be particularly diverse or abundant compared to adjacent areas.

The Project will implement mitigation measures provided in the Dredging EMP (refer AEIS Appendix F) and the Project EMP (refer AEIS Appendix G), and associated management plans, to reduce the likelihood and magnitude of potential Project impacts on soft sediment habitats and benthic macroinvertebrates. The implementation of mitigation measures contained in these EMPs will reduce residual Project impacts upon soft sediment habitats and benthic macroinvertebrates.

9.7.2 Significant residual adverse impact assessment

As identified in the Project EIS Section 9.15.7 (significant residual adverse impact assessment) no soft sediment habitats or benthic macroinvertebrate species are listed as a MNES under the provisions of the EPBC Act or are listed as a MSES under the provisions of the *Environmental Offsets Regulation 2014*. As such, a significant residual adverse impact assessment has not been conducted for the value. Therefore the significant residual adverse impact assessment has not be reassessed for the AEIS.

9.7.3 Summary

This section supplements the Project EIS Section 9.15.8 (soft sediment habitats and benthic macroinvertebrates – assessment summary).

Based on the Project EIS Section 9.15.1 to 9.15.5 and the above supplementary assessment, the Project activities are not likely to have a significant residual adverse impact on the soft sediment habitats and benthic macroinvertebrates.

The Project will implement mitigation measures provided in the Dredging EMP and Project EMP (refer AEIS Appendices F and G, respectively), and associated management plans to reduce the likelihood and magnitude of potential Project impacts on soft sediment habitats and benthic macroinvertebrates.

9.8 Migratory birds

9.8.1 Potential indirect impacts on migratory birds

This section supplements the Project EIS Section 9.17 (migratory birds – potential impacts and risk assessment).

Migratory birds defined in this section are considered those which are listed as Migratory under the EPBC Act and/or Special least concern under the provisions of the NC Act.

Migratory shorebird habitat is known to occur within 5km of the Project impact areas (Wildlife Unlimited 2016; 2017; 2018; Choi et al. 2017). This consists of six local roost sites and potential foraging habitat (refer Figure 9.22).

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The Narrows
Graham's Creek
Western Basin Expansion Reclamation Area
Friend Point
Site 7
NAR1
Northern Reclamation Area
Site 1
Southern Reclamation Area
Site 2
SMIS
Curtis Island
North Entrance
FAC4
Facing Island
Port Limits
Coral Sea
FAIS
Clinton Ash Ponds
Gladstone
Calliope River
Gatcombe Channel
South Trees Island
East Banks DMPA
Marine Park Line
Golding Cutting Channel
Site 3
Site 4
Boyne Island
Site 5
BOYN
Site 6
Tannum Sands
Boyne River
Wild Cattle Island
Tiber Point
NR07
Colosseum Inlet
Rodds Peninsula
Rodds Bay

Legend

- Proposed additional navigational aids
- Proposed removal of navigational aids
- Reposition of existing navigational aids
- Western Basin Expansion reclamation area
- Great Barrier Reef Marine Park boundary
- Initial dredging works for barge access channel
- Barge unloading facility
- Proposed Channel Duplication Project extent
- Existing shipping channels
- Port of Gladstone Port limits
- East Banks dredged material placement area (DMPA)
- Potential habitat for migratory birds
- Important roost sites
- Field survey locations

Important roosts on the Curtis Coast (Wildlife Unlimited Annual Summer Survey)

2013
- Roost 100-499 birds
- Roost >1000 birds

2015
- Roost 100-499 birds
- Roost >1000 birds

2016
- Roost 100-499 birds
- Roost 500-999 birds
- Roost >1000 birds

2017
- Roost 100-499 birds
- Roost >1000 birds

Note:
Birdlife Australia (2015) - note that this layer has been amended to reflect Aurecon field surveys within areas of assessment.

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Important roosts on the Curtis Coast: Report for Migratory Shorebird Monitoring - Port Curtis and the Curtis Coast - Annual Summer Survey, prepared by Wildlife Unlimited (2013), (2015), (2016), (2017)

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Map by: RB

0 1,900 3,800 Metres

Date: 09/08/2019 Version: 6 Job No: 237374
Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 9.22: Potential habitat for migratory shorebirds and important roost sites

The Project EIS identified that the proposed WBE reclamation area provides important migratory shorebird foraging habitat (refer Project EIS Section 9.16.2), with areas having maximum exposure during half-tide constituting higher habitat value when compared to those with minimal exposure (Wildlife Unlimited 2017). To the north of the WBE reclamation area, an important roost site for the *Numenius madagascariensis* (Eastern curlew) has been documented (i.e. 400m north of the WBE reclamation area at Friend Point on Kangaroo Island). Annual shorebird monitoring undertaken in 2015 indicates that the Friend Point roost site (NAR1) may constitute 'critical migratory shorebird habitat' in the upper Gladstone harbour area (Wildlife Unlimited 2015).

The NAR1 roost site on the shoreline at Friend Point has been identified as of 'local importance' due to the number of species and individuals that use the site (IMEMS Pty Ltd 2013). During periods of tidal inundation, migratory shorebirds from the NAR1 roost site have been observed to move further inland to the claypan (Wildlife Unlimited 2015).

Migratory shorebird foraging sites that are located close to roost sites are preferentially selected over foraging sites that are further away (Coleman and Milton 2012; Wildlife Unlimited 2016; 2017; Choi et al. 2017; Lilleyman et al. 2016). Given the proximity of foraging habitat within the proposed WBE reclamation area to the NAR1 Friend Point roost site north of the WBE reclamation area, literature indicates that this area will be preferentially selected by migratory shorebirds, increasing its ecological value for such avian species (Wildlife Unlimited 2017).

There is potential for indirect impacts to areas considered to be important to migratory shorebirds from the Project (i.e. proposed WBE reclamation area). These consist of the intertidal and subtidal foraging areas adjacent to the WBE reclamation area extending approximately 400m to the north to include the NAR1 Friend Point roost site.

Potential migratory shorebird foraging habitat located to the north of the Friend Point roost site was not considered of the highest quality as it is typically not exposed at half tide (Wildlife Unlimited 2017). Therefore, potential shorebird foraging habitat areas further north of the Friend Point roosting area were not included as part of the Project's potential indirect impact area.

The Project (i.e. proposed WBE reclamation area) will result in the potential direct and permanent loss of approximately 275.37ha of potential migratory shorebird habitat and potential indirect impact of approximately 203.93ha (refer Table 9.27). Overall, the direct and indirect loss of this potential habitat due to establishment of the WBE reclamation area, equates to approximately 2.05% of the total area of the potential habitat in the Port Curtis region.

Figure 9.23 identifies the potential migratory shorebird habitat that will be potentially directly and indirectly impacted on by the Project.

Table 9.27 Project potential direct and indirect impacts on migratory shorebird foraging/roosting areas

Project activity	Direct Project impact area on migratory shorebird habitat	Potential indirect Project impact area on migratory shorebird habitat	Total area of potential impact on migratory shorebird habitat
WBE reclamation area (southern area)	110.39ha	203.93ha[1]	479.30ha
WBE reclamation area (northern area)	164.98ha		
BUF	0ha	0ha	0ha
Initial dredging works (barge access channel)	0ha	0ha	0ha
Channel duplication dredging (Stages 1 and 2 combined)	0ha	0ha	0ha
Total area	**275.37ha**	**203.93ha**	**479.30ha**

Table note:

1 The Project potential indirect impact area for the establishment of the WBE reclamation area has been combined for the southern and northern area. The potential Project indirect impact area is based on a distance of approximately 400m from the proposed WBE reclamation area and includes the Friend Point roost site.

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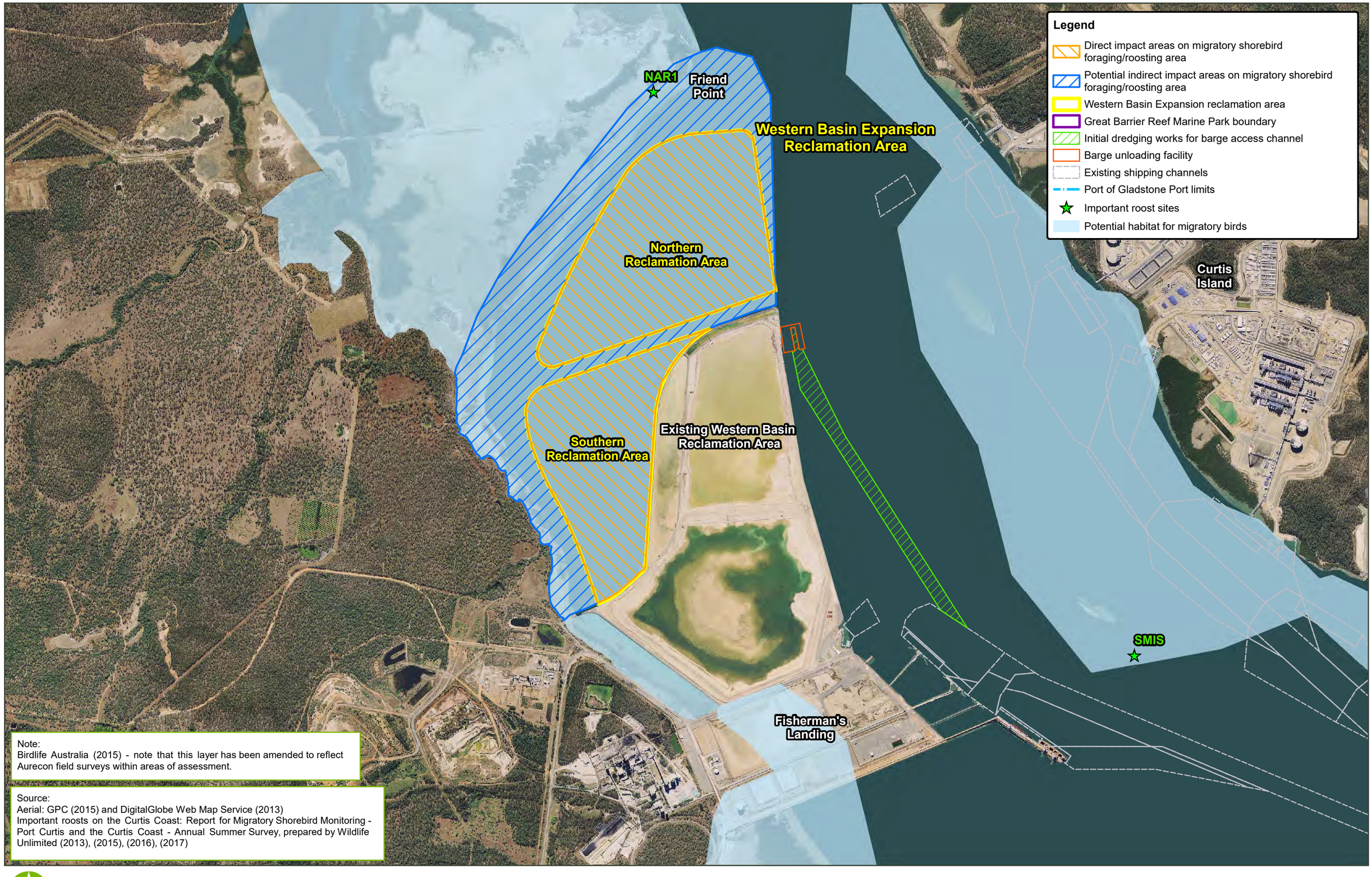

Note:
Birdlife Australia (2015) - note that this layer has been amended to reflect Aurecon field surveys within areas of assessment.

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Important roosts on the Curtis Coast: Report for Migratory Shorebird Monitoring - Port Curtis and the Curtis Coast - Annual Summer Survey, prepared by Wildlife Unlimited (2013), (2015), (2016), (2017)

Map by: RB P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_372.mxd 08/08/2019 10:36

0 310 620 Metres

Date: 08/08/2019 Version: 6 Job No: 237374

Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 9.23: Potential Project direct and indirect impact areas on migratory shorebird foraging and roosting areas

Although indirect impact areas have been calculated for the foraging/roosting areas associated with Friend Point roosting site (NAR1) there are a number of indirect impacts that have the potential to occur that have a non-definable indirect impact area and cannot be quantified, such as:

- The effects of the displacement of migratory shorebirds
- New roost sites being compatible with migratory shorebirds
- Changes in marine water velocities resulting in change to foraging habitat
- Anthropogenic impacts.

The establishment of the WBE reclamation area results in the direct and permanent loss of shorebird habitat which has the potential to cause an indirect impact on the displacement of migratory shorebirds. Many migratory shorebirds show strong fidelity to sites in their non-breeding grounds (Coleman and Milton 2012). Such strong fidelity, may be maladaptive and stressors that cause alteration to their normal routine may result in decreased feeding activity, increased energy consumption and subsequent loss of biological fitness which has the potential to increase mortality and impede migratory patterns and behaviours. Roost sites for migratory shorebirds provide a number of benefits, including protection from predators, an ability to rest and ability to access feeding grounds located proximate to such areas (Lilleyman et al. 2016; Choi et al. 2013; Jackson 2017).

The loss of foraging habitat will result in the need for migratory shorebirds to find new roost and foraging sites within the Port or travel greater distances from current roosts to feeding grounds that remain unaffected by Project related impacts. When migratory shorebirds are required to move to new roosting locations, there is potential for new roosts to provide sub-optimal conditions when compared to the established/original roost location. Forced establishment of new roosting locations has the potential to increase intra and interspecific competitive processes for resources, including space and food and may potentially result in increased energy use (i.e. birds flying further distances to feed) which has the potential to increase mortality of migratory shorebirds by decreasing biological fitness though decreased feeding efficiency/resource accumulation.

Disturbance and displacement of migratory shorebirds can result in reduced food intake and increased energy expenditure, potentially resulting in reduced use or abandonment of preferred feeding and roosting areas (Geering et al. 2007). Disturbances resulting in increased time spent in alarm flight can adversely impact shorebird energy reserves required for migration, can alter the selection of roosting and foraging sites, and has the potential to ultimately affect the survival of migratory shorebirds through reductions in resource accumulation (Collop et al. 2016; Lilleyman et al. 2016).

The hydrodynamic modelling of erosion and siltation impacts indicate that there will be an increase in the velocity in the channel between the reclamation area and the coastline area and therefore increasing the potential for erosion and siltation. Changes in marine water velocities, erosion and siltation have the potential to result in the decrease in abundance or altered distribution of prey resources.

Hydrodynamic and water quality impacts have the potential to result in indirect impacts to migratory shorebirds by altering the suitability of foraging habitat resulting in changes in foraging and roosting behaviour (e.g. reduced intake of prey items or movement to alternative foraging locations if available).

Further, anthropogenic impacts (i.e. increased fishing, development on foraging areas) have the potential to indirectly impact migratory shorebird foraging/roosting.

Although birds are highly mobile, repetitive disruption to foraging, breeding or roosting behaviours will result in birds wasting energy relocating, particularly for migratory birds that require these resources for their long migrations which are essential components of their breeding cycle.

There are no known migratory pelagic bird roost sites within the Project impact areas.

9.8.2 Potential cumulative and synergistic impacts from Project activities

This section supplements the Project EIS Section 9.17 (migratory birds – potential impacts and risk assessment).

The cumulative impact assessment that is applicable to the Project, considering foreseeable 'significant' projects and exogenous factors such as flood events and climate change is provided in the Project EIS (Chapter 21 – cumulative impact assessment and Appendix P). As such this section provides the cumulative assessment of the Project activities (i.e. the establishment of the WBE reclamation area and BUF, dredging activities, installation and removal of navigational aids, and operation and maintenance) as a whole.

To identify potential synergistic impacts on migratory birds, this section provides an assessment of the potential cumulative Project impacts that were previously addressed individually as discrete Project activities on migratory birds (refer Project EIS Sections 9.17.2 to 9.17.5).

The Project activities can be described as occurring in discrete spatial areas although there is some temporal overlap of Project activities. The spatial categories are described below and their location (i.e. area of direct impact) is provided in Figure 9.2.

- Establishment of the WBE reclamation area and BUF
- Dredging activities
- Removal and installation of navigational aids
- Stabilisation and maintenance activities.

The Project dredging works will be undertaken as either a staged dredging campaign (i.e. over two stages) or as a singular campaign. Figure 9.24 illustrates the Project activity timeframes and dredging campaign options.

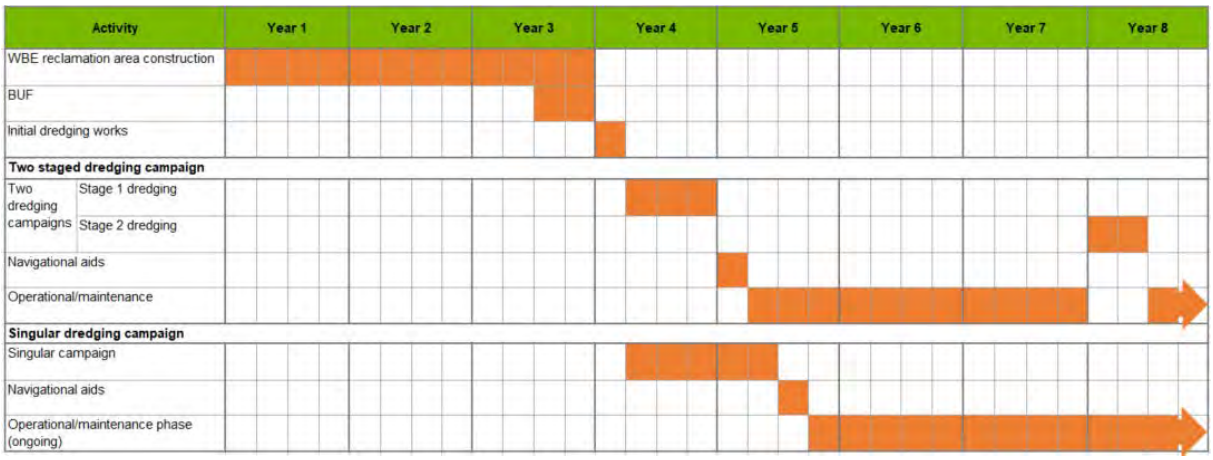

Figure 9.24 Indicative Project activity timeframes

Whilst the location of direct impacts is discrete, it is acknowledged that indirect impacts arising from the discrete Project locations (e.g. silt plumes, increased noise and vibration, alterations to water quality and increased vessel movement) have the potential to result in impacts that overlap in a spatial and temporal context. Given this overlap, synergistic interactions resulting from multiple Project related impacts have the potential to impact upon migratory birds, with the results being greater than the sum of any of the single stressors alone.

Potential cumulative impacts were assessed in conjunction with potential synergistic impacts from Project activities. Cumulative impacts were defined as an accumulation of impacts from all Project activities. These were considered to be independent of temporal constraints and constituted a contributing factor driving synergistic processes. Accordingly, cumulative impacts were not assessed *per se* but rather, were assessed within the synergistic impact assessment and were incorporated into the significant residual adverse impact assessment.

Synergistic impacts result from multiple processes which act simultaneously upon a particular value. The magnitude of impact would be a function of the initial direct impact and further direct impacts (as an accumulation) and/or a function of the initial direct impact with potentiation from further indirect impacts (as a synergy) with consideration for any amplification associated with the multiple factors acting simultaneously.

To identify potential Project synergistic impacts upon migratory birds, the Project EIS impact assessment outcomes (as a whole of program rather than discrete Project activities) were assessed (refer Project EIS Sections 9.17.2 to 9.17.5 and AEIS Appendices E1, E2 and E3). This enabled potential Project direct impacts (and indirect impacts) to be identified and the potential for contribution towards synergistic processes upon key threatening process to be considered. This approach acknowledged the potential scale of the Project related impacts on the value and its potential to impact upon the value's capacity for recovery from the impact, by contributing to a recognised threatening process.

Significant synergistic impacts were defined as potential synergistic impacts that had the capacity to contribute towards threatening processes that are recognised for a value (e.g. migratory birds). The resulting likelihood of risk identified the likely contribution of synergistic pathways upon the residual adverse impact of that value.

The synergistic assessment utilised a qualitative risk approach to determine the potential risk of a significant synergistic impact. Noting that a quantitative analysis was not possible as data related to synergistic processes is traditionally non-tractable to analysis, a risk-based assessment was utilised.

Potential Project related impacts assessed as potentially significant (post implementation of impact mitigation measures) were identified as potential pathways for significant synergistic impacts and consisted of:

- Direct and/or permanent loss of foraging habitat
- Direct mortality and injury
- Increase noise and vibration.

The framework of assessment focussed on:

- The potential Project activity impacts
- The synergistic pathways associated with the Project activities
- How the potentiated impacts contribute to key threatening processes, and
- The likelihood of risk of significant impact (refer Table 9.28) from the synergistic impact contribution to key threatening processes.

Table 9.28 Likelihood definitions for potential impacts occurring over the life of the Project

Description	Frequency
Unlikely	Unlikely but not trivial. May occur during construction/life of the Project but probability < 50%
Potential	Less likely than not, but still considerable; probability of about 50% chance of occurring over the life of the Project
Likely	Likely to occur during construction/life of the Project or during a 12 month timeframe; probability up to 90% chance of occurring

Potential impacts to threatening processes (across all Project activities) have been identified in the Project EIS Sections 9.17.2 to 9.17.5. These sections outline the initial Project impacts which contribute to the synergies with other potential Project impacts. For further detail, refer to applicable potential Project activity impacts within the Project EIS Sections 9.13.2 to 9.13.5.

Increased impact associated with competition, resource accumulation, reproductive opportunity loss and a reduction in biological fitness were assessed as pathways for the potential to contribute to key threatening processes as potential indirect synergistic impacts. Potential indirect synergistic impacts were typically associated with the potential to reduce a value's life history parameters (e.g. reduced growth, reproduction, resource accumulation), through to the potential reduction in population resilience as a contributing factor towards key threatening processes. Increased competition has been considered to initially derive from Project potential impacts, including permanent removal of habitat, short term decline in water quality, increase in noise and vibration, and short term increase in sedimentation. Additionally, migratory shorebirds show fidelity to their roosting and foraging sites and prefer to roost close to foraging areas (Coleman and Milton 2012). This fidelity may adversely impact upon survival rates when the habitat is permanently lost or altered. Roosting sites have been identified near the WBE reclamation area, and establishment of Project infrastructure may alter roosting behaviour due to the loss of foraging habitat. The generation of noise, vibration and dust during the Project has the potential to cause disturbance to foraging, roosting and migratory behaviour.

Reductions in biological fitness has been considered to derive from all of the initial impacts, as potential reproductive and resource accumulation opportunities were considered to be contributing factors to this synergistic pathway. Synergistic impacts which act upon resilience were considered to result in potential reduction in individual and population biological fitness.

The potential Project synergistic impacts (includes both direct and indirect impacts) on migratory birds include:

- Direct and/or permanent loss of foraging habitat
- Alteration of habitat
- Increase in waste materials
- Hydrodynamic and water quality impacts
- Contaminant and sediment release
- Erosion and sedimentation
- Increased noise, vibration and dust.

Table 9.29 provides a summary of the potential synergistic impacts from the Project as a whole on migratory birds. For the purposes of determination of the risk assessment with significant synergistic impact, Project direct impacts were contained in concert with synergistic pathways to determine the potential of synergistic impacts that will contribute towards key threatening processes. The likelihood of risk was determined based on Table 9.28 definitions.

Table 9.29 Risk of significant synergistic impact from identified Project impacts on migratory birds

Migratory bird value	Species threats identified in relevant research articles, and MSES criteria[#]	Project direct impact (as result of whole program)	Potential Project pathways acting in synergy with Project impact	Potential indirect synergistic impact contributing to key threatening process	Likelihood of risk of significant impact
Critically endangered or endangered migratory shorebirds under the EPBC Act, and important habitat	■ **Habitat loss** ■ **Habitat modification** ■ **Anthropogenic disturbance** ■ Climate variability and change ■ Harvesting of shorebird prey ■ Fisheries by-catch ■ Hunting.	Permanent loss and alteration of habitat (including foraging habitat)	■ Permanent change of habitat ■ Temporary decline in water quality ■ Increased vessel movement ■ Increased noise and vibration	■ Increase in potential mortality from contact with dredging equipment from modification of habitat use ■ Reduction in individual and population resilience ■ Minor reduction of life-history parameters ■ Displacement of foraging species ■ Increased travel time to feed	Likely
		Direct mortality and injury	■ Permanent change of habitat ■ Temporary decline in water quality ■ Increased noise and vibration	■ Increase in potential mortality from contact with dredging equipment from modification of habitat use ■ Reduction in individual and population resilience ■ Minor reduction of life-history parameters ■ Displacement of foraging species ■ Alteration of behaviour	Potential
		Potential noise, vibration and dust impacts	■ Potential vessel interaction ■ Temporary decline in water quality	■ Reduction in individual and population resilience ■ Minor reduction of life-history parameters ■ Displacement of foraging species	Potential
		Hydrological and water quality impacts	■ Permanent change of habitat ■ Increased vessel movement ■ Increased noise and vibration	■ Reduction in individual and population resilience ■ Minor reduction of life-history parameters ■ Displacement of foraging species ■ Alteration of behaviour	Potential

Migratory bird value	Species threats identified in relevant research articles, and MSES criteria[#]	Project direct impact (as result of whole program)	Potential Project pathways acting in synergy with Project impact	Potential indirect synergistic impact contributing to key threatening process	Likelihood of risk of significant impact
Vulnerable and/or migratory shorebirds under the EPBC Act, and habitat other than important habitat	■ **Habitat loss** ■ **Habitat modification** ■ **Anthropogenic disturbance** ■ Climate variability and change ■ Harvesting of shorebird prey ■ Fisheries by-catch ■ Hunting.	Permanent loss and alteration of habitat (including foraging habitat)	■ Permanent change of habitat ■ Temporary decline in water quality ■ Increased vessel movement ■ Increased noise and vibration	■ Increase in potential mortality from contact with dredging equipment from modification of habitat use ■ Reduction in individual and population resilience ■ Minor reduction of life-history parameters ■ Displacement of foraging species ■ Increased travel time to feed	Likely
		Direct mortality and injury	■ Permanent change of habitat ■ Temporary decline in water quality ■ Increased noise and vibration	■ Increase in potential mortality from contact with dredging equipment from modification of habitat use ■ Reduction in individual and population resilience ■ Minor reduction of life-history parameters ■ Displacement of foraging species ■ Alteration of behaviour	Potential
		Potential noise, vibration and dust impacts	■ Potential vessel interaction ■ Temporary decline in water quality	■ Reduction in individual and population resilience ■ Minor reduction of life-history parameters ■ Displacement of foraging species	Potential
		Hydrological and water quality impacts	■ Permanent change of habitat ■ Increased vessel movement ■ Increased noise and vibration	■ Reduction in individual and population resilience ■ Minor reduction of life-history parameters ■ Displacement of foraging species ■ Alteration of behaviour	Potential

Migratory bird value	Species threats identified in relevant research articles, and MSES criteria#	Project direct impact (as result of whole program)	Potential Project pathways acting in synergy with Project impact	Potential indirect synergistic impact contributing to key threatening process	Likelihood of risk of significant impact
Critically endangered or endangered migratory seabirds under the EPBC Act, and important habitat	■ **Habitat loss** ■ **Habitat modification** ■ **Anthropogenic disturbance** ■ Climate variability and change ■ Harvesting of shorebird prey ■ Fisheries by-catch ■ Hunting.	Permanent loss and alteration of habitat (including foraging habitat)	■ Permanent change of habitat ■ Temporary decline in water quality ■ Increased vessel movement ■ Increased noise and vibration	■ Increase in potential mortality from contact with dredging equipment from modification of habitat use ■ Reduction in individual and population resilience ■ Minor reduction of life-history parameters ■ Displacement of foraging species	Potential
		Direct mortality and injury	■ Permanent change of habitat ■ Temporary decline in water quality ■ Increased noise and vibration	■ Increase in potential mortality from contact with dredging equipment from modification of habitat use ■ Reduction in individual and population resilience ■ Minor reduction of life-history parameters ■ Displacement of foraging species ■ Alteration of behaviour	Potential
		Potential noise, vibration and dust impacts	■ Potential vessel interaction ■ Temporary decline in water quality	■ Reduction in individual and population resilience ■ Minor reduction of life-history parameters ■ Displacement of foraging species	Potential
		Hydrological and water quality impacts	■ Permanent change of habitat ■ Increased vessel movement ■ Increased noise and vibration	■ Reduction in individual and population resilience ■ Minor reduction of life-history parameters ■ Displacement of foraging species ■ Alteration of behaviour	Potential

Table note:

Bold identifies threats acknowledged in relevant conservation advices, recovery plans and threat abatement plans which are those potentially impacted by Project activities.

The assessment identified that the Project has the potential risk of significant synergistic impact for migratory birds and seabirds due to:

- Permanent loss and alteration of habitat
- Alteration in behaviours
- Potential direct mortality and injury.

A significant residual adverse impact assessment has been conducted for migratory bird values as the Project was identified as potentially having a residual sequential impact on the value. The significant residual adverse impact assessment for migratory bird values is provided in Section 9.8.3.

9.8.3 Significant residual adverse impact assessment

This section supplements the Project EIS Section 9.17.7 (significant residual adverse impact assessment).

The Project EIS provided a significant residual adverse impact assessment to identify if the Project will, or is considered likely to have, a significant residual adverse impact on migratory bird values (refer Section 9.17.7 of the Project EIS). The significant residual adverse impact assessment concluded that the proposed Project activities will have a significant residual adverse impact on migratory shorebirds, and will not have a significant residual adverse impact on migratory seabirds.

The Project cumulative and synergistic impact assessment (refer Section 9.8.2) did not change the Project EIS finding for the significant residual adverse impact assessment on migratory seabirds and as such the significant residual adverse impact assessment has not been reassessed as part of the AEIS.

The significant residual adverse impact assessment for migratory bird values has been reviewed as part of the AEIS to ensure that the Project activities have been assessed at their broadest scope (i.e. the cumulative impact of all Project activities have been assessed) and that potential offsite and indirect Project impacts have been included in the significance assessment. This assessment has considered indirect Project impacts as per the definition of 'offsite and indirect' impacts provided in the *Queensland Environmental Offsets Policy Significant Residual Impact Guideline* (EHP 2014a) and the *Matters of National Environmental Significance Significant Impact Guidelines, Version 1.1* (DoE 2013).

Offsite and indirect impacts are identified via the Project impact magnitude assessment. The magnitude of a potential Project impact is a product of the temporal duration of the potential impact and the spatial scale of the impact. For each impact the estimated duration of the impact is identified (i.e. its anticipated temporal extent) and classified as temporary, short term, medium term, long term or permanent. The anticipated spatial extent of the potential impact is classified as undetectable, contained extent, local area or extensive. The consequence of the potential Project impact is determined by combining the impacts temporal and spatial extents in the magnitude matrix. Appendix E1 provides further information and definitions regarding Project assessment of magnitude.

For the purposes of this significance assessment of offsite and indirect impacts, the magnitude assessments of the potential Project residual impacts relative to the significant impact criteria assessed were considered. The consequence assessments for each relative Project residual impact were considered with respect to the potential combined, cumulative Project impact to ensure that the impact assessment was conducted with respect to the Project's broadest scope (i.e. all Project activities).

Following the review undertaken as part of this AEIS, the Project is considered likely to have a significant residual adverse impact on migratory shorebirds within the potential Project direct and indirect impact areas illustrated in Figure 9.23 and described in Table 9.30.

The Project is not considered likely to have a significant residual adverse impact on migratory seabirds in the Project direct and indirect impact areas. Information to support these assessment outcomes is provided in Table 9.30 and should be read in conjunction with the significant residual adverse impact assessments presented in Section 9.17.7 of the Project EIS.

Table 9.30 Significant residual adverse impact assessment for migratory bird values – supplementary information

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Supplementary supporting information**
MNES – Endangered, vulnerable, migratory species ■ Lead to a long term decrease in the size of a population of a species# ■ Reduce the area of occupancy of the species# ■ Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline# ■ Adversely affect habitat critical to the survival of a species# ■ Substantially modify (including by fragmentation, altering fire regimes, alerting nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species# ■ Disrupt the breeding cycle of a population# ■ Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species ■ Interfere with the recovery of the species# **MSES – Protected wildlife habitat#** ■ Lead to a long term decrease in the size of a local population ■ Reduce the extent of occurrence of the species ■ Cause disruption to ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species ■ Interfere with the recovery of the species	**Migratory shorebirds:** Potentially significant impact **Migratory seabirds:** Unlikely to have a significant impact	Project impacts have been identified which have the potential to adversely impact the migratory bird values detailed in this significant impact assessment criteria. The potential for these impacts to extend to offsite and indirect impact areas has been evaluated via the Project activity's magnitude assessment. The results are summarised below. ■ Permanent loss and alteration of migratory shorebird habitat during the establishment of the WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be permanent in duration (temporal) and contained in extent (spatial) ■ Direct mortality and injury of migratory shorebirds during the establishment of the WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be medium in duration (temporal) and contained in extent (spatial) ■ Potential noise, vibration and dust impacts during the establishment of the WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be medium in duration (temporal) and contained in extent (spatial) ■ Hydrodynamic and water quality impacts resulting in habitat alteration during the establishment of the WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be permanent in duration (temporal) and contained in extent (spatial) ■ Contaminant and sediment releases resulting in impacts on habitat during the establishment of the WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be medium in duration (temporal) and contained in extent (spatial) ■ Potential noise, vibration and dust impacts during dredging activities – Low magnitude: Potential residual impact considered to be short term in duration (temporal) and contained in extent (spatial) ■ Direct mortality and injury due to vessel movements during dredging activities – Moderate magnitude: Potential residual impact considered to be short term in duration (temporal) and contained in extent (spatial)

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Supplementary supporting information**
		■ Short term decline in water quality during dredging activities – Low magnitude: Potential residual impact considered to be short term in duration (temporal) and contained in extent (spatial) ■ Loss of food sources and impacts on migratory bird prey during dredging activities – Moderate magnitude: Potential residual impact considered to be short term in duration (temporal) and within the local area (spatial) ■ Contaminant and sediment release during the removal and installation of navigational aids – Low magnitude: Potential residual impact considered to be temporary in duration (temporal) and contained in extent (spatial) ■ Potential noise, vibration and dust impacts during stabilisation and establishment of the final Project landform in the WBE reclamation area – Low magnitude: Potential residual impact considered to be short term in duration (temporal) and contained in extent (spatial) The Project activities cumulative and synergistic impacts have been incorporated into the significant residual adverse impact assessment for this significant impact assessment criteria. Establishment of the WBE reclamation area will result in the permanent loss of migratory shorebird foraging habitat within the Project direct impact area. This activity has the potential to reduce the area of occupancy for migratory shorebirds and have a significant residual adverse impact on offsite shorebird roost sites and foraging habitat within the adjoining Project indirect impact area (refer Figure 9.23). Migratory shorebirds show fidelity to their roosting and foraging sites and prefer to roost close to foraging areas (Coleman and Milton 2012). This fidelity may adversely impact upon local population survival rates when the habitat is permanently lost or altered. The Friend Point roost site (NAR1) is considered likely to be subject to significant indirect Project impacts due to the loss of foraging habitat within the WBE reclamation area. The cumulative impact of this loss of foraging habitat combined with potential Project indirect impacts such as noise, vibration and dust impacts, and hydrological and water quality impacts resulting in habitat alteration are considered likely to have a potential significant impact on important foraging and roosting habitat within the offsite WBE reclamation indirect impact area (i.e. within approximately 400m of the proposed WBE reclamation area and includes the Friend Point roost site).

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Supplementary supporting information**
		The Project dredging activities have the potential to have a synergistic impact on local migratory seabird populations. This is due to the high risks of potential noise, vibration and dust impacts and potential direct mortality and injury due to vessel movements. The significance of any potential synergistic impact on migratory seabird populations is considered to be low with respect to nature of habitat impacted (i.e. general nature of the species open water foraging habitat which is not in close proximity to roosting sites), and the species ability to migrate vast distances in the event of a temporary declines in habitat values. Furthermore there are no known migratory seabird roost sites located within close proximity to the Project. The Project is considered unlikely to have a significant residual impact on this assessment criteria for migratory seabirds in offsite and Project indirect impact areas. The significant residual adverse impact to migratory shorebirds as a result of the Project includes: ■ Direct disturbance of 275.37ha of foraging habitat as a result of the establishment of the WBE reclamation area ■ Indirect disturbance of 203.93ha of foraging habitat as a result of the establishment of the WBE reclamation area.
MNES – Endangered, vulnerable, migratory species ■ Fragment an existing population into two or more populations# **MSES – Protected wildlife habitat#** ■ Fragment an existing population ■ Result in genetically distinct populations forming as a result of habitat isolation	**Migratory shorebirds:** Unlikely to have a significant impact **Migratory seabirds:** Unlikely to have a significant impact	Project impacts have been identified which have the potential to fragment migratory bird populations. The potential for these impacts to extend to offsite and indirect impact areas has been evaluated via the Project activity's magnitude assessment. The results are summarised below. ■ Potential noise, vibration and dust impacts during the establishment of the WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be medium term in duration (temporal) and contained in extent (spatial) ■ Potential noise, vibration and dust impacts during dredging activities and the establishment of the final Project landform in the WBE reclamation area – Low magnitude: Potential residual impact considered to be short term in duration (temporal) and contained in extent (spatial) The Project activities cumulative and synergistic impacts have been incorporated into the significant residual adverse impact assessment for this significant impact assessment criteria. Local and important roost sites for migratory shorebirds have been identified in offsite and indirect Project impact areas (refer Figure 9.23).

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Supplementary supporting information**
		Although the Project is considered likely to reduce the occupancy of local migratory shorebird populations (as discussed and assessed above), with respect to the mobile nature of migratory shorebirds and the availability of adjacent foraging habitat, the Project is considered unlikely to have a significant impact on the fragmentation of existing species populations. The nature of the Project activities and associated potential impacts will not impede the movement of migratory bird species to the extent that population fragmentation is considered likely to occur. There are no known migratory seabird roost sites located within close proximity to the Project and given the general nature of the species foraging habitat (i.e. open waters) and the highly mobile nature of the species, the Project activities are considered unlikely to have a significant impact on the fragmentation existing species populations. With consideration to the sequential timing and discrete locations of the Project activities and the aforementioned magnitude levels of any potential residual impact, the Project is not considered likely to have a significant residual adverse impact on this significant impact assessment criteria.
MNES – Endangered, vulnerable, migratory species ■ Result in invasive species that are harmful to an endangered, vulnerable or migratory species becoming established in the species' habitat **MSES – Protected wildlife habitat#** ■ Result in invasive species that are harmful to an endangered or vulnerable species becoming established in the endangered or vulnerable species' habitat	**Migratory shorebirds:** Unlikely to have a significant impact **Migratory seabirds:** Unlikely to have a significant impact	Project impacts have been identified which have the potential to result in the introduction and spread of invasive species that are harmful to migratory bird species and their habitat. The potential for these impacts to extend to offsite and indirect impact areas has been evaluated via the Project activity's magnitude assessment. The results are summarised below. ■ Reduced suitability of migratory shorebird habitat due to the introduction and/or spread of pests and/or weeds during the establishment of the WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be medium term in duration (temporal) and contained in extent (spatial) ■ Introduction and/or spread of invasive species during the stabilisation and maintenance activities of the final Project landform in the WBE reclamation area – Low magnitude: Potential residual impact considered to be short term in duration (temporal) and contained in extent (spatial) The Project activities cumulative and synergistic impacts have been incorporated into the significant residual adverse impact assessment for this significant impact assessment criteria.

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Supplementary supporting information**
		Unmitigated, the introduction and spread of invasive species into the local environment can have a significant and compounding impact on offsite and indirect Project impact areas. However with the implementation of the appropriate management plans (refer AEIS Appendices F to H) to minimise any risk of occurrence and to provide timely response measures in the unlikely event of an incident, the potential residual Project impact on this criteria to offsite and indirect impact areas is considered unlikely to be significant. With consideration to the sequential timing and discrete locations of the Project activities and the aforementioned magnitude levels of any potential residual impact, the Project is not considered likely to have a significant cumulative impact on this significant impact assessment criteria.
MNES – Endangered, vulnerable, migratory species ■ Introduce disease that may cause the species to decline[#] **MSES – Protected wildlife habitat[#]** ■ Introduce disease that may cause the population to decline	**Migratory shorebirds:** Unlikely to have a significant impact **Migratory seabirds:** Unlikely to have a significant impact	Project impacts have been identified which have the potential to introduce disease that may cause the decline of migratory bird species and populations. The potential for these impacts to extend to offsite and indirect impact areas has been evaluated via the Project activity's magnitude assessment. The results are summarised below. ■ Potential increase in waste material and marine debris during the establishment of the WBE reclamation area and BUF – Low magnitude: Potential residual impact considered to be short term in duration (temporal) and contained in extent (spatial) ■ Contaminant and sediment release during the establishment of WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be medium term in duration (temporal) and contained in extent (spatial) ■ Contaminant and sediment release during dredging activities and the stabilisation and maintenance activities of the final Project landform in the WBE reclamation area – Low magnitude: Potential residual impact considered to be short term in duration (temporal) and contained in extent (spatial) ■ Contaminant and sediment release during the removal and installation of navigational aids – Low magnitude: Potential residual impact considered to be temporary in duration (temporal) and contained in extent (spatial)

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Supplementary supporting information**
		The Project activities cumulative and synergistic impacts have been incorporated into the significant residual adverse impact assessment for this significant impact assessment criteria. Unmitigated, the introduction of disease into the local environment can have a significant and compounding impact on indirect Project impact areas. However with the implementation of the appropriate management plans (refer AEIS Appendices F to H) to minimise any risk of occurrence and to provide timely response measures in the unlikely event of an incident, the potential residual Project impact on this criteria to offsite and indirect impact areas is considered unlikely to be significant. With consideration to the sequential timing and discrete locations of the Project activities and the aforementioned magnitude levels of any potential residual impact, the Project is not considered likely to have a significant residual adverse impact on this significant impact assessment criteria.

Table notes:

\# Criteria is not relevant for migratory species which are not listed as species of conservation significance under the EPBC Act and/or NC Act

** Includes the identification of potential Project impacts on significant impact assessment criteria, spatial and temporal assessment (i.e. magnitude assessment) of the potential Project residual impact on offsite and indirect impact areas and cumulative Project impact assessment

9.8.4 Summary

This section supplements the Project EIS Section 9.17.8 (migratory birds – assessment summary).

Based on the Project EIS Section 9.17.7 and the above supplementary assessment, the Project activities below are likely to have a significant residual adverse impact on the migratory shorebird values.

- Direct disturbance from the establishment of the WBE reclamation area on migratory shorebird foraging habitat (i.e. direct impact area of 275.37ha)
- Indirect impacts from the establishment of the WBE reclamation area (i.e. potential Project noise, vibration and dust impacts, potential direct mortality and potential habitat alteration due to potential hydrological and water quality impacts) on migratory shorebird foraging habitat and the Friend Point shorebird roost site (NAR1) (i.e. predicted indirect impact area of 203.93ha). Further there are a number of indirect impacts from the Project activities that are not measurable and cannot be defined such as behavioural shifts in migratory shorebirds as a result of roost site attractiveness, removal of feeding grounds and anthropogenic disturbance.

The Project will implement mitigation measures provided in the Dredging EMP and Project EMP (refer AEIS Appendices F and G, respectively), and associated management plans to reduce the likelihood and magnitude of potential Project impacts on migratory shorebirds values.

The Project significant residual adverse impact on migratory shorebird values will be offset by implementing the Channel Duplication Project Offset Strategy (refer AEIS Appendix E4 for the draft strategy).

The Project is not considered likely to have a significant residual adverse impact on migratory seabirds in the Project direct and indirect impact areas. There are no known migratory seabird roost sites located within close proximity to the Project and given the general nature of the species foraging habitat (i.e. open waters) and the highly mobile nature of the species, the Project activities are considered unlikely to have a significant impact on migratory seabird populations.

9.9 Marine turtles – existing environment

This section replaces the Project EIS Section 9.18 (marine turtle – existing environment) which provides background and marine turtle values relevant to the Project impact areas.

9.9.1 Background

There are seven extant species of marine turtle worldwide and Australia has resident or migratory populations of six of these species, all of which occur within the GBRWHA (GBRMPA 2018a). These species include the Green turtle (*Chelonia mydas*), Loggerhead turtle (*Caretta caretta*), Hawksbill turtle (*Eretmochelys imbricata*), Flatback turtle (*Natator depressus*), Leatherback turtle (*Dermochelys coriacea*), and Olive ridley turtle (*Lepidochelys olivacea*) (GBRMPA 2018a).

It is commonly known that the Port Curtis region supports populations of Green, and Flatback turtles, while other species such as the Hawksbill, Loggerhead and Olive ridley turtles are known to occur in the GBRWHA but are recorded within Port Curtis either occasionally or rarely (GBRMPA 2018a; Limpus et al. 2013a-e). The majority of sightings and captures of Leatherback turtles in Queensland waters have occurred from Hervey Bay south to the Gold Coast (Limpus et al. 2013a-e). Leatherback turtles are rarely encountered in waters of the Great Barrier Reef and therefore rarely encountered in the waters in the vicinity of Port Curtis and Port Alma.

Marine turtles undertake extensive migrations of up to 3,000km between nesting beaches and feeding areas, but repeatedly return to the same nesting and feeding areas throughout their lives. In Queensland, marine turtles breed at a limited number of nesting sites with varying density. Individual females return at intervals to nest at beaches in the same area in which they were born (Limpus and Chatto 2004).

The methodology implemented to describe the marine turtle values is provided in the Project EIS Appendix I1 (Section 14.2).

9.9.2 Marine turtle values

9.9.2.1 Species of conservation significance

The results of the desktop assessment were used to determine the likelihood of occurrence of marine turtle species within the Port Curtis region (within and proximal to coastal waters likely to be impacted by Project activities). The Project EIS Appendix I1 (Appendix B), provides the likelihood of occurrence assessments for all fauna species identified in the database searches.

Table 9.31 identifies the likelihood of occurrence for the six marine turtles known from the GBRWHA, and their likelihood of occurring in Port Curtis. This assessment identified that the Flatback and Green turtles are known to occur in the region on a regular basis (e.g. nesting and/or foraging), with the Loggerhead turtle occasionally nesting in Port Curtis. The Hawksbill turtle is identified as having a moderate likelihood of occurrence as they are known to occasionally migrate through Port Curtis and potential foraging grounds exist within Port Curtis. The Leatherback and the Olive ridley turtles are considered to have a low likelihood of occurrence within Port Curtis, as they are rarely encountered in waters in or surrounding Port Curtis (Limpus et al. 2013d). The likelihood of occurrence categorical rating is used to inform the likelihood definitions for potential impacts occurring over the life of the Project (refer Table 10, Appendix I2) and subsequently as a determinant variable in the assessment of significant residual adverse impact.

Table 9.31 Conservation status of marine turtles found in Australia and likelihood of occurring in Port Curtis

Common name	Scientific name	Conservation status		Preferred habitat	Likelihood of occurring in Port Curtis
		NC Act	EPBC Act		
Green turtle	*Chelonia mydas*	Vulnerable	Vulnerable Migratory Marine	Open, sandy beaches, rocky reef, inshore seagrass beds or algae mats	Confirmed (feed in the region and occasionally breed in the region)
Flatback turtle	*Natator depressus*	Vulnerable	Vulnerable Migratory Marine	Nests on open sandy beaches without reef front, shallow inshore waters	Confirmed (breed in the region)
Loggerhead turtle	*Caretta caretta*	Endangered	Endangered Migratory Marine	Open, sandy beaches, tidal and subtidal habitat	Moderate (foraging habitat present and utilised)
Hawksbill turtle	*Eretmochelys imbricata*	Endangered	Vulnerable Migratory Marine	Open sandy beaches, coral and rocky reefs, and seagrass	Moderate (suitable foraging habitat exists)
Olive ridley turtle	*Lepidochelys olivacea*	Endangered	Endangered Migratory Marine	Open, sandy beaches, open marine waters	Low (suitable foraging habitat exists with limited evidence of residency)

Common name	Scientific name	Conservation status		Preferred habitat	Likelihood of occurring in Port Curtis
		NC Act	EPBC Act		
Leatherback turtle	*Dermochelys coriacea*	Endangered	Endangered Migratory Marine	Open, sandy beaches, open marine waters	Low (pelagic species, may occasionally migrate through the region)

Source: DoEE (2019a-d); DES (2019); BMT WBM (2014)

Long term baseline data of nesting and internesting turtle movements has been collected for a number of important nesting beaches in the Port Curtis region over the years by former EHP (now DES), JCU and TropWATER. Long term monitoring of nesting sites at Curtis Island by EHP has occurred since 1969 (and annually since 1994). More recently, monitoring of turtle nesting behaviour has been undertaken by Clifton and Bell (2003); Limpus et al. (2012); Hamann et al. (2015a); Limpus et al. (2015); Fitzsimmons and Limpus (2016); Limpus et al. (2016a); Pople et al. (2016), Hamann et al. (2017a), Limpus et al. (2017b) and Limpus et al. (2018a).

The Port Curtis region provides potential habitats for the Green, Flatback, Loggerhead, Hawksbill and Olive riddle turtles, including nesting and/or foraging areas (refer Figure 9.25), making it an important location for the conservation of marine turtles in Australia.

It should be noted that marine turtle field studies have focused on shallow water feeding Green turtles, resulting in an absence of surveys focused on deeper water feeding species/populations and a knowledge gap regarding deep water foraging habitats.

Flatback turtles are known to nest on several beaches in the region (and low density breeding expected on any seaward facing beach), including Curtis Island (South End Beach), Facing Island, Hummock Hill Island, and Tannum Sands (Limpus et al. 2002; 2013a-e), with peak nesting activity occurring in mid-November to mid-December, and peak hatching period during February. The Port of Gladstone is known internesting habitat for Flatback turtles (Hamman et al. 2017b).

In Queensland, marine turtles breed at a limited number of nesting sites with varying density. In a breeding year, individual females migrate over long distances between feeding and nesting grounds, and return to nest at beaches in the same area in which they were born (Limpus and Chatto 2004). The nesting females of most species will nest multiple times during a nesting season, at intervals of two to four years over the course of their lifetime.

The incubation period of the eggs varies from six weeks to two months, during which time the eggs in each nest hatch synchronously. Emergence from the nesting chamber occurs synchronously during the night and hatchlings instinctively head towards the light horizon (i.e. moonlight on the sea) which indicates the location of the sea. In general, mature marine turtles have extremely small home ranges and single turtles will generally forage over little more than a few kilometres (Hamann et al. 2015b).

Further species-specific information is provided below for the six marine turtle species known to utilise Port Curtis, and additional information is also provided in the Project EIS Appendix I1 (Section 14).

9.9.2.2 Green turtle

Green turtles are the most common species of turtle found in Port Curtis utilising the area for feeding on a diet of seagrass (including *Halophila, Halodule and Zostera* species), algae and mangrove fruits (Limpus 2008a; Limpus et al. 2013b). Aerial and boat-based surveys for marine turtles undertaken in Port Curtis in 2008/2009 to assess habitat utilisation, recorded a total of 522 turtles with the most commonly observed species being Green turtles (GHD 2009). These surveys recorded a large number of juvenile and sub-adult Green turtles, although overall the densities of these local cohorts are not well documented. Immature turtles are regularly encountered in the shallow water habitats, while larger turtles are found in the deeper subtidal water (Limpus et al. 2013b; Limpus et al. 2017a).

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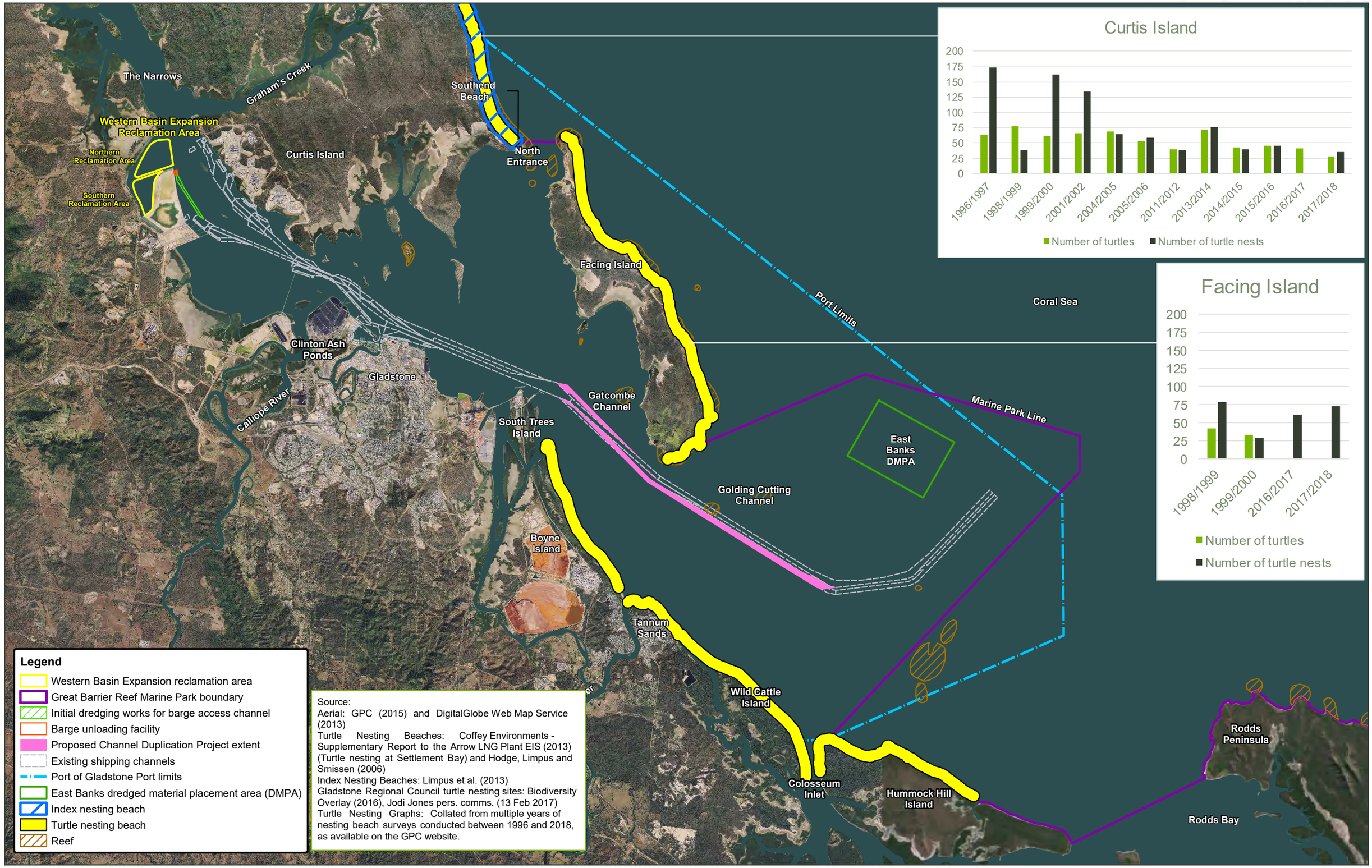

Legend

- Western Basin Expansion reclamation area
- Great Barrier Reef Marine Park boundary
- Initial dredging works for barge access channel
- Barge unloading facility
- Proposed Channel Duplication Project extent
- Existing shipping channels
- Port of Gladstone Port limits
- East Banks dredged material placement area (DMPA)
- Index nesting beach
- Turtle nesting beach
- Reef

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Turtle Nesting Beaches: Coffey Environments - Supplementary Report to the Arrow LNG Plant EIS (2013) (Turtle nesting at Settlement Bay) and Hodge, Limpus and Smissen (2006)
Index Nesting Beaches: Limpus et al. (2013)
Gladstone Regional Council turtle nesting sites: Biodiversity Overlay (2016), Jodi Jones pers. comms. (13 Feb 2017)
Turtle Nesting Graphs: Collated from multiple years of nesting beach surveys conducted between 1996 and 2018, as available on the GPC website.

Map by: RB P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_420.mxd 09/08/2019 10:38

0 1,900 3,800 Metres

Date: 09/08/2019 Version: 2 Job No: 237374
Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 9.25: General location of marine turtle nesting areas in Port Curtis

With a rich diversity of seagrasses, reef algae and mangroves, Port Curtis provides an important resource to foraging Green turtles. Within Port Curtis during 2016, Green turtles were recorded foraging on seagrass (*Zostera muelleri* and *Halophila ovalis*), mangrove (*Avicennia marina* propagules; *Rhizophora stylosa* propagules and apical shoots) and a range of algal species (Chlorophyte: *Ulva polyclada*, Rhodophyte: *Catenella nipae*, *Hynea* sp. and *Gracillaria* sp.) (Limpus et al. 2016b). This study observed Green turtles foraging within Port Curtis displaying very diverse vegetarian diets across a range of sampling sites throughout the Port, with diet also varying seasonally between sampling locations within the Port (Limpus et al. 2016b). Seagrass (*Zostera muelleri* and *Halophila ovalis*) are considered the principle foraging food source for the Green turtle whereas algae and mangroves are a supplementary food source.

While Green turtles have been recorded nesting within the Port Curtis region on the beaches of Curtis Island and Facing Island (as isolated nesting events), they prefer the offshore islands of the Great Barrier Reef (Limpus et al. 2000; Limpus et al. 2006; Limpus 2008a, Limpus et al. 2013b). There is currently no evidence of Green turtle internesting habitat within the Port. Green turtle nesting for the southern Great Barrier Reef management unit (population) commences in mid to late October, peaking in late December to early January, and ends in late March to early April (Limpus et al. 2013b). The region provides internesting habitat for southern Great Barrier Reef populations of nesting females (Limpus et al. 2013b).

Limpus et al. (2016b; 2017a) collected data on Green turtles within Port Curtis to determine if the area is an important aggregation area for the species. Observations were made of their behaviour (i.e. courtship behaviour) and the breeding condition of captured individuals during their 2016 and 2017 breeding seasons (Limpus et al. 2016b; 2017a). The data collected by Limpus et al. (2016b; 2017a), indicate that Port Curtis is not a significant area for aggregation of breeding Green turtles for courtship and mating.

Satellite tagging studies undertaken as part of the Ecosystem Research and Monitoring Program (ERMP) by Hamann et al. (2015a; 2016; 2017a) indicate that Green turtles have very distinct home ranges and strong site fidelity within Port Curtis. The studies recorded small home ranges for the tracked turtles (ranging from 4km^2 to 62km^2 (mean of 24km^2)) and that the tracked turtles predominantly used intertidal and shallow water habitats, including areas of Port Curtis that coincide with high levels of human use (e.g. vessel activity, fishing) (refer Figure 9.26 and Figure 9.27) (Hamman et al. 2015a; 2016). A large number of turtles were observed to have converged at Pelican Banks seagrass meadows. Overall, tracking data from the 2014 to 2017 period (34 turtles) identified found a high degree of site fidelity to foraging habitat (Hamann et al. 2017a). Diving data from the reporting period also indicated that Green turtles in the Port of Gladstone region spend most of their time at water depths of less than 10m.

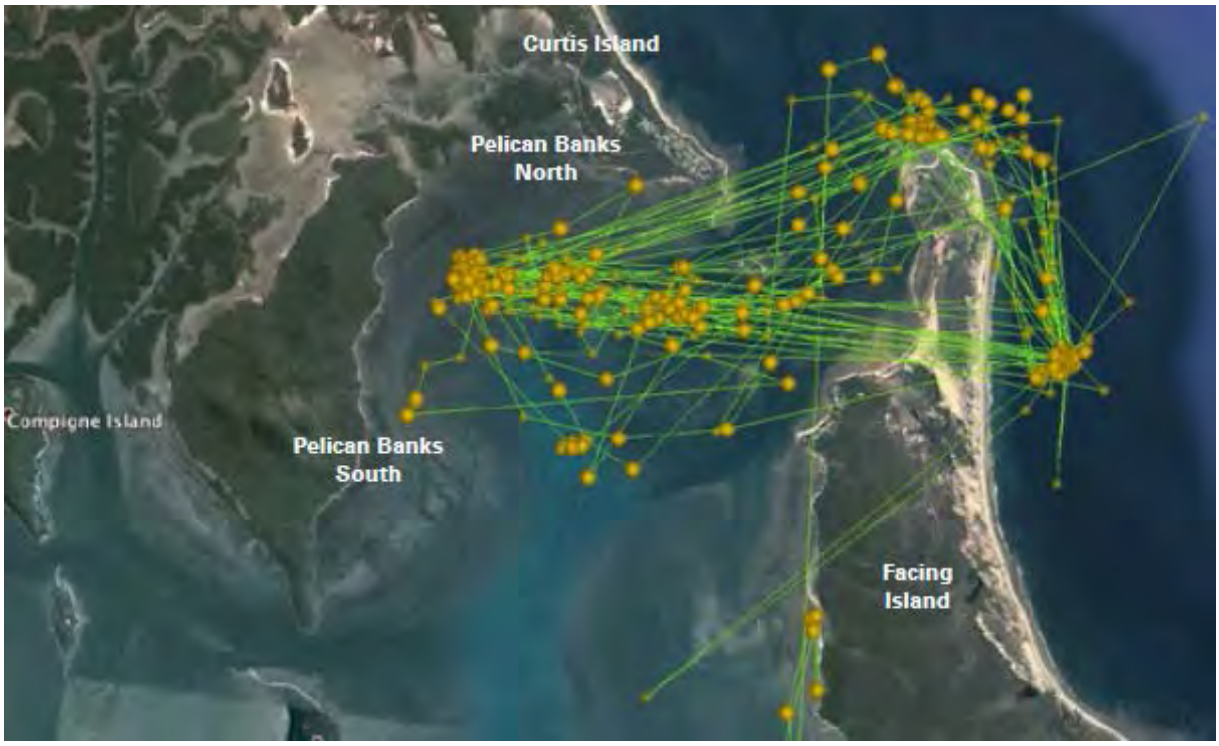

Figure 9.26 **Tracking data of a Green turtle tagged in Port Curtis**

Source: GPC (2015c) via JCU TropWATER

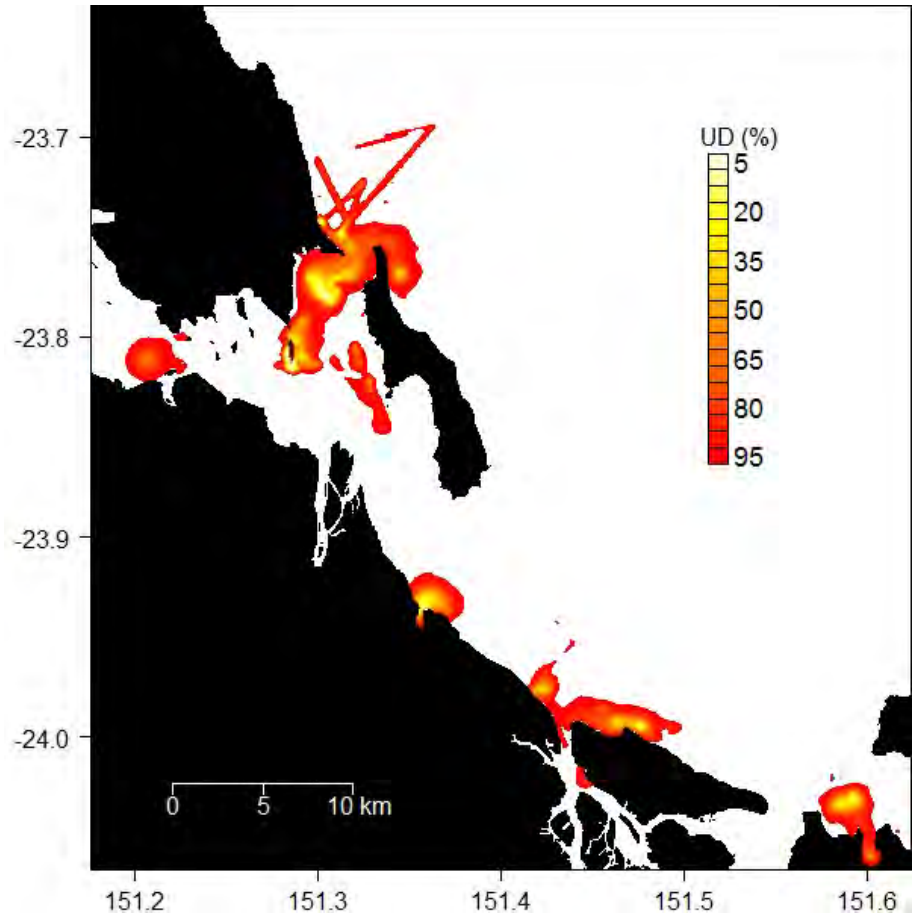

Figure 9.27 **Home ranges of Green turtles tracked via satellite within Port Curtis (2014)**

Figure note:

UD (%) = refers to the percentage of time each 100m grid is used by the turtle during foraging

Source: Hamann et al. (2015a)

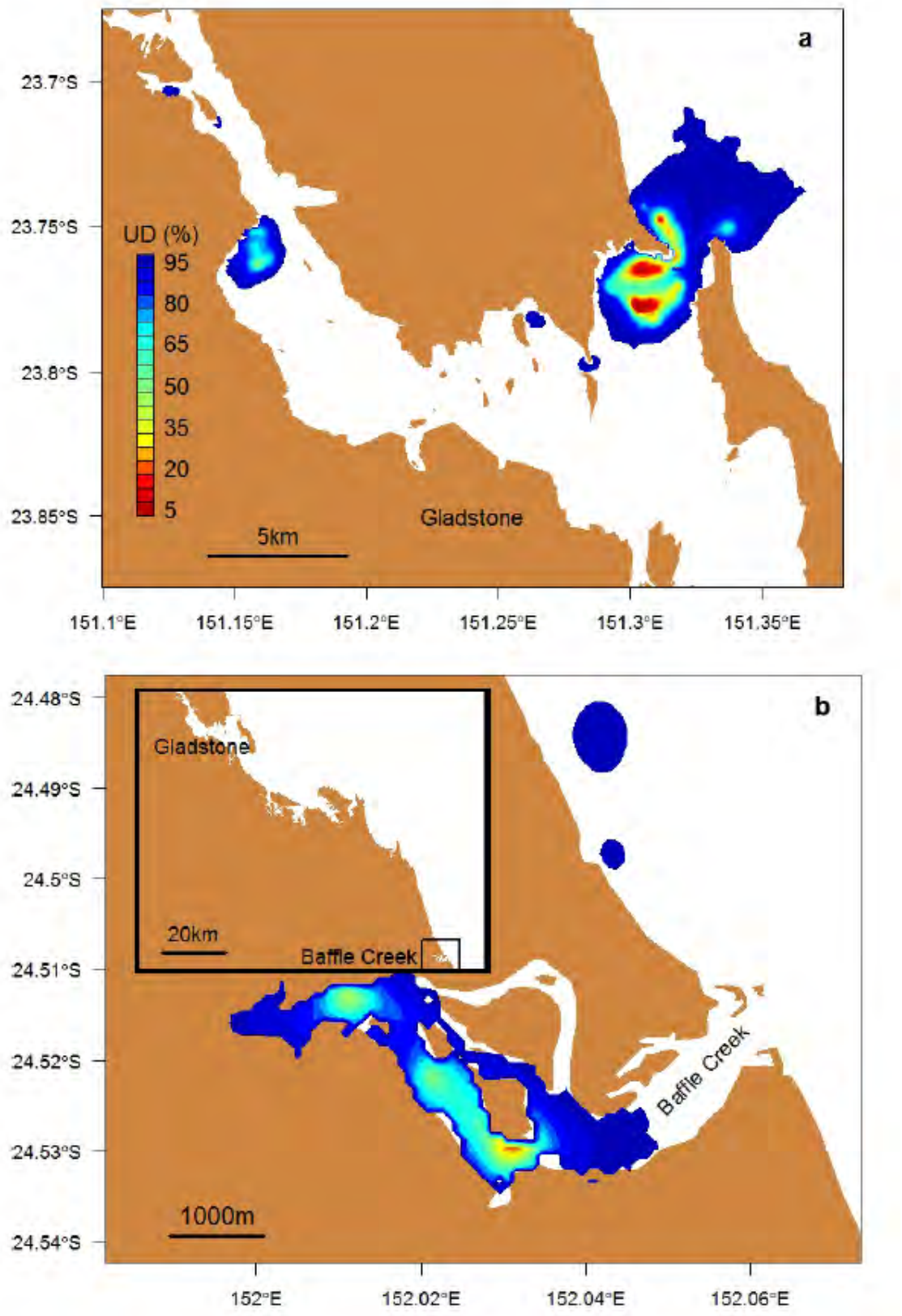

Figure 9.28 Home ranges of Green turtles tracked via satellite within Port Curtis (2015-2016)

Figure note:

UD (%) = refers to the percentage of time each 100m grid is used by the turtle during foraging
This is based on the 11 Green turtles captured and release in Port Curtis between July 2015 and February 2016. Ten of the turtles resettled in the vicinity of the original capture points, and one turtle moved south and settled in Baffle Creek.

Source: Hamann et al. (2016).

Limpus et al. (2016b; 2017a) assessed foraging behaviour of Green turtles within Port Curtis. Turtles were either captured or observed during the study, with approximately half of the Green turtles captured from Pelican Banks (refer Figure 9.29 and Figure 9.30) (n=162, 49.4% of all captures) (Limpus et al. 2016b). Green turtles that were observed but not captured were also observed predominantly located at Pelican Banks (refer Figure 9.31). Similar results were also found by Limpus et al. (2017a) (refer Figure 9.32). The data collected indicated that adult Green turtles were most abundant at Pelican Banks and Wiggins Island, with small, juvenile turtles dominating the captures in proximity to mangrove habitats (Limpus et al. 2016b; 2017a; Babcock et al. 2015).

More recently, population monitoring of Green turtles within Port Curtis utilising GPS satellite telemetry was completed during April-October 2018 (Limpus et al. 2018b). The majority of Green turtles captured in shallow intertidal areas around mangroves or rocky reefs were juvenile, whilst the majority of larger Green turtles were captured in deeper tidal and subtidal waters at Pelican Banks, South Trees, and off southern Wild Cattle Island. Green turtles captured at Pelican Banks typically exhibited a bimodal foraging behaviour, repeatedly moving between Pelican Banks and offshore reef habitats.

Figure 9.29 Locations where Green turtles were captured in Port Curtis 2016

Source: Limpus et al. (2016b)

Figure 9.30 Locations where Green turtles were captured in Port Curtis 2017

Source: Limpus et al. (2017a)

Figure 9.31 Locations where Green turtles were observed but not captured in Port Curtis 2016

Source: Limpus (2016b)

Figure 9.32 Locations where Green turtles were observed but not captured in Port Curtis 2017

Source: Limpus et al. (2017a)

In response to the increasing incidence of strandings of sick, injured and dead Green turtles by mid-2011, especially small immature turtles, studies were undertaken by the former DERM (now DES) to assess the health of resident Green turtle populations in Queensland. A more in-depth veterinary assessment associated with this study was also conducted in July 2011 by Eden et al. (2011).

A range of pathological health assessments of Green turtles were undertaken in the Port of Gladstone since 2011 (Eden et al. 2011; Gaus et al. 2012; Flint 2015) (refer Project EIS Appendix I1 (Section 14.5.2)). These health assessments included the general external health assessments as well as clinical assessments (e.g. sampling and analysis of blood and tissue samples to determine levels of contaminant groups present in samples) of the Green turtle population within the Port. High levels of heavy metals, and underlying disease processes consistent with potential toxin exposure and chronic environmental stressors, were found in Green turtles sampled in 2011 (Gaus et al. 2012).

Poor health assessments and clinical results indicating high levels of contaminants were present in a large proportion of the Green turtles within the Port of Gladstone, indicating regional level factors (of natural or anthropogenic origin) affecting all age classes of the population (Flint 2015). It has been reported that this is likely to be a result of the ingestion of toxins present in either water or seagrass, though based on the current data it is not able to be determined if this is an acute or chronic impact (Flint 2015). The most recent health assessments of Green turtles indicate that the population has recovered significantly from the 2011 and 2013 population health assessments in Port Curtis (Flint 2015).

External health assessments have been conducted alongside the yearly assessment of Green turtle foraging populations within Port Curtis (Limpus et al. 2017a). External assessment of general health (as body condition) have been conducted from seasonal assessments in 2016 and 2017. Results indicate a significant difference in body condition between sexes of large turtles (curved carapace length > 88 cm) from a range of sites across Pelican banks, Facing Island, Boyne Estuary and the Western basin, within Port Curtis (Limpus et al. 2017a).

9.9.2.3 Flatback turtle

A carnivorous species, Flatback turtles utilise the abundant invertebrate resources of the Great Barrier Reef and its coastal areas, including Port Curtis (Chatto 1998; Limpus 2007). Despite an absence of formal studies of Flatback turtle diet in eastern Australia, incidental observations of food items include sea pens and soft corals, furthermore the limited diet data for large immature and adult Flatback turtles in eastern Australia suggests that they are carnivorous, feeding principally on benthic, soft-bodied macroinvertebrates, including soft corals and sea pens (Limpus et al. 2013e).

A study of Flatback turtles off the Kimberly coast utilised distributional modelling to show that the species preferred foraging in waters 60m to 90m deep and in association with complex, benthic geomorphology (i.e. banks, shoals, terraces, deep holes and valleys) thought to support a high abundance of sessile invertebrates (Thums et al. 2017). In addition, post hatchling Flatback turtles are known to forage on plankton in pelagic waters (Limpus et al. 2013e) and may be encountered at the entrances to Port Alma and Port Curtis. Flatback turtles are not known to be associated with rocky reefs or coral reefs in Australian waters (Limpus et al. 2013e).

Flatback turtles are the dominant nesting marine turtle species in the Port Curtis region (Limpus et al. 2013e). The species is known to nest at beaches in the region, including Facing Island, Hummock Hill Island and Tannum Sands (refer Figure 9.33) (though these are not known as primary rookeries) (Limpus et al. 2002). South End Beach (as an index nesting beach) on the southern tip of Curtis Island is approximately 5km in length and is one of 30 rookeries reporting 10 to 100 females present at the nesting beach annually, and there are at least 50 additional, smaller rookeries reporting between one and ten females present at the nesting habitat in each reproductive season (Limpus et al. 2013e). In some years, there is occasional nesting by Green turtles and/or Loggerhead turtles. While the rookery has been monitored intermittently since 1969 (Limpus et al. 2014; 2016a), it has been monitored annually since 1994 (Limpus et al. 2014; 2016a).

The peak period of nesting activity is mid-November to mid-December, with the peak period of hatching during February. Nesting numbers vary between seasons (Limpus et al. 2014). During the 2014-2015 breeding season a moderately sized population with 40 nesting females was recorded on Curtis Island during peak nesting in late November to early December 2014 (Limpus et al. 2015). The 2015-2016 breeding season again recorded a moderately sized population of nesting Flatback turtles, with 44 nesting females recorded at South End Beach on Curtis Island (Pople et al. 2016). Recent studies have found that the Curtis Island Flatback turtle population is of moderate size however it was also mentioned that the nesting population has approximately halved during the past decade during the two-week mid-season census period (Limpus et al. 2017b; 2018a).

Flatback turtles have been known to enter Port Curtis during part of their internesting period (Limpus et al. 2013e; Hamann et al. 2015c; Hamann et al. 2017b). Satellite tracking studies have shown internesting Flatback turtles utilising habitat in the Mid Harbour (around the existing Gatcombe and Auckland Shipping Channels) and in the Outer Harbour zone and in waters off the coasts of Facing and Curtis Islands (Hamann et al. 2015c; Hamann et al. 2017b).

Recent studies by Hamann et al. (2015b; 2015c; 2017b) undertaken as part of the ERMP, used GPS satellite tags to examine the movement patterns of female Flatback turtles nesting at Curtis Island to understand whether the turtles used the Port Curtis region during their internesting period. Data was collected from November 2013 to March 2014, and then again in November 2014 to July 2015. A recent report was compiled using data from November 2013 to January 2016. To examine habitat use, the distribution and density of GPS locations was examined for each tagged turtle to determine key use areas (refer Figure 9.34) (Hamann et al. 2015b; Hamman et al. 2015c; Hamann et al. 2017b).

During the 2013-2014 (as a single study year) study, seven of the eight turtles that were tracked spent time within the waters of the Port. Three had 50% core use areas in the Mid Harbour zone of the Port, around the existing Gatcombe and Auckland Channels, and another four turtles used habitat within the limits of the Port, but outside of the Mid Harbour zone. The results of the 2014-2015 study show that seven of the 11 tracked turtles spent at least 50% of their time (during the internesting period) within the Mid Harbour zone of the Port (Hamman et al. 2015d). The 2013 to 2016 report concluded that the waters around Curtis and Facing Islands and the waters between Facing Island and the mainland provided suitable internesting habitat for the Flatback turtle (Hamann et al. 2017b). A similar study in coastal waters off the Pilbara coast of Western Australia, documented internesting movements ranging from 3.4km to 62.1km (Whittock et al. 2014).

It should be noted that the majority of marine turtle field studies involving telemetry have focused on shallow water feeding Green turtles, resulting in an absence of surveys focused on deeper water feeding species/populations and a knowledge gap regarding deep water foraging habitats use. However Flatback turtle tagging studies have focused on nesting turtles and habitat used during internesting. The need for management actions for the Flatback turtle in the Port Curtis region focussed on the preservation of deep water foraging grounds and maintenance of the index beach on Curtis Island has been identified. Given the individuals are not believed to leave the continental shelf, Australia has a distinct east coast genetic stock of Flatback turtles and preservation of all breeding sites within the Great Barrier Reef is important for conservation of the species (Limpus et al. 2013e).

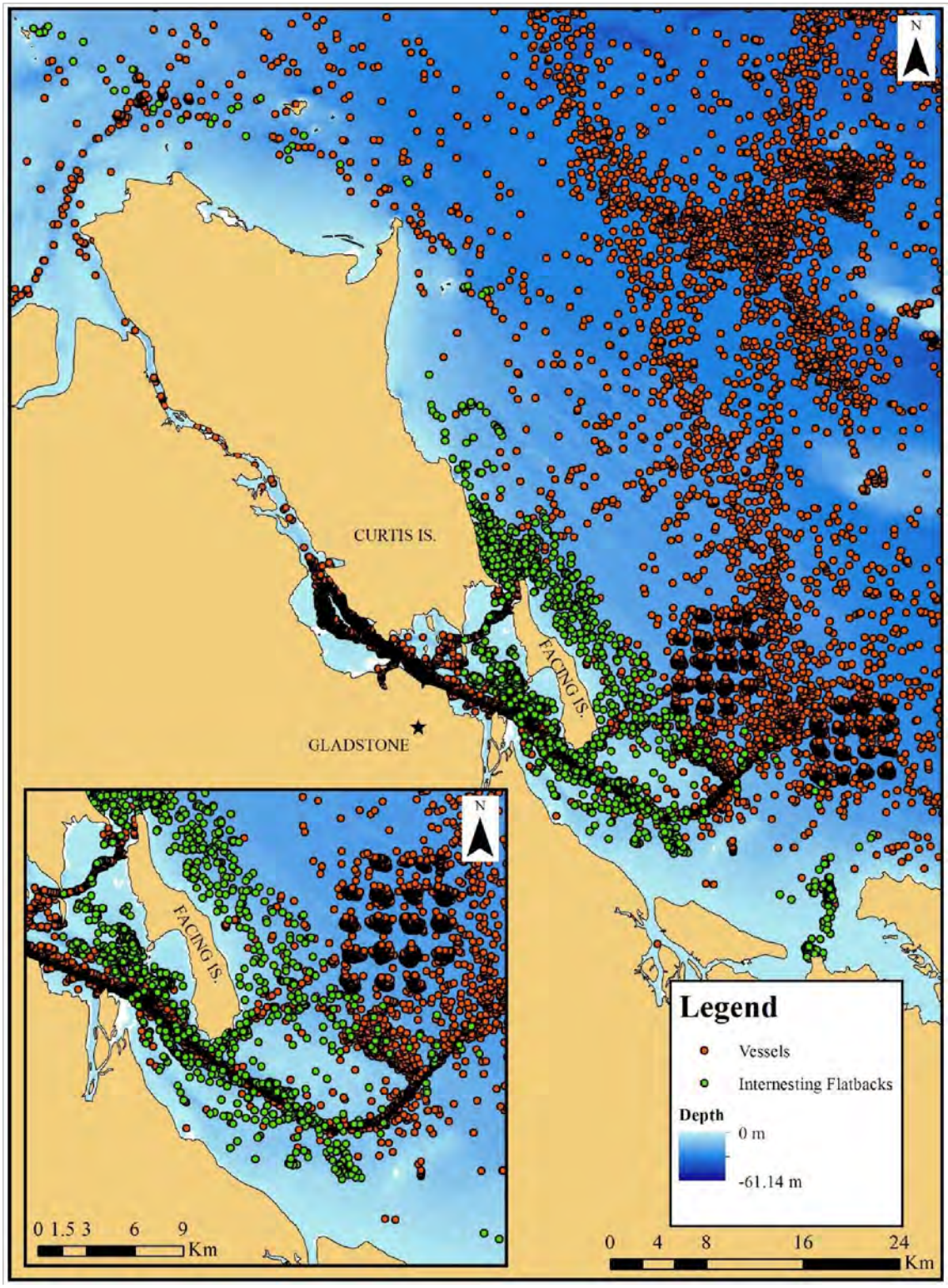

Figure 9.33 **GPS points for eight Flatback turtles tracked during their internesting period (November to December 2013)**

Figure note:

Overlap of locations for commercial vessels and locations (best location per turtle each 3 hours) of Flatback turtles between November and December 2014. Red dots are the hourly locations of vessels and the green dots are the turtle locations. Darker areas indicate high accumulation of shipping locations in the same area. The grid-like patterns of shipping locations to the east of Facing Island are the anchoring sites for ships.

Source: Hamann et al. (2015c)

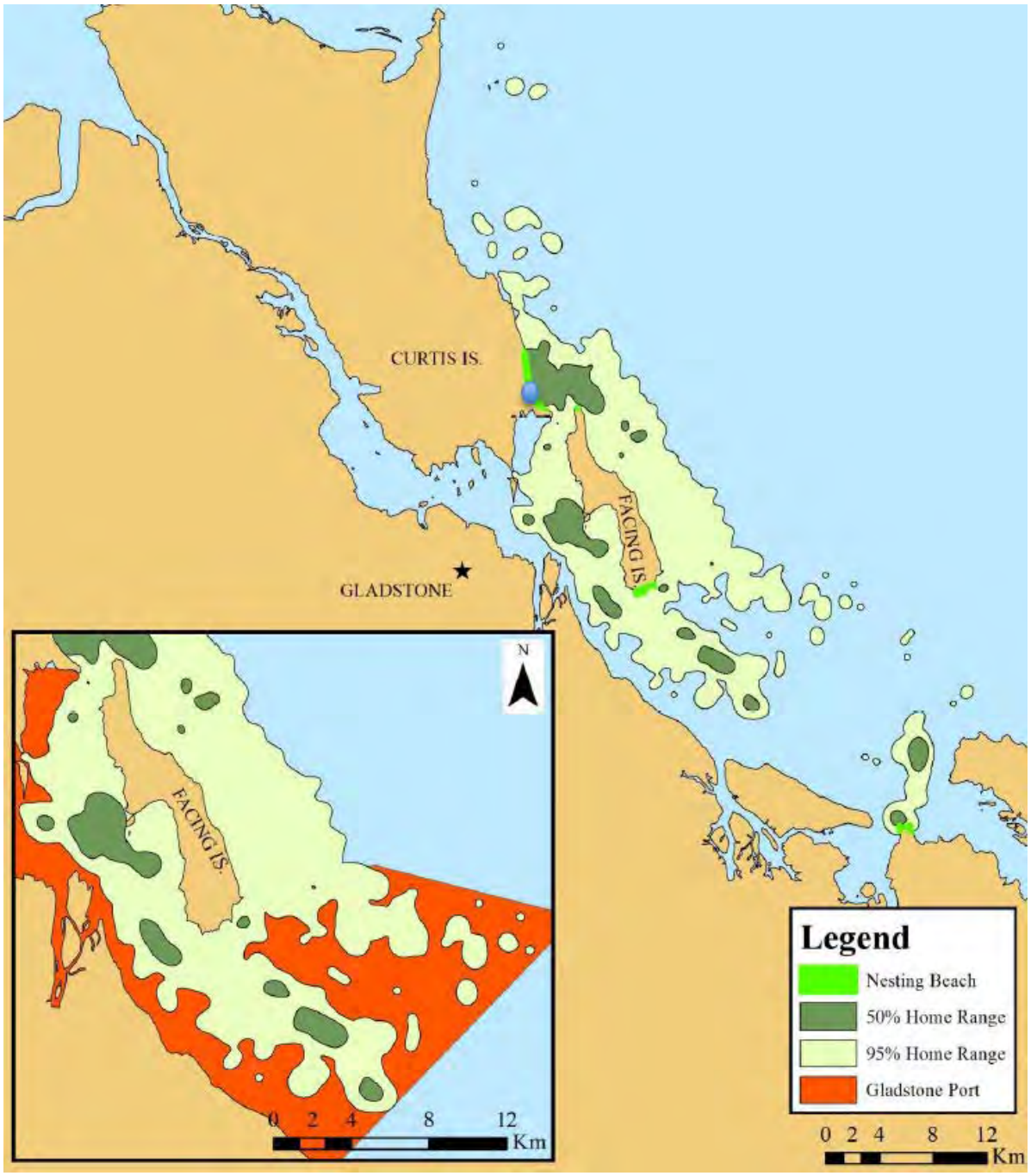

Figure 9.34 **Core habitat use areas for 11 Flatback turtles tracked during their internesting period(s) during November and December 2015**

Figure note:

Each turtle was tagged after nesting on South End beach on Curtis Island (blue dot). This figure does not show all nesting beaches for marine turtles, only those beaches where the 11 satellite tagged Flatback turtles were recorded using beaches for additional nesting attempts.

Source: Hamann et al. (2015c)

9.9.2.4 Loggerhead turtle

Historically the Loggerhead turtle population in Queensland had declined by 86% as a result of mortality from prawn trawling operations, however since the introduction of turtle excluder devices in 2000 the Queensland Loggerhead turtle population has rebounded (DES 2018a).

The peak period of nesting is during December, with hatching occurring in the following months up until the end of April (DoEE 2019d). In addition to the Woongarra Coast (including Mon Repos Beach), other nesting rookeries for Loggerhead turtles include Wreck Rock beaches (to the south of Port Curtis), Wreck Island, Heron Island, and North West Island (to the northwest of Port Curtis) (Limpus et al. 2013a).

Adult and large-immature Loggerhead turtles are carnivorous and specialised in feeding on hard-bodied, slow-moving invertebrates (Limpus 2008b). The invertebrate biomass is supported by the rich diversity of seagrasses, algal turfs, and sand and mud flats, the latter of which are utilised by Loggerhead turtles during high tides. Primary prey taxa include benthic gastropod and bivalve molluscs, portunid crabs and hermit crabs (Limpus et al. 2001). Taxa less frequently predated by Loggerhead turtles include other invertebrates (e.g. jellyfish, anemones, holothurians and sea urchins) and fish (Limpus et al. 1994; Limpus et al. 2001).

The Port Curtis region provides a range of suitable foraging habitats for the Loggerhead turtle. Loggerhead turtles are known to utilise a wide range of tidal and subtidal habitats, including coral and rocky reefs, seagrass meadows, and soft-bottomed and or mud areas (GBRMPA 2018b), including deeper soft bottom habitats between the Great Barrier Reef and the mainland (Robins and Mayer 1998).

Nesting habitats collectively form the major rookery of the Capricornia Cays National Park (Limpus 2008b) with breeding Loggerhead turtles supported by the foraging resources of the Port Curtis region. Isolated Loggerhead turtles nest on beaches within Port Curtis waters, but not on an annual basis (Limpus et al. 2013a). Internesting habitat for Loggerhead turtles has not been identified within the Port of Gladstone waters but may occur, although to date no known targeted foraging and internesting studies of the Loggerhead turtle within the Port have been conducted (Limpus et al. 2013a).

The Port Curtis region and southern Great Barrier Reef provide a potential foraging and nesting resource for Loggerhead turtles, with turtles known to nest occasionally on the beaches of Curtis and Facing Islands (Limpus et al. 2013a).

In summary, the Loggerhead turtle has been observed within the Project impact areas (Limpus et al. 2013a) and the likelihood of occurrence of this species is moderate due to the potential of foraging habitat, known observation and the previous observations of foraging ground fidelity within individuals of the species (Limpus et al. 1994), however it has not been demonstrated that there is a significant foraging population within Port Curtis.

9.9.2.5 Hawksbill turtle

There are no known Hawksbill turtle nesting beaches in Queensland outside of the northern Great Barrier Reef and Torres Strait. However, small populations of predominantly sub-adult and juvenile turtles are found in resident populations in the southern parts of Queensland. This is in contrast with the northern parts of Queensland, where the largest remaining populations in the world are found (Limpus et al. 2013c). The multiple genetic stocks of Hawksbill turtle populations nesting within north Queensland and the eastern Coral Sea region are all severely depleted and the mixed stocks of Hawksbill turtles foraging within the GBRWHA are currently in decline.

Suitable foraging habitat for adult and large-immature Hawksbill turtles across central Queensland coastal waters include subtidal and tidal coral reefs and rocky reefs (DoEE 2019a), seagrass meadows and deeper, soft-bottomed habitats (Poiner and Harris 1999; Robins et al. 2002). Hawksbill turtles are omnivorous, feeding on sponges, hydroids, cephalopods, gastropods, cnidarians, seagrass and algae (Carr and Stancyk 1975; Whiting 2000). The broader Port Curtis region (including areas of the Great Barrier Reef east of Port Curtis) includes areas of soft coral, algae and seagrass, which form part of their dietary requirements (Limpus 2009), making the Port Curtis region a potential resident feeding ground and resource for the species. In this context, it is important for the conservation of the species that resident foraging grounds and surrounding reefs for juvenile and sub-adult age classes are preserved. It should be noted that marine turtle field studies have focused on shallow water feeding Green turtles, resulting in an absence of surveys focused on deeper water feeding species/populations and a knowledge gap regarding deep water foraging habitats.

Migration data has indicated that Hawksbill turtles foraging within a 500km radius of Port Alma and Port Curtis are most likely to originate from the nesting populations in eastern Papua New Guinea, Solomon Islands or Vanuatu (Limpus et al. 2013c). Although there is a significant Hawksbill turtle population in the coral reefs offshore from Port Curtis, and Hawksbill turtles may forage in Port Curtis, however it has not been demonstrated that there is a significant foraging population within Port Curtis (Limpus et al. 2013e; Santos 2015).

In summary, no significant Hawksbill turtle foraging population has been observed within the Port Curtis, however a variety of potential Hawksbill turtle habitats are considered to occur within the Project impact areas. While true occupancy cannot be determined from current data (as records are typically stranded individuals) (Limpus et al. 2013c), the likelihood of occurrence of species within the Project impact areas is considered moderate.

9.9.2.6 Olive ridley turtle

Olive ridley turtles are not known to nest on the east coast of Australia. Low density nesting is known to occur along the north western coast of Cape York between Weipa and Bamaga (Limpus and Roper 1977; Limpus et al. 1983). The Olive ridley nesting population within Queensland is a unique and endemic genetic stock to Queensland. The annual nesting population is currently estimated as a few adult females annually and with an annual recruitment of new females into the breeding population approaching zero.

Satellite telemetry studies in the Northern Territory (Whiting 2004) have confirmed that the northern Australian breeding Olive ridley turtles undertake post-breeding migrations to disperse to widely scattered foraging areas within the Australian continental shelf. Five adult females tracked via satellite telemetry from Cape van Dieman (near Darwin), migrated to foraging areas 427km to 1,358km distant from the nesting beach (Whiting 2004).

Adult, Australian Olive ridley turtles forage on benthic communities on the northern Australian continental shelf (Limpus 2008c). Satellite telemetry studies of post-breeding migrations of adult females have confirmed this with all five tracked tagged turtles remaining within continental shelf waters (Whiting 2004). Olive ridley turtles are wide spread and regularly encountered by fishers over soft bottom habitats along the east Australian coast inside the Great Barrier Reef from south Queensland northward to Torres Strait (Harris 1994; Robins and Mayer 1998). It should be noted that marine turtle field studies have focused on shallow water feeding Green turtles, resulting in an absence of surveys focused on deeper water feeding species/populations and a knowledge gap regarding deep water foraging habitats.

While the species has been only rarely reported from within Port Alma and Port Curtis, Olive ridley turtles have been recorded throughout the broader area of interest (500km radius) with respect to Port Alma and Port Curtis (Limpus et al. 2013d). Within the Mackay to Moreton Bay broader area of interest, the vast majority of Olive ridley turtle records are from Hervey Bay southwards (i.e. south of the Great Barrier Reef) (Limpus et al. 2008c).

Except for a single capture in Edgecombe Bay in central Queensland (I. Bell, pers. comm.), the species has not been recorded living in coral reef habitat or shallow inshore seagrass flats. Olive ridley turtles are not normally encountered foraging over intertidal seagrass pastures or the immediately adjacent subtidal habitats of coastal Queensland (Limpus and Reed 1985; Limpus et al. 1994; 2005). The species was most frequently captured at 6m to 35m depth within the Queensland east coast trawl fishery (Robins and Mayer 1998). Within the neritic habitats (over the continental shelf) of northern Australia, adult and large immature Olive ridley turtles are carnivorous, feeding principally on gastropod molluscs and small crabs (Conway 1994; unpublished data, EPA Queensland Turtle Conservation Project).

The modelled zones of potential Project impact would expect to make up a small percentage of potential species habitat across the proximal neritic zones around Port Curtis and beyond the zone of influence of dredging activities. Quantification of use of the zones are not possible (due to gaps in knowledge of habitat use), however, the Olive ridley turtle has not been observed in seagrass meadows or subtidal habitat (as foraging grounds). Therefore the species would be expected to utilise, at a similar rate, foraging habitat surrounding the potential Project impact areas.

The Olive ridley turtle would be expected to occur with proximity to the zones of potential Project impact from the dredging activities, however records from Limpus et al. (2013d) demonstrates that the majority of known species observations occur south of the Project impact areas.

Key knowledge gaps exist in regard to the foraging areas of the Olive ridley turtle and while this uncertainty provides necessity to anticipate the species to occur within the potential Project impact areas, this same uncertainty and current knowledge of distribution suggest the species are likely to occur at a higher number (and general occurrence) in areas further south of the potential Project impact areas.

Two observations of the Olive ridley turtle have occurred in close proximity to the potential Project impact areas, however the qualification of likelihood of occurrence strictly against the use of the area as foraging habitat requires consideration against known observations (as a dredging incident and beach-washed) (Limpus 2013e). Although these observations indicate occupancy, the observations may not be representative of functional occupancy due to potentially compromised individuals indicating occupancy. Therefore, the likelihood of occurrence of the Olive ridley turtle species would more accurately be described as low due to potential foraging habitat, within identifiable migratory pathways (intersecting the potential Project impact areas) of the species (i.e. Queensland coastline) (refer Table 9.31 and Table 9.33).

9.9.2.7 Leatherback turtle

Suitable habitat for the Leatherback turtle is present within the Project area to be dredged, and the marine areas of the WBE reclamation area. Noting this, the Leatherback turtle are typically pelagic feeders and are rarely encountered in the waters of the Great Barrier Reef (DoEE 2019b).

No large rookeries of nesting Leatherback turtles have been recorded in Australia. Scattered nesting has been reported along the south Queensland coast from Bundaberg to Round Hill Head and along the coast of Arnhem Land from Coburg Peninsula to Maningrida, including Crocker Island. Some nesting has occurred in northern New South Wales near Ballina. The last recorded nesting in Queensland was in 1996 (DoEE 2019b).

From observation of life-history parameters, the Leatherback turtle is expected to have a low likelihood of occurrence within Port Curtis (and the Project area) and the majority of sightings and captures of Leatherback turtles in Queensland waters have occurred from Hervey Bay south to the Gold Coast (Limpus et al. 2013a-e). Leatherback turtles are rarely encountered in waters of the Great Barrier Reef and therefore rarely encountered in the waters in the vicinity of Port Curtis and Port Alma. Therefore, Leatherback turtles have been excluded from the assessment of potential Project impacts.

9.10 Marine turtles – potential impacts

This section replaces the Project EIS Section 9.19 (marine turtle – potential impacts and risk assessment) which provides an assessment of the potential impacts and the associated risks of the various Project activities on the marine turtle values within the Gladstone region.

Project mitigation measures to reduce the potential Project impacts on marine turtles during Project activities are included in the Dredging EMP, Project EMP and Environmental Monitoring Procedure (refer EIS Appendices F to H).

9.10.1.1 Section content

This section provides a discussion of the potential impacts and risk assessment for marine turtles and their habitats associated with the Project activities. Table 9.32 summarises the Project activities and the relevant section containing the impact assessment discussion.

Table 9.32 Summary of Project activities and section addressed (marine turtles)

Project activity	Section
Establishment of the WBE reclamation area and BUF, including: ■ Site preparation ■ Establishment of the site compound, offices and temporary areas ■ Source and transport of reclamation bund wall material ■ Placement of core and armour material, and geotextile fabric ■ Sheet piling (or similar earth retaining structure) and fill placement for the BUF	Section 9.10.2
Dredging activities, including: ■ Initial dredging works for the barge access channel ■ Dredging to duplicate the Gatcombe and Golding Cutting shipping channels ■ Dredging vessel movements ■ Unloading and placement of dredged material in the WB and WBE reclamation areas	Section 9.10.3
Removal and installation of navigational aids	Section 9.10.4
Stabilisation and maintenance activities on the WBE reclamation area	Section 9.10.5

Operation of the duplicated shipping channels and maintenance dredging activities are discussed in the Project EIS Sections 9.23 and 9.24, respectively.

It is important to note that this section focuses on marine turtle species which are associated with the range of habitats considered within the Project impact areas. The Project potential impact and risk assessment for other marine fauna values are provided in the Project EIS Section 9.9 (seagrass meadows), Section 9.13 (fish and marine reptiles (excluding marine turtles)) and Section 9.20 (marine mammals) and supplementary information contained in Sections 9 of this Project AEIS.

Potential impacts and risk assessments have been conducted based on the marine turtle values described in Section 9.9. Reference to each of the marine turtle species that has a confirmed, moderate and low likelihood (Olive ridley turtle only) of occurring within the Project impact areas have been included in this risk assessment.

In reference to the Project EIS methodology (refer Project EIS Appendix I2 and Project AEIS Appendix E1), an alteration to the methodology has been incorporated to acknowledge the current scientific uncertainty and use of precautionary principle when identifying the potential impact of Project activities on the Olive ridley turtle. This single exception to the standard Project EIS methodology has incorporated the Olive ridley turtle (removing the excluding requirement of only including species of moderate, high and confirmed likelihood of occurrence) into the Project impact assessment process, alongside the Green turtle, Flatback turtle, Loggerhead turtle and Hawksbill turtle.

Where potential Project impacts are considered to impact marine turtles regardless of species, no separation of potential impact against species are made.

9.10.1.2 Sensitivity ratings

The sensitivity criteria and ratings which are used to assess the consequence of potential impacts to ecological receptors are provided in Appendix I2 of Project EIS. Based on the sensitivity descriptions in the Project EIS Appendix I2 (Section 3.1 (refer Table 3.1 for the criteria used to define sensitivity ratings)), the sensitivity ratings for marine turtles are as defined in Table 9.33.

Table 9.33 Sensitivity ratings for marine turtles

Marine turtle species	Conservation status under the EPBC Act and/or NC Act	Sensitivity rating	Likelihood of occurrence within Project impact areas
Green turtle (*Chelonia mydas*)	EPBC Act – Vulnerable, Migratory, Marine NC Act – Vulnerable	High	Confirmed
Flatback turtle (*Natator depressus*)	EPBC Act - Vulnerable, Migratory, Marine NC Act – Vulnerable	High	Confirmed
Loggerhead turtle (*Caretta caretta*)	EPBC Act – Endangered, Migratory, Marine NC Act – Endangered	Very high	Moderate
Hawksbill turtle (*Eretmochelys imbricata*)	EPBC Act – Vulnerable, Migratory, Marine NC Act – Endangered	Very high	Moderate
Olive ridley turtle (*Lepidochelys olivacea*)	EPBC Act – Endangered, Migratory, Marine NC Act – Endangered	Very high	Low

9.10.2 Establishment of the dredged material placement area and barge unloading facility

9.10.2.1 Permanent loss and alteration of habitat

According to the *Vulnerability Assessment for the Great Barrier Reef: Marine Turtles* (GBRMPA 2014b) a significant pressure on marine turtles in the Great Barrier Reef region is the loss and degradation of habitat through coastal development.

The areas of intertidal and subtidal habitat impact potentially associated with Project activities (including BUF and reclamation area construction, and dredging works) are provided in Table 9.34. The areas incorporate the historic mapping of seagrass meadows and are considered a true potential habitat loss or impact rather than realised impact as seagrass mapping of the Project zone of influence is to be undertaken prior to Project activities commencing.

The proposed Project (i.e. the WBE reclamation area and the area to be dredged) provides foraging habitat for the five species of marine turtles such as seagrass, algae, molluscs, crustaceans, echinoderms, sea pens, soft corals and encrusting invertebrates. Therefore all Project activities have the potential to impact on potential foraging habitat for marine turtles. Table 9.34 provides a summary of potential foraging habitat impact areas on the five marine turtle species (i.e. Green turtle, Flatback turtle, Loggerhead turtle, Hawksbill turtle and Olive ridley turtle) as a result of the establishment of the WBE reclamation area and BUF.

Table 9.34 Potential Project impact areas to marine turtle foraging habitat (WBE reclamation area and BUF)

Project activity	Direct impact area on historic seagrass foraging habitat	Indirect impact area on historic seagrass foraging habitat	Total potential foraging habitat for marine turtles within the direct impact area (WBE reclamation area and BUF) (e.g. seagrass, macroalgae, molluscs, crustaceans)[1]
WBE reclamation area (southern area)	110.48ha	99.41ha[3]	111.12ha
WBE reclamation area (northern area)	164.75ha		164.98ha
BUF	0ha[2]	0ha[4]	2.10ha
Total	**275.23ha**	**99.41ha**	**278.20ha**

Table notes:

1 Mangroves and other marine plants are not located in the Project direct impact area and therefore, not included within the foraging habitat for marine turtles.
2 Direct impact is considered to be negligible after consideration of existing indirect impact from the existing Western Basin reclamation area and is therefore excluded from the impact assessment.
3 The Project potential indirect impact area for the establishment of the WBE reclamation area has been combined for the southern and northern area. The Project indirect impact area is based on erosion and sedimentation impacts due to changes in tidal velocities adjacent to the WBE reclamation area
4 The indirect impact is considered to be associated from the existing Western Basin reclamation area and is therefore excluded from the impact assessment.

The WBE reclamation area (northern and southern areas) contains a seagrass meadow (GPC Monitoring Meadow 8) made up of aggregated patches of light *H. ovalis* with mixed species, including *H. ovalis, Z. muelleri*, and *H. decipiens* based on the latest annual long term monitoring survey (Chartrand et al. 2019).

This Project activity and potential exposure of marine turtles to loss of seagrass in the WBE reclamation area will be permanent and irreversible, however is restricted to a contained area, and is therefore considered moderate in magnitude.

Adaptive design measures will be implemented during the Project detailed design phase to reduce the impact of habitat loss at the WBE reclamation area and BUF (refer Project AEIS Appendix G). Project design will minimise where practical the permanent loss of areas that are very high and high sensitivity within the WBE reclamation area and BUF direct disturbance area. Project mitigation measures are provided further in the AEIS Appendix G.

The post mitigation risk ratings associated with an unavoidable direct and permanent loss of intertidal and subtidal marine turtle habitat during the establishment of the WBE reclamation area and BUF are very high for the Green turtle, high for Loggerhead and Hawksbill turtles and medium for the Flatback and Olive ridley turtle. Further detail on the potential impact and risk ratings is provided below and in AEIS Appendix E3.

Green turtle potential impact

Several tagging studies using satellite and acoustic tracking have found that Pelican Banks and Wiggins Island seagrass meadows are critical habitat for the Green turtle population of Port Curtis (Babcock et al. 2015; Limpus et al. 2016b). Recent studies have shown many Green turtles in Port Curtis have small home ranges and were resident for all or most of the study period, although a high proportion of Green turtles moved in and out of the Port (Hamann et al. 2017a).

Green turtle tracking studies undertaken in July 2015 found that one Green turtle out of 11 captured at Pelican Banks shifted between Pelican Banks and the Western Basin area (within the area of the WBE reclamation area) (Hamann et al. 2016). Green turtles and Loggerhead turtles were located/sighted from boat and land based surveys in the area of the WBE reclamation area (FRC Environmental 2011).

The inshore region of Port Curtis, including the WBE reclamation area, provides valuable habitat for juvenile and adult Green turtles in the form of foraging at seagrass meadows (including species *Z. muelleri*, *Halodule and Halophila*) and other food sources such as mangroves and macroalgae.

Seagrass habitat and species types found in the coastal areas of Port Curtis are abundant in the wider Fitzroy NRM region at Shoalwater Bay, Keppel Islands, Rodds Bay and Hervey Bay (McKenzie et al. 2014) representing habitat for Green turtles in the wider region.

Due to the permanent loss of important Green turtle habitat from the establishment of the WBE reclamation area, the potential impact and the post mitigation risk levels for the Green turtle are considered to be very high.

Flatback turtle potential impact

Foraging requirement studies of the Flatback turtle indicate that the adults/sub-adults forage over complex, benthic geomorphology at depth (typically 60m to 90m deep) to obtain prey resources (Thums et al. 2017). Additionally, post hatchling Flatback turtles are known to forage on plankton in pelagic waters at the entrances to Port Alma and Port Curtis and are not considered reliant on intertidal or subtidal areas within and adjoining the WBE reclamation area.

Due to the known foraging behaviour of the Flatback turtle within the Port of Gladstone it is considered unlikely to depend on the intertidal and subtidal areas at the WBE reclamation area and BUF to an extent where populations will be adversely impacted by the WBE reclamation area and BUF establishment (Thums et al. 2017; Limpus et al. 2013e). Due to the permanent loss of important Flatback turtle habitat from the establishment of the WBE reclamation area the potential impact and the post mitigation risk levels for the Flatback turtle was considered to be medium.

Hawksbill turtle potential impact

The omnivorous Hawksbill turtle feeds in a wide range of tidal and subtidal habitats, including reefs, seagrass meadows and soft-bottomed sand or mud areas (Limpus 2008b). It is therefore considered that the establishment of the WBE reclamation area will result in the permanent loss of foraging habitat for Hawksbill turtles, in the form of seagrass meadows. Due to the permanent loss of important Hawksbill turtle habitat from the establishment of the WBE reclamation area, the potential impact and the post mitigation risk levels for the Hawksbill turtle are considered to be high.

Loggerhead turtle potential impact

The Loggerhead turtle forages at a range of depths, including tidal and subtidal waters, over a range of substrates, including coral reefs, rocky reefs, mudflats and soft-bottomed habitats (Limpus et al. 2008b). It is therefore considered that the establishment of the WBE reclamation area will result in the permanent loss of foraging habitat for Loggerhead turtles, in the form of seagrass meadows. Due to the permanent loss of important Loggerhead turtle habitat from the establishment of the WBE reclamation area the potential impact and the post mitigation risk levels for the Loggerhead turtle are considered to be high.

Olive ridley turtle potential impact

Olive ridley turtle populations are rarely encountered in intertidal seagrass meadows or reef habitats, preferring to feed at subtidal soft-bottomed habitats (Limpus 2007; Robins and Mayer 1998; DoEE 2019c). The establishment of the WBE reclamation area and BUF is not considered to result in the permanent loss or alteration of habitat for this turtle species.

The post mitigation risk ratings associated with Project impacts on the Olive ridley turtle from an unavoidable permanent loss of foraging habitat from the WBE reclamation area are considered medium.

9.10.2.2 Potential noise impacts

Increased underwater noise has the potential to be generated during the construction of the bund walls at the WBE reclamation area and piling works (or similar earth retaining structural works) at the BUF. Excessive levels of underwater noise have the potential to impact a variety of marine animals, including marine turtles through:

- Trauma to hearing (temporary or permanent)
- Trauma to non-hearing tissue (barotraumas)
- Alteration of behaviour (e.g. avoidance of predators, interfering with the acquisition of prey or mates, displacement from essential habitat areas, selection of appropriate nesting sites)
- Masking of biologically significant sounds (BOEM 2014; McCarthy 2004; Slade and Dunlop 2014).

Marine animals vary in their sensitivities to underwater noise with ear anatomy, frequency range and amplitude sensitivity each playing a role (Ketten 1998). A limited number of studies have been conducted on the acoustic sensitivity of marine turtles and little is known about the extent to which marine turtles use their auditory environment (BOEM 2014).

The auditory range of marine turtles is believed to be of low frequency and significantly less than other marine animals such as dolphins and dugongs, in the range of 50Hz to 1,000Hz depending on species and age (Ketten and Bartol 2005). Marine turtles appear most sensitive to noise at frequencies of between 100 hertz (Hz) to 400Hz (Ketten and Bartol 2005; Popper et al. 2014). Marine turtles are thought to detect a limited frequency range (200Hz to 700Hz) (BOEM 2014). In the absence of recommended damage criteria for marine turtles, it was considered that the same criteria used for fish is applicable as a conservative measure (Popper et al. 2014). Impacts to marine turtles from shipping noise or other continuous noise are considered low and no relevant assessment criteria are suggested (refer the Project EIS Chapter 13).

An assessment of the underwater noise to be generated as a result of Project activities was undertaken (refer Project EIS Chapter 13 and Appendix K2). The primary sources of noise from the establishment of the WBE reclamation area and BUF are predicted to occur during the placement of armour and core material into marine waters, primarily the dumping of rocks from trucks during bund wall construction. Sheet piling will also be a source of noise from the BUF.

When modelled for a variety of hertz values across the one-third octave bank central frequency, underwater noise generated during rock dumping events was calculated not to exceed a sound exposure level (SEL) of approximately 182 decibel (dB) re 1µPa^{2}S at 1m from the rock dumping area.

An assessment of the potential underwater noise impacts during rock dumping indicated that it is unlikely that marine turtles would be at risk of peak acoustic pressure damage from underwater rock dumping until they are within the range of direct physical impact from the dumping rock material. For marine turtles, the SEL threshold level for mortality and potential mortal injury is 210dB re 1μPa^{2}S. The underwater noise predicted to be generated from rock dumping is significantly below this threshold (i.e. 182dB re 1μPa^{2}S at 1m from the rock dumping area). Given the relatively low noise emissions and non-impulsive characteristics of dumping rock material at the WBE reclamation area (as well as the relatively higher baseline underwater noise environment within the Inner Harbour) it is likely that marine turtles will avoid the rock dumping locations. As such, it is unlikely that they would remain stationary near rock dumping locations and be affected by this activity.

Non-pulse development activities such as vibratory sheet piling (for BUF construction) are not expected to result in significant adverse noise impacts to marine turtles due to the relatively low noise emissions from these activities.

Further information of the zones of noise impact are provided in the Project EIS Section 13.6.2 and Appendix K2.

Analysis of potential noise masking indicates marine turtles will not respond with a behavioural displacement response during foraging and communication during rock dumping activity.

This Project activity and potential exposure of marine turtles to these impacts will be temporary and restricted to a contained area and therefore low in magnitude.

The post mitigation risk ratings associated with potential impacts of increased noise on Green, Hawksbill and Loggerhead turtle species during the establishment of the WBE reclamation area and BUF are high. The post mitigation risk rating for the Flatback and Olive ridley turtle species was considered to be medium.

The Project AEIS Appendices E2 and E3 provides detail on the assessment of this potential impact and the resultant risk rating.

The impact and risk assessment for this activity is informed by the results of the Project noise impact assessment (refer Project EIS Chapter 13 and Appendix K2).

Mitigation measures to reduce the impacts of underwater noise on marine turtles during the WBE reclamation area and BUF establishment are included in the Project EMP (refer Project AEIS Appendix G).

9.10.2.3 Short term decline in water quality in the marine environment

Establishment of the WBE reclamation area (northern and southern areas) bund walls and BUF will be undertaken over a three year period and will involve the placement of core material directly over existing sediments, followed by armour material being placed along the seaward exposed face. Fine material of less than 12mm in diameter will be removed from the bund wall construction material prior to use, to reduce the potential turbidity and sedimentation impacts when it is placed into the marine environment. The construction activities associated with the establishment of the WBE reclamation area and BUF have the potential to impact the water quality of the receiving environment (i.e. enclosed coastal waters of Port Curtis) and impact marine turtles either directly through exposure to contaminants and increased turbidity, or indirectly through a decline of important habitat. A detailed assessment of the potential impacts to water quality as a result of Project activities is provided in the Project EIS Section 8.6, and supplementary information provided in Chapter 8 of this AEIS.

Suspended sediments in the water column can increase light attenuation and reduce the amount of benthic light reaching seagrass meadows, which are potential foraging habitat for Green turtles (Erftemeijer and Lewis 2006; Sofonia and Unsworth 2010).

The waters of Port Curtis are naturally turbid with higher turbidity levels experienced during the wet season flood events and during the spring and neap tide periods of the tidal cycle (Commonwealth of Australia 2013). However, despite the naturally high levels of turbidity experienced within Port Curtis, the area is known to support Green turtles (Limpus 2008a). During 2011, a significant increase in turtle strandings was recorded along with an increased prevalence of ill health and disease (Meager and Limpus 2012). This was attributed to poor health as a result of malnutrition (Eden et al. 2011), which was partly attributed to the decline of seagrass abundance across all Port Curtis seagrass meadows particularly following major flood events (McCormack et al. 2013).

A study was undertaken in May 2014 by the University of Queensland and the former EHP to assess the health status of Green turtles within Port Curtis. The findings from the study suggested that the Green turtle population of Port Curtis has made a significant, but not a complete recovery since the increase in strandings and elevated disease prevalence recorded in 2011 (Flint 2015).

The presence of PASS was evident in the samples collected at the WBE reclamation area (refer Project EIS Chapter 5). If PASS is encountered during establishment of the WBE reclamation area mitigation measures will be implemented (refer Project EIS Chapter 5). Water quality, in particular the presence of contaminants in water, has been identified as a significant source of marine turtle illness, injury and death (Brodie et al. 2014), and declining water quality due to catchment runoff has been outlined as a major pressure on marine turtles in the GBRMP (GBRMPA 2014b). Declines in water quality can lead to harmful and potentially fatal outcomes in marine turtle populations such as:

- Potentially toxic levels of contaminants building up in tissues and eggs as a result of contaminants from agricultural, urban and industrial sources
- Immunosuppression as a result of exposure to heavy metals, organic contaminants and algal toxins
- Adverse health effects through harmful algal and cyanobacterial blooms as a result of eutrophication in waters through increased nutrient supply (Brodie et al. 2014).

Previous studies on marine turtles suggest they have good eyesight and that their ability to distinguish colours are an important factor in their foraging ecology (Swimmer et al. 2005; Fehring 1972). This suggests that marine turtle species that feed in seagrass meadows and reef environments (i.e. Green turtles and Hawksbill turtles) that have the potential to be impacted by turbid waters are expected to actively avoid turbid waters generated by Project activities.

Contaminants (e.g. hydrocarbons) and sediment-laden runoff have the potential to be released during the placement of core and armour material at the WBE reclamation area and BUF or via spills from vehicles and/or onsite storage facilities. The risks of contaminants in water and their impact on marine turtles have been highlighted in recent years through studies in Port Curtis which found a range of heavy metals (e.g. arsenic, cadmium, cobalt, mercury, nickel, selenium, and vanadium) present in Green turtles at concentrations above those reported for Green turtles and marine mammal species from other locations (Gaus et al. 2012; Flint et al. 2015).

This Project activity and potential exposure of marine turtles to these impacts will be short term and restricted to the local area and therefore moderate in magnitude.

The post mitigation risk ratings associated with potential impacts of a release of sediment laden runoff and/or contaminants to marine waters impacting marine turtles during the establishment of the WBE reclamation area and BUF are medium.

The Project AEIS Appendices E2 and E3 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to minimise marine water quality being impacted during the WBE reclamation area and BUF establishment and adversely impacting marine turtles are included in the Project EMP and Environmental Monitoring Procedure (refer AEIS Appendices G and H, respectively).

9.10.2.4 Entrapment and direct contact with construction plant

Construction equipment required for the establishment of the reclamation bund walls includes trucks and a small number of excavators and/or dozers required to assist in the placement of material. Core material will be placed directly over the existing sediments and bund material will then be shaped by bulldozer, grader or long arm excavator depending on location and required bund profile. Armour material will then be placed along the outer exposed face of the bund wall.

The *Marine wildlife stranding and mortality database annual report* (Meager and Limpus 2012) reported six Green turtles were trapped inside bund walls during land reclamation works in Port Curtis in 2011, although all turtles were rescued and released back into their natural habitat. The closure of the WBE reclamation area and BUF has the potential to entrap marine turtle species.

The risk of construction plant directly impacting marine turtles is considered low given the land-based construction methods and mitigation measures to be employed. However, there is potential for marine turtles to be impacted by the placement of rock into marine areas during construction of the bund wall. In the unlikely instance that work boats are required as part of these construction works, to avoid striking marine turtles the work boats will include marine fauna spotters and vessels will be slow moving with movements localised between the WBE reclamation area, the BUF and the existing Port facilities (e.g. Gladstone Marina).

This Project activity and potential exposure of marine turtles to these impacts will be temporary and within a local area and therefore low in magnitude.

The post mitigation risk ratings associated with adverse impacts on marine turtles associated with the direct contact or entrapment within the reclamation areas during establishment of the WBE reclamation area and BUF are low for the Flatback turtle, and medium for the Green, Hawksbill, Loggerhead, and Olive ridley turtles.

The Project AEIS Appendix E2 and E3 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to avoid injury or death to marine turtles occurring as a result of direct contact with construction plant, rock placement, or entrapment within a reclamation area are included the Project EMP (refer Project AEIS Appendix G).

9.10.2.5 Potential artificial lighting impacts

No night time works are proposed as part of the establishment of the WBE reclamation area and BUF. However, artificial lighting will be required for safety during night time hours which will generate minor light spillage into the marine environment.

Artificial light is not known to have a major effect on the foraging behaviour of turtles. However, hatchlings which use natural lighting to guide them to the ocean (a pivotal moment in their lifecycle) may become disorientated from altered light horizons from coastal development or brightly illuminated facilities on islands or at sea (e.g. oil and gas facilities) (Witherington 1992). Artificial lighting also has the potential to impact on the number of female adult turtles attempting to nest (Witherington 1992).

As no night works are proposed to be undertaken during the establishment of the WBE reclamation area and BUF, and the works are not located in the vicinity of any known turtle nesting beaches, this Project activity will not adversely impact on marine turtles within Port Curtis. Furthermore, the inner harbour of the Port currently receives elevated artificial light levels from existing Port, industrial and residential development on the mainland or Curtis Island.

This Project activity and potential exposure of marine turtles to these impacts will be within the medium term and restricted to a contained area and therefore low in magnitude.

The post mitigation risk ratings associated with adverse impacts on marine turtles from a potential increase in artificial lighting during establishment of the WBE reclamation area and BUF are low for the Green and Flatback turtles, and medium for the Hawksbill, Loggerhead, and Olive ridley turtles.

The Project AEIS Appendix E2 and E3 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to avoid potential lighting impacts on marine turtles during the WBE reclamation area and BUF establishment are included in the Project EMP (refer Project AEIS Appendix G).

9.10.2.6 Potential increase in waste material and marine debris

Construction activities associated with the establishment of the WBE reclamation area and BUF will involve the generation of some waste material which has the potential to enter the marine environment (i.e. potential marine debris). Direct impacts to marine turtles from ingestion and entanglement with marine debris is a well-documented source of marine turtle injury and death (Meager and Limpus 2012).

Harmful marine debris is commonly associated with discarded fishing equipment, but it may also include solid non-biodegradable floating materials and plastic waste washed or blown from the land or vessels into the sea. This can include (but is not limited to) plastics bags, bottles, food packaging, strapping bands, sheeting and synthetic ropes.

This Project activity, and potential exposure of marine turtles to these impacts, will be within the medium term and restricted to a contained area, therefore moderate in magnitude.

The post mitigation risk ratings associated with impacts on marine turtles from a potential increase in waste material and marine debris during establishment of the WBE reclamation area and BUF are low for the Flatback turtles, and medium for the Green, Hawksbill, Loggerhead, and Olive ridley turtles.

The AEIS Appendix E2 and E3 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to minimise and avoid waste materials entering the marine environment during the WBE reclamation area and BUF establishment are included in the Project EMP (refer AEIS Appendix G).

9.10.2.7 Increase in hard substrate

The establishment of the WBE reclamation area will involve the construction of outer (i.e. seaward) reclamation area bund walls, and internal bund walls for the management of dredging decant water. Part of the BUF outer wall will also be constructed of the same rock material. The construction of rock walls within the marine environment provides three dimensional artificial habitats in intertidal and subtidal areas which have the potential to promote species settlement such as algae, fish and sessile fauna. While it is expected to take several years for the rock wall to establish diverse fauna and flora assemblages, there is the potential for the bund walls to provide reef-like habitat and food resources for some marine turtles.

The creation of new rock wall habitat has the potential to lead to a localised increase in food resource availability for some marine turtle species, although it is not well understood to what extent marine turtles feed on the existing rock wall habitats in Port Curtis. A recent study within Port Curtis of Green turtles, the most abundant marine turtle species in the area, found no evidence of Green turtles utilising Port infrastructure for resting or foraging (refer Limpus et al. 2018). Other marine turtle species that forage on reef (coral and rocky) substrates (i.e. Hawksbill and Loggerhead turtles) may utilise the proposed WBE reclamation area rock wall for foraging.

This Project activity and potential benefit to marine turtles from this increase in hard substrate will be permanent and within a contained area and therefore moderate in magnitude.

The post mitigation risk ratings associated with adverse impacts on marine turtles from a potential increase in hard substrate during establishment of the WBE reclamation area and BUF are medium for the Green, Flatback, Hawksbill, Loggerhead, and Olive ridley turtles.

The AEIS Appendix E2 and E3 provides detail on the assessment of this potential impact and the resultant risk rating.

9.10.3 Dredging activities

9.10.3.1 Context of impact

Approximately 12.6Mm^3 of seabed material will be removed from the channel duplication area to be dredged during dredging activities for the Project and approximately 0.25Mm^3 of material dredged for the barge access channel.

9.10.3.2 Permanent loss and alteration of habitat

For the assessment of the loss and alteration of habitat for marine turtles associated with this Project activity, foraging habitat and internesting habitat are considered in this section (refer Table 9.35). Dredging activities will not result in impacts on known nesting beaches. It is acknowledged that marine turtles will move throughout Port Curtis and may come in contact with vessels as a result of dredging activities, this potential impact is discussed in the Project EIS Section 9.10.3.5.

Currently marine turtle utilisation of shipping channels has not been quantified, however it is possible that they may use the Gatcombe and Golding Cutting shipping channels. Turtle tracking studies undertaken to date have focused on shallow water feeding (e.g. seagrass meadows), rather than from the shipping channels within Port Curtis, while Flatback turtle internesting females have been observed within the Gatcombe and Golding Cutting channel duplication area (Hamann et al. 2015c). As such, uncertainty around the current and future use of the dredging the channel persists, and potential impacts are considered possible in relation to the uncertainty.

Green, Flatback, Loggerhead, Hawksbill and Olive ridley turtles are all known to forage on benthic macroinvertebrates in deeper subtidal waters. Existing Port shipping channels are unlikely to provide abundant foraging resources due to ongoing annual disturbance from port maintenance dredging. The proposed channel duplication extent includes areas which support benthic macroinvertebrates and is likely to include areas of suitable foraging habitat for Green, Flatback, Hawksbill, Loggerhead and Olive ridley turtles.

Table 9.35 Potential Project impact areas to marine turtle foraging habitat (areas to be dredged)

Project activity	Direct impact area on historic seagrass foraging habitat	Indirect impact area on historic seagrass foraging habitat	Total potential foraging habitat for marine turtles within the direct impact area (areas to be dredged) (e.g. seagrass, algae, molluscs, crustaceans)
Barge access channel	0ha[1]	0ha[2]	19.03ha
Area to be dredged (Stage 1 and Stage 2 combined)	35.65ha	876.98ha[3]	421.40ha
Total	**35.65ha**	**876.98ha**	**440.43ha**

Table notes:

1 Direct impact is considered to be negligible after consideration of existing indirect impact from the existing Western Basin reclamation area and is therefore excluded from the impact assessment.
2 The indirect impact is considered to be associated from the existing Western Basin reclamation area and is therefore excluded from the impact assessment.
3 The Project indirect impact area is based on the high zone of impact associated within the channel duplication dredging activities.

The Project dredging activity and the potential for impacts on marine turtle foraging habitat areas may be long term and within a contained area, and therefore moderate in magnitude.

Adaptive design measures will be implemented during the Project detailed design phase, including dredging methodology to reduce the impact of habitat loss at the areas to be dredged (refer AEIS Appendix F). Project design will minimise where practical the permanent loss of areas of important habitat within the areas to be dredged.

Further details on the potential impact and risk ratings are provided below and in the AEIS Appendices E2 and E3 provides detail on the assessment of this potential impact and the resultant risk rating.

Green turtle potential impact

Potential Green turtle foraging habitat (i.e. deep water seagrass meadows) is mapped within the area to be dredged for the duplication of the shipping channels. Baseline deep water seagrass surveys within Port Curtis and Rodds Bay undertaken in years 2002, 2009, 2013 and 2014 only recorded sparse seagrass meadows in the area to be dredged for the channel duplication in 2002. In contrast, areas of historic seagrass mapping extent exist within the area to be dredged and are likely to be permanently lost (refer Figure 9.10a and Figure 9.10b). This impact will be relatively small in the context of the wider region and is not considered to be a significant impact on the Green turtle. The indirect impacts of changes in water quality within the zones of impact (refer Figure 9.8) are likely to be temporary and not result in permanent loss or alteration of habitat.

Given that there are limited areas of seagrass meadows within the high or medium zones of impact, the temporary nature of the dredge plume and the ability to modify the dredger to reduce the impacts and the limited extent of seagrass meadows within the zones of high and moderate impact, it is expected that the water quality impacts from Project activities are unlikely to impact the seagrass meadows in the area for a long term duration. Ensuring that the seagrasses near the channel receive adequate light during the growing season for seed regeneration and recruitment will assist in ensuring long term impacts are reduced.

Regionally the Project is unlikely to cause recruitment failure due to the large extent of seagrass and therefore seed recruitment within the area is unlikely to be impacted by dredging in the long term. Seagrass monitoring will occur, however, prior, during and after dredging to ensure that no significant impacts do occur to seagrass meadows and that reactive mitigation can occur. The zone of medium impact extends to the seagrass meadows surveyed east of South Trees Island and Boyne Island. Although the short term turbidity plumes are not expected to impact these meadows in the long term, regular water quality and BPAR monitoring will occur to ensure that adaptive management is adopted to reduce the potential impacts to these meadows. Other seagrass meadows within the Port are within the zone of low impact or zone of influence, however the monitoring proposed in the Environmental Monitoring Procedure (refer AEIS Appendix H) will confirm their presence prior to dredging.

Due to limited Project mitigation specific to this potential impact the post mitigation risk levels for the Green turtle from an unavoidable loss of foraging habitat in areas to be dredged are considered medium.

Flatback turtle potential impact

Flatback turtles are considered to utilise the existing Port shipping channels and are expected to be impacted by Project dredging activities. Previous studies have indicated that adults/sub-adults forage over complex, benthic geomorphology at depth (typically 60m to 90m deep) to obtain prey resources (Thums et al. 2017), however are noted to dive to shallow depths during interesting activities due to depth profile constraints associated with proximal habitat off Curtis Island (Sperling et al. 2007).

Post hatchling Flatback turtles are known to forage on plankton in pelagic waters at the entrances to Port Alma and Port Curtis. Salmon et al. (2010) has hypothesised that the post-hatchling foraging behaviour enables foraging in turbid waters, and as such, limited loss or alteration of habitat of post-hatchling Flatback turtles is considered likely due to Project dredging activities.

The proposed areas to be dredged include internesting habitat for the Flatback turtle (refer Figure 9.33). Permanent loss and alteration of internesting habitat is not expected to have an indirect adverse impact on reproduction for Flatback turtles nesting at beaches in the region, including Facing Island, Hummock Hill Island and Tannum Sands (refer Figure 9.34).

Due to the permanent loss of Flatback turtle internesting habitat from dredging activities, the potential impact and the post mitigation risk levels for the Flatback turtle are considered high.

Hawksbill and Loggerhead turtles potential impact

Loggerhead and Hawksbill turtles are expected to utilise the existing Port shipping channel and are expected to be impacted by Project dredging activities in regard to a permanent loss and alteration of habitat. Adults and sub-adults of both species are expected to forage over a range of tidal and subtidal waters, including the soft benthic habitat associated with Project dredging activities (Limpus et al. 2008b; 2008d).

Due to the permanent loss of Loggerhead and Hawksbill turtle foraging habitat from dredging activities the potential impact and the post mitigation risk levels for the Loggerhead and Hawksbill turtles are considered high.

Olive ridley turtle potential impact

Olive ridley turtle populations are rarely encountered in seagrass meadows or reef habitats, preferring to feed at subtidal soft-bottomed habitats (Limpus 2007; Robins and Mayer 1998; DoEE 2019c). Existing Port shipping channels are unlikely to provide abundant foraging resources due to ongoing annual disturbance from Port maintenance dredging. The permanent loss of subtidal benthic foraging habitat has the potential to have an impact on Olive ridley turtles. However, with consideration of the available habitat (as existing within the Port shipping channels) and the low likelihood of occurrence of the Olive ridley turtle, the dredging alteration of the habitat is not considered a significant impact.

Due to the permanent loss of Olive ridley turtle foraging habitat from dredging activities the potential impact and the post mitigation risk levels for the Olive ridley turtle are considered medium.

9.10.3.3 Potential underwater noise impacts

Dredging activities will generate underwater noise at the areas to be dredged. This will form a persistent source of underwater noise, and will continue intermittently during dredging activities. Dredging activities will generate underwater noise primarily through the operation of underwater pumps/piping and draghead dragging of seabed material. Excessive levels of underwater noise have the potential to impact a variety of marine animals, including turtles (refer examples in Project EIS Section 9.10.2.2). The primary sources of noise from dredging activities are predicted to occur during dredging using a TSHD and CSD.

A detailed review of underwater sound propagation, natural and anthropogenic sources of marine noise, and the potential vulnerabilities of receptors (i.e. marine fauna) of interest is provided in Project EIS Appendix I1 (Section 13). Noise modelling was undertaken at the following locations as part of this impact assessment (refer Project EIS Chapter 13 and Appendix K2):

- TSHD and CSD dredging of the barge access channel
- WBE reclamation area (northern area)
- WBE reclamation area (southern area)
- TSHD dredging operation at Gatcombe Channel (northern end) adjacent to South Trees Island seagrass meadows
- TSHD dredging of Golding Cutting Channel (middle area)
- TSHD dredging of Golding Cutting Channel (southern end).

Impacts to marine turtles from shipping noise or other continuous noise are considered low and no relevant assessment criteria are suggested (refer Project EIS Appendix K2).

The risk of underwater noise generated through dredging activities resulting in acute hearing damage to marine turtles is considered low. Intermittent cumulative increases to ambient underwater noise is also considered to be low. Data on marine turtle underwater hearing is limited to a few relevant studies however these studies indicate low frequencies between 50Hz and 1,200Hz with most sensitivity at a range of about 100Hz to 400Hz (refer Project EIS Appendix K2).

This Project activity and potential exposure of marine turtles to these impacts will be medium term and within a contained area, therefore moderate in magnitude. This is due to the relatively low noise emissions from these activities.

The post mitigation risk ratings associated with increased noise and vibration impacting on marine turtles during dredging activities are medium for the Green and Flatback turtles, and high for the Hawksbill, Loggerhead, and Olive ridley turtles.

AEIS Appendices E2 and E3 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to reduce the impacts of underwater noise on marine turtles during dredging activities are included in the Dredging EMP (refer AEIS Appendix F).

9.10.3.4 Potential vessel strike impacts

Vessel movements associated with dredging activities pose a potential risk to marine turtles in Port Curtis. Marine turtles are particularly prone to vessel collision while surfacing to breathe and rest after dives, or whilst feeding or mating in shallow seagrass meadows or coral reef areas (Brodie et al. 2014). The risk of vessel strike for marine turtles is highly influenced by vessel speed and water depth (Hazel et al. 2007).

While specific vessel types and sizes have not been confirmed for the Project, based on the nature and volume of the material to be dredged, the preferred dredging equipment includes TSHD and CSD dredgers and other vessels (including barges, pushbusters, tugs and other support vessels).

Studies suggest that the risk of boat strike is considerably reduced when vessel speeds are below 10 knots, allowing sufficient time for both turtles and vessel operators to avoid collision (SKM 2014; Hazel et al. 2007). Larger vessels such as dredgers and work boats are slow-moving and are not likely to present a significant threat to marine turtles in terms of vessel strike, while smaller work boats capable of travelling at faster speeds may present a higher risk (refer Section 9.10.3.5 for impact assessment associated with direct contact with dredging equipment).

The *Vulnerability Assessment for the Great Barrier Reef* (GBRMPA 2014b) describes the direct impact of boat strike and Port dredging on marine turtles as a ‘moderate concern’ for Green turtles and Loggerhead turtles in the southern Great Barrier Reef region behind other ‘high concern’ impacts such as cumulative impacts from human-related activities (i.e. coastal development, declining water quality, climate change, ingestion and entanglement of marine debris, fishing by-catch, and Indigenous fishing).

The distance between the vessel hull or propeller and the seabed can also play a role in the risk of boat strike, particularly for Green turtles in shallower areas where they may be foraging or resting at the seabed (Hazel 2009). Deeper waters present less of a risk. Dredging activities at the area to be dredged associated with the channel duplication will be undertaken in deeper waters (approximately -7m and -16m LAT) presenting less of a risk of vessel strike to marine turtles during these works.

Whilst deeper water may present a reduction in risk in regard to direct vessel strikes, the potential for an increase in internesting Flatback turtle interaction is considered during and after Project activities, in strict regard to the dredging impact area. The potential increase in vessel traffic may result in higher numbers of negative interactions, particularly for those internesting turtles utilising surface sections of the dredging impact area.

The Port of Gladstone currently experiences a high volume of commercial and recreational vessel traffic. The nature, scale and volume of Project vessel movements are considered minor compared to the existing Port vessel movements. It should be noted that vessel numbers required to complete the Project will be considerably lower than those required during the Western Basin capital dredging and LNG development on Curtis Island between 2011 and 2015.

There is potential for vessel strikes with Green, Flatback, Hawksbill, Loggerhead and Olive ridley turtles during dredging activities.

This Project activity and potential for impacts on marine turtles will be within the medium term and within a contained extent, therefore moderate in magnitude.

The post mitigation risk ratings associated with potential vessel strike impacting on marine turtles during dredging activities are medium for the Green and Flatback turtles, and high for the Hawksbill, Loggerhead, and Olive ridley turtles.

AEIS Appendices E2 and E3 provide detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to reduce the risk of vessel strike on marine turtles during dredging activities are included in the Project Dredging EMP (refer AEIS Appendix F).

9.10.3.5 Direct contact with dredging equipment

Dredging activities have the potential to impact on marine turtles through direct contact with dredging equipment. However, the annual reported mortality of Green turtles in Queensland during Port dredging operations from 1999 to 2011 is relatively low with 0.5 per year recorded for Green turtles, and 0.6 per year for Loggerhead turtles (Limpus et al. 2013a). Two turtle deaths (one juvenile Green turtle and one juvenile Olive ridley turtle) recorded in the Gladstone region during 2011 were attributed to dredging operations (Meager and Limpus 2012).

The 2013 to 2016 survey of internesting Flatback turtles have identified that the waters around Curtis and Facing Islands and the waters between Facing Island and the mainland provided suitable internesting habitat for the Flatback turtle (Hamann et al. 2017b).

This risk of dredgers directly impacting on marine turtles will depend on the type of dredging plant being used. A TSHD poses a greater risk of interaction with a marine turtle, often resulting in injury or death, as TSHDs are slow-moving, quiet and have strong suction power at the draghead (Goldberg et al. 2015). Turtles often inhabit nearshore areas where dredgers operate and during the cooler months often seek the warmer waters of deep water channels (Dobbs 2001). In Gladstone, Green turtle tracking and habitat studies by Hamann et al. (2015a) recorded Green turtles regularly using the North Entrance between Curtis Island and Facing Island (i.e. access point in and out of the Port for small vessels), while female Flatback turtles have been tracked in the Mid and Outer Harbour zones around the deeper channels (i.e. shipping channels) during internesting periods (Hamann et al. 2015b) (refer Figure 9.8 for the zone locations).

The CSD, clamshell, pipeline, and other types of dredgers generally pose a lower risk of impacts to marine turtles due to design and operational differences (Dickerson et al. 2004).

The Project dredging activity and potential exposure of marine turtles to these impacts will be medium term and within a contained extent and therefore moderate in magnitude. While the likelihood of the impact occurring post mitigation is possible it is unlikely that these potential impacts will result in an adverse impact on marine turtle populations, or their habitat.

The post mitigation risk ratings associated with potential impacts on marine turtles through direct contact with dredging equipment is high for the Green, Flatback, Hawksbill, Loggerhead, and Olive ridley turtles.

AEIS Appendices E2 and E3 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to reduce the risk of injury or death to marine turtles occurring as a result of direct contact with dredging equipment during dredging activities are included the Dredging EMP (refer AEIS Appendix F).

9.10.3.6 Temporary decline in water quality in the marine environment

The potential impacts to water quality as a result of dredging projects have been widely studied and water quality, in particular the presence of contaminants in water, has been identified as a major source of marine turtle illness, injury and death (Brodie et al. 2014).

A detailed assessment of the potential impacts to water quality as a result of Project dredging activities is provided in Project EIS Section 8.6. This includes an assessment of the risk of dredging activities resulting in a decline in water quality, predominantly through increased turbidity, including:

- Dredging (i.e. turbidity generated at the dredger head, overflow and propwash)
- Dredging vessel movements
- Dredged material unloading and placement (e.g. potential bund wall seepage)
- Licenced discharge of dredging decant water from the Western Basin and WBE reclamation areas.

The Project EIS Section 9.10.2.3 discusses the sources of potential impacts on marine turtles associated with short term declines in water quality. Therefore, these sources are not further discussed in this section.

During dredging activities, there is potential for temporary impacts on marine turtle foraging habitat (e.g. seagrass meadows and subtidal soft-bottomed substrates with benthic macroinvertebrates) and the release of contaminants into marine environments (and potential indirect impacts on turtle health) (refer AEIS Section 9.10.2.3).

Temporary decline in deep water seagrass turtle habitat

AEIS Section 9.10.3.2 discusses the outcome of the hydrodynamic modelling and the predicted impacts to water quality and potential impact that this might have on seagrass meadows and suitable habitat for marine turtles. It is important to note that there are large areas of comparable habitat within the Port Curtis region that are not expected to experience a temporary decline in water quality from Project dredging activities.

Potential Green turtle foraging habitat (i.e. deep water seagrass meadows) is mapped within the area to be dredged for the duplication of the shipping channels. Baseline deep water seagrass surveys within Port Curtis and Rodds Bay undertaken in years 2002, 2009, 2013 and 2014 only recorded sparse seagrass meadows in the area to be dredged for the channel duplication in 2002. In contrast, areas of historic seagrass mapping extent exist within the area proposed to be dredged and are likely to be permanently lost (refer Figure 9.10a and Figure 9.10b). This impact will be relatively small in the context of the wider region and is not considered to be a significant impact on the Green turtle. The indirect impacts of reductions in water quality within the zones of impact (refer Figure 9.8) are likely to be temporary and not resulting in permanent loss or alteration of habitat.

Implementation of the Environmental Monitoring Procedure as part of the Dredging EMP (refer AEIS Appendices F and H, respectively) will ensure seagrass meadows in the zones of low to medium impact and the zone of influence will remain available for marine turtles subject to natural variations throughout the year.

Dredging activities that effect water quality will likely be contained to certain areas at any given time (i.e. only one dredger will be working at particular points within the areas to be dredged at any given time). The Dredging EMP will be implemented during dredging activities which will minimise and mitigate potential impacts to water quality from dredging activities. A detailed monitoring procedure has also been designed to survey coastal and deep water seagrass meadows and monitoring water quality throughout the Port and offshore areas prior to, during and after Project activities to ensure that any changes to water quality is identified and management measures can be implemented. These plans include adaptive and reactive management measures to be adopted during dredging activities which will focus on minimising impacts at key sensitive receptors such as seagrass meadows. Mitigation measures to minimise water quality impacts are provided in AEIS Appendices F and H, respectively.

The Project dredging activity and potential exposure of marine turtles to these impacts will be medium term and within a local area, and therefore moderate in magnitude.

The post mitigation risk ratings associated with temporary decline in water quality impacting on marine turtles during dredging activities are high for the Green turtle, and medium for the Flatback, Hawksbill, Loggerhead, and Olive ridley turtles.

AEIS Appendices E2 and E3 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to minimise the impact of short term declines in water quality during dredging activities on marine turtles are included in the Dredging EMP and Environmental Monitoring Procedure (refer AEIS Appendices F and H, respectively).

Potential indirect impacts on turtle health from contaminants

Desktop and field geochemical investigations undertaken for the Project concluded that the marine sediments to be removed from the areas to be dredged are considered ‘clean’ as per the NAGD (Commonwealth of Australia 2009) and the potential for contaminants to be mobilised into the water column during dredging activities is considered to be low (refer Project EIS Section 6.5 and Project EIS Appendices E4 and E6). Based on these results the potential for marine turtles to be impacted by contaminants from sediment to be dredged during the Project is therefore also considered low.

Adaptive design measures will be implemented during the Project detailed design phase to minimise the potential impacts to water quality (refer Project EIS Section 9.27). Project design of the WBE reclamation area and BUF will incorporate geotextile material to be placed within the inner face of the bund wall reclamation area in order to minimise the migration of dredged material fines through the bund wall to the marine waters of Port Curtis. Furthermore, the location of the reclamation area licenced dewatering discharge point will be placed at a location where seagrass is not present (or have the potential to grow), to avoid potential impacts to marine turtle habitat through scouring of the seabed. The release of dredging decant waters will be controlled by a licenced discharge point and weir box with conditions which will dictate the water quality criteria to be met prior to discharge.

This Project activity and potential exposure of marine turtles to these impacts will be medium term and within a local area, and therefore moderate in magnitude.

The post mitigation risk ratings associated with potential indirect impacts on marine turtle health impacting on marine turtles during dredging activities are medium for all five marine turtle species of subject to this assessment.

AEIS Appendices E2 and E3 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to minimise the impact of temporary declines in water quality during dredging activities on marine turtles are included the Dredging EMP and the Environmental Monitoring Procedure (refer AEIS Appendices F and H, respectively).

Temporary decline in benthic macroinvertebrate turtle foraging habitat

Areas supporting benthic macroinvertebrates provide suitable foraging habitat for Green, Flatback, Hawksbill, Loggerhead and Olive ridley turtles will potentially be indirectly impacted by Project dredging activities (within areas of moderate and high impact, but removed from the dredging footprint). There is potential for a temporary decline in water quality to adversely impact filter feeding macroinvertebrates such as bivalves and sea pens as these communities may be sensitive to changes in sediment load and exposure to contaminants. There is potential for a temporary decline in the quality or condition of foraging habitat (i.e. benthic macroinvertebrate assemblages) in the zones of impact (refer Figure 9.8) during dredging activities.

The Project dredging activity and potential exposure of Green, Flatback, Loggerhead, Olive ridley and Hawksbill turtles to these impacts will be medium term and within a local area, and therefore moderate in magnitude.

The post mitigation risk ratings associated with temporary decline in benthic macroinvertebrate foraging habitat impacting on marine turtles during dredging activities are high for the Green and Flatback turtles, and very high for the Hawksbill, Loggerhead, and Olive ridley turtles.

AEIS Appendices E2 and E3 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to minimise the impact of short term declines in water quality during dredging activities on marine turtles are included the Dredging EMP and the Environmental Monitoring Procedure (refer AEIS Appendices F and H, respectively).

9.10.3.7 Potential artificial lighting impacts

Artificial lighting will be required for safety and navigation during night time hours on dredgers and work boats for dredging activities. Artificial light is not known to have a major effect on the foraging behaviour in turtles but it has the potential to impact nesting females and hatching ocean finding behaviour, as detailed in AEIS Section 9.10.2.5.

The closest nesting areas for Flatback turtles in relation to the area to be dredged for the channel duplication are located 2km north at Gatcombe Head on Facing Island. Areas where nesting is known to occur are located approximately 4.5km to 5.5km south of the area to be dredged at Lilley's Beach (Boyne Island), Hummock Hill, Tannum Sands and along the coast to Colosseum Inlet (refer Project EIS Figure 9.15). Additional nesting areas further from the area to be dredged include the eastern coast of Facing Island, Curtis Island and Peak Island.

Artificial lighting from the Project dredging activities is unlikely to impact nesting or foraging adult marine turtles, but may impact the in-water dispersal of hatchling turtles. Whilst the in-water dispersal of hatchlings is primarily determined by ocean currents, artificial lighting can diminish the response of turtles to ocean currents, result in hatchling turtles expending energy swimming against currents, lead to disorientation and result in hatchling turtles lingering around artificial light sources (Limpus et al. 2003; Whelan and Wyneken 2007; Harewood and Horrocks 2008; Thums et al. 2016). These impacts may result in reduced survival in hatchling turtles, primarily due to increased predation rates.

The State government introduced a statewide sea turtle sensitive area model code which sets provisions to protect sea turtles from new development along the coastline. The purpose of the sea turtle sensitive area code is to ensure that development does not create harm to sea turtle nesting and sea turtle activity by avoiding adverse impacts generated from artificial lighting. The outcomes of this code will be considered within the mitigation and management measures for the Project.

The Project dredging activity and potential exposure of marine turtles to these impacts will be medium term and restricted to a contained area and therefore moderate in magnitude.

The post mitigation risk ratings associated with potential artificial lighting impacts on marine turtles during dredging activities are high for the Green and Flatback turtles, and medium for the Hawksbill, Loggerhead, and Olive ridley turtles.

AEIS Appendices E2 and E3 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to minimise impacts from artificial lighting on marine turtles are included in the Dredging EMP (refer AEIS Appendix F).

9.10.3.8 Increase in waste material and marine debris

Project dredging activities have the potential for some waste material (e.g. marine debris) to enter the marine environment. Direct impacts to marine turtles from ingestion and entanglement of marine debris are a major source of turtle injury and death (Commonwealth of Australia 2016b; DoEE 2016). The AEIS Section 9.10.2.6 contains further information on the potential sources of waste material and marine debris associated with Project activities.

This Project activity and potential exposure of marine turtles to these impacts will be medium term and restricted to a contained area, therefore moderate in magnitude. It is unlikely that these potential impacts will result in adverse impacts on marine turtle populations, or their habitat.

The post mitigation risk ratings associated with an increase in waste material and marine debris impacting on marine turtles during dredging activities are low for the Green and Flatback turtles, and medium for the Hawksbill, Loggerhead, and Olive ridley turtles.

AEIS Appendix E2 and E3 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to minimise and avoid waste materials entering the marine environment during Project dredging activities are included in the Dredging EMP (refer AEIS Appendix F).

9.10.4 Removal and installation of navigational aids

9.10.4.1 Noise and vibration impacts

The installation of navigational aids will involve use of a Junttan hydraulic piling hammer that is anticipated to generate the highest levels of underwater noise during the Project, approximately 204dB for the impact piling and 168dB for the piling barge (refer Project EIS Chapter 13 and Appendix K2). As stated in AEIS Section 9.10.2.2, excessive levels of underwater noise have the potential to impact a variety of marine animals, including turtles. The specific size of the Junttan hydraulic hammer is yet to be determined but is expected to be in the range of 124dB. Two existing navigational aids will be removed and five existing navigational aids will be removed and reinstalled using a barge pile extractor.

The installation of new navigational aids (i.e. pilling) is estimated to take two to three days per pile. Installation is anticipated to be undertaken during daylight hours over a period of two to three months, with hammering undertaken intermittently. An assessment of underwater noise and vibration baseline levels along with predicted noise and vibration impacts from installation of the navigational aids were modelled by SLR (refer Project EIS Appendix K2). The following criteria were modelled as part of this assessment:

- Range of SEL levels for impact piling and operation of the piling barge
- Noise sources, including Junttan hydraulic impact hammer use and piling barge operation supporting navigational aid installation
- Noise generating mechanisms of impact piling and propeller/thruster use
- Modelled point source depth ‘mid water column’ for the impact piling and ‘near surface’ for the supporting barge
- Multiple pulses noise type for the impact piling and non-pulses, continuous noise type for the supporting barge.

Estimates of the underwater noise generated from the installation of navigational aids range from 15dB (RMS SPL parameter) and 28dB (Peak SPL parameter) for distances closer than 2km to the source, whilst for distances further than 10km away, an estimation of 10dB is derived.

Mortal injuries can be inflicted on marine turtles through a single piling strike within a distance of 35m during piling activity associated with the removal and installation of navigational aids (SLR 2019b). Noise emitted by a single strike is also predicted to cause avoidance at a distance of up to 600m whilst changes in behaviour can be expected up to a distance of 2km from piling location (SLR 2019b).

Piling noise exposure for an extended duration also has potential to cause mortal injury to marine turtles at further distances (SLR 2019b). The maximum zone of impact that will cause mortal injury to marine turtles for a one hour exposure duration (i.e. 6,000 strikes) was predicted up to 160m from the piling location (SLR 2019b).

It is important to note that there has been minimal research undertaken on the impacts of noise and vibration impact assessment on marine turtles.

This Project activity and potential exposure of marine turtles to these impacts will be temporary and within the local area, and therefore low in magnitude. It is considered that the regular pulses from piling activities may result in avoidance behaviour, therefore the likelihood of the impact occurring post mitigation is possible.

The post mitigation risk ratings associated with noise and vibration impacting on marine turtles during dredging activities are medium for all five marine turtles subject to this assessment.

AEIS Appendix E2 and E3 provides detail on the assessment of this potential impact and the resultant risk rating.

This impact and risk assessment for this activity is informed by the results of the Project noise and vibration impact assessment (refer Project EIS Chapter 13 and Appendix K2).

Mitigation measures to avoid or minimise potential noise impacts to marine turtles generated through piling activities are included in the Project EMP (refer AEIS Appendix G). A range of noise mitigation techniques can be utilised for marine piling activities that can reliably reduce the sound energy at the source across the range of frequencies that overlap the functional auditory range of marine megafauna species, including marine turtles.

9.10.4.2 Direct contact with construction plant

Vessel activity associated with the removal and installation of navigational aids has the potential to pose a risk to marine turtles in Port Curtis. The risk of vessel strike for marine turtles is highly influenced by vessel speed and water depth (Hazel et al. 2007). While specific vessel types and sizes have not been confirmed for the removal and installation of navigational aids, based on the proposed activities a barge, tug boat and work boats will be required to complete the works. Installation and removal of navigational aids will be undertaken in a variety of depths which can influence the risks associated with vessel strike.

Port Curtis currently experiences a high volume of commercial and recreational vessel traffic and the addition of the Project vessels will not significantly increase the risk of vessel strike to marine turtles above the overall existing risk that exists in Port Curtis.

This Project activity and potential exposure of marine turtles to these impacts will be temporary and within the local area, and therefore low in magnitude.

The post mitigation risk ratings associated with potential impacts on marine turtles through direct contact with construction plant during removal and installation of navigational aids is therefore low for all five species of marine turtles subject to this assessment.

9.10.4.3 Potential artificial lighting impacts

Artificial lighting on the Project navigational aid vessels will be required for safety and navigation. The removal and installation of navigational aids is not proposed to occur outside of daylight hours. As such, minimal lighting will be required on the navigational aid vessels in relation to existing light glow from the coastline and is not expected to significantly add to local light pollution.

The artificial lighting risk to marine turtles (principally marine turtle nesting adults and hatchlings) during this Project activity is therefore low for the Green, Flatback, Hawksbill, Loggerhead and Olive ridley turtles.

9.10.5 Stabilisation and maintenance activities

9.10.5.1 Short term decline in water quality

Release of contaminants

The use of vehicles during surface stabilisation and maintenance works at the Western Basin and WBE reclamation areas has the potential to result in the release of contaminants (e.g. hydrocarbons). The release of contaminants may lead to the degradation of intertidal or subtidal habitats located downstream of, or adjacent to, the final Project landform. This may impact marine life, including marine turtles via direct contact with contaminants or the ingestion of contaminated food source.

This Project activity and potential exposure of marine turtles to these impacts will be within the short term and within a contained extent and therefore low in magnitude.

The post mitigation risk ratings associated with the release of contaminants impacting on marine turtles during dredging activities are low for the Green and Flatback turtles, and medium for the Hawksbill, Loggerhead, and Olive ridley turtles.

AEIS Appendices E2 and E3 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to avoid contaminant releases impacting marine turtles and marine turtle habitat during surface stabilisation and maintenance works at the WBE reclamation area and BUF are included in the Project EMP (refer AEIS Appendix G).

Soil erosion and sedimentation

Soil erosion of the final Project landforms and downstream sedimentation have the potential to have an impact on the quality of adjacent intertidal and subtidal habitats. Erosion and runoff can result in decreased water quality which has the potential to impact on the condition of marine turtle habitat such as seagrass meadows. This Project activity and potential exposure of marine turtles to these impacts will be within the short term and within a contained extent and therefore low in magnitude.

This Project activity and potential exposure of marine turtles to these impacts will be within the short term and within a contained extent and therefore low in magnitude.

The post mitigation risk ratings associated soil erosion and sedimentation impacting on marine turtles during dredging activities are low for the Green and Flatback turtles, and medium for the Hawksbill, Loggerhead, and Olive ridley turtles.

AEIS Appendix E2 and E3 provides detail on the assessment of this potential impact and the resultant risk rating.

Mitigation measures to avoid soil erosion and runoff impacting marine turtles or marine turtle habitat during surface stabilisation and maintenance works at the WBE reclamation area and BUF are included in the Project EMP (refer AEIS Appendix G).

9.10.5.2 Potential artificial lighting impacts

Artificial lighting during stabilisation and maintenance activities will be required for safety. The stabilisation and maintenance works on the final Project landforms are not proposed to occur outside of daylight hours. The artificial lighting risk to marine turtles during this Project activity is low for the Green and Flatback turtles and medium for the Hawksbill, Loggerhead and Olive ridley turtles.

9.10.6 Potential cumulative and synergistic impacts from Project activities

The cumulative impact assessment that is applicable to the Project, considering foreseeable 'significant' projects and exogenous factors such as flood events and climate change, is provided in the Project EIS (Chapter 21 – cumulative impact assessment and Appendix P). As such this section only provides the cumulative assessment of the Project activities (i.e. the establishment of the WBE reclamation area and BUF, dredging activities, installation and removal of navigational aids and operation and maintenance) as a whole.

To identify potential synergistic impacts on marine turtles, this section provides an assessment of the potential cumulative Project impacts that were previously addressed individually as discrete Project activities on marine turtles (refer Section 9.10.2 to 9.10.5).

The Project activities can be described as occurring in discrete spatial areas although there is some temporal overlap of Project activities. The spatial categories are described below and their location (i.e. area of direct impact) is provided in Figure 9.2.

- Establishment of the WBE reclamation area and BUF
- Dredging activities
- Removal and installation of navigational aids
- Stabilisation and maintenance activities.

The Project dredging works will be undertaken as either a staged dredging campaign (i.e. over two stages) or as a singular campaign. Figure 9.35 illustrates the Project activity timeframes and dredging campaign options.

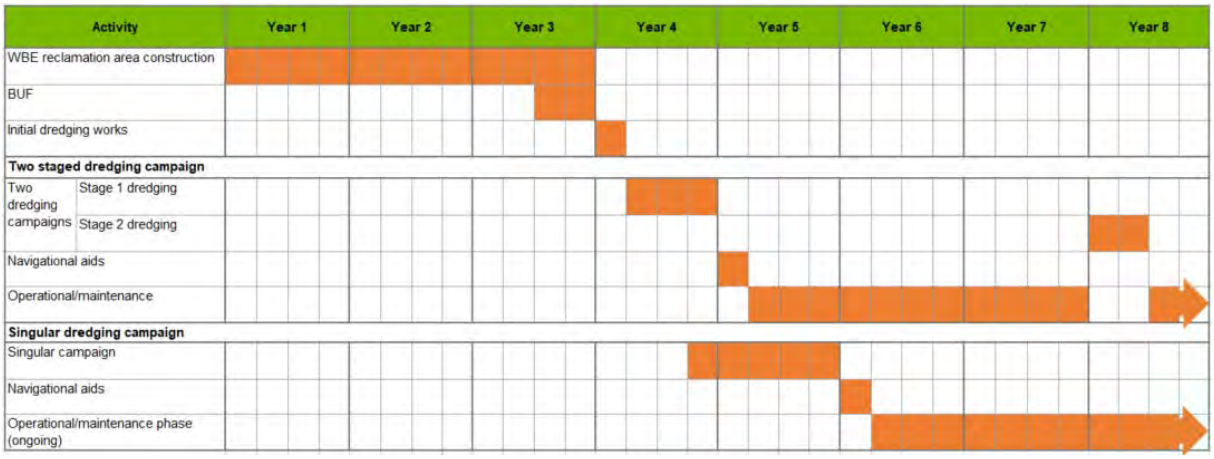

Figure 9.35 Indicative Project activity timeframes

Whilst the location of direct impacts is discrete, it is acknowledged that indirect impacts arising from the discrete Project locations (e.g. silt plumes, alterations to water quality and increased vessel movement) have the potential to result in impacts that overlap in a spatial and temporal context. Given this overlap, synergistic interactions resulting from multiple Project related impacts have the potential to impact upon marine turtles and associated habitat, with the results being greater than the sum of any of the single stressors alone.

Potential cumulative impacts were assessed in conjunction with potential synergistic impacts from Project activities. Cumulative impacts were defined as an accumulation of impact from all Project activities. These were considered to be independent of temporal constraints and constituted contributing factors driving synergistic processes. Accordingly, cumulative impacts were not assessed *per se* but rather, were assessed within the synergistic impact assessment and were incorporated into the significant residual adverse impact assessment.

Synergistic impacts result from multiple processes which act simultaneously upon a particular value. The magnitude of impact would be a function of the initial direct impact and further direct impacts (as an accumulation) and/or a function of the initial direct impact with potentiation from further indirect impacts (as a synergy) with consideration for any amplification associated with the multiple factors acting simultaneously.

To identify potential Project synergistic impacts upon marine turtles, the Project EIS impact assessment outcomes (as a whole of program rather than discrete Project activities) were assessed (refer AEIS Section 9.10 and AEIS Appendices E1, E2 and E3). This enabled potential Project direct impacts (and indirect impacts) to be identified and the potential for contribution towards synergistic impacts upon key threatening processes to be considered. This approach acknowledged the potential scale of the Project related impacts on the value and its potential to impact upon the value's capacity for recovery from the impact, by contributing to a recognised threatening process.

Significant synergistic impacts were defined as potential synergistic impacts that had the capacity to contribute to threatening processes. The resulting likelihood of risk identified the likely contribution of synergistic pathways upon the residual adverse impact to the marine turtle species.

The synergistic impact assessment utilised a qualitative risk approach to determine the potential risk of a significant synergistic impact. Noting that a quantitative analysis was not possible as data related to synergistic processes is traditionally non-tractable to analysis, a risk-based assessment was utilised.

Potential Project related impacts assessed as potentially significant (post implementation of impact mitigation measures) were identified as potential pathways for significant synergistic impacts and consisted of:

- Permanent loss of habitat
- Potential increase in noise and vibration
- Potential artificial lighting
- Potential vessel strike
- Direct contact with dredging equipment.

The assessment approach utilised two key considerations. Initially, identification of potential pan-specific (hereby referring to the Green turtle, Flatback turtle, Hawksbill turtle, Loggerhead turtle and Olive ridley turtle) impacts within the Port Curtis region, incorporating the direct foraging and the indirect foraging Project impact areas.

Secondly, an assessment of risk was undertaken for key regional marine turtle species (i.e. Green turtle resident foraging populations and Flatback turtle internesting populations). The identified foraging grounds of identified resident Green turtle population that rely or require areas of foraging and the identified behaviour of internesting Flatback turtles to utilise shipping channels associated with Project dredging activities were assessed separately from the pan-specific assessment to identify species-specific synergistic risks.

The framework of assessment focussed on:

- The potential Project activity impacts
- The synergistic pathways associated with the Project activities
- How the potentiated impacts contribute to key threatening processes

- The likelihood of risk of significant impact (refer Table 9.36) from the synergistic impact contribution to key threatening processes.

Table 9.36 Likelihood definitions for potential impacts occurring over the life of the Project

Description	Frequency
Unlikely	Unlikely but not trivial. May occur during construction/life of the Project but probability < 50%
Potential	Less likely than not, but still considerable; probability of about 50% chance of occurring over the life of the Project
Likely	Likely to occur during construction/life of the Project or during a 12 month timeframe; probability up to 90% chance of occurring

Potential impacts to threatening processes (across all Project activities) have been identified in Sections 9.10.2 to 9.10.5. These sections outline the initial Project impact which contribute to the synergies with other potential Project impacts. For further detail, refer to applicable potential Project activity impacts within Section 9.10.2 to 9.10.5.

Increased impact associated with competition, resource accumulation, breeding opportunity loss and a reduction in biological fitness were assessed as pathways for the potential to contribute to key threatening processes as potential indirect synergistic impacts. Potential indirect synergistic impacts were typically associated with potential to reduce a values life history parameters (e.g. reduced growth, reproduction, resource accumulation), through to the potential reduction in population resilience as a contributing factor towards key threatening processes. Increased competition has been considered to initially derive from Project potential impacts, including permanent removal of foraging resource, potential increase in noise and potential vessel interaction.

Resource accumulation and breeding opportunity loss has been considered to initially derive from Project potential impacts, including permanent removal of foraging resource, potential noise increase, potential artificial lighting, potential vessel interactions and direct contact with dredging equipment.

Reductions in biological fitness has been considered to derive from all of the initial impacts, as potential competition increase, and resource and breeding opportunities were considered to be contributing factors to this synergistic pathway. Synergistic impacts which act upon resilience were considered to result in potential reduction in individual and population biological fitness.

Synergistic impacts have the potential to derive from the following impacts:

- Permanent loss and/or alteration of foraging habitat
- Potential vessel interaction
- Direct contact with dredging equipment
- Short term decline in water quality
- Artificial lighting
- Potential underwater noise and vibration.

No synergistic impacts have the potential to derive from entrapment in WBE reclamation area. Any impact on an entrapped turtle will be a direct impact rather than a combination of impacts. In the instance of a release from entrapment, synergistic impacts would likely follow those of permanent loss and/or alteration of habitat.

Exogenous factors (such as extreme flood events) may increase vulnerability of marine turtles to external stressors. These are expected to affect their habitat, principally through a loss of foraging resource (including but not limited to, seagrass meadows). Whilst foraging-site fidelity is considered within this impact, the true impact of extreme flood events is not achievable, and therefore is considered, but not included as a specific impact in the synergistic impact assessment. The Project EMP (refer AEIS Appendix G) will provide mitigation/management measures to be implemented during serve extreme events to limit active dredging sediment suspension. This is considered to limit active dredging suspension occurring in addition to natural resuspension occurrence associated with high-energy climatic conditions.

Table 9.37 provides a summary of the synergistic impacts from the Project as a whole on marine turtles. For the purposes of determination of the risk assessment with significant synergistic impact, Project direct impacts were contained in concert with synergistic pathways to determine the potential of synergistic impacts, that will contribute towards key threatening processes. The likelihood of risk was determined based on Table 9.36 definitions.

Table 9.37 Risk of significant synergistic impact from identified Project impacts on marine turtle values

Marine turtle value	Species threats identified in relevant conservation advices, recovery plans and threat abatement plans[#]	Project direct impact (as result of whole program)	Potential Project pathways acting in synergy with Project impact	Potential indirect synergistic impact contributing to key threatening process	Likelihood of risk of significant impact (refer Table 9.36)
Endangered and Migratory marine turtles (Loggerhead turtle, Olive ridley turtle) under the EPBC Act and NC Act, and important habitat Vulnerable and Migratory marine turtle (Hawksbill turtle) under the EPBC Act and Endangered marine turtle (Hawksbill turtle) under the NC Act, and habitat other than important habitat	■ **Loss of habitat** ■ **Coastal development** ■ **Deteriorating water quality** ■ **Acoustic and light disturbance to marine turtle species** ■ Unknown levels of harvest by indigenous Australians and unsustainable levels of harvest by people in neighbouring countries of the Asia/Pacific region ■ International take ■ Predation of turtle eggs by native and introduced animals ■ **Vessel disturbance and strike** ■ Bycatch of marine turtles in fisheries ■ **Injury and fatality to vertebrate marine life caused by harmful marine debris** ■ Climate variability and change ■ **Disease and pathogens** ■ Recreational activities	Permanent removal of foraging resource	■ Permanent change of habitat ■ Temporary decline in water quality ■ Potential vessel interaction	■ Reduction in individual and population resilience ■ Compounding impact on individual resource partitioning (compromised physiology) from reduction of foraging resource and water quality degradation (all Project activities) ■ Increase in potential vessel strike from compromised individuals ■ Minor reduction of life-history parameters	Potential
		Potential noise increase	■ Permanent change of habitat ■ Temporary decline in water quality	■ Reduction in individual and population resilience ■ Minor reduction of life-history parameters	Unlikely
		Potential artificial lighting	■ Potential vessel interaction	■ Reduction in population recruitment through increased vessel interaction and predation on potential hatchlings	Unlikely
		Potential vessel interaction	■ Permanent change of habitat ■ Temporary decline in water quality	■ Increase in potential vessel interaction from modification of habitat use ■ Minor reduction in life-history parameters ■ Reduction in population resilience	Potential
		Direct contact with dredging equipment	■ Permanent change of habitat ■ Temporary decline in water quality	■ Increase in potential mortality from contact with dredging equipment from modification of habitat use ■ Reduction in population resilience	Potential

Marine turtle value	Species threats identified in relevant conservation advices, recovery plans and threat abatement plans[#]	Project direct impact (as result of whole program)	Potential Project pathways acting in synergy with Project impact	Potential indirect synergistic impact contributing to key threatening process	Likelihood of risk of significant impact (refer Table 9.36)
Vulnerable and Migratory marine turtles (Green turtle, Flatback turtle) under the EPBC Act and NC Act, and habitat other than important habitat		Permanent removal of foraging resource	■ Permanent loss of habitat ■ Temporary decline in water quality ■ Potential vessel interaction	■ Reduction in individual and population resilience ■ Compounding impact on individual resource partitioning (compromised physiology) from reduction of foraging resource and water quality degradation (all Project activities) ■ Increase in potential vessel strike from compromised individuals ■ Minor reduction in reproductive success	Likely
		Potential noise increase	■ Permanent change of habitat ■ Temporary decline in water quality	■ Reduction in individual and population resilience ■ Minor reduction life-history parameters	Unlikely
		Potential artificial lighting	■ Potential vessel interaction	■ Reduction in population recruitment through increased vessel interaction and predation of hatchlings	Unlikely
		Potential vessel interaction	■ Permanent change of habitat ■ Temporary decline in water quality	■ Increase in potential vessel interaction from modification of habitat use ■ Minor reduction in life-history parameters ■ Reduction in population resilience	Potential
		Direct contact with dredging equipment	■ Permanent change of habitat ■ Temporary decline in water quality	■ Increase in potential mortality from contact with dredging equipment from modification of habitat use ■ Reduction in recruitment from loss of gravid females ■ Reduction in population resilience	Potential

Table note:

Bold identifies threats acknowledged in relevant conservation advices, recovery plans and threat abatement plans which are those potentially impacted by Project activities

The assessment identified that the Project has the potential risk of significant synergistic impact for the Green turtle, due to the direct loss/alteration to foraging habitat leading to potential loss of biological fitness. Further, the Project has the potential risk of significant synergistic impact for the Flatback turtle due to disruption of foraging habitat, with specific consideration to potential reproductive success decreases leading to potential loss of biological fitness.

The significance of any potential synergist impacts on Hawksbill, Loggerhead and Olive ridley turtles is considered to be low.

A significant residual adverse impact assessment has been conducted for marine turtles as the Project was identified as potentially having a residual sequential impact on the value. The significant residual adverse impact assessment for marine turtles is provided in Section 9.10.8.

9.10.7 Threatening processes for species of conservation significance and migratory species

Threatening processes which may lead to the progressive loss of species of conservation significance or migratory species, including ecologically significant habitat, have been assessed with regards to the potential Project impacts. Threatening processes for species of conservation significance and migratory marine turtle species which have been confirmed to occur, or are considered to have a high or moderate likelihood of occurrence within the Project impact areas (refer Table 9.31) have been identified from the relevant species recovery plan, conservation listing advice and/or threat abatement plan.

As per the alternative methodology discussed in Section 9.10.1.1, the Olive ridley turtle has been included into the threatening process assessment, with acknowledgement of the scientific uncertainty and consideration of the low likelihood of occurrence of this species within the Project impact areas.

The potential Project impacts which have been provided in Sections 9.10.2 to 9.10.5 have been assessed with regard to their potential contribution to the species threatening processes (refer AEIS Appendix E2).

Residual impacts on threatening process have the potential to result where an impact has a high or very high risk rating. Marine turtle species for which potential Project impacts are considered to have a residual impact on a threatening process which may lead to the progressive loss of the species or ecologically significant habitat (refer AEIS Appendix E2, item Q3.1) will be subject to a significant residual adverse impact assessment. The significant residual adverse impact assessment is provided below.

9.10.8 Significant residual adverse impact assessment

The significant residual adverse impact assessment for marine turtle values has been has been conducted to identify if the Project will, or is considered likely to have a significant residual adverse impact on a marine turtle species which are defined as a MNES and/or a MSES. The significant residual adverse impact assessment reviewed as part of the AEIS aims to ensure that the Project activities have been assessed at their broadest scope (i.e. the cumulative impact of all Project activities have been assessed) and that potential offsite and indirect Project impacts have been included in the significance assessment. This assessment has considered indirect Project impacts as per the definition of ‘offsite and indirect’ impacts provided in the *Queensland Environmental Offsets Policy Significant Residual Impact Guideline* (EHP 2014a) and the *Matters of National Environmental Significance Significant Impact Guidelines, Version 1.1* (DoE 2013).

Offsite and indirect impacts are identified via the Project impact magnitude assessment. The magnitude of a potential Project impact is a product of the temporal duration of the potential impact and the spatial scale of the impact. For each impact the estimated duration of the impact is identified (i.e. its anticipated temporal extent) and classified as temporary, short term, medium term, long term or permanent. The anticipated spatial extent of the potential impact is classified as undetectable, contained extent, local area or extensive. The consequence of the potential Project impact is determined by combining the impacts temporal and spatial extents in the magnitude matrix. AEIS Appendix E1 provides further information and definitions regarding Project assessment of magnitude.

For the purposes of this significance assessment of offsite and indirect impacts, the magnitude assessments of the potential Project residual impacts relative to the significant impact criteria assessed in were considered. The consequence assessments for each relative Project residual impact were considered with respect to the potential combined, cumulative Project impact to ensure that the impact assessment was conducted with respect to the Project's broadest scope (i.e. all Project activities).

The significant residual adverse impact assessment has been prepared for marine turtle species which are considered to have a low likelihood (for Olive ridley turtle only as discussed in Section 9.10.1.1), moderate, high or confirmed likelihood of occurrence within the Project impact areas.

This assessment of significant residual adverse impacts considers the significance of potential Project impacts after the implementation of the Project mitigation measures included in the AEIS Appendices F to H.

Table 9.38 includes the marine turtle species which are subject to this significant residual adverse impact assessment, due to Project impacts having:

- Very high or high consequence (post mitigation measures) on a species (refer Section 9.10 and AEIS Appendix E3), and/or
- A residual potential impact to a key threatening process (refer AEIS Appendix E2).

Table 9.38 Marine turtle species subject to significant residual adverse impact assessment

Fauna value	MNES	MSES	Significance assessment
Green turtle (*Chelonia mydas*) *Conservation status:* EPBC Act: Vulnerable and Migratory NC Act: Vulnerable	Vulnerable listed species Migratory species	Protected wildlife habitat	Table 9.39
Flatback turtle (*Natator depressus*) *Conservation status:* EPBC Act: Vulnerable and Migratory NC Act: Vulnerable	Vulnerable listed species Migratory species	Protected wildlife habitat	Table 9.39
Loggerhead turtle (*Caretta caretta*) *Conservation status:* EPBC Act: Endangered and Migratory NC Act: Endangered	Endangered listed species Migratory species	Protected wildlife habitat	Table 9.39
Hawksbill turtle (*Eretmochelys imbricata*) *Conservation status:* EPBC Act: Vulnerable and Migratory NC Act: Endangered	Vulnerable listed species Migratory species	Protected wildlife habitat	Table 9.39

Fauna value	MNES	MSES	Significance assessment
Olive ridley turtle (*Lepidochelys olivacea*) *Conservation status:* EPBC Act: Endangered and Migratory NC Act: Endangered	Endangered listed species Migratory species	Protected wildlife habitat	Table 9.39

The MNES significant impact assessment criteria for listed and migratory species (DoEE 2013) and the significant impact assessment criteria for protected wildlife habitat (EHP 2014d) have been used for the marine turtle significant residual adverse impact assessment (refer Table 9.39). Potential impact in regard to threatening processes has been derived from potential Project impacts (refer Section 9.10) and synergistic potential impacts (refer Section 9.10.6) and are summarised within Table 9.39. Where appropriate (i.e. where significant residual adverse impact may differ between species), the significant residual adverse impact assessment has been narrowed to each species.

The significant residual adverse impact assessment concluded that the proposed Project activities will have a significant residual adverse impact on the Green turtle. No significant residual adverse impact from Project activities are expected on the Flatback turtle, Hawksbill turtle, Loggerhead turtle or Olive ridley turtle.

Table 9.39 Significant residual adverse impact assessment – Marine turtles

Significant impact assessment criteria	Assessment outcome for marine turtle species[1]	Supplementary supporting information
MNES – Endangered, vulnerable, migratory species ■ Lead to a long term decrease in the size of a population of a species ■ Reduce the area of occupancy of the species ■ Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline ■ Adversely affect habitat critical to the survival of a species ■ Substantially modify (including by fragmentation, altering fire regimes, alerting nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species. **MSES – Protected wildlife habitat** ■ Lead to a long term decrease in the size of a local population ■ Reduce the extent of occurrence of the species Cause disruption to ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species.	**Green turtle:** Potentially significant impact **Flatback turtle:** Unlikely to have significant impact **Loggerhead turtle:** Unlikely to have significant impact **Hawksbill turtle:** Unlikely to have significant impact **Olive ridley turtle:** Unlikely to have significant impact	Project impacts have been identified which have the potential to adversely impact the marine turtles detailed in the adjacent significant impact assessment criteria. The potential for these impacts to extend to offsite and indirect impact areas has been evaluated via the Project activity's magnitude assessment. The results are summarised below. ■ Permanent loss and alteration of marine turtle habitat during the establishment of the WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be permanent in duration (temporal) and contained in extent (spatial) ■ Direct mortality and injury of marine turtles during the establishment of the WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be medium in duration (temporal) and contained in extent (spatial) ■ Potential noise, vibration and dust impacts during the establishment of the WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be medium in duration (temporal) and contained in extent (spatial) ■ Hydrodynamic and water quality impacts resulting in habitat alteration during the establishment of the WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be permanent in duration (temporal) and contained in extent (spatial) ■ Contaminant and sediment releases resulting in impacts on habitat during the establishment of the WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be medium in duration (temporal) and contained in extent (spatial) ■ Potential noise, vibration and dust impacts during dredging activities – Moderate magnitude: Potential residual impact considered to be short term in duration (temporal) and contained in extent (spatial) ■ Direct mortality and injury due to vessel movements during dredging activities – Moderate magnitude: Potential residual impact considered to be short term in duration (temporal) and contained in extent (spatial)

Significant impact assessment criteria	Assessment outcome for marine turtle species[1]	Supplementary supporting information
		The Project activities cumulative and synergistic impacts have been incorporated into the significant residual adverse impact assessment for this significant impact assessment criteria. The establishment of the WBE reclamation area, BUF and dredging activities will result in the direct removal and permanent loss of seagrass, algae and benthic habitats which provide potential foraging resources for marine turtle species. This impact is considered to be moderate in magnitude due to being permanent in duration (temporal) and contained in extent (spatial). It is important to note that no part of Port Cutis is listed as an area of 'Critical Habitat' for marine turtles, as defined under Section 207A of the EPBC Act (DoEE 2017). Impacts to coastal processes and hydrodynamics through establishment of the duplicated shipping channel are expected to be minor. *Green turtle* The inshore region of Port Curtis provides habitat for juvenile and sub-adult Green turtles in the form of foraging grounds and food sources such as seagrass meadows (including species *Z. muelleri*, *Halodule* and *Halophila*) along with mangroves and macroalgae (Limpus 2008a). The seagrass habitat and species types found in the coastal areas of Port Curtis are abundant in the wider Fitzory NRM region at Shoalwater Bay, Keppel Islands, Rodds Bay and Hervey Bay (McKenzie et al. 2014) which suggests there remains appropriate habitat for Green turtles in the wider region. The Project direct impact areas incorporate the historic mapping of seagrass meadows and are considered a true potential habitat loss or impact rather than realised impact as seagrass mapping of the Project zone of influence is to be undertaken prior to Project activities commencing. The Project involves the permanent loss of seagrass meadows from establishment of the WBE reclamation area. This includes the direct and indirect disturbance of seagrass communities recorded from all seagrass surveys (2002 to 2018 historic mapping), including: ■ Approximately 110.48ha within the WBE reclamation area (southern area) ■ Approximately 164.75ha within the WBE reclamation area (northern area) ■ Approximately 99.41ha within the areas adjoining WBE reclamation area (indirect impacts from erosion and sedimentation due to changes in tidal velocities adjoining the WBE reclamation area). The historic extent of seagrass meadows within the area to be dredged for the channel duplication is 35.65ha, however no seagrass has been recorded in the channel duplication footprint since 2002. Baseline surveys of this area will be undertaken prior to the commencement of dredging to determine the extent of seagrass that will be directly impacted within the area to be dredged and indirectly impacted in the zone of high impact for the channel duplication dredging.

Significant impact assessment criteria	Assessment outcome for marine turtle species[1]	Supplementary supporting information
		Further the Project dredging has the potential to have indirect impacts on seagrass meadows that are mapped within the Project dredging zone of high impact which is approximately 876.98ha mapped from historic extent (i.e. 2002 to 2018). However the permanent loss of deep water seagrass within the Project zone of high impact (i.e. indirect impact area) is unlikely due to the implementation of adaptive management measures contained in the Environmental Monitoring Procedure (refer AEIS Appendix H). The Project is considered likely to have a significant residual impact on this assessment criteria for Green turtle in offsite and Project indirect impact areas as a synergistic impact. The loss of seagrass meadows within the Project impact areas is not anticipated to affect the overall abundance of Green turtles in Port Curtis, given that *H. ovalis* and *Z. muelleri* are the dominant seagrass species in coastal meadows in Port Curtis (Carter et al. 2015). Any potential Project indirect impacts to deep water seagrass meadows as a result of increased turbidity through dredging activities is expected to be temporary and effectively mitigated through an adaptive Dredging EMP (refer AEIS Appendix F) and Project EMP (refer AEIS Appendix G) and the Environmental Monitoring Procedure (refer AEIS Appendix H). Noting that the potential Project indirect impacts are expected to be mitigated, the synergistic impacts and direct loss of foraging habitat has the potential to have significant residual impact on the Green turtle. Under this significant impact assessment criteria there is likely to be significant residual adverse impact to Green turtle foraging habitat due to: ■ Permanent loss of 374.64ha of seagrass meadows as a result of the establishment of WBE reclamation area, including: – 110.48ha from the establishment of the WBE reclamation area (southern area) – 164.75ha from the establishment of the WBE reclamation area (northern area) – 99.41ha from indirect impacts from the establishment of the WBE reclamation area. ■ Permanent loss of 35.65ha of seagrass meadows at the channel duplication area to be dredged. **Green turtle significant impact: Likely** *Flatback turtle/Loggerhead turtle* The Flatback turtle and the Loggerhead turtle are carnivorous species with a diet that includes soft corals, jellyfish, cuttlefish, sea-pens, sea-cucumbers and invertebrates such as gastropods and bivalve molluscs (Chatto 1998; Limpus 2007). Total potential foraging habitat for Flatback and Loggerhead turtle within the direct impact area (WBE reclamation area and BUF and areas to be dredged) includes 718.63ha, however the Flatback and Loggerhead turtles are considered unlikely to heavily depend on the intertidal and subtidal areas around the WBE reclamation area, BUF footprint and the zone of impact from dredging activities, to the extent that the direct loss of seagrass and benthic habitat would result in a negative impact on species populations.

Significant impact assessment criteria	Assessment outcome for marine turtle species[1]	Supplementary supporting information
		With consideration to the sequential timing and discrete locations of the Project activities and the aforementioned magnitude levels of any potential residual impact, the Project is not considered likely to have a significant residual adverse impact on this significant impact assessment criteria. A consideration of the potential risk associated with internesting Flatback and Loggerhead turtles within the dredging direct-impact area has identified potential impact from dredging activities and increased vessel use (including other impacts not identified as contributing to key threatening processes). Consideration of specific fauna management and soft-start policies to be utilised as part of Project-standard dredging methodologies were identified as mitigating factors against threatening criteria associated with dredging activities. Whilst not considered in the significant impact assessment, the potential consideration of environmental window planning is also acknowledged as a mitigating factor in regard to dredging activities. While post-mitigation risk ratings for the Loggerhead turtle are very high in regard to the loss of benthic macroinvertebrates, the consideration of localised impact, medium term impact and potential foraging habitat around the dredging direct-impact area have identified no significant residual impact. This is principally due to the high potential of proximal foraging habitat coupled with the key criteria regarding adverse impacts affecting species survival. **Flatback/Loggerhead turtle significant impact: Unlikely** *Hawksbill turtle* The Hawksbill turtle is not considered to have a significant population within Port Curtis however areas of soft coral, algae and seagrass within Port Curtis may provide potential foraging habitat for the species (Limpus 2009). Total potential foraging habitat for Hawksbill turtle within the direct impact area (WBE reclamation area and BUF and areas to be dredged) includes 718.63ha, however the Hawksbill turtle is considered unlikely to heavily depend on the intertidal and subtidal areas around the WBE reclamation area, BUF footprint and the zone of impact from dredging activities, to the extent that the direct loss of seagrass and benthic habitat would result in a negative impact on species populations. With consideration to the sequential timing and discrete locations of the Project activities and the aforementioned magnitude levels of any potential residual impact, the Project is not considered likely to have a significant cumulative impact on this significant impact assessment criteria. **Hawksbill turtle significant impact: Unlikely** *Olive ridley turtle* The Olive ridley turtle is not currently considered to have a significant nesting or foraging population within Port Curtis however areas of soft-benthic habitat may provide foraging habitat or the species within the Project impact areas. Total potential foraging habitat for Olive ridley turtle within the direct impact area (WBE reclamation area and BUF and areas to be dredged) includes 718.63ha, however noting the deficiency in data in regard to distribution within Port Curtis, it is expected that significant habitat for foraging activities of the Olive ridley turtle will not be impacted within the WBE reclamation area, BUF footprint and the zone of impact from dredging activities.

Significant impact assessment criteria	Assessment outcome for marine turtle species[1]	Supplementary supporting information
		With consideration to the sequential timing and discrete locations of the Project activities and the aforementioned magnitude levels of any potential residual impact, the Project is not considered likely to have a significant residual adverse impact on this significant impact assessment criteria. **Olive ridley turtle significant impact: Unlikely**
MNES significant impact assessment criteria – Endangered, vulnerable, migratory species: ■ Fragment an existing population into two or more populations **MSES significant impact assessment criteria – Protected wildlife habitat:** ■ Fragment an existing population ■ Result in genetically distinct populations forming as a result of habitat isolation	**All marine turtles[2]:** Unlikely to have significant impact	**General marine turtle significant impact: Unlikely** Project impacts have been identified which have the potential to fragment marine turtle populations. The potential for these impacts to extend to offsite and indirect impact areas has been evaluated via the Project activity's magnitude assessment. The results are summarised below. ■ Permanent loss and alteration of migratory shorebird habitat during the establishment of the WBE reclamation area and BUF and dredging activities – Moderate magnitude: Potential residual impact considered to be permanent in duration (temporal) and contained in extent (spatial) ■ Potential noise, vibration and dust impacts during the establishment of the WBE reclamation area and BUF and dredging activities – Moderate magnitude: Potential residual impact considered to be medium term in duration (temporal) and contained in extent (spatial) As marine turtles move through different stages of their life history they require different habitats. Different habitat requirements include natal beaches, mating habitats, internesting habitats, foraging habitats and pelagic habitats (DoEE 2017). The establishment of the WBE reclamation area and BUF are not considered to create a barrier to species movement between habitats. Furthermore, the dredging activities are associated with the existing shipping channel, as such, not creating disturbance or barriers to movement in new areas. The loss of habitat (permanent or temporary), is not considered of an extent to functionally fragment any of these marine turtle populations, in regard to the creation of a physical barrier or biogeographical isolator. The Project activities are not anticipated to result in genetically distinct populations forming as a result of habitat isolation. The Project is not considered likely to create a significant barrier to species movement through the marine environment or fragment marine turtle populations. With consideration to the sequential timing and discrete locations of the Project activities and the aforementioned magnitude levels of any potential residual impact, the Project is not considered likely to have a significant residual adverse impact on this significant impact assessment criteria.

Significant impact assessment criteria	Assessment outcome for marine turtle species[1]	Supplementary supporting information
MNES significant impact assessment criteria – Endangered, vulnerable, migratory species: ■ Disrupt the breeding cycle of a population Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	**All marine turtles[2]:** Unlikely to have significant impact	Project activities will not involve direct disturbance in areas within or adjacent to marine turtle nesting beaches. This impact is considered to be moderate in magnitude due to being permanent in duration (temporal) and contained in extent (spatial). Nesting marine turtles will often move from their feeding grounds to areas near nesting beaches for mating. Marine turtle nesting beaches are present within Port Curtis. The establishment of the WBE reclamation area, BUF and dredging activities have the potential to result in acoustic impacts and light spill from machinery and dredgers. Noise may alter the behaviour patterns of marine turtles (e.g. avoidance of predators, interfering with the acquisition of prey or mates, selection of appropriate nesting sites). It is unlikely that temporary or permanent hearing trauma will result from the establishment of the WBE reclamation area, BUF or the dredging activities. Underwater noise impacts from navigational aid activity is expected to have the largest impact on marine turtles with a single strike having potential to cause mortal injury within 35m from piling location, avoidance of source at up to 600m and behavioural changes exhibited within 2km from piling location. Marine turtle hatchlings use natural lighting to guide them to the ocean and may become disorientated from altered light horizons from artificial light sources. Artificial lighting may also affect the number of female adult turtles attempting to nest (Witherington 1992; Limpus 2007). Marine turtle nesting beaches in relation to the areas to be dredged, the WBE reclamation area and BUF are located at Southend Beach on Curtis Island, along the east coast of Facing Island from Gatcombe Head and on beaches from Tannum Sands to Wild Cattle Island/Colosseum Inlet. The seaward position of dredge plant and vessels during dredging activities poses a low risk to disturbing hatching and nesting behaviour. Furthermore, the increase of artificial lighting from dredging vessels with comparison to the overall background light levels from industrial facilities and commercial ships in Port Curtis is considered low. Potential adverse impacts on environmental values, including marine turtles, as a result of noise and artificial light sources will be reduced via the implementation of appropriate mitigation measures contained in the Dredging EMP and Project EMP (refer AEIS Appendices F and G, respectively). With consideration to the sequential timing and discrete locations of the Project activities and the aforementioned magnitude levels of any potential residual impact, the Project is not considered likely to have a significant cumulative impact on this significant impact assessment criteria.

Significant impact assessment criteria	Assessment outcome for marine turtle species[1]	Supplementary supporting information
		Green turtle The Green turtle has been recorded nesting within the Port Curtis region on the beaches of Curtis Island and Facing Island (Limpus et al. 2000). Limpus et al. (2017a) collected data on Green turtles within Port Curtis to determine if the area is an important aggregation area for the species. The results identified that no Green turtles significant courtship occurred within the Port Curtis region. However, approximately 5% of adult females and 38% of adult male Green turtles were identified as potentially preparing for the 2017-2018 breeding season (Limpus et al. 2017a), indicating that while breeding resources were viable within the Port, no significant breeding aggregations occurred. **Green turtle significant impact: Unlikely** *Flatback turtle* Flatback turtles are the dominant nesting marine turtle species in the Port Curtis region (Limpus et al. 2013e). The 2015-2016 breeding season recorded a moderately sized population of nesting Flatback turtles, with 44 nesting females recorded at South End Beach on Curtis Island (Limpus et al. 2016b). The stability of the previous two years of census data indicates that the eastern Australian Flatback turtle stock breeding at Curtis Island has had a stable breeding population over recent decades (or a single generation for this species) (Limpus et al. 2015; 2016b). With consideration of potential synergistic impact to the change in internesting behaviours of the turtle and potential increase in vessel interactions, the Project activities are considered to be consistent with existing disturbances within the Port and as such the Project is not anticipated to have a significant residual adverse impact on the current stability of Flatback turtle nesting within the Port Curtis region. **Flatback turtle significant impact: Unlikely** *Loggerhead turtle* Loggerhead turtles are known to nest occasionally on the beaches of Curtis and Facing Islands, but not on an annual basis (Limpus et al. 2013a). Noting the potential for the disruption of the breeding cycle of the Loggerhead turtle, the disruption to the breeding cycle through disruption to foraging turtles is not expected to result in significant residual adverse impact. **Loggerhead turtle significant impact: Unlikely** *Hawksbill turtle* There are no known Hawksbill turtle nesting beaches in Queensland outside of the northern Great Barrier Reef and Torres Strait. While disruption to foraging Hawksbill turtles may occur from Project activities, the disruption to the breeding cycle through disruption to foraging turtles is not expected to result in significant residual adverse impact. **Hawksbill turtle significant impact: Unlikely**

Significant impact assessment criteria	Assessment outcome for marine turtle species[1]	Supplementary supporting information
		Olive ridley turtle There are no known Olive ridley turtle nesting beaches known from the Eastern coastline of Australia. The nature of the Project activities is considered to be consistent with existing disturbances within the Port. In conjunction with the low likelihood of occurrence of foraging Olive ridley turtles, the Project is not expected to adversely impact the turtle through a serious disruption to lifecycle. **Olive ridley turtle significant impact: Unlikely**
MNES significant impact assessment criteria – Endangered, vulnerable, migratory species: ■ Result in invasive species that are harmful to an endangered, vulnerable or migratory species becoming established in the species' habitat. **MSES significant impact assessment criteria – Protected wildlife habitat:** ■ Result in invasive species that are harmful to an endangered, vulnerable or migratory species becoming established in the species' habitat.	**All marine turtles[2]:** Unlikely to have significant impact	**General marine turtle significant impact: Unlikely** The predation of marine turtle eggs by native and introduced fauna is a threatening process to marine turtle species (DoEE 2017). The Project will not have a direct impact on marine turtle nesting areas in Port Curtis. The establishment of the WBE reclamation area and BUF may facilitate the spread of pest species across the landscape. There are no marine turtle nesting beaches within the direct or indirect Project impact areas where vegetation clearing works will occur (i.e. WBE reclamation area and BUF). Project activities will not involve direct disturbance in areas within or adjacent to marine turtle nesting beaches. Any potential Project impacts in regards to species predation vulnerability is considered negligible. The likelihood of the Project introducing or spreading pest species across the local landscape is considered to be reduced and managed via the implementation of mitigation measures included in the Dredging EMP and Project EMP (refer AEIS Appendices F and G, respectively). With consideration to the sequential timing and discrete locations of the Project activities and the aforementioned magnitude levels of any potential residual impact, the Project is not considered likely to have a significant residual adverse impact on this significant impact assessment criteria.
MNES significant impact assessment criteria – Endangered, vulnerable, migratory species: ■ Introduce disease that may cause the species to decline. **MSES significant impact assessment criteria – Protected wildlife habitat:** Introduce disease that may cause the species to decline.	**All marine turtles[2]:** Unlikely to have significant impact	**General marine turtle significant impact: Unlikely** Project impacts have been identified which have the potential to introduce disease that may cause the decline of marine turtle species and populations. The potential for these impacts to extend to offsite and indirect impact areas has been evaluated via the Project activity's magnitude assessment. The results are summarised below. ■ Potential increase in waste material and marine debris during the establishment of the WBE reclamation area and BUF – Low magnitude: Potential residual impact considered to be short term in duration (temporal) and contained in extent (spatial)

Significant impact assessment criteria	Assessment outcome for marine turtle species[1]	Supplementary supporting information
		■ Contaminant and sediment release during the establishment of WBE reclamation area and BUF and dredging activities – Moderate magnitude: Potential residual impact considered to be medium term in duration (temporal) and contained in extent (spatial) Disease is a contributing process to mortality in marine turtles. Harmful contaminants such as pesticides, heavy metals, organochlorides and sewage from the land or from boats can pollute marine turtle feeding grounds and increase incidence of disease. High levels of heavy metals, and underlying disease processes consistent with potential toxin exposure and chronic environmental stressors have been recorded in Green turtles sampled in the Boyne River estuary (Limpus et al. 2012b; Gaus et al. 2012). The marine wildlife stranding and mortality database annual report 2011 found that one out of the 39 deceased Loggerhead turtles examined in Queensland in 2011 was determined to have died from disease/ill health. The annual report also found that 19 out of the 107 deceased Hawksbill turtles examined in Queensland in 2011 were determined to have died from disease/ill health (Meager and Limpus 2012). The study in May 2014 re-assessed the health of Green turtles to utilise turtle health as an indicator of environmental recovery and/or stressor persistence (Flint 2015). The study determined that the population has recovered significantly from the 2011 and 2013 population health assessments in Port Curtis (Flint 2015). The nature of Project activities is considered unlikely to introduce disease that may cause species decline. The movement of materials, equipment and sediment, which may act as transport mediums for disease, will be subject to the Project EMP and Dredging EMP (refer AEIS Appendices F and G, respectively). Any potential Project impacts in regards to the introduction or spread of harmful diseases to marine turtles is considered to be negligible. With consideration to the sequential timing and discrete locations of the Project activities and the aforementioned magnitude levels of any potential residual impact, the Project is not considered likely to have a significant residual adverse impact on this significant impact assessment criteria.
MNES significant impact assessment criteria – Endangered, vulnerable, migratory species: ■ Interfere with the recovery of the species.	**All marine turtles[2]:** Unlikely to have significant impact	**General marine turtle significant impact: Unlikely** The objective of the Recovery Plan for Marine Turtles in Australia (DoEE 2017) is to 'minimise anthropogenic threats to allow for the conservation status of marine turtles to improve so that they can be removed from the EPBC Act threatened species list'.

Significant impact assessment criteria	Assessment outcome for marine turtle species[1]	Supplementary supporting information
MSES significant impact assessment criteria – Protected wildlife habitat: ■ Interfere with the recovery of the species.		Key actions identified in the species recovery plan include: ■ Assessing and addressing threats – Maintain and improve efficacy of legal and management protection – Adaptively manage turtle stocks to reduce risk and build resilience to climate change and variability – Reduce the impacts from marine debris – Minimise chemical and terrestrial discharge – Address international take within and outside Australia's jurisdiction – Reduce impacts from terrestrial predation – Reduce international and domestic fisheries bycatch – Minimise light pollution – Address the impacts of coastal development/infrastructure and dredging and trawling – Maintain and improve sustainable Indigenous management of marine turtles ■ Enabling and measuring recovery – Determine trends at index beaches – Understand population demographics at key foraging grounds – Address information gaps to better facilitate the recovery of marine turtle stocks (DoEE 2017) The recovery plan will address impacts from dredging and enable the recovery of turtle species. However, the Project is not likely to result in un-mitigated impacts that will interfere with the recovery of the species. The nature of the Project activities will not interfere or impede the aforementioned recovery actions for marine turtles. With consideration to the sequential timing and discrete locations of the Project activities and the aforementioned magnitude levels of any potential residual impact, the Project is not considered likely to have a significant cumulative impact on this significant impact assessment criteria.

Table notes:

1 Where applicable MNES and MSES criteria are separated due to specific exceedance criteria of applicable guideline
2 Refers to Green turtle, Flatback turtle, Hawksbill turtle, Loggerhead turtle and Olive ridley turtle

9.10.9 Summary

To describe the marine fauna assemblages and key habitat values within the Project impact areas, a review of government databases, scientific literature and recent ecological surveys was conducted.

The Project impact areas include intertidal and subtidal environments which provide habitat value for marine turtle species, most notably Green turtles and Flatback turtles. Other marine turtle species are occasionally recorded in the Port Curtis region such as Loggerhead turtles (which occasionally nest in the region) and Hawksbill turtles, while Olive ridley turtles are rarely encountered (Limpus et al. 2013a-e). The majority of sightings and captures of Leatherback turtles in Queensland waters have occurred from Hervey Bay south to the Gold Coast (Limpus et al. 2013a-e). Leatherback turtles are rarely encountered in waters of the Great Barrier Reef and therefore rarely encountered in the waters in the vicinity of Port Curtis and Port Alma. Therefore Leatherback turtles have been excluded from the assessment of potential Project impacts.

The Port Curtis region provides potential habitats for these six species of turtles, including nesting and foraging areas, making it an important location for the conservation of marine turtles in Australia. Flatback turtles are known to nest on several beaches in the region, including Curtis Island (South End Beach), Facing Island, Hummock Hill Island, and Tannum Sands (Limpus et al. 2002; 2013a-e), with peak nesting activity occurring in mid-November to mid-December, and peak hatching period during February. The Port of Gladstone is known internesting habitat for Flatback turtles (Hamman et al. 2015c; 2017).

In Queensland, marine turtles breed at a limited number of nesting sites with varying density. In a breeding year, individual females migrate over long distances between feeding and nesting grounds, and return to nest at beaches in the same area in which they were born (Limpus and Chatto 2004). The nesting females of most species will nest multiple times during a nesting season, at intervals of two to four years over the course of their lifetime.

Potential impacts to marine turtles from Project activities include the permanent loss and alteration of habitat, potential noise impacts, temporary declines in water quality, entrapment and interactions with Project equipment, potential artificial lighting, an increase in waste material and marine debris, and an increase in hard substrate.

The Project will implement mitigation measures provided in the Project EMP (refer AEIS Appendix G), Dredging EMP (refer AEIS Appendix F), and associated management plans to reduce the likelihood and magnitude of potential Project impacts on marine turtles. The implementation of mitigation measures contained in the aforementioned management plans will reduce residual Project impacts on marine turtles.

The assessment of synergistic post-mitigated Project impacts identified the potential for potentiation of impact (from interaction of impacts across the Project as a whole) from the permanent removal of foraging resource, direct contact with dredging equipment, artificial lighting and increased vessel interaction.

The risk of potential synergistic impact was used within the assessment of significant residual impacts for the marine turtles considered to have a low likelihood of occurrence (Olive ridley turtle only), moderate, high or confirmed likelihood of occurrence within the Project impact areas.

The significant residual adverse impact assessment concluded that the proposed Project activities are likely to result in a significant residual adverse impact on the Green turtle from a direct loss of foraging habitat which may lead to a long term decrease in the size of the local population.

The Project activities below are likely to have a significant residual adverse impact on the Green turtle foraging habitat:

- Permanent loss of 374.64ha of seagrass meadows as a result of the establishment of WBE reclamation area, including:
  - 110.48ha from the establishment of the WBE reclamation area (southern area)

  - 164.75ha from the establishment of the WBE reclamation area (northern area)
  - 99.41ha from indirect impacts for the establishment of the WBE reclamation area (refer Figure 9.10a)
- Permanent loss of 35.65ha of seagrass meadows at the channel duplication area to be dredged (refer Figure 9.10b).

Project activities are unlikely to result in a significant residual adverse impact on the Flatback turtle, Loggerhead turtle, Hawksbill turtle and Olive ridley turtle.

The Project will implement mitigation measures provided in the Dredging EMP and Project EMP (refer AEIS Appendices F and G, respectively), and associated management plans to reduce the likelihood and magnitude of potential Project impacts on marine turtles.

The Project potential significant residual adverse impact on Green turtle foraging habitat will be offset by implementing the Channel Duplication Project Offset Strategy (refer AEIS Appendix E4 for the draft strategy).

Although significant residual impact is considered unlikely for internesting Flatback and Loggerhead turtles, scientific uncertainty is present in the numbers of these turtles that may utilise the Port shipping channels after completion of Project activities. In consideration of the disparity of scientific knowledge between the Green turtle and these two marine turtle species, a monitoring program of Port shipping channel use is considered appropriate, as part of the Green turtle offset strategy for the potential significant residual adverse impact on Green turtle foraging habitat.

9.11 Marine mammals

9.11.1 Overview

This section supplements the Project EIS Section 9.20.1 (marine mammals existing environment – background).

The 10 marine mammal species of conservation significance (listed under the provisions of the EPBC Act and/or the NC Act) that are known to occur within Queensland waters are listed in Table 9.40.

Table 9.40 Marine mammal species of conservation significance known from Queensland waters

Common name	Scientific name	EPBC Act status	NC Act status
Australian humpback dolphin	*Sousa sahulensis*	Migratory	Vulnerable
Australian snubfin dolphin	*Orcaella heinsohni*	Migratory	Vulnerable
Blue whale	*Balaenoptera musculus*	Endangered	Least concern
Bryde's whale	*Balaenoptera edenig*	Migratory	Least concern
Dugong	*Dugong dugon*	Migratory	Vulnerable
Humpback whale	*Megaptera novaeangliae*	Vulnerable	Vulnerable
Killer whale	*Orcinus orca*	Migratory	Not listed
Sei whale	*Balaenoptera borealis*	Vulnerable	Least concern
Southern right whale	*Eubalaena australis*	Endangered	Least concern
Sperm whale	*Physeter microcephalus*	Migratory	Least concern

Table note:
Excludes data recorded prior to 1980

Source: DoEE (2019c); DES (2019a) and ALA (2019)

It should be noted that Long-nosed fur seals (*Arctocephalus forsteri*) often visit the Gladstone area during winter (e.g. Pancake Creek, eastern side of Facing Island and fairway buoy) (DES unpublished data; DES Project EIS submission comment ID 12.88; DES 2017b). Pancake Creek is located 31.7km south of the Project area to be dredged and is outside of the Project study area and potential Project direct and indirect impact areas. In addition the Long-nosed fur seal distribution includes Western Australia, South Australia, Tasmania and New Zealand, where breeding typically occurs in South Australia and New Zealand (Shaughnessy et al. 2015; Department of Primary Industries, Parks, Water and Environment 2018). The Long-nosed fur seal is listed as least concern under the NC Act and listed as migratory under the EPBC Act.

9.11.2 Whales

9.11.2.1 Overview

This section replaces the Project EIS Section 9.20.2.1 (whales – overview).

Port Curtis and adjoining waterways support a range of marine mammal species, including whales, dolphins and dugongs. Marine mammal species form an important component of the marine biodiversity values of the GBRMPA due to their ability to regulate and maintain balance in the food chain. They do this by managing the abundance of prey species that have the ability to reduce the populations of species at the bottom of the food chain to unsustainable levels. In addition, whales, dolphins and dugongs are iconic species that hold special significance for many users of the Great Barrier Reef.

The desktop assessment identified 10 whale species with the potential to occur within the regional search area (refer Table 9.41). DES submission comment ID 12.87 and ID 12.88 noted that there has been a single record of the Southern right whale at Rock Cod Shoals in 2018 (refer AEIS Appendix A).

Table 9.41 Whale species known or predicted to occur within the Project EIS search area and regional search area

Scientific name	Common name	EPBC Act status	NC Act status	Likelihood of occurrence
Balaenoptera acutorostrata unknown *subsp.*	Dwarf minke whale	Not listed	Not listed	Low
Balaenoptera bonaerensis	Antarctic minke whale	Migratory	Not listed	Low
Balaenoptera omurai	Omura whale	Data deficient	Not listed	Low
Balaenoptera physalus	Fin whale	Vulnerable Migratory	Not listed	Low
Balaenoptera borealis	Sei whale	Vulnerable Migratory	Least concern	Low
Balaenoptera edeni	Bryde's whale	Migratory	Least concern	Low
Balaenoptera musculus	Blue whale	Endangered Migratory	Least concern	Low
Eubalaena australis	Southern right whale	Endangered Migratory	Least concern	Confirmed*

Scientific name	Common name	EPBC Act status	NC Act status	Likelihood of occurrence
Megaptera novaeangliae	Humpback whale	Vulnerable Migratory	Vulnerable	Confirmed
Physeter macrocephalus	Sperm whale	Migratory	Least concern	Low

Table notes:

Excludes data recorded prior to 1980

*Updated based on DES submission comment ID 12.87 and ID 12.88

Likelihood of occurrence:

Low: Records for the species from the Project EIS database search area from a reliable data source but not specifically recorded within the Project impact areas. Predictive habitat (DSITI 2015) may have been modelled within the Project impact areas for the species. Suitable habitat for this species does not exist within the Project impact areas

Confirmed: Multiple records for the species in the Project EIS database search area from a reliable data source (e.g. previous studies, specimen-backed database records, predictive habitat modelling [DSITI 2015]) or species confirmed during Project EIS field investigations, and suitable habitat exists within the Project impact areas

Source: DoEE (2019c); DES (2019a) and ALA (2019)

9.11.2.2 Humpback whales

This section supplements the Project EIS Section 9.20.2.1 (whales – important habitat).

As the size of the Humpback whale population increases, the number of Humpback whales visiting the Port is expected to increase.

Humpback whales migrate every year along the east coast of Australia between April and November (Department of Environment and Water Resources 2007). The exact timing of migration varies every year depending on water temperature, sea ice, predation risk, prey abundance and the location of feeding ground (Department of Environment and Water Resources 2007). A Project EIS submission comment made by DES (comment ID 12.88) raised that the migration season is also lengthening, with migrants now expected from May to October (with low numbers also reported in April and November).

9.11.3 Dolphins

9.11.3.1 Contaminants in Humpback and Snubfin dolphins and turbid plume impacts on dolphin feeding

Recent studies by Weijs et al. (2016) indicate that polychlorinated biphenyls (PCBs) and pesticides in the blubber of humpback dolphins in Moreton Bay were high. Further reviews by Finlayson et al. (2019) have found that biopsy samples taken from Humpback and Snubfin dolphin species within the Port of Gladstone, showed that PCBs, dichlorodiphenyltrichloroethane (DDT) and benzene hexachloro (HCB) were comparable to concentrations found in dolphins worldwide. However levels were high and exceeded levels known to cause adverse affects to marine mammals.

The impact of contaminants on dolphin health are not well understood, however desktop and field geochemical investigations undertaken for the Project concluded that the marine sediments to be removed from the areas to be dredged are considered ‘clean’ as per NAGD (2009) and the potential for contaminants to be mobilised into the water column during Project dredging activities is considered to be low (refer Project EIS Section 6.5 and Appendices E4 and E6).

Fish are also known to avoid turbid plumes and this avoidance may impact the feeding behaviours of dolphins. While dolphins are known to forage in turbid waters, if fish avoid these turbid areas it may reduce availability of fish. However due to the large range of locations that dolphins forage, within the Port of Gladstone, the potential Project impact on dolphin species is considered to be low.

9.11.3.2 Bioaccumulation in marine mammals

Contaminants continually enter marine systems through multiple pathways with some of these contaminants having the inherent capacity to biomagnify in predator tissues through the consumption of prey items.

Marine mammals are primarily exposed to contaminants through their food. These contaminants, particularly those that are resistant to biodegradation and/or transformation, can bioaccumulate and biomagnify in top order predators (e.g. dolphins), typically to concentrations exceeding those in their prey (Finlayson et al. 2018).

A Sampling and Analysis Plan for the Project is required to be developed and implemented prior to commencement of dredging in accordance with requirements set out in the National Assessment Guidelines for Dredging (NAGD). This sampling program will provide an indication of contaminant concentrations in sediments.

9.11.3.3 Hearing thresholds of the Humpback dolphin

A primary sensor to aid in navigation, orientation, foraging and communication for dolphins is hearing. There have only been a few dolphin species researched for hearing as a function of hearing threshold versus frequency of sound stimulus. Li et al. (2012) carried out auditory evoked-potential methods of the Indo-Pacific humpback dolphin (*Sousa chinensis*) (now known as the Australian humpback dolphin (*Sousa sahulensis*)). Fourteen frequencies ranging from 5.6kHz to 152kHz were studied. The audiogram, which is a function of hearing threshold versus stimulus carrier frequency, presented a U-shape with a region of high hearing sensitivity (within 20dB of the lowest threshold) between approximately 20kHz and 120kHz (Li et al. 2012). It was found that the Indo-Pacific humpback dolphin sensitive hearing frequency approximately ranges from 5kHz to 120kHz, which has a certain overlap with medium-to-high frequency underwater noise (Li et al. 2012; Li et al. 2015).

Li et al. (2012) found that intraspecific variations in hearing capabilities of dolphin species (i.e. Atlantic bottlenose and Pacific bottlenose) exist. Li et al. (2012) concluded that there is more to learn about hearing and other various environmental conditions for individual species.

9.11.3.4 Dolphin – existing values

This section replaces the Project EIS Section 9.20.2.2 (existing values – dolphins).

Overview

The desktop assessment identified the potential for occurrence of 10 dolphin species within the Project EIS search area (refer Table 9.42).

Though 10 species of dolphin are predicted to potentially occur within the Project EIS search area (i.e. those species listed in Table 9.42), only two species of coastal dolphin (i.e. Australian humpback dolphin and the Indo-Pacific bottlenose dolphin) are frequently encountered within the vicinity of Port Curtis and adjacent areas such as Port Alma (GPC 2012a; GHD 2009; GHD 2011a; GHD 2011b; GHD 2012; Blue Planet Marine 2013; Cagnazzi 2013; 2015a; 2015b; 2016; 2017).

Table 9.42 Dolphin species known or predicted to occur within the Project EIS search area

Scientific name	Common name	EPBC Act	NC Act	Likelihood of occurrence within Port Curtis
Orcaella heinsohni[+]	Australian snubfin dolphin	Migratory	Vulnerable	Low (typically encountered in the Port Alma region, to the north of Curtis Island)
Orcinus orca	Killer whale	Migratory	Least concern	Low (preferred habitat not present within Port Curtis)

Scientific name	Common name	EPBC Act	NC Act	Likelihood of occurrence within Port Curtis
Pseudorca crassidens	False killer whale	Not listed	Least concern	Low (preferred habitat not present within Port Curtis)
*Sousa sahulensis**	Australian humpback dolphin	Migratory	Vulnerable	Confirmed (frequently recorded within Port Curtis, including The Narrows)
Stenella attenuata	Pantropical spotted dolphin	Not listed	Least concern	Low (this species has not been detected during recent targeted dolphin surveys within Port Curtis (Cagnazzi 2014, 2015a, 2015b, 2016, 2017))
Stenella longirostris	Spinner dolphin	Not listed	Least concern	Low^ (typically recorded off the coast of Curtis Island and Facing Island)
Tursiops aduncus	Indo-Pacific bottlenose dolphin^	Not listed	Least concern	Confirmed^ (this species has been identified in open waters, off the coast of Curtis Island)
Tursiops truncatus s. str.	Common bottlenose dolphin^	Not listed	Least concern	Low^ (typically recorded off the coast of Curtis Island and Facing Island)

Table notes:

\+ Formerly known as Irrawaddy dolphin (*Orcaella brevirostris*)

* Formerly known as Indo-Pacific humpback dolphin (*Sousa chinensis*)

^ Updated based on DES Project EIS submission comment ID 12.89 (refer AEIS Appendix A)

Likelihood of occurrence:

Low: Records for the species from the Project EIS database search area from a reliable data source but not specifically recorded within the Project impact areas. Predictive habitat (DSITI 2015) may have been modelled within the Project impact areas for the species. Suitable habitat for this species does not exist within the Project impact areas

Confirmed: Multiple records for the species in the Project EIS database search area from a reliable data source (e.g. previous studies, specimen-backed database records, predictive habitat modelling [DSITI 2015]) or species confirmed during Project EIS field investigations, and suitable habitat exists within the Project impact areas

Source: DoEE (2019c); DES (2019a); ALA (2019); Cagnazzi (2015a; 2015b; 2016)

As noted from the DES Project EIS submission comment 12.89 only the Australian humpback dolphin is frequently found in the Port. Indo-Pacific bottlenose dolphins have also been reported in the Port. Within the seaward areas of the dredging works, Spinner dolphins, Common bottlenose dolphins and False killer whales may be encountered (but are rare in the area).

Australian humpback dolphin

The Australian humpback dolphins is currently considered vulnerable under the International Union for Conservation of Nature (IUCN) Red List of threatened species (Parra et al. 2017; Parra and Cagnazzi 2015).

Dolphin surveys conducted within the Port Curtis and Port Alma regions recorded the Australian humpback dolphin as the most frequently encountered dolphin species throughout the survey area (refer Project EIS Appendix I1 (Section 15.2.3)) (Cagnazzi 2017). It has been noted that the species are thought to be coastally obligate and found within 20km from the mainland coast (Parra and Cagnazzi 2016; Raudino et al. 2018; Parra 2006; Parra and Cagnazzi 2016; DoEE 2018). Cagnazzi (2017) found that the majority of sightings of Australian humpback dolphins occurred in Port Curtis followed by Port Alma and Keppel Sands, and to a lesser extent in Rodds Bay and East Curtis Island. During these surveys, a large number of sightings of Australian humpback dolphins were observed throughout The Narrows, however it was noted that the extent to which this species uses The Narrows is not yet fully understood (Cagnazzi 2017).

Research on genetic data suggest that Australian humpback dolphins exist as a metapopulation of small and relatively isolated populations with limited gene flow (Parra et al. 2018; Parra and Cagnazzi 2016; Raudino et al. 2018). Further it has been observed that Australian humpback dolphins live in small and relatively isolated populations with limited gene flow among them (Parra and Cagnazzi 2016; Parra et al. 2018).

It was estimated that the number of Australian humpback dolphins using Port Curtis between 2007-2011 ranged between 84 in 2007 to 45 in 2011. In 2011, a large flood event occurred, and the WBDDP commenced which potentially resulted in the significant decline of the Australian humpback dolphin by 40% (Cagnazzi 2013; Cagnazzi 2017). The number of humpback dolphins that used Port Curtis during each primary period varied from 101 in 2014 to 124 in 2015 and back to 108 in 2016 (Cagnazzi 2017). Based on the 2016 study, the number of Australian humpback dolphins have returned to their original level prior to 2011 (Cagnazzi 2017).

Research on available abundance estimates are limited and it has indicated that Australian humpback dolphins occur in small populations averaging 54-89 individuals (0.1-0.19 individuals per km^2). More specifically, population estimates within the Curtis coast include 45-84 individuals (0.09-0.16 individuals per km^2) (Cagnazzi 2013; Parra and Cagnazzi 2016; Parra et al. 2018).

Australian humpback dolphins are thought to be opportunist-generalist feeders, eating a wide variety of coastal and estuarine-associated fishes, although reef, littoral and demersal fish species are also taken. Bony fish, some cephalopods and crustaceans have also been recorded as prey. Australian humpback dolphins are recorded feeding in association with prawn trawlers in Moreton Bay and presumably elsewhere throughout the species' range in Australia (Bannister et al. 1996; Ross et al. 1994). Feeding may occur in a variety of habitats, from mangroves to sandy bottom estuaries and embankments to rock and/or coral reefs. Feeding primarily occurs in shallow waters (< 20m depth) and may incorporate beaching behaviour on sandbanks.

Indo-Pacific bottlenose dolphin

In Australia, the Indo-Pacific bottlenose dolphin is restricted to inshore areas such as bays and estuaries, nearshore waters, open coast environments, and shallow offshore waters, including coastal areas around oceanic islands (locally referred to as the ‘Inshore bottlenose dolphin) (Hale et al. 2000).

Australia snubfin dolphin

This section replaces the Project EIS Section 9.20.2.2 (Australian snubfin dolphin).

Dolphin surveys conducted within the Port Curtis and Port Alma regions recorded the Australian snubfin dolphin as occurring only within the northern area of The Narrows (Cagnazzi 2017). It has been noted that the extent to which this species uses The Narrows is not yet fully understood (Cagnazzi 2017).

Australian snubfin dolphin sightings south of Port Alma are considered rare (DES 2018b; Cagnazzi 2017). It has been reported that only one Australian snubfin dolphin has been reported in the Port (D. Cagnazzi, pers. comm.). The Australian snubfin dolphin that was reported in Rodds Harbour was part of a group of Australian humpback dolphins and has the potential to be a hybrid of a dolphin that joined the group of Australian humpback dolphins at a very young age (D. Cagnazzi, pers. comm.). Therefore there is no resident population of Australian snubfin dolphins in Port Curtis, nor are there occasional sightings. Australian snubfin dolphins have the potential to move through the Narrows, but over the ten years of observations, an Australian snubfin dolphin has not been reported (D. Cagnazzi, pers. comm.). Cagnazzi (2017) study found that all sightings of Australian snubfin dolphins were recorded in Port Alma and Keppel Sands.

9.11.4 Potential cumulative and synergistic impacts from Project activities

This section supplements the Project EIS Section 9.21 (marine mammals – potential impacts and risk assessment) which provides an assessment of the potential impacts of the various Project activities on marine mammals, including whales, dolphins and dugongs.

The cumulative impact assessment that is applicable to the Project, considering foreseeable 'significant' projects and exogenous factors such as flood events and climate change is provided in the Project EIS (Chapter 21 – cumulative impact assessment and Appendix P). This section only provides the cumulative assessment of the Project activities (i.e. the establishment of the WBE reclamation area and BUF, dredging activities, installation and removal of navigational aids and operation and maintenance) as a whole.

To identify potential synergistic impacts on marine mammals, this section provides an assessment of the potential cumulative Project impacts that were previously addressed individually as discrete Project activities on marine mammals (refer Section 9.21.2 to 9.21.5).

The Project activities can be described as occurring in discrete spatial areas although there is some temporal overlap of Project activities. The spatial categories are described below and their location (i.e. area of direct impact) is provided in Figure 9.2.

- Establishment of the WBE reclamation area and BUF
- Dredging activities
- Removal and installation of navigational aids
- Stabilisation and maintenance activities.

The Project dredging works will be undertaken as either a staged dredging campaign (i.e. over two stages) or as a singular campaign. Figure 9.36 illustrates the Project activity timeframes and dredging campaign options.

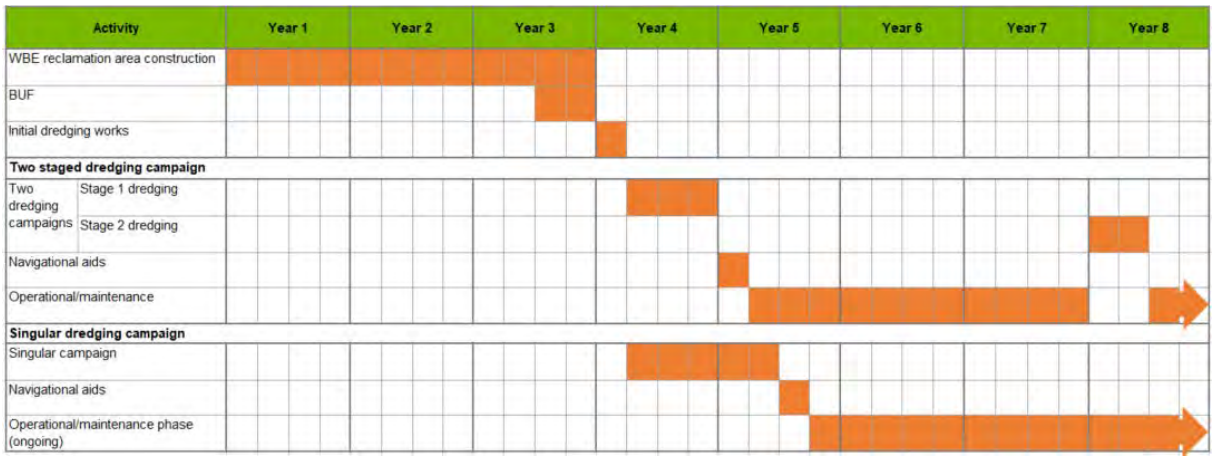

Figure 9.36 Indicative Project activity timeframes

Whilst the location of direct impacts is discrete, it is acknowledged that indirect impacts arising from the discrete Project locations (e.g. silt plumes, alterations to water quality and increased vessel movement) have the potential to result in impacts that overlap in a spatial and temporal context. Given this overlap, synergistic interactions resulting from multiple Project related impacts have the potential to impact upon marine mammals, with the results being greater than the sum of any of the single stressors alone.

Potential cumulative impacts were assessed in conjunction with potential synergistic impacts from Project activities. Cumulative impacts were defined as an accumulation of impact from all Project activities. These were considered to be independent of temporal constraints and constituted contributing factors driving synergistic processes. Accordingly, cumulative impacts were not assessed *per se* but rather, were assessed within the synergistic impact assessment and were incorporated into the significant residual adverse impact assessment.

Synergistic impacts result from multiple processes which act simultaneously upon a particular value. The magnitude of impact would be a function of the initial direct impact and further direct impacts (as an accumulation) and/or a function of the initial direct impact with potentiation from further indirect impacts (as a synergy) with consideration for any amplification associated with the multiple factors acting simultaneously.

To identify potential Project synergistic impacts upon marine mammals, the Project EIS impact assessment outcomes (as a whole of program rather than discrete Project activities) were assessed (refer AEIS Section 9.21 and AEIS Appendices E1, E2 and E3). This enabled potential Project direct impacts (and indirect impacts) to be identified and the potential for contribution towards synergistic processes upon key threatening processes to be considered. This approach acknowledged the potential scale of the Project related impacts on the value and its potential to impact upon the value's capacity for recovery from the impact, by contributing to a recognised threatening process.

Significant synergistic impacts were defined as potential synergistic impacts that had the capacity to contribute towards threatening processes that are recognised for a value (e.g. marine mammals). The resulting likelihood of risk identified the likely contribution of synergistic pathways upon the residual adverse impact of that value.

The synergistic assessment utilised a qualitative risk approach to determine the potential risk of a significant synergistic impact. Noting that a quantitative analysis was not possible as data related to synergistic processes is traditionally non-tractable to analysis, a risk-based assessment was utilised.

Potential Project related impacts assessed as potentially significant (post implementation of impact mitigation measures) were identified as potential pathways for significant synergistic impacts and consisted of:

- Permanent loss of habitat
- Potential increase in noise and vibration
- Potential vessel strike
- Increase in waste material
- Direct contact with dredging equipment
- Short term declines in waste quality.

The framework of assessment focussed on:

- The potential Project activity impacts
- The synergistic pathways associated with the Project activities
- How the potentiated impacts contribute to key threatening processes
- The likelihood of risk of significant impact (refer Table 9.43) from the synergistic impact contribution to key threatening processes.

Table 9.43 Likelihood definitions for potential impacts occurring over the life of the Project

Description	Frequency
Unlikely	Unlikely but not trivial. May occur during construction/life of the Project but probability < 50%
Potential	Less likely than not, but still considerable; probability of about 50% chance of occurring over the life of the Project
Likely	Likely to occur during construction/life of the Project or during a 12 month timeframe; probability up to 90% chance of occurring

Potential impacts to threatening processes (across all Project activities) have been identified in Project EIS Sections 9.21.2 to 9.21.5. These sections outline the initial Project impacts which contribute to the synergies with other potential Project impacts. For further detail, refer to applicable potential Project activity impacts within Project EIS Section 9.21.2 to 9.21.5.

Increased impact associated with competition, resource accumulation, reproductive opportunity loss and a reduction in biological fitness were assessed as pathways for the potential to contribute to key threatening processes as potential indirect synergistic impacts. Potential indirect synergistic impacts were typically associated with potential to reduce a value's life history parameters (e.g. reduced growth, reproduction, resource accumulation), through to the potential reduction in population resilience as a contributing factor towards key threatening processes. Increased competition has been considered to initially derive from Project potential impacts, including permanent removal of habitat, short term decline in water quality, and short term increase in turbidity and sedimentation.

Resource accumulation has been considered to initially derive from Project potential impacts, including permanent removal of foraging resource, potential noise increase, potential vessel interactions and direct contact with dredging equipment.

Reductions in biological fitness has been considered to derive from all of the initial impacts, as potential competition increase, and resource and reproduction opportunities were considered to be contributing factors to this synergistic pathway. Synergistic impacts which act upon resilience were considered to result in potential reduction in individual and population biological fitness.

The sections below provide the synergistic impact assessment for whales, dolphins and dugongs separately.

9.11.4.1 Whales

The potential Project synergistic impacts (includes both direct and indirect impacts) to whales include:

- Permanent loss and alteration to habitat
- Direct contact with construction plant
- Increase in waste material
- Increase in noise and vibration
- Potential vessel strike
- Short term decline in water quality.

Table 9.44 provides a summary of the synergistic impacts from the Project as a whole on Humpback whales. For the purposes of determination of the risk assessment with significant synergistic impact, Project direct impacts were contained in concert with synergistic pathways to determine the potential of synergistic impacts, that will contribute to key threatening processes. The likelihood of risk was determined based on Table 9.43 definitions.

Table 9.44 Risk of significant synergistic impact from identified Project impacts on Humpback whale

Marine mammal value	Species threats identified in relevant conservation advices, recovery plans and threat abatement plans[#]	Project direct impact (as result of whole program)	Potential Project pathways acting in synergy with Project impact	Potential indirect synergistic impact contributing to key threatening processes	Likelihood of risk of significant impact (refer Table 9.43)
Humpback whale Vulnerable under the EPBC Act and NC Act, Migratory under EPBC Act	▪ Habitat modification through climate change ▪ Commercial whaling ▪ Entanglement and bycatch in fishing nets and long-lines ▪ **Noise interference (i.e. seismic surveys, acute and chronic industrial noise, shipping noise, aircraft noise)** ▪ **Vessel strike** ▪ Overharvesting of prey (i.e. competition with commercial fisheries) ▪ Oil spills and acute/chronic chemical discharge ▪ Wildlife tourism (i.e. feeding wild dolphins, whale watching) ▪ Injury and fatality to vertebrate marine life caused by harmful marine debris	Permanent loss and alteration to habitat	▪ Permanent change of habitat ▪ Temporary decline in water quality ▪ Potential vessel interaction	▪ Reduction in individual and population resilience ▪ Compounding impact on individual resource partitioning (compromised physiology) from reduction of foraging resource and water quality degradation (all Project activities) ▪ Minor reduction of life-history parameters ▪ Alteration of behaviours	Unlikely
		Potential noise and vibration increase	▪ Permanent change of habitat ▪ Temporary decline in water quality ▪ Increase waste materials	▪ Reduction in individual and population resilience ▪ Minor reduction of life-history parameters ▪ Alteration of behaviours	Unlikely
		Potential vessel interaction	▪ Permanent change of habitat ▪ Temporary decline in water quality	▪ Increase in potential vessel interaction from modification of habitat use ▪ Minor reduction in life-history parameters ▪ Reduction in population resilience	Unlikely
		Direct contact with dredging equipment	▪ Permanent change of habitat ▪ Temporary decline in water quality ▪ Increase waste materials	▪ Increase in potential mortality from contact with dredging equipment from modification of habitat use ▪ Reduction in population resilience	Unlikely

Table note:

Bold identifies threats acknowledged in relevant conservation advices, recovery plans and threat abatement plans which are potentially impacted by Project activities

The assessment identified that the Project has an unlikely potential risk of significant synergistic impact for Humpback whales due to:

- No key habitat for whales being disrupted
- No anticipated impact to reproduction.

Any indirect impacts as a result of the Project (i.e. increase in under water noise and vibration levels, erosion, siltation and short term declines in water quality) will be avoided, minimised and mitigated through the implementation of mitigation measures in the Dredging EMP and Project EMP (refer AEIS Appendix F and G, respectively).

9.11.4.2 Dolphins

The potential Project synergistic impacts (includes both direct and indirect impacts) to dolphins include:

- Permanent loss and alteration to habitat
- Entrapment and direct contact with construction plant
- Increase in waste material
- Increase in noise and vibration
- Potential vessel strike
- Short term declines in water quality.

Exogenous factors (such as extreme flood events) may increase vulnerability of dolphins to external stressors. These are expected to affect their habitat, principally through a loss of foraging resource (including but not limited to, seagrass meadows). Whilst foraging-site fidelity is considered within this impact, the true impact from extreme flood events is not achievable, and therefore is considered, but not included as a specific impact in the synergistic impact assessment. The Project EMP (refer AEIS Appendix G) will provide mitigation/management measures to be implemented during serve extreme events to limit active dredging sediment suspension. This is considered to limit active dredging suspension occurring in addition to natural resuspension occurrence associated with high-energy climatic conditions.

Table 9.45 provides a summary of the synergistic impacts from the Project as a whole on dolphins. For the purposes of determination of the risk assessment with significant synergistic impact, Project direct impacts were contained in concert with synergistic pathways to determine the potential of synergistic impacts, that will contribute to key threatening processes. The likelihood of risk was determined based on Table 9.43 definitions.

Table 9.45 Risk of significant synergistic impact from identified Project impacts on dolphins

Marine mammal value	Species threats identified in relevant conservation advices, recovery plans and threat abatement plans[#]	Project direct impact (as result of whole program)	Potential Project pathways acting in synergy with Project impact	Potential indirect synergistic impact contributing to key threatening processes	Likelihood of risk of significant impact (refer Table 9.43)
Australian humpback and Australian snubfin dolphin Migratory under EPBC Act and Vulnerable under the NC Act	▪ **Direct loss of habitat (i.e. from coastal development)** ▪ Commercial fishing (including entanglement in fishing nets and lines, bycatch, vessel strike, competition for prey resources ▪ **Oil spills** ▪ **Vessel strike** ▪ **Acoustic disturbance from ports and shipping activities** ▪ Habitat modifications through climate change ▪ Declining water quality due to catchment run-off	Permanent loss and alteration of habitat (including foraging habitat)	▪ Permanent change of habitat ▪ Temporary decline in water quality ▪ Release of contaminants	▪ Reduction in individual and population resilience ▪ Compounding impact on individual resource partitioning (compromised physiology) from reduction of foraging resource and water quality degradation (all Project activities) ▪ Increase in potential vessel strike from compromised individuals ▪ Minor reduction of life-history parameters	Potential
		Potential noise and vibration increase	▪ Permanent change of habitat ▪ Temporary decline in water quality	▪ Reduction in individual and population resilience ▪ Minor reduction of life-history parameters ▪ Alterations in behaviour	Unlikely
		Potential vessel interaction	▪ Permanent change of habitat ▪ Temporary decline in water quality ▪ Increase waste material	▪ Increase in potential vessel interaction from modification of habitat use ▪ Minor reduction in life-history parameters ▪ Reduction in population resilience	Unlikely
		Direct contact with dredging equipment	▪ Permanent change of habitat	▪ Increase in potential mortality from contact with dredging equipment from modification of habitat use ▪ Reduction in population resilience	Unlikely

Marine mammal value	Species threats identified in relevant conservation advices, recovery plans and threat abatement plans[#]	Project direct impact (as result of whole program)	Potential Project pathways acting in synergy with Project impact	Potential indirect synergistic impact contributing to key threatening processes	Likelihood of risk of significant impact (refer Table 9.43)
		Short term decline in water quality	■ Increase waste material ■ Release of contaminants	■ Reduction in individual and population resilience ■ Minor reduction of life-history parameters ■ Alterations in behaviour	Unlikely

Table note:

Bold identifies threats acknowledged in relevant conservation advices, recovery plans and threat abatement plans which are those potentially impacted by Project activities

The assessment identified that the Project has a potential risk of significant synergistic impact to dolphins from the permanent loss and alternation of habitat, and an unlikely risk of significant synergistic impact for dolphins from noise and vibration, vessel interaction and entrapment and direct contact with construction plant due to mitigation measures provided in the Dredging EMP and Project EMP (refer AEIS Appendices F and G, respectively) and associated management plans.

A significant residual adverse impact assessment has been conducted for dolphin values as the Project was identified as potentially having a residual sequential impact on the value. The significant residual adverse impact assessment for dolphin values is provided in Section 9.11.4.1.

9.11.4.3 Dugongs

The potential Project synergistic impacts (includes both direct and indirect impacts) to dugongs include:

- Permanent loss and alteration to habitat
- Entrapment and direct contact with construction plant
- Increase in waste material
- Increase noise and vibration
- Potential vessel strike
- Short term declines in water quality.

Exogenous factors (such as extreme flood events) may increase vulnerability of dugongs to external stressors. These are expected to affect their habitat, principally through a loss of foraging resource (including but not limited to, seagrass meadows). Whilst foraging-site fidelity is considered within this impact, the true impact from extreme flood events is not achievable, and therefore is considered, but not included as a specific impact in the synergistic impact assessment. The Project EMP (refer AEIS Appendix G) will provide mitigation/management measures to be implemented during serve extreme events to limit active dredging sediment suspension. This is considered to limit active dredging suspension occurring in addition to natural resuspension occurrence associated with high-energy climatic conditions.

Table 9.46 provides a summary of the synergistic impacts from the Project as a whole on dugong. For the purposes of determination of the risk assessment with significant synergistic impact, Project direct impacts were contained in concert with synergistic pathways to determine the potential of synergistic impacts, that will contribute to key threatening processes. The likelihood of risk was determined based on Table 9.43 definitions.

Table 9.46 Risk of significant synergistic impact from identified Project impacts on dugong

Marine mammal value	Species threats identified in relevant conservation advices, recovery plans and threat abatement plans[#]	Project direct impact (as result of whole program)	Potential Project pathways acting in synergy with Project impact	Potential indirect synergistic impact contributing to key threatening processes	Likelihood of risk of significant impact (refer Table 9.43)
Dugong Migratory under the EPBC Act and Vulnerable under NC Act	■ **Habitat degradation, including coastal development, port expansion and aquaculture** ■ **Injury and fatality caused by harmful marine debris** ■ Entanglement and incidental bycatch in fisheries gear ■ Entanglement in shark netting ■ Indigenous hunting ■ **Vessel strike** ■ **Anthropogenic noise and acoustic disturbance** ■ Climate variability and change	Permanent removal of foraging resource	■ Permanent change of habitat ■ Temporary decline in water quality ■ Potential vessel interaction	■ Reduction in individual and population resilience ■ Compounding impact on individual resource partitioning (compromised physiology) from reduction of foraging resource and water quality degradation (all Project activities) ■ Increase in potential vessel strike from compromised individuals ■ Minor reduction of life-history parameters ■ Alterations to behaviour	Potential
		Potential noise increase	■ Permanent change of habitat ■ Temporary decline in water quality ■ Increase waste material	■ Reduction in individual and population resilience ■ Minor reduction of life-history parameters	Unlikely
		Potential vessel interaction	■ Permanent change of habitat ■ Temporary decline in water quality	■ Increase in potential vessel interaction from modification of habitat use ■ Minor reduction in life-history parameters ■ Reduction in population resilience	Potential
		Direct contact with dredging equipment	■ Permanent change of habitat	■ Increase in potential mortality from contact with dredging equipment from modification of habitat use ■ Reduction in population resilience	Potential

Marine mammal value	Species threats identified in relevant conservation advices, recovery plans and threat abatement plans[#]	Project direct impact (as result of whole program)	Potential Project pathways acting in synergy with Project impact	Potential indirect synergistic impact contributing to key threatening processes	Likelihood of risk of significant impact (refer Table 9.43)
		Short term decline in water quality	■ Increase waste material ■ Release of contaminants	■ Reduction in individual and population resilience ■ Minor reduction of life-history parameters ■ Alterations in behaviour	Unlikely

Table note:

Bold identifies threats acknowledged in relevant conservation advices, recovery plans and threat abatement plans which are those potentially impacted by Project activities

The assessment identified that the Project has the potential risk of significant synergistic impact for dugongs due to:

- Permanent and direct loss of foraging habitat
- Potential habitat alteration.

The Project will implement mitigation measures provided in the Dredging EMP and Project EMP (refer AEIS Appendices F and G, respectively) and associated management plans to reduce the risk of potential Project impacts on dugongs.

A significant residual adverse impact assessment has been conducted for dugong values as the Project was identified as potentially having a residual sequential impact on the value. The significant residual adverse impact assessment for dugongs is provided in Section 9.11.4.2.

9.11.5 Significant residual adverse impact assessment

This section replaces the Project EIS Section 9.21.7 (marine mammals – significant residual adverse impact assessment).

A significant residual adverse impact assessment has been conducted to identify if the Project will, or is considered likely to have, a significant residual adverse impact on any marine mammal value which is defined as a MNES or MSES. The significant residual adverse impact assessment reviewed as part of the AEIS to ensure that the Project activities have been assessed at their broadest scope (i.e. the cumulative impact of all Project activities have been assessed) and that potential offsite and indirect Project impacts have been included in the significance assessment. This assessment has considered indirect Project impacts as per the definition of 'offsite and indirect' impacts provided in the *Queensland Environmental Offsets Policy Significant Residual Impact Guideline* (EHP 2014a) and the *Matters of National Environmental Significance Significant Impact Guidelines, Version 1.1* (DoE 2013).

Offsite and indirect impacts are identified via the Project impact magnitude assessment. The magnitude of a potential Project impact is a product of the temporal duration of the potential impact and the spatial scale of the impact. For each impact the estimated duration of the impact is identified (i.e. its anticipated temporal extent) and classified as temporary, short term, medium term, long term or permanent. The anticipated spatial extent of the potential impact is classified as undetectable, contained extent, local area or extensive. The consequence of the potential Project impact is determined by combining the impacts temporal and spatial extent in the magnitude matrix. AEIS Appendix E1 provides further information and definitions regarding Project assessment of magnitude.

For the purposes of this significance assessment of offsite and indirect impacts, the magnitude assessments of the potential Project residual impacts relative to the significant impact criteria assessed in were considered. The consequence assessments for each relative Project residual impact were considered with respect to the potential combined, cumulative Project impact to ensure that the impact assessment was conducted with respect to the Project's broadest scope (i.e. all Project activities).

Significant residual adverse impact assessments have been conducted for MNES and/or MSES marine mammal species which are considered to have a moderate or high likelihood of occurrence within the Project impact areas (refer Project EIS Appendix I1 (Appendix B)).

This assessment of significant residual adverse impacts considers the significance of potential Project impacts after the implementation of the Project mitigation measures included in the Dredging EMP and Project EMP (refer AEIS Appendix F and G, respectively).

Table 9.47 includes the marine mammal species which are subject to this significant residual adverse impact assessment, due to Project impacts having the potential to result in:

- Very high or high risk (post mitigation measures) on a species (refer Project EIS Sections 9.21.2 to 9.21.5), and/or

- A residual impact to a key threatening process (refer AEIS Appendix E3, Item 4.0).

Table 9.47 Marine mammal MNES and MSES subject to significant residual adverse impact assessment

Fauna value	MNES	MSES	Significance assessment
Australian snubfin dolphin (*Orcaella heinsohni*)	Migratory species	Protected wildlife habitat	9.11.5.1
Australian humpback dolphin *(Sousa sahulensis)*	Migratory species	Protected wildlife habitat	9.11.5.1
Dugong (*Dugong dugon*)	Migratory species	Protected wildlife habitat	9.11.5.2

9.11.5.1 Dolphin

The Australian humpback dolphin and the Australian snubfin dolphin are listed as migratory species under the provisions of the EPBC Act and vulnerable under the provisions of the NC Act.

The significant residual adverse impact assessment presented in Table 9.48 has been conducted with respect to the MNES significant impact assessment criteria for migratory species (DoE 2013b) and the significant impact assessment criteria for protected wildlife habitat (EHP 2014b).

The significant residual adverse impact assessment concluded that the proposed Project activities are unlikely to have a significant residual adverse impact on the Australian humpback dolphin or the Australian snubfin dolphin.

Table 9.48 Significant residual adverse impact assessment for MNES and MSES dolphins

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
MNES significant impact assessment criteria – Migratory species ■ Substantially modify (including by fragmentation, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species **MSES significant impact assessment criteria – Protected wildlife habitat** ■ Lead to a long term decrease in the size of a local population ■ Reduce the extent of occurrence of the species **Cause disruption to ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species**	**Australian snubfin dolphin:** unlikely to have a significant impact **Australian humpback dolphin:** unlikely to have a significant impact	**Unlikely to have a significant impact** Project impacts have been identified which have the potential to adversely impact the dolphin values detailed in this significant impact assessment criteria. The potential for these impacts to extend to offsite and indirect impact areas has been evaluated via the Project activity's magnitude assessment. The results are summarised below. ■ Direct mortality and injury of Australian snubfin dolphin during the establishment of the WBE reclamation area and BUF – Low magnitude: Potential residual impact considered to be medium in duration (temporal) and contained in extent (spatial) ■ Potential noise, vibration and dust impacts during the establishment of the WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be medium in duration (temporal) and contained in extent (spatial) ■ Hydrodynamic and water quality impacts resulting in habitat alteration during the establishment of the WBE reclamation area and BUF – Low magnitude: Potential residual impact considered to be permanent in duration (temporal) and contained in extent (spatial) ■ Contaminant and sediment releases resulting in impacts on habitat during the establishment of the WBE reclamation area and BUF – Low magnitude: Potential residual impact considered to be permanent in duration (temporal) and contained in extent (spatial) The Project activities cumulative and synergistic impacts have been incorporated into the significant residual adverse impact assessment for this significant impact assessment criteria. The Project will result in the direct removal of potential habitat for the Australian humpback dolphin and the Australian snubfin dolphin, however the Project activities are not anticipated to reduce the extent of species occurrence or lead to a long term decrease in the species populations. The establishment of the WBE reclamation area and BUF will have a direct and indirect impact (i.e. from erosion and sedimentation associated with changes in tidal velocities adjoining the WBE reclamation area) on approximately 374.64ha of potential habitat (e.g. feeding) for the Australian humpback dolphin and the Australian snubfin dolphin.

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
		The Australian humpback dolphin and the Australian snubfin dolphin are commonly found in protective shallow waters (< 20m), at the mouths of creeks and estuaries, and in tidal channels. The species feed primarily on coastal and estuarine fish species, along with crustaceans, bivalves, and cephalopods (Australian snubfin only) (Parra and Jedensjö 2009). The release of contaminants may lead to the degradation of intertidal or subtidal habitats located adjacent to the final Project land form and result in impacts to marine life, including inshore dolphin species, via direct contact with contaminants or the ingestion of contaminated food source. Mitigation measures to avoid contaminant releases impacting inshore dolphin species and their habitat during surface stabilisation and maintenance works at the Western Basin and WBE reclamation areas will be included in the Project EMP and Dredging EMP (refer AEIS Appendices F and G, respectively). Dredging activities may result in a short term decline in water quality and have a potential to adversely impact inshore dolphin habitat. Potential impacts to water quality as a result of dredging activities will be managed in accordance with the Dredging EMP. The Australian humpback dolphin does not display any apparent preference for clear or turbid waters, and have been reported in a variety of coastal habitats, from coastal lagoons and enclosed bays with mangrove forests and seagrass meadows through to open coastal waters with rock and/or coral reefs. The western section of Moreton Bay and the lower reaches of the Brisbane River have been identified as potential key habitats for the Australian humpback dolphin (Hale et al. 1998). The Australian humpback dolphins preferred habitats are associated with biophysical features such as depth, the distance to estuaries and rocky reefs, and they often demonstrate long term fidelity to specific areas (Meager et al. 2018). Whilst the Australian humpback dolphin does display clear habitat preferences, suitable habitat does occur within Port Curtis and surrounding locations of the WBE reclamation area. The Project works will occur outside of potential key habitat areas for the species and is not considered likely to remove ecologically significant locations for the species to the extent that the species populations would decline in extent and numbers. Surveys of inshore dolphins in Port Curtis reported in Cagnazzi (2013) found that small to medium groups of Australian humpback dolphins used the footprint of the WBE reclamation area as an area for foraging and feeding/travelling. Large groups (11 to 21) of Australian humpback dolphins were recorded to use the waters around the channel duplication areas to be dredged, predominantly for foraging, but also for travelling, milling, feeding and socialising (Cagnazzi 2013). Cagnazzi (2017) found that there was no clear evidence of genetic bottlenecks in the Port Curtis population of the Australian humpback dolphin, with low genetic diversity recorded in the species considered to be a natural characteristic of the species in Australian waters.

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
		Although the WBE reclamation area removes an area of habitat for the Australian humpback dolphin which could ultimately result in behavioural disturbances and short term displacement, this species is known to be resilient to a degree of disturbance, as indicated from previous studies within the Port. The Australian humpback dolphin population in Port Curtis is considered to be resilient to a degree of disturbance. In 2011, following large flood events and the concurrent commencement of the WBDDP, the number of Australian humpback dolphins in Port Curtis declined by approximately 40%. Surveys conducted in 2014-2016 found that the population numbers of the species in Port Curtis returned to their pre-2011 population numbers (Cagnazzi 2017). With respect to the short timeframe of the population recovery, the observed decline in Australian humpback dolphins in Port Curtis could be partially explained by a temporary shift in the species distribution (i.e. it was considered that the core group of Australian humpback dolphins in Port Curtis moved to nearby regions and waited until more suitable conditions were re-established in Port Curtis before they returned) (Cagnazzi 2017). The Australian snubfin dolphin is known to occur within the Fitzroy River but there is little evidence in support of the species occupying Port Curtis. The closest species occurrence recorded in the ALA for the Australian snubfin dolphin to the Project impact areas was a single individual recorded in 1997, situated on the north coast of Camp Island, approximately 35km north of the WBE reclamation area. Isolated species occurrence recordings have been collected near Bundaberg (recorded in 1994) and Yeppoon (recorded in 1999) (ALA 2019). Recent studies suggest that the Australian snubfin dolphin is unlikely to occur in substantial numbers in waters south of The Narrows (Cagnazzi 2013; 2017). Dolphin mark-recapture (photo-identification) surveys conducted over the period of 2014-2016 within the Port Curtis and Port Alma regions recorded Australian snubfin dolphins only in the northern section of The Narrows (Cagnazzi 2017). The Australian snubfin dolphin appears to occur in 'hotspots', with areas of higher population densities recorded along the east coast (DoEE 2018a). Australian snubfin dolphin occurrence recordings in the ALA database appear to be congregated around Townsville and Mackay (ALA 2019). With limited recordings of the Australian snubfin dolphin within Port Curtis, it is considered unlikely that potential species habitat within the Project impact areas supports significant populations of the Australian snubfin dolphin. Potential species habitat within the Project impact areas is considered unlikely to represent important habitat or ecologically significant locations for the species. The direct removal of potential habitat for the Australian snubfin dolphin is not considered likely to have a significant impact on the extent or size of any local species populations which may be present. Adaptive design measures will be implemented during the Project detailed design phase to reduce the impact of potential inshore dolphin habitat loss from the WBE reclamation area (refer AEIS Appendix H). With consideration to the sequential timing and discrete locations of the Project activities and the aforementioned magnitude levels of any potential residual impact, the Project is not considered likely to have a significant residual adverse impact on this significant impact assessment criteria.

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
MSES significant impact assessment criteria – Protected wildlife habitat ■ Fragment an existing population **Result in genetically distinct populations forming as a result of habitat isolation**	**Australian snubfin dolphin:** unlikely to have a significant impact **Australian humpback dolphin:** unlikely to have a significant impact	**Unlikely to have a significant impact** Project impacts have been identified which have the potential to fragment dolphin populations. The potential for these impacts to extend to offsite and indirect impact areas has been evaluated via the Project activity's magnitude assessment. The results are summarised below. ■ Potential noise, vibration and dust impacts during the establishment of the WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be medium term in duration (temporal) and contained in extent (spatial) ■ Hydrodynamic and water quality impacts resulting in habitat alteration during the establishment of the WBE reclamation area and BUF – Low magnitude: Potential residual impact considered to be permanent in duration (temporal) and contained in extent (spatial) The Project activities cumulative and synergistic impacts have been incorporated into the significant residual adverse impact assessment for this significant impact assessment criteria. Australian humpback dolphins and Australian snubfin dolphins are considered to be strictly inshore, coastal and estuarine dolphin species (Cagnazzi 2013). Australian humpback dolphins and Australian snubfin dolphins share similar habitat preferences. The species are considered to be potentially sympatric (occurring in the same areas) throughout most of their Australian range (Parra 2006; DoEE 2018a). The Australian humpback dolphin and Australian snubfin dolphin appear to occur in 'hotspots', with areas of higher population densities recorded along the east coast (DoEE 2018a; DoEE 2018b). Associated with coastal waters less than 10m deep and approximately 6km offshore, the Australian humpback dolphin is understood to have a continuous distribution along the east Australian coast (DoEE 2018b). The species is understood to have a large home range (DoEE 2018b). Recent studies suggest Australian snubfin dolphins are unlikely to inhabit Port Curtis and waters south of The Narrows (Cagnazzi 2013; 2017). Systematic boat-based surveys for the species conducted in Cleveland Bay, approximately 650km north of the Project impact areas, suggested that the Australian snubfin dolphin have large home ranges, with tracked individuals spending less than 30 days within the 310km^2 Cleveland Bay (Townsville) study area. The Project activities are not considered to impede the movement of inshore dolphin species, including the Australian humpback dolphin and the Australian snubfin dolphin. The establishment of the WBE reclamation area and BUF is not considered to create a barrier to dolphin movement between habitats. Furthermore, the dredging activities are associated with the existing shipping channel, and as such, will not create disturbance or barriers to movement in new areas.

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
		The Project activities are not anticipated to result in genetically distinct populations forming as a result of habitat isolation. Project impacts are not considered to fragment habitat or create barriers to movement which would result in the genetic isolation of a species. The Australian snubfin dolphin is considered unlikely to occur within Port Curtis and as such the Project is considered unlikely to impact on genetically distinct species populations or result in the genetic isolation of a species. With consideration to the sequential timing and discrete locations of the Project activities and the aforementioned magnitude levels of any potential residual impact, the Project is not considered likely to have a significant residual adverse impact on this significant impact assessment criteria.
MNES significant impact assessment criteria – Migratory species **Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species**	**Australian snubfin dolphin:** unlikely to have a significant impact **Australian humpback dolphin:** unlikely to have a significant impact	**Unlikely to have a significant impact** Project impacts have been identified which have the potential to fragment dolphin habitats. The potential for these impacts to extend to offsite and indirect impact areas has been evaluated via the Project activity's magnitude assessment. The results are summarised below. ■ Potential noise, vibration and dust impacts during the establishment of the WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be medium term in duration (temporal) and contained in extent (spatial) ■ Potential vessel strike during the establishment of the WBE reclamation area and BUF and dredging works – Moderate magnitude: Potential residual impact considered to be medium term in duration (temporal) and contained in extent (spatial) The Project activities cumulative and synergistic impacts have been incorporated into the significant residual adverse impact assessment for this significant impact assessment criteria. The Project activities are not considered likely to seriously disrupt the lifecycle of an ecologically significant proportion of the Australian humpback dolphin or the Australian snubfin dolphin population. The Australian humpback dolphin is understood to have a large home range and a continuous distribution along the inshore environments of the eastern Australian coastline (DoEE 2018b).

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
		Studies have suggested that the Australian snubfin dolphin is unlikely to inhabit Port Curtis and waters south of The Narrows (Cagnazzi 2013), the Project impact areas are not considered likely to support an ecologically significant proportion of the Australian snubfin dolphin population. The Australian humpback dolphin and the Australian snubfin dolphin are thought to be opportunist and generalist feeders, eating a wide variety of coastal and estuarine-associated fishes. Feeding may occur in a variety of habitats, from mangroves to sandy bottom estuaries and embankments to rock and/or coral reefs. Feeding primarily occurs in shallow waters (< 20m depth) and may incorporate beaching behaviour on sandbanks (DoEE 2018a; DoEE 2018b). The species are not considered to require specialised environments for to facilitate feeding activities. Limited life cycle data is available for the Australian humpback dolphin and the Australian snubfin dolphin. Australian humpback dolphin calves may be born throughout the year, with peaks in calves recorded in the spring and summer months (DoEE 2018b). Australian snubfin dolphins have been observed socialising year round in Cleveland Bay (Townsville, Queensland), suggesting that Australian snubfin dolphins may mate year round. Furthermore, Australian snubfin dolphin calves have been recorded year round in Cleveland Bay, indicating that this species may not have a particular calving period (DoEE 2018a). No calving areas for the Australian humpback dolphin or the Australian snubfin dolphin are known in Australian waters (DoEE 2018a; DoEE 2018b). Direct species mortality through vessel strike may disrupt the species breeding cycle. Vessel movements during the Project activities has the potential to result in vessel strike with individuals. Mitigation measures to reduce the risk of vessel strike on dolphins will be included in the Project EMP and Dredging EMP (refer AEIS Appendix F and G, respectively). Elevated levels of some organochlorine compounds and PAHs have been detected in dolphin biopsy samples in central and southern Great Barrier Reef. These elevated levels could impair the reproductive capabilities of the Australian humpback dolphin and the Australian snubfin dolphin (Woinarski et al. 2014). The movement of materials and equipment, which may act as transport mediums for toxic elements and disease, will be subject to the Project EMP. Management plans included in Project EMP and Dredging EMP will contain measures to reduce the potential for Project activities to introduce harmful contaminants into the marine environment. Australian humpback dolphins which occur within Port Curtis persist in an environment which experiences generally naturally turbid background conditions. The Project has a potential to result in decreased water quality through works associated with the establishment of the WBE reclamation area, BUF and dredging activities. Potential Project impacts associated with decreased water quality will be managed in accordance with the Dredging EMP (refer AEIS Appendix F).

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
		Project activities also have the potential to result in increased underwater noise and vibration. Excessive levels of underwater noise may impact on inshore dolphin species via trauma to hearing (temporary or permanent), trauma to non-hearing tissue (barotraumas), alteration of behaviour (e.g. avoidance of predators, interfering with the acquisition of prey or mates, displacement from essential habitat areas) and masking of biologically significant sounds. An assessment of the underwater noise and vibration predicted to be generated as a result of Project activities was undertaken (refer Project EIS Chapter 13). The assessment concluded that it is unlikely that marine mammals in Port Curtis (i.e. dugongs, dolphins and whales) would be at risk of peak acoustic pressure damage from underwater noise and vibration levels generated by the establishment of the WBE reclamation area, BUF or dredging activities. Analysis of potential noise masking indicates the possibility of a behavioural displacement response during foraging and communication for the period of Project works at distances less than 3.4km from the activity. Noise emitted from the removal and installation of navigational aids from a single piling strike was found not to cause PTS-onset injury for dolphins however, zones of impact for permanent threshold shift (PTS)-onset extend from 50m for 1-minute duration, 310m for a 10-minute duration and 1.4km for a 1-hour duration. Noise from a single piling strike associated with navigational aid activity is predicted to cause temporary threshold shift (TTS) onset in dolphins within 18m of the source location, while multiple piling strikes would cause TTS onset within 700m for 100 strikes (i.e. 1 minute duration) and 6km for 6,000 strikes (i.e. 1 hour duration) (SLR 2019b). Through the implementation of management measures contained in the Dredging EMP and Project EMP (refer AEIS Appendices F and G, respectively), the Project is not anticipated to result in significant impacts to the behaviour or lifecycle of the Australian humpback dolphin or the Australian snubfin dolphin. With consideration to the sequential timing and discrete locations of the Project activities and the aforementioned magnitude levels of any potential residual impact, the Project is not considered likely to have a significant residual adverse impact on this significant impact assessment criteria.

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
MNES significant impact assessment criteria – Migratory species ■ Result in invasive species that are harmful to an endangered, vulnerable or migratory species becoming established in the species' habitat **MSES significant impact assessment criteria – Protected wildlife habitat** ■ Result in invasive species that are harmful to an endangered or vulnerable species becoming established in the endangered or vulnerable species' habitat	**Australian snubfin dolphin:** unlikely to have a significant impact **Australian humpback dolphin:** unlikely to have a significant impact	**Unlikely to have a significant impact** Project impacts have been identified which have the potential to result in the introduction and spread of invasive species that are harmful to dolphin species and their habitat. The potential for these impacts to extend to offsite and indirect impact areas has been evaluated via the Project activity's magnitude assessment. The results are summarised below. ■ Increase in waste during the establishment of the WBE reclamation area and BUF and dredging activities – Low magnitude: Potential residual impact considered to be medium term in duration (temporal) and contained in extent (spatial). The Project activities cumulative and synergistic impacts have been incorporated into the significant residual adverse impact assessment for this significant impact assessment criteria. Invasive species have not been identified as a key threatening process to the Australian humpback dolphin or the Australian snubfin dolphin (DoEE 2018a; DoEE 2018b; Woinarski et al. 2014). The operation and movement of marine plant during Project activities has the potential to result in the introduction and/or spread of invasive species in the marine environment. The likelihood of the Project introducing or spreading invasive species within the marine environment is considered to be reduced and effectively managed via the implementation of mitigation measures included in the Project EMP (refer AEIS Appendix G). With consideration to the sequential timing and discrete locations of the Project activities and the aforementioned magnitude levels of any potential residual impact, the Project is not considered likely to have a significant residual adverse impact on this significant impact assessment criteria.
MSES significant impact assessment criteria – Protected wildlife habitat **Introduce disease that may cause the population to decline**	**Australian snubfin dolphin:** unlikely to have a significant impact **Australian humpback dolphin:** unlikely to have a significant impact	**Unlikely to have a significant impact** Project impacts have been identified which have the potential to introduce disease that may cause the decline of dolphin species and populations. The potential for these impacts to extend to offsite and indirect impact areas has been evaluated via the Project activity's magnitude assessment. The results are summarised below. ■ Potential increase in waste material and marine debris during the establishment of the WBE reclamation area and BUF – Low magnitude: Potential residual impact considered to be short term in duration (temporal) and contained in extent (spatial) ■ Contaminant and sediment release during the establishment of WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be medium term in duration (temporal) and contained in extent (spatial)

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
		The Project activities cumulative and synergistic impacts have been incorporated into the significant residual adverse impact assessment for this significant impact assessment criteria. Pollution of habitat for the Australian humpback dolphin and the Australian snubfin dolphin has been identified as a threatening process to the species (DoEE 2018a; DoEE 2018b; Woinarski et al. 2014). Pollution can introduce and spread harmful pathogens and disease into the marine environment and have a detrimental impact on inshore dolphin species. Harmful contaminants such as pesticides, heavy metals, organochlorides and sewage from the land or from boats can pollute the marine environment and increase incidence of disease. Contaminants which have been recorded in marine mammals, including dolphins, and are suspected to have a negative impact on marine mammal health include organohalogen compounds, PCBs and polychlorinated dibenzo-p-dioxin and dibenzofuran compounds. Elevated levels of some organochlorine compounds and PAHs have been detected from dolphin biopsy samples collected from central and southern Great Barrier Reef. These elevated levels could impair the species immune, endocrine and nervous systems, health status or reproduction (Woinarski et al. 2014). Infections of the parasite *Toxoplasmosis gondii* have been recorded in Australian humpback dolphins in the Townsville region. *T.gondii* is a terrestrial parasite that can be fatal or have deleterious effects on the health of marine mammals (DoEE 2018a). Pathogens may enter the environment through pollution and present a risk to the inshore dolphin populations, including the Australian humpback dolphin and the Australian snubfin dolphin. The nature of Project activities is considered unlikely to introduce disease that may cause species decline. The Dredging EMP and Project EMP (refer AEIS Appendices F and G, respectively) will include mitigation measures to minimise the potential of Project activities introducing disease to Port Curtis which may cause species decline. The movement of materials and equipment, which may act as transport mediums for disease, will be subject to the Project EMP. Management plans included in the Dredging EMP will contain measures to reduce the potential for Project activities to introduce harmful contaminants into the marine environment. Any potential Project impact associated with the introduction or spread of harmful diseases to Australian humpback dolphins or Australian snubfin dolphins is considered to be negligible. With consideration to the sequential timing and discrete locations of the Project activities and the aforementioned magnitude levels of any potential residual impact, the Project is not considered likely to have a significant cumulative impact on this significant impact assessment criteria.

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
MSES significant impact assessment criteria – Protected wildlife habitat ■ Interfere with the recovery of the species	**Australian snubfin dolphin:** unlikely to have a significant impact **Australian humpback dolphin:** unlikely to have a significant impact	**Unlikely to have a significant impact** There are no adopted or made recovery plans for the Australian humpback dolphin or the Australian snubfin dolphin (DoEE 2018a; DoEE 2018b). The *Action Plan for Australian Mammals 2012* (Woinarski et al. 2014) identifies key management actions which are recommended to help conserve viable populations of the Australian humpback dolphin and the Australian snubfin dolphin. Specific management actions have been recommended across two themes, active mitigation of threats and community engagement. Specific actions include: ■ Ensure high levels of protection in important habitats ■ Reduce incidental catch in nets and other fisheries impacts ■ Improve national coordinated planning and management of port and coastal development ■ Enhance community education programs to increase awareness and reporting of sightings of the species. Inform stakeholders including Traditional Owners, fishers and other users of marine environments, of best practice codes of conduct for avoiding injury or death of Australian humpback dolphins and Australian snubfin dolphins. With respect to the nature of the Project activities, the Project is not considered likely to result in impacts that will interfere or impede with the aforementioned specific recovery actions for the Australian humpback dolphin or the Australian snubfin dolphin. The Dredging EMP and Project EMP (refer AEIS Appendices F and G, respectively) will include mitigation measures to minimise the potential of Project activities introducing disease to Port Curtis which may cause species decline. The movement of materials and equipment, which may act as transport mediums for disease, will be subject to the Project EMP. Management plans included in the Dredging EMP will contain measures to reduce the potential for Project activities to introduce harmful contaminants into the marine environment.

Table note:

** Includes the identification of potential Project impacts on significant impact assessment criteria, spatial and temporal assessment (i.e. magnitude assessment) of the potential Project residual impact on offsite and indirect impact areas and cumulative Project impact assessment

9.11.5.2 Dugong

The dugong is a migratory species under the EPBC Act and a vulnerable listed species under the NC Act. Consequently, the MNES significant impact assessment criteria for migratory species (DoE 2013) and the significant impact assessment criteria for protected wildlife habitat (EHP 2014a) have been used for the dugong significant residual adverse impact assessment (refer Table 9.49).

The significant residual adverse impact assessment concluded that the proposed Project activities have the potential to have a significant residual adverse impact on the dugong.

Table 9.49 Significant residual adverse impact assessment for MNES and MSES dugong values

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
MNES significant impact assessment criteria – Migratory species ■ Substantially modify (including by fragmentation, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species **MSES significant impact assessment criteria – Protected wildlife habitat** ■ Lead to a long term decrease in the size of a local population ■ Reduce the extent of occurrence of the species ■ Cause disruption to ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species	**Dugong:** Potentially significant impact	**Potentially significant (MSES criteria)** **Unlikely (MNES criteria as the Project impact areas are not considered to be important habitat)** Project impacts have been identified which have the potential to adversely impact the dugong values detailed in the adjacent significant impact assessment criteria. The potential for these impacts to extend to offsite and indirect impact areas has been evaluated via the Project activity's magnitude assessment. The results are summarised below. ■ Permanent loss and alteration of dugong habitat during the establishment of the WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be permanent in duration (temporal) and contained in extent (spatial) ■ Potential noise, vibration and dust impacts during the establishment of the WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be medium in duration (temporal) and contained in extent (spatial) ■ Hydrodynamic and water quality impacts resulting in habitat alteration during the establishment of the WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be permanent in duration (temporal) and contained in extent (spatial) ■ Contaminant and sediment releases resulting in impacts on habitat during the establishment of the WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be medium in duration (temporal) and contained in extent (spatial) The Project activities cumulative and synergistic impacts have been incorporated into the significant residual adverse impact assessment for this significant impact assessment criteria. The Port Curtis region supports a relatively small population of dugongs, although the area is considered to be regionally significant to the south Queensland population. The area of Port Curtis from Rodds Bay to The Narrows was declared a DPA Zone B (restricted use) in 1997 to recognise the importance of Port Curtis seagrass habitat to populations (Sobtzick et al. 2013; Cleguer et al. 2015a).

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
		To identify important areas of habitat and to quantify habitat utilisation in the urban coastal waters of Queensland, Grech et al. (2008) incorporated the JCU TropWATER aerial survey data (1986 to 2011) to develop a spatial model of relative dugong density. Within Port Curtis and Rodds Bay, the relative density shown in the model outputs ranged between low and medium density (i.e. 0 to 0.25 dugongs per square kilometre). Aerial surveys conducted by GHD for the WBDDP EIS baseline surveys (2009) confirmed several dugong sightings within and immediately adjacent to the WBE reclamation area during May and November (GHD 2009). The WBE reclamation area (northern and southern areas) and adjoining areas contain seagrass meadows (GPC Monitoring Meadow 8), which consists of isolated patches of moderate *H. ovalis* and *Z. muelleri*, based on the latest annual survey (Chartrand et al. 2019). The Project involves the permanent loss of seagrass meadows from establishment of the WBE reclamation area. This includes the direct and indirect disturbance of seagrass communities recorded from all seagrass surveys (2002 to 2018 historic mapping), including: ■ Approximately 110.48ha within the WBE reclamation area (southern area) ■ Approximately 164.75ha within the WBE reclamation area (northern area) ■ Approximately 99.41ha within the areas adjoining WBE reclamation area (indirect impacts from erosion and sedimentation due to changes in tidal velocities adjoining the WBE reclamation area). The historic extent of seagrass meadows within the area to be dredged for the channel duplication is 35.65ha of deep water seagrass, however no seagrass has been recorded in the channel duplication footprint since 2002. Baseline surveys of this area will be undertaken prior to the commencement of dredging to determine the extent of seagrass that will be directly impacted within the area to be dredged and indirectly impacted in the zone of high impact for the channel duplication. Further the Project dredging has the potential to have indirect impacts on seagrass meadows that are mapped within the Project dredging zone of high impact which is approximately 876.98ha mapped from historic extent (i.e. 2002 to 2018). However the permanent loss of deep water seagrass within the Project zone of high impact (i.e. indirect impact area) is unlikely due to the implementation of adaptive management measures contained in the Environmental Monitoring Procedure (refer AEIS Appendix H). Project activities also have the potential to result in increased underwater noise and vibration. Excessive levels of underwater noise may disrupt the behaviour of dugongs at ecologically significant locations (e.g. alter foraging behaviour in seagrass meadows). Potential Project impacts to dugongs associated with the generation of underwater noise and vibration would be managed in accordance with the Project EMP and Dredging EMP (refer AEIS Appendices F and G, respectively).

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
		The Port Curtis region is situated within the Queensland Urban Coast. Port Curtis has not been identified as one of the important dugong habitat areas within the Queensland Urban Coast, with the most important habitat areas situated within the Moreton Bay and Hervey Bay regions. As such, potential Project impacts on dugong populations and habitat are not anticipated to impact on an area of important habitat for the migratory species. The Project is not anticipated to have a significant impact on the dugong in accordance with the MNES significant impact guidelines for migratory species (DoE 2013). The establishment of the WBE reclamation area will result in the direct loss of seagrass communities which have the potential to reduce the extent of occurrence of local dugong populations. Furthermore, noise generated during Project activities is considered likely to cause disruption to the species (i.e. foraging behaviour). The Project is considered to have a potential significant impact on local dugong populations in accordance with the MSES significant impact guidelines for protected wildlife habitat (EHP 2014b). Under this significant impact assessment criteria there is likely to be significant residual adverse impact to dugong foraging habitat due to: ■ Permanent loss of 374.64ha of seagrass meadows as a result of the establishment of WBE reclamation area, including: – 110.48ha from the establishment of the WBE reclamation area (southern area) – 164.75ha from the establishment of the WBE reclamation area (northern area) – 99.41ha from indirect impacts for the establishment of the WBE reclamation area. Permanent loss of 35.65ha of seagrass meadows at the channel duplication area to be dredged.
MSES significant impact assessment criteria – Protected wildlife habitat ■ Fragment an existing population **Result in genetically distinct populations forming as a result of habitat isolation**	**Dugong:** unlikely to have a significant impact	**Unlikely to have a significant impact** Project impacts have been identified which have the potential to fragment dugong populations. The potential for these impacts to extend to offsite and indirect impact areas has been evaluated via the Project activity's magnitude assessment. The results are summarised below. ■ Permanent loss and alteration of dugong habitat during the establishment of the WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be permanent in duration (temporal) and contained in extent (spatial) The Project activities cumulative and synergistic impacts have been incorporated into the significant residual adverse impact assessment for this significant impact assessment criteria.

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
		The scale of movement in dugongs is individualistic and heterogenous. Movement studies using tracking devices have recorded dugong movements on a micro-scale (< 15km), mesoscale (between 15-100km) and a macroscale (between 100-560km) (Sheppard et al. 2006). Movement studies have found that the home ranges of dugongs can overlap between individuals and that most individuals maintain a close association with inshore seagrass beds (DoEE 2019e; Sheppard et al. 2006). The seagrass meadows within the Port Curtis region potentially provide connectivity habitat between larger dugong habitat areas at Shoalwater Bay to the north and Hervey Bay to the south (Sobtzick et al. 2013; Cleguer et al. 2015a). The establishment of the WBE reclamation area has the potential to result in indirect impacts from erosion and sedimentation due to changes in tidal velocities adjoining the WBE reclamation area. These indirect impacts have the potential to result in the fragmentation of approximately 99.41ha of seagrass meadows mapped in the area between the northern and southern WBE reclamation areas and between the WBE reclamation area and the mainland (i.e. based on the 2002 to 2018 historic seagrass surveys). This seagrass meadow area has been included within the Project's permanent loss of dugong foraging habitat assessed under the first significant impact assessment criteria. Permanent loss of 374.64ha of seagrass meadows as a result of the establishment of WBE reclamation area, including: ■ 110.48ha from the establishment of the WBE reclamation area (southern area) ■ 164.75ha from the establishment of the WBE reclamation area (northern area) ■ 99.41ha from indirect impacts for the establishment of the WBE reclamation area. Baseline surveys will be undertaken prior to commencement of the Project to map areas of seagrass meadows that are likely to be impacted by Project activities. This will further inform the assessment of fragmentation of marine communities, including seagrass meadows, especially deep water seagrass. Seagrass adjacent to the Western Basin and WBE reclamation areas will be monitored following construction to identify actual impacts, or to determine if it persists following construction. There is potential for indirect fragmentation of seagrass within the area to be dredged. However the permanent loss of deep water seagrass within the Project zone of high impact (i.e. indirect impact area) is unlikely due to the implementation of adaptive management measures contained in the Environmental Monitoring Procedure (refer AEIS Appendix H). The Project activities will not impede dugong movement. The establishment of the WBE reclamation area and BUF are not considered to create a barrier to dugong movement between habitats. Furthermore, the dredging activities are associated with the existing shipping channel, as such, will not create disturbance or barriers to species movement in new areas.

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
		The Project activities are not anticipated to result in genetically distinct dugong populations forming as a result of habitat isolation. The Project is not considered likely to create a significant barrier to species movement through the marine environment or fragment dugong populations. Additionally, with respect to the proportion of Port Curtis seagrass meadows being directly impacted by the Project and the capacity of dugongs for long range movements, the direct loss of seagrass meadows within the Project impact areas is not considered to have a significant impact on connectivity values for the dugong which would result in the fragmentation of populations or result in genetically distinct populations forming.
MNES significant impact assessment criteria – Migratory species ■ Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species	**Dugong:** unlikely to have a significant impact	**Unlikely to have a significant impact** Project impacts have been identified which have the potential to fragment dugong populations. The potential for these impacts to extend to offsite and indirect impact areas has been evaluated via the Project activity's magnitude assessment. The results are summarised below. ■ Potential noise, vibration and dust impacts during the establishment of the WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be medium term in duration (temporal) and contained in extent (spatial) ■ Short term decline in water quality during dredging activities – Low magnitude: Potential residual impact considered to be short term in duration (temporal) and contained in extent (spatial). The Project activities cumulative and synergistic impacts have been incorporated into the significant residual adverse impact assessment for this significant impact assessment criteria. The Project activities are not considered likely to seriously disrupt the lifecycle of an ecologically significant proportion of the dugong population. The dugong diet consists primarily of seagrass (along with macroinvertebrates and algae) (Marsh et al. 2011). Dugongs have the potential to be displaced by a lack of suitable habitat or a loss of food sources and can travel long distances in search for seagrass (Marsh et al. 2002; Sheppard et al. 2006). The Project will involve the direct removal of seagrass meadows and may disrupt the foraging activities of local dugong populations. Dugongs are thought to use specialised habitats for various activities, such as the use of tidal sandbanks and estuaries for calving (Hughes and Oxley-Oxland 1971; Marsh et al. 1984; Marsh et al. 2003). Mating herds of dugong have been observed in Moreton Bay, Shark Bay and the northern Great Barrier Reef region (DoEE 2019e; Marsh et al. 2003). The Project will not have a direct impact on tidal sandbank or estuary areas which are known to support dugong calving.

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
		As the dugong is a long-lived and slow breeding species, direct mortality of dugongs through vessel strike may disrupt the species breeding cycle (DoEE 2019e). Vessel movements during the Project activities have the potential to result in vessel strike with individuals. Mitigation measures to reduce the risk of vessel strike on dugongs will be included in the Dredging EMP. Dugongs delay breeding in adverse environmental conditions (DoEE 2019e). The Project has a potential to result in decreased water quality through works associated with the establishment of the WBE reclamation area and BUF and dredging activities. The resident population of dugongs within Port Curtis persist in an environment which experiences naturally turbid background conditions. Through the implementation of management measures contained in the Project management plan framework (i.e. Dredging EMP and Project EMP), the Project is not anticipated to result in significant impacts to the dugong behaviour due to decreased water quality. Project activities have the potential to result in increased underwater noise and vibration. Excessive levels of underwater noise may impact on dugongs via trauma to hearing (temporary or permanent), trauma to non-hearing tissue (barotraumas), alteration of behaviour (e.g. avoidance of predators, interfering with the acquisition of prey or mates, displacement from essential habitat areas) and masking of biologically significant sounds. An assessment of the underwater noise and vibration predicted to be generated as a result of Project activities was undertaken by SLR (refer Project EIS Chapter 13). The assessment concluded that it is unlikely that marine mammals in Port Curtis (i.e. dugongs, dolphins and whales) would be at risk of peak acoustic pressure damage from underwater noise and vibration levels generated by the establishment of the WBE reclamation area or dredging activities. Potential risk of dugong mortal injuries within a 160m radius of piling activities associated with the removal and installation of navigation aids was identified, and potential behavioural displacement responses by dugong was identified within a 2km radius of the activity (refer Project EIS Chapter 13). Potential Project impacts to dugongs associated with the generation of underwater noise and vibration would be managed in accordance with the noise and vibration management plan (NVMP). The local dugong population present in Port Curtis is not considered to represent an ecologically significant proportion of the dugong population. The Queensland coastline extends from Cooktown to the Queensland/New South Wales border and includes a number of specific areas along the urban coast, adjacent to the GBRWHA, which support dugong populations. Port Curtis is situated on the Queensland Urban Coast and supports dugong populations. Port Curtis has not been identified as one of the important dugong habitat areas within the Queensland Urban Coast, with the most important habitat areas situated within the Moreton Bay and Hervey Bay regions (DoEE 2019e). The Project activities are not considered likely to have a significant impact on the lifecycle of an ecologically significant proportion of a dugong population. With consideration to the sequential timing and discrete locations of the Project activities and the aforementioned magnitude levels of any potential residual impact, the Project is not considered likely to have a significant residual adverse impact on this significant impact assessment criteria.

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
MNES significant impact assessment criteria – Migratory species ■ Result in invasive species that are harmful to an endangered, vulnerable or migratory species becoming established in the species' habitat **MSES significant impact assessment criteria – Protected wildlife habitat** ■ Result in invasive species that are harmful to an endangered or vulnerable species becoming established in the endangered or vulnerable species' habitat	**Dugong:** unlikely to have a significant impact	**Unlikely to have a significant impact** Project impacts have been identified which have the potential to result in the introduction and spread of invasive species that are harmful to dugongs and their habitat. The potential for these impacts to extend to offsite and indirect impact areas has been evaluated via the Project activity's magnitude assessment. The results are summarised below. ■ Increase in waste during the establishment of the WBE reclamation area and BUF and dredging activities – Low magnitude: Potential residual impact considered to be medium term in duration (temporal) and contained in extent (spatial). The Project activities cumulative and synergistic impacts have been incorporated into the significant residual adverse impact assessment for this significant impact assessment criteria. Invasive species have not been identified as a key threatening process to the dugong (DoEE 2019; Woinarski et al. 2014). The operation and movement of marine plant during Project activities has the potential to result in the introduction and/or spread of invasive species in the marine environment. The likelihood of the Project introducing or spreading invasive species within the marine environment is considered to be reduced and effectively managed via the implementation of mitigation measures included in the Dredging EMP and Project EMP (refer to AEIS Appendices F and G, respectively). With consideration to the sequential timing and discrete locations of the Project activities and the aforementioned magnitude levels of any potential residual impact, the Project is not considered likely to have a significant residual adverse impact on this significant impact assessment criteria.
MSES significant impact assessment criteria – Protected wildlife habitat ■ Introduce disease that may cause the population to decline	**Dugong:** unlikely to have a significant impact	**Unlikely to have a significant impact** Project impacts have been identified which have the potential to introduce disease that may cause the decline of dugongs and populations. The potential for these impacts to extend to offsite and indirect impact areas has been evaluated via the Project activity's magnitude assessment. The results are summarised below. ■ Potential increase in waste material and marine debris during the establishment of the WBE reclamation area and BUF – Low magnitude: Potential residual impact considered to be short term in duration (temporal) and contained in extent (spatial)

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
		■ Contaminant and sediment release during the establishment of WBE reclamation area and BUF – Moderate magnitude: Potential residual impact considered to be medium term in duration (temporal) and contained in extent (spatial) The Project activities cumulative and synergistic impacts have been incorporated into the significant residual adverse impact assessment for this significant impact assessment criteria. Disease has not been identified as a key threatening process to the dugong (DoEE 2019e; Woinarski et al. 2014). Marine pollution has been attributed to poor health status in dugong populations and has been identified as a threat factor to the species (Woinarski et al. 2014). Harmful contaminants such as pesticides, heavy metals, organochlorides and sewage from the land or from boats can pollute marine waters and increase incidence of disease. The nature of Project activities is considered unlikely to introduce disease that may cause species decline. To minimise the potential of Project activities introducing disease to Port Curtis which may cause species decline, a Project EMP will be developed and implemented. The movement of materials and equipment, which may act as transport mediums for disease, will be subject to the Project EMP. Management plans within the Dredging EMP and Project EMP will contain measures to reduce the potential for Project activities to introduce harmful contaminants into the marine environment. Any potential Project impact in regards to the introduction or spread of harmful diseases to dugongs is considered to be negligible. With consideration to the sequential timing and discrete locations of the Project activities and the aforementioned magnitude levels of any potential residual impact, the Project is not considered likely to have a significant residual adverse impact on this significant impact assessment criteria.

Significant impact assessment criteria	Assessment outcome for MNES and MSES species	Information**
MSES significant impact assessment criteria – Protected wildlife habitat ■ Interfere with the recovery of the species	**Dugong:** unlikely to have a significant impact	**Unlikely to have a significant impact** There is no adopted or drafted recovery plan for the dugong (DoEE 2019e). The *Action Plan for Australian Mammals 2012* (Woinarski et al. 2014) identifies key management actions recommended to help conserve viable populations of the dugong. Specific management actions have been recommended across two themes, active mitigation of threats and community engagement. Specific actions include: ■ Ensure high levels of protection in important habitats ■ Reduce incidental catch in nets from shark exclusion devices and fisheries ■ Manage Indigenous hunt to ensure it is sustainable ■ Improve national coordinated planning and management of coastal development, port expansion, and vessel movements to reduce risks to dugong and their seagrass habitats ■ Enhance education programs to inform fishers and other users of marine environments of best practice codes of conduct for avoiding dugong injury or death, minimising seagrass loss, and ensuring future hunting is sustainable With respect to the nature of the Project activities, the Project is not considered likely to result in impacts that will interfere or impede with the aforementioned specific actions for dugong recovery. With consideration to the sequential timing and discrete locations of the Project activities and the aforementioned magnitude levels of any potential residual impact, the Project is not considered likely to have a significant residual adverse impact on this significant impact assessment criteria.

Table note:

** Includes the identification of potential Project impacts on significant impact assessment criteria, spatial and temporal assessment (i.e. magnitude assessment) of the potential Project residual impact on offsite and indirect impact areas and cumulative Project impact assessment

9.11.6 Summary

This section supplements the Project EIS Section 9.21.8 (marine mammals – assessment summary).

Based on the Project EIS Section 9.21.7 and the above supplementary assessment, the Project activities below are likely to have a significant residual adverse impact on the dugong foraging habitat.

- Direct disturbance of 374.64ha of seagrass meadows as a result of the establishment of WBE reclamation area
  - 110.48ha from the establishment of the WBE reclamation area (southern area)
  - 164.75ha from the establishment of the WBE reclamation area (northern area)
  - 99.41ha from indirect impacts for the establishment of the WBE reclamation area.
- Direct disturbance of 35.65ha of seagrass meadows at the area to be dredged (refer Figure 9.10a and Figure 9.10b).

Based on the assessment, the Project activities are unlikely to have a significant residual adverse impact on dolphins or whales as the Project activities will occur outside of potential key habitat areas for the species and are not considered likely to remove ecologically significant locations for the species to the extent that the species populations would decline in extent and numbers. The Project is not likely to seriously disrupt the lifecycle of an ecologically significant proportion of the assessed dolphin and whale species.

The Project will implement mitigation measures provided in the Dredging EMP and Project EMP (refer AEIS Appendices F and G, respectively), and associated management plans to reduce the likelihood and magnitude of potential Project impacts on marine mammals.

The Project potential significant residual adverse impact on dugong foraging habitat will be offset by implementing the Channel Duplication Project Offset Strategy (refer AEIS Appendix E4 for the draft strategy).

9.12 Cumulative impact of historic development within the Port of Gladstone

9.12.1 Historic Port of Gladstone development

This section supplements the Project EIS Chapter 9 (nature conservation) and Chapter 21 (cumulative impact assessment).

In 1847, the site of Gladstone was chosen to be the seat of power for the North Australian colony, housing a penal settlement for the repatriation of convicts into the free settlement. Changes in government in England led to a change of plans and Gladstone was not proclaimed a settlement until January 1854 (GPC 2012).

The early development of the Gladstone region was driven by gold exploration throughout the western regions, such as the Boyne Valley. Between 1853 and 1879, the townships of Calliope and Many Peaks became lively settlements due to gold discoveries. These communities grew even further when gold was commercially mined in the region during the early 1900s. Copper was also mined in the Boyne Valley throughout the late 1800s (GPC 2012).

In commercial shipping terms, the Gladstone region has long been recognised as important, particularly the safe harbour of Gladstone (GPC 2012).

The establishment of the Gladstone Customs House in 1860 led to the slow development of the Gladstone Harbour. In 1863, work began on Auckland Wharf and navigational aids for Port Curtis were installed at Gatcombe Head in 1868 (GPC 2012).

The first major wharf at Gladstone was built in 1885. Exports through the Port initially included meat, butter, wool, sugar, horses and cattle. The current major cargo, coal, was first handled in 1925 at Auckland Point.

The formation of the Gladstone Harbour Board (now known as GPC) in 1914 led to increased activity in the Port through active advertisement (GPC 2012).

During the early 1950s the Port transformed from a declining primary industry export base to the multi-million tonne export centre it is today. In 1954, the Port pioneered bulk coal handling in Queensland by developing and operating coal handling facilities.

Facilities to service the growing requirements of industrial processing activities at Gladstone were constructed from the late 1960s. The South Trees wharves were completed in 1967 to provide for QAL, the Barney Point Coal Terminal facility was completed in 1968, and a grain export terminal was opened in 1971.

Traffic handled at the Port increased from 206,000t in 1960 to more than 10Mt in 1970.

The first stage of the RG Tanna Coal Terminal was completed in 1980 and the first shipment of coking coal was exported to Japan that year. The RG Tanna Coal Terminal is now the fifth largest coal export Port in the world.

Berths at Fisherman's Landing were established to provide for the cement production facility (now Cement Australia) with construction commencing in 1980. Construction was completed in 1981, the same year that the Great Barrier Reef was inscribed on the United Nations Educational, Scientific and Cultural Organisation (UNESCO) World Heritage List.

The Boyne Wharf was established to provide for an aluminium smelter that was opened in 1982. Construction for the Boyne Wharf commenced prior to the inscription of the Great Barrier Reef on the UNESCO World Heritage List.

The GSDA was declared in 1993 following the completion of a Gladstone Industrial Land Study which was undertaken by the Queensland Government to identify appropriate locations to accommodate future industrial development for a period of at least 30 years.

In the late 1990s, additional berths were also established at Fisherman's Landing to provide for the alumina refinery (now Rio Tinto) and a multi-user bulk liquids berth.

In recent years, the Port has continued to expand, with the construction of LNG plants on Curtis Island, and the first stage of the WICT which will provide 27Mtpa of new export capacity from the Port of Gladstone. The WICT can expand to a total of approximately 84Mtpa of long term export capacity when fully developed.

The Port of Gladstone continues to play a key role in facilitating industrial development and the expansion of the local and regional economy.

9.12.2 Summary of environmental impacts for historic Port of Gladstone development

Table 9.50 provides a summary of the likely environmental impacts that have occurred in relation to the development of the Gladstone area and Port of Gladstone since the late 1880s. It is important to note this summary is general in nature to provide acknowledgement that long-standing development and operation of the Port has impacted, and continues to impact (in the context of Government approved development) on the environmental values of the area.

Table 9.50 Summary of likely impacts from the historic development of Gladstone and the Port

Environmental value	Likely impacts from the historic development of Gladstone and the Port
Flora	■ Direct loss of flora species and vegetation communities within development footprints ■ Indirect impacts on flora species and vegetation communities from development edge effects (e.g. weeds, pests, waste material, increase in dust levels) ■ Changes to hydrological regimes and tidal restriction
Fauna	■ Direct loss of fauna species habitat and/or corridors from development footprints ■ Indirect impacts on fauna species and adjoining fauna habitat from development edge effects (e.g. increase in noise, vibration and dust levels, disruption to behaviour/life-cycle, weeds, pests, waste material) ■ Direct mortality and/or injury to fauna ■ Increase in light and transport impacts on fauna species ■ Changes to hydrological regimes and tidal restriction ■ Barriers to fauna movement (e.g. fish) ■ Urban and industrial development impacts (e.g. decrease in stormwater quality, increased nutrients, increased heavy metals, increase in noise levels, decrease in air quality, waste material, etc.) ■ Tourism impacts on fauna species (e.g. decrease in water quality, increase in noise levels, decrease in air quality, waste material, etc.) ■ Commercial shipping impacts on marine fauna species (e.g. increase in noise and vibration levels, waste material, etc.) ■ Recreational and commercial boating and fishing impacts on marine fauna species (e.g. vessel strikes, decrease in water quality, increase in noise and vibration level, waste material, etc.)
Water quality	■ Erosion, sedimentation and decreased water quality in terrestrial waterways and marine areas
Groundwater	■ Alteration of groundwater levels and/or quality ■ Over allocation and/or over use of groundwater ■ Loss of groundwater as a source for ecosystems
Air quality	■ Decrease in air quality within the Gladstone airshed
Noise and vibration	■ Increase in noise and vibration levels within the Gladstone area and Port marine waters
Cultural heritage	■ Direct impacts on cultural heritage sites during vegetation clearing and land disturbance for the development ■ Loss of Traditional Owner access to land as a result of construction and/or operation of Port infrastructure
Social	■ Reduced access to foreshore area for residents and tourists as a result of construction and/or operation of Port infrastructure ■ Increase in light, dust, noise and vibration levels resulting in a decreased level of social amenity for residents and tourists ■ Decrease in visual amenity for residents, recreational users and tourists

9.12.3 Cumulative impact consideration

There are three categories of 'other projects' that are relevant to assessing potential cumulative impacts of the Project:

- Past projects, which have been completed prior to the impact assessment
- Present projects, which are either under construction or commenced operation at the time of the impact assessment
- Future projects, which are planned or approved for a time in the future, but have not yet commenced.

There are two areas of the Project EIS where the influence of these types of projects have been considered, including:

- Chapter 21 and Appendix P of the Project EIS present the results of a cumulative impact assessment for the Project, considering the potential combined impacts of the Project and reasonably foreseeable future projects
- The influence of past and present projects on environmental values is described in relation to wildlife habitat in Chapter 9 of the Project EIS (nature conservation). The desktop and field surveys completed as part of the Project EIS to describe the existing environment inherently considered the influence of past and present projects on the environmental values that may be affected by the Project.

This approach is consistent with the EIS Terms of Reference for the Project and relevant industry guidelines on the successful implementation of cumulative impact assessments. For example, the Minerals Council of Australia Cumulative Environmental Impact Assessment Industry Guide (MCA 2015) states that *'past and present activities are relatively easily assessed by considering the ambient or current environmental conditions and, where known, the trend of environmental values and indicators. In many instances this is already done as part of standard EIA processes'.*

While the EPBC Act outlines a process for the strategic assessment of multiple future projects at a location, the application of such assessments retrospectively for past projects is not a requirement of contemporary impact assessment processes.

As discussed in Section 9.12.1, over a period of more than a century, there has been significant industrialisation of the city and Gladstone Harbour, particularly since the 1960s. Present industrial facilities include an aluminium refinery and smelter, chemical plants, a power station, coal handling terminals, a cement production facility and LNG facilities. All past and present projects of the Gladstone region had influenced or were influencing the existing environment at the time of the environmental studies completed for the EIS. The potential for such impacts to act cumulatively with those of the Project were therefore an inherent component of the impact assessment.

There would be several limitations to completing a quantitative assessment of the impacts of historic port developments in the Gladstone region and considering these impacts alongside those predicted for the Project, including:

- Many of the past projects were completed several decades ago, prior to the existence of contemporary impact assessment processes. Information on environmental values disturbed during construction of these projects is likely to be extremely limited.

- The presence, area and composition of marine habitats can be highly variable in estuarine environments over time, particularly for areas that have been modified, such as Port Curtis. Environmental values are also influenced by many and varied factors through time. For example, while reclamation often involves the loss of mangrove habitats at specific locations, increased sedimentation from human activities in the catchment can also result in the expansion of mangrove communities at other locations (SKM 2013), replacing habitats that were 'naturally occurring' there previously. Similarly, the location and composition of seagrass communities in Port Curtis are known to be highly variable from year to year, and appear to be primarily influenced by the amount of rainfall occurring in local catchments (Chartrand et al. 2019).
- The Port Curtis estuarine environment is likely to have been subject to significant changes during the 100 year period over which past port developments have taken place. Some of these changes have been driven by industrial development, while others are unrelated to such influences and are driven by factors such as floods, urban development and agricultural activities in the catchment. This ever changing 'baseline' makes it impossible to undertake a reliable quantitative assessment of the cumulative impacts of previous projects, even if information was available on the environmental values disturbed for each project.

It is important to note that the Project EIS and AEIS is based on the existing environmental values that are currently (within the period of the baseline EIS studies and other background data and reports) within the Project potential direct and indirect impact areas, which have been altered to some degree from the historical development of Gladstone and the Port.

There are a number of Queensland Government policy positions that are also relevant when considering the balance between future development within the Gladstone region and the Port, and the potential impacts on environmental values, including:

- The GSDA was declared by the Queensland Government in 1993. The vision for the GSDA includes a statement for Gladstone to be the preferred location for the establishment of industrial development of regional, state and national significance and supporting infrastructure
- The Ports Act was established by the Queensland Government in 2015, to balance the protection of the Great Barrier Reef with development of the State's major bulk commodity ports in that region. The Ports Act prohibits major capital dredging for the development of new or expanded port facilities in the GBRWHA outside of the priority ports of Gladstone, Townsville, Hay Point/Mackay and Abbot Point
- The Ports Act also prohibits the sea-based placement of port-related capital dredged material within the GBRWHA. The net effect of this provision and the Project Revised DMPOI (refer AEIS Appendix C) is that the preferred option for the placement of dredged material from the Project is the beneficial reuse of dredged material on low lying or tidal lands located immediately adjacent to the coast (i.e. proposed WBE reclamation area).

These legislative and policy positions have the net effect of encouraging the concentration of industrial development and associated port development in a small number of key locations along the Great Barrier Reef coast, in preference to the alternative of developing several smaller ports distributed throughout multiple locations. While such an approach is likely to increase the potential for cumulative impacts at those locations where major ports exist, there are benefits at a broader scale (across the GBRWHA) of having a small number of industrial hubs where extensive port development is undertaken.

9.13 Ecology potential impacts and risk assessment ratings

Risk assessment rating tables relevant to the potential Project impacts on ecological values have been updated based on the AEIS assessments and are provided in AEIS Appendix E3. This Appendix provides the working detail supporting the risk ratings for each potential Project impact on an ecological value. The appendix details the consequence and likelihood of the potential Project impact, and the resultant risk rating.

9.14 Environmental windows

This section supplements the Project EIS Section 2.4 (dredging component of the Project), Section 2.5 (reclamation and dredged material placement), Section 2.10 (environmental design features and principles) and Chapter 9 (nature conservation).

An 'environmental window' in the context of this Project is defined as times where ecological communities, habitats, species, and/or values are most susceptible to Project activity impacts. For example, the use of environmental windows for a project's construction phase would avoid or minimise (where avoidance is not practical) periods of high risk or greater stress and critical or sensitive phases of the life cycle of sensitive species. Environmental windows can be considered a management strategy used to minimise the impacts of dredging on specific marine flora and fauna values through temporal restrictions on dredging.

In September 2016, the DTMR released the *Maintenance Dredging Strategy for Great Barrier Reef World Heritage Area Ports: Technical Supporting Document*; which identified the following environmental windows to be considered by Queensland port authorities during the development of their maintenance dredging strategies and environmental management plans:

- Seagrass – the seagrass growing season during spring and summer is the environmental window. Seagrass may also be more sensitive immediately after major storm events and tropical cyclone activities.
- Coral reefs and rocky reef communities – the environmental window for corals is during the spawning season. The time of year that corals spawn depends on their location, where on the inshore reefs, corals usually start spawning one to six nights after the first full moon in October, whereas those in the outer reefs spawn during November or December. Macroalgal communities and coral reefs, like seagrass, may also be more sensitive immediately after major tropical cyclone activities.
- Marine turtles – the turtle-nesting season, which generally occurs between October and February, is the environmental window
- Dugongs – Dugongs and their feeding trails are commonly noted in the seagrass meadows of the Port of Gladstone (e.g. Wiggins Island and Pelican Banks)
- Cetaceans – commonly noted in the intertidal area of the Port.

In summary, the relevant Port of Gladstone environmental windows are provided in Table 9.51 and Figure 9.37.

Table 9.51 Summary of Port of Gladstone environmental windows

Environmental value	Environmental window (Event: Time period)
Seagrass	Growing season: July to December
Corals	Spawning inshore reefs: up to 6 days after first full moon in October* Spawning Great Barrier Reef region: up to 6 days after first full moon in November*

Environmental value	Environmental window (Event: Time period)
Flatback turtles	Mating: unknown Nesting: October to January (peak: late November to early December) Hatching: December to March (peak: February)
Green turtles	Foraging: all year round in the Port of Gladstone Nesting: late November to January
Loggerhead turtles	Observed to be present in the Port of Gladstone, peak period of nesting is December
Eastern curlew	Foraging and roosting prior to migration for breeding: range July to March (peak: December to February)
Grey-tailed tattler	Foraging and roosting prior to migration for breeding: range August to April (peak: October to March)
Terek sandpiper	Foraging and roosting prior to migration for breeding: range August to May (peak: October to March)
Lesser sand plover	Foraging and roosting prior to migration for breeding: range September to March (peak: October to March)
Ruddy turnstone	Foraging and roosting prior to migration for breeding: range September to March (peak: October to March)
Dolphins	No known significant events or time periods for the Port of Gladstone
Dugongs	No known significant events or time periods for the Port of Gladstone, however small resident population forages all year round, and seagrass meadows within the Port Gladstone provide an important connective habitat between Shoalwater Bay and Hervey Bay
Whales	Migration through the Great Barrier Reef region: June to August

Table note:

* Spawning time period can vary according to suitable conditions

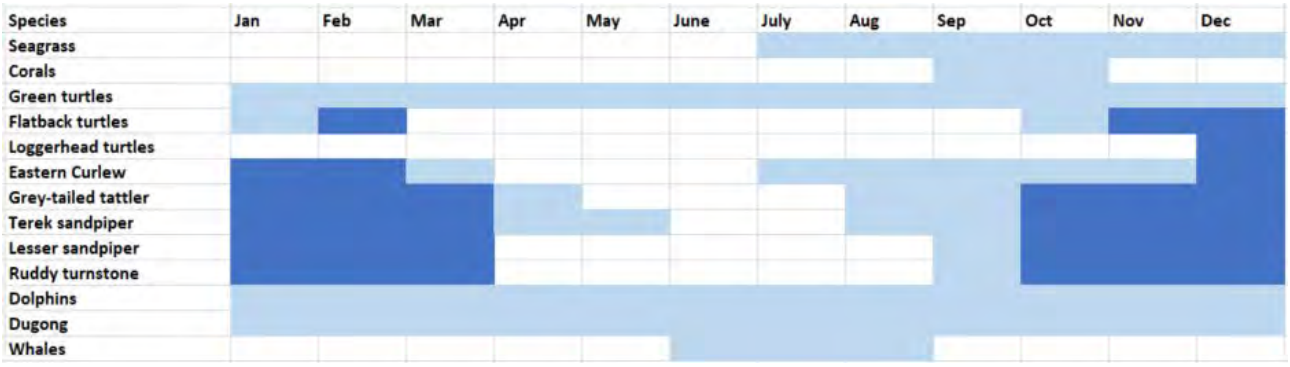

Figure 9.37 Summary of Port of Gladstone environmental windows

Figure note:

Light blue indicates the known growing, foraging, nesting and hatching for species and dark blue indicates the peak period for the species

The Project activities can be described as occurring in discrete spatial and temporal categories. The spatial categories are described below and their location (i.e. area of direct impact) is shown in Figure 9.2.

- Establishment of the WBE reclamation area and BUF
- Dredging activities
- Removal and installation of navigational aids
- Stabilisation and maintenance activities.

The Project temporal aspects (i.e. timeframe of Project activities) are shown in Figure 9.38, which illustrates that the Project construction activities (i.e. establishment of the WBE and BUF, initial dredging and channel duplication dredging, and the installation of navigational aids) will be occurring in series and continuously for up to 4.25 years (including stage 1 dredging only) with a 2 to 3 year gap (or potentially longer) between the Stage 1 and Stage 2 dredging campaigns. For the singular dredging campaign, Project construction activities will be occurring in series and continuously for up to 5.75 years.

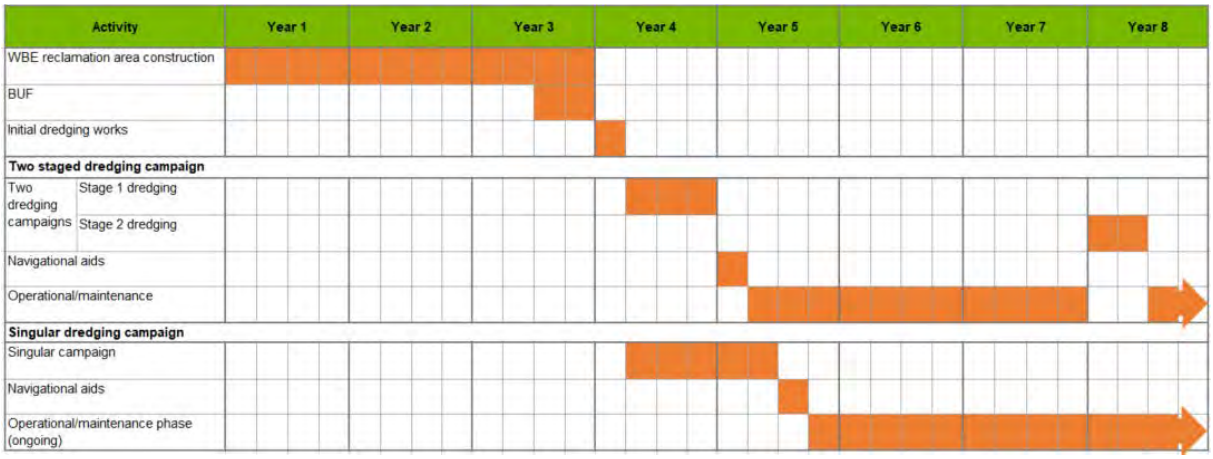

Figure 9.38 Indicative Project activity timeframes

While the extended and continuous timeframe of the Project construction activities does not allow these Project activities to avoid the Port of Gladstone environmental windows for key ecological values, the Project will consider the following when undertaking Project activities within the relevant Port of Gladstone spatial and temporal environmental windows:

- Minimising Project activities or applying specific mitigation measures within close proximity to the Friend Point migratory shorebird roost site
- Minimising Project activities or applying specific mitigation measures within key environmental windows, including:
  - Seagrass growing season
  - Migratory shorebird foraging and roosting prior to migration for breeding
  - Coral spawning periods
  - Flatback turtle internesting.

While Project construction activities are unable to avoid the Port of Gladstone environmental windows, a range of mitigation measure will be implemented during the Project to minimise the potential ecological impacts on these environmental windows. The Project mitigation measures are contained in the following management plans within the Dredging EMP and Project EMP (refer AEIS Appendices F and G, respectively):

- Acid sulfate soil management plan
- Air quality management plan
- Fauna management plan
- Vegetation management plan
- Pest and weed management plan
- Noise and vibration management plan
- Waste management plan
- Water quality management plan and Environmental Monitoring Procedure (refer AEIS Appendix H).

The additional mitigation measures provided below have been identified to minimise potential Project impacts on the Port of Gladstone environmental windows. These measures have been included in the relevant Project management plans.

- In the event that two or more of any endangered or vulnerable species of marine megafauna are fatally injured on any two out of three consecutive days, the dredging operation must stop and not re-commence until consultation with DES has occurred and direction has been given by DES to allow re-commencement
- Retrieved turtle carcasses (and parts of) shall be immediately notified on the RSPCA Hotline 1300 264 625 (1300 ANIMAL), to allow prompt collection by DES for analysis.

9.15 Matters of National Environmental Significance and Matters of State Environmental Significance

9.15.1 Avoidance of impacts to Matters of National Environmental Significance and Matters of State Environmental Significance

This section supplements the Dredging EMP (refer AEIS Appendix F) and the Project EMP (refer AEIS Appendix G).

The Project has sought to avoid impacts to MNES and MSES by adopting the following measures/actions:

- The selection of the WBE reclamation area as the proposed dredged material placement area for the Project and WBDDP future dredging stages results in the need for constructing only one new/expansion reclamation area to accommodate 36.29Mm^3 (insitu) of capital dredged material from both projects, rather than the construction of two or more new reclamation areas (refer AEIS Appendix C)
- During the Project impact assessment process the WBE reclamation area bund areas were changed to avoid direct impacts on the mainland mangroves and terrestrial flora and fauna habitat
- During detailed design, adaptive design measures will be implemented to reduce the potential impacts of the Project on ecological values within and adjacent to the Project impact areas. The detailed design phase will seek to avoid impacts on ecological values in the first instance. Where impacts are unavoidable, the design of structures, systems and/or ancillary works will seek to minimise potential impacts on ecological values. Examples of how adaptive design measures will be implemented during the detailed design phase of the Project include:
  - Design of stormwater management systems associated with the reclamation area to appropriately locate discharge points away from sensitive ecological receptors, such as seagrass meadows
  - Design of the reclamation area discharge points to prevent fauna entering the reclamation area and potentially becoming stranded/trapped, and to enable any fauna within the reclamation area safe egress into the marine/intertidal environment
  - Location of construction compounds, site offices, storage or stockpiling areas in consideration of existing ecological values. These will be located within existing disturbed areas where suitable, and with adjacent ecological values and potential for indirect impacts on these values considered during detailed design and siting.
- Consideration of implementing environmental windows for Project activities where practical (refer Section 9.14)

- The clearing or removal of terrestrial, intertidal or marine vegetation (where unavoidable) will be restricted to the minimum required to enable the safe construction and maintenance of the Project, including minimising disturbance to ecologically sensitive areas
- Parking of vehicles, stockpiling, or storage of plant/equipment will not be permitted within areas of native vegetation. Tree protection zones will be established where Project impact areas are within/adjacent to remnant vegetation, as identified by a suitably qualified person (e.g. arborist, ecologist, environmental officer/manager).
- The implementation of adaptive management measures will act to ensure dredging-related plumes do not cause long term harm to sensitive ecological receptors, including corals and seagrass. Ongoing water quality and BPAR monitoring will be conducted at a range of sites that are within the expected range of sediment plumes generated by the Project dredging activities. This will allow for adaptive management relating to both the extent of potential sedimentation impacts on corals, and potential light impacts (as a result of increased turbidity) on seagrass meadows (i.e. including coastal and deep water seagrass meadows) (refer AEIS Appendix H).
- Standard operating procedures to be undertaken by contractors during piling activities include pre-start, soft start, normal operation, stand-by operation, and shut-down procedures
- An exclusion/safety zone will be created around the perimeter of the pile driving activities. During the works, a suitably qualified marine fauna spotter will be present to ensure that pile driving will not be carried out while:
  - Dugongs, marine turtles, dolphins, whales or other protected marine species are within 300m of operations
  - Migratory birds are within 25m of operations

  Activities will be placed on hold for the period of time it takes the animal to leave the exclusion/safety zone of its own accord.

  The following fauna safety shut-down zones will be also be implemented for continuous impact piling durations using the fauna spotter:

Table 9.52 Fauna safety shut-down zones

Noise exposure threshold based on cumulative SEL (within a 24-hour period)		Observation zone	Shut-down zone
Duration with continuous piling @ 100 strikes/min	Cumulative SEL < 198dB re 1µPa^2·S		
≤ 1 min	≤ 50m	1.0km	50m
10 min	310m	1.0km	310m
60 min	1.4km	2.0km	1.4km

- Avoid conducting impact piling during the following times where practical:
  - When marine mammals are likely to be breeding, calving, feeding or resting in biologically important habitats nearby
  - Humpback whale migration season from June to August
  - During marine turtle (Loggerhead turtle and Flatback turtle) peak nesting activity period from November to December, and February.
- Dredge and pump equipment will be fitted with noise suppression devices, and noisy plant or equipment will be acoustically treated or housed
- Dredging operations will not be undertaken in unsuitable conditions (i.e. outside the operational parameters of the dredge, for example in high energy situations such as storm surges)
- Dredging activities will be restricted to the Project's approved areas and depths

- No waste (including sewage) must be released to the environment, stored, transferred or disposed contrary to any conditions of Project approvals
- Waste generated during dredging will be managed in accordance with the waste hierarchy, and must be stored, handled and transferred in a proper and efficient manner to prevent environmental harm
- TSHD dredge heads must be capable of, and have fitted, fauna exclusion devices, including but not limited to, turtle deflectors
- Barges must be fitted with 'green valves' in the overflow pipe to control the amount of air contained in the excess water (i.e. reducing turbidity)
- No blasting will be undertaken as part of the Project
- Implementation of a Ballast Water Management Plan (BWMP) in accordance with the Australian Ballast Water Management Requirements (Version 6) (Commonwealth of Australia 2016)
- For Project vessel speed limits will be enforced to prevent injuries to marine fauna. For Project vessels go slow zones will be established in shallow areas, less than 5m in depth. Vessels travelling in these areas will not travel on the plane.
- Lighting solutions will be implemented to reduce potential marine fauna attraction to the Project direct impact area and Project vessels, and to avoid potential habitat fragmentation and fauna disturbance
- The dredged material will remain in a saturated state in the barges and during placement in the WBE reclamation area, to minimise the potential for oxidation of PASS. Dredged materials will not be stored in the barges or trucks for more than 24 hours and will be kept saturated.
- Dredging of identified PASS 'hot spot' areas will occur within the early stages, where practicable, to allow strategic placement of sediments containing PASS within the safe PASS reinternment level (SPRL) in the WBE reclamation area
- Any runoff from the Western Basin and WBE reclamation areas (sediment above water level) will be directed towards a series of internal ponds and tested (for pH, metals, etc.) prior to discharge into Port Curtis via the licenced discharge point
- Design specifications for the WBE reclamation area and BUF will avoid disturbance of marine and terrestrial surface and subsurface soils, where practical. Where disturbance is unavoidable, the design specification will endeavour to minimise the disturbance footprint.
- To prevent the oxidation of PASS material through the potential creation of a 'mud wave' during bund wall construction:
  - Unconsolidated materials (i.e. the mud wave, if generated) above the mean high water neap will be excavated and contained separately in a designated treatment area
  - Excavated materials will be tested by a National Association of Testing Authorities (NATA) accredited laboratory for SPOCAS and treated with the required amount of aglime
  - Sediments will be validated at a rate of 1 sample/1,000m^3, prior to re-instatement into the reclamation area. Validation shall confirm, using SPOCAS analysis, that the sediment has no potential acidity and the laboratory calculated liming rate is < 1kg $CaCO_3$/tonne.
- Removal of intertidal vegetation will be restricted to the minimum required, to enable the safe construction and operation of the WBE reclamation area, including minimising disturbance to ecologically sensitive areas, such as adjacent seagrass and mangrove communities
- Implementation of Species Management Programs for conservation significant species where required under the NC Act
- WBE reclamation area outer bund wall construction occurring adjacent to sensitive habitats (e.g. shorebird habitat) will be conducted in the presence of a fauna spotter catcher

- The fauna spotter catcher will have the authority to initiate a 'stop-work' order within the buffer zone of an active breeding place (i.e. 50m for all raptor, owl, and conservation significant species; 30m for all other species)
- During construction of the WBE reclamation area and BUF, migratory shorebirds utilising the adjoining Friend Point roost site will be monitored by a suitably qualified person (e.g. fauna spotter catcher, ecologist) to determine if adaptive management of Project activities is required. This will include monitoring impacts in response to a range of construction-related activities, including potential noise and dust impacts; vehicle movements; and the potential introduction and/or spread of pest species (e.g. foxes, wild dogs). Works will cease and mitigation measures developed where the suitably qualified person identifies that the Project activities are resulting in frequent alarm or flight responses, or avoidance of the adjoining Friend Point roost site and foraging habitat. The results of the monitoring will be reported and will include the identification of adaptive management measures to be implemented to avoid or reduce impacts on these species.
- A bund wall closure plan will be prepared to manage potential impacts on marine and intertidal fauna species. This plan will include the following measures:
  - When construction of the WBE reclamation area and BUF reaches the stage where the bund/sheet piling wall is to be closed, a suitably qualified and experienced marine spotter will be present to minimise the risk of marine fauna being stranded within the WBE reclamation area and BUF
  - If there are any instances of overflow from marine waters into the reclamation area or BUF once it has been closed, the area within the reclamation area or BUF bund will be immediately inspected for any stranded fauna
  - Fish capture/salvage techniques will be implemented, as provided in the Fish Salvage Guidelines (DAF 2018b), if required
  - All personnel involved in the capture and salvage of fauna will be appropriately inducted and trained
  - Fauna exclusion measures will be installed on the seaward facing side of all discharge points to prevent fauna entering into the reclamation area via the discharge points. Exclusion measures will allow fauna within the reclamation area to leave and re-enter the marine environment (e.g. one-way gates), regular checking to avoid being left open and marine fauna entering.
- Hazardous substances with the potential to impact fauna and associated habitat will be stored within suitably contained and bunded areas, and located an appropriate distance from waterbodies and/or sensitive habitats
- The Project direct impact areas will remain free of plastic shopping bags to reduce detrimental impacts to marine and migratory species that occur within the areas that have the potential to be impacted by the project activities
- Where practical the construction compound and other laydown areas will be located within existing cleared and/or disturbed areas that are considered to be of low ecological value
- Avoid movement of soil and fill material from weed affected areas to 'clean' sites
- Avoid and/or minimise the use of herbicides and pesticides within or near intertidal/marine areas and drainage lines. Only use products that are specifically formulated for use in environmentally sensitive areas.
- Vehicle movement will be restricted to designated roads and temporary tracks, wherever practicable
- Broadband reversing alarms are to be used instead of tonal reversing alarms where the Friend Point roost site is within 1km of proposed construction works
- All equipment will be turned off when not in use

- Where practical, refuelling of heavy vehicles hauling material for the construction of the WBE reclamation area will not occur at the WBE reclamation area
- The implementation of other mitigation measures provided in the Project EMP, Dredging EMP and Environmental Monitoring Procedure (refer AEIS Appendices F to H, respectively) will also assist in avoiding and minimising potential Project impacts on MNES and MSES.

With the effective implementation of the Project EMP, Dredging EMP and Environmental Monitoring Procedure (refer AEIS Appendices F to H, respectively) within the framework of the GPC EMS, the Project EIS and AIES has concluded that the majority of ecological impacts from Project activities fall within the significance range of low to moderate and are acceptable in the context of:

- A Port infrastructure project to be carried out within Port limits with the objective of improving operational and economic efficiency of the Port and reducing vessel incident risk
- The Project aligns with national, State and regional policies regarding sustainable growth of priority ports, including the National Ports Strategy, Ports Act and the Master Plan for the priority Port of Gladstone 2018 in response to Reef 2050. In particular, the Port of Gladstone is one of only four priority ports within the GBRWHA which have been identified for port and industrial expansion over the next 30 years and beyond.
- The Project EIS and AEIS significant residual adverse impact assessments have concluded that the establishment of the WBE reclamation area and Project dredging activities will potentially result in a significant residual adverse impact on:
  - Migratory shorebird foraging habitat, including for threatened migratory shorebirds (loss of 479.30ha) (MNES and MSES)
  - Dugong foraging habitat (loss of 374.64ha at WBE reclamation area and loss of 35.65ha at the channel duplication area to be dredged) (MNES and MSES)
  - Green turtle foraging habitat (loss of 374.64ha at WBE reclamation area and loss of 85.33ha at the channel duplication area to be dredged) (MNES and MSES)
  - Marine plant (including seagrass and macroalgae) (loss of 374.64ha at WBE reclamation area and loss of 85.33ha at the channel duplication area to be dredged) (MSES)
  - Wetlands and watercourses (HES wetlands) (loss of 73.61ha) (MSES)
  - Beach stone curlew (resident shorebird) foraging habitat (loss of 479.30ha) (MSES).
- A Draft Channel Duplication Project Offset Strategy has been developed as part of this AEIS to mitigate the above significant residual adverse impacts on ecological values (refer AEIS Appendix E4).

9.15.2 Increased turbidity impacts during dredging on marine fauna species

The potential Project impacts on marine fauna from increases in turbidity have been addressed in the following Project EIS and/or AEIS sections:

- Project EIS Section 9.13.3 (fish and marine reptiles) and AEIS Section 9.6.3
- Project Section 9.15.3 (soft sediment habitats and benthic macroinvertebrates) and AEIS Section 9.7.1
- AEIS Section 9.10 (marine turtles)
- Project EIS Section 9.21.3 (marine mammals).

The predicted changes in water quality (turbidity) from Project dredging activities are provided in Project EIS Section 8.6.6 (impacts of dredging activities and dewatering) and the AEIS Appendix D. The results of the modelling are a direct input into the assessment of potential Project impacts on marine fauna from increases in turbidity.

The overall Project capital works program scenario modelled the expected operations for all three components of the dredging program in series (i.e. initial dredging works, Stage 1 and Stage 2).

The Project EIS Figure 8.18 to Figure 8.21 give an overall indication of the spatial distribution of the predicted Project dredging impacts of the dredging program in its entirety. These figures show percentiles (depth averaged turbidity) and deposition rate due to dredging overall of the 14 day windows during the campaign throughout the model domain.

These figures give an overall indication of the spatial distribution of dredging impacts characteristic of the dredging program in its entirety, including all sources of suspended sediment. The average change in the turbidity percentiles was calculated for each stage of the dredging campaign, and the overall impact at each location in the model was taken as the largest predicted impact from any of the Project stages. These impact figures were used as the basis for derivation of the water quality zones of impact/influence results (refer AEIS Appendix D (Section 5.4.2)).

The modelling results indicate that some short term impacts to turbidity levels are expected throughout the Port area, with the highest increases in areas outside the Port where wave activity can resuspend existing sediment and dredged sediment after initial deposition. It is important to note that the ambient (background) turbidity level is high throughout the study area (refer top panel in Project EIS Figure 8.18). The modelling results indicate minor sustained impacts (refer Project EIS Figure 8.19) to the turbidity level within the Port, and higher sustained (but temporary) effects in the vicinity of the area to be dredged and further offshore (due to resuspension activity).

The term ‘short term’ is used in the Project impact assessment due to the risk definition adopted for duration of the potential impact which is an input into the magnitude of the potential risk. Short term, for the purposes of the Project risk assessment, is defined as up to 1 year (i.e. 6 to 12 months or up to 2 seasons (wet/dry).

Notwithstanding the risk definition of short term, the Project impact assessment has appropriately considered the impact of increased turbidity on the marine fauna within Port of Gladstone during the Project dredging activities due to the incorporation of the predicted Project turbidity modelling and water quality zones of impact into the ecological impact assessment.

9.15.3 Matters of National and State Environmental Significance relevant to the Project

This section replaces the Project EIS Section 9.26 (matters of national and state environmental significance) and 9.29.13 (significant residual adverse impact).

A summary of the MNES located in the Project impact areas is provided in Table 9.53, including the relevant sections of the EPBC Act. The table outlines where controlling provisions under the EPBC Act are not relevant to the Project activities (e.g. nuclear actions).

A summary of the MSES located in the Project impact areas, and a summary of the likelihood of significant impacts occurring as a result of the Project is provided in Table 9.54.

Table 9.53 Matters of national environmental significance and their relevance to the Project

MNES in relation to the Project	Summary of values/species present within the Project impact areas	Summary of Project impacts and significant impact assessment
World Heritage properties (Sections 12 and 15A) and National Heritage places (Sections 15B and 15C)		
The areas to be dredged (including the channel duplication and barge access channel), location of new navigational aids, the WBE reclamation area and BUF are situated within the boundaries of the GBRWHA which is both a World Heritage property and a National Heritage place (i.e. Project activities below the LAT within the Port are located within the GBRWHA)	Project EIS Section 9.25 provides a summary of the local expression of the OUV of the GBRWHA within the Port of Gladstone, and that are therefore relevant to the Project. The 2012 *Statement of Outstanding Universal Value for the Great Barrier Reef World Heritage Area* establishes that the GBRWHA meets all four natural heritage criteria of the current Operational Guidelines, all of which are considered to be present within the Port of Gladstone. These are: ■ Criterion vii – contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance ■ Criterion viii – be outstanding examples representing major stages of earth's history, including the record of life, significant ongoing geological processes in the development of landforms, or significant geomorphic or physiographic features ■ Criterion ix – be outstanding examples representing significant ongoing ecological and biological processes in the evolution and development of terrestrial, freshwater, coastal and marine ecosystems and communities of plants and animals ■ Criterion x – contain the most important and significant natural habitats for in situ conservation of biological diversity, including those containing threatened species of OUV from the point of view of science or conservation	**No significant impacts are expected** The Project activities have the potential to have impacts on several values that contribute to the OUV of the GBRWHA, including: ■ Loss of seagrass meadows as a result of the establishment of the WBE reclamation area, equating to approximately 374.64ha based on historical mapping and the loss of seagrass including macroalgae in the channel duplication area to be dredged equates to approximately 85.33ha ■ Potential impacts on marine fauna (including dugong and other marine mammals) through direct loss of habitat and indirect impacts such as underwater noise, temporary impacts on water quality including the suspension and resuspension of fine sediments, vessel strike and direct contact with dredging equipment ■ Potential impacts on migratory shorebirds through direct loss of foraging habitat and potential indirect impacts associated with establishment of the WBE reclamation area and BUF (e.g. noise and dust impacts) The Project is therefore likely to have an impact on the expression of GBRWHA values at the local-level (i.e. Port Curtis), however it is unlikely that this would result in the loss or significant diminishment of the local expression of these values in Port Curtis. With the implementation of the Dredging EMP (refer AEIS Appendix F) and the Project EMP (refer AEIS Appendix G), it is unlikely that the Project will result in the notable loss, damage, degradation and/or modification of values of the GBRWHA.

MNES in relation to the Project	Summary of values/species present within the Project impact areas	Summary of Project impacts and significant impact assessment
Wetlands of international importance (Ramsar wetlands) (Sections 16 and 17B)		
No Ramsar wetlands are located within close proximity to the Project impact areas. Shoalwater and Corio Bay Ramsar wetlands are located approximately 98km to the north of the WBE reclamation area	▪ These wetlands are located outside of the Project impact areas and will not be impacted by the Project	**No significant impacts are expected** The Project will not impact on Ramsar wetlands.
Nationally threatened species and ecological communities (Section 18 and 18A)		
Subtropical and Temperate Coastal Saltmarsh TEC is known to occur in Project indirect impact areas	▪ There will be no direct loss of this TEC as a result of the Project activities, however this TEC is located within the Project indirect impact areas as it is situated approximately 200m to 300m west of the WBE reclamation area	**No significant impacts are expected** As this TEC is located more than 200m from the nearest direct impact area (i.e. the WBE reclamation area), the Project will not result in the direct loss of this TEC. With the implementation of the Dredging EMP (refer AEIS Appendix F) and the Project EMP (refer AEIS Appendix G), it is unlikely that the Project will significantly impact on the Coastal Saltmarsh TEC.
Suitable habitat for threatened flora species occurs in Project indirect impact areas	▪ No threatened flora species were identified during Project EIS field investigations and no species are known to occur within the direct impact areas as identified during previous and Project EIS studies ▪ Potentially suitable habitat identified within Project potential indirect impact areas, approximately 200m west of the WBE reclamation area	**No significant impacts are expected** Potential suitable habitat for threatened flora species was identified through database searches as occurring approximately 200m west of the WBE reclamation area. With the implementation of the Dredging EMP (refer AEIS Appendix F) and the Project EMP (refer AEIS Appendix G), it is unlikely that the Project will significantly impact on threatened flora species or potentially suitable habitat for threatened flora species.
Marine turtle species are known to forage and nest within Port Curtis, and foraging habitat is present within the Project impact areas (direct and potential indirect impact areas)	▪ Flatback turtle known to nest regularly in Port Curtis ▪ Green turtle known to occur in Port Curtis on a regular basis (only occasionally for nesting) ▪ Loggerhead turtle occasionally nests in Port Curtis ▪ Hawksbill turtle occasionally migrates/forages through Port Curtis ▪ Olive ridley turtle irregularly migrates/forages through Port Curtis	**Green turtle:** Potentially significant impact **Flatback turtle:** Unlikely to have significant impact **Loggerhead turtle:** Unlikely to have significant impact **Hawksbill turtle:** Unlikely to have significant impact **Olive ridley turtle:** Unlikely to have significant impact The Project will not result in direct or significant impacts on known marine turtle nesting beaches in the Port Curtis region.

MNES in relation to the Project	Summary of values/species present within the Project impact areas	Summary of Project impacts and significant impact assessment
		The establishment of the WBE reclamation area and BUF, and dredging activities will result in the direct removal and permanent loss of seagrass, algae and benthic habitats which provide potential foraging resources for the Green turtle species. The inshore region of Port Curtis provides habitat for juvenile, sub-adult and adult Green turtles in the form of foraging grounds and food sources such as seagrass meadows (including species *Z. muelleri*, *Halodule* and *Halophila*) along with mangroves and macroalgae (Limpus 2008a). The Project involves the permanent loss of seagrass meadows from establishment of the WBE reclamation area. This includes the direct and indirect disturbance of seagrass communities recorded from all seagrass surveys (2002 to 2018 historic mapping), including: ■ Approximately 110.48ha within the WBE reclamation area (southern area) ■ Approximately 164.75ha within the WBE reclamation area (northern area) ■ Approximately 99.41ha within the areas adjoining WBE reclamation area (indirect impacts from erosion and sedimentation due to changes in tidal velocities adjoining the WBE reclamation area). The historic extent of seagrass meadows within the channel duplication area to be dredged for the channel duplication is 35.65ha of deep water seagrass, however no seagrass has been recorded in the channel duplication footprint since 2002. Baseline surveys of this area will be undertaken prior to the commencement of dredging to determine the extent of seagrass that will be directly impacted within the channel duplication area to be dredged and indirectly impacted in the zone of high impact for the channel duplication. Further the Project dredging has the potential to have indirect impacts on seagrass meadows that are mapped within the Project dredging zone of high impact which is approximately 876.98ha mapped from historic extent (i.e. 2002 to 2018). However the permanent loss of deep water seagrass within the Project zone of high impact (i.e. indirect impact area) is unlikely due to the implementation of adaptive management measures contained in the Environmental Monitoring Procedure (refer AEIS Appendix H). The loss of seagrass meadows within the Project impact areas is not anticipated to affect the overall abundance of Green turtles in Port Curtis, given that *H. ovalis* and *Z. muelleri* are the dominant seagrass species in coastal meadows in Port Curtis.

MNES in relation to the Project	Summary of values/species present within the Project impact areas	Summary of Project impacts and significant impact assessment
		The Flatback, Loggerhead and Hawksbill turtles are considered unlikely to heavily depend on the intertidal and subtidal areas around the WBE reclamation area, BUF footprint and the zone of impact from dredging activities. Further the significant habitat for foraging activities of the Olive ridley turtle will not be impacted within the WBE reclamation area, BUF footprint and the zone of impact from dredging activities. The Project has the potential to result in impacts on marine turtles as a result of noise and artificial light sources during dredging and piling activities, however these potential impacts will be short term and contained in extent. The Project potential impacts are not considered to have a significant impact on the marine turtle lifecycle, including breeding activities; or on the availability of suitable foraging habitat. Noting that the potential Project impacts are expected to be mitigated and controlled for Flatback, Loggerhead, Hawksbill and Olive ridley turtles, the synergistic impacts and direct loss of foraging habitat has the potential to have significant residual impact on the Green turtle. There is likely to be significant residual adverse impact to Green turtle foraging habitat due to: ■ Permanent loss of 374.64ha of seagrass as a result of the establishment of WBE reclamation area, including: – 110.48ha from the establishment of the WBE reclamation area (southern area) – 164.75ha from the establishment of the WBE reclamation area (northern area) – 99.41ha from indirect impacts for the establishment of the WBE reclamation area. ■ Permanent loss of 35.65ha of seagrass meadows at the channel duplication area to be dredged.
Marine mammal species are known to occur within Port Curtis	■ Humpback whale known to occur in Port Curtis ■ Other marine mammals occur within Port Curtis, however are not listed as threatened species under the EPBC Act (refer to assessments for migratory species below)	**No significant impacts are expected** Several whale species can be can be found seasonally migrating in coastal waters around the Port Curtis region, and Humpback whales are occasionally seen within Port of Gladstone. However, it is unlikely that the Project impacts will result in significant direct impacts on this species or important habitat for this species.

MNES in relation to the Project	Summary of values/species present within the Project impact areas	Summary of Project impacts and significant impact assessment
Threatened migratory shorebirds are known from the Port Curtis, and foraging and roosting habitat is located within Project impact areas	The Project impact areas include known foraging and roosting habitat for threatened migratory shorebirds including: ■ Western Alaskan bar-tailed godwit ■ Curlew sandpiper ■ Eastern curlew ■ Great knot ■ Northern Siberian bar-tailed godwit ■ Red knot ■ Greater sand plover ■ Lesser sand plover	**Potentially significant impact** Project activities will involve the direct disturbance of migratory shorebird foraging habitat, including disturbance within and adjacent to areas of important migratory shorebird habitat (i.e. important roost sites). Project activities also have the potential to result in noise and dust impacts and may disturb migratory shorebird foraging and are anticipated to increase the level of noise and dust in areas of adjacent shorebird habitat. This may result in the potential to disturb roosting and/or foraging behaviours of migratory shorebirds. Disturbance of migratory shorebirds can result in reduced food intake and increased energy expenditure, and has the potential to result in reduced use or abandonment of preferred feeding and roosting areas (Geering et al. 2007). Disturbances resulting in increased time spent in alarm flight, can adversely impact shorebird energy reserves required for migration, and can alter the selection of roosting and foraging sites, and has the potential to ultimately affect the survival of migratory shorebirds (Collop et al. 2016; Lilleyman et al. 2016). Adaptive design measures will be implemented during the Project detailed design phase to reduce the impact of migratory shorebird habitat loss at the WBE reclamation area (refer AEIS Appendix I). Shorebird behaviour will be monitored during establishment of the WBE reclamation area and BUF with adaptive management strategies implemented where activities are likely to result in a significant impact on migratory shorebird species in important habitats. The Dredging EMP and Project EMP (refer AEIS Appendices F and G, respectively) include mitigation measures to minimise the potential to disturb migratory shorebirds as a result of noise and dust impacts associated with Project activities. The significant residual adverse impact to migratory shorebirds as a result of the Project includes: ■ Direct disturbance of 275.37ha of foraging habitat as a result of the establishment of the WBE reclamation area ■ Indirect disturbance of 203.93ha of foraging habitat as a result of the establishment of the WBE reclamation area.

MNES in relation to the Project	Summary of values/species present within the Project impact areas	Summary of Project impacts and significant impact assessment
Threatened migratory seabirds have a moderate potential to occur within the Project impact areas	The Project impact areas include potential habitat for threatened migratory seabirds including: ■ Black-browed albatross ■ Campbell albatross ■ Chatham albatross ■ Fairy prion (southern) ■ Kermadec petrel (western) ■ Salvin's albatross ■ Shy albatross ■ Southern giant-petrel ■ White bellied storm petrel	**No significant impacts are expected** The Project is not considered likely to destroy an area of important habitat or cause significant disruption to an ecologically significant area of habitat for migratory seabird species. There are no known areas of breeding habitat for migratory seabird species situated within the direct or potential indirect Project impact areas. Migratory seabird species exhibit a broad range of diets and foraging behaviours (DSEWPC 2011), and thus are not reliant on specific habitat requirements to facilitate foraging activities. The migratory seabird species subject to this assessment feed predominantly on fish, however also eat crustaceans, insects, annelids and molluscs (Garnett and Crowley 2000). Migratory seabird species are not considered to be reliant on specific microhabitats or prey resources to facilitate foraging activity. With consideration to the species capacity for long range movements, all waters within Australian jurisdiction can be considered to constitute foraging habitat for albatross and giant petrel species. Critical foraging habitat for albatross and giant petrel species is considered to occur in waters south of 25 degrees latitude, due to the closer proximity of these waters to nesting locations (DSEWPC 2011). It is unlikely that the Project activities will result in significant impacts on the potential migratory seabird foraging habitat located in the Project impact areas, and it is therefore unlikely that the Project would impact on migratory seabird populations. Potential impacts on foraging habitat will be minimised through the implementation of mitigation measures in the Dredging EMP (refer AEIS Appendix F) and Project EMP (refer AEIS Appendix G).
Potentially suitable habitat for two threatened fauna species occurs within terrestrial and intertidal Project impact areas	Potential habitat for the following threatened species occurs in the Project indirect impact areas: ■ Koala ■ Water mouse	**No significant impacts are expected** There is no habitat for the Koala within the direct impact areas, and the areas of modelled potential habitat for the Water mouse (based on known habitat requirements) do not extend into the direct impact areas. Potential habitat for both species has been mapped within the Project indirect impact areas, near the WBE reclamation area.

MNES in relation to the Project	Summary of values/species present within the Project impact areas	Summary of Project impacts and significant impact assessment
		Project activities are not likely to result in impacts on the Koala or potentially suitable habitat for this species, as the Project impact areas are situated in intertidal and subtidal environments. Potential habitat for the Water mouse is located in the Project indirect areas associated with the mangrove and coastal saltmarsh communities along the coastline to the west of the WBE reclamation area. There is potential for indirect impacts on areas adjacent to potential habitat as a result of minor predicted changes in erosion, siltation and tidal velocities due to the establishment of the WBE reclamation area and BUF. However, areas of vegetation along the coastline will be monitored prior to, during and post construction of the reclamation area to identify potential adverse impacts. In the event that adverse impacts are identified on these vegetation communities (and associated potential Water mouse habitat), adaptive management strategies will be implemented. The Project activities may also result in short term declines in water quality, noise and dust impacts, however, with the implementation of the Dredging EMP (refer AEIS Appendix F) and the Project EMP (refer AEIS Appendix G), these potential impacts are not likely to have a significant impact on the Water mouse, or on potential habitat mapped for this species.
Migratory species (Section 20 and 20A)		
Migratory marine fish species are confirmed or have a moderate likelihood of occurring in the Project impact areas	The Project impact areas provide suitable habitat for: ■ Five shark species ■ Two manta ray species	**No significant impacts are expected** The WBE reclamation area is not considered to be habitat for other migratory Chondrichthyan species listed under the EPBC Act. Dredging activities will result in the temporary loss of potential habitat for Chondrichthyan species (including species listed as migratory under the EPBC Act) associated with the duplication of the shipping channels the BUF and the barge access channel. This temporary loss is not expected to result in significant impacts on these species as the areas to be dredged are not known to be ecologically significant or important habitat. The Project activities may also result in underwater noise impacts and short term declines in water quality, however, with the implementation of the Dredging EMP (refer AEIS Appendix F) and the Project EMP (refer AEIS Appendix G), these potential impacts are not likely to impact on the size of a population, area of occupancy or important habitat for Chondrichthyan species.

MNES in relation to the Project	Summary of values/species present within the Project impact areas	Summary of Project impacts and significant impact assessment
Migratory reptiles are known to occur or have a moderate likelihood of occurring within the Project impact areas	■ Five marine turtles (refer assessment for marine turtles above)	**Green turtle:** Potentially significant impact **Flatback turtle:** Unlikely to have significant impact **Loggerhead turtle:** Unlikely to have significant impact **Hawksbill turtle:** Unlikely to have significant impact **Olive ridley turtle:** Unlikely to have significant Refer to assessments provided above for threatened marine turtles.
	■ Saltwater crocodile (*Crocodylus porosus*)	**No significant impacts are expected** Preferred nesting habitat of the Saltwater crocodile includes elevated, isolated freshwater swamps that do not experience the influence of tidal movements. The Project is not considered to directly impact key nesting habitat for the Saltwater crocodile. The primary feed sources for the Saltwater crocodile are defined by common and widespread species, including crustaceans, insects and mammals. The Project will have a potential impact on intertidal foraging resources within the WBE reclamation area and BUF, however with respect to the non-specific nature of the foraging resources and the mobility of the Saltwater crocodile and that the works will not isolate species movement, the Project is not anticipated to have a significant impact on the foraging resources for the Saltwater crocodile. The Dredging EMP and Project EMP (refer AEIS Appendices F and G, respectively) include specific mitigation measures to be implemented during Project activities to minimise any potential for direct and indirect impacts on the Saltwater crocodile and areas of potential habitat.
Migratory marine mammal species are confirmed or have a moderate likelihood of occurring in the Project impact areas	■ Humpback whale known to occur in Port Curtis ■ Australian humpback dolphin known to occur in Port Curtis, and has been recorded in the Project impact areas ■ Dugong known to occur in Port Curtis and foraging habitat is present within Project impact areas	**No significant impacts are expected for whales** Refer to assessment provided above for threatened marine mammals, including the Humpback whale. **No significant impacts are expected Australian humpback dolphin** **Potential significant impact to the dugong** The establishment of the WBE reclamation area and BUF, and dredging activities will result in the direct removal and permanent loss of seagrass, algae and benthic habitats which provide potential foraging resources for dugong.

MNES in relation to the Project	Summary of values/species present within the Project impact areas	Summary of Project impacts and significant impact assessment
		The Project involves the permanent loss of seagrass meadows from establishment of the WBE reclamation area. This includes the direct and indirect disturbance of seagrass communities recorded from all seagrass surveys (2002 to 2018 historic mapping), including: ■ Approximately 110.48ha within the WBE reclamation area (southern area) ■ Approximately 164.75ha within the WBE reclamation area (northern area) ■ Approximately 99.41ha within the areas adjoining WBE reclamation area (indirect impacts from erosion and sedimentation due to changes in tidal velocities adjoining the WBE reclamation area). The historic extent of seagrass meadows within the area to be dredged for the channel duplication is 35.65ha of deep water seagrass, however no seagrass has been recorded in the channel duplication footprint since 2002. Baseline surveys of this area will be undertaken prior to the commencement of dredging to determine the extent of seagrass that will be directly impacted within the area to be dredged and indirectly impacted in the zone of high impact for the channel duplication. Further the Project dredging has the potential to have indirect impacts on seagrass meadows that are mapped within the Project dredging zone of high impact which is approximately 876.98ha mapped from historic extent (i.e. 2002 to 2018). However the permanent loss of deep water seagrass within the Project zone of high impact (i.e. indirect impact area) is unlikely due to the implementation of adaptive management measures contained in the Environmental Monitoring Procedure (refer AEIS Appendix H). Given the availability of similar habitat in the surrounding areas, the potential habitat associated with the WBE reclamation area and BUF is not considered to be important habitat for the Australian humpback dolphin. The Project has the potential to result in adverse impacts on dugong and the Australian humpback dolphin as a result of noise associated with dredging and piling activities, however these potential impacts will be short term and contained in extent, and will be managed through the implementation of the Dredging EMP (refer AEIS Appendix F). During dredging activities, a short term decline in water quality is expected to occur in the form of increased turbidity caused by sediment resuspension, predominantly concentrated in and around the areas to be dredged (referred to as the ‘zone of high impact’). Increased turbidity has the potential to impact important dugong and dolphin habitat at seagrass meadows through temporarily decreasing benthic light conditions and smothering through sediment deposition.

MNES in relation to the Project	Summary of values/species present within the Project impact areas	Summary of Project impacts and significant impact assessment
		The Dredging EMP will be implemented during dredging activities which will minimise and mitigate potential impacts to water quality from dredging activities (refer AEIS Appendix F). These plans include adaptive management measures to be adopted during dredging activities which will focus on minimising impacts at key sensitive receptors such as seagrass meadows (e.g. by focussing on benthic light thresholds). Mitigation measures to minimise water quality impacts are provided in the Dredging EMP (refer AEIS Appendix F). With the implementation of the Dredging EMP and Project EMP (refer AEIS Appendices F and G, respectively) it is unlikely that the Project will have a significant impact on the Australian humpback dolphin or the whale. There is likely to be significant residual adverse impact to dugong foraging habitat due to: ■ Permanent loss of 374.64ha of seagrass meadows as a result of the establishment of WBE reclamation area, including: – 110.48ha from the establishment of the WBE reclamation area (southern area) – 164.75ha from the establishment of the WBE reclamation area (northern area) – 99.41ha from indirect impacts for the establishment of the WBE reclamation area. ■ Permanent loss of 35.65ha of seagrass meadows at the channel duplication area to be dredged.
Migratory bird species are confirmed or have a moderate likelihood of occurring in the Project impact areas	■ Sixty migratory bird species are confirmed or have a moderate likelihood of occurrence within in the Project impact areas, this includes migratory shorebirds and migratory seabirds ■ Including populations which have exceeded approximately 0.1% of the flyway population on at least one occasion for the following species: – Eastern curlew – Grey-tailed tattler – Terek sandpiper – Lesser sand plover – Ruddy turnstone	**Potentially significant impact for migratory shorebirds** **No significant impacts are expected for migratory seabirds** Refer to assessments provided above for threatened shorebird and seabird species.

MNES in relation to the Project	Summary of values/species present within the Project impact areas	Summary of Project impacts and significant impact assessment
Commonwealth marine areas (Sections 23 and 24A)		
Commonwealth marine areas include any part of the sea, including the waters, seabed and airspace, within Australia's exclusive economic zone and/or over the continental shelf of Australia. Commonwealth marine areas stretch from 3 to 200 nautical miles from the coast. The Project impact areas are not located within Commonwealth marine areas, with the nearest Commonwealth marine areas situated more than 9km from the area to be dredged and the new navigational aids.	Not applicable to the Project	Not applicable to the Project
Great Barrier Reef Marine Park (Sections 24B and 24C)		
The GBRMP boundary is situated on the open coastal waters side of Curtis and Facing Islands, with the closest Project impact area located more than 2km southwest of the boundary (i.e. the areas to be dredged, near the southern end of Facing Island)	■ The GBRMP is located outside of the Project direct impact areas (i.e. nearest direct impact area is approximately 2km from the GBRMP boundary) ■ Indirect impacts associated with dredging are likely to result in short term declines in water quality within the GBRMP boundary	**No significant impacts are expected** The Project dredging activities have the potential to result in increased turbidity and sedimentation including the suspension and resuspension of fine sediments, within the local area, which may also extend into the GBRMP. Hydrodynamic modelling predicts zones of impact extending into the GBRMP along the eastern side of Facing Island. These zones are predominantly low impact zones, with some localised areas of moderate to high impact. Any declines in water quality in the GBRMP will be temporary in nature and within a contained extent. With the implementation of the Dredging EMP (refer AEIS Appendix F) and the Environmental Monitoring Procedure (refer AEIS Appendix G), it is unlikely that the Project will have a significant impact on the GBRMP.
Nuclear actions (including uranium mining) (Sections 21 and 22A)		
Not relevant to the Project	Not applicable to the Project	Not applicable to the Project
A water resource, in relation to coal seam gas development and large coal mining development (Sections 24D and 24E)		
Not relevant to the Project	Not applicable to the Project	Not applicable to the Project

Table 9.54 Matters of State environmental significance and their relevance to the Project

MSES in relation to the Project	Summary of values/species present within the Project impact areas	Summary of the Project impacts and significant impact assessment
Regulated vegetation		
Regulated vegetation mapped within the WBE reclamation area, BUF and barge access channel potential indirect impact area	■ No regulated vegetation is mapped within the Project direct impact areas ■ 111.67ha of remnant vegetation is mapped within 500m of the WBE reclamation area and BUF (i.e. indirect impact area)	**No significant residual adverse impacts are expected** As the Project activities will not involve the direct disturbance of Prescribed REs, no significant residual adverse impacts are expected to occur as a result of the Project activities. Project activities are not expected to result in high or significant impacts to regulated vegetation within the indirect impact area.
Connectivity areas		
Connectivity value of regulated vegetation	■ There are no core remnant areas occurring within the WBE reclamation area and BUF. The percent change of core remnant areas at a local scale following Project impact is 0%.	**No significant residual adverse impacts are expected** The EHP Landscape Fragmentation and Connectivity Tool analysis determined that any Project impact on connectivity areas is not significant. The analysis is specific to the terrestrial connectivity values of regulated vegetation.
Wetlands and watercourse		
MSES HES wetlands mapped within the Project potential direct and indirect impact areas	■ 48.63ha mapped within the WBE reclamation area (direct impact area) ■ 24.98ha mapped within the WBE reclamation area and BUF potential indirect impact area ■ 0ha mapped within the areas to be dredged, or within the potential indirect impact area	**Significant residual adverse impact is likely to occur** The establishment of the WBE reclamation area will result in the direct disturbance of approximately 48.62ha of mapped HES wetlands. The loss of these HES wetlands is also likely to have an adverse impact on wetland fauna species, in particular resident and migratory shorebirds that are known to roost and forage within close proximity to the WBE reclamation area. Project activities have the potential to have an indirect adverse impact on HES wetlands which are situated within proximity to the WBE reclamation area. Approximately 24.98ha of HES wetlands are mapped within the WBE reclamation area indirect impact area. Project activities are unlikely to result in adverse impacts as a result of impacts on water quality, changes in hydrodynamic regimes, increased marine debris, spread of pest and weed species and the accidental release of contaminants. Mitigation measures outlined in the Dredging EMP (refer AEIS Appendix F) and Project EMP (refer AEIS Appendix G) will be implemented to reduce the potential impacts on wetlands.

MSES in relation to the Project	Summary of values/species present within the Project impact areas	Summary of the Project impacts and significant impact assessment
Designated precinct in a strategic environment area		
The Project impact areas are not situated within a strategic environmental area	▪ There are no strategic environmental areas mapped within the Project direct or potential indirect impact areas	**No significant residual adverse impacts are expected** The Project activities are not expected to have a significant impact on any mapped strategic environmental areas.
Protected wildlife habitat		
Protected Dugong habitat mapped within the Project impact areas	▪ The areas to be dredged, the BUF, barge access channel and the WBE reclamation area are located within the Rodds Bay DPA Zone B ▪ The area which extends from Friend Point, at the base of The Narrows, to the bottom of Rodds Bay was declared the 'Rodds Bay DPA Zone B' to recognise the importance of the seagrass communities present as important habitat for the Dugong	**Significant residual adverse impact is likely to occur for dugong** Project activities are not considered to have a significant impact on dugong as assessed in accordance with the MNES migratory impact criteria (refer Section 9.11.5.2). However, the establishment of the WBE reclamation area will result in the direct loss of seagrass communities which have the potential to reduce the extent of occurrence of local dugong populations. The Project is considered to have a potential significant impact on local dugong populations in accordance with the MSES significant impact guidelines for protected wildlife habitat (EHP 2014b).
Other threatened wildlife known to occur in Port Curtis	▪ Humpback whale is known to occur in Port Curtis ▪ Australian humpback dolphin is known to occur in Port Curtis, and has been recorded in the Project impact areas ▪ The Beach stone curlew was recorded within the Project indirect impact areas during Project EIS field investigations, and the Saltwater crocodile has the potential to occur in Project impact areas ▪ Coastal sheathtail bat is known to occur. During the Project EIS field investigations, no roost sites (i.e. sea caves) for the Coastal sheathtail bat were identified within the Project direct or indirect impact areas	**No significant residual adverse impacts are expected for the Humpback whale or the Australian humpback dolphin** Refer to assessments provided above for the Humpback whale and Australian humpback dolphin. **Significant residual adverse impact is likely to occur for Beach stone curlew** The Beach stone curlew is a largely sedentary species (EHP 2013b). The species was recorded within the indirect impact areas associated with the WBE reclamation during the Project EIS field investigations (i.e. approximately 200m from the reclamation area footprint). The exposed mudflats and saltmarsh communities within the WBE reclamation area direct impact area are likely provide suitable foraging habitat for the species. The mangrove communities within the WBE reclamation area indirect impact area provide suitable high tide roosting habitat for the species. The Beach stone curlew constructs nests in mangroves, estuaries, coral ridges or amongst short grass and scattered casuarinas. No nests for the Beach stone curlew were identified within the Project impact area during EIS field investigations, however the mangrove communities within the WBE reclamation area indirect impact area do provide potential breeding habitat for the species. The removal of foraging habitat for the species at the WBE reclamation area may potentially impact on an ecologically significant location for the Beach stone curlew. The Project is not anticipated to impact on ecologically significant locations for the Coastal sheathtail bat.

MSES in relation to the Project	Summary of values/species present within the Project impact areas	Summary of the Project impacts and significant impact assessment
		Adaptive design measures will be implemented during the Project detailed design phase to reduce the impact of shorebird habitat loss at the WBE reclamation area (including potential foraging habitat for the Beach stone curlew). Project activities may also have impact on the Beach stone curlew as a result of potential noise and dust impacts associated with the establishment of the WBE reclamation area. Shorebird behaviour will be monitored during establishment of the WBE reclamation area, with adaptive management strategies implemented where activities are likely to result in a significant impact on shorebird species (refer Section 9.8). The Dredging EMP and Project EMP (refer AEIS Appendices F and G, respectively) include mitigation measures to minimise the potential to disturb migratory shorebirds as a result of noise and dust impacts associated with Project activities.
Marine turtle species are known to forage and nest within Port Curtis, and foraging habitat is present within the Project impact areas (direct and potential indirect impact areas)	■ Flatback turtle known to nest regularly in Port Curtis ■ Green turtle known to occur in Port Curtis on a regular basis (only occasionally for nesting) ■ Loggerhead turtle occasionally nests in Port Curtis ■ Hawksbill turtle occasionally migrates/forages through Port Curtis ■ Olive ridley turtle irregularly migrates/forages through Port Curtis	**Green turtle:** Potentially significant impact **Flatback turtle:** Unlikely to have significant impact **Loggerhead turtle:** Unlikely to have significant impact **Hawksbill turtle:** Unlikely to have significant impact **Olive ridley turtle:** Unlikely to have significant Refer to assessments provided above for threatened marine turtles.
The Estuary stingray is likely to utilise habitat within the Project impact areas	■ The Project impact areas associated with the WBE reclamation area provide suitable habitat for the Estuary stingray	**No significant residual adverse impacts are expected** The construction of the WBE reclamation area will result in the direct and permanent loss of potential habitat for the Estuary stingray. With the implementation of mitigation measures outlined in the Dredging EMP (refer AEIS Appendix F) and the Project EMP (refer AEIS Appendix G), it is unlikely that the Project will result in impacts on the Estuary stingray.

MSES in relation to the Project	Summary of values/species present within the Project impact areas	Summary of the Project impacts and significant impact assessment
Threatened migratory shorebirds, and migratory shorebirds and seabirds listed as special least concern species are known from areas adjacent to the Project impact areas and potential habitat is located within the Project impact areas	The Project impact areas include potential habitat for threatened migratory shorebirds including: ■ Western Alaskan bar-tailed godwit ■ Curlew sandpiper ■ Eastern curlew ■ Great knot ■ Northern Siberian bar-tailed godwit ■ Red knot ■ Greater sand plover ■ Lesser sand plover ■ The Project impact areas include potential habitat for a range of special least concern migratory shorebirds and seabirds	**No significant impacts are expected for migratory seabirds** Refer to assessments provided above for threatened migratory seabirds. **Potentially significant impacts for migratory shorebirds** Refer to assessments provided above for threatened migratory shorebirds.
Habitat for several endangered and vulnerable species is known or predicted to occur within the Project impact areas	Essential habitat is mapped within the Project indirect impact areas associated with the Western Basin and WBE reclamation areas, including: ■ 258.34ha of Essential Habitat for the Coastal sheathtail bat ■ 14.81ha of Essential Habitat for the Koala ■ 5.17ha of Essential Habitat for the Water mouse	**No significant residual adverse impacts are expected for Coastal sheathtail bat, Koala, Water mouse or Saltwater crocodile** Refer to the summary provided in Project EIS Section 9.7.8 for a summary of the potential impacts for Water mouse, Koala and Saltwater crocodile. Essential habitat is mapped for the Coastal sheathtail within the WBE reclamation area indirect impact area. These areas of habitat are considered likely to provide potential foraging habitat for the species. The Coastal sheathtail bat is associated with a large variety of habitats close to the sea, including mangroves, coastal sand dunes, Melaleuca swamps, rainforest and any other habitats within foraging range of the species roosts. The Coastal sheathtail bat is not considered to have specialised or specific resources for foraging. During the Project EIS field investigations, no roost sites (i.e. sea caves) for the Coastal sheathtail bat were identified within the Project direct or indirect impact areas. The Project is not anticipated to impact on ecologically significant locations for the Coastal sheathtail bat. Given the broad habitat requirements of this species, their highly mobile nature, availability of suitable habitat in the broader region, and the predominantly intertidal and subtidal nature of the Project activities, it is unlikely that the Project will have a significant residual adverse impact on this species.

MSES in relation to the Project	Summary of values/species present within the Project impact areas	Summary of the Project impacts and significant impact assessment
Protected areas		
There are no protected areas, under the provisions of the NC Act, present within the Project impact areas	■ There are no protected areas mapped under the provisions of the NC Act within the Project impact areas	**No significant residual adverse impacts are expected** The Project activities are not expected to have an impact on protected areas listed under the provisions of the NC Act.
Highly protected zones of State marine parks		
The GBRMP boundary is situated on the open coastal waters side of Curtis and Facing Islands, with the closest Project impact area located more than 2km southwest of the boundary (i.e. the areas to be dredged, near the southern end of Facing Island)	■ There are no highly protected areas of a Queensland marine park within the Project impact areas ■ The nearest highly protected zones are located more than 15km to the south of the Project impact areas near Rodds Peninsula	**No significant residual adverse impacts are expected** The Project activities are not expected to have an impact on highly protected zones within the GBRMP.
Fish habitat areas		
There are no declared FHA present within the Project direct impact areas	■ Declared FHA 'Colosseum Inlet', 'Rodds Harbour' and 'Dē-răl-lĭ (Calliope River)' are located outside of the Project impact areas	**No significant residual adverse impacts are expected** There are no FHAs in the Project direct impact areas. The nearest FHA to the Project impact areas is the Dē-răl-lĭ (Calliope River) FHA which is situated approximately 15km to the east of the areas to be dredged for the barge access channel. There may be potential impacts associated with dredging activities that extend into the Calliope River (i.e. short term declines in water quality as a result of minor increases in turbidity). However, these impacts are not expected to have an adverse impact on the FHA as predicted by water quality modelling. The Project is unlikely to have adverse impacts on the FHAs located within and surrounding Port Curtis.

MSES in relation to the Project	Summary of values/species present within the Project impact areas	Summary of the Project impacts and significant impact assessment
Waterway providing for fish passage		
Project area contains a tidal waterway providing for fish passage	■ The WBE reclamation area is situated within an area considered to be a tidal waterway providing for fish passage	**No significant residual adverse impacts are expected** The proposed WBE reclamation area is not considered waterway barrier works as defined under the Fisheries Act (refer Section 9.6.2). There may be potential impact on tidal passage for local marine fauna species. Design measures will be implemented to mitigate impact the WBE reclamation area on the hydrological and tidal regime in order to mitigate indirect impacts on local marine fauna species.
Marine plants		
Marine plant species are present within the Project impact areas	■ Seagrass and macroalgae communities are present within the Project impact areas ■ Marine plant communities are also present within the Project indirect impact areas (e.g. mangroves, macroalgae, coastal saltmarsh communities)	**Significant residual adverse impact likely to occur** The historic seagrass mapping indicates all of the locations where seagrass has been previously recorded (i.e. not necessarily all at one point in time). It is also noted that macroalgae can occupy habitats such as seagrass meadows, and as such impacts to macroalgae within the WBE reclamation area have been addressed in the assessment of potential seagrass meadow impacts. The Project involves the permanent loss of seagrass meadows and macroalgae from establishment of the WBE reclamation area. This includes the direct and indirect disturbance of seagrass communities recorded from all seagrass surveys (2002 to 2018 historic mapping), including: ■ Approximately 110.48ha within the WBE reclamation area (southern area) ■ Approximately 164.75ha within the WBE reclamation area (northern area) ■ Approximately 99.41ha within the areas adjoining WBE reclamation area (indirect impacts from erosion and sedimentation due to changes in tidal velocities adjoining the WBE reclamation area). The cumulative and synergistic impact assessment identified that the Project has the potential risk of significant synergistic impact for seagrass and macroalgae values due to: ■ Permanent and direct loss of seagrass meadows and macroalgae ■ Potential habitat alteration due to potential hydrological and water quality impacts.

MSES in relation to the Project	Summary of values/species present within the Project impact areas	Summary of the Project impacts and significant impact assessment
		The historic extent of seagrass meadows and macroalgae within the area to be dredged for the channel duplication is 85.33ha (comprising 35.65ha of deep water seagrass and 49.68ha of macroalgae), however no seagrass has been recorded in the channel duplication footprint since 2002. Baseline surveys of this area will be undertaken prior to the commencement of dredging to determine the extent of seagrass that will be directly impacted within the area to be dredged and indirectly impacted in the zone of high impact for the channel duplication. Further the Project dredging has the potential to have indirect impacts on seagrass meadows that are mapped within the Project dredging zone of high impact which is approximately 1,664.03ha (comprising 876.98ha of seagrass and 787.05ha of macroalgae) mapped from historic extent (i.e. 2002 to 2018). However the permanent loss of deep water seagrass and macroalgae within the Project zone of high impact (i.e. indirect impact area) is unlikely due to the implementation of adaptive management measures contained in the Environmental Monitoring Procedure (refer AEIS Appendix H). The historic seagrass within the BUF and barge access channel is considered to be negligible. The Project indirect impact to the historically mapped seagrass adjoining the BUF is considered to be have been removed by the existing WBDDP reclamation area and therefore this seagrass is excluded from the Project impact assessment. Other marine plants such as mangroves, samphires and saltmarshes are not directly impacted by the Project. Therefore the significance of any potential cumulative and synergistic impacts on mangroves, saltmarshes and other marine plants is considered to be low. With the implementation of mitigation measures outlined in the Dredging EMP (refer AEIS Appendix F) and the Project EMP (refer AEIS Appendix G), it is unlikely that the Project will result in impacts on the mangrove and saltmarsh communities on the coastline adjacent to the WBE reclamation area.

MSES in relation to the Project	Summary of values/species present within the Project impact areas	Summary of the Project impacts and significant impact assessment
		There is likely to be significant residual adverse impact to marine plants due to: ■ Permanent loss of 374.64ha of marine plants (including seagrass meadows and macroalgae (fish habitat)) as a result of the establishment of WBE reclamation area, including: – 110.48ha from the establishment of the WBE reclamation area (southern area) – 164.75ha from the establishment of the WBE reclamation area (northern area) – 99.41ha from indirect impacts from the establishment of the WBE reclamation area. ■ Permanent loss of 85.33ha of marine plants (including seagrass meadows and macroalgae (fish habitat)) at the channel duplication area to be dredged.
Legally secured offset areas		
There are no legally secured offset areas situated within the Project impact areas	■ There are no strategic environmental areas mapped within the Project impact areas	**No significant residual adverse impacts are expected** The Project activities are not expected to have an impact on any mapped strategic environmental areas.

9.15.4 Summary of the findings of the significant residual adverse impact assessment

This section replaces Project EIS Section 9.29.13 (significant residual adverse impact assessments).

Significant residual adverse impact assessments have been conducted to identify if the Project will, or is considered likely to have a significant residual adverse impact on ecological values which are defined as a MNES or a MSES. Table 9.55 summarises the Project activities that are likely to result in a significant residual adverse impact on MNES and/or MSES. Figure 9.39 to Figure 9.46 identify the MNES and MSES values that require offsetting.

Table 9.55 Summary of Project activities likely to result in a significant residual adverse impact on MNES and/or MSES

Project activity and disturbance footprint	Ecological value
Establishment of the WBE reclamation area	**MNES** ■ Migratory shorebird foraging habitat, including for threatened migratory shorebirds (loss of 479.30ha) ■ Green turtle foraging habitat (loss of 374.64ha) ■ Dugong foraging habitat (loss of 374.64ha) **MSES** ■ Marine plant (including seagrass and macroalgae) (loss of 374.64ha) ■ Green turtle foraging habitat (loss of 374.64ha) ■ Dugong foraging habitat (loss of 374.64ha) ■ Wetlands and watercourses (HES wetlands) (loss of 73.61ha) ■ Migratory shorebird foraging habitat, including for threatened migratory shorebirds (loss of 479.30ha) ■ Beach stone curlew (resident shorebird) foraging habitat (loss of 479.30ha)
Channel duplication areas to be dredged	**MNES** ■ Green turtle foraging habitat (loss of 85.33ha) ■ Dugong foraging habitat (loss of 35.65ha) **MSES** ■ Marine plant (including seagrass and macroalgae) (loss of 85.33ha) ■ Green turtle foraging habitat (loss of 85.33ha) ■ Dugong foraging habitat (loss of 35.65ha)
BUF and initial dredging works	No significant residual adverse impact expected on MNES and/or MSES
Installation of navigational aids	No significant residual adverse impact expected on MNES and/or MSES
Maintenance activities on the WB and WBE reclamation areas	No significant residual adverse impact expected on MNES and/or MSES

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Western Basin Expansion Reclamation Area

Northern Reclamation Area

Southern Reclamation Area

Existing Western Basin Reclamation Area

Fisherman's Landing

Legend

- Project direct impact on listed threatened/migratory species and protected wildlife habitat (MNES and MSES) (migratory shorebird foraging/roosting area)
- Project indirect impact on listed threatened/migratory species and protected wildlife habitat (MNES and MSES) (migratory shorebird foraging/roosting area)
- Western Basin Expansion reclamation area
- Initial dredging works for barge access channel
- Barge unloading facility
- Existing shipping channels

Note:
Under the Queensland Offset framework an offset will only be imposed if the Commonwealth has not already considered impacts on the prescribed activity under the relevant Commonwealth Act. This is relevant for this prescribed environmental matter which is a MNES and a MSES.

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)

Map by: RB
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0 255 510 Metres

Date: 24/09/2019 Version: 1 Job No: 237374
Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 9.39: Location of MNES and MSES ecological values (listed threatened/migratory species and protected wildlife habitat (Migratory shorebird foraging roosting area)) that require offsetting within and adjoining the Western Basin Expansion reclamation area

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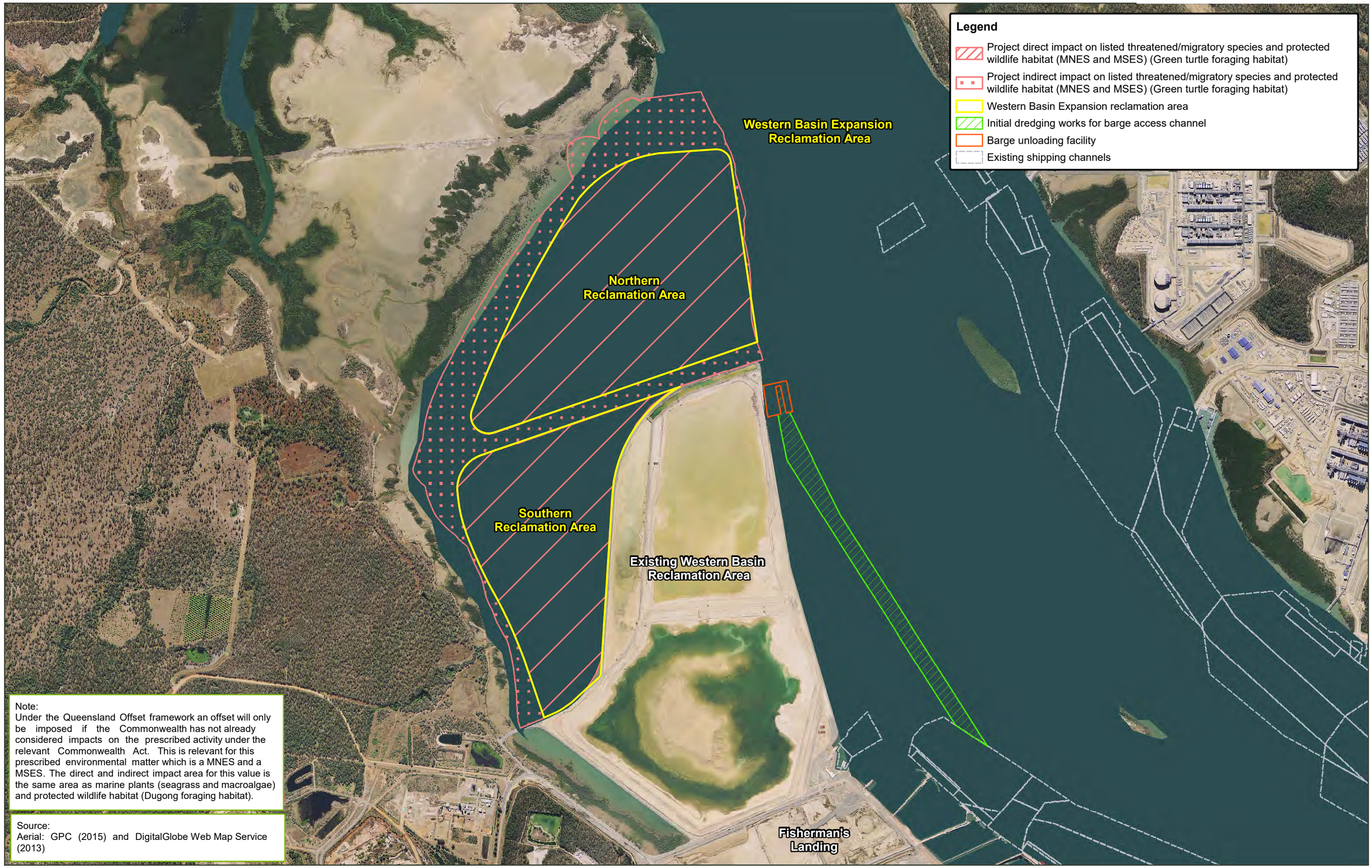

Note:
Under the Queensland Offset framework an offset will only be imposed if the Commonwealth has not already considered impacts on the prescribed activity under the relevant Commonwealth Act. This is relevant for this prescribed environmental matter which is a MNES and a MSES. The direct and indirect impact area for this value is the same area as marine plants (seagrass and macroalgae) and protected wildlife habitat (Dugong foraging habitat).

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)

Map by: RB P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_385_1_Fig9.40_AEIS.mxd 24/09/2019 10:42

0 255 510 Metres

Date: 24/09/2019 Version: 1 Job No: 237374

Coordinate system: GDA_1994_MGA_Zone_56

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Figure 9.40: Location of MNES and MSES ecological values (listed threatened/migratory species and protected wildlife habitat (Green turtle foraging habitat)) that require offsetting within and adjoining the Western Basin Expansion reclamation area

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Western Basin Expansion Reclamation Area

Northern Reclamation Area

Southern Reclamation Area

Existing Western Basin Reclamation Area

Fisherman's Landing

Legend

- Project direct impact on migratory species (MNES) and protected wildlife habitat (MSES) (Dugong foraging habitat)
- Project indirect impact on migratory species (MNES) and protected wildlife habitat (MSES) (Dugong foraging habitat)
- Western Basin Expansion reclamation area
- Initial dredging works for barge access channel
- Barge unloading facility
- Existing shipping channels

Note:
Under the Queensland Offset framework an offset will only be imposed if the Commonwealth has not already considered impacts on the prescribed activity under the relevant Commonwealth Act. This is relevant for this prescribed environmental matter which is a MNES and a MSES. The direct and indirect impact area for this value is the same area as marine plants (seagrass and macroalgae) and protected wildlife habitat (Green turtle foraging habitat).

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)

Map by: RB P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_385_1_Fig9.41_AEIS.mxd 24/09/2019 10:44

0 255 510 Metres

Date: 24/09/2019 Version: 1 Job No: 237374

Coordinate system: GDA_1994_MGA_Zone_56

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Figure 9.41: Location of MNES and MSES ecological values (listed threatened/migratory species and protected wildlife habitat (Dugong foraging habitat)) that require offsetting within and adjoining the Western Basin Expansion reclamation area

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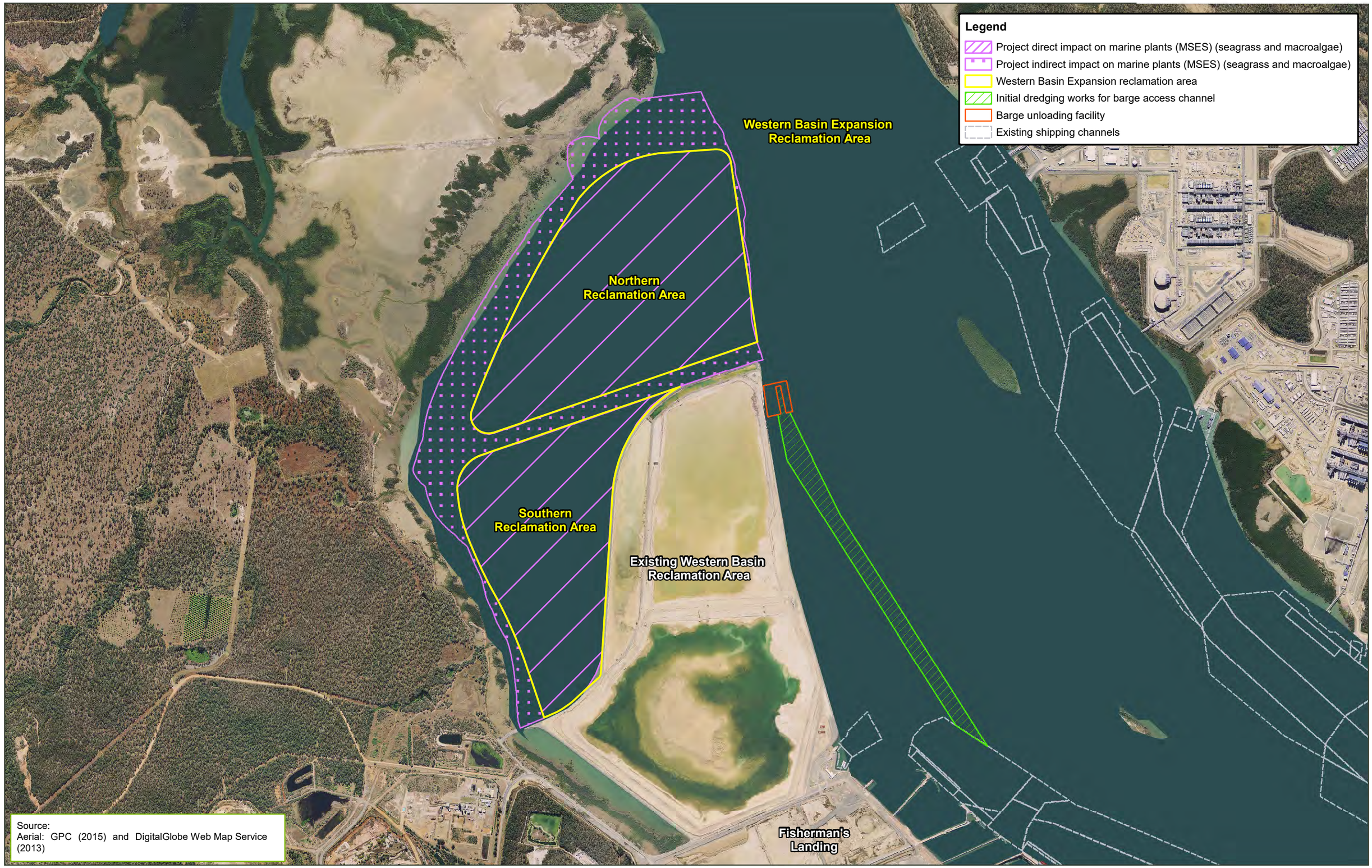

Map by: RB P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_385_1_Fig9.42_AEIS.mxd 24/09/2019 10:45

0 255 510 Metres

Date: 24/09/2019 Version: 1 Job No: 237374

Coordinate system: GDA_1994_MGA_Zone_56

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Figure 9.42: Location of MSES ecological values (marine plants) that require offsetting within and adjoining the Western Basin Expansion reclamation area

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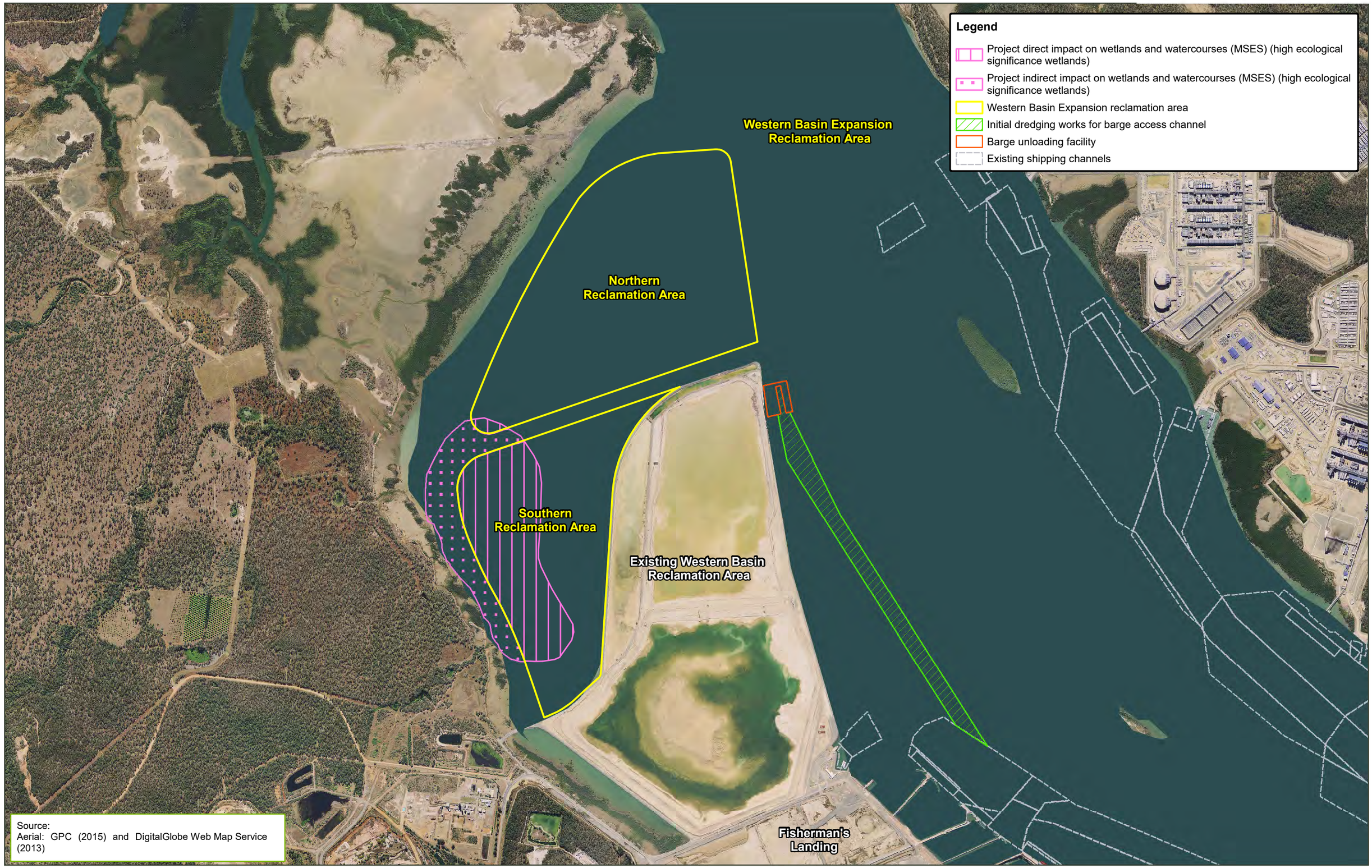

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)

Map by: RB P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_385_1_Fig9.43_AEIS.mxd 24/09/2019 10:47

0 255 510 Metres

Date: 24/09/2019 Version: 1 Job No: 237374

Coordinate system: GDA_1994_MGA_Zone_56

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Figure 9.43: Location of MSES ecological values (wetlands and watercourses (high ecological significance wetlands)) that require offsetting within and adjoining the Western Basin Expansion reclamation area

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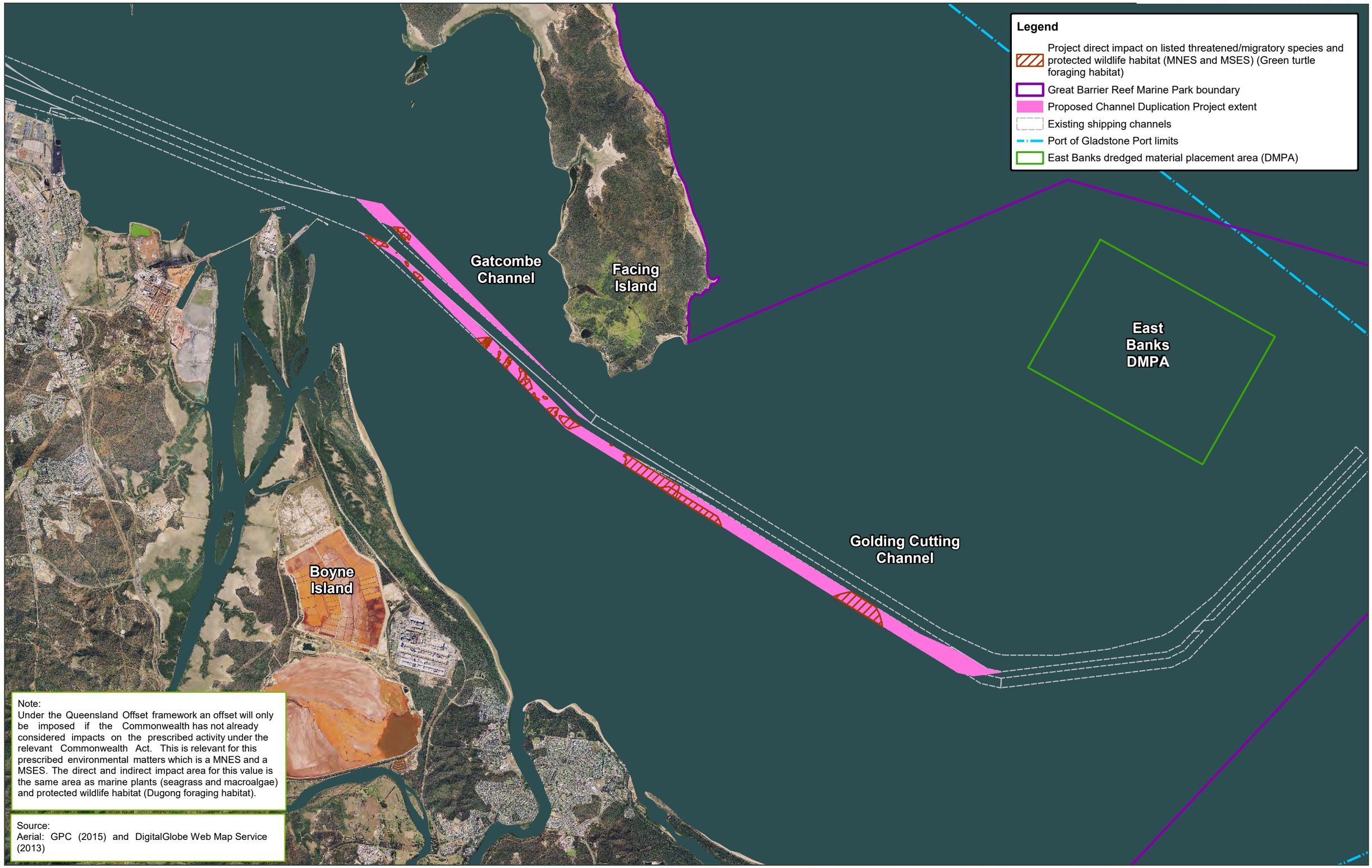

Note:
Under the Queensland Offset framework an offset will only be imposed if the Commonwealth has not already considered impacts on the prescribed activity under the relevant Commonwealth Act. This is relevant for this prescribed environmental matters which is a MNES and a MSES. The direct and indirect impact area for this value is the same area as marine plants (seagrass and macroalgae) and protected wildlife habitat (Dugong foraging habitat).

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)

Map by: RB P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_385_2_Fig9.44_AEIS.mxd 20/09/2019 12:26

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Date: 20/09/2019 Version: 0 Job No: 237374

Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 9.44: Location of MNES and MSES ecological values (listed threatened/migratory species and protected wildlife habitat (Green turtle foraging habitat)) that require offsetting within the channel duplication area to be dredged

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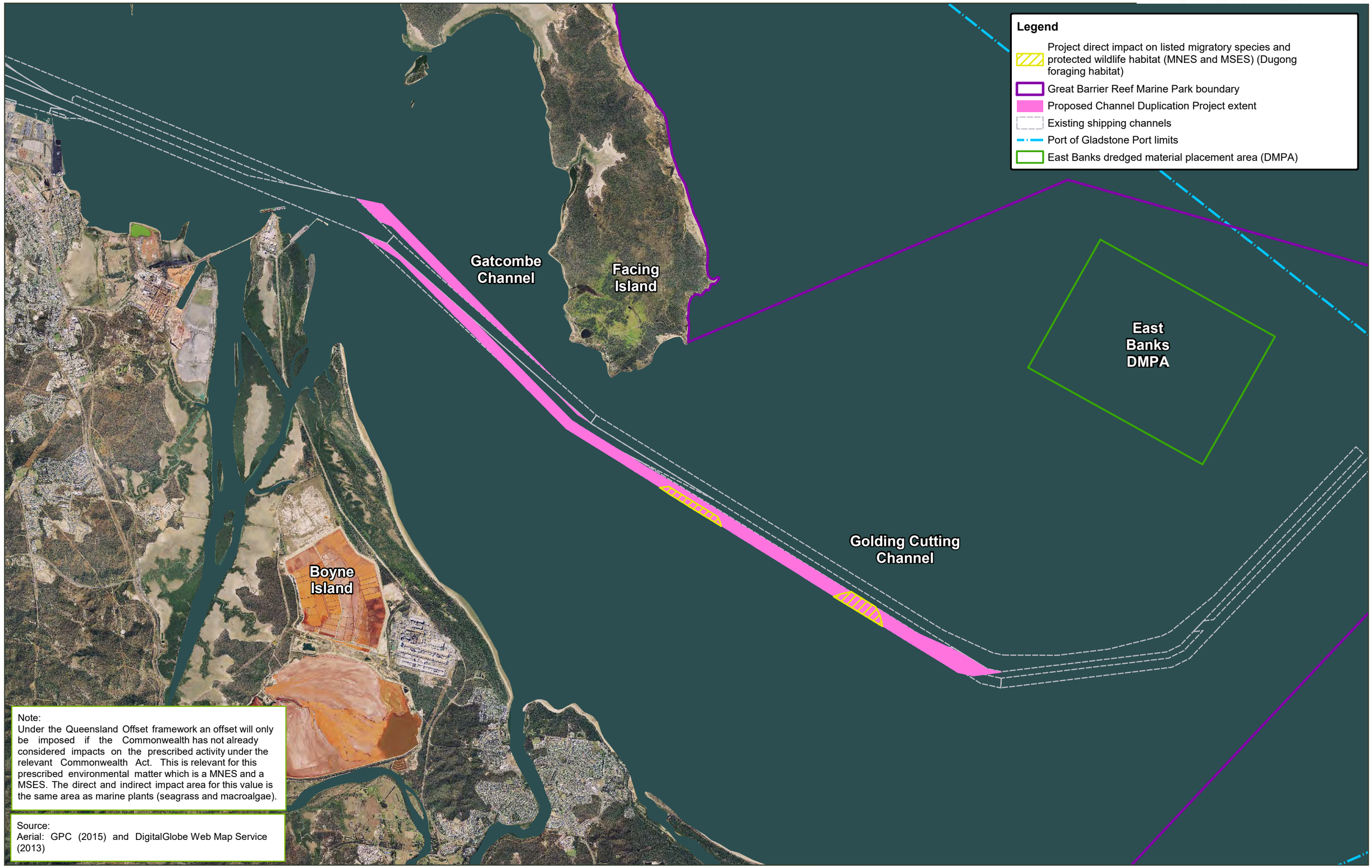

Note:
Under the Queensland Offset framework an offset will only be imposed if the Commonwealth has not already considered impacts on the prescribed activity under the relevant Commonwealth Act. This is relevant for this prescribed environmental matter which is a MNES and a MSES. The direct and indirect impact area for this value is the same area as marine plants (seagrass and macroalgae).

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)

Map by: RB
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Date: 20/09/2019 Version: 0 Job No: 237374
Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 9.45: Location of MNES and MSES ecological values (migratory species and protected wildlife habitat (Dugong foraging habitat)) that require offsetting within the channel duplication area to be dredged

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Legend

- Project direct impact on marine plants (MSES) (seagrass and macroalgae)
- Great Barrier Reef Marine Park boundary
- Proposed Channel Duplication Project extent
- Existing shipping channels
- Port of Gladstone Port limits
- East Banks dredged material placement area (DMPA)

Gatcombe Channel

Facing Island

East Banks DMPA

Golding Cutting Channel

Boyne Island

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)

Map by: RB P:\GIS\Projects\237374_GPC_Channel_Duplication_EIS\237374_EIS_385_2_Fig9.46_AEIS.mxd 20/09/2019 12:27

0 800 1,600 Metres

Date: 20/09/2019 Version: 0 Job No: 237374

Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 9.46: Location of MSES ecological values (marine plants) that require offsetting within the channel duplication area to be dredged