Port of **Mackay**

Appendix F

Environmental Values Assessment

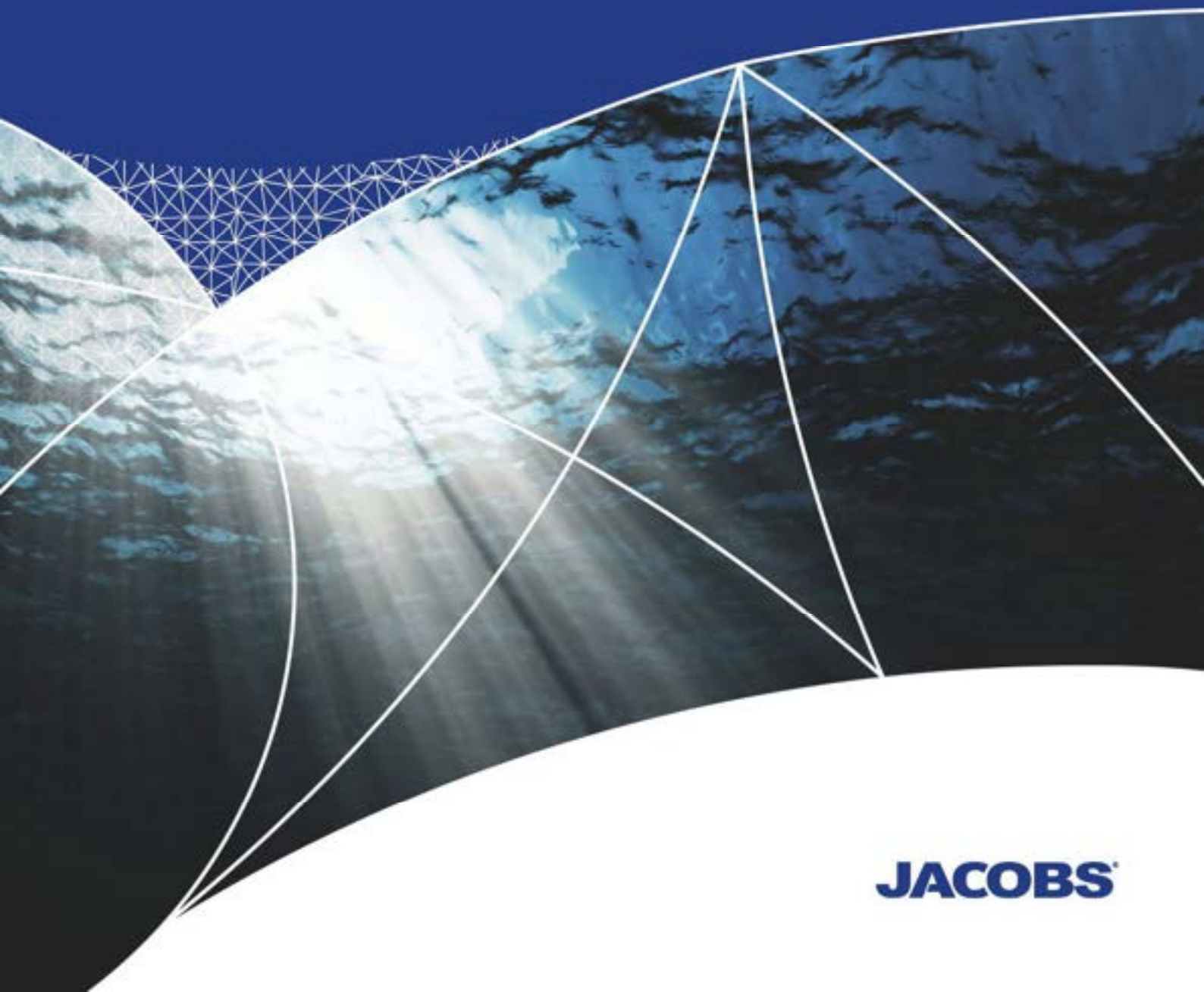
Port of Hay Point

North Queensland Bulk Ports Corporation

Environmental Values Assessment

Revision 2

2 September 2016



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Port of Hay Point

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About this report

The sole purpose of this report and the associated services performed by Jacobs is to review the Environmental Values in the coastal environs of the Port of Hay Point, in accordance with the scope of services set out in the contract between Jacobs and North Queensland Bulk Ports Corporation (NQBP).

In preparing this report, Jacobs has relied upon information prepared by NQBP, as well as other information available in the public domain. Jacobs has not attempted to verify the accuracy or completeness of this information, and has not conducted any new field studies or data analyses.

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Executive summary

Introduction

As a response to increasing interest and concern, both within Australia and internationally, about the management of the Great Barrier Reef (GBR) and the ongoing conservation of its World Heritage values, the Commonwealth and Queensland governments have recently completed a comprehensive Strategy Assessment of the GBR. One action item from the assessment is the development of a long-term sustainability plan to guide the future management of the GBR.

North Queensland Bulk Ports (NQBP), as owner of both the Port of Hay Point and the Port of Mackay, is an important stakeholder in the future management of the GBR. As an important stakeholder, NQBP seeks to take a leadership role in the continued sustainable development and management of ports within the GBR. As part of this leadership role, NQBP understand that the environmental implications of port management decisions cannot be adequately assessed without a good understanding of the environmental values in and around the ports and how these relate to both the long-term sustainability of the ports and the GBR.

This Environmental Values Assessment (EVA) has been developed to support the environmentally sustainable management of the ports. The EVA seeks to compile information about the environmental values in the vicinity of the ports in a single location. It is hoped the availability of the information will strengthen stakeholder relationships and general awareness of port activities in the context of surrounding values.

The study area for the EVA includes both marine and terrestrial areas. The marine study area extends in the north from the waters around Keswick and St Bees islands, west to Finlaysons Point on the mainland, and in the south from Digby Island and west to Llewellyn Bay. The terrestrial study area extends from just north of Mackay Harbour to Sarina Beach in the south, with the western boundary of the terrestrial study area following the alignment of the Bruce Highway. The boundaries of the study area were defined to provide a manageable spatial scale for the assessment, while encompassing the area most likely to be directly influenced by port activities. However, due to the relationship of certain environmental values (such as catchments, wetlands and social aspects), the assessment is not restricted to the defined boundaries.

Methods

The EVA is based entirely on available environmental data and information. No new studies or ground-truthing of available information was conducted in preparing the report. Information from relevant Commonwealth, State and local government databases was reviewed. In addition to database searches, other information sources included published literature, environmental impact assessments and associated documents, monitoring and assessment reports, Mackay Regional Council's planning scheme, periodic status reports and general web sites.

When the information review was complete, the information gathered was synthesised into summaries for each of the environmental values. Environmental values have been grouped into six broad categories: landform and biota, air quality, freshwater aquatic ecosystems, marine aquatic ecosystems, and social values. For each environmental value, the information is summarised to provide a regional summary, a description of places within the study area, an overview the values, the condition and variability, and variability of the value.

Environmental values

There are numerous environmental values within the study area that have been reviewed as part of this assessment. These environmental values have been grouped into five broad categories: landform and biota, air quality, aquatic ecosystems (freshwater), aquatic ecosystems (marine) and social values. Environmental values within the landform and biota category relate to terrestrial values such as land resources, terrestrial flora and fauna and flooding. Air quality relates to the values associated with dust, noise and lighting. Aquatic ecosystems has been divided into freshwater and marine. Freshwater aquatic ecosystems includes both surface water and groundwater resources and quality, catchments, mangroves and wetlands, as well as freshwater fish. Marine aquatic ecosystems includes oceanographic processes, marine water quality and sediments, coral reefs,

seagrass, marine fauna (both benthic fauna and megafauna) and underwater noise. Social values include public amenity, tourism and recreation, traffic, waste generation, fisheries and cultural heritage (both indigenous and non-indigenous heritage.

The GBR is the most recognisable natural asset of the study area, with the GBR being listed as a world heritage area in 1981. The Great Barrier Reef World Heritage Area (GBRWHA) is listed based on four World Heritage criteria for Outstanding Universal Value (OUV). The criteria are as follows:

- Natural beauty and natural phenomena (Criterion (vii))
- Major stages of the Earth's evolutionary history (Criterion (viii))
- Ecological and biological processes (Criterion (ix))
- Habitats for conservation of biodiversity (Criterion (x))

Some of the environmental values reviewed as part of this EVA make a direct contribution to the OUV (e.g. dugong (*Dugong dugon*)), some make a minor or incremental contribution (e.g., inshore coral reefs) and some benefit from the recognised OUV of the GBR (e.g. commercial and recreational fisheries). Each of the values however, has been considered in relation to the regional context, the places where the environmental values are located within the study area, an overview of the value (i.e., why it is a value), the condition and variability of the value and the vulnerability of the value. Table ES1 summarises the contribution to OUV and importance of each of the environmental values, as well summarising what this means for the study area.

Gap analysis

Many of the environmental values in the study area have been extensively studied and documented, particularly the marine environments. However, there are still gaps in knowledge for a number of environmental values. The focus of many of the studies are focused on a specific issue (such as GBR health) or associated with the assessment of potential impacts associated with new development. Monitoring of environmental values is similar to the studies, monitoring has often been targeted project-specific and short-term. NQBP however, has established a long-term program to monitor water quality and seagrass and macroinvertebrate communities within the study area. A number of studies and monitoring programs have also been carried out to provide 'snapshots' of the environmental conditions or aspects in the study area. These studies do not necessarily provide any connection to previous studies or allow comparison of the results.

Despite these gaps, there is still a large body of information available that allows for a reasonably complete understanding of the environmental values within the study area.

Future risks

A desire to live and enjoy recreational activities within coastal areas has seen extensive development along the coastal fringe of the study area. This has resulted in much of the remaining undeveloped terrestrial areas now providing important habitat for flora and fauna. Direct disturbance of these areas would place further pressure on the remaining environmental values in the study area. As with the terrestrial areas, marine areas within the study area are used for transport (shipping), fisheries and port related activities, as well as providing important habitat for a range of marine species. Direct disturbance (such as direct disturbance by placement of dredge material in the marine environment) and indirect disturbance (such as decreased water quality and increased sediment loads from terrestrial areas) can impact marine environmental values.

The resiliance of each of the environmental values varies with each value. However, the main factor that influences resilence for all environmental values is the pressure that the value faces now and in the future. If the value is under a number of different pressures, resilience to a new or increasing pressure is reduced. Some environmental values have been shown to be quite resilient, while others are less resilient, For example, seagrass beds in the study area have been shown to be quite resilient to periodic disturbances; however, terrestrial vegetation (once disturbed) can take a long time to recover, if it ever does.

Table ES1: Summary of environmental values within the study area

Environmental value	Contribution to OUV	Summary of importance	What does this mean?
Landform and biota			
Soil quality, erosion and sedimentation	Soils do not directly contribute to OUV. However, soils do provide the foundation for vegetation and fauna communities, which contribute to visual amenity and appreciation. Erosion increases sediment loads to the GBR lagoon, which is one of the main threats to the health of the reef.	The region has some of the highest-value sugarcane and grazing land in Queensland. Good quality agricultural land (GQAL) for cane production has been lost to urban development, mainly around Mackay. GQAL for cane production has been degraded along the coast between Sarina and Mackay. Expansion westward is constrained by transport links and water availability.	Exposed soils, due to agricultural or other development, may contribute to increased sediment loads to the GBR lagoon. Land management practices to minimise sediment entering the GBR lagoon is one of the highest priorities for improved water quality. Fragmentation and/or loss of GQAL for non-agricultural uses, through continued land development in the study area, have the potential to influence the output from the study area.
Terrestrial vegetation communities	On the mainland, regional ecosystems (REs) do not directly contribute to OUV but provide land-sea linkages and complement visual amenity and visual appreciation, which indirectly enhance OUV. Island vegetation communities directly relate to OUV criteria in that they represent ecosystems that have evolved over millennia and provide habitat for populations of rare or endangered species of flora and fauna.	Endangered, of concern and of least concern regional ecosystems (REs) all occur within the study area. About 2% of the mapped remnant vegetation within the study area contains REs that represent threatened ecological communities (TECs) under the *Environment Protection and Biodiversity Conservation Act 1999*. This includes potentially 127.1 ha of the Broad Leaf Tea-tree TEC and 136.2 ha of Littoral Rainforest And Coastal Vine Thickets TEC. The endangered and of-concern REs, as well as the TECs, in the study are considered important due to a combination of their biodiversity values, the low extent of remaining vegetation and the degree of pressure they are under from threatening processes such as clearing and climate change. The Broad Leaf Tea-tree TEC is also habitat for the endangered lesser swamp orchid (*Phaius australis*).	The study area contains terrestrial vegetation communities that are considered to be important at both the Commonwealth and State levels. Increased development for urban, tourism, agricultural expansion and industrial development places pressure on the remaining vegetated areas. Reduction in the area of vegetation communities in the study area also decreases the habitat for endangered and threatened species of flora and fauna. State legislation and the Mackay Regional Council Planning Scheme endeavour to protect the remaining vegetation communities by placing restrictions on the clearing of certain vegetation communities. Future development within the study area may be restricted by the remaining areas of remnant vegetation.

Environmental value	Contribution to OUV	Summary of importance	What does this mean?
Threatened terrestrial flora	On the mainland, threatened flora does not directly contribute to OUV. Although no records of threatened flora exist on islands in the study area, threatened species that could exist directly relate to OUV criteria in that they form part of ecosystems that have evolved over millennia and are considered rare or endangered species. Threatened terrestrial flora in the study area therefore makes a minor contribution to OUV.	Threatened flora in the study area are considered important. The following threatened species are of importance within the study area: • Black ironbox (*Eucalyptus raveretiana*) has been recorded within the study area and is suspected to exist in low numbers • Byfield matchstick (*Comesperma oblongatum*) has a restricted distribution and while not recorded in the study area, may exist given the vegetation communities present in the study area • Holly-leaved graptophyllum (*Graptophyllum ilicifolium*) has a restricted distribution within the study area • Lesser swamp orchid (*Phaius australis*) exists in low numbers • *Neisosperma kilneri* is known from only three localities in Queensland, while not recorded in the study area, may exist given the vegetation communities present in the study area • *Omphalea celata* is also known from only three sites in Queensland, including a record in the study area	The study area is known to contain threatened flora species. Increased development for urban, tourism, agricultural expansion and industrial development places pressure on the vegetated areas, which have the potential to contain specimens of threatened species. State legislation endeavours to protect the remaining threatened flora by placing restrictions on the clearing of vegetation communities. Similar to clearing of vegetation communities, future development within the study area may be restricted by the remaining areas of remnant vegetation and sites where threatened flora species are either known to occur or have the potential to occur.
Terrestrial fauna	Terrestrial fauna in the study area contribute at least indirectly to OUV, particularly mobile fauna on the mainland that occur on the fringe of the World Heritage Area, such as migratory shorebirds. Threatened species that inhabit coastal islands in the study area directly relate to OUV criteria in that they form part of ecosystems that have evolved over millennia and are considered rare or endangered species.	The migratory and threatened species in the study area are considered important. Sandringham Bay is internationally significant for the eastern curlew (*Numenius madagascariensis*), lesser sand plover (*Charadrius mongolus*) and the great knot (*Calidris tenuirostris*), and nationally important for the Terek sandpiper (*Xenus cinereus*), bar-tailed godwit (*Limosa lapponica*) and ruddy turnstone (*Arenaria interpres*). Mackay Town Beach is an internationally important site for the eastern curlew, the great knot, and lesser sand plover. The mouth and banks of the Pioneer River and Armstrongs Beach are nationally important shorebird roosting sites. Sandfly Creek	The main threats to threatened and migratory species in the study area are related to land clearing, habitat degradation, week and pest fauna invasion and inappropriate and altered fire regimes. Shorebird numbers have also been declining in some areas of the study area, due to disturbances from human activities and a general global decline in shorebird numbers. Similar to clearing of vegetation communities, future development within the study area may be restricted by the remaining areas of known habitat for threatened species.

Environmental value	Contribution to OUV	Summary of importance	What does this mean?
		Environmental Reserve is also a nationally important shorebird roost site.	
Flooding	Flooding is considered an important component of connectivity between the land and sea, which is an ecosystem process. As such, flooding within the study area is considered to have a incremental contribution to OUV.	Natural flooding cycles are vital for the movement of nutrients and recharging of groundwater systems.	Flooding can increase the sedimentation into aquatic ecosystems. As such, changes in the flood regime (due to climate change for example) have the potential to increase sediment to the GBR lagoon. Flooding also presents risks to infrastructure and social values. Clean up and recovery costs can place significant strain on local economies.
Air quality			
Air quality, noise and lighting	Air quality has indirect contributions to natural beauty and natural phenomena OUV, by supporting their continued health, survival and aesthetic value.	Air quality and noise are currently at most a minor issue in the study area, with the exception of communities near the Port of Hay Point. Long term monitoring and ongoing improvement measures at the Port of Hay Point have led to improvements in air quality and noise.	Air quality, noise and lighting have the potential to impact humans and animals, such as shorebirds and turtles. Impacts can include health and wellbeing, as well as amenity. Increased development within the study area has the potential to change air quality, noise and lighting to such an extent that humans and animals are impacted. Changes to existing management practices at the ports have led to improvements in air quality and noise in the vicinity of the ports.
Aquatic ecosystems – freshwater			
Catchments	Catchments do not directly contribute to OUV; however, they provide support for aquatic and terrestrial communities which contribute to visual amenity and appreciation.	Catchments are an important resource for aquatic and terrestrial communities, recreation and provide a number of services to local industries. Water quality within the study area catchments range from very poor to good and very poor to very good for riparian vegetation.	Sediment loads to the GBR is one of the main threats to the health of the reef. Improving water quality and riparian vegetation through improving land management practices within the study area catchments seeks to reduce sediment loads. Considerable efforts have been made to improve management of agricultural and urban water quality within the study area. Improved grazing and cane

Environmental value	Contribution to OUV	Summary of importance	What does this mean?
			farming management practices are the highest priority for improved water quality entering the GBR.
Waterways and ephemeral water bodies	The waterways and ephemeral water bodies in the study area are outside the GBRWHA and thus do not contribute directly to OUV. However, they are indirectly linked to the OUV of ecological processes and biodiversity conservation, in regulating flows of water, nutrients and sediment to the GBR. In addition, some marine species use the waterways at discrete stages of their life cycle.	The Pioneer River is the most significant of the water resources in the study area. It flows through Mackay and discharges to the GBR approximately 5 km south of the Port of Mackay. The river supplies Mackay with potable water, as well as water for agricultural and grazing purposes. The Pioneer River also delivers large quantities of water and sediment to the GBR lagoon during flood events. Other notable resources include: • Lake Varfield, which has local conservation significance • Rocky Dam Creek, which is classified as high ecological value waters • Goosepond Creek, which is a significant freshwater nursery habitat for small freshwater fishes	Changes to watercourses, through changes in watercourse channels, introduction of waterway barriers and water extraction, can change the flow of water and sediment in the watercourses, and ultimately the marine waters. These changes to watercourses can also influence the ability for some marine species to complete their life cycle, with many of these species recognised as valuable species for the recreational and commercial fishing industry. Existing and future development within the study area can have direct impacts on waterways. The Healthy Rivers to Reef Partnership has identified key activities in the region for which management practices are being monitored; these are agriculture, industry, aquaculture, ports, tourism, urban development and fishing.
Surface water quality	Fresh waters in the study area are outside the GBRWHA and thus their water quality does not directly contribute to OUV. They are strongly linked to the OUV of natural beauty, ecological processes and biodiversity conservation; however, because declining water quality of runoff from GBR catchments is considered the greatest direct threat, to the health of the GBR.	Reduction of nutrient, sediment and pesticide inputs to the GBR in freshwater runoff is identified as the top priority for improved health of the GBR. Some improvements have already been realised, but continued management and water quality improvements are critical to enhancing the resilience of the GBR to other threats, such as climate change.	Connections and pressures between ecological communities, land use and waterways are well known. Considerable efforts have been made to improve management of agricultural and urban water quality within the study area. Improved grazing and cane farming management practices are the highest priority for improved water quality entering the GBR.
Groundwater quality	Groundwater contributes to the natural beauty of wetlands and the maintenance of biological diversity. As such, groundwater quality within the study area is considered to have a incremental contribution to OUV.	Groundwater resources within the study area are important to both the local community (by providing water for domestic, agricultural and industrial uses) as well as the environment (for groundwater dependent ecosystems (GDEs)). Many GDEs include wetlands, the health of which can directly relate to the health and resilience of the reef.	Over extraction and/or contamination of groundwater resources through land use activities can impact the quality and quantity of groundwater resources available for both human and environmental use.
Wetlands	Mainland wetlands do not directly relate to OUV; however, there is a significant indirect	Wetlands play an important role in the environmental health of the GBR. They maintain and improve water quality and	There has been extensive clearing in much of the wetland areas within the study area. While significant

Environmental value	Contribution to OUV	Summary of importance	What does this mean?
	contribution to all OUV criteria as environmental flows and water quality directly relate to the health and resilience of the reef. Wetlands are also important for shorebirds, which are an important element of OUV.	have been likened to functioning as 'kidneys' for catchments because they filter out pollutants. They are important habitats for shorebirds, threatened species, and this is generally reflected by their level of protection. Wetlands also provide habitat for a number of bird species. Their importance is increased due to the extent of past clearing as well as current threatening processes. There are no internationally significant (Ramsar) wetlands in close proximity to the study area. Several wetlands of national, state and local significance occur in the study area. This includes: • Nationally Significant Wetlands: Sandringham Bay – Bakers Creek Aggregation, northwest of Hay Point, and Sarina Inlet – Ince Bay Aggregation south of Hay Point • Clusters of state significant wetlands northwest of Mackay Harbour and south to Dudgeon Point, Lake Barfield, near Campwin Beach, and Sarina Inlet • Locally significant wetlands between Andergrove/Mackay Harbour/Cremorne, Dudgeon Point/Louisa Creek, Lake Barfield, Campwin Beach, Sandfly Creek Environmental Reserve, Town Beach and Far Beach area, the Keeleys Road wetlands.	wetland areas are recognised within the study area, not all of these areas are protected from future development. Those areas that are protected continue to be vulnerable to altered hydrology, changes to water quality and disturbances such as introduction of weeds, pests (especially pigs) and illegal dumping. Further deterioration and/or clearing of these areas have the potential to directly impact the health and resilience of the reef.
Mangroves	Mangroves in the GBRWHA are habitats for conservation of biodiversity. In particular, 21 of the 37 mangrove species in the GBRWHA occur in the region; mangrove diversity is explicit in the GBRWHA statement of OUV. These species are widespread in the GBRWHA, and some other areas within the GBRWHA have higher	Mangroves are recognised as providing valuable environmental benefits such as providing erosion protection for coastal land, providing breeding habitat for economically important species and maintaining coastal water quality (by retaining, removing and processing nutrients, sediments and other pollutants from terrestrial and marine waters).	There has been historical clearing and dieback of mangroves within the study area. Mangrove areas continue to be threatened by coastal development. Disturbance events, such as storms and cyclones, can also damage mangroves. Increased storm intensity and frequency also has the potential to alter mangrove ecosystems.

Environmental value	Contribution to OUV	Summary of importance	What does this mean?
	mangrove diversity than the study area; however, the regional significnace and extent of mangroves within the study area means that they are an important contributor to OUV at the property scale. Mangroves also contribute to OUV by providing critical habitat for many species of conservation significance and through their role in biological filtration.	Important areas of mangroves include: • Sand Bay, north of the terrestrial extent of the study area, listed as a wetland of national importance • Slade Point and McCreadys Creek, which lie north of the Port of Mackay • Basset Basin, which is an estuary of the Pioneer River and provides important nurseries. It is a declared Fish Habitat Area • The Sandringham Bay – Bakers Creek Aggregation, listed as a wetland of national importance in part because of its mangrove diversity • Mangroves at Hay Point Peninsula, which consist of 22 ha • Sarina Inlet – Ince Bay Aggregation, south of the terrestrial extent of the study area, listed as a wetland of national importance	Further deterioration and/or clearing of these areas have the potential to impact the contribution that they make to OUV.
Freshwater fish	On the mainland, freshwater fauna values within the study area do not directly contribute to OUV; however, some species move between freshwater systems and the GBRWHA and therefore contribute to biodiversity conservation, and is also an important ecological/biological process. Threatened species that inhabit coastal islands in the study area directly relate to OUV criteria in that they form part of ecosystems that have evolved over millennia and are important for biodiversity conservation.	Recreational fishers take a number of species in the waterways, including jungle perch, barramundi, mangrove jack, sleepy cod, sooty grunter and eel-tailed catfish – all of which use freshwater systems at some stage of their lifecycle. Important habitat areas include: • The Pioneer River, which runs through Mackay and is an important system for freshwater fauna • Sandy, Alligator and Bakers creeks, which are other important freshwater systems in the vicinity of the Port of Hay Point • Goosepond Creek, which is a significant freshwater nursery habitat	The major activities affecting the vulnerability of freshwater fish relate to the modification of natural waterways and changes in water quality. Modification of waterway flow and blocking of fish passages affects the movement of fish within the system. These factors can directly affect the ability for freshwater fish to breed, feed and disperse throughout the freshwater system and can result in reduced species abundance and diversity.

Environmental value	Contribution to OUV	Summary of importance	What does this mean?
Aquatic ecosystems – marine			
Oceanographic processes	Oceanography contributes to some aspects of OUV, including ecological and biological processes and processes of geological and geomorphic evolution, linking continental islands, coral cays and reefs. Examples include water currents and tides which form the foundation of ecological processes, and the distribution of larvae.	Oceanographic processes are a major contributing factor to the distribution of sediments and formation of geological features of the GBR. They are important for dispersing larval forms of marine organisms and thereby increasing diversity at a local and regional scale.	Climate change is the primary threat to oceanographic processes of the GBR, raising sea levels and causing more frequent and more extreme weather. At a local scale, coastal development such as reclamation may cause some minor changes in oceanographic processes near the shore. Changes in oceanography can change the distribution of sediments and larval forms of marine organisms.
Marine water quality and sediment	Water quality directly contributes to OUV by maintaining ecological and biological processes, biodiversity, and natural beauty and natural phenomena. Maintenance of water quality in the study area contributes incrementally to OUV but not at the scale of the World Heritage property.	Marine water quality is integral to the health and resilience of the world's largest coral reef ecosystem (GBR), including examples of all stages of reef development. It also helps to support a mature ecosystem that has evolved with high biodiversity, including over 4,000 species of molluscs and over 1,500 species of fish, plus a great diversity of sponges, anemones, marine worms, crustaceans and many others.	Land-based activities are the most important contributor to the decline in water quality on the GBR. The Mackay-Whitsunday catchments have the highest risk rating of GBR catchments, largely due to nutrient and pesticide runoff from extensive cane farming. State and Commonwealth governments have invested in numerous regional and whole-of-GBR management initiatives to protect and improve the condition of the GBR, through improved agricultural practices. Water Quality Guidelines for the GBRMP define trigger values for sediment, nutrients and pesticide concentrations to maintain GBR ecosystem health. However, a 2015 review of the progress in water quality improvements concluded that only transformational changes (well beyond current management arrangements) will be necessary to achieve water quality targets.

Environmental value	Contribution to OUV	Summary of importance	What does this mean?
Coral reefs	Coral reefs of the study area contribute to the OUV of the GBR by providing biological diversity, while making a small contribution to the world's largest coral reef ecosystem and the mosaic of reefs, islands and cays of the GBR. The study area is dominated by inshore coral reefs which are in general decline along the GBR coast. Coral reefs directly contribute to numerous elements of OUV thoroughout the GBRWHA. Coral reefs of the study area are an important value as they provide a structural and biological basis for high levels of species diversity. The study area is also dominated by inshore coral reefs which are in general decline along the GBR coast. Remaining inshore coral reefs therefore have importance in maintaining the biological diversity of the GBR system.	Coral reefs are the foundation of the GBR ecosystem. Important habitat areas within the study area include: • Hay Reef and at Victor Islet • Round Top Island • Flat Top Island • Taroba Rocks • Dudgeon Point Such locations are not unique or notable at a whole of GBR scale. However, they do make an important contribution to the diversity of inshore coastal waters and are representative of coral reef habitats that are in decline across the GBR coast.	The study area does not contain any unique or notable coral reefs at a whole of GBR scale, the dominance of inshore coral reefs means the study area is important in maintaining the biological diversity of the GBR. While recent coral cover declines in the southern region of the GBR have been attributed to naturally occurring events (cyclones and floods, crown-of-thorns seastar (*Acanthaster planci*) (COTS) outbreaks and mass bleaching events), the frequency of these events can reduce the corals and reef systems resilience to these disturbance events. Increased nutrient, sediment and pesticide loads from land-based sources reduce the natural resilience of reefs to these disturbances. This is why improvements in catchment land-use practices are a priority for management of the GBR.
Seagrass	Seagrass meadows are an attribute of OUV that provide important feeding habitat for listed threatened and listed migratory species. They also act as nursery areas for numerous vertebrate and invertebrate species. The vast biodiversity and sensitivity to changes in water quality inherent in seagrass communities makes seagrasses important indicators in overall health of coastal ecosystems. Within the study area, seagrass habitats provide a small contribution to OUV, by providing habitat for a range of species including dugong and turtles, as well as the contribution to ecosystem processes.	Seagrasses are extremely important to ecosystem function and provide a habitat for listed threatened and listed migratory species. They also act as nursery areas for numerous vertebrate and invertebrate species and are important indicators of ecosystem health. Seagrass habitats within the study area are not particularly notable or important, when compared with other regions along the GBR coast. However, at a local scale, they provide a small contribution to the maintenance of habitat values for some threatened species, such as turtles, dugong and shorebirds.	While seagrass habitats contribute to ecosystem function and provide habitat, seagrass meadows are often highly variable, both seasonally and inter-annually. Deepwater meadows are particularly variable Species of *Halophila*, which are common offshore at Hay Point, have reproductive characteristics that enable recovery from periodic disturbances. These characteristics include producing seeds that can lay dormant in the sediment for a number of years and rapidly recruit when conditions are right. However, the more dense coastal seagrass meadows are unlikely to show such resilience. Seagrass surveys conducted at Hay Point have shown that dredging had a negative impact during the program; however, the low-density deepwater seagrass meadows recovered within 12 months of the cessation of the dredging program.

Environmental value	Contribution to OUV	Summary of importance	What does this mean?
Benthic fauna	Some 93% of the GBRWMA is soft-sediment habitat; infauna are the dominant biological component of this habitat. Though no aspect of soft-bottom infauna communities is directly attributable to the statement of OUV, benthic fauna are critical in maintaining ecosystem function.	Benthic infauna communities have key roles in cycling nutrients and organic matter. They play an important role in mixing sediment, oxygenating and immobilising fine material down into the sediment column, as well as being critically important as the base of the food web for a variety of other species.	Benthic infauna can be impacted by natural disturbance and by man-made disturbances, such as sedimentation associated with dredging-related sediment plumes and spoil deposition. Infauna typically has short generation times, so their communities tend to respond relatively rapidly to changes in the environment.
Megafauna	A number of marine megafauna listed for protection at the Commonwealth level are either known to occur or may potentially occur (i.e. habitat exists which may support a resident population, breeding or feeding) in the study area. Species, such as dugong, are cited as one of the World Heritage values of the GBR.	The study area provides general habitat for megafauna, but is not recognised as a significant area (for breeding, feeding, critical habitat etc.) for any megafauna.	Many marine megafauna are mobile species that may travel large distances, which may expose them to numerous impacts occurring within and outside of the study area. The vulnerability of megafauna also varies depending upon the species. A number of potential impacts to megafauna can however, be associated with port related activities. These include impacts associated with boat strike/disturbance, marine pollution, habitat loss and degradation, underwater noise, light pollution and dredging.
Social values			
Tourism, recreation and public amenity	Tourism and associated public amenities do not directly provide for OUV but maintaining the OUV is critical to the tourism industry.	All offshore islands and large sections of the coastal fringe have been identified as having landscape character and/or forming part of the image corridor. The coastal fringe north and south of Hay Point is also mapped as part of the landscape character. Mackay is also the jumping-off point for the outer reef. Specific areas for tourism and associated public amenities include: • The GBR and offshore islands • Brampton and Keswick Islands • Armstrong, Sarina, Salonika and Grasstree beaches (south of the Port of Hay Point)	Tourism contributes approximately 3% of the economic output from the region, generating an estimated output of $457,403 million. The iconic nature of the GBR and offshore island gives tourists a reason to visit the region. The strong focus of natural tourism destinations means that deterioration in the EVs of these natural assets has the potential to impact the tourist industry in the region. Further, development and growth in the study area has the potential to change the public amenity of the area. Balancing future growth and changes in the community is crucial to sustaining the liveability of the region.

Environmental value	Contribution to OUV	Summary of importance	What does this mean?
		• Shoal and Slade points • The Port of Hay Point lookout	
Fisheries	Fisheries do not directly provide for OUV but do provide a financial incentive to maintain and support OUV, they also are a potential threat to OUV.	Commercial and recreational fishing is important to the Mackay-Whitsunday Region. Important areas for fisheries include: • Newry Island and Newry Bay • Llewellyn Bay • Dudgeon Point and the Hay Point coastline • Newry Region	Commercial catches of some species have been declining in the GBR. Zoning within the GBRMP is established to protect areas that are important to specific species or spawning areas, and to provide refuges intended to enhance fish populations generally.
Non-indigenous heritage	The GBR was declared a World Heritage Area in 1981, internationally recognised by the World Heritage Committee for its outstanding universal value. As such it contributes to the listed OUV outlined below: • Globally outstanding example of an ecosystem evolved over millennia through glacial cycles • Significant diversity of reef and island morphologies reflecting geomorphic, oceanographic and environmental processes • Complex string of reef structures along the coast • World's largest coral reef ecosystem, including examples of all stages of reef development	Aside from the GBRWHA, non-indigenous heritage places listed for protection in the study area are generally restricted to sites in Mackay. Both the Mount Hector Conservation Park and Flat Top Island lighthouse were listed on the Register of the National Estate, which was closed in 2007 and no longer has any statutory authority. Important cultural heritage areas include: • The GBRWHA • Mount Hector Conservation Park • Flat Top Island lighthouse	Aside from the GBRWHA, non-indigenous heritage places listed for protection in the study area are generally within the developed, urban area of Mackay. Howerver, this does not mean that additional sites of local and State heritage significance will not be identified in the future.

Environmental value	Contribution to OUV	Summary of importance	What does this mean?
Indigenous heritage	The Great Barrier Reef Marine Park Authority (GBRMPA) works with Aboriginal and Torres Strait Islander Traditional Owners and acknowledges their continuing social, cultural, economic and spiritual connections to the GBR region. Therefore, indigenous heritage plays an integral part in the GBR and an indirect part in many aspects of the OUV.	Indigenous heritage plays an integral part in the GBR and, therefore, an indirect part in many aspects of the OUV. Other important areas include: • The Mount Hector Conservation Park • A fish trap of archaeological significance has been located in the small bay between the Dalrymple Bay Coal Terminal and Hay Point Coal Terminal.	Aboriginal cultural heritage can be both tangible items or objects and intangible elements, such as places of significance due to the connection and sense of belonging that the people have with the landscape and each other or the significance they have in creation stories and lore. The primary source of the value of cultural heritage is from the Aboriginal people to which the heritage relates. Cultural knowledge and other information relating specifically to their heritage is often integral to determining the value of a cultural heritage item or place.

1. Introduction

1.1 Background

As a response to increasing interest and concern, both within Australia and internationally, about the management of the Great Barrier Reef (GBR) and the ongoing conservation of its World Heritage values, the Commonwealth and Queensland Governments have recently completed a comprehensive Strategic Assessment of the GBR. One result of the Strategic Assessment is the development of a Long Term Sustainability Plan to guide future management of the GBR.

North Queensland Bulk Ports (NQBP) has taken a leadership role in the sustainable development and management of ports in the context of improved management of the GBR. Examples include supporting environmental initiatives of the Queensland Ports Association and the Mackay-Whitsunday Rivers to Reef Partnership, the commencement of voluntary ambient monitoring programs surrounding its ports in Central Queensland and the release of the NQBP Sustainability Plan 2015+. These initiatives demonstrate a commitment to work with the community to improve science-based decision making and environmental outcomes in the Great Barrier Reef Marine Park (GBRMP) and Great Barrier Reef World Heritage Area (GBRWHA), and beyond.

1.2 The environmental values assessment

The Port of Hay Point is about 40 km south of Mackay and is one of the largest coal ports in the world. The Port currently comprises two separate coal terminals; these are the Hay Point Coal Terminal (HPCT) and the Dalrymple Bay Coal Terminal (DBCT). Port-related infrastructure includes purpose-built rail in-loading facilities, onshore stockyards and offshore jetties leading to wharves. The Port lies within the GBRWHA and adjacent to the GBRMP.

NQBP commissioned this environmental values assessment (EVA) to support the environmentally sustainable management of the Port of Hay Point. There are a variety of ecosystems in the environs of the Port of Hay Point that sustain natural systems and provide benefits to a range of stakeholders. These environmental values (EVs) span across both the land and marine environments within the study area (Figure 1–1). The environmental implications of port management decisions cannot be adequately assessed without a good understanding of the environmental values (EVs) – ecological, socioeconomic, and cultural – of areas potentially influenced by port activities.

Most of the EVs surrounding the Port of Hay Point have been extensively studied, but there has been no single repository for this information. Much of the information is held in various Commonwealth or Queensland databases. A great deal of information on the EVs of the ports is unpublished and held by multiple parties, for example, port tenants and consultants. A great deal of information has been produced for environmental impact assessments of different projects, and is thus targeted to specific proposals; although generally relevant to the overall EVs surrounding the Port there are often gaps where information was not collected unless relevant to the proposal being assessed.

The objective of the EVA is to compile available information about the EVs in the vicinity of the Port of Hay Point in a single location, to provide a comprehensive and consistent resource for decision-making. The compilation of diverse information about a broad range of EVs is also intended to provide context, to allow focus on the key EVs that need to be considered in relation to port management. It is hoped the availability of the information will strengthen stakeholder relationships and general awareness of port activities in the context of surrounding values.

This report was prepared in conjunction with development of a geodatabase that includes all spatially referenced data used in preparing the report. Together, the database and this EVA are intended to be "living documents" that can be continually updated and reviewed as new information becomes available.

Figure 1-1 Conceptual diagram of environmental values surrounding the Port of Hay Point

2. Methods

The EVA is based entirely on available environmental data and information. No new studies or ground-truthing of available information were conducted in preparing the report.

2.1 Study area

The defined EVA marine study area extends in the north from the waters around Keswick and St Bees islands, west to Finlaysons Point on the mainland, and in the south from Digby Island west to Llewellyn Bay (Figure 2–1, Figure 2–2 and Figure 2–3). On the terrestrial side, the study area extends to just north of Mackay Harbour, and west to the Bruce Highway as far as south as Sarina Beach.

The marine extent of the study area is larger than the mainland extent for several reasons. Interactions in marine ecosystems typically extend over large spatial scales than in terrestrial systems because of the relative lack of physical barriers and long-distance transport mechanisms in the fluid environment. Selection of the marine extent also considered past and current monitoring locations, which include sites at Keswick Island in the north and Freshwater Point in the south. With the decision to extend the study area as far south as Freshwater Point, it seemed logical to include Llewellyn Bay, given its association with Sarina Inlet, and as a result the Northumberland Islands, with Digby Island at their southern extent.

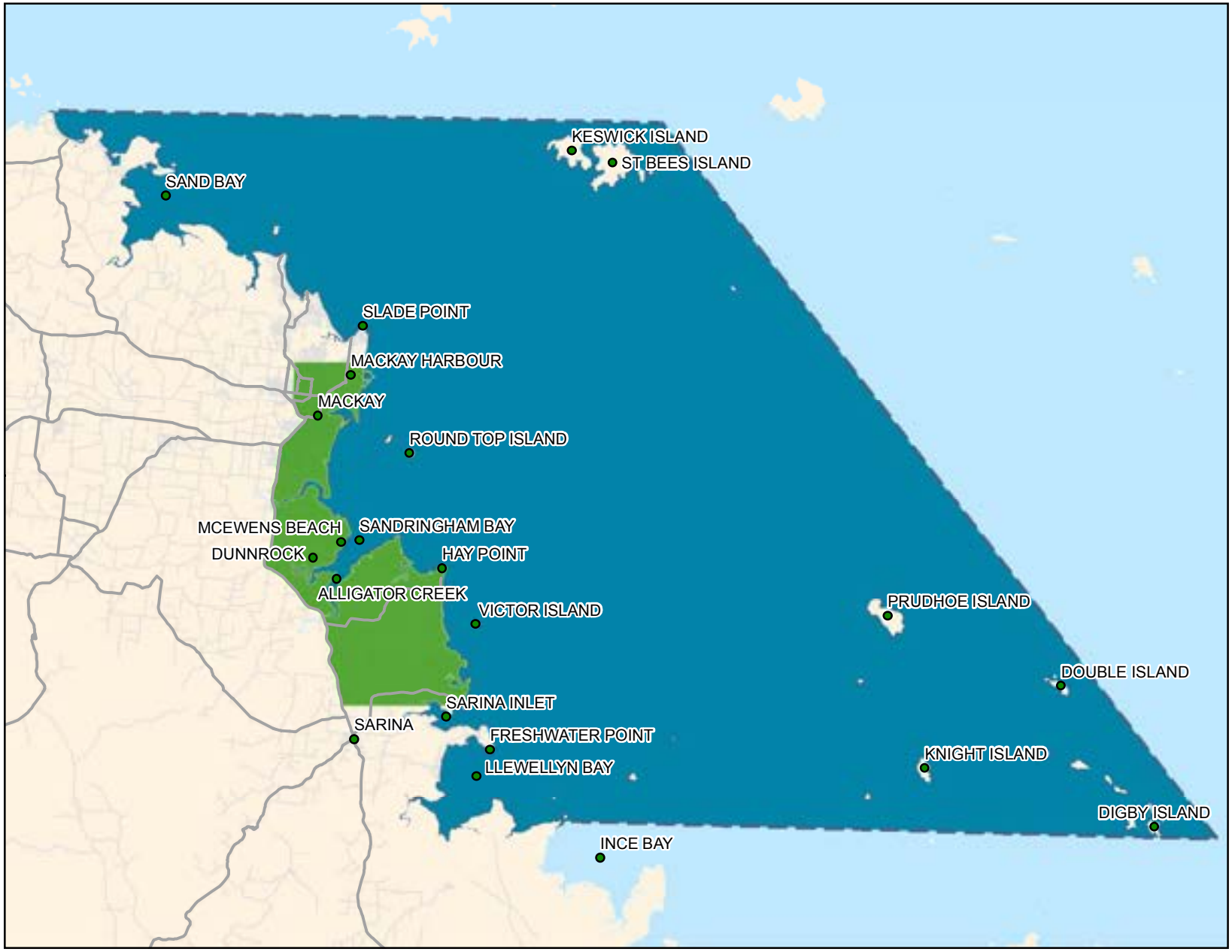
On the mainland, the spatial scale of influence is smaller. The study area was selected to extend north of the Port of Mackay to take into account potential interactions between the two ports, both operated by NQBP. Sarina Beach, to the south, lies a similar distance from Hay Point, and it was considered that the Bruce Highway is an appropriate landward boundary of significant influence of port operations.

It is acknowledged that the boundaries of the study area are somewhat arbitrary. For example, Ince Bay forms part of a recognised wetland aggregation with Sarina Inlet and Llewellyn Bay, and thus the extension of the marine boundary southward to include Ince Bay could be justified. Similarly, the Bruce Highway is an artificial boundary, and many ecosystem processes, particularly catchment processes, extend much further inland. The boundaries of the study area were defined to provide a manageable spatial scale for the assessment while encompassing the area most likely to be directly influenced by port activities. Some aspects of the EVA, for example, quantification of the spatial extent of different ecosystems, have been strictly analysed on the basis of the defined study area. However, from a broader ecosystem perspective the EVA is not restricted to the defined boundaries: Ince Bay, for example, is considered as part of the Sarina Inlet - Ince Bay wetland aggregation and catchments are dealt with well west of the Bruce Highway.

The study area falls within the Mackay-Whitsunday Region, which extends from Eden Lassie Creek catchment south of Bowen in the north to Flaggy Rock Creek catchment in the south, a land area of more than 900,000 ha. The region is bounded to the east by the GBRWHA, Whitsunday Islands and Coral Sea. The Mackay-Whitsunday Region occupies only about 2% of the GBR region, but the coastal length of the region accounts for approximately 20% of the GBR catchment's coastline.

The GBR is the most recognisable natural asset of the area. However, some areas outside the marine park are also important habitat for a number of migratory shorebirds and contain valuable stands of remnant vegetation. In addition to the ports, agriculture, tourism and fisheries are important contributors to the local and State economy. Mackay is the major city within the study area, with the surrounding urban area extending north and south, toward the ports. There are small, mainly coastal, communities scattered throughout the study area, including Louisa Creek, Half Tide, McEwens Beach and Bakers Creek.

Figure 2-1 The EVA Study Area



LEGEND

- Landmass Project Extent
- Ocean Project Extent

GDA94

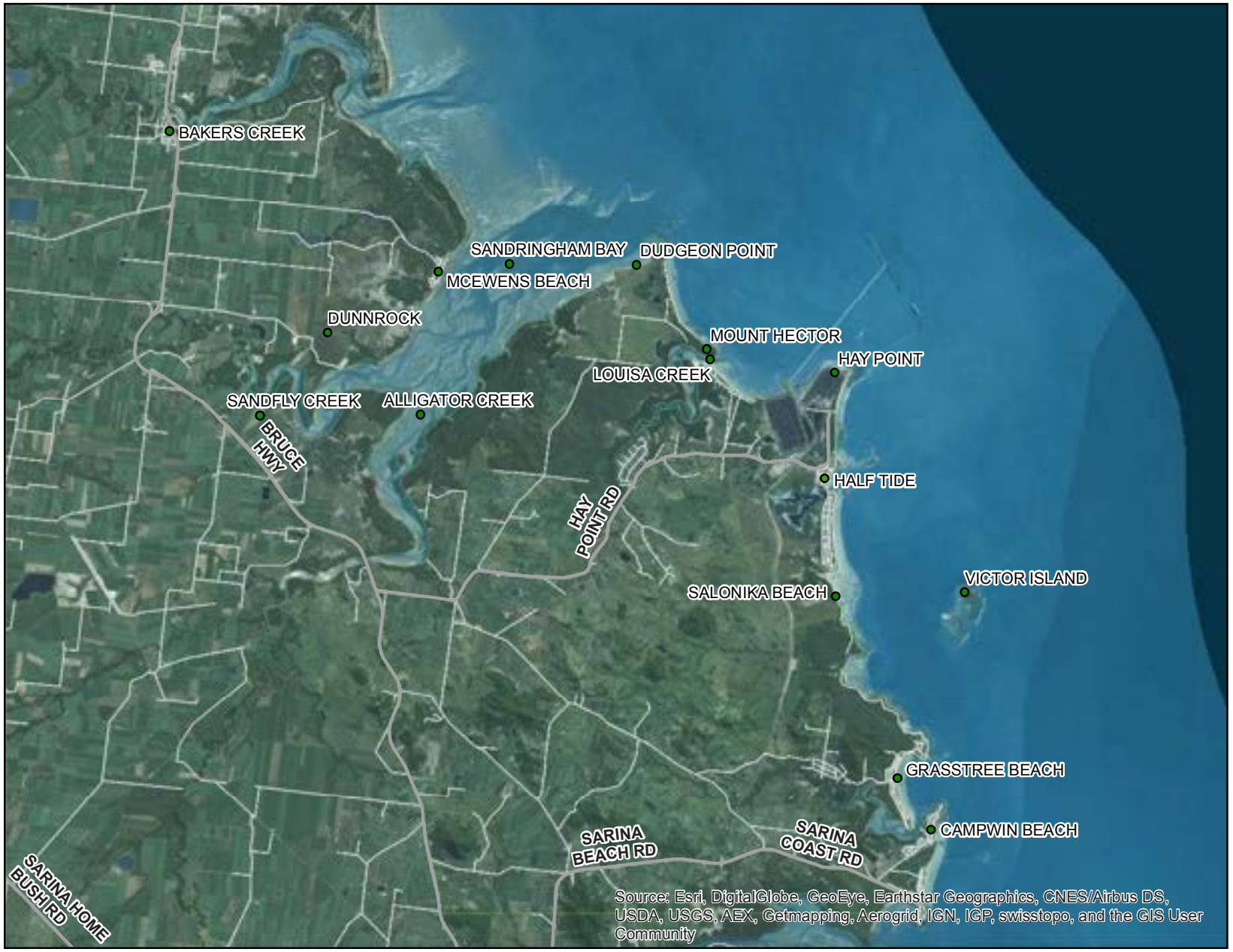
A4 1:550,000

0 5 10 15 20

Kilometres

JACOBS

Figure 2-2 Study Area - Port of Hay Point focus



LEGEND

- Localities
- Highways & Main Roads

GDA94

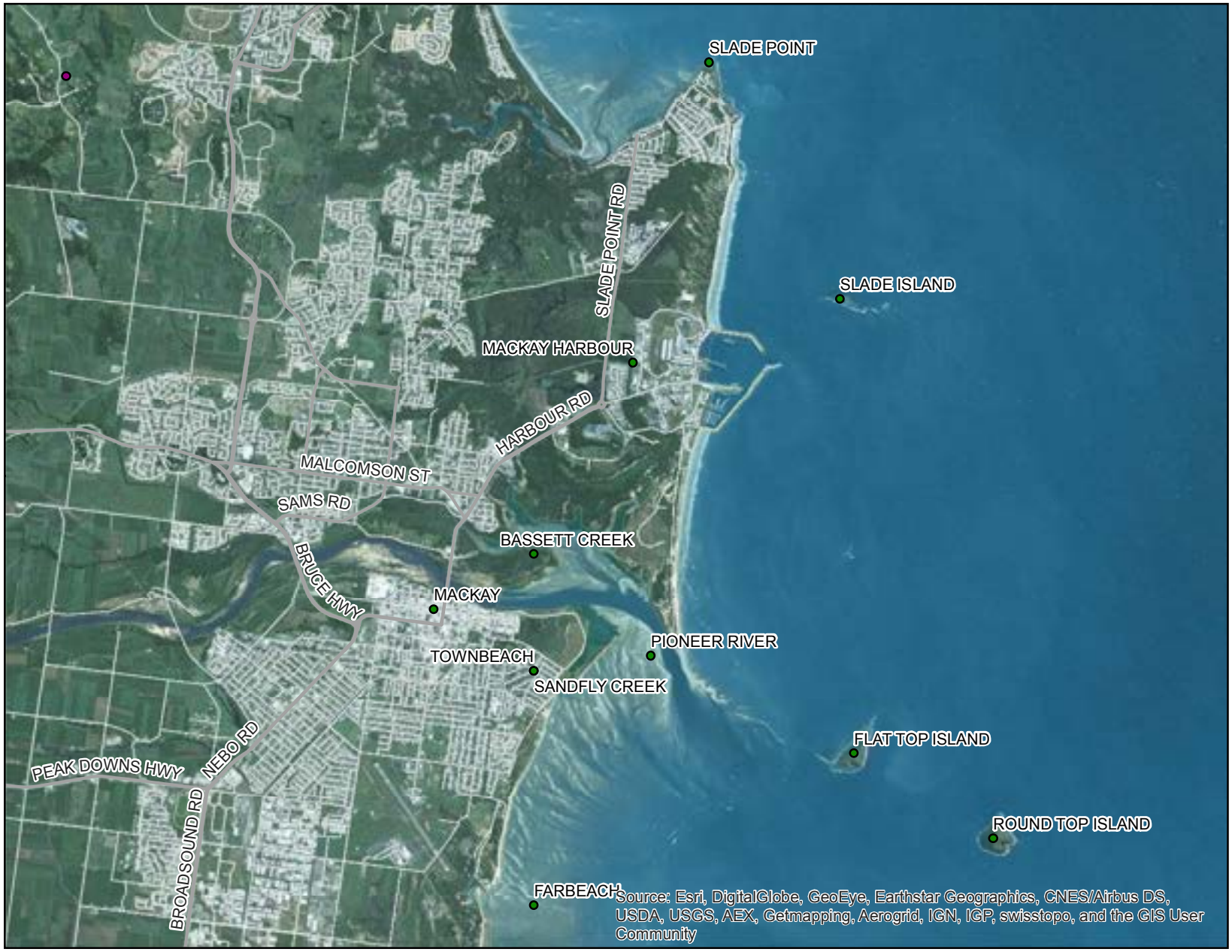
A4 1:140,000

0 1 2 3 4

Kilometres

JACOBS

Figure 2-3 Study Area - Port of Mackay Focus



LEGEND

- Localities
- Highways & Main Roads

GDA94

A4 1:90,000

0 1 2 3 4

Kilometres

JACOBS

2.2 Information sources

Available information from State, Commonwealth and other databases was reviewed to identify the EVs of the study area and their condition and vulnerability. These databases were:

- Department of Environment and Heritage Protection (DEHP) 2016, *Wildlife Online*, accessed 23 February 2016, available at https://environment.ehp.qld.gov.au/report-request/species-list/
- Department of Natural Resources and Mines (DNRM) 2016, *Regional Ecosystem Description Database*, available at https://www.qld.gov.au/environment/plants-animals/plants/ecosystems/about/
- Mature regrowth mapping Queensland government and Central Coast Regional Ecosystem mapping version 9: DNRM 2015, *Regulated Vegetation Mapping*, available at https://data.qld.gov.au/dataset/vegetation-management-act-series
- DEHP 2015, *Modelled potential habitat for selected threatened species in Queensland*, available at https://data.qld.gov.au/dataset/modelled-potential-habitat-for-selected-threatened-species-in-queensland/resource/8e5aab97-7b16-45e7-8a4b-2db765b851ab
- DEHP 2016, *Queensland Heritage Register*, available at https://environment.ehp.qld.gov.au/heritage-register/.
- Maritime Archaeological Association of Queensland shipwrecks database. Accessed 28 June 2016 at http://www.maaq.org.au/shipwrecks.php
- Department of the Environment and Energy 2016, Australian national shipwreck database. Accessed on 23 June 2016 at https://www.environment.gov.au/heritage/historic-shipwrecks/australian-national-shipwreck-database
- Commonwealth Department of the Environment and Energy 2016, *Protected Matters Search Tool*, available at http://www.environment.gov.au/epbc/pmst/
- Commonwealth Department of the Environment and Energy 2016, *Species Profile and Threats Database (SPRAT)*, available at http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl
- Department of the Environment and Energy (2016) Australian Heritage Database. February. Accessed on 18 February 2016 at http://www.environment.gov.au/cgi-bin/ahdb/search.pl.
- Atlas of Living Australia, available at http://www.ala.org.au/

In addition to database searches, we identified and reviewed a number of other information sources, including:

- Local planning schemes
- Survey, monitoring and assessment reports
- Environmental impact statements and associated documents
- Published literature
- Periodic status reports and yearbooks
- General web sites

The body of the report summarises the information, with the information sources listed at the conclusion of each section to retain an easy-to-read format. For each section, items of information relevant to the environmental values discussed in that section were compiled as the documents and data were reviewed, and when the reviews were complete the information was synthesised into the summaries presented in the report sections. Standard approaches to the assessment of condition and vulnerability, as outlined in recent publications such as the *Great Barrier Reef Outlook Report*, *Strategic Assessment and GBRMPA vulnerability assessment framework*, have been applied. Some of the information presented in the report, for example the areas of various habitat types, were derived from analysis of spatial information downloaded from Queensland and Commonwealth databases. These analyses were performed using the geodatabase compiled as an ancillary to this report.

2.3 Outstanding Universal Values of the World Heritage Area

The GBRWHA is listed on the basis of four World Heritage criteria for Outstanding Universal Value (OUV):

- Natural beauty and natural phenomena (Criterion (vii))
- Major stages of the Earth's evolutionary history (Criterion (viii))
- Ecological and biological processes (Criterion (ix))
- Habitats for conservation of biodiversity (Criterion (x))

The Statement of Outstanding Universal Value for the GBRWHA describes the attributes of the GBR that contribute to its OUV; these have also been summarised in the *Great Barrier Reef Outlook Report 2014*. The EVA classified the overall GBR attributes that contribute to OUV in three categories according to their presence and importance in the study area:

- Not present: Given the vast spatial scale of the GBRWHA, not all of the attributes that contribute to OUV are present in any given area at the relatively small spatial scale of the EVA study area.
- Minor or incremental contribution: Many of the processes and features that contribute to the GBR's OUV occur on large spatial scales relative to the study area. Any such attribute that occurs in a given area contributes to OUV - all such features are important. However, at the scale of the EVA study area some features within an area may represent a relatively minor contribution to OUV, because certain physical or biological features may not be important or abundant relative to other areas of the reef. They may also make an incremental contribution, when features or processes are widespread in the GBR ecosystem so the contribution of any given area is proportional to its relative size. For example, the GBRWHA listing notes that there are 242 bird species in the property - obviously not all of these occur in the study area but the composite species diversity of the property as a whole is the accumulation of diversity in smaller areas.
- Significant contribution at the scale of the World Heritage property: In some cases, specific places within the GBR make important contributions to OUV on the scale of the whole reef; sometimes such places are explicitly identified in the Statement of Outstanding Universal Value. For example, Raine Island (not within the study area) is the world's largest green turtle (*Chelonia mydas*) breeding site and therefore significant not only at the scale of the entire GBRWHA but also globally.

2.4 Structure of this document

The format of the main report, which comprises five chapters is:

- Chapter 1 Introduction – an introduction detailing background, project history and report conventions
- Chapter 2 Methods (this chapter) – a description of the method, study area and information sources used for the EVA. Also provides a description of the OUV for the GBRWHA.
- Chapter 3 Environmental values – each of the EVs are summarised to provide a regional summary, overview of the values, description of places where the EVs are in the study area, condition and variability and the information sources used. Environmental values have been grouped into five categories, which are as follows:
    - Landform and biota
    - Air quality
    - Aquatic ecosystems – freshwater
    - Aquatic ecosystems – marine
    - Social values
- Chapter 4 Gap analysis – identificaiton of gaps…
- Chapter 5 A conceptual approach to future risks and opportunities – description of the vulnerability of values to port activities and the resilience of environmental values to change.

3. Environmental Values

3.1 Outstanding Universal Value

Table 3–1 shows a summary of the attributes contributing to the GBRWHA's OUV, and their EVA classifications based on presence and importance in the study area. None of the specific locations referred to in the World Heritage listing, for example green turtle breeding on Green Island and the Cod Hole tourist attraction, occur in the study area. There are no coral cays in the study area, so it does not contribute to aspects of OUV specific to cays. Dugongs are sometimes seen in the study area, but there are no major feeding grounds and no resident population. Similarly, though humpback whales migrate through the study area there are no records of calving, and while low-density sea turtle nesting occurs there are no regionally significant rookeries. No major seabird breeding sites are known in the study area. Reef fish spawning aggregations are unlikely to occur on the fringing reefs in the study area. Spawning aggregations typically occur on prominent features, such as spurs, channels, bommies, or steep drop-offs, often on the outer edges of reefs, which have strong currents flowing into deep water (Johannes, 1981; Russell, 2001).

The study area does make a contribution to OUV under the majority of the Property's listing criteria. In all cases, this contribution is incremental, in that the study area supports a subset of the features and processes (e.g. natural beauty, biodiversity, coral reef accretion) identified in the listing. However, none of the study area's contributions to OUV are critical contributions at the scale of the World Heritage Property.

Further information regarding these attributes, except those not present in the study area, is presented in subsequent sections.

Table 3-1 Attributes of the GBR that contribute to its OUV under the four World Heritage listing criteria and their classification in this EVA

Natural beauty and natural phenomena	Major stages of Earth's evolutionary history	Ecological and biological processes	Habitats for conservation of biodiversity
Superlative natural beauty above and below the water	Globally outstanding example of an ecosystem evolved over millennia through glacial cycles	Significant diversity of reef and island morphologies reflecting geomorphic, oceanographic and environmental processes	One of the richest, most complex natural ecosystems on earth, and most significant for biodiversity conservation, supporting tens of thousands of species, many of global conservation significance
Complex string of reef structures along the coast	Environmental history recorded in old massive corals	Cross-shelf, longshore and vertical connectivity	Coral reefs contain 400 species of corals in 60 genera
Mosaic of reefs, islands and cays produces an unparalleled aerial panorama of seascapes	World's largest coral reef ecosystem, including examples of all stages of reef development	Ecological processes including upwellings, larval dispersal and migration	Half the world's mangrove diversity
Green vegetated islands, sandy beaches and azure waters in the Whitsunday Islands	Processes of geological and geomorphic evolution linking continental islands, coral cays and reefs	Erosion and accretion of coral reefs, sand banks and coral cays	Many seagrass species
Vast mangrove forests, vegetated mountains, lush rainforest gullies in the Hinchinbrook Channel	Continental slope, deep oceanic waters and abyssal plains	Beds of *Halimeda* algae producing calcification over millenia	Major feeding grounds for dugong

Natural beauty and natural phenomena	Major stages of Earth's evolutionary history	Ecological and biological processes	Habitats for conservation of biodiversity
Globally important breeding colonies of seabirds and marine turtles on coral cays		Mature ecosystem that has evolved high biodiversity over millenia, including over 4,000 species of molluscs and over 1,500 species of fish, plus a great diversity of sponges, anemones, marine worms, crustaceans and many others	At least 30 species of cetaceans
Green turtle breeding on Raine Island		Vegetation on cays and continental islands exemplifying the role of birds in seed dispersal and plant colonisation	Significant area for humpback whale calving
Aggregations of over-wintering butterflies on continental islands			Regionally important marine turtle rookeries
Diversity of shapes, sizes and colours of hard and soft corals			Six of the world's seven marine turtle species
Thousands of reef fish species with a myriad of shapes, sizes and colours			242 bird species
Cod Hole as a tourist attraction			22 seabird species breed on cays and some continental islands, some sites are globally significant breeding sites
Annual coral spawning			Thousands of plant species on continental islands
Migrating whales			Some coral cays have distinct flora and fauna
Nesting turtles			
Significant spawning aggregations of many fish species			

Table legend	
	Not present
	Minor/incremental contribution
	Contribution at the property scale

Information sources

Birkett, R. (2014). Coastal and Inland Flood Hazards in Mackay Region. May. Available at http://reefcatchments.com.au/files/2013/12/Flood-Hazards-Mackay-Birkett-.pdf. Mackay Regional Council.

Great Barrier Reef Marine Park Authority (2014). Great Barrier Reef Outlook Report 2014. Great Barrier Reef Marine Parks Authority. Townsville, Queensland.

Johannes R.E. (1981). Words of the Lagoon: Fishing and Marine Lore in the Palau District of Micronesia, Berkeley: University of California Press.

Lucas P.H.C., Webb T., Valentine P.S. & Marsh H. (1997). The Outstanding Universal Value of the Great Barrier Reef World Heritage Area. May. Great Barrier Reef Marine Park Authority, Australia.

Russell, M. (2001). Spawning aggregations of reef fishes on the Great Barrier Reef: implications for management. Great Barrier Reef Marine Park Authority, Townsville.

3.2 Landform and biota

3.2.1 Soil quality, erosion and sedimentation

AREA PROFILE: SOIL QUALITY, EROSION AND SEDIMENTATION

Soils are the foundation of healthy ecosystems and a strong agricultural industry. Soil quality is assessed through a number of properties, such as nutrient status, salinity, water holding capacity, erodibility and its contribution of sediment into aquatic systems. Port of Mackay soils consist of Quaternary alluvium and lacustrine deposits (sand, silt, mud and gravel). Good quality agricultural land (GQAL) occurs north west of the Port of Mackay and north and west of the Port of Hay Point. As a result of its geology and topography, the study area is not particularly susceptible to erosion and sedimentation, and it is not seismically active.

Environmental Values

Soil has economic and environmental value. Irrigated sugarcane land in the Mackay/Isaac region has a positive economic impact. Degradation of soils can impact negatively on the environment, through the contribution of eroded sediments into aquatic ecosystems, erosion of soils through human impact and the exposure of acid sulfate soils (ASS).

Contribution to OUV

Soils do not directly contribute to OUV; however, they provide the foundation for vegetation and fauna communities, which contribute to visual amenity and appreciation. Erosion increases sediment loads to the GBR lagoon, which is one of the main threats to the health of the reef.

Vulnerability

Clearing for agriculture and urban development are the major activities that contribute to soil degradation. Demand for urban development has led to the loss of some GQAL for sugarcane production, mainly around Mackay. Seawater intrusion in the coastal strip between Sarina and Mackay has also led to degradation of productive sugarcane land. Exposure of ASS may result in the generation of sulphuric acid which can have a flow-on effect for surrounding areas and waterways.

Gaps

No notable gaps in the available information have been identified from the perspective of the EVA.

Summary of Importance

The region has some of the highest-value sugarcane and grazing land in Queensland. GQAL for cane production has been lost to urban development, mainly around Mackay. GQAL for cane production has been

AREA PROFILE: SOIL QUALITY, EROSION AND SEDIMENTATION

degraded along the coast between Sarina and Mackay. Expansion westward is constrained by transport links and water availability.

What does this mean?

Exposed soils, due to agricultural or other development, may contribute to increased sediment loads to the GBR lagoon. Land management practices to minimise sediment entering the GBR lagoon is one of the highest priorities for improved water quality.

Fragmentation and/or loss of GQAL for non-agricultural uses, through continued land development in the study area, have the potential to influence the economic output from the study area.

Regional summary

The study area lies within the Proserpine-Sarina Lowlands biogeographic subregion of the Central Queensland Coast bioregion. This subregion is characterised by alluvial and estuarine sediments that are interspersed with acid intrusive hills and bluffs to the east, and foothills and low ranges located on intermediate to basic volcanic and metasediments to the west. The existing coastline of Mackay and Hay Point was formed through the deposition of sediments during the Holocene epoch. Onshore transport of sand and other sediments from the continental slope offshore contributed to formation of the beaches during the early Holocene.

The Port of Mackay area is characterised by rocky outcrops (Mt Bassett dolerite and Whitsunday Volcanics), foredunes and parabolic dune systems, low-lying freshwater wetlands, grasslands, and remnants of older beach ridges west of the Slade Point Road. The soils are comprised of Quarternary (quartz sand, mud, sandy mud, muddy sand and minor gravel, gravel, sand and mud, quartzose to shelly sand) and Cretaceous material (basalt and dolerite dyke swarm with screens of Carmila beds, Whitsunday Volcanics, Campwyn beds and/or Calen Coal Measures; rhyolitic to andesitic volcanoclastic rocks including ignimbrite, minor flows, conglomerate and sandstone).

Geological maps for the study area show that Dudgeon Point and the Port of Hay Point are dominated by Quarternary Alluvium (comprised of sand, silt, mud, clay and gravel) and the Campwyn Beds (comprised of andesitic and rhyolitic flows and pyroclastics, mudstone, siltstone, lithic arenite, limestone, oolitic limestone and conglomerate). The Quarternary deposits are associated with low-lying areas that may be ASS. The Cretaceous materials place limitations on areas for excavation. There is a third geological unit (Tertiary Volcanic) at the mouth of Louisa Creek.

Agriculture is a dominant land use in the study area and broader region. Agriculture is dominated by sugarcane production and grazing, but there are a range of other agricultural activities due to the favourable climate and soils.

The study area is not particularly vulnerable to erosion, as a result of its geology and topography. Exposed soils and cleared channels may be eroded during periods of heavy rainfall, particularly during tropical cyclones. Natural hazards, such as landslides, can cause loss of life, and damage to property, infrastructure and the environment.

Seismically, the region is considered to be low risk, with no known geological fault lines or other tectonic features in the vicinity. The Geoscience Australia earthquake database contains one earthquake record in the Mackay region, a magnitude 4.7 earthquake centred approximately 30 km offshore of Mackay in 1960.

Overview of values

Soil has direct economic value for plant growth, especially crops, as well as through structural support for infrastructure development. Soil also supports a variety of important habitats, including coastal dunes, wetlands, terrestrial vegetation and rocky outcrops. Erosion and the contribution of eroded sediments, along with the exposure of ASS can contribute negatively to a range of other values (such as water quality).

As of 2012, irrigated sugarcane land in the Mackay Regional Council local government area had the highest economic value, ($18,000/ha) for this land category in Queensland. Dryland sugarcane land and grazing land were also at the high end of the Queensland market. Prices for grazing land however, have been elevated by demand from developers for urban expansion.

Description of places

Development of the ports has mainly occurred on coastal dunes. In Mackay, hard rock resources were extracted from a quarry at Mt Bassett and used primarily for construction of the breakwaters at Mackay Harbour.

Soils around the Port of Mackay Port consist of Quaternary alluvium and lacustrine deposits (sand, silt, mud and gravel). Surface geology in the Mackay coastal region is dominated by two units: the primarily Palaeozoic (around 200 million years old) volcanic and sedimentary bedrock outcrops of the Campwyn beds (at Slade Point) and relatively recent Holocene (up to 10,000 years old) deposition of coastal sediments.

Dominant soil types in the area of the Port of Mackay include:

- Rudosols which are poorly developed but widespread, generally with low fertility and low water holding capacity.
- Podosols which are typically sandy soils distinguished by a bleached lower topsoil and coloured subsoil which is caused by the accumulation of organic compounds, aluminium and/or iron. These soils have a moderate risk for erodibility.
- Anthroposols which are the result of profound anthropogenic modification, truncation or burial of the original soil horizons, or the creation of new soil parent materials.
- Hydrosols which are soils saturated with water for long periods of time, typically greenish-grey or containing strongly contrasting iron-stained colours, which may be ASS. These soils have strong waterlogging features at or near the surface.

Based on the underlying geology, five broad soil groups were identified as likely to occur in the Dudgeon Point/Port of Hay Point area. These include a variety of physical, chemical and nutrient characteristics which influence how the soils can be used and managed. These soil groups include:

- Sedentary soils (mainly shallow stony acidic brown lithosols)
- Ferric, sodic, yellow chromosols
- Ferric, mottled, subnatric, yellow grey sodosols
- Humose, extratidal hydrosols
- Straticrudosols

GQAL occurs north of Keeleys Road, northwest of the Port of Mackay. GQAL lies west and north of the Port of Hay Point.

A broad indicator of a 15% slope or greater is used in Queensland to identify landslide hazard. The most recent mapping, completed for the draft Mackay Region Planning Scheme, shows areas with 15% or greater slope north and southwest of the Port of Mackay. Around the Port of Hay Point, patches of 15% slope or greater are mapped to the north, west and southwest.

ASS mapping indicates that ASS occurs in tidal parts of the Hay Point-Armstrong Beach area. There are potential acid sulfate soils (PASS) in the mangroves at a depth of less than 0.5 m and between 0.5 m to 1 m thick. Soils below 5 m Australian height datum (AHD) have a low potential for acid generation.

Major ASS potential exists in many coastal areas around Mackay. Estuary, swamp and associated flood plain areas generally have high to extreme acid-sulfate potential. Land in the Port of Mackay at or below 5 m AHD may contain PASS.

Condition and variability

Development in coastal areas places pressure on GQAL, through loss of land to infrastructure development or through fragmentation. This has mainly occurred around Mackay. Seawater intrusion into freshwater aquifers has impacted the coastal sugarcane land east of the Bruce Highway between Sarina and Mackay, primarily as a result of groundwater extraction.

According to the Queensland Agricultural Land Audit, about 26% of suitable sugarcane land in the Mackay, Isaac and Whitsunday region is under cane production. By contrast, some 92% of suitable grazing land is under production.

While the study area itself is not particularly prone to erosion, this is not necessarily true of the catchments in the hinterland. In general, erosion, and as a result sediment inputs to the GBR lagoon, have increased since pre-European times as a result of clearing and land use. Kroon *et al*. (2012) estimated that total suspended solids (TSS) loads in the Pioneer Basin have increased only about 4% since pre-European time. By contrast, there has been an estimated 10-fold increase in TSS loads in the Plane Basin, and a six-fold increase in the Mackay-Whitsunday Natural Resource Management (NRM) region. No estimates are available for individual sub-catchments.

Around one third of the Hay Point shoreline leading into Dalrymple Bay is comprised of revetments armoured with concrete. Rocky volcanic outcrops can result in slope stability issues due to the shallow soil depth. Sediment is discharged from rivers in the study area into the GBR. Most of the coarse (sand and gravelly) sediments are deposited near river mouths but finer mud particles may be transported much further. McEwens Beach, north of Hay Point, has a history of beach erosion.

Vulnerability

Threats to soil in the study area include acidification, erosion and instability (i.e. landslide hazard). Disturbance of ASS through excavation, filling or lowering of the water table may result in the generation of sulphuric acid. Land and water in surrounding areas can become highly acidic, causing water discolouration and, more importantly, significant ecosystem degradation.

In principle, cane production could expand westward to compensate for losses of GQAL to urbanisation and seawater intrusion. However, such expansion is constrained by transport infrastructure and access to water.

Disturbance of highly erosive soils can increase the potential for erosion and increased sediment inputs to aquatic systems. Areas undergoing development or stockpiling materials on areas that are geotechnically unstable can result in structure failure and, again, increased sediment loads entering the system.

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3.2.2 Terrestrial vegetation communities

AREA PROFILE: TERRESTRIAL VEGETATION COMMUNITIES

There are 31 regional ecosystem (RE) types mapped in the study area. In general, the region includes mangroves, dunal vegetation, vine forest, swamps and wetlands, open eucalypt forest and tussock grassland. Endangered and of-concern REs occur in patches throughout the study area and are generally scattered along the coastline. Approximately 11,824 ha of vegetation is mapped as remnant REs, with regrowth vegetation also occurring predominantly along watercourses.

Two threatened ecological communities (TECs) listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) occur within the study area. These are Littoral Rainforest and Coastal Vine Thickets of Eastern Australia and Broad Leaf Tea-tree (*Melaleuca viridiflora*) Woodlands in High Rainfall Coastal North Queensland (Broad Leaf Tea-tree TEC).

Environmental Values

The vegetation communities in the study area provide:

- Areas of remnant vegetation including TEC
- Storm protection for urban and inland areas
- Tourism, recreational opportunities and scenic amenity
- Movement corridors for wildlife
- Food, shelter and breeding resources for resident fauna including threatened species.
- Critical seasonal food resources for migratory fauna
- Biological resources and ecosystem services such as nutrient cycling and sustaining water and air quality

Contribution to OUV

On the mainland, REs do not directly contribute to OUV but provide land-sea linkages and complement visual amenity and visual appreciation, which indirectly enhance OUV. Island vegetation communities directly relate to OUV criteria in that they represent ecosystems that have evolved over millennia and provide habitat for

AREA PROFILE: TERRESTRIAL VEGETATION COMMUNITIES

populations of rare or endangered species of flora and fauna.

Vulnerability

Vegetation is generally threatened by increasing development (clearing and fragmentation) including urban development, tourism, agricultural expansion and industrial development. Other threatening processes include soil compaction and erosion, introduction of weeds and other pests (e.g. feral animals and myrtle rust), illegal waste dumping and changes to natural fire regimes.

Furthermore, most of the threatened REs and TECs in the study area are coastal vegetation communities that are vulnerable to the predicted impacts of climate change. Primarily, this is predicted to include more variable rainfall combined with more intense/frequent storm and cyclone damage and sea level rise.

Gaps

REs are mapped at a scale of 1:50,000. Detailed ground-truthing of REs within the study area has not been undertaken in most areas. If undertaken, more accurate mapping would be generated and therefore the extent and types of mapped REs may change.

Summary of Importance

About 2% of the mapped remnant vegetation within the study area contains REs that represent TECs under the EPBC Act. This includes potentially 127.1 ha of the Broad Leaf Tea-tree TEC and 136.2 ha of Littoral Rainforest And Coastal Vine Thickets TEC.However, the extent of these TECs is likely to be less due to their inclusion in mixed polygons.

Five REs have a significant proportion of their total occurrence within the study area. This includes 8.1.4 (of concern), 8.2.13 (endangered), 8.12.13 (of concern), 8.12.25 (of concern), 8.12.27 (endangered), which have 13.8%, 21%, 21.4%, 31.5% and 26.9% of their entire Queensland occurrence within the study area, respectively. Dominant vegetation types include mangrove forests, saltpans, open forest, woodland and tussock grassland.

Of the 11,823 ha of mapped remnant RE in the study area, a majority (4,243 ha, 36%) is mapped as of-concern remnant REs. In addition, 1,376.7 ha (12%) is mapped as endangered and 16,203.7 ha (52%) is mapped as least-concern remnant RE.

The endangered and of-concern REs as well as the TECs in the study are considered important due to a combination of their biodiversity values, the low extent of remaining vegetation and the degree of pressure they are under from threatening processes such as clearing and climate change. The Broad Leaf Tea-tree TEC is also habitat for the endangered lesser swamp orchid (*Phaius australis*; see Section 3.2.3).

Key areas of importance include:

- Louisa Creek, north of Hay Point, which supports isolated remnant patches of vegetation. It is important for conservation and connectivity of vegetation.
- The area of TEC near Hay Point, which provides an important buffer between the Port and turtle nesting sites to the south (see Section 3.5.7).
- The Mount Hector Conservation Park (approximately 2 km north of the Port of Hay Point, bordering port land at Dudgeon Point), which provides some important bird habitats, including low-lying mangroves and pandanus swamps behind the dunes.
- Dudgeon Point, which has good connectivity to coastal environments, including the adjacent Mount Hector Conservation Park and Sandringham Bay – Bakers Creek Aggregation to the north.
- The Pioneer River mouth/Bassett Basin area, located approximately 3 km south of the Port of Mackay, which has a diverse range of mangrove species

AREA PROFILE: TERRESTRIAL VEGETATION COMMUNITIES

What does this mean?

The study area contains terrestrial vegetation communities that are considered to be important at both the Commonwealth and State levels. Increasing development for urban, tourism, agricultural expansion and industrial development places pressure on the remaining vegetated areas.

Reduction in the area of vegetation communities in the study area also decreases the habitat for endangered and threatened species of flora and fauna.

State legislation and the Mackay Regional Council Planning Scheme endeavour to protect the remaining vegetation communities by placing restrictions on the clearing of vegetation communities.

Regional summary

The region includes several broad vegetation types, including mangroves, dunal vegetation, vine forest, swamps and wetlands, open eucalypt forest and tussock grassland.

Melaleuca swamps of the region are known for their ground orchid diversity. Louisa Creek, north of Hay Point, supports isolated remnant patches of rainforest, littoral forest, lowland closed forest, and coastal eucalypt open forest that is almost free of weeds. This patch of remnant vegetation is important for conservation and connectivity of vegetation.

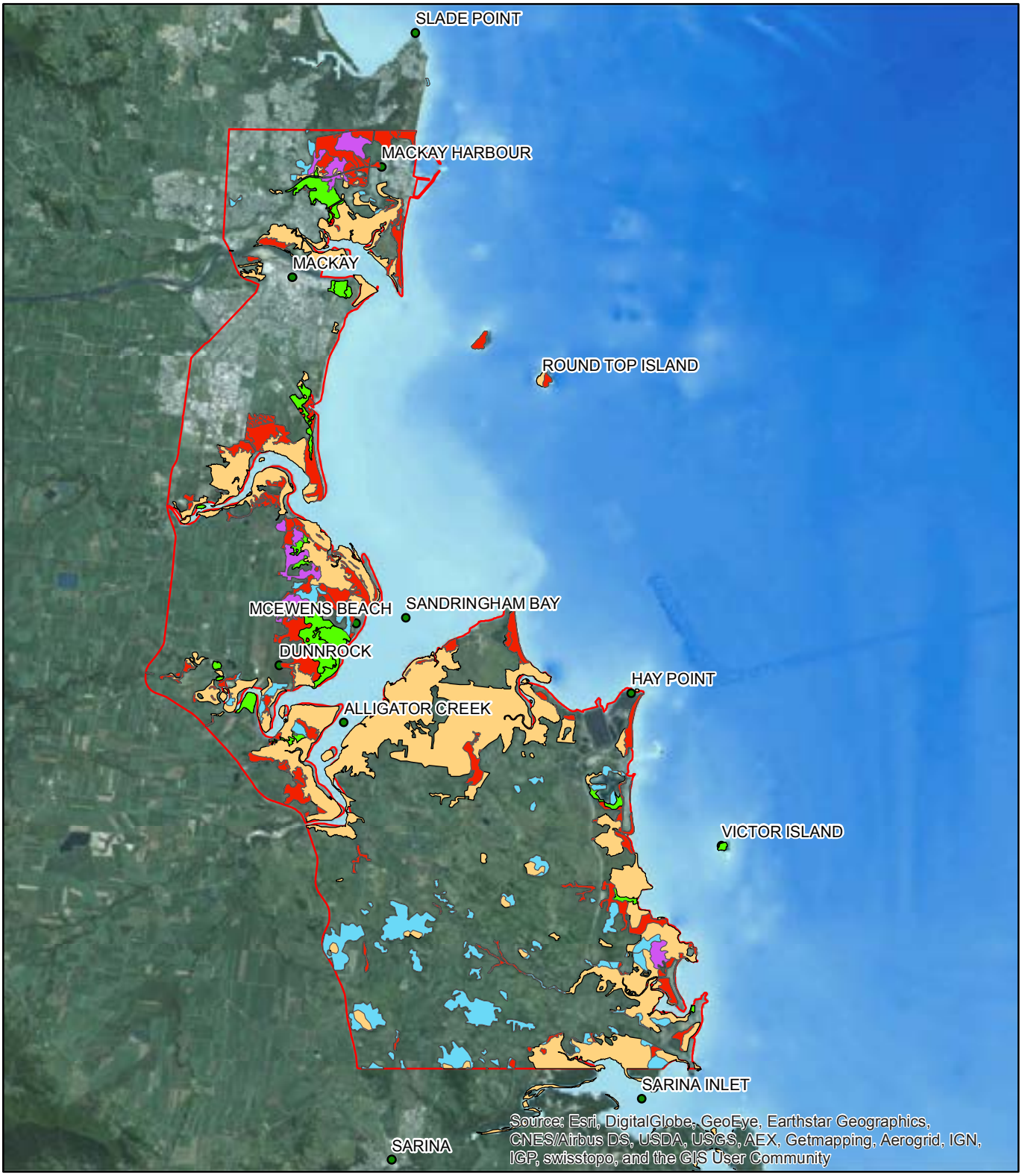
Remnant vegetation generally provides good connectivity along the coastal seaboard, with regrowth vegetation enhancing the connectivity of habitat in inland areas (Figure 3–1). Two TECs, Littoral Rainforest and Coastal Vine Thickets of Eastern Australia and Broad Leaf Tea-tree TEC), also occur within the study area (Figure 3–2). About 13% of the mapped remnant REs within the study area is considered to represent a TEC. In addition to the TECs, endangered REs occur in patches throughout the study area and are generally scattered along the coastline.

Around the Port of Hay Point, patches of endangered REs occur at Lake Barfield, as well as around Grasstree Beach, Campwin Beach and Sarina Beach, northwest and west of McEwens Beach and south and west of Dunnrock. Isolated patches also occur between Alligator Creek, Sarina and Campwin Beach. In the north of the study area, patches of endangered REs occur northwest of Mackay Harbour. Of-concern REs also occur within the study area, generally in small patches both on the coast in the inland parts of the study area. Remnant vegetation at Dudgeon Point is largely intact and has high levels of connectivity to adjacent coastal environments.

The biodiversity status listing of REs is based on an assessment of the condition of remnant vegetation, in addition to the criteria used to determine the class (e.g. endangered, of concern) under the *Vegetation Management Act 1999* (VM Act). The biodiversity status of all the endangered REs within the study area is considered to be endangered. The biodiversity status of approximately half of the of-concern REs found within the study area is also considered to be endangered. The remaining of-concern REs have a biodiversity status of of concern. Two REs within the study area are listed as least concern under the VM Act, however, have a biodiversity status as of concern. REs in the study area with a biodiversity classification of endangered or of concern are shown in Figure 3–3.

Regrowth vegetation in the study area increases connectivity between remnant vegetation patches, and provides a buffer from edge effects, such as weed invasion and fire. Extensive mature regrowth patches in the study area are around Dudgeon Point, Freshwater Point, Sarina, and Alligator Creek in the south. Scattered small patches of mature regrowth occur in the vicinity of Mackay Harbour and Mackay and in occasional isolated patches from Mackay Airport to Dunnrock in the north of the study area.

Figure 3-1 Regional Ecosystem classification under the VM Act



LEGEND

- Landmass Project Extent
- Ocean Project Extent

Regional Ecosystem Biodiversity Classification

- Endangered - Dominant Vegetation
- Endangered -Sub-dominant
- Of Concern - Dominant
- Of Concern - Sub-Dominant
- Least Concern

[GDA94 | MGA55]

A4 1:200,000

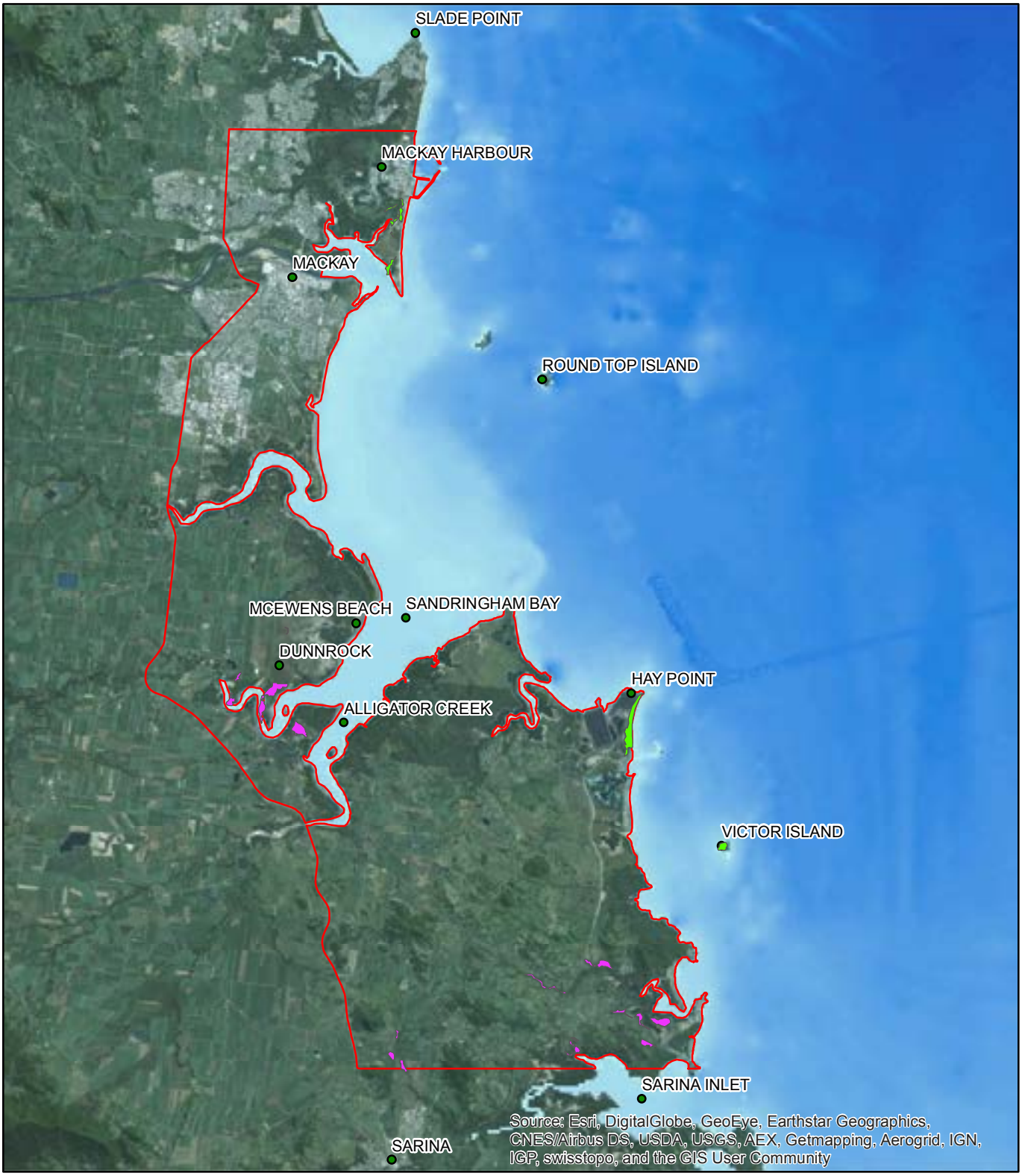
N

0 5 10

Kilometers

JACOBS

Figure 3-2 Potential Threatened Ecological Communities in the study area



LEGEND

- Landmass Project Extent
- Ocean Project Extent

Potential Threatened Ecological Communities

- Littoral Rainforest and Coastal Vine Thickets of Eastern Australia
- Broad Leaf Tea-tree (*Melaleuca viridiflora*) Woodlands in High Rainfall Coastal North Queensland

[GDA94 | MGA55]

A4 1:200,000

N

0 5 10

Kilometers

JACOBS

Figure 3-3 Biodiversity classifications of endangered and of-concern REs in the study area

LEGEND

- Landmass Project Extent
- Ocean Project Extent

Regional Ecosystem Biodiversity Classification

- Endangered - Dominant Vegetation
- Endangered -Sub-dominant
- Of Concern - Dominant
- Of Concern - Sub-Dominant

[GDA94 | MGA55]

A4 1:200,000

N

0 5 10

Kilometers

JACOBS

Overview of values

Coastal vegetation protects urban and inland areas from storm impacts, provides critical seasonal food resources for migratory fauna, and continual food and shelter resources for resident fauna, including threatened species. The area of TEC near Hay Point in particular provides an important buffer between the Port and turtle nesting sites to the south (see Section 3.5.7).

The Mount Hector Conservation Park (approximately 2 km north of the Port of Hay Point, bordering port land at Dudgeon Point) provides some important bird habitats, including low-lying mangroves and pandanus swamps behind the dunes. Estuaries of Sandy and Bakers Creeks, which both flow into Sandringham Bay, contain extensive stands of intertidal wetland vegetation. Most of the mangrove community is at the mouth of the Bakers Creek Conservation Park.

Dudgeon Point has good connectivity to coastal environments, including the adjacent Mount Hector Conservation Park and Sandringham Bay – Bakers Creek Aggregation to the north, but has limited connectivity to the west due to past clearing.

The Pioneer River mouth/Bassett Basin area, located approximately 3 km south of the Port of Mackay, has a diverse range of mangrove species, with 16 species recorded in the Bassett Basin area.

The TEC of Littoral Rainforest and Coastal Vine Thickets of Eastern Australia provides an important stepping stone along the eastern Australian coast for migratory and marine birds and flying-foxes. The community also provides a buffer to coastal erosion and wind damage, and provides natural refugia, suitable nest sites and food resources for resident and migratory bird species. Several other EPBC Act listed plant, bird, mammal and frog species also known to inhabit TEC (see Sections 3.2.3 and 3.2.4). Remnant vegetation containing REs that constitute Littoral Rainforest and Coastal Vine Thickets TEC occur across 136.2 ha of the study area, with a further 26.9 ha of mature regrowth mapped that has the potential to be the TEC.

The Broad Leaf Tea-tree TEC is important for the function of the GBR. It connects the terrestrial and marine environments, regulates overland flows and provides spawning, recruitment and refuge areas for aquatic species. It also functions as a storage and source of nutrients and sediment trap. The community is also known to be habitat for several threatened ground orchid species, including the lesser swamp orchid (*Phaius australis*). It provides habitat for ground-burrowing frogs, reptiles and native rodents, such as the delicate mouse (*Pseudomys delicatulus*) and the Broad Leaf Tea-tree is a vital food source for many animals, especially honeyeaters, butterflies, gliders, and flying foxes. The study area consists of 127.7 ha of remnant vegetation containing Res that constitute the Broad Leaf Tea-tree TEC, with a further 236.6 ha of mature regrowth mapped that has the potential o be the TEC.

Both TECs have been significantly reduced and fragmented by sand mining, agriculture and coastal development. This is particularly the case for RE 8.3.2, which was formerly the largest regional ecosystem related to the Broad Leaf Tea-tree TEC and is the only RE in the study area that represents this TEC.

Thirty-one RE types are mapped in the study area, with over 11,800 ha of vegetation considered to be remnant. Of this, approximately 1,376.7 ha is mapped as endangered remnant RE and 4,243.3 ha is mapped as of concern remnant RE, with the remainder (1,041 ha) mapped as least-concern remnant RE. REs are mapped in Figure 3–1, with details of each RE provided in Table 3–2. Further information on the values of each RE is presented in Appendix A.

Table 3-2. Summary of of-concern and endangered Regional Ecosystems and Threatened Ecological Communities in the study area

RE Code	Name	VMA Class[1]	BD status[2]	Total area within study area (ha)	% of Qld total	TEC?
8.1.1	Mangrove closed forest of marine clay plains and estuaries	LC	NCAP	3,942.8	9.8	No
8.1.2	Samphire open forbland on saltpans and plains adjacent to mangroves	LC	OC	464.1	4.4	No
8.1.3	*Sporobolus virginicus* tussock grassland on marine sediments	OC	OC	522.9	12.4	No
8.1.4	*Schoenoplectus subulatus* and/or *Eleocharis dulcis* sedgeland or *Paspalum vaginatum* tussock grassland	OC	E	197.8	13.8	No
8.1.5	*Melaleuca* spp. and/or *Eucalyptus* tereticornis and/or *Corymbia tessellaris* woodland with a ground stratum of salt tolerant grasses and sedges, usually in a narrow zone adjoining tidal ecosystems	OC	E	70.3	5.8	No
8.2.1	*Casuarina equisetifolia* woodland and/or sparse herbland to open scrub on foredunes and beaches	OC	OC	52.3	5.7	No
8.2.2	Semi-evergreen microphyll vine thicket to vine forest, on coastal dunes	OC	E	26.3	1.2	Yes
8.2.6	*Corymbia tessellaris* +/- *Acacia leptocarpa* +/- *Allocasuarina littoralis* +/- *Banksia integrifolia* +/- rainforest species open forest on parallel dunes	OC	OC	414.1	8.7	No
8.2.7	*Melaleuca* spp. and/or *Lophostemon suaveolens* and/or *Eucalyptus robusta* open forest in wetlands associated with parabolic dunes	OC	E	127.6	4.1	No
8.2.9	Tussock grassland on coastal dunes	OC	E	30.9	15.7	No
8.2.13	*Melaleuca* spp. and/or *Corymbia* spp. and/or *Lophostemon suaveolens* and/or *Acacia* spp. open forest on dune sands mixed with alluvial material +/- marine sediments	E	E	121.8	21.0	No
8.3.1	Semi-deciduous to evergreen notophyll to mesophyll vine forest, +/- sclerophyll emergents, fringing or in the vicinity of watercourses	OC	E	13.6	0.2	No
8.3.2	*Melaleuca viridiflora* woodland on seasonally inundated alluvial plains with impeded drainage	E	E	120.3	1.6	Yes
8.3.3	*Melaleuca leucadendra* and/or *M. fluviatilis* and/or *Casuarina cunninghamiana* +/- *Syncarpia glomulifera* open forest, on creek banks	LC	OC	16.0	0.1	No
8.3.4	Freshwater wetlands with permanent water and aquatic vegetation	E	E	18.2	3.2	No
8.3.5	*Eucalyptus platyphylla* and/or *Lophostemon suaveolens* and/or *Corymbia clarksoniana* woodland on alluvial plains	OC	E	243.8	1.1	No
8.3.6	*Eucalyptus tereticornis* and/or *Corymbia intermedia* (or *C. clarksoniana*) and/or *C. tessellaris* +/- *Lophostemon suaveolens* open forest on alluvial levees and lower terrace	OC	E	6.3	0.04	No
8.3.10	Semi-evergreen to evergreen notophyll vine forest, on gently to moderately-sloping alluvial fans adjacent to ranges	OC	OC	2.1	0.1	No
8.3.12	*Imperata cylindrica* and/or *Sorghum nitidum* forma *aristatum* and/or *Ischaemum australe* tussock grassland on alluvial and old marine plains	E	E	170.4	15.7	No
8.3.13	*Eucalyptus tereticornis* and/or *Corymbia tessellaris* and/or *Melaleuca* spp. woodland on alluvial and marine plains, often adjacent to estuarine	OC	E	98.8	1.4	No

RE Code	Name	VMA Class[1]	BD status[2]	Total area within study area (ha)	% of Qld total	TEC?
	areas					
8.12.3	*Corymbia tessellaris* and/or *Eucalyptus tereticornis* +/- *C. intermedia* +/- *C. clarksoniana* open forest with a secondary tree layer of *Livistona decora*, on low hills on Mesozoic to Proterozoic igneous rocks	LC	NCAP	141.1	0.2	No
8.12.11	Evergreen to semi-evergreen, notophyll to microphyll, vine forest to vine thicket, of foothills and uplands on Mesozoic to Proterozoic igneous rocks	LC	NCAP	553.7	3.4	No
8.12.12	*Eucalyptus tereticornis* and/or *Corymbia* spp. and/or *E. platyphylla* and/or *Lophostemon suaveolens* woodland to open forest on hill slopes on Mesozoic to Proterozoic igneous rocks	LC	NCAP	644.8	0.7	No
8.12.13	Tussock grassland, or *Xanthorrhoea latifolia* shrubland, including areas recently colonised by *Timonius timon* var. *timon* shrubland, on slopes of islands and headlands, on Mesozoic to Proterozoic igneous rocks and Tertiary acid to intermediate volcanics	OC	OC	1,033.4	21.4	No
8.12.14	*Eucalyptus drepanophylla* and/or *E. crebra* and/or *E. exserta* and/or *Acacia spirorbis* subsp. *solandri* and/or *Lophostemon confertus* low woodland on islands and headlands, on Mesozoic to Proterozoic igneous rocks, and Tertiary acid to intermediate volcanics	LC	NCAP	212.8	1.3	No
8.12.18	Semi-evergreen notophyll/microphyll to complex notophyll *Argyrodendron* spp. vine forest +/- *Araucaria cunninghamii*, of foothills and uplands on near-coastal ranges and islands, on Mesozoic to Proterozoic igneous rocks	LC	NCAP	42.1	0.2	No
8.12.20	*Eucalyptus drepanophylla* and/or *E. platyphylla* ± *Corymbia* spp. ± *E. crebra* woodland on low gently undulating landscapes on Mesozoic to Proterozoic igneous rocks	LC	NCAP	3.9	<0.1	No
8.12.22	*Eucalyptus drepanophylla* and/or *Corymbia clarksoniana* +/- *C. erythrophloia* +/- *E. platyphylla* +/- *E. exserta* +/- *C. trachyphloia* woodland on hills and ranges at low to moderate altitudes, in drier areas	LC	NCAP	1,177.1	2.7	No
8.12.25	*Eucalyptus tereticornis* +/- *E. tereticornis* x *E. platyphylla* woodland on hill slopes of islands on Mesozoic to Proterozoic igneous rocks	OC	OC	155.4	31.5	No
8.12.26	*Corymbia tessellaris* and/or *Eucalyptus tereticornis* open forest on hill slopes of islands and near coastal areas, on Mesozoic to Proterozoic igneous rocks, and Tertiary acid to intermediate volcanics	OC	E	4.5	0.1	No
8.12.27	*Corymbia tessellaris* and/or *Eucalyptus tereticornis* +/- *C. intermedia* +/- *C. clarksoniana* open forest with a secondary tree layer of *Livistona decora*, on low hills on Mesozoic to Proterozoic igneous rocks	E	E	777.3	26.9	No
8.12.29	*Allocasuarina littoralis* and/or *Lophostemon confertus* and/or Acacia spp. and/or *Grevillea banksii* open shrubland on islands and headlands, on Mesozoic to Proterozoic igneous and Tertiary acid to intermediate rocks	OC	OC	417.6	7.2	No

1 *Vegetation Management Act 1999* status – E = endangered, OC = of concern, LE = least concern

2 Biodiversity status – E = endangered, OC = of concern, NCAP = no concern at present/least concern

Five REs have a significant proportion of their total occurrence within the study area. This includes 8.1.4 (of-concern), 8.2.13 (endangered), 8.12.13 (of-concern), 8.12.25 (of-concern), 8.12.27 (endangered), which have 13.8%, 21.0%, 21.4%, 31.5% and 26.9% of their entire Queensland occurrence within the study area, respectively.

Description of places

Remnant vegetation occurs in isolated clusters along the coastal parts of the study area. Patches of considerable remnant vegetation include (Figure 3–1):

- Slade Point to Cremorne, including around Mackay Harbour
- Bakers Creek to McEwens Beach and Dunnrock, and around Sandringham Bay to Dudgeon Point and Mount Hector Conservation Park
- Hay Point to Campwin Beach
- Sarina Beach, extending outside the study area around Sarina Inlet to Armstrong Beach, including Freshwater Point
- Isolated elevated areas between Alligator Creek, Sarina, and Campwin Beach
- Offshore islands

The TEC of Littoral Rainforest and Coastal Vine Thickets of Eastern Australia, listed as critically endangered, generally occurs within 2 km of the coast and on offshore islands, or adjacent to a large body of salt water, such as an estuary, where it is subject to marine influence. The TEC occurs, either as dominant or sub-dominant, in the vicinity of both ports. Near the Port of Hay Point, the TEC occurs east of Hay Point Road. The TEC occurs in two locations south of the Port of Mackay, behind the Mackay Surf Lifesaving Club and along Bassett Creek, as well as on East Point.

The Broad Leaf Tea-tree TEC, listed as endangered, mostly occurs within 20 km of the coast and is in a number of locations in the study area, mostly south of the Port of Hay Point. The TEC occurs in the lower reaches of Cabbage Tree Creek (including adjacent to the lagoon behind Grasstree Beach), behind Sarina Beach, near the Campwin Beach Road intersection and also south of Sarina Coast Road, near the Grasstree Road intersection. The TEC is also located in and adjacent to the Sandringham Bay Conservation Park and Dunnrock, north of the Port of Hay Point.

Condition and variability

Remnant vegetation across the study area is generally fragmented due to a range of urban, infrastructure and agricultural land-uses. The condition of vegetation in many areas is unknown and represents a knowledge gap.

All remnant vegetation at Dudgeon Point has moderate to high vegetation integrity and is of significant conservation value. Dudgeon Point also has good connectivity to coastal environments, including the adjacent Mount Hector Conservation Park and Sandringham Bay – Bakers Creek Aggregation, but it has limited connectivity inland due to clearing.

A series of revegetation and rehabilitation projects have been conducted to improve coastal ecosystem functioning in the study area. Sites include Half Tide Beach, Salonika Beach, Grasstree Beach, Campwin Beach and Sarina Beach south of the Port of Hay Point, and Louisa Creek to the north.

Vulnerability

Coastal vegetation is generally threatened by increasing development including urban development, tourism, agricultural expansion and industrial development. Direct clearing, as well as increased fragmentation and isolation of vegetation communities, increases the vulnerability of vegetation and associated values.

Many of the REs in the study area are vulnerable to the anticipated impacts of climate change. More intense and frequent storm damage, including cyclone damage, increases the vulnerability of coastal scrubs, forests, and woodlands. Higher and more frequent storm surges and erosion are expected to increase the vulnerability of REs containing dune/swale and wetland vegetation. Sea level rise and coastal inundation increase the vulnerability of saltmarshes, swamps, tea-tree woodlands/forests, and freshwater wetlands. Saltmarshes and wetlands that are compressed between the coast and urban areas are particularly vulnerable to climate change because they will be unable to migrate upslope as coastal inundation occurs.

Given the Littoral Rainforest and Coastal Vine Thickets TEC's location in the coastal fringe, this TEC is vulnerable to fragmentation by coastal development. Most of the TEC is not protected in reserves, increasing the development pressure placed on it. Where the TEC is in reserves, it is considered to be highly impacted by visitors. Threatening processes include soil compaction and erosion, introduction of weeds and other pests, illegal waste dumping and increased fire risk.

The Broad Leaf Tea-tree TEC needs regular, low-intensity fires. However, due to the establishment of invasive species such as pines, fires in the TEC can burn hotter and more frequently than they otherwise would, preventing regeneration of broad-leaved tea tree. Exclusion of fire can lead to shrub invasion.

The Broad Leaf Tea-tree TEC is also vulnerable to gradual fragmentation by clearing for agriculture, urban development, fence lines and fire breaks, roads, and dams. Changes in surface water drainage, natural rainfall patterns, groundwater, and water quality due to development within and adjoining the TEC also increase pressure on the TEC. Weed invasion and introduction of pest species such as cattle, pigs and goats also increase vulnerability. The introduced fungus myrtle rust also makes this TEC more vulnerable.

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3.2.3 Threatened terrestrial flora

AREA PROFILE: THREATENED TERRESTRIAL FLORA

Four threatened flora species have been recorded in the study area:

- Black ironbox (*Eucalyptus raveretiana*), listed vulnerable under the EPBC Act and least-concern under the NC Act
- Lesser swamp orchid (*Phaius australis*), listed endangered under the EPBC Act and NC Act
- Holly-leaved graptophyllum (*Graptophyllum ilicifolium*), listed vulnerable under the EPBC Act and the NC Act
- *Omphalea celata,* listed as vulnerable under the EPBC Act and the NC Act

Two other threatened species, although not recorded, may also exist in the study area given that vegetation communities favourable as habitat are present. These are:

- Byfield matchstick (*Comesperma oblongatum*), listed vulnerable under the EPBC Act and the NC Act
- *Neisosperma ilneri*, listed vulnerable under the EPBC Act and the NC Act

Environmental Values

Conservation significance classification provides a framework to prioritise conservation and management of these species, especially if they are threatened by extinction. In general, the flora in the study area plays a role in national identity and cultural significance, biodiversity and ecosystem health.

Threatened flora is present in the study area as scattered individuals. However, there are also patches of suitable habitat within the study area. This includes large alluvial areas that have the potential to support black ironbox, and an area of swamp that has potential to support lesser swamp orchid at East Point.

Contribution to OUV

On the mainland, threatened flora does not directly contribute to OUV. Although no records of threatened flora exist on islands in the study area, threatened species that could exist directly relate to OUV criteria in that they form part of ecosystems that have evolved over millennia and are considered rare or endangered species. Threatened terrestrial flora in the study area therefore makes a minor contribution to OUV.

AREA PROFILE: THREATENED TERRESTRIAL FLORA

Vulnerability
Threats to threatened species in the study area are related to land clearing, habitat degradation, weed invasion, inappropriate and altered fire regimes and poaching.
Gaps
Additional threatened species and unknown populations of known threatened species are likely to exist in the study area, though no records currently exist. Furthermore, the spatial accuracy of records associated with the holly-leaved graptophyllumand *Omphalea celata* is considered to be low.
Summary of Importance
The threatened flora in the study area are considered important. With respect to the study area: • Black ironbox is suspected to exist in low numbers and is threatened by smothering by rubber vine (*Cryptostegia grandiflora*) and degradation from water resource developments. • Byfield matchstick has a restricted distribution and is threatened by broad scale clearing, inappropriate fire regimes and fragmentation. • Holly-leaved graptophyllum has a restricted distribution and is threatened by the effects of lantana (*Lantana camara*). • Lesser swamp orchid exists in low numbers and is threatened by illegal collection and habitat loss. • *Neisosperma kilneri* is known from only three localities and is threatened by vegetation clearing and exotic weeds such as lantana. • *Omphalea celata* is also known from only three sites and is threatened by exotic weeds.
What does this mean?
The study area is known to contain threatened flora species. Increased development for urban, tourism, agricultural expansion and industrial development places pressure on the vegetated areas, which have the potential to contain specimens of threatened species. State legislation endeavours to protect the remaining vegetation communities by placing restrictions on the clearing of threatened flora. Similar to clearing of vegetation communities, future development within the study area may be restricted by the remaining areas of remnant vegetation and sites where threatened flora species are either known to occur or have the potential to occur.

Regional summary

The variety of vegetation communities in the region provides a wide range of habitats for flora. There are over 400 plant species recorded in the region; only a handful are considered threatened. Most records of threatened species in the wider region are located outside of the study area in Eungella National Park, Airlie Beach, Shoalwater Bay and Byfield National Park.

Overview of values

There are records of four threatened species within the study area, with two other threatened species having potential to occur. These species include:

- Black ironbox (*Eucalyptus raveretiana*), listed as endangered under the EPBC Act and least concern under the NC Act
- Byfield matchstick (*Comesperma oblongatum*), listed as vulnerable under the EPBC Act and NC Act

- Lesser swamp orchid (*Phaius australis*), listed as endangered under the EPBC Act and NC Act
- Holly-leaved graptophyllum (*Graptophyllum ilicifolium*), listed as vulnerable under the EPBC Act and the NC Act
- *Neisosperma kilneri,* listed as vulnerable under the EPBC Act and NC Act
- *Omphalea celata,* listed as vulnerable under the EPBC Act and the NC Act

Table 3–3 lists flora species likely to occur in the study area as well as their associated habitat and distribution.

There is also a record of Siah's backbone (*Streblus pendulinus*) at Mackay; however, this species is only considered threatened on Norfolk Island.

Table 3-3 Threatened flora known or likely to occur in the study area

Species	EPBC Act	NC Act	Distribution	Habitat	Likelihood of occurrence
Comesperma oblongatum Byfield matchstick	V	V	Endemic to coastal central Queensland; recorded in relatively low number of collections from north east of Rockhampton to south of Gladstone.	Rocky outcrops, exposed headlands in gravelly or sandy soils, lowland scrub, heathland, grassland. Known to occur in RE 8.12.13.	Potential. Known to occur in RE 8.12.13 of which there is 1,175 ha in the study area.
Eucalyptus raveretiana Black ironbox	E	E	Wide distribution in coastal and sub-coastal areas of Queensland, from south of Townsville to Nebo, around Rockhampton, and areas 100 km west of Rockhampton. While considered locally common on some permanent streams, only known to occur at 23 sites in Queensland.	Usually grows along watercourses, sometimes on river flats or open woodland. Generally co-dominant with melaleucas and eucalypts, and occasionally river oak and semi-evergreen vine thicket.	Three individuals known to occur in study area west of Dunnrock. A considerable area of potential habitat exists within the study area, though no other records of this species are known to exist. This is likely due to a paucity of survey effort.
Graptophyllum ilicifolium Holly-leaved graptophyllum	V	V	Endemic to central Queensland coast in the Mackay area, with a disjunct population at Miriam Vale	Grows along rocky drainage lines in following areas/substrates: Mt Jukes (predominantly of quartz and feldspar); Mt Blackwood (largely blackwood quartz syenite); Mt Adder, Mt De Moleyns and the east section of Mt Blackwood National Park (sedimentary rocks). Occurs in tall to very tall mixed notophyll forest.	Potential. Two records exists in the study area (1983 and no date), however the spatial accuracy of these records is low.
Neisosperma kilneri	V	V	Known from three localities: near Proserpine, Mt Dryander and Mackay in Queensland.	Grows in notophyll vine forest in alluvium near creeks. Known to occur in RE 8.3.1 and 8.3.10.	Potential.
Omphalea celata	V	V	Known from three sites in central east Queensland. Locations include Hazlewood Gorge, near Eungella; Gloucester Island, near Bowen; and Cooper Creek in the Homevale Station area, north-west of Nebo.	At Hazlewood Gorge, grows in fragmented semi-evergreen vine thicket along a watercourse on weathered metamorphics in a steep-sided gorge at an altitude of 560 m. On Gloucester Island, grows in a rocky granitic gully near *Araucaria* microphyll vineforest. At Cooper Creek, grows in the creek bed and adjacent bank.	Low, though some potential exists. One record in the study area from 2001, however the spatial accuracy of this record is low.

Species	EPBC Act	NC Act	Distribution	Habitat	Likelihood of occurrence
Phaius australis Lesser swamp orchid	E	E	Distribution tentatively described as north from Lake Cathie (near Port Macquarie), but mainly north of Evans Head to the Barron River in northeast Queensland, although it is rare (only 1 or 2 records) in the latter region and the populations are now thought to be extinct.	Commonly associated with coastal wet heath/sedgeland wetlands, swampy grassland or swampy forest, often with broad-leaved tea tree or swamp mahogany.	Known to occur in study area.

Description of places

Figure 3–4 shows the location of threatened flora records as well as habitat modelled as high probability of occurrence. As mentioned above, the points associated with holly-leaved graptophyllum and Omphalea celata have very low spatial accuracy and are likely to be located in the general vicinity of the recorded locations.

The lesser swamp orchid has been recorded on private property west of Mackay, and southeast of Mackay Harbour (at East Point). The actual location of these records is confidential and withheld by DEHP.

There are five known locations of black ironbox within the study area. These include three records from Sandy Creek, one from Black Springs Golf Course, just west of the Bruce Highway, and one from east of Sarina near the railway line to Hay Point.

Condition and variability

The condition of the threatened flora species record within the study area is unknown. Generally, the condition of the species' populations and the nature of the past and current threats have contributed to these species being listed as threatened under State and Commonwealth legislation. Present and continuing threats are discussed below.

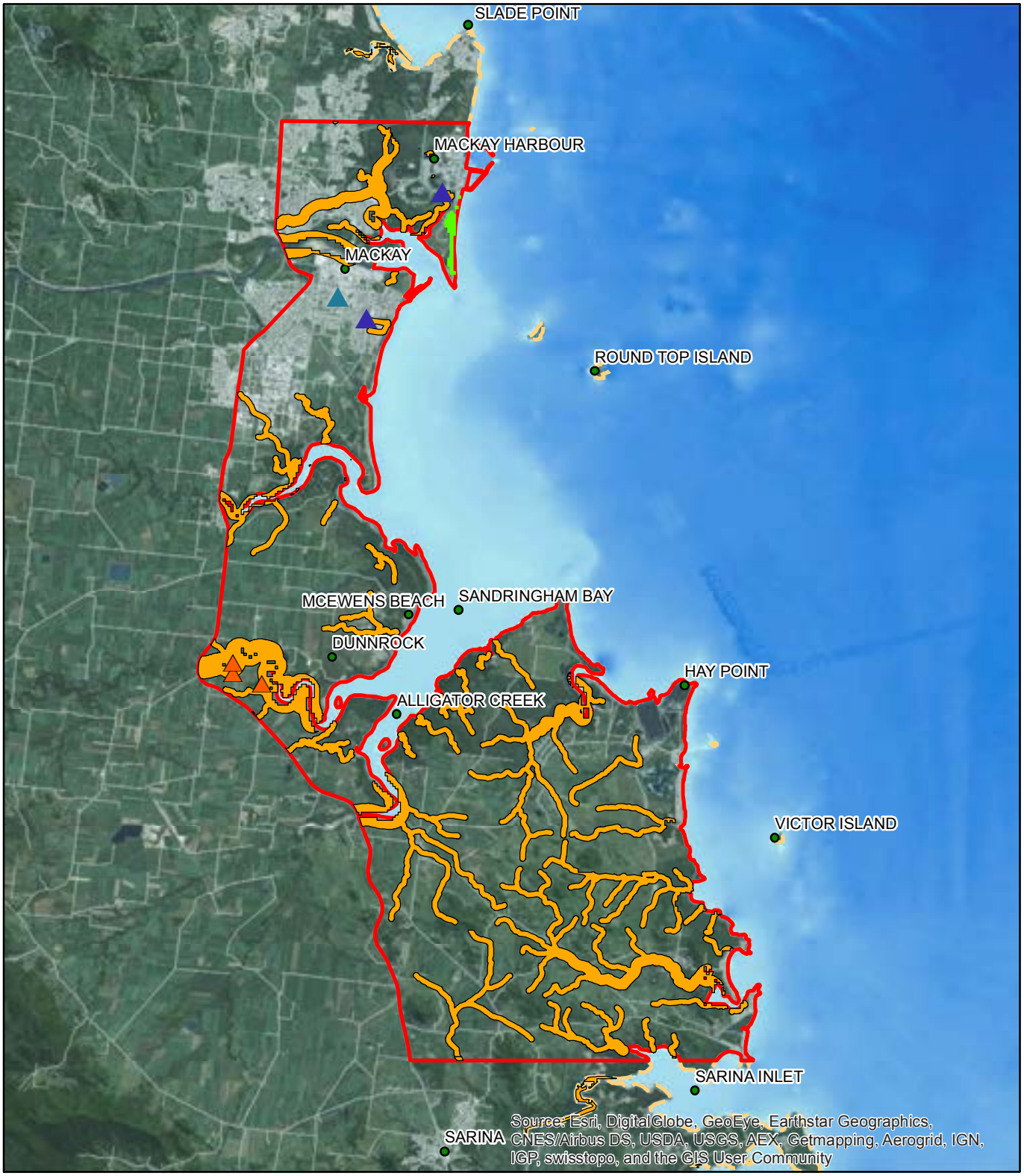
Vulnerability

Table 3–4 outlines the specific vulnerabilities and threats associated with each threatened species that is predicted to occur in the study area.

Table 3-4 Threatened flora species vulnerability and threats

Species	Vulnerability
Comesperma oblongatum Byfield matchstick	The main identified threats are the species' restricted distribution, broad-scale vegetation clearing, inappropriate fire regimes, and fragmentation.
Eucalyptus raveretiana Black ironbox	Vulnerable to weed invasion, changes in hydrology and timber harvesting.
Graptophyllum ilicifolium Holly-leaved graptophyllum	The primary threats are related to the species' restricted distribution and that it is commonly confined to narrow creek margins. Competition from weeds such as lantana (*Lantana camara*) could also threaten the habitat and possibly increase fire risk and intensity due to fuel build-up.
Neisosperma kilneri	The main identified threats are vegetation clearing; invasion by exotic weeds such as lantana; and inappropriate plant collection.
Omphalea celata	The main potential threats to include invasion by exotic weeds such as lantana, and damage to plants from landslide at the Hazelwood Gorge population.
Phaius australis Lesser swamp orchid	Vulnerable to poaching as it is one of Australia's most desired orchids. Habitat loss also increases vulnerability.

Figure 3-4 High potential habitat and records of threatened flora species



LEGEND

- Landmass Project Extent
- Ocean Project Extent

Threatened Flora High Potential Habitat Classes

- *Phiaus Australis High*
- *Eucalyptus Raveretiana High*

ALA Threatened Flora Records

- Eucalyptus raveretiana
- Graptophyllum ilicifolium
- Omphalea celata

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3.2.4 Threatened terrestrial fauna

AREA PROFILE: THREATENED TERRESTRIAL FAUNA

The study area is rich in faunal diversity, with approximately 280 birds, 30 reptiles, 25 mammals, and 15 frog species recorded. Seventeen fauna species of conservation concern have been recorded in the study area, which is well-known for shorebird roosting and feeding habitat. Undeveloped coastal areas in the study area are considered important habitat for one or more species of conservation concern.

The study area supports over 23,000 shorebirds each year during their annual migration (Harding and Milton, 2003), which is approximately 0.2% of the East-Asian – Australasian Flyway population. Many shorebird species that utilitse habitat within the study area are threatened.

Threatened and near-threatened species that have been recorded in the study area include:

- Australian painted snipe
- Bar-tailed godwit
- Beach stone-curlew
- Curlew sandpiper
- Eastern curlew
- Great knot
- Greater sand plover
- Lesser sand plover
- Red know
- Glossy black-cockatoo (northern)
- Grey falcon
- Estuarine crocodile
- Tusked frog
- Bare-rumped sheathtail bat
- Coastal sheathtail bat
- Koala

AREA PROFILE: THREATENED TERRESTRIAL FAUNA

- Northern quoll
- Water mouse

Environmental Values

Conservation significance classification provides a framework to prioritise conservation and management of these species, especially if they are threatened by extinction. In general, the fauna of the study area play a role in national identity and cultural significance, ecosystem health and the economy. Shorebird roosting and feeding sites are important and support internationally significant numbers of some species, including critically endangered species. The study area is part of the Repulse Bay to Ince Bay Important Bird Area, which has high numbers of beach stone-curlew and eastern curlew.

Key habitat areas include:

- The area from the Port of Mackay to Armstrong Beach, which contains 12 significant shorebird roosting areas, and another 18 known roosting areas
- Internationally important shorebird habitat at Sandringham Bay and Mackay Town Beach
- Nationally important shorebird roosting sites at the mouth and banks of the Pioneer River, Armstrong Beach, and Sandfly Creek
- Other locally important sites for shorebirds, including Bakers Creek, Dudgeon Point, Shellgrit Creek and Shellgrit Creek entrance, McEwans Beach, McEwans Beach Swamp, Dunnrock South Arm and Lake Barfield
- Wetland, woodland, and foredune areas surrounding the Port of Mackay, where the eastern curlew and beach stone-curlew are known to occur
- Sarina and Campwin Beach and St Bees Island, where koalas have been recorded
- Fursden Creek and Bakers Creek, where flying foxes have been recorded

  Alligator Creek and Freshwater Point, where the bare-rumped sheathtail bat and the coastal sheathtail bat have been recorded, respectively

Contribution to OUV

Terrestrial fauna in the study area contribute indirectly to OUV, particularly mobile fauna on the mainland that occur on the fringe of the World Heritage Area, such as migratory shorebirds. Large aggregations of shorebirds, when they occur, may constitute a superlative natural phenomon and contribute to OUV. Threatened species that inhabit coastal islands in the study area directly relate to OUV criteria in that they form part of ecosystems that have evolved over millennia and are considered rare or endangered species.

Vulnerability

Threats to significant species in the study area are related to land clearing, habitat degradation, weed and pest fauna invasion, and inappropriate and altered fire regimes. Upstream pesticide use leading to potential pollution of intertidal feeding areas raises concerns about effects in the food chain for migratory species.

Shorebird numbers have been declining in some areas of the study area due to disturbances from human activities, as well as due to a general global decline in shorebird numbers.

Disturbance to shorebirds from recreational and other activities reduces the time available for roosting at high tide and disrupts feeding patterns, leading to a reduction in energy available for migration and breeding. This could lead to failed migration or reduced breeding at the end of the migration.

Gaps

This assessment has relied on existing information and existing records of threatened and migratory fauna. Additional unrecorded threatened fauna species are likely to exist in the study area.

AREA PROFILE: THREATENED TERRESTRIAL FAUNA

Summary of Importance
The migratory and threatened species in the study area are considered important. Sandringham Bay is internationally significant for the eastern curlew, lesser sand plover and the great knot, and nationally important for the Terek sandpiper, bar-tailed godwit and ruddy turnstone. Mackay Town Beach is an internationally important site for the eastern curlew, the great knot, and lesser sand plover. The mouth and banks of the Pioneer River and Armstrongs Beach are nationally important shorebird roosting sites. Sandfly Creek Environmental Reserve is also a nationally important shorebird roost site. Other threatened species also occur in the study area.
What does this mean?
The main threats to threatened and migratory species in the study area are related to land clearing, habitat degradation, week and pest fauna invasion and inappropriate and altered fire regimes. Shorebird numbers have also been declining in some areas of the study area, due to disturbances from human activities and a general global decline in shorebird numbers. Similar to clearing of vegetation communities, future development within the study area may be restricted by the remaining areas of known habitat for threatened species.

Regional summary

The study area is rich in faunal diversity, with approximately 280 birds, 30 reptiles, 25 mammals, and 15 frog species recorded. The study area is home to 14 fauna species of conservation concern and well-known for shorebird roosting and feeding habitat. The majority of undeveloped coastal areas in the study area are considered important habitat for one or more species of conservation concern.

The area from Repulse Bay (to the north of the study area) to Cape Palmerston (in the south of the study area) is an important roosting and feeding habitat for migratory shorebirds. Over 1% of the East Asian - Australasian flyway population of seven migratory shorebird species uses this area and the study area is considered to be a significant staging area for these species. Migratory shorebirds use sheltered coasts with large intertidal mudflats or sandflats, often with seagrass beds. They are often recorded in saltmarsh and on mudflats fringed by mangroves, and will sometimes use mangroves.

The study area supports over 23,000 shorebirds each year during their annual migration, which is approximately 0.2% of the East-Asian – Australasian Flyway population. The area from the Port of Mackay to Armstrong Beach contains 12 significant shorebird roosting areas, and another 18 known roosting areas. Sandringham Bay is also a nationally and internationally significant area for five migratory shorebird species.

Overview of values

EPBC Act-listed migratory shorebirds known to occur between Repulse Bay and Cape Palmerston are shown in Table 3–5.

Table 3-5 EPBC-listed migratory shorebirds recorded between Repulse Bay and Cape Palmerston

Species	Common Name	EPBC Act Migratory	EPBC Act Marine	EPBC Act Threatened Species	NC Act Threatened Species
Actitis hypoleucos	Common sandpiper	✓	✓	-	-
Arenaria interpres	Ruddy turnstone	✓	✓	-	-

Species	Common Name	EPBC Act Migratory	EPBC Act Marine	EPBC Act Threatened Species	NC Act Threatened Species
Calidris acuminata	Sharp-tailed sandpiper	✓	✓	-	-
Calidris alba	Sanderling	✓	✓	-	-
Calidris canutus	Red knot	✓	✓	Endangered	-
Calidris ferruginea	Curlew sandpiper	✓	✓	Critically endangered	-
Calidris ruficollis	Red-necked stint	✓	✓	-	-
Calidris tenuirostris	Great knot	✓	✓	Critically endangered	-
Charadrius bicinctus	Double-banded plover	✓	✓	-	-
Charadrius leschenaultia	Greater sand plover	✓	✓	Vulnerable	-
Charadrius mongolus	Lesser sand plover	✓	✓	Endangered	-
Gallinago hardwickii	Latham's snipe	✓	✓	-	-
Limicola falcinellus	Broad-billed sandpiper	✓	✓	-	-
Limnodromus semipalmatus	Asian dowitcher	✓	✓	-	-
Limosa lapponica	Bar-tailed godwit	✓	✓	-	-
Limosa limosa	Black-tailed godwit	✓	✓	-	-
Numenius madagascariensis	Eastern curlew	✓	✓	Critically endangered	Vulnerable
Numenius minutus	Little curlew	✓	✓	-	-
Numenius phaeopus	Whimbrel	✓	✓	-	-
Pluvialis fulva	Pacific golden plover	✓	✓	-	-
Pluvialis squatarola	Grey plover	✓	✓	-	-
Tringa brevipes	Grey-tailed tattler	✓	✓	-	-
Tringa incana	Wandering tattler	✓	✓	-	-
Tringa nebularia	Common greenshank	✓	✓	-	-
Tringa stagnatilis	Marsh sandpiper	✓	✓	-	-
Xenus cinereus	Terek sandpiper	✓	✓	-	-

The eastern curlew, curlew sandpiper and the non-migratory beach stone-curlew, are frequently encountered along the coastline from Mackay Harbour in the north to Armstrong Beach in the south.

The lesser sand plover, grey-tailed tattler, whimbrel and red-necked stint are known to rest and feed in the study area for an extended period to build energy reserves on the northward migration. Grey-tailed tattler, whimbrel, pacific golden plover and greater sand plover rest and feed in the study area on the southward migration.

Other birds of conservation significance that have been recorded include:

- The Australian painted snipe (*Rostratula australis*) has been recorded in West Mackay and is listed as vulnerable under the NC Act and endangered under the EPBC Act.
- The grey falcon (*Falco hypoleucos*) has been recorded north of the mouth of Baker's Creek. The species is listed as vulnerable under the NC Act.
- The glossy black-cockatoo (northern) (*Calyptorhynchus lathami erebus*) has been recorded at St Bees Island. The species is listed as vulnerable under the NC Act.

The study area has a number of key bird watching areas. McEwens Beach and surroundings is an excellent area for viewing waterbirds, melaleuca feeders (e.g. honeyeaters) and mangrove birds. North of the study area, the Harbour Wetlands (behind Mackay Harbour) and the Pioneer River near East Point are known for viewing waterbirds, waders and terns. Pioneer River South is a key site for viewing beach stone-curlews, bush birds, waders and terns. Key birdwatching sites in and around Mackay city include Andergrove Caravan Park (for ducks, bush birds and the buff-banded rail), Gooseponds (for bush birds and waterbirds) and the Mackay Regional Botanic Gardens for a variety of birds, including the red-whiskered bulbul (*Pycnonotus jocosus*).

Threatened fauna species that use the creeks and estuaries include the water mouse (*Xeromys myoides*), tusked frog (*Adelotus brevis*) and estuarine crocodile (*Crocodylus porosus*), all listed as vulnerable under the NC Act. The water mouse has a particular stronghold in the area and is listed as vulnerable under the EPBC Act.

A number of bat species occur in the study area, including flying foxes. These long-range pollinators and fruit dispersers are vital for seed dispersal, cross-pollination and healthy ecosystem functioning. The bare-rumped sheathtail bat (*Saccolaimus saccolaimus*), listed as endangered under the NC Act and critically endangered under the EPBC Act, and the coastal sheathtail bat (*Taphozous australis*) have both been recorded in the study area. The only flying fox records in the study area are for the black flying fox (*Pteropus alecto*) which is not listed as a threatened species; however, the grey-headed flying fox (*Pteropus poliocephalus*), listed as vulnerable under the EPBC Act is also predicted to occur in the study area and has been recorded nearby.

Other listed species listed recorded in the study area include the koala (*Phascolarctos cinereus*), listed as vulnerable under the NC Act and EPBC Act and the northern quoll (*Dasyurus hallucatus*), listed as endangered under the EPBC Act but least-concern under the NC Act.

Threatened species records and high-potential habitat in the study area are mapped in Figure 3–5.

Description of places

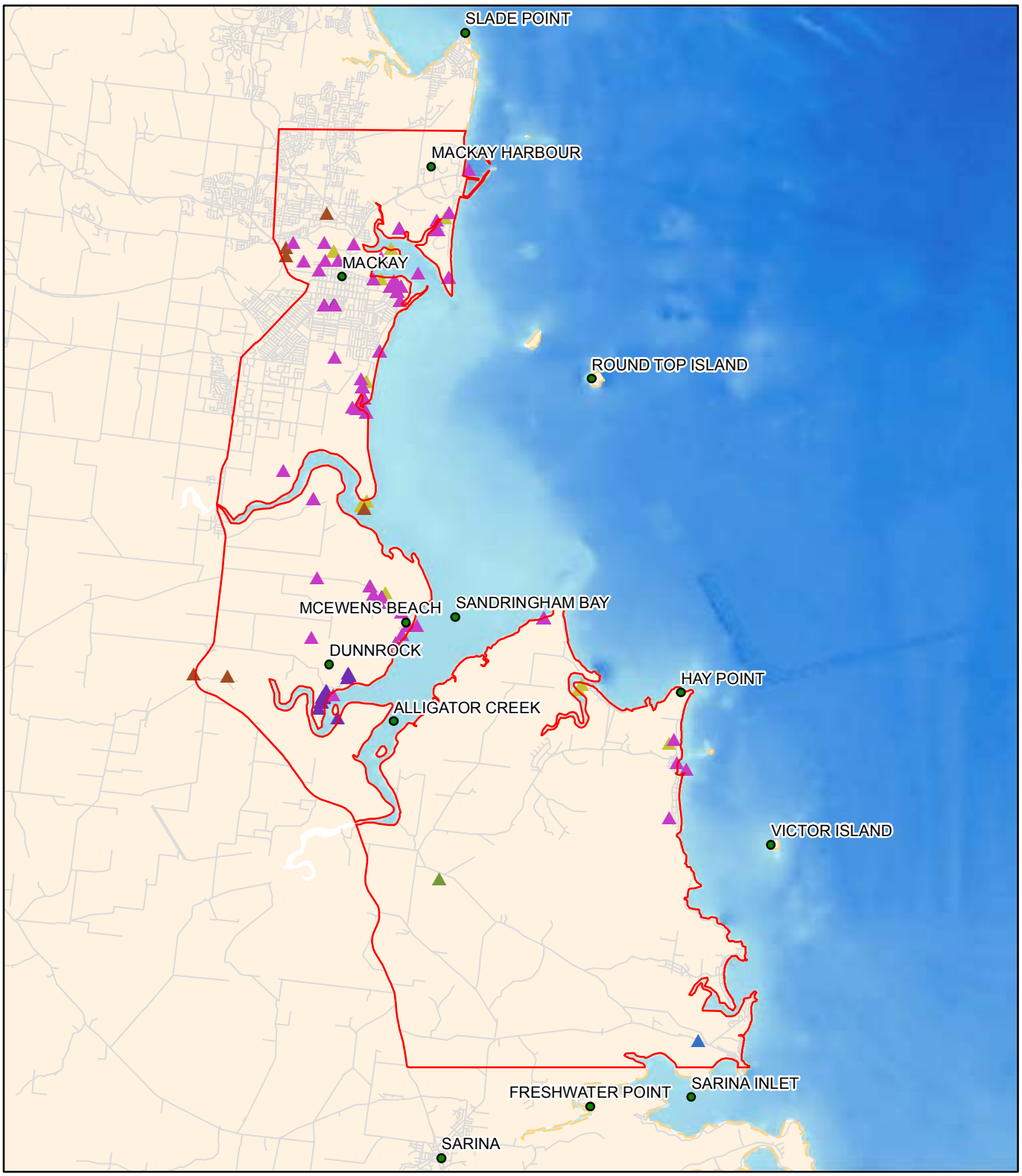
Important habitats in Australia for migratory shorebirds under the EPBC Act include those recognised as nationally or internationally important. According to this approach, wetland habitat should be considered internationally important if it regularly supports:

- One per cent of the individuals in a population of one species or subspecies of waterbird, or
- A total abundance of at least 20,000 waterbirds.

Migratory shorebird habitat is defined as nationally important if it regularly supports:

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

Figure 3-5 Records of threatened fauna species



LEGEND

- Landmass Project Extent
- Ocean Project Extent

ALA Threatened Fauna Records

- Curlew sandpiper
- Beach stone-curlew
- Eastern curlew
- Australian painted snipe
- Grey falcon
- Koala
- Northern quoll
- Bare-rumped sheathtail bat
- Coastal sheathtail bat
- Water mouse
- Tusked frog
- Estuarine crocodile

[GDA94 | MGA55]

A4 1:200,000

N

0 5 10

Kilometres

JACOBS

Sandringham Bay is internationally important for the eastern curlew, lesser sand plover and great knot, and nationally important for the Terek sandpiper (*Xenus cinereus*), bar-tailed godwit and ruddy turnstone (*Arenaria interpres*).

Mackay Town Beach is also an internationally important site for the eastern curlew, the great knot, and lesser sand plover. Mackay Town Beach has large areas of intertidal flats that are suitable for shorebird feeding. Over 4,000 roosting shorebirds have been recorded and it is estimated that the shorebird feeding area density is 25 birds/100 m^2. Other species known to feed at Town Beach include the bar-tailed godwit, whimbrel and grey-tailed tattler.

The mouth and banks of the Pioneer River and Armstrongs Beach, where more than 2,000 shorebirds have been recorded roosting, are nationally important shorebird roost sites. The mouth and banks of the Pioneer River are comprised of tidal marine grass/samphire areas, river bank and offshore sandbanks. Species of note that roost in the area include bar-tailed godwit, eastern curlew, great knot, whimbrel, grey-tailed tattler and lesser sand plover. The shorebird roosting area at Armstrong Beach runs the length of the beach from Figtree Creek north to Freshwater Creek.

Sandfly Creek Environmental Reserve (south bank of the Pioneer River, near the mouth) is also a nationally important shorebird roost site because it supports one of the highest diversities of shorebirds in the region, with up to 29 species recorded (22 migratory and 7 resident).

Other, locally important, sites include Bakers Creek, Dudgeon Point, Shellgrit Creek including the entrance, McEwans Beach, McEwans Beach Swamp, Dunnrock South Arm and Lake Barfield.

The Dunnrock South Arm shorebird roosting area consists of mangroves edging Bell Creek entrance, south of Dunnrock. Up to 500 shorebirds have been recorded roosting in this area. The Dudgeon Point coastline includes beach and rocks and over 1,000 roosting shorebirds have been recorded.

Lake Barfield is a man-made wetland with wet margins and low branches of dead vegetation adjacent to a freshwater lake south of the Port of Hay Point. Up to 800 shorebirds have been recoded roosting at the site, including grey plover, common greenshank (*Tringa nebularia*) and great knot.

The north bank of Bakers Creek has an estimated shorebird feeding density of 11 birds/100 m^2 and over 1,000 roosting shorebirds have been recorded there. The bank of Bakers Creek mouth is a beach behind emerging mangroves with up to 600 shorebirds recorded roosting. Nesting sites for the beach stone-curlew also occur in the Bakers Creek Conservation Park.

Shellgrit Creek in Mackay is a shallow bank and part of a wetland. The area supports reasonable numbers of shorebird species that occur in the region in internationally significant numbers, including bar-tailed godwit, eastern curlew, great knot, grey-tailed tattler and whimbrel. Over 1,000 shorebirds have been recorded roosting at the site. Shellgrit Creek entrance consists of a sandbank within the mouth of the creek. Up to 800 shorebirds have been recorded roosting at the site.

McEwans Beach contains large areas of intertidal flats and is a recognised feeding area for the great knot. Up to 300 shorebirds have been recorded roosting at the site and the feeding area for shorebirds has an estimated density of 29 birds/100 m^2. McEwans Beach south includes the banks inside the entrance of a small creek about 200 m to 300 m south of the main creek, south of McEwans Beach. Up to 700 shorebirds have been recorded roosting there. McEwans Beach Swamp is the clay pan north of the road to McEwans Beach and has had up to 800 shorebirds recorded roosting.

The eastern curlew and beach stone-curlew are also known to occur in the undeveloped wetland, woodland, and foredune areas surrounding the Port of Mackay.

Regarding terrestrial mammals, the northern quoll has been recorded in Mackay. It also may occur on undeveloped land in the Port of Mackay. The most likely areas for the northern quoll to occur at the Port are rocky or foredune areas.

Koalas have been recorded at Sarina and Campwin Beach, while the tusked frog has been recorded in Mackay. Flying foxes are known to roost at Fursden Creek and Bakers Creek. The bare-rumped sheathtail bat has been recorded near Alligator Creek, and the coastal sheathtail bat at Freshwater Point.

Condition and variability

While the area is recognised as internationally and nationally important for shorebirds, the condition of the roosting and feeding sites varies. The Pioneer River is subject to high levels of disturbance and there are indications of a gradual decline in overall shorebird numbers. There has been significant decline in lesser sand plovers roosting there. Shorebird declines may be due to disturbance because the physical nature of the roost has not changed. This may be particularly relevant for lesser sand plovers, which prefer to roost near the river where disturbance from fishing is more frequent.

Armstrong Beach is subject to high levels of disturbance; however, shorebird numbers are variable but stable. Shellgrit Creek is subject to disturbance from vehicles, but shorebird numbers are also stable. Shorebird numbers on the north bank of Bakers Creek have declined by 65% over the past 11 years. The cause of the decline is unknown, but human disturbance is suspected to be involved.

Approximately 13% of the global population for the curlew sandpiper occurs in the East Asian-Australasian Flyway. The species usually forages and roosts in intertidal mudflats in sheltered coastal areas and also around non-tidal swamps, lakes and lagoons near the coast. Numbers have declined across Australia, and at a rate of approximately 6.3% per year in Queensland.

Vulnerability

Disturbance is the major threat to shorebirds at all high-tide roost sites. Even in seemingly remote areas, there can be fishers and vehicles on beaches that can disturb shorebirds. Of the significant roosts, disturbance has occurred at 14 of the 29 sites. The highest levels of disturbance were recorded at Pioneer River mouth and Armstrong Beach. Most disturbances were recorded in January, reflecting the increased use of coastal areas during the holiday period. Disturbances were mainly from people walking, with and without dogs, vehicles and boats.

Disturbance of shorebirds reduces the time available for roosting at high tide, leading to excessive energy use at a time when they need to maximise their reserves for migration. This could lead to failed migration or reduced breeding at the end of the migration.

Ongoing coastal development also increases the vulnerability of roosting sites. Upstream pesticide use leading to potential pollution of the intertidal feeding areas raises concerns about effects in the food chain.

In Australia, the eastern curlew is vulnerable to human disturbance that can interrupt feeding and deplete energy stores that are required for migration, as well as habitat loss.

Beach stone curlews breed in spring/summer. Nests are often located on sandbanks, sandpits, or islands in estuaries, coral ridges, among mangroves, or in the sand surrounded by short grass and scattered casuarinas (she-oaks). The species is vulnerable to pollution from industrial development, introduced predators (dogs, cats, pigs), and human disturbance.

Other threatened species are vulnerable to continued habitat fragmentation and a reduction in the condition of existing habitat from the spread of weeds and pests.

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3.2.5 Flooding

AREA PROFILE: FLOODING

The Mackay and Hay Point region is susceptible to flooding due to the low lying topography and the course of the Pioneer River through the city of Mackay.
Environmental Values
Flooding provides a number of valuable services, including water filtration, purification, retention of nutrients, groundwater recharge and provision of habitat for many species. Some flora and fauna species are also dependent on flooding cycles.
Contribution to OUV
Flooding is considered an important component of connectivity between the land and sea, which is an ecosystem process. As such, flooding within the study area is considered to have a incremental contribution to OUV.
Vulnerability
The Mackay region is particularly vulnerable to storm surges and tidal inundation. These events can impact on erosion-prone areas, increasing sedimentation into aquatic ecosystems. There is potential for future flooding events to become more severe in the face of climate change which can cause significant environmental and infrastructure damage.
Gaps
No notable gaps in the available information have been identified from the perspective of the EVA.
Summary of Importance
Natural flooding cycles are vital for the movement of nutrients and recharging of groundwater systems.
What does this mean?
Flooding can increase the sedimentation into aquatic ecosystems. As such, changes in the flood regime (due to climate change for example) have the potential to increase sediment to the GBR lagoon. Flooding also presents risks to infrastructure and social values. Clean up and recovery costs can place significant strain on local economies.

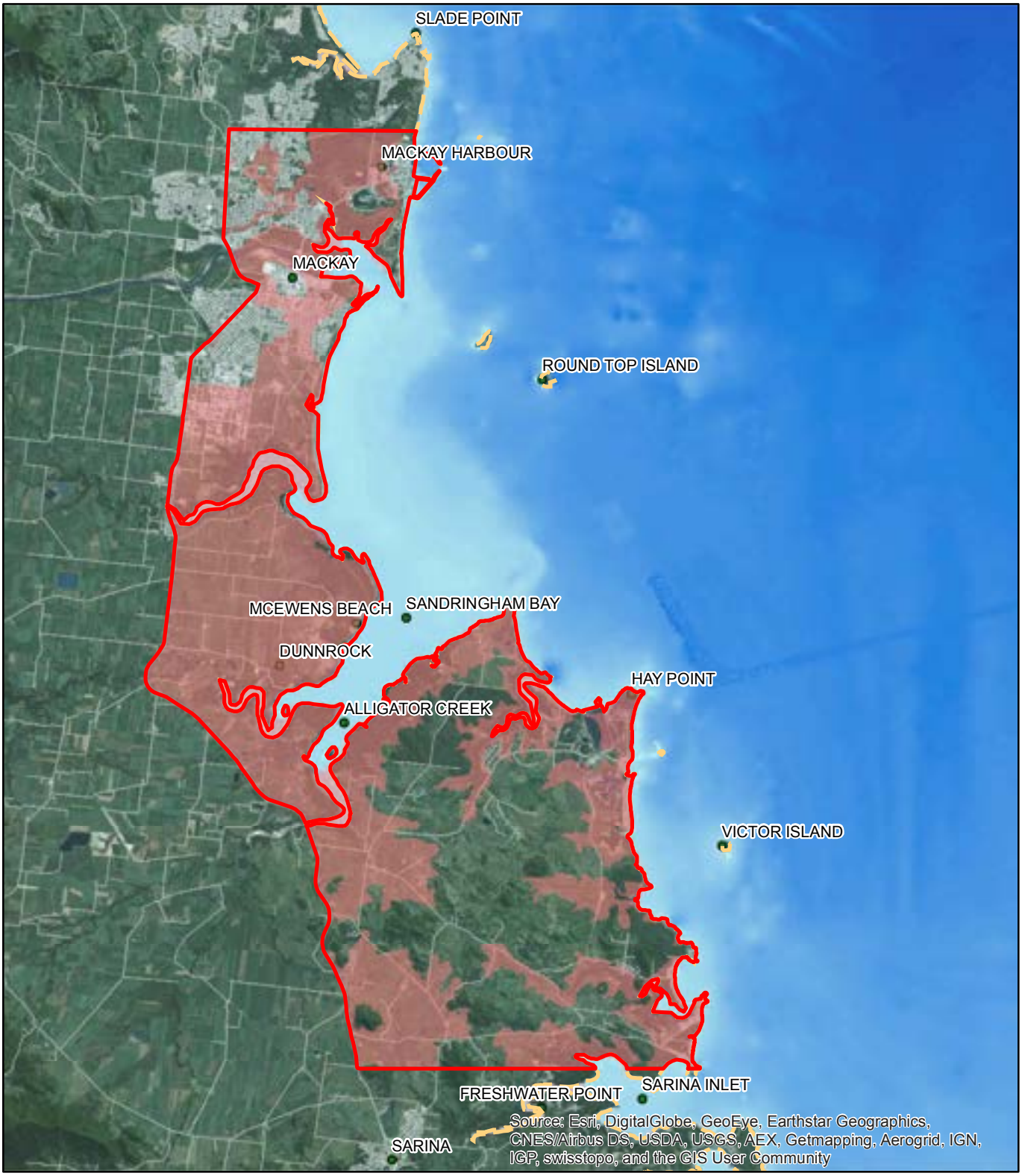
Regional summary

The Queensland Government's floodplain mapping by the Department of Natural Resources and Mines (DNRM) Rapid Hazard Assessment, and the Pioneer River riverine flood gauge mapping by Mackay Regional Council show that flood inundation in the Mackay and Hay Point region is potentially quite extensive (Figure 3–6). This is due to the low-lying nature of the topography, extending inland to the Mackay Highlands, and the course of the Pioneer River through the city of Mackay.

Overview of values

Floods and high rainfall events often pose risks to life, property and infrastructure. However, floods also play a significant role in sustaining ecosystem services. They can provide a wide range of valuable services including water filtration and purification, retention of nutrients, groundwater recharge and provision of habitat for many species. Flooding is a part of the natural cycle of many ecosystems and some flora and fauna species are dependent on flooding cycles.

Figure 3-6 Areas subject to flood inundation based on Queensland Floodplain Assessment



LEGEND

- Landmass Project Extent
- Ocean Project Extent
- Floodplain Extent

[Geographical Coordinate System: GDA 94]

A4 1:200,000

N

0 5 10

Kilometers

JACOBS

Flushing of waterways and input of freshwater to coastal ecosystems influence inshore lagoons, reefs, saltmarshes, mangroves and freshwater wetlands. Overbank flows promote nutrient cycling and give riverine organisms access to floodplain resources, which may stimulate spawning and recruitment, or stimulate germination and re-establishment of aquatic plants. Habitat for aquatic organisms may be created or maintained by changes in stream cover and structural complexity (e.g. through deposition of rocks, branches or sediments). The depth, duration and timing of flood events are important for the dispersal, reproduction and establishment of wetland biota and small changes may alter wetland species composition.

Increased water supply to wetland areas enables protection of the wetland environments. This creates habitat for many fauna species, such as wading birds, fish, turtles and frogs. Wetland areas are also recognised as valuable to local communities for recreational purposes, such as bird watching, kayaking and fishing (see Section 3.4.5).

High-rainfall events flush waterways and renew flow to ephemeral waterways, regenerating life in these areas. Floodwaters can trigger breeding, migration and dispersal of many species. Water storage areas, such as water supply dams, are replenished to be able to continue to supply water post-flood and during times of drought.

Floods can change topography, soils, vegetation and physical features over time. They disperse organic material and nutrients throughout the floodplain. Heavy rainfall events and flooding may help move sediments accumulated at points along waterways (e.g. mouth of the Pioneer River), which then contributes to changes to downstream sediment characteristics.

Description of places

There have been a number of significant flood events in the Mackay region over the last 150 years. Areas within Port of Mackay land are subject to riverine flooding, and much of the area is located within the ‘high hazard area’ (i.e., greater than 1.0 m water depth) and ‘medium hazard area’ (i.e., less than 1.0 m water depth), according to the Coastal Hazard Areas Storm Tide Inundation Area mapping.

Significant coastal and flood events in the Mackay region are generally associated with cyclones. Notable cyclones occurred in 1898, 1918, 1988, 2010 and 2014. Cyclone Eline hit the region in 1898 and changed the mouth of the Pioneer River. In 1918, an unnamed cyclone caused one of the most significant storm surges ever seen in Australia. Cyclone Charlie in 1988 caused widespread flooding. Cyclone Ului in 2010 also caused widespread flooding and significant damage in Mackay (Figure 3-7). In 2014, Cyclone Dylan generated the highest storm tide ever measured in Mackay.

Figure 3-7 Flooding and damage from Cyclone Ului on Victoria Street (Source: ABC News 2010)

Other examples of major floods are the largest recorded flood of the Pioneer River include 1958 flood, flash floods from heavy rainfall at Gooseponds in November of 2000, and a flood in 2008 that affected more than 4,000 Mackay homes.

Various structures, such as levee banks and sea training walls, have been constructed in and around the Pioneer River to protect Mackay and surrounding area from flooding and storm surges. Training walls have been constructed near the river mouth. Levee banks have been constructed on the southern and northern banks of the river and along Goosepond Creek. There are a number of water storages, including Teemburra Dam, Mirani Weir, Marian Weir, and the Dumbleton Rocks Weir, on the Pioneer River, but these are unlikely to have a significant impact on flood behaviour in the Pioneer River system.

Condition and variability

Flooding and heavy rainfall events in the Mackay region primarily occur in summer, the wet and cyclone season. Low-lying areas on the western side of the Port of Mackay act as an important flood pathway for northward-flowing floodwaters from the Pioneer River. These areas are protected under the *Coastal Protection and Management Act 1995* (Qld).

The Pioneer River widens and becomes shallower near its entrance to the GBR lagoon. Periodic flood discharges can extend large distances offshore, delivering nutrients, sediment and pesticides. Discharges of 4,000 m^3/s have caused flooding in Mackay, but peak flows of 10,000 m^3/s have been recorded. Such freshwater flows can have a significant localised impact on coastal hydrodynamics, and contribute to declines in water quality on the GBR. Pioneer River floodwaters may sometimes flow into Sandy and/or Bakers Creeks to the south.

In 2011, flood levels and flood extents for the Pioneer River and Bakers Creek were estimated for a range of storm durations for five-year, 50-year, 100-year, 200-year and 500-year average recurrence interval (ARI) flood events. The five-year flood event was generally contained by the banks of the Pioneer River, with no overflows from the Pioneer River to Bakers Creek. The 50-year event caused minor inundation of urban areas between the Pioneer River and the Mackay airport. Estimated depths of inundation were less than 0.5 m. Some overbank inundation occurred on the southern floodplain of Goosepond Creek, which drains into Fursden Creek, as well as upstream of Walkerston along Bakers Creek. In the 100-year event, the Mackay city levee was predicted to be overtopped, mainly to the west. Goosepond Creek overflowed to the Pioneer River and significant areas of north Mackay were inundated. For the 200 and 500-year events, substantial inundation was predicted through the urban areas of Mackay, North Mackay, Walkerston and Bakers Creek, with inundation depths from 1.0 m to over 2.0 m in some places.

Vulnerability

Coastal development has occurred along much of the Mackay coast in erosion-prone areas, which has led to the construction of protective rock walls. The Mackay region is rated as one of the most vulnerable sections of the Queensland coast in terms of risk of storm tide inundation, and is vulnerable to storm surges of up to 5 m. Coastal areas and low-lying suburbs set back from the shoreline are subject to storm tide inundation risk, and natural dune systems and vegetation are important to mitigate this risk. The low-lying nature of much of the study area means that a number of residential areas are prone to coastal flooding, including areas of South Mackay and East Mackay.

Flood-prone land affects land-use potential and the types of infrastructure that may be constructed. High-velocity flows during flooding often result in erosion and sedimentation.

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3.3 Air quality

AREA PROFILE: AIR QUALITY, NOISE AND LIGHTING

The Hay Point coal terminals exclusively export coal, and the primary air pollutant emitted is coal dust. Dust control measures are implemented to reduce or eliminate emissions. Exhaust emissions from plant and equipment also occur, but are considered to be minor compared to coal dust emissions.

Air pollutants that are not derived from coal terminal activities in the region may include sand and fine dust from wind erosion of beaches and non-vegetated surfaces, salt spray, material from fires, pollens, grass seeds and emissions from agriculture, including cane burning and sugar mill operations. The distribution of these materials varies with season and meteorological conditions.

NQBP, along with the two terminal operators, manage a permanent community air quality monitoring program immediately upwind and downwind of the coal terminals at the Port of Hay Point. Four monitoring stations provide continuous information on Total Suspended Particles (TSP), noise and meteorological conditions. The program has been in place since 1993 and monthly reports are made available on the NQBP website.

In 2013, NQBP also commenced a dust monitoring program at McEwens Beach. The solar monitoring station continuously measures PM_{10} and $PM_{2.5}$, with monthly reports also made available on the NQBP website.

The Department of Environment and Heritage Protection (DEHP) also has a regional monitoring location in West Mackay that monitors PM_{10}.

Environmental Values

Air quality values include protecting the health and biodiversity of ecosystems and the health and wellbeing of humans. The aesthetics of the environment, including the appearance of structures and agriculture, are also important.

Airborne particles may contribute to increased rates of respiratory illness in human populations. Adverse effects are influenced by particle size, intensity of exposure, the chemical nature of the particles, the presence or absence of pre-existing conditions and meteorological conditions. Particle inhalation is also known to cause health impacts in birds, and dust in the atmosphere or on surfaces reduces visual amenity. Good air quality avoids these issues.

Noise from traffic, port operations and other sources can reduce amenity for residents and can disturb shorebirds. Noise monitoring at the Port of Hay Point shows that noise levels in nearby communities have been reduced.

Light can influence the nesting and hatching for turtles, and feeding and resting for shorebirds. Artificial light can have a significant effect on these species.

AREA PROFILE: AIR QUALITY, NOISE AND LIGHTING

Contribution to OUV
Air quality has indirect contributions to natural beauty and natural phenomena OUV, by supporting their continued health, survival and aesthetic value.
Vulnerability
Threats to air quality are primarily related to possible increases in population, development, industrial activity or agricultural emissions. At this time, air quality in the study area appears stable, or possibly improving due to improvements in vehicle and industrial emissions, and dust control at the coal terminals. Climate change could lead to deterioration in air quality by increasing the frequency of bush fires.
Gaps
Air quality and noise monitoring is conducted at only a few locations in the study area. As these locations are in areas most likely to experience reduced air quality and noise. Very little regional data is available in relation to light, sources and impacts. This is not a particularly important gap.
Summary of Importance
Air quality and noise are currently at most a minor issue in the study area, with the exception of communities near the Port of Hay Point. Long term monitoring and ongoing improvement measures at the Port of Hay Point have led to improvements in air quality and noise.
What does this mean?
Air quality, noise and lighting have the potential to impact humans and animals, such as shorebirds and turtles. Impacts can include health and wellbeing, as well as amenity. Increased development within the study area has the potential to change air quality, noise and lighting to such an extent that humans and animals are impacted. As described above, changes to existing management practices at the ports have led to improvements in air quality and noise in the vicinity of the ports.

3.3.1 Dust emissions

Regional summary

The National Environmental Protection (Air Quality) Measure 1998 (NEPM) and the *Environmental Protection (Air) Policy 2008* (EPP Air) are the two primary guidance sources for air quality management in Queensland. An Air Quality Index with the rating categories of no data, very good, good, fair, poor and very poor is used to rate air quality. The Queensland Government operates an air quality monitoring station in West Mackay. Monitoring in 2014 and 2015 showed that air quality in West Mackay was generally well below EPP Air targets, with the average air quality index for PM_{10} rated as good.

Air pollutants that are not derived from coal terminal activities in the region may include sand and fine dust from wind erosion of beaches and non-vegetated surfaces, salt spray, material from fires, pollens, grass seeds and dust from agriculture, including cane burning and sugar mill operations. The distribution of these materials varies with season and meteorological conditions.

Overview of values

Air quality values include protecting the health and biodiversity of ecosystems and the health and wellbeing of humans. Particle inhalation is also known to cause health impacts in birds, and dust in the atmosphere or on surfaces reduces visual amenity. Good air quality avoids these issues.

Description of places

Both Hay Point coal terminals exclusively export coal, and the primary air pollutant emitted is coal dust. Dust control measures are implemented to reduce or eliminate emissions. Exhaust emissions from plant and equipment also occur, but are considered to be minor compared to coal dust emissions.

Historically, high levels of dust emissions were generated at the Port of Hay Point. This was in the early stages of port development, and operation and dust management practices have been enhanced to reduce dust emissions. Residents of Louisa Creek have made complaints about dust emissions from the Port of Hay Point; however, no complaints have been received from Half Tide or Salonika Beach residents. The timing of dust complaints is correlated with certain meteorological conditions (high temperatures, low rainfall, relatively high winds from the east-southeast to east-northeast). Most complaints occurred when dust emission rates were more than twice the average, indicating that they related to atypical events rather than normal operations.

There are no records of complaints relating to air quality originating from the Port of Mackay.

Condition and variability

The 2014 monitoring at Hay Point showed the air quality index to be primarily very good to good. There were a small number of fair ratings, and few ratings of poor or very poor during the year. Air quality monitoring to measure the finer fractions of particulate matter in the air commenced at McEwens Beach in 2013. A large proportion of air quality index ratings at McEwens Beach in 2014 were ‘very good’ to ‘good’ and only a small proportion were rated as ‘fair’ to ‘poor’. The majority of air quality index ratings at West Mackay were also good to very good, with only a small proportion rated fair to very poor in both 2014 and 2015.

There were no exceedances of the Ambient Air Quality National Environment Protection Measure (AAQ NEPM) at Mackay during 2014.

Vulnerability

Airborne particles can contribute to increased rates of respiratory illness in local communities. Adverse effects are influenced by particle size, intensity of exposure, the chemical nature of the particles, the presence or absence of pre-existing conditions and meteorological conditions. Particle inhalation can cause health impacts in birds. Dust in the atmosphere or on surfaces can reduce visual amenity.

The proximity of Louisa Creek, Half-Tide Beach and Salonika Beach to the coal terminals exposes these areas to potential impacts from dust emissions from the Port of Hay Point, mainly from the coal stockpiles and during construction activities. Louisa Creek is located approximately 300 m to the north at the closest point and is the closest sensitive receptor. Half-Tide Beach and Salonika Beach are to the south, with the closest residence about 600 m from DBCT. Prevailing winds are generally from the southeast, generally resulting in dust emissions on the northwestern side of the coal terminals.

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3.3.2 Noise

Regional summary

The main sources of noise are associated with industrial activities, transportation, construction and urban areas. Within the study area, noise sources are generally associated with the major urban and industrial centres; however, commercial ship and recreational vessels movement associated with the ports is also a contributor to underwater noise. While large stretches of the coastline remain undeveloped, and therefore have relatively low anthropogenic noise levels, population growth, urbanisation and industrial development continue to increase noise sources in the region.

Overview of values

Acoustic values are generally associated with human health and wellbeing and community amenity; however, noise can also affect the health and biodiversity of ecosystems. Undeveloped coastal areas in the study area are valuable, providing natural areas with limited noise. Underwater noise has been shown to adversely affect marine species, such as whales and dolphins.

Description of places

Noise in the vicinity of the ports is dominated by shipping, and coal and commodity export/import activities. Underwater noise generated at the ports is periodic; sources include large vessels, commercial and recreational fishing vessels and ships.

Louisa Creek, Half-Tide Beach and Salonika Beach residential areas are in close proximity to the Port of Hay Point. In the vicinity of the Port of Mackay are the residential areas of Mackay Harbour, Slade Point and North Mackay. Outside of these residential areas, land uses surrounding the Port of Hay Point are mostly used for rural and rural-residential activities and environmental/vacant land surrounding the Port of Mackay.

Condition and variability

A noise-monitoring program at the coal terminals and in surrounding residential areas was established in 1993 by the Port of Hay Point. At the Port of Mackay, there are no records of noise complaints relating to Port operations.

North and south of the Port of Hay Point are shorebird roosting and feeding areas (see Section 3.2.4), and there are bird watching areas west and south of the Port of Mackay. Shorebirds can be particularly sensitive to noise, but are often well habituated to noise occurring in the vicinity to port environments.

Vulnerability

Noise can affect both humans and animals, ranging from minor disturbance to impacts on sleep and health, or in the case of animals to their behaviour and breeding success. Responses to noise vary between people, and between animals. The type, duration and frequency of noise all contribute to how it may impact people and animals. Residential communities and local animal populations, particularly shorebirds, are potentially vulnerable to increased noise that could result from new future activities.

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3.3.3 Lighting

Regional summary

The main sources of artificial lighting are developed, residential, and industrial areas and city centres. Ports and shipping are required to use lighting for navigational and operational safety. Within the study area, particularly along the coastline from Bakers Creek to Dudgeon Creek, there are stretches of coastline that remain undeveloped with relatively little artificial lighting.

Overview of values

Artificial lighting can have a significant effect on a number of fauna species, particularly sea turtles and shorebirds. Light can influence nesting and hatching for turtles, and feeding and resting for shorebirds.

Description of places

The main sources of artificial light in the study area are the city of Mackay and surrounding suburbs and townships. The ports also emit artificial light associated with conveyors, berths, loading areas, buildings and shipping. Most shipping light is restricted to shipping channels, although fishing vessels also emit artificial light.

Condition and variability

As much of the study area is either undeveloped or with limited rural development, artificial lighting impacts are limited. Artificial light from urban areas is likely to increase with population growth. The Mackay and District Turtle Watch Association is working with Mackay Regional Council to install appropriate ‘turtle-friendly’ lighting at residential beaches in the region to reduce the effects of light pollution on turtles. Future port expansion could increase artificial light levels in the vicinity, but future development can also incorporate light-sensitive design to mitigate the effects of increased light.

Vulnerability

Light spill onto beach areas can interfere with nesting marine turtles and emerging hatchlings by disorienting the animals, which use the natural light horizon of the moon and stars to orientate. Artificial light can also discourage adult female turtles from coming ashore to nest. Lighting can also interfere with birds, particularly

nocturnal shorebirds, affecting their roosting, resting and feeding habits. However, as with noise, shorebirds roosting, resting and feeding in the vicinity of port environments are often well habituated to artificial light occurring in these areas. Continued coastal development and the associated lighting are likely to increase the vulnerability of these species.

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3.4 Aquatic ecosystems – freshwater

3.4.1 Catchments

AREA PROFILE: CATCHMENTS

Catchments support a variety of activities, industries, infrastructure and provide a range of goods and services. There are two major catchments in the study area, the Pioneer Basin and the Plane Basin. The Pioneer catchment runs from the Port of Mackay south to Sandringham Bay. The Plane Basin encompasses all waterways south of the Pioneer River within the boundaries of the study area.
Environmental Values
Catchments have a number of environmental, social and economic values. Catchment resources are used in rural, residential, commercial, industrial and agricultural activities and they also play an important role in aquatic and terrestrial habitats. Additionally, catchment areas are used for sport and recreation and hold a number of social values in the community.
Contribution to OUV
Catchments do not directly contribute to OUV; however, they provide support for aquatic and terrestrial communities which contribute to visual amenity and appreciation.
Vulnerability
The major threat to catchments is flooding and the changes in the frequency and severity of floods. Land clearing in catchment areas may also contribute to reduced water quality and erosion.
Gaps
No notable gaps in the available information have been identified from the perspective of the EVA.
Summary of Importance
Catchments are an important resource for aquatic and terrestrial communities, recreation and provide a number of services to local industries.

AREA PROFILE: CATCHMENTS

What does this mean?
Sediment loads to the GBR is one of the main threats to the health of the reef. Improving water quality and riparian vegetation through improving land management practices within the study area catchments seeks to reduce sediment loads. Considerable efforts have been made to improve management of agricultural and urban water quality within the study area. Improved grazing and cane farming management practices are the highest priority for improved water quality entering the GBR.

Regional summary

There are two major catchments in the study area, the Pioneer Basin and the Plane Basin. The Pioneer Basin has six sub-catchments, and the Plane Basin has nine. Queensland has a water resource planning process to manage the allocation and sustainable management of fresh water.

The area from the Port of Mackay south to Sandringham Bay is within the Pioneer Valley Catchment. The Pioneer Valley Catchment environmental flow objectives, performance indicators, watercourse information and management strategies for surface water and groundwater are outlined in the Water Resource (Pioneer Valley) Plan 2002, which was revised in 2014. The northern boundary of the Pioneer Valley Catchment intersects the Port of Mackay. The northern section of the Port of Mackay is not located in a water resource planning area. The Port of Hay Point is not within a water resource planning area.

Overview of values

Catchments support a variety of activities, industries and infrastructure, and provide a range of goods and services. Land in catchments may be used for purposes relating to rural, residential, commercial, industrial or agricultural activities. These areas support aquatic habitats, and flora and fauna, and may also be used for tourism, sport and recreation, open space or public parklands.

Description of places

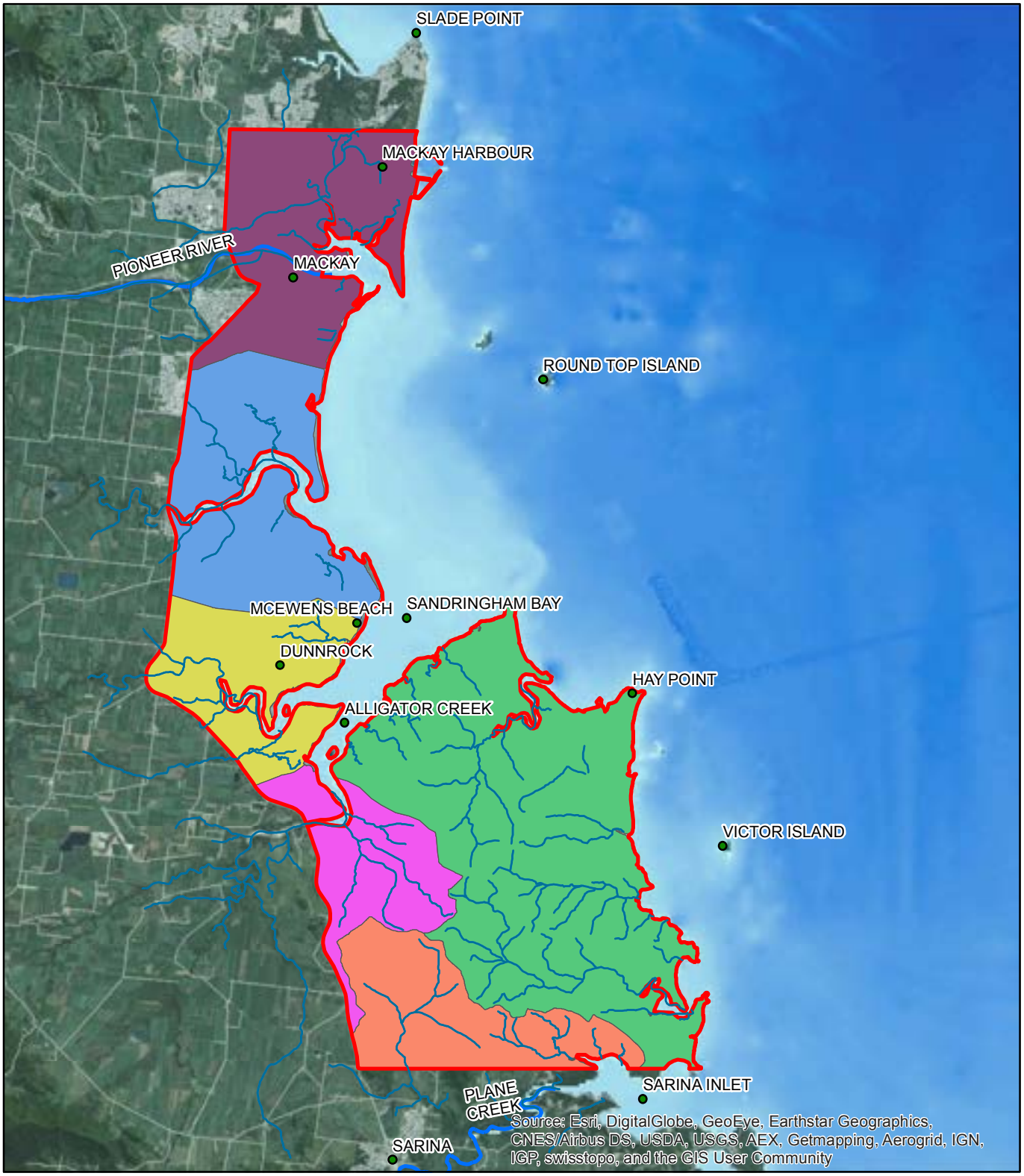
The Pioneer River sub-catchment is the predominant catchment in the study area and is a sub-catchment of the Pioneer Basin. Other sub-catchments in the Pioneer Basin are Pioneer Valley, Mackay City, Goosepond Creek, Janes Creek and Vines Creek.

The Plane Basin encompasses all waterways south of the Pioneer River within the boundaries of the study area. The sub-catchments Bakers Creek, Sandy Creek, Alligator Creek, Cabbage Tree Creek, Louisa Creek, Sarina Beach, Plane Creek, Rocky Dam Creek and Cape Creek (see Figure 3–8). Sarina Beach sub-catchment includes Hector Conservation Park and Hay Point.

Condition and variability

Mackay City sub-catchment's overall freshwater ecosystem health rating for 2014 was moderate, with ambient water quality and riparian vegetation in the sub-catchment rated very poor. Pressures in this catchment include multiple high-intensity land uses including cane production (about 5,615 ha), urban and industrial development (6,348 ha), grazing/forestry (686 ha) and horticulture/cropping (15 ha). Considerable efforts have been made to improve management of agricultural and urban water quality, and improved grazing and cane farming management practices are the highest priority for improved water quality entering the GBR.

Figure 3-8 Subcatchments and waterways in the study area



LEGEND

- Landmass Project Extent
- Ocean Project Extent

Subcatchment

- Alligator Creek
- Bakers Creek
- Cabbage Tree & Louisa creeks
- Mackay City
- Plane Creek
- Sandy Creek

[Geographical Coordinate System: GDA 94]

A4 1:200,000

N

0 5 10

Kilometers

JACOBS

The 2014 freshwater ecosystem health ratings for the Pioneer River, Bakers Creek, Sandy Creek, Alligator Creek sub-catchments were ‘poor’ to ‘very poor’, except in the upper parts of some catchments. This assessment was based largely on water quality, as well as the condition of riparian vegetation. The main land-use pressures are cane production and grazing/forestry, with significantly smaller areas of urban/intensive uses and horticulture/cropping. High priorities for management in these sub-catchments include improvements to riparian vegetation, nutrient and residual herbicide reduction, improvements to connectivity and fish habitat, fish passage, and fish diversity and abundance, and bed and bank stabilisation.

The Sarina Beach, Plane Creek and Rocky Dam Creek sub-catchments were rated ‘moderate’ in 2014, with water quality rated ‘poor’ to ‘good’ and riparian vegetation rated ‘moderate’. The primary land uses in these areas are cane production and grazing/forestry. Port activities at Hay Point have some influence on the Sarina Beach sub-catchment. Rocky Dam Creek flows into high-ecological-value waters of the Llewellyn Bay Dugong Protection Area (DPA). Considerable efforts have been made by cane farmers and graziers in the Rocky Dam Creek sub-catchment to improve management practices. As for the sub-catchments rated as ‘poor’ to ‘very poor’, management priorities in these three sub-catchments include improvements to riparian vegetation, nutrient and residual herbicide reduction, improvements to connectivity and fish habitat, fish passage, and fish diversity and abundance, and bed and bank stabilisation.

Cape Creek sub-catchment was rated ‘good’ in 2014, with ratings of ‘moderate’ for ambient water quality and ‘very good’ for riparian vegetation and flow. Water from this sub-catchment flows into Ince Bay and adjacent inshore reefs, where regionally significant seagrass beds support dugong and turtle populations. More than 50% of the sub-catchment is comprised of National Park, with no cane production and relatively little grazing/forestry (4,960 ha), urban/intensive uses (117 ha) and horticulture/cropping (22 ha). Management priorities include improvements to grazing practices to reduce nutrients and residual herbicides, as well as improvements to fish habitats.

Vulnerability

Catchments are vulnerable to flooding, including changes in the frequency and severity of floods. Land clearing and development also affect EVs in catchments, including habitat loss and reduced water quality. Water quality is also influenced by runoff and contamination from activities undertaken throughout the catchment.

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3.4.2 Waterways and ephemeral water bodies

AREA PROFILE: WATERWAYS AND EPHEMERAL WATER BODIES

The catchments described in Section 3.4.1 have many small streams and tributaries in addition to the Pioneer River and creeks. There are also many ephemeral water bodies that fill with abundant rainfall and periodically dry out, either seasonally or on a longer time scale.

Environmental Values

Waterways provide freshwater inputs to estuaries and habitat that supports a wide range of flora and fauna. Rare, threatened and migratory/resident bird species found in the region (e.g. shorebirds and waders) and other animals such as reptiles, frogs and fish use these waterways. Surface waters also provide benefits to local communities for recreational fisheries and supply water to livestock.

Contribution to OUV

The waterways and ephemeral water bodies in the study area are outside the GBRWHA and thus do not contribute directly to OUV. However, they are indirectly linked to the OUV of ecological processes and biodiversity conservation, in regulating flows of water, nutrients and sediment to the GBR. In addition, some marine species use the waterways at discrete stages of their life cycle.

Vulnerability

Modifications of watercourses increase their vulnerability and can change flows of water and sediment, resulting in changes to coastal marine waters areas such as Sandringham Bay and Sarina Inlet. Water extraction changes water available for environmental flows, and therefore ecosystem function. Erosion, trampling of banks and aquatic and riparian vegetation by livestock and human visitors, and contaminants from the catchment are also threats. The Healthy Rivers to Reef Partnership identifies agriculture, industry, aquaculture, ports, tourism, urban development and fishing as key activities for which management practices are being monitored.

Gaps

No notable gaps in the available information have been identified from the perspective of the EVA.

Summary of Importance

The Pioneer River is the most significant of the water resources in the study area. It flows through Mackay and discharges to the GBR approximately 5 km south of the Port of Mackay. The river supplies Mackay with potable water, as well as water for agricultural and grazing purposes. The Pioneer River also delivers large quantities of water and sediment to the GBR lagoon during flood events.

Other notable resources include:

- Lake Varfield, which has local conservation significance
- Rocky Dam Creek, which is classified as high ecological value waters
- Goosepond Creek, which is a significant freshwater nursery habitat for small freshwater fishes

What does this mean?

Changes to watercourses, through changes in watercourse channels, introduction of waterway barriers and water extraction, can change the flow of water and sediment in the watercourses, and ultimately the marine waters. These changes to watercourses can also influence the ability for some marine species to complete their life cycle, with many of these species recognised as valuable species for the recreational and commercial fishing industry.

Existing and future development within the study area can have direct impacts on waterways. The Healthy Rivers to Reef Partnership has identified key activities in the region for which management practices are being

AREA PROFILE: WATERWAYS AND EPHEMERAL WATER BODIES

monitored; these are agriculture, industry, aquaculture, ports, tourism, urban development and fishing.

Regional summary

The catchments described in Section 3.4.1 have many small streams and tributaries in addition to the Pioneer River and creeks. There are also many ephemeral water bodies that fill with abundant rainfall and periodically dry out, either seasonally or on a longer time scale.

Overview of values

Waterways provide freshwater inputs to estuaries and habitat that supports a wide range of flora and fauna. Rare, threatened and migratory/resident bird species found in the region (e.g. shorebirds and waders) and other animals such as reptiles, frogs and fish use these waterways. Surface waters also provide benefits to local communities for recreational fishing and water supply to for livestock.

EVs associated with water quality have been defined under Queensland's Environmental Protection Policy (Water) 2009 (EPP Water), giving them a statutory status. EPP Water defines the EVs as 'the qualities of a waterway that make it suitable to support particular aquatic ecosystems and human uses'. These EVs have also been developed as part of the Water Quality Improvement Plan for the Mackay Whitsunday Region, which aims to protect aquatic ecosystems and the capacity of the waterways to support human use.

The recognised EVs for the freshwater and estuarine reaches of creeks and rivers in the region are listed in the EPP Water, which identifies the EVs of the Pioneer River and Plane Creek Basins as:

- Aquatic ecosystems and the intrinsic value of the systems, habitat and wildlife in waterways and riparian areas
- Irrigation for crops, pastures, parks, gardens, recreational areas
- Farm supply and use for domestic farm water, other than drinking water
- Stock water for livestock
- Aquaculture
- Human consumption of aquatic foods
- Recreation with direct contact (e.g. swimming), indirect contact (e.g. boating) and no contact (e.g. walking and picnicking) with water
- Raw drinking water supply
- Industrial use
- Cultural and spiritual values for Indigenous and non-Indigenous cultural heritage, including symbols/landmarks/icons, lifestyles, hunting/gathering, ritual responsibilities and aesthetic, historical, scientific, social or other significance

Description of places

Watercourses in and around the Port of Hay Point include Louisa Creek, which is west of Hay Point and discharges into Dalrymple Bay between DBCT and Dudgeon Point. Grendon Creek runs through the DBCT rail loop and discharges into Lake Barfield, south of the Port of Hay Point.

There are ephemeral waterways in the Dudgeon Point area north of the Port of Hay Point. These ephemeral waterways are influenced by upstream grazing. Sandfly Creek, northeast of Hay Point, is ephemeral. It only flows during rainfall events and discharges into Sandringham Bay. The creek receives runoff from the DBCT industrial dam during heavy rainfall events.

Lake Barfield, immediately southeast of the Port of Hay Point and east of Half-Tide Beach, was converted from a tidal inlet to an artificial freshwater body in the 1960s. The lake varies between freshwater and estuarine conditions, but supports freshwater fauna including significant bird species. The lake is of local conservation significance. It receives inputs from Grendon Creek, as well as stormwater discharge from the Port of Hay Point.

Grasstree Creek, about 8 km south of Hay Point, discharges into Grasstree Beach. Further south, Plane Creek, about 12 km south of the Hay Point, discharges into Sarina Inlet. Cherry Tree Creek feeds into Rocky Dam Creek and then into Llewelyn Bay, about 20 km south of Hay Point. The whole area of Rocky Dam Creek is classified as high ecological value waters. About 30 km south are the Ince Bay freshwater ecosystems.

Sandy Creek, Bakers Creek, Bell Creek, Alligator Creek and Splitters Creek are the main waterways in the Sarina Catchment and discharge into Sandringham Bay. Sandy Creek and Bakers Creek are located between Mackay and Hay Point. Both creeks are south of the Pioneer River and discharge into south of McEwens Beach. Bell Creek feeds into Alligator Creek west of the Bruce Highway, with Alligator Creek (north of Dudgeon Point) discharging between McEwens Beach and Dudgeon Point.

The Pioneer River flows through Mackay and discharges about 5 km south of the Port of Mackay. The Pioneer River supplies Mackay with potable water, as well as water for agricultural and grazing. The Pioneer River delivers large quantities of water and sediment to the GBR lagoon during flood events.

Goosepond Creek is a central wetland lagoon in North Mackay. It is a significant freshwater nursery habitat for small freshwater fishes including gudgeons, bony bream, glassfish, hardyhead and rainbow fish. The lagoon also supports eels, catfish and species, such as mullet and barramundi that move between freshwater and marine systems.

Condition and variability

Overall, the condition of basins within the study area range from good to poor, further detail on the water quality and freshwater fish habitats is provided in Sections 3.4.3 and 3.4.7). Key pollutants of concern in the Mackay-Whitsunday Region are dissolved and particulate forms of nitrogen and phosphorus, suspended sediment and residual herbicides (e.g. ametryn, atrazine, diuron, hexazinone, tebuthiuron). Most inputs are from diffuse agricultural sources.

Vulnerability

Modifications of watercourses increase their vulnerability. Modifications to watercourse channels can change flows of water and sediment in the watercourses themselves, and ultimately coastal marine waters areas such as Sandringham Bay and Sarina Inlet. Water extraction changes water available for environmental flows, and therefore ecosystem function.

Small watercourses in the Hay Point area, including the lower reaches of Louisa Creek, may be vulnerable to potential erosion or contamination from coal terminal operations (e.g. coal fines from site runoff, or contamination from a spill). Lake Barfield, Grendon Creek and Sandfly Creek receive inputs from coal terminal overflows (e.g. industrial dam discharge).

The Healthy Rivers to Reef Partnership has identified key activities in the region for which management practices are being monitored; these are agriculture, industry, aquaculture, ports, tourism, urban development and fishing.

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3.4.3 Surface water quality

AREA PROFILE: SURFACE WATER QUALITY

Surface water quality within the study area varies considerably based on the catchment area, land uses within the catchment and hydrological conditions. At the regional scale however, the water quality of fresh water entering the GBR lagoon in the region has deteriorated substantially over the past 150 years due to cane production, grazing, urban development and horticulture. Discharges to the lagoon of sediment and nutrients from the GBR catchment as a whole are estimated to be five times higher than in pre-European times. The freshwater ecosystems in the study area are mostly rated poor to very poor (Section 3.4.1). Land use and disturbance in the catchments drive surface water quality and ultimately ecosystem quality.

Environmental Values

Surface water quality values include habitat values that support a wide range of flora and fauna. Surface water resources in the study ara are also used for domestic and urban water supply, and as such, water quality is important for the continued use of this important resource.

Contribution to OUV

Fresh waters in the study area are outside the GBRWHA and thus their water quality does not directly contribute to OUV. They are strongly linked to the OUV of natural beauty, ecological processes and biodiversity conservation; however, because declining water quality of runoff from GBR catchments is considered the greatest direct threat, to the health of the GBR.

Vulnerability

Changes in land use, in particular grazing and cane farming, are the greatest threat to freshwater quality. These activities are a major source of nutrient, sediment and pesticide inputs. In the GBR catchment as a whole, sediment and nutrient inputs to the GBR have increased five-fold since pre-European times. There have been some recent improvements in water quality as a result of the Reef Water Quality Protection Plan (Reef Plan) and further investment in water quality improvement is expected. Increased stormwater runoff and erosion associated with industrial, urban and infrastructure development also increase the vulnerability of watercourses to decreased water quality.

Gaps

No notable gaps in the available information have been identified from the perspective of the EVA.

Summary of Importance

Reduction of nutrient, sediment and pesticide inputs to the GBR in freshwater runoff is identified as the top priority for improved health of the GBR. Some improvements have already been realised, but continued management and water quality improvements are critical to enhancing the resilience of the GBR to other threats, such as climate change.

What does this mean?

Connections and pressures between ecological communities, land use and waterways are well known. Considerable efforts have been made to improve management of agricultural and urban water quality within the study area. Improved grazing and cane farming management practices are the highest priority for improved water quality entering the GBR.

Regional summary

The water quality of fresh water entering the GBR lagoon in the region has deteriorated substantially over the past 150 years due to cane production, grazing, urban development and horticulture. Discharges to the lagoon of sediment and nutrients from the GBR catchment as a whole are estimated to be five times higher than in pre-European times. The freshwater ecosystems in the study area are mostly rated poor to very poor (Section 3.4.1). Land use and disturbance in the catchments drive surface water quality and ultimately ecosystem quality.

Overview of values

Surface water quality values include habitat values that support a wide range of flora and fauna. Surface water resources in the study ara are also used for domestic and urban water supply, and as such, water quality is important for the continued use of this important resource.

Description of places

Drainage networks and the terrain in and around the Port of Hay Point have been highly modified. Almost all drainage from the operational areas, including the northern limits of the stockpiles, drain into intertidal wetlands via a series of water storage/sedimentation ponds. These ponds improve the water quality of the discharges. Areas south of the port, including the rail corridors and DBCT unloading facilities, drain towards Lake Barfield.

In the area under the control of the Port of Mackay there are still areas of relatively intact coastal dunes, and freshwater and estuarine wetlands. However, development of the port and the city of Mackay has modified natural drainage patterns and tidal flows. The extent of tidal inundation has been reduced in some areas and changes to freshwater inflow have occurred due to stormwater drainage systems.

Condition and variability

Inshore monitoring of the Whitsunday Islands showed that sites were influenced by inputs from the Pioneer River and the majority of pollutants identified were sourced from agriculture. A cooperative approach to monitoring and management of waterways in the Mackay-Whitsunday Region has been developed under the Reef Plan, created in 2003 to address many of the water quality issues. Reef Plan was last updated in 2013. The ‘Paddock to Reef’ monitoring and evaluation program was established to assess the success of Reef Plan implementation. Report cards have been published since 2009 to indicate changes in water quality and management. The report cards indicate that, while improvements are occurring, they are not occurring at a fast enough rate to achieve Reef Plan targets.

Stormwater from both Hay Point coal terminals is collected, treated in sedimentation ponds to remove coal and soil and then stored in large dams for reuse on site, for example in dust suppression. Water discharge from the coal terminals is infrequent due to this reuse and the availability of large storage volumes. Stormwater at the Port of Mackay is captured and treated where possible. NQBP is upgrading the stormwater system to include integrated stormwater treatment devices (e.g. gross pollutant traps, sediment traps). NQBP is working with port tenants to improve water quality and minimise contaminants entering waterways, including Mackay Harbour.

There are no community sewage treatment plants (STPs) in the Hay Point area, although there was a small STP at the local caravan park before its recent closure. Most residences are on individual septic systems. DBCT has two packaged treatment plants for processing onsite sewage, which is piped to the site industrial dam after treatment.

Sandringham Bay has a freshwater ecosystem health rating. It has high levels of nutrients and pesticides, with Sandy Creek having the highest concentrations of diuron recorded in any waterway entering the GBR lagoon. Five of the seven sub-catchments feeding into Sandringham Bay are rated very poor for event water quality and four very poor for ambient water quality.

Most of these sub-catchments have moderate fish community health; however, two are rated poor and one good. Flow regimes have been significantly altered due to the implementation of irrigation schemes and associated water extraction, with three sub-catchments being scored as poor, two as moderate and one each as good and very good. Existing riparian vegetation is low, with two sub-catchments having a score of very poor, four of poor, and only one good score. In most sub-catchments fish passage has been heavily restricted, with two sub-catchments in very poor condition, three in poor, one in moderate and one in very good condition.

Sarina Inlet, south of Hay Point, is rated moderate for the condition of the connected freshwater ecosystems. It is fed by two sub-catchments (Sarina Beach and Plane Creek), both of which have received scores of poor for event water quality, and good for ambient water quality. The sub-catchments received ecosystem health indicator scores of moderate for fish community health and riparian vegetation. Sarina Beach sub-catchment received a score of good for flow, while Plane Creek sub-catchment received a moderate score. Barriers to fish migration are a particular issue in both sub-catchments. Plane Creek scored very poor, with significant barriers including major weirs.

Ince Bay, just south of the study area, has an overall rating of good for freshwater ecosystems. Cape Creek sub-catchment is rated very good for flow, riparian vegetation, and barriers to fish migration, while fish community health is rated good. Event water quality is rated moderate, and ambient water quality as good.

Event water quality in the Rocky Dam Creek sub-catchment is rated poor due to high levels of dissolved inorganic nitrogen (DIN), particulate nitrogen and total suspended solids (TSS). Ambient water quality is rated moderate. Fish community health, flow, riparian vegetation and barriers to fish migration in Rocky Dam Creek are rated moderate.

Freshwater ecosystems of the Seaforth Coast, in the north of the marine study area, have an overall rating of moderate. Water quality was the lowest-rated indicator, with event water quality rated moderate to very poor. Ambient water quality is mostly rated moderate, with Reliance Creek rated very poor and Murray Creek rated good. Major pollutants of concern include dissolved DIN and diuron.

The scores for fish community health and flow are moderate or good for most sub-catchments, with Murray and Constant Creeks receiving a poor rating for flow. Riparian vegetation is impacted, with all sub-catchments rated as poor or moderate. Sub-catchments scored from very poor to moderate for barriers to fish movement.

Vulnerability

Connections and pressures between ecological communities, land use and waterways are well known. The ecological condition of rivers and streams is influenced by not only the in-stream uses, but also adjacent and upstream land uses. These activities are a major source of nutrient, sediment and pesticide inputs to the GBR. Soil disturbance, erosion, increased stormwater runoff and erosion associated with agricultural, industrial, urban and infrastructure development increase the vulnerability of watercourses to decreased water quality. Programs to improve the agricultural land management practices within the study area are being implemented at the State and Commonwealth levels.

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3.4.4 Groundwater quality

AREA PROFILE: GROUNDWATER QUALITY

Groundwater of the study area is utilised by humans through extraction by bores, and supports communities of plants, animals and other organisms in wetlands and streams.

Environmental Values

Groundwater sourced from the Mackay coastal plains is a very important resource to the local community, providing water for irrigating sugar cane farms, supplying the sugar milling industry, urban use, rural use and stock watering. Groundwater contributes to local wetlands which support a range of freshwater, estuarine and marine flora and fauna and recreational activities such as fishing.

Contribution to OUV

Groundwater contributes to the natural beauty of wetlands and the maintenance of biological diversity.

Vulnerability

Over extraction of groundwater can disrupt the natural hydrological cycle, affecting groundwater values. Pollution from industrial and domestic activities is also a threat to groundwater values.

Gaps
The contribution of groundwater (compared with surface water) to sustaining local wetlands within the study area is not well studied.
Summary of Importance
Groundwater resources within the study area are important to both the local community (by providing water for domestic, agricultural and industrial uses) as well as the environment (for groundwater dependent ecosystems (GDEs)). Many GDEs include wetlands, the health of which can directly relate to the health and resilience of the reef.
What does this mean?
Over extraction and/or contamination of groundwater resources through land use activities can impact the quality and quantity of groundwater resources available for both human and environmental use.

Regional summary

The Port of Mackay is located partially within the Pioneer North East groundwater sub-catchment of the Pioneer Valley Water Resource Plan area. The northern area of the Port of Mackay sits outside of the Pioneer Valley Water Resource Plan area. The Port of Hay Point is wholly outside of a water resource plan area; however, is located within the declared Sarina subartesian area.

There is an extensive number of registered water bores used privately and by the Queensland Government across the Mackay and Hay Point region. There are also numerous groundwater-dependent ecosystems (GDEs), which are communities of plants, animals and other organisms that are dependent on groundwater for their survival (e.g. wetlands, streams) in the area.

Overview of values

Groundwater sourced from the Mackay coastal plains is a very important resource to the local community, providing water for irrigating sugar cane farms, supplying the sugar milling industry, urban use, rural use and stock watering. Groundwater resources provide many values to the ecosystems that are dependent upon them. GDEs are ecosystems which require access to groundwater, either on a permanent or intermittent basis, to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services.

Description of places

Groundwater sub-catchments within the study area include Pioneer North East, Seawater Intrusion Area (which includes Mackay), Sandringham Creek and Alligator Creek. The Port of Mackay is partially within the Pioneer North East sub-catchment. Under the Pioneer Valley Water Resource Plan (Pioneer Valley WRP) about 82,000 ML per annum of groundwater has been allocated. Additional groundwater is extracted for stock and domestic purposes, but these volumes are small and do not require a licence for extraction.

Groundwater use in 2002-2003 in the Pioneer Valley was high, with approximately 52,395 ML used for irrigation, industrial and municipal purposes. The area southeast of Sandringham Bay, which includes the Port of Hay Point, is located within the Sarina subartesian area. Within this area, extraction that is not for stock or domestic purposes or a prescribed activity requires a water entitlement, permit or seasonal water assignment notice.

Condition and variability

Groundwater in the region is commonly saline, related to the condition of the aquifer system. Over-allocation of groundwater resources is a regional issue, particularly along the coast. The extensive use of groundwater in the

Mackay coastal plains (Seawater Intrusion Area sub-catchment), together with periods of drought, has caused the intrusion of seawater, reduced groundwater levels and changes to the reliability of supply to some areas.

The aquifer systems in the Hay Point/Dudgeon Point area are in the declared Sarina subartesian area. Groundwater in the declared area is generally shallow, with low to medium permeability. The area does not provide potable water. Groundwater at Hay Point is typically saline; pH is generally in neutral range and mildly alkaline in some areas. This water is not suitable for use as drinking water or for livestock. Groundwater monitoring at DBCT in 1994 and 1995 showed that water levels ranged from 3.7 m to 6.7 m below the surface (with seasonal fluctuations). Rainfall events almost immediately affected groundwater levels, but tidal fluctuations did not.

Vulnerability

Groundwater extraction and/or over-allocation of groundwater resources can disrupt the hydrological cycle alter the variability of groundwater levels and consequently affect the timing and volume of groundwater availability. Water Resource Plans (WRPs) aim to establish a management framework outlining the desired outcomes and objectives, and strategies for achieving a sustainable balance between users and the environment. The area north Sandringham Bay is within a WRP. The area southeast of Sandringham Bay is not. However, groundwater use still is regulated by being a declared subartesian area under the *Water Act 2000* (Qld).

Sources of groundwater contamination in the study area include leachate from coal stockpile areas, wastewater from STPs and leaks from fuel storage tanks. Appropriate design of coal stockpile leachate collection systems and groundwater monitoring to identify contamination should assist in managing these risks.

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3.4.5 Wetlands

AREA PROFILE: WETLANDS

Wetlands are classified into lacustrine (lake), palustrine (marsh or swamp), and riverine or estuarine. The study area contains mostly estuarine wetlands associated with the local rivers and bays, though Lake Barfield and Keely Road Wetlands are examples of palustrine wetlands.

Environmental Values

Wetlands provide the following values:

- Recreational opportunities (e.g. fishing, bird watching, boating)
- Flood control
- Water quality enhancement
- Cultural significance
- Storm protection for urban and inland areas
- Habitat and breeding habitat for economically important species
- Food, shelter and breeding resources for resident fauna including threatened species.
- Critical seasonal food resources for migratory fauna

Contribution to OUV

Mainland wetlands do not directly relate to OUV; however, there is a significant indirect contribution to all OUV criteria as environmental flows and water quality directly relate to the health and resilience of the reef. Wetlands are also important for shorebirds, which are an important element of OUV.

Vulnerability

Wetlands in the study area are threatened by the following processes:

- Changes in the catchment that groundwater hydrology
- Removal of surrounding and wetland vegetation
- Weed infestation
- Water volume changes due changes in catchment runoff
- Water extraction
- Fishing
- Recreation and grazing
- Waste dumping
- Excessive inflow of nutrients and sediments and catchment generated contaminants
- Storm tide erosion
- Permanent inundation due to sea level rise, and increased storm frequency and intensity from climate change

Gaps

No notable gaps in the available information have been identified from the perspective of the EVA.

AREA PROFILE: WETLANDS

Summary of Importance

Wetlands play an important role in the environmental health of the GBR. They maintain and improve water quality and have been likened to functioning as 'kidneys' for catchments because they filter out pollutants. They are important habitats for shorebirds, threatened species, and this is generally reflected by their level of protection.

Their importance is increased due to the extent of past clearing as well as current threatening processes.

There are no internationally significant (Ramsar) wetlands in close proximity to the study area. Several wetlands of national, state and local significance occur in the study area. This includes:

- Nationally Significant Wetlands: Sandringham Bay – Bakers Creek Aggregation, northwest of Hay Point, and Sarina Inlet – Ince Bay Aggregation south of Hay Point
- Clusters of state significant wetlands northwest of Mackay Harbour and south to Dudgeon Point, Lake Barfield, near Campwin Beach, and Sarina Inlet
- Locally significant wetlands between Andergrove/Mackay Harbour/Cremorne, Dudgeon Point/Louisa Creek, Lake Barfield, Campwin Beach, Sandfly Creek Environmental Reserve, Town Beach and Far Beach area, the Keeleys Road wetlands.

What does this mean?

There has been extensive clearing in much of the wetland areas within the study area. While significant wetland areas are recognised within the study area, not all of these areas are protected from future development. Those areas that are protected continue to be vulnerable to altered hydrology, changes to water quality and disturbances such as introduction of weeds, pests (especially pigs) and illegal dumping.

Further deterioration and/or clearing of these areas have the potential to directly impact the health and resilience of the reef.

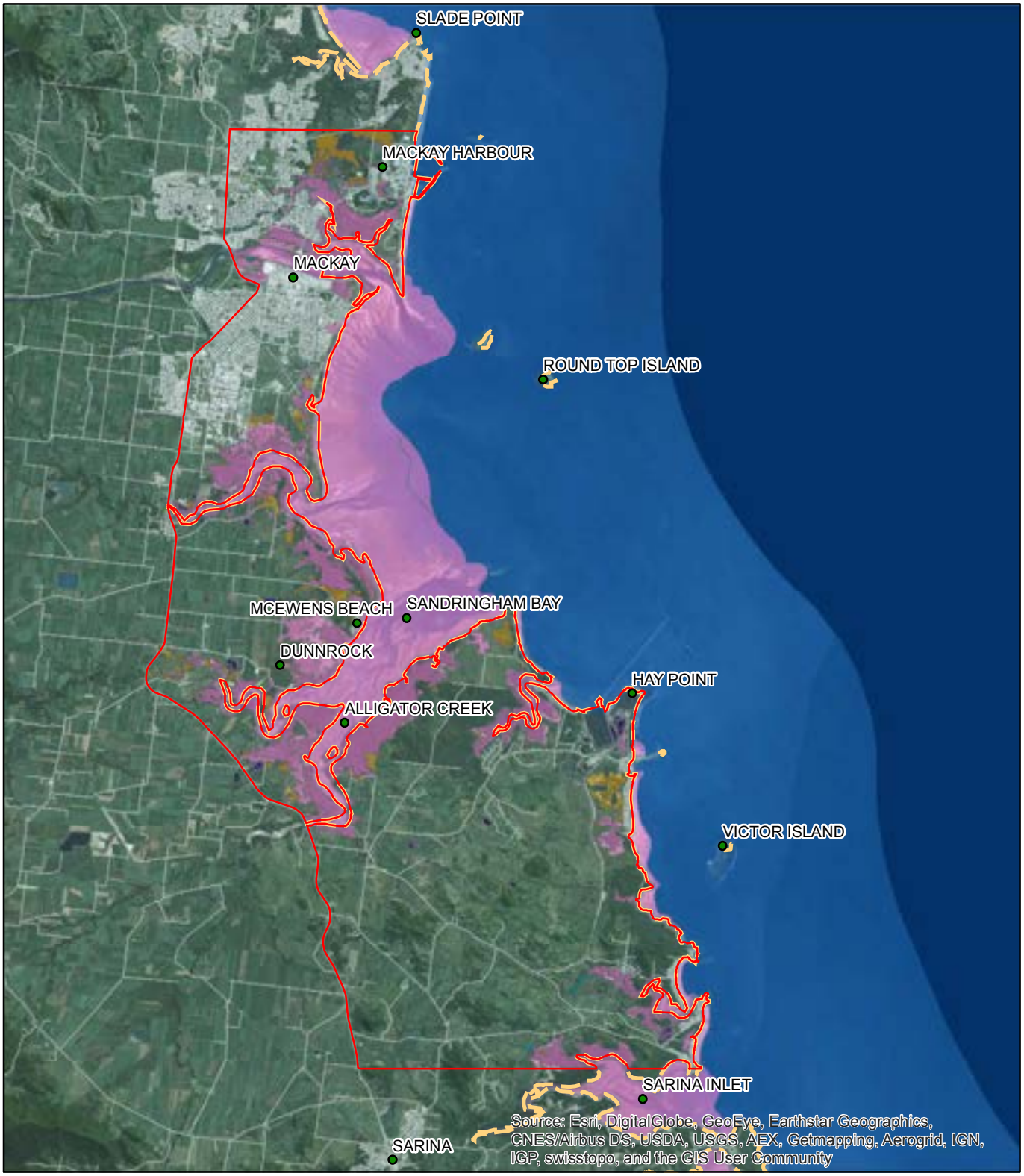
Regional summary

Wetlands are classified into lacustrine (lake), palustrine (marsh or swamp), and riverine or estuarine. The study area contains mostly estuarine wetlands associated with the local rivers and bays (Figure 3–9), though Lake Barfield and Keely Road Wetlands are examples of palustrine wetlands. Even though most wetlands in the study area are not freshwater, they are dealt with in this section because of the close linkage to freshwater systems. Mangroves are dealt with in more detail in Section 3.4.6.

The coastal area around Hay Point contains two nationally important wetland areas, the Sandringham Bay – Bakers Creek Aggregation, northwest of Hay Point, and the Sarina Inlet – Ince Bay Aggregation south of Hay Point.

Clusters of wetlands that are Matters of State Environmental Significance (MSES) occur northwest of Mackay Harbour and south to Dudgeon Point, Lake Barfield, near Campwin Beach, and Sarina Inlet.

Figure 3-9 Wetlands by type in the study area



LEGEND

- Landmass Project Extent
- Ocean Project Extent

Wetland Types

- Estuarine
- Lacustrine
- Marine
- Palustrine
- Riverine

[Geographical Coordinate System: GDA 94]

A4 1:200,000

N

0 5 10

Kilometers

JACOBS

Clusters of locally significant wetlands occur between Andergrove/Mackay Harbour/Cremorne in the north of the study area. In the south of the study area, locally significant wetlands occur around Dudgeon Point/Louisa Creek, Lake Barfield Campwin Beach. There are four wetlands of local importance at the Sandfly Creek Environmental Reserve, Town Beach and Far Beach area, the Keeleys Road wetlands and at Lake Barfield.

MSES Wetlands and the two Nationally Important Wetlands in the study area are shown in Figure 3–10. There are no internationally significant (Ramsar) wetlands in close proximity to the ports, with Shoalwater and Corio Bays being the closest. These sites are approximately 160 km south east of Hay Point.

Overview of values

The Sandringham Bay – Bakers Creek and Sarina Inlet – Ince Bay aggregations are most noted for their estuarine wetlands, including mangroves, and importance for shorebirds; however, they are also known to have a low density of flatback (*Natator depressus*) and infrequent green turtle (*Chelonia mydas*) nesting. These areas also support GDEs, such as low-lying coastal swamps, alluvia, and coastal sand mass (beach ridges).

The Sandringham Bay – Bakers Creek Aggregation is significant because of a very extensive expanse of intertidal and shallow water habitat, the diversity of the shoreline, and the extent of the mangroves. These wetlands provide seasonally important feeding habitats for waders and other shorebirds, with the broad areas of the Sandringham Bay intertidal flats providing an important shorebird habitat. Waders and shorebirds are most abundant between August and April.

The Sarina Inlet – Ince Bay Aggregation, south of Hay Point, includes Sarina Inlet, Llewellyn Bay, and Ince Bay. Most of the aggregation is outside the terrestrial extent of the study area, and Ince Bay is outside the marine extent, but the aggregation is included herein given its close linkage to the GBR and its OUV. The aggregation is significant as a good example of a diverse, hydrologically related aggregation of marine, estuarine and freshwater wetlands in the Central Queensland Coast bioregion. Notable flora includes seagrass, mangroves, freshwater aquatic plants and paperbark (*Melaleuca nervosa*).

Shorebirds inhabit both aggregations, including:

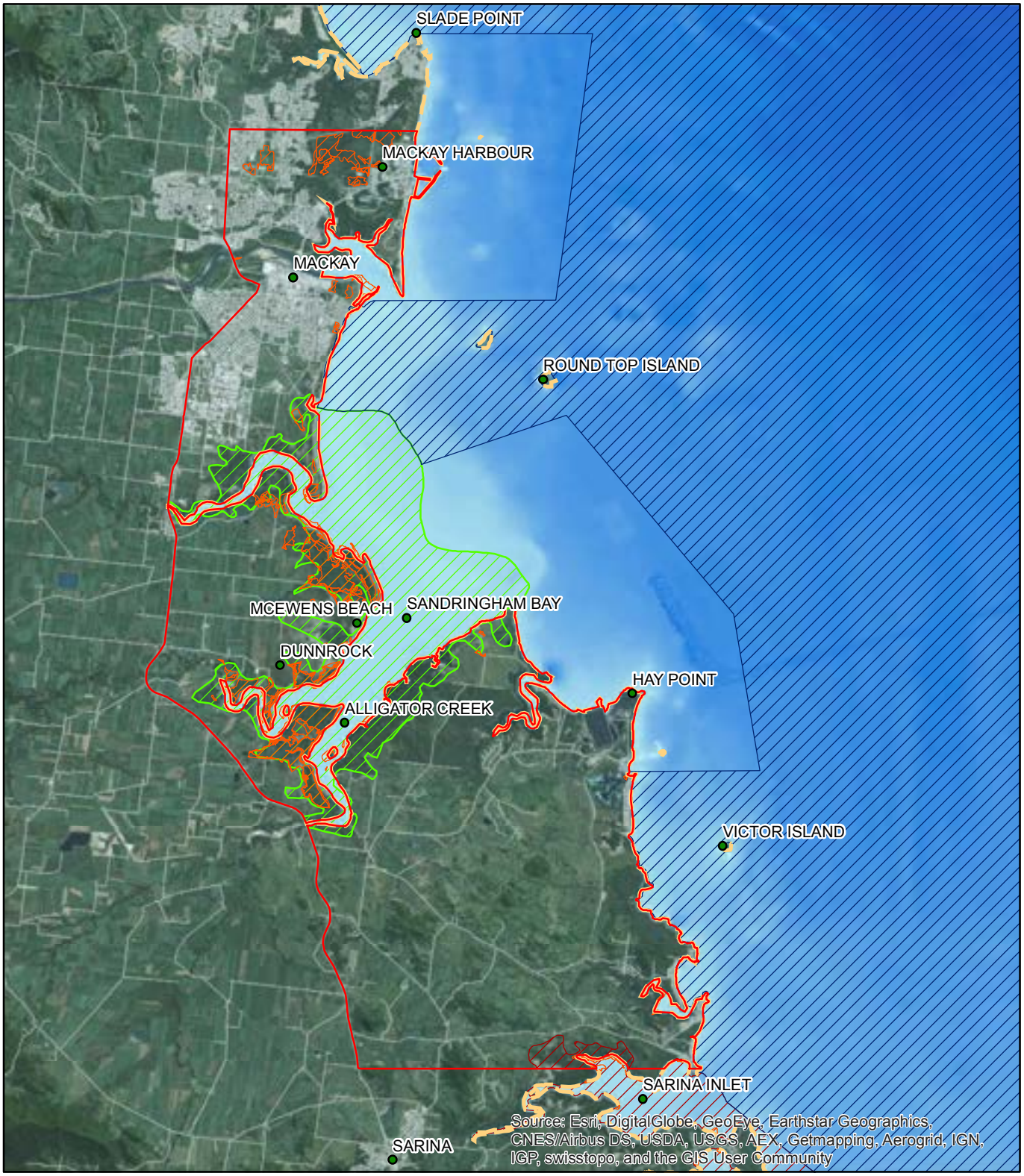
- The critically endangered eastern curlew
- The internationally significant migratory shorebirds the lesser sand plover and great knot
- The nationally important migratory shorebirds the Terek sandpiper, bar-tailed godwit and ruddy turnstone
- The grey plover (*Pluvialis squatarola*, Pacific golden plover (*Pluvialis fulva*), greater sand plover, whimbrel, grey-tailed tattler, greenshank, marsh sandpiper (*Tringa stagnatilis*), black-tailed godwit (*Limosa limosa*), bar-tailed godwit, sharp-tailed sandpiper (*Calidris acuminate*), and red-necked stint (*Calidris ruficollis*)

The Sandringham Bay – Bakers Creek Aggregation also supports:

- The critically endangered curlew sandpiper
- The vulnerable beach stone-curlew
- Other migratory shorebirds recorded including the double-banded plover (*Charadrius bicinctus*), oriental plover (*Charadrius veredus*), little curlew (*Numenius minutus*), red knot (*Calidris canutus*).

Sandfly Creek Environmental Reserve, a locally significant wetland, contains a number of endangered and of-concern REs and supports a diverse assemblage of fauna, notably birds. It is an important fish nursery habitat and a nesting area for estuarine crocodiles. A number of internationally and nationally significant migratory shorebird populations occur in the wetland area, including the eastern curlew and beach stone-curlew. The wetland provides excellent opportunities for science education at all levels, particularly in relation to coastal processes, estuarine biodiversity, and ecosystem services. The reserve is also a popular recreational area.

Figure 3-10 MSES and nationally important wetlands



LEGEND

- Landmass Project Extent
- Ocean Project Extent
- Matters of State Environmental Significance Wetlands

Directory of Important Wetlands

- Great Barrier Reef Marine Park
- Sandringham Bay - Bakers Creek Aggregation
- Sarina Inlet - Ince Bay Aggregation

[Geographical Coordinate System: GDA 94]

A4 1:200,000

N

0 5 10

Kilometers

JACOBS

Town Beach and Far Beach, locally significant wetlands, contain multiple shorebird roost sites, primarily around the Pioneer River mouth banks, northern Town Beach, and Shellgrit Creek. Pioneer River mouth banks and Shellgrit Creek, which are considered significant for the region. The area also contains about 4 km of potential turtle nesting habitat, with low-density nesting of turtles recorded in the area. It is also potential habitat for the water mouse, coastal sheathtail bat and the northern quoll.

Keeleys Road Wetlands, a locally significant wetland, contains a range of endangered and of-concern REs and has a high floral diversity. It is a refuge for the Pacific golden plover and broad-billed sandpiper (*Limicola falcinellus*).

Lake Barfield, a locally significant wetland, supports a range of freshwater fauna, including a range of significant bird species including migratory shorebirds, which have been recorded from the wet margins and low branches of dead vegetation surrounding the lake. Migratory shorebirds known to occur in the wetland area include the eastern curlew, beach stone-curlew, grey plover, common greenshank and great knot. The woodland and open forest adjacent to Lake Barfield is also an important refuge and movement corridor for bushland birds.

Description of places

The Sandringham Bay – Bakers Creek Aggregation has about 26 lacustrine/palustrine wetlands. Most of the aggregation is below 5 m above sea level (ASL). It includes low coastal plains adjacent to marine waters, and also small areas of saline clay pans.

The Sarina Inlet – Ince Bay Aggregation extends from Sarina Inlet, approximately 12 km south of the Port of Hay Point to Ince Bay, which is located outside of the study area. The aggregation covers 279 km^2 and contains about 38 lacustrine/palustrine wetlands. It also includes low coastal plains with adjacent small islets, inshore coral reef, extensive shallow water, subtidal and intertidal mudflats and associated marine waters.

Sandfly Creek Environmental Reserve extends from the south bank of the Pioneer River, near the river mouth. It contains a diverse community of mangroves, saltmarsh and marine couch in the estuarine area, as well as beach dune vegetation. Town Beach and Far Beach are on a stretch of tidal beach east of Mackay. Keeleys Road Wetlands is located behind Mackay Harbour and provides drainage for Andergrove and Mackay Harbour.

Condition and variability

There has been extensive clearing in much of the adjacent upland areas, and to the edge of mangrove communities in parts of the Sandringham Bay – Bakers Creek Aggregation. A large proportion of the terrestrial land immediately surrounding the coastal wetland has been cultivated. The aggregation does however, include portions of the Bakers Creek Nature Refuge, Bakers Creek Conservation Park and the Sandringham Bay Conservation Park, which are generally in good condition and protected under conservation tenure. The extent of the Sarina Inlet – Ince Bay Aggregation has had limited clearing, with an estimated 99% of the pre-clearing extent remaining.

Hydrological changes as a result of urban and agricultural development, as well as waterway barriers, have changed the wetland conditions. Hydrological changes are recognised as a main pressure in the riverine and freshwater wetlands in the study area. Exotic pests and weeds are also present within the wetland areas, contributing to a decline in wetland condition and in some water quality.

Vulnerability

Both the Sandringham Bay – Bakers Creek and Sarina Inlet – Ince Bay aggregations are vulnerable to hydrological changes impacting on GDEs. Land outside the conservation areas of the Sandringham Bay – Bakers Creek Aggregation is held in leasehold and freehold title, with some unallocated State land. Continued clearing in these areas would reduce the overall area of mangroves, and clearing and adjacent cultivation has the potential to alter hydrology and water quality. The Sarina Inlet – Ince Bay Aggregation has had low-level impacts from fishing, recreation and grazing. There is also potential for freshwater wetlands to be invaded by pasture species from surrounding cultivation.

Sandfly Creek Environmental Reserve and Town and Far Beaches have had incidents of weeds, illegal waste dumping, and trampling and compaction of vegetation and soil by people and vehicles. Town and Far Beaches have also had shorebird roost site disturbance, as well as storm tide erosion and permanent inundation due to sea level rise, and increased storm frequency and intensity from climate change. Keeleys Road Wetlands has had incidents of weeds and feral animals.

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3.4.6 Mangroves

AREA PROFILE: MANGROVES

Mangroves are a dominant feature along the Mackay/Whitsunday coast, occupying 64,000 ha of tidal land in the region. Of the 37 species of mangrove in the GBRWHA, 21 occur in the Mackay region. The most common are the red, grey and yellow mangroves.

Environmental Values

Mangroves provide:

- Erosion protection for coastal land during extreme events
- Breeding habitat for economically important species
- Food, shelter and breeding resources for fauna, including threatened, marine and migratory species listed under the EPBC Act and NC Act
- Critical seasonal food resources for migratory fauna
- Maintenance of coastal water quality by retaining, removing and processing nutrients, sediments and other pollutants from terrestrial and marine sources
- High levels of carbon storage

Mangrove communities in the study area have high environmental value. The importance of mangroves as habitat and nursery sites for recreational and commercial fisheries is reflected in value of the Mackay region mud crab fishery of $1.35 million in 2000. Recreational fisheries are significant in the area, with fishers spending approximately $42 million annually, and recreational fisheries have high social value.

Their importance is also reflected in the fact that they provide habitat for threatened fauna such as the water mouse, green turtle, dugong, and beach stone-curlew. They also form part of internationally, nationally and locally important habitat for shorebirds.

Contribution to OUV

Mangroves in the GBRWHA are habitats for conservation of biodiversity. In particular, 21 of the 37 mangrove species in the GBRWHA occur in the region; mangrove diversity is explicit in the GBRWHA statement of OUV (see Table 3–1). These species are widespread in the GBRWHA, and some other areas within the GBRWHA have higher mangrove diversity than the study area; however, the regional significnace and extent of mangroves within the study area means that they are an important contributor to OUV at the property scale. Mangroves also contribute to OUV by providing critical habitat for many species of conservation significance and through their role in biological filtration.

Vulnerability

Major threats to mangrove systems include coastal development and associated clearing, dieback, aquaculture development, climatic change and increased disturbance events such as cyclones and storms. Changes in water quality and increases in pollution are also recognised as factors that place mangrove communities at risk.

Between 1953 and 1995, approximately 9% of the mangroves originally in the Mackay region were cleared. Widespread dieback of the grey mangrove in the region was first observed in the 1990s, and by 2002 had increased to more than 30 km^2.

Gaps

No notable gaps in the available information have been identified from the perspective of the EVA.

AREA PROFILE: MANGROVES

Summary of Importance

Important areas of mangroves include:

- Sand Bay, north of the terrestrial extent of the study area, listed as a wetland of national importance
- Slade Point and McCreadys Creek, which lie north of the Port of Mackay
- Basset Basin, which is an estuary of the Pioneer River and provides important nurseries. It is a declared Fish Habitat Area
- The Sandringham Bay – Bakers Creek Aggregation, listed as a wetland of national importance in part because of its mangrove diversity
- Mangroves at Hay Point Peninsula, which consist of 22 ha
- Sarina Inlet – Ince Bay Aggregation, south of the terrestrial extent of the study area, listed as a wetland of national importance

What does this mean?

There has been historical clearing and dieback of mangroves within the study area. Mangrove areas continue to be threatened by coastal development. Disturbance events, such as storms and cyclones, can also damage mangroves. Increased storm intensity and frequency also has the potential to alter mangrove ecosystems.

Further deterioration and/or clearing of these areas has the potential to impact the contribution that they make to OUV

Regional summary

Mangroves and estuarine wetlands are a dominant feature along the Mackay/Whitsunday coast, occupying 64,094 ha of tidal land in the region. There are 21 species of mangrove in the Mackay region. Mangrove structural formations in the region range from closed forest to low scrubland, with 2 m– 8 m high closed scrubs being most common. Most communities are monospecific stands of red mangrove (*Rhizophora stylosa*), grey mangrove (*Aviciennia marina*), or yellow mangrove (*Ceriops tagal*).

The Sand Bay wetlands are north of Shoal Point, outside the terrestrial extent of the study area but within the marine extent. These wetlands are in a declared Fish Habitat Area (FHA) assigned a management level of A – very strict management. Sand Bay has extensive mud flats with mangrove forests, which provide important fish and shorebird habitat.

The Pioneer River has a significant area of mangroves. The Sandringham Bay – Bakers Creek Aggregation has very extensive mangrove areas and is listed as a wetland of national importance in part because of the diversity of mangroves. The Sarina Inlet – Ince Bay Aggregation also has extensive mangrove stands. Most of the other creeks in the study area have smaller areas of mangroves, which also occur in patchy fringes along the open coast on both the mainland and islands.

Overview of values

Mangroves provide important habitat for many fish and crustacean species. Some of these depend on mangroves, seagrass beds and/or mudflats at different stages of their lifecycle, and mangroves provide an important link between these habitats. Maintaining this connectivity enhances biodiversity.

Mangroves play an important role in linking terrestrial and marine environments, with a number of species using them as habitat. For example, flying foxes use mangroves to roost during the day, and forage in surrounding terrestrial habitats at night. Some species, such as barramundi, striped mullet (*Mugil cephalus*) and mangrove jack live part of their life cycle in freshwater, moving into marine areas to spawn.

Commercially and recreationally important species including barramundi, grey mackerel (*Scomberomorus semifasciatus*), whiting (*Merlangius merlangus*), mud crabs (*Scylla serrata*), and tiger and banana prawns (*Penaeus monodon* and *Fenneropenaeus merguiensis*) use mangroves at some point in their life cycles. The importance of mangroves as habitat and nursery sites for recreational and commercial fishery is reflected in the estimated value of these sectors. The economic value of the mud crab fishery in 2000 in the Mackay region was $1.35 million. Recreational fisheries are significant in the area, with fishers spending approximately $42 million annually, and many species targeted by recreational fishers depend on mangroves. However, the economic value of mangroves is much higher than these combined because of their importance as nursery habitat for many species which are harvested in other habitats.

Mangroves are also habitat for a number of vulnerable species. The Mackay region is an important area for the water mouse, which inhabits mangrove communities dominated by the yellow and orange mangroves (*Ceriops tagal* and *Bruguiera* spp.), which make up 25% of the mangrove area in the study area. Green turtles sometimes forage in mangrove areas for fallen fruits, and dugongs sometimes shelter in mangrove channels. The beach stone curlew uses mangrove areas for foraging and shelter.

Mangroves are also important for coastal protection, reducing the effects of storm surges and cyclones. Their extensive root systems stabilise the shoreline, reducing erosion, and mangroves are an effective wind break between sea and land. Mangroves also act as a water filter and are an important buffer between land and reef systems. Land runoff flows through mangrove systems, which trap, process and store sediment, organic matter and nutrients, as well as pollutants such as metals and pesticides.

Mangroves are important sinks for suspended solids in coastal GBR waters. As the tidal cycle pumps water in and out of mangrove systems, sediments suspended in coastal water are deposited in the mangroves, improving coastal water quality.

Sandringham Bay is nationally important for shorebirds. Sandy, Alligator and Bakers Creeks flow into Sandringham Bay and support a large area of mangrove forests. The ecosystem services mangrove communities provide in the creeks are valuable for the ongoing health of Sandringham Bay.

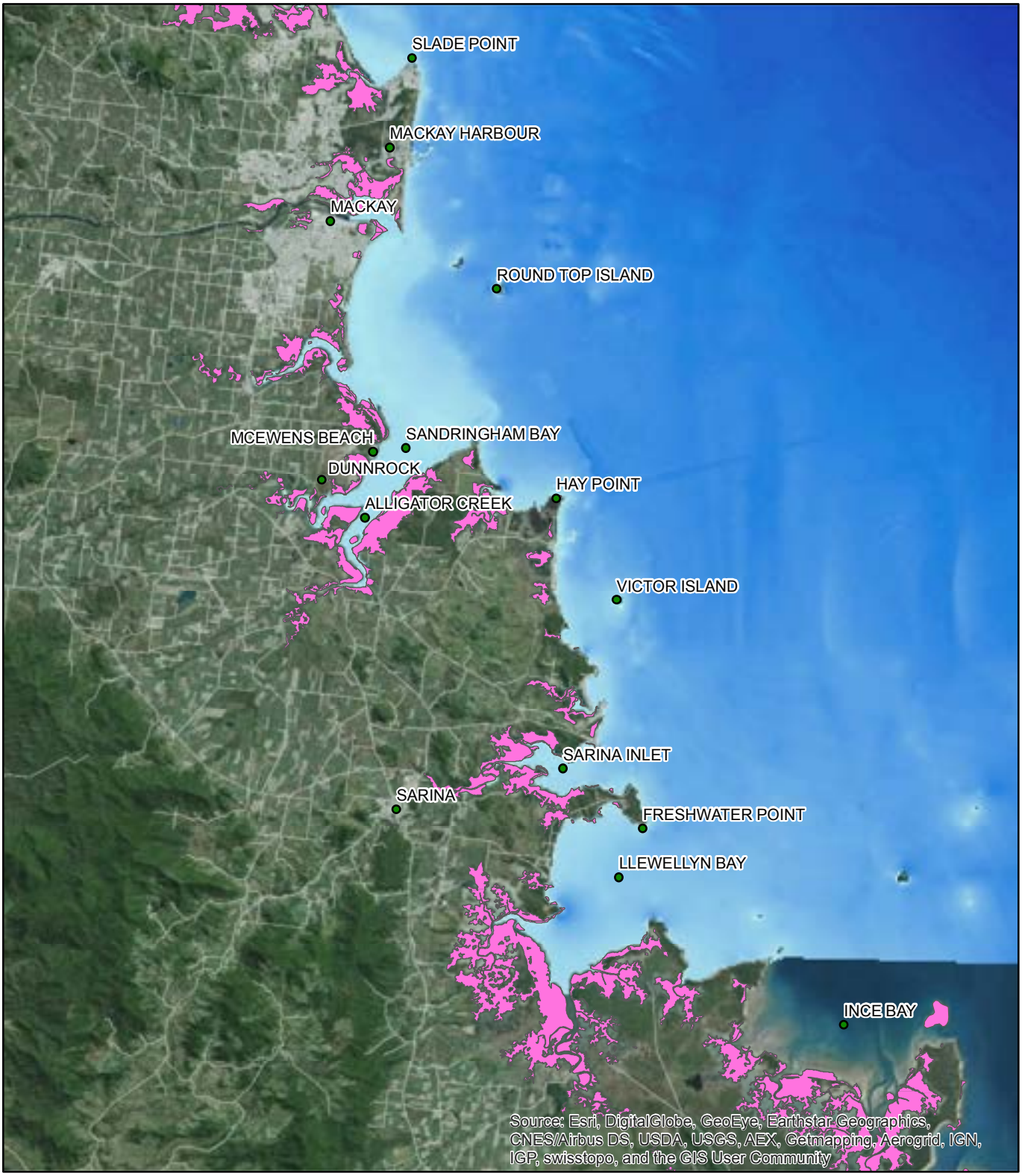
Recent studies have shown mangroves in the tropics are among the most carbon rich ecosystems in the world, with the capacity to store large amounts of carbon in very deep soils, and at a high rate due to their high primary productivity. Both of these functions are valuable in climate change mitigation. On the other hand, the destruction and modification of mangrove areas has the potential to release stored carbon.

Mangroves are important cultural training grounds for teaching children about traditional fishing methods and traditional ways to use resources. Mangroves themselves are also an important food source, providing medicines and materials for tool making.

Description of places

Mangroves in the Mackay Region are concentrated around the Pioneer River, Bakers Creek/Sandringham Bay and McCreadys Creek/Slade Point areas, as well as in Sand Bay (Figure 3–11). The Pioneer River, which runs through the city of Mackay, and Bassett Basin lie south of the Port of Mackay. Basset Basin is an estuary of the Pioneer River and provides important nurseries. It was declared an FHA in 1993 and is assigned management category B (i.e., where existing or planned use requires a more flexible management approach). Prior to this it was a wetland reserve and managed to enhance existing and future fishing activities. Mangroves and related tree communities make up 4.2 km^2 of the 6.6 km^2 FHA. Declared fisheries values of Basset Basin include barramundi, blue threadfin (or blue salmon, *Eleutheronema tetradactylum*), bream (*Acanthopagrus* spp.), estuary cod (*Epinephelus* spp.), flathead (*Platycephalus* spp.), grunter (various species, mangrove jack, queenfish (*Scomberoides* spp.), whiting (*Sillago* spp.), mud crabs, tiger prawns, and grey mackerel.

Figure 3-11 Mangrove communities in the study area



LEGEND

Mangroves and related tree communities

[Geographical Coordinate System: GDA 94]

A4 1:300,000

N

0 5 10

Kilometers

JACOBS

The Sandringham Bay – Bakers Creek Aggregation supports the largest area of mangroves in the study area. Mangroves and related tree communities comprise 19.3 km^2, or 79.6%, of the 24.3 km^2 of vegetation in the listed wetland. Sandy and Alligator creeks, which flow into Sandringham Bay, are included in the Aggregation and have extensive mangrove communities. About 55% of the wetland area of Alligator Creek consists of mangroves, for example.

The Sarina Inlet – Ince Bay Aggregation, though mostly outside the study area, has an even larger area of mangroves, some 66.0 km^2 – 57.9% of the vegetation in the listed wetland.

The Hay Point Peninsula has 22 ha of mangroves in enclosed wetland area on the southeast side of the peninsula. Minor stands have colonised rocky shorelines on both the northwestern and southeastern shores. There are minor stands (mostly *Avicennia*) on the eastern and southern sides of Hay Point. Louisa Creek has an extensive mangrove community.

Slade Point and McCreadys Creek lie north of the Port of Mackay. There is a stand of mangroves approximately half-way along the western shoreline of Slade Point. This section is relatively sheltered from wave energy and the tidal flows from McCreadys Creek, which makes it an ideal area for mangrove growth. Occasionally the mangroves in this area are smothered by the passage of a sand shoal, causing short-term dieback.

Condition and variability

Mangrove areas naturally change over time. Prolonged drought and increased soil salinity may cause dieback of some species, which are then often replaced by more salt-tolerant species. Variability can also be caused by large storm events or cyclones, generating large amounts of sediment in floodwater, bringing potential pest outbreaks, and causing death, dieback or impaired growth.

Between 1953 and 1995, approximately 9% of the mangroves originally in the Mackay region were cleared. Widespread dieback of the grey mangrove in the region was first observed in the 1990s, and by 2002 had increased to more than 30 km^2. This dieback was correlated with herbicides, particularly diuron, which was used to control weeds in agricultural crops such as sugarcane and bananas. The use of diuron in Australia has been reviewed, restrictions on application rates for sugarcane and bananas, and no-spray windows for sugarcane, have been imposed.

Mangroves in the Sandringham Bay – Bakers Creek and Sarina Inlet – Ince Bay Aggregations remain largely intact. In 2013 the overall estuarine wetland area in the Sandringham Bay – Bakers Creek Aggregation retained 98.8 % of the pre-clearance area, and the area of mangroves specifically was the same as in 2001. Similarly, in the Sarina Inlet – Ince Bay Aggregation the 2013 extent of estuarine wetland was 97.3% of the pre-clearance extent and again the mangrove extent was unchanged since 2001. Designation of these aggregations as nationally important wetlands affords them considerable protection.

Vulnerability

Major threats to mangrove systems include coastal development and associated clearing, dieback, aquaculture development, climatic change and increased disturbance events such as cyclones and storms. Changes in water quality and increases in pollution are also recognised as factors that place mangrove communities at risk. Specifically, mangrove dieback has been a significant threat to mangrove communities within the study area. Although the main mangrove specices affected by dieback has been the grey mangrove, with other species appearing virtually unaffected.

Coastal development, including urban, tourism and infrastructure, results in the physical removal of mangroves, hydrological changes and potential loss of connectivity. The Sandringham Bay – Bakers Creek and Sarina Inlet – Ince Bay Aggregations and most other mangroves in the study area are largely protected from such direct impacts.

Coastal development can also result in pollution and decreased water quality. Increased levels of nutrients, pesticides and sediments from urban and agricultural development in upper catchments can impact mangrove ecosystems in the lower catchments.

Increased development also often results in stormwater discharges at point locations. Grapsid crabs (family Grapsidae) are important 'ecosystem engineers' as they help process leaf litter and aerate soils; however, there are now significantly fewer or no grapsid crabs in some mangrove areas. Stormwater discharge has been identified as the most likely cause of these declines.

Aquaculture can also increase siltation, erosion and nutrients in mangrove areas. Built coastal protection infrastructure, such as break walls and bund walls, can change tidal flows and may also affect erosion patterns, increasing the vulnerability of mangroves.

Disturbance events, such as storms and cyclones damaging mangroves and potentially introducing pests, can also increase the mangrove vulnerability. While recent studies have shown that mangroves may mitigate the effects of climate change, sea level rise and increased storm intensity and frequency also have the potential to alter mangrove ecosystems.

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3.4.7 Freshwater fish

AREA PROFILE: FRESHWATER FISH

There are 300 species of freshwater fish in Australia, of which 45 are found in the Mackay-Whitsunday Region. Of these, 22 require free access to estuarine and marine waters to complete their lifecycle.

Environmental Values

Freshwater fish support:

- Commercial and recreational fisheries
- National identity and cultural significance
- Ecosystem health

Contribution to OUV

On the mainland, freshwater fauna values within the study area do not directly contribute to OUV, however some species move between freshwater systems and the GBRWHA and therefore contribute to biodiversity conservation. Threatened species that inhabit coastal islands in the study area directly relate to OUV criteria in that they form part of ecosystems that have evolved over millennia and are important for biodiversity conservation.

Vulnerability

The major activities affecting the vulnerability of freshwater fish relate to the modification of natural waterways (e.g. barriers to fish movement, habitat degradation) and changes in water quality.

Water quality degradation from erosion, sedimentation, increased nutrients and pesticides from urban and agricultural sources can also affect the vulnerability of freshwater fish.

Gaps

No notable gaps in the available information have been identified from the perspective of the EVA.

Summary of Importance

Recreational fishers take a number of species in the waterways, including jungle perch, barramundi, mangrove jack, sleepy cod, sooty grunter and eel-tailed catfish – all of which use freshwater systems at some stage of their lifecycle.

Important habitat areas include:

- The Pioneer River, which runs through Mackay and is an important system for freshwater fauna
- Sandy, Alligator and Bakers creeks, which are other important freshwater systems in the vicinity of the Port of Hay Point
- Goosepond Creek, which is a significant freshwater nursery habitat

What does this mean?

The major activities affecting the vulnerability of freshwater fish relate to the modification of natural waterways and changes in water quality. Modification of waterway flow and blocking of fish passages affects the movement of fish within the system. These factors can directly affect the ability for freshwater fish to breed,

AREA PROFILE: FRESHWATER FISH

feed and disperse throughout the freshwater system and can result in reduced species abundance and diversity.

Regional summary

There are 300 species of freshwater fish in Australia, of which 45 are found in the Mackay-Whitsunday Region. Of these 45 species, 22 require free access to estuarine and marine waters to complete their lifecycle. Many of these species support commercial and recreational fisheries.

Overview of values

Freshwater habitats are valuable for both commercial and recreational fishers. Commercial fishing only occurs in the estuarine and marine waters of Queensland; however, many of the commercially harvested species, such as barramundi, mangrove jack and striped mullet, require access to freshwater habitats at some stage of their life cycle. Recreational fishers take a number of species in the waterways, including jungle perch (*Kuhlia rupestris*), barramundi (*Lates calcarifer*), mangrove jack (*Lutjanus argentimaculatus*), sleepy cod (*Oxyeleotris lineolatus)*, sooty grunter (*Hephaestus fuliginosus*) and eel-tailed catfish (*Tandanus tandanus*) – all of which use freshwater systems at some stage of their lifecycle. Freshwater tributaries of the Pioneer River provide excellent riverine fishing.

Freshwater habitats are also valuable for recreational and agricultural use. Fresh water is taken for both stock and domestic supplies, and in certain circumstances for irrigation. The systems are also used by residents and tourists for swimming and water sports.

Many riverine and wetland areas have profound cultural value. The animals and plants found in these areas often have traditional cultural significance. They are valued for food, medicines, tools and fibre, as well as activities such as story places and seasonal indicators.

Description of places

The Pioneer River runs through Mackay and is an important system for water supply and ecosystem services and is recognised as a significant riverine fisheries area. The river discharges south of the Port of Mackay. Sandy, Alligator and Bakers Creeks are other important freshwater systems in the vicinity of the Port of Hay Point.

Goosepond Creek flows through North Mackay and discharges to the lower reaches of the Pioneer River. Goosepond Creek is a focus of the Mackay Whitsunday Natural Resource Management Group (MWNRMG) healthy waterways program with a long-term objective to improve or increase the amount of fish habitat and therefore, overall fish numbers.

Species such as barramundi, mangrove jack and striped mullet all live in freshwater or upper estuaries within the study area for portions of their lives. These species generally enter the freshwater systems as juveniles and leave as adults to spawn at sea. Other freshwater fish species known to occur within the freshwater systems in the study area include sleepy cod, sooty grunter and eeltail catfish.

Condition and variability

Fish habitat condition in the Pioneer River catchment is moderate in forested upper areas that have well-protected or undisturbed terrestrial areas, while small streams in agricultural areas, such as cane farms, are very poor. Large stream sections in the lower catchment have some good habitat, with the Pioneer River having a moderately healthy fish community even though the area has been highly modified by water infrastructure and development, which has fragmented fish communities and limited movement of migratory species.

The stream condition in the catchment for Sandy, Alligator and Bakers Creeks is highly disturbed, with poor fish habitat condition. Some areas where there is extensive farming are degraded, in some cases losing all fish habitat. Cane farming and low stream relief have led to extremely reduced fish communities. Where there are permanent water holes and good riparian vegetation, fish communities are healthier.

Goosepond Creek is a significant freshwater nursery habitat, but like many watercourses in the Mackay-Whitsunday Region contains numerous barriers to fish movement. These barriers are built for a variety of purposes, such as irrigation, flow management, flood control, road crossings for urban beatification, and recreation. However, they can affect the passage of juvenile fish that have spawned in the lower areas of the catchment and are attempting to migrate upstream or restrict the fish movement during the dry season. Goosepond Creek forms part of the MWNRMG and Queensland Fisheries Service fishway project. This project rehabilitated fish passages at seven barriers along Goosepond Creek. Data to date shows that the fishways has facilitated the movement of significant numbers of fish, with successful passage of fish as small as 15 mm.

Vulnerability

The major activities affecting the vulnerability of freshwater fish relate to the modification of natural waterways and changes in water quality. Modification of waterway flow and blocking of fish passages affects the movement of fish within the system. Many species move upstream either as juveniles or after being spawned in the lower reaches, or as required for survival in the dry season. Freshwater fish are particularly vulnerable to mortality through predation and disease and are not resilient in prolonged dry seasons. An entire year of recruitment can be lost in a short period if migration is delayed.

Goosepond Creek was recognised as having numerous barriers to fish movement and in 2003, a project was carried out to rehabilitate fish passage barriers to improve the ability for fish to move within the watercourse. Freshwater fish communities within the study area are also protected by State legislation that limit the size and take (bag limits), as well as seasonal closures for some species during their breeding seasons.

Water quality degradation from erosion, sedimentation, increased nutrients and pesticides from urban and agricultural sources can also affect the vulnerability of freshwater fish. Removal of riparian vegetation reduces habitat areas within the streams, as well as increasing erosion. This also removes a natural filtration system which helps to prevent excess nutrients from moving down the waterway and into marine areas.

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3.5 Aquatic ecosystems – marine

3.5.1 Oceanographic processes

AREA PROFILE: OCEANOGRAPHIC PROCESSES

Circulation on the GBR lagoon is driven by tides, wind-driven currents and regional oceanic circulation. Local currents in the study area are primarily driven by the tides but, especially on the mid- and outer shelf, are influenced by the predominantly southeast winds and large-scale oceanic currents and inflows from the Coral Sea. When the waves strike the coast they generate northward-flowing longshore currents in and up to tens of metres offshore of the surf zone. These longshore currents transport large amounts of sediment to the north, and generate the northward-facing points, spits, sand islands, and bays and estuaries seen all along the Queensland coast.

Environmental Values

Oceanographic processes fundamentally drive the GBR ecosystem at scales from individual beaches, bays and reefs to the GBR ecosystem as a whole. Currents and wave energy also largely determine the nature of sediments in the GBR lagoon. Water currents can transport the larval stages of marine organisms across large geographic scales (hundreds of kilometres), contributing to diversity in some locations. The study area has a large tidal range of up to 7 m.

Contribution to OUV

Oceanography contributes to some aspects of OUV, including ecological and biological processes and processes of geological and geomorphic evolution, linking continental islands, coral cays and reefs. Examples include water currents and tides which form the foundation of ecological processes, and the distribution of larvae.

Vulnerability

Climate change is the primary threat to oceanographic processes of the GBR, raising sea levels and causing more frequent and more extreme weather. At a local scale, coastal development such as reclamation may cause some minor changes in oceanographic processes near the shore.

Gaps

There is no information regarding how human activities might have altered the study area's oceanographic processes. Gaps in information include the local alterations to coastal processes after development and the local vulnerability to these alterations.

Summary of Importance

Oceanographic processes are a major contributing factor to the distribution of sediments and formation of geological features of the GBR. They are important for dispersing larval forms of marine organisms and thereby increasing diversity at a local and regional scale.

What does this mean?

Changes in oceanography can change the distribution of sediments and larval forms of marine organisms

Regional summary

Circulation on the GBR lagoon is driven by tides, wind-driven currents and regional oceanic circulation. Local currents are primarily driven by the tides but, especially on the mid- and outer shelf, are influenced by the predominantly southeast winds and large-scale oceanic currents and inflows from the Coral Sea. Geomorphology, for example water depth, passes between reefs and islands, and estuaries and bays also shape circulation on the GBR.

The southeast winds are generally strongest between May and October and drive a general northward flow of lagoonal waters. The southeasterlies weaken from November to April, and the predominantly northward lagoonal flow sometimes reverses. The study area is protected to some degree from wave energy by the GBR, but the distance of the outer reefs, some 100 km east, provides a southeasterly fetch of about 500 km, allowing the development of significant localised wave energy. When the waves strike the coast they generate northward-flowing longshore currents in and up to tens of metres offshore of the surf zone. These longshore currents transport large amounts of sediment to the north, and generate the northward-facing points, spits, sand islands, and bays and estuaries seen all along the Queensland coast.

Tides in the study area are semi-diurnal (high tide occurs twice daily), with a considerable difference in the height of successive tides. Tidal current dominate in inshore areas beyond the wave-driven longshore current.

The dominant oceanic current is the East Australian Current (EAC), which is part of the general South Pacific circulation and flows southward along the outer edge of the GBR and then along the coast to southern New South Wales. Because the EAC flows beyond the outer edge of the GBR it does not directly drive currents on the reef. However, the EAC impinges on the reef, forcing large amounts of water into the GBR lagoon. This water must eventually exit the lagoon, and it does so by reinforcing the wind-driven northward flow so that there is a net movement of water from the lagoon into the Gulf of Papua.

Overview of values

Oceanographic processes fundamentally drive the GBR ecosystem at scales from individual beaches, bays and reefs to the GBR ecosystem as a whole. As noted above, wave-driven longshore currents shape the geomorphology of the coast. Waves and currents also influence habitats further offshore. For example, coral and other communities on the southern sides of islands, exposed to waves driven by the southeasterlies and the northward-flowing current, are markedly different from communities on the lee side. Tide, wind, and wave energy drive strong mixing, distributing oxygen and nutrients through the water column. An important exception occurs during major floods, when a lens of fresh water from river discharges forms at the surface. These river plumes can move tens or hundreds of kilometres, carrying nutrients, sediments, pesticides and other pollutants northward and out across the shelf. The nutrient inputs are thought to trigger outbreaks of the crown-of-thorns seastar (COTS, *Acanthaster planci*) on outer reefs in the central GBR; such outbreaks are a major cause of declines in coral abundance that have occurred in recent decades.

Currents and wave energy also largely determine the nature of sediments in the GBR lagoon, though the balance of sediment sources such as river inputs and biological production of calcium carbonate (limestone) by corals, calcareous macroalgae, molluscs and other organisms with calcium carbonate skeletons or shells also have a strong influence. Sediments are coarser in high-energy habitats, and areas further offshore (away from river inputs of land-derived sediment) generally have higher levels of calcium carbonate. Sediment characteristics largely determine the nature of biological communities living on the bottom and in the sediment.

Description of places

The study area is in a peak tidal region of Queensland and experiences some of the largest tidal ranges in Australia. Spring tide ranges of about 6 m, and up to over 7 m, drive currents that can be more than 0.5 m/s (2 knots). Tidal currents generally flood towards the south-southeast and ebb towards the north-northeast. The ebb currents are slightly stronger than the flood currents.

The study area is protected from oceanic waves by the GBR and its islands. The wave climate is also influenced by shoals to the southeast. The Port of Mackay outside the breakwater and the nearby spoil ground experience

significant wave heights to about 2.5 m, and greater than 0.5 m about 55% of the time. Significant wave heights at Hay Point port waters generally do not exceed 2.5 m, but can reach 4.5 m to 5 m. Most of the study area has little protection from wind and frequently experiences rough seas.

Condition and variability

Currents and other wind-driven oceanographic processes are naturally variable on time scales from hours to millennia. The concept of "condition" has little relevance in the sense that such processes can be healthy or degraded. Human activities have however, produced localised changes in oceanography. For example, breakwaters and seawalls affect the wave climate and sediment transport processes and dredged channels intercept the natural longshore movement of sediment (creating the need for maintenance dredging).

Construction of Mackay Harbour interrupted the natural south-to-north movement of sediment along Harbour Beach, and sand accretion now occurs south of the harbour, with erosion to the north. Prevailing coastal processes result in the continued accumulation of fine sediments in the Port of Mackay channel, wing basin and berth pockets (estimated 40,000-50,000 m^3/y). Maintenance dredging has been completed at the Port of Mackay since the 1960s, with dredged material going to the existing placement area, approximately 3 km northeast of the port entrance, for at least 30 years.

Littoral transport near Hay Point typically occurs from south to north, however, there are noticeable variations in the vicinity of Dudgeon Point, where fine sediments are easily transported by tides and flood currents in Sandringham Bay. Sediments further offshore become finer as water depth increases, where sediment transport is also reduced. Bathymetric and hydrodynamic modelling studies have shown that the bulk of sediments deposited at the Hay Point dredged material disposal site are stable and remain where they were placed, with some of the fine material gradually dispersing from the site.

There is no information available regarding how human activities might have altered the study area's oceanography. Except for greatly increased river inputs due to changes in land use it is unlikely that there have been substantial changes at more than very local scales given the level of development. Oceanographic variability is driven by global and regional processes, and is predicted to change markedly as a result of climate change.

Vulnerability

The primary vulnerability of oceanographic processes in the study area is to climate change. Climate change is expected to raise sea level and cause more frequent and more extreme weather, including flooding rains, storms and cyclones. Oceanic currents and the general atmospheric circulation as also expected to be affected. Vulnerability at the scale of the study area has not been assessed.

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3.5.2 Marine water quality

AREA PROFILE: MARINE WATER QUALITY AND SEDIMENT

Poor marine water quality caused by agricultural run-off is a key risk to the values of the GBR. The Queensland and Australian Governments have invested in regional and whole-of-GBR management initiatives to protect and improve GBR water quality, through improved agricultural practices and other instruments. A Water Science Taskforce reviewed progress in water quality improvements in 2015 and concluded that only transformational changes - well beyond current management arrangements - are needed to achieve water quality targets.

In the Mackay-Whitsunday region the primary agricultural land use is cane farming. Fertilisers and pesticides used in cane farming increase nutrient and pesticide loads to the GBR. Most runoff in the Mackay-Whitsunday Region occurs in the wet season (December to March).

In 2014 NQBP established an ambient water quality monitoring program in the coastal zone around the Ports of Hay Point and Mackay. The program commenced with 12 monitoring sites covering a 60 km stretch of the coast from Slade Point to Freshwater Point and offshore to Keswick Island. The first year of monitoring showed the water column to be well mixed, with the exception of a turbid bottom layer caused by sediment resuspension, with water turbidity and suspended solids driven predominately by wave energy. Monitoring also showed elevated nutrient concentrations.

Environmental Values

Water quality, in particular suspended sediment and nutrient concentrations commensurate with pre-development natural conditions, as well as pesticide concentrations below levels of effect, underpin most if not all of the environmental values of the study area and broader GBR. Water Quality Guidelines for the GBRMP define trigger values for sediment, nutrients and pesticide concentrations to maintain GBR ecosystem health.

AREA PROFILE: MARINE WATER QUALITY AND SEDIMENT

Contribution to OUV
Water quality directly contributes to OUV by maintaining ecological and biological processes, biodiversity, and natural beauty and natural phenomena. Maintenance of water quality in the study area contributes incrementally to OUV but not at the scale of the World Heritage property.
Vulnerability
Land-based agricultural, urban and industrial sources are the most important contributor to the decline in water quality on the GBR, along with cyclones, COTS, and coral bleaching. The Mackay-Whitsunday catchments have the highest risk rating of GBR catchments (see Section 3.4.1), largely due to nutrient and pesticide runoff from extensive cane farming.
Gaps
Water quality in the study area is well documented. There are no major gaps identified, with ongoing ambient monitoring programs in place.
Summary of Importance
Marine water quality is integral to the health and resilience of the world's largest coral reef ecosystem (GBR), including examples of all stages of reef development. It also helps to support a mature ecosystem that has evolved with high biodiversity, including over 4,000 species of molluscs and over 1,500 species of fish, plus a great diversity of sponges, anemones, marine worms, crustaceans and many others.
What does this mean?
As discussed above, land-based activities are the most important contributor to the decline in water quality on the GBR, with the Mackay-Whitsunday catchments having the highest risk rating of GBR catchments. State and Commonwealth governments have invested in numerous regional and whole-of-GBR management initiatives to protect and improve the condition of the GBR, mainly through improved agricultural practices. Water Quality Guidelines for the GBRMP define trigger values for sediment, nutrients and pesticide concentrations to maintain GBR ecosystem health. However, a 2015 review of the progress in water quality improvements concluded that only transformational changes (well beyond current management arrangements) will be necessary to achieve water quality targets.

Regional summary

The GBR extends over 2,000 km along the coast of Queensland. The GBR catchment consists of 35 main river catchments that discharge into the GBR. The Mackay-Whitsunday Region has high levels of rainfall in summer (December to March), which is when most water discharge into the marine environment occurs.

Land uses along the coast range from mining, urban development, grazing and agriculture, including bananas grains and sugarcane. Sugarcane is the dominate land use in the study area catchments. Land use in the catchments plays a significant role in the area's water quality. The fertilisers and pesticides used in cane farming contribute substantially to nutrient and pesticide loads to the GBR.

The Mackay Whitsunday Water Quality Improvement Plan 2014-2021 identifies that key water quality pollutants of concern in the region are dissolved and particulate forms of nitrogen and phosphorus, suspended sediment, and the residual herbicides ametryn, atrazine, diuron, hexazinone, and tebuthiuron. Agricultural, sugarcane farming and grazing are recognised as diffuse sources of these nutrient and herbicide pollutants.

Overview of values

The GBR is both a World Heritage Area and a multiple use Marine Park. The values of the GBR include aquatic ecosystems, primary industries, recreation, aesthetics, and cultural and spiritual values. The management intent for waters with aquatic ecosystem values depends on their ecosystem condition and community needs and aspirations.

Ecosystem values of high quality marine water quality also include low nutrient waters that facilitate coral growth and other healthy marine ecosystems. The resilience of the system to short-term pulses of poor water quality (e.g., affects of floods) is also an important value.

Water Quality Guidelines for the GBRMP describe the concentrations and trigger values for sediment, nutrients and pesticides that have been established for the maintenance of marine species and ecosystem health of the GBR. The guidelines are applied to the management of activities that may influence water quality, as part of the Australian National Water Quality Management Strategy.

Description of places

Inshore and offshore marine water quality is influenced by the water quality of the contributing catchments (refer Section 3.4.1). Significant places vulnerable to reduced water quality in the marine study area include Sandringham Bay, Sarina Inlet, Ince Bay and the Seaforth Coast. Sandringham Bay receiving waters stretch from just north of Hay Point up to Shoal Point north of Mackay. Sarina Inlet receiving waters stretch from Freshwater Point north to Hay Point. The receiving waters of Ince Bay are located between Notch Point in the south and Freshwater Point in the north. Seaforth Coast receiving waters stretch from Shoal Point north to Midge Point.

The Sandringham Bay receiving waters have been given an overall condition score of very poor. The receiving waters include Mackay City, Pioneer River Main Channel, Upper Cattle Creek, Blacks Creek, Bakers Creek, Sandy Creek, Alligator Creek. The majority of the receiving waters are mapped as very high risk by the Marine Risk Index.[1] While Sandringham Bay has only small amounts of the region's coral and seagrass, 37% of coral and 80% of seagrass are in a high to very high risk range, mostly due to poor water quality entering the Bay from the highly impacted land in the feeder sub-catchments (see Section 3.4.1).

Sarina Inlet water quality has an overall condition score of poor. Poor event water quality has resulted in much of Sarina Inlet being mapped as high risk by the Marine Risk Index. Sarina Inlet has little coral; however, of the coral that does exist 14% is at high risk. In contrast, 20% of the region's seagrass grows in the Sarina Inlet, and all of it is located in areas that have a high to very high risk from water quality.

Water quality in Ince Bay has been rated as poor. Most of the bay is mapped as high to very high risk by the Marine Risk Index. Of the coral present in Ince Bay, 7% is at high risk. The majority (69%) of seagrass meadows are in the high to very high risk categories.

Seaforth Coast has received an overall condition score of very poor. As a result of the poor water quality entering the receiving waters, the Marine Risk Index identifies a high to very high risk for the area. Over 30% of all coral and 73% of all seagrass located within Seaforth Coast receiving waters are mapped as being at a high or very high risk from the impacts of water quality. Of these areas, 12% of coral and 9% of seagrass was classified as being at high risk from the impacts of water quality.

[1] The Marine Risk Index was used in the *2014 Water Quality Improvement* Plan for the Mackay, Whitsunday and Isaak Regions. The index uses pollutant loads and an estimated risk of degraded water quality to coral reefs and seagrass communities to provide a relative risk for the marine environment of the NRM regions of the GBR.

Condition and variability

In 2014 NQBP established an ambient water quality monitoring program in the coastal zone around the ports of Hay Point and Mackay. The program commenced with 12 monitoring sites covering a 60 km stretch of the coast from Slade Point to Freshwater Point and offshore to Keswick Island. The first year of monitoring showed the water column to be well mixed, with the exception of a turbid bottom layer caused by sediment resuspension, with water turbidity and suspended solids driven predominately by wave energy.

Monitoring also showed elevated nutrient concentrations. Total nitrogen and DIN were above water quality guidelines for the Mackay-Whitsunday Region, likely due to agricultural and urban inputs. The highest total nitrogen and DIN values occurred during August 2015, particularly at sites east of the cardinal marker near the Mackay sediment relocation areas, and at Victor Islet, Mackay Harbour and Keswick Island. Mackay Harbour had the highest nitrate concentrations, above the guideline. Ammonia concentrations, though having greater among-site variability, exceeded the guideline at all sites except Flat Top Island in all surveys except survey three. The highest values were again observed at Mackay Harbour, as well as at Slade Point. These exceedances reflect the trend of increasing nutrient levels shown in the Reef Plan report cards for the Mackay-Whitsunday Area (2009 to 2014), and probably reflect a broader catchment-scale water quality challenge for the region.

Heavy metals were generally not detectable in the monitoring. This may be due to the low rainfall over the monitoring period. The exception was Mackay marina, where copper and lead were detected, though these elevated levels seemed to be localised.

PS II herbicides (e.g. atrazine, diuron, simazine) were generally low to undetectable, although diuron was detected at most sites. The low concentrations were probably likely due to the low rainfall during the surveys. Another study in 2009 found the Mackay-Whitsunday Region to have among the highest diuron and atrazine concentrations in GBR waters, exceeding water quality guidelines. This reflects cane farming as the main land use in the region.

Elevated turbidity along the coastline was observed, with long peaks recorded for periods longer than a week. Data indicated sediment deposition was not high; the turbidity was likely from the sediment resuspension by wave and tide energy.

A biomarker for the potential presence of coal dust has been detected in high concentrations inshore, decreasing out to the shelf break, about 180 m offshore. Coal residues exceeding the guidelines were detected offshore of Hay Point in 2009 and 2010. The toxicity values approach those in the US Environmental Protection Agency (US EPA) guidelines.

Organic pollutants are cycled in the marine system through sediment resuspension, colonisation by marine algae and bacteria, packaging into zooplankton faecal pellets and resettlement to the sediments, where they undergo further modification. With each cycle they are moved further offshore, and with the strong ebb tide currents in the Mackay Whitsunday Region, the pollutants can become widespread.

Dredging can mobilise sediments into the water column, increasing turbidity and reducing light penetration, in turn affecting light-dependent organisms including corals and seagrass. Major capital dredging in 2006 at the Port of Hay Point generated widespread turbidity plumes, affecting some coral communities at least temporarily. Conversely, backhoe dredging in 2010 and 2011 generated very low turbidity well below levels of environmental concern. Satellite imagery and data from NQBP's marine monitoring program shows that strong winds, especially from the southeast, can generate very high natural turbidity throughout the study area, with turbidity at Hay Point exceeding the trigger level established for dredging even when dredging is not underway.

Vulnerability

Water quality in the study area is vulnerable to the same threats and pressures as the rest of the GBR. Land-based agricultural, urban and industrial sources are the most important contributor to the decline in water quality on the GBR, along with cyclones, COTS, and coral bleaching leading to declines in coral cover. The Mackay-

Whitsunday catchments have the highest risk rating of GBR catchments (see Section 3.4.1), due largely to cane farming, which generates large quantities of DIN and PS-II herbicides runoff per unit area.

Poor water quality caused by land based agricultural run-off is a key risk to the values of the GBR. The Queensland and Australian Governments have invested in numerous regional and whole-of-GBR management initiatives to protect and improve the condition of the GBR, through improved agricultural practices. A Water Science Taskforce reviewed progress in water quality improvements in 2015 and concluded that only transformational changes (well beyond current management arrangements) will be necessary to achieve water quality targets.

Pesticides from agriculture damage seagrass beds, corals and mangroves. Of particular concern are PS II pesticides that include diuron, atrazine and simazine. Pesticide runoff into the GBR lagoon occurs mainly during the wet season. Most recent water quality monitoring at Hay Point was undertaken during a dry year, and monitoring results indicated low to no detection of PS II herbicides. However, diuron was still detected across the monitored area.

High TSS concentrations and sediment deposition can cause coral mortality by reducing light or smothering. A pattern has been observed more broadly in North Queensland coastal environments whereby during dry periods with minimal rainfall, elevated turbidity along the coastline is driven by the wind-driven resuspension of sediment. This was observed in the 2014 water quality monitoring and this phenomenon may be exacerbated in the future with increasing effects of climate change.

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3.5.3 Marine sediments

Regional summary

GBR surface sediments across the shelf are generally dominated by carbonate, but on the inner shelf including in the study area the composition is primarily terrigenous. Terrigenous surface sediments in the GBR inner shelf zone are derived from river point sources, often becoming trapped near the coast and deposited near river mouths. Sediments in the study area are predominantly sandy (Figure 3–12).

Sediment transport in the GBR is influenced by the southeast trade winds, nearshore wind-driven currents, storms, cyclone events, fluvial inputs and coastal morphology. The persistent wind and swell in the shallow waters of coastal areas promote sediment transport. The interaction of waves and tides captures suspended terrigenous material within the coastal areas. This results in higher turbidity in nearshore waters (<20 m water depth) and reduces the exchange of water between the inner and mid-shelf. Suspended sediment concentrations are therefore higher during prolonged periods of strong southeast winds and during storm and cyclone events. The shallow water, inner shelf sediment facies are mostly derived from fluvial inputs and quartz grains derived from continental islands. Sediment dispersal on the inner shelf is primarily towards the north west due to the predominant northwesterly along-shore current generated by the south east trade winds between March and October.

Overview of values

Non-reefal sedimentary environments comprise 95% of the total GBRMP and are a key component of the GBR ecosystem, supporting a variety of benthic communities (refer to Section 3.5.6). Sediments provide habitat for infauna and substrata for many marine species/communities, and play an important role as a sink for contaminants. Sandy sediments provide a useful resource to the region – sand is extracted from the Pioneer River and adjacent beaches for commercial uses and benefits the local community through the supply of valuable materials.

Description of places

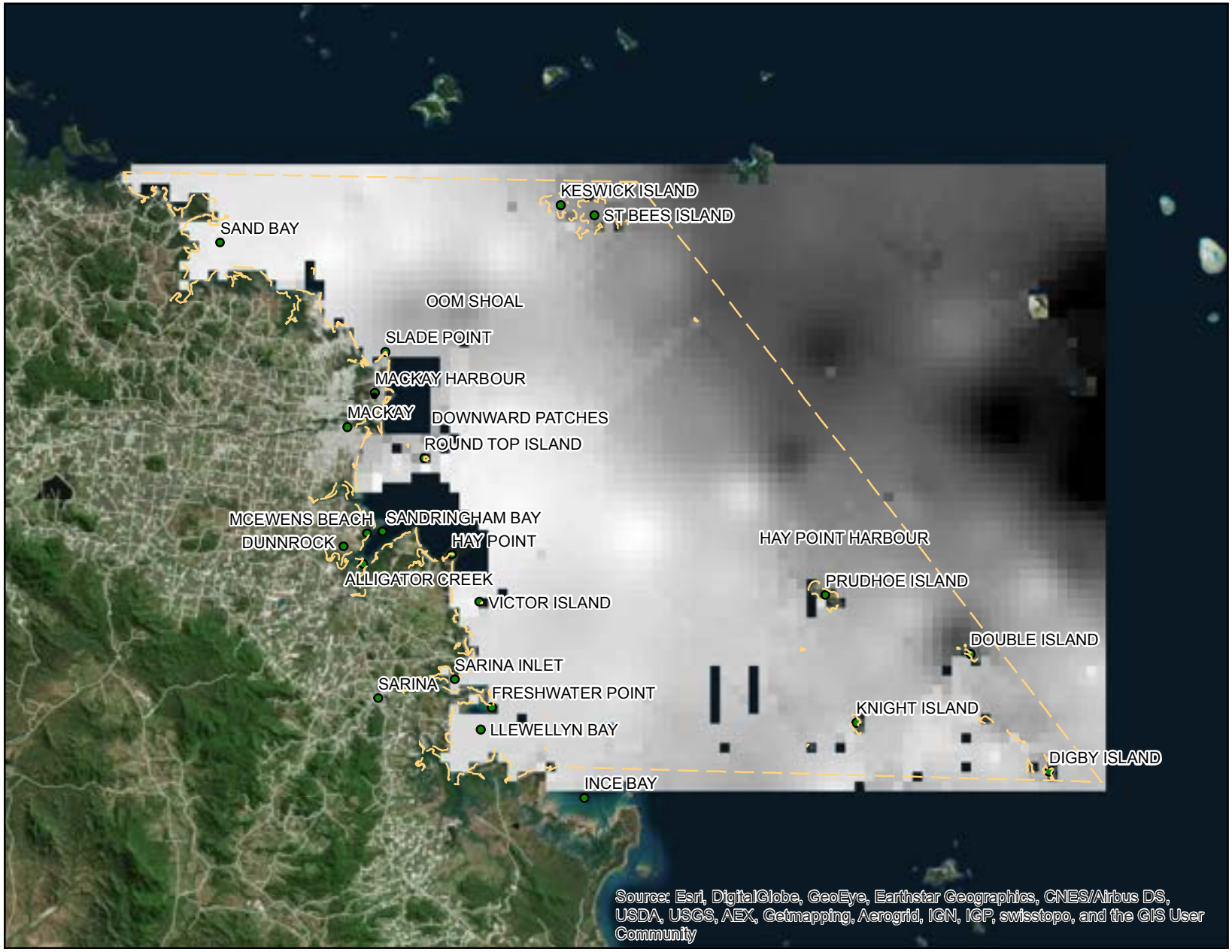
The coastline from Mackay and south of Hay Point is primarily intertidal flats and beaches primarily comprised of terrigenous sediments, with a series of small embayments and rocky outcrops. Rocky shores fringe the coastline, such as Dudgeon Point, the mouth of Louisa Creek, Tug Harbour and Point Victor.

The seabed in the study area is predominantly open sandy substrate and the strong tidal currents re-suspend fine sediments. Islands offshore of Mackay/Hay Point (e.g. Round Top, Flat Top, and Victor Islet) are fully exposed to the south easterly winds, and wave action re-suspends sediments and increases turbidity in the area. The intertidal sand and mud flats north of Dudgeon Point in Sandringham Bay are extensive and extend inshore into Bakers Creek, Sandy Creek, Bell Creek and Alligator Creek, and up to 4 km from the shoreline.

Condition and variability

Sediment transport in the region is primarily driven in a northward direction by the action of waves and tidal flows. A large proportion of coastal sediment transport occurs in the surf zone, where wave-induced longshore currents interact with strong nearshore tidal currents, wind-driven flows, return flows as well as the large local tidal range. Tropical cyclones may create very strong currents that locally redistribute sediments, erode substrates and control river flood plumes.

Figure 3-12 Sand content in surface sediment in the vicinity of the study area



LEGEND

Landmass Project Extent

Ocean Project Extent

Sand content

Value

High : 99.3306

Low : 7.45178

GDA94

A4 1:655,850

0 5 10

Kilometers

JACOBS

In Mackay, the Pioneer River distributes gravel, silt and sand loads to the foreshore south of the Port of Mackay. Many of the coarser sediments accumulate within the shoals at the river mouth. The accumulation of sediments near the mouth of the Pioneer River occurs at an estimated rate of 45,000 m^3/y. Commercial extraction of sand for reclamation of coastal lands and as raw material for the construction industry has also occurred for many years in the Mackay region, with sand extracted primarily from the Pioneer River and adjacent beaches.

Dredged sediments from the Port of Mackay are 80%-97% silt/clay (<75 µm), with the remainder primarily fine sands and gravel. Sediments at the spoil ground are coarse and primarily sand and gravel, which reflects the highly dispersive nature of the site and prevalent coastal conditions. Prevailing ocean currents and wave action readily mobilise the fine particle sediments at the spoil ground, resulting in minimal accumulation of these sediments.

Marine sediment contamination testing at the ports is required at least every five years prior to dredging, provided that no significant event has occurred within or adjacent to a port that may influence sediment quality. Sediment quality within the Port of Mackay has been completed on a regular basis since 1993, primarily in the swing basin and channel areas. A range of contaminants have been detected, however, the sediments comply with ocean disposal criteria. Sediments dredged from the Port of Mackay are considered ‘clean’ to ‘lightly contaminated’, and are suitable for offshore disposal as well as onshore recycling or reuse. Acid generation potential of the sediments is rated as minor, therefore specific management of ASS is not required.

Historically, contaminants of concern at the Port of Mackay include tributyltin (TBT), heavy metals, and polyaromatic hydrocarbons (PAHs). TBT contamination has mainly occurred in the Port of Mackay berth pockets, derived from ships' antifouling. TBT levels in the sediments should continually decrease, as TBT is now banned in antifoulants. Exceedances of some metals (copper, lead, zinc) in sediments have occurred near the base of the slipway (outside the dredged areas), and elevated PAHs have been detected in the tug berths. Organochlorine pesticides (DDD, DDE and DDT) were detected in Mackay Harbour but generally pesticides, PCBs and TPHs have been below detection.

The sediment profile at the Port of Hay Point generally consists of a thin (<300 mm) veneer of silty sand, underlaid by sands, clays and very stiff clays, interspersed with gravels, calcite nodules and decomposed bedrock.

Vulnerability

Agricultural and port activities, including coal stockpiling and ship loading, have the most potential to introduce contaminants into marine sediments in the Hay Point region. There are no significant urban or industrial contaminant sources near Hay Point. The location of the Hay Point coal terminals more than 3 km offshore in open water means that silty, organic-rich sediments, which are more likely to accumulate contaminants than sands, do not accumulate. Dredged sediments at the Port of Hay Point comply with criteria for ocean disposal. Antimony concentrations have sometimes been elevated, but as a natural occurrence in ancient sediments. Dredged sediment nutrient concentrations are low, as are the extent of PASS.

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3.5.4 Coral reefs

AREA PROFILE: CORAL REEFS

Coral reefs are the foundation of the GBR ecosystem. It is the world's largest reef ecosystem, ranging over 14 degrees in latitude and is made up of 2,900 separate coral reefs.

The fringing reefs of the GBR vary considerably, from species-poor muddy reefs, often close to river mouths, to fragile hard and soft coral communities in inlets and bays. Around Shoalwater Bay area (south of the study area), conditions are not favourable for extensive reef formation

Conditions improve from the southern Mackay Islands, with shallow clear water, and improve further again around the Mackay-Whitsunday islands with shallow warm water and high island density providing excellent conditions for reef formation.

Cross-shelf (west to east) conditions for coral growth are influenced by distance from the coast, with inshore

AREA PROFILE: CORAL REEFS

and fringing reefs exposed to lower wave energy and higher levels of turbidity sedimentation than the outer margin of the reef. Some inshore reefs, however, experience strong tidal energy, which can influence coral community composition.

Environmental Values

Inshore coral reefs, such as those within the study area, make an important contribution to the world heritage values of the GBR. They contribute to the diversity of inshore waters, fisheries and tourism values and are in general decline along the GBR coast. They also make a contribution to OUV by being a small part of the broader GBR.

The largest assemblage of coral reefs in the world, the GBR is internationally recognised as a biodiversity hot spot, with more than 1,625 fish (133 sharks and rays), 3,000 mollusc, and 630 echinoderm species, 6 species of marine turtle, dugongs, and whales and dolphins. Vast number of species in other groups also inhabit the reef. Reef health is important for maintaining this species diversity. The interconnectedness and variety of habitats is important for the GBR to be able to withstand, recover and adapt to changing environments, that is, for the reef's resilience.

The reef also plays a role in protecting the coastline from wave action and tropical storms.

The economic value of the GBR is substantial, both through commercial and recreational fishing and tourism. More than two million people visit the reef every year, equating to $2 billion in tourism revenue.

Contribution to OUV

Coral reefs of the study area contribute to the OUV of the GBR by providing biological diversity, while making a small contribution to the world's largest coral reef ecosystem and the mosaic of reefs, islands and cays of the GBR. The study area is dominated by inshore coral reefs which are in general decline along the GBR coast.

Coral reefs directly contribute to numerous elements of OUV thoroughout the GBRWHA. Coral reefs of the study area are an important value as they provide a structural and biological basis for high levels of species diversity. The study area is also dominated by inshore coral reefs which are in general decline along the GBR coast. Remaining inshore coral reefs therefore have importance in maintaining the biological diversity of the GBR system.

Vulnerability

While recent in-water surveys have identified that the average coral loss within the study area is 0%, coral reefs within the study area are vulnerable to similar pressures as the rest of the GBR. Sustained high turbidity and sediment deposition can damage or kill corals. Recent coral cover declines in the southern region of the GBR have been attributed to cyclones and floods. The increased frequency of cyclones and floods, and therefore possible COTS outbreaks, due to climate change reduces the recovery time between events. Furthermore, increased nutrient, sediment and pesticide loads from land-based sources reduce the natural resilience of reefs to these disturbances. This is why improvements in catchment land-use practices are a priority for management of the GBR.

Another serious threat to the GBR's resilience is ocean acidification, a result of human carbon dioxide emissions that is separate from climate change *per se*. Ocean acidification makes it more difficult for corals and other reef organisms to produce their calcium carbonate skeletons and shells, and therefore reduces resilience.

Gaps

Coral reefs within the study and monitored in and around the ports, with monitoring undertaken during each dredging program. Gaps in information and understanding relate to sites and reefs that are further away from the ports.

Summary of Importance

Coral reefs are the foundation of the GBR ecosystem. It is the world's largest reef ecosystem, including:

AREA PROFILE: CORAL REEFS

- Significant diversity of reef and island morphologies reflecting geomorphic, oceanographic and environmental processes
- Complex string of reef structures along the coast
- Environmental history recorded in old massive corals
- Mosaic of reefs, islands and cays produces an unparalleled aerial panorama of seascapes
- World's largest coral reef ecosystem, including examples of all stages of reef development

Important habitat areas include:

- Hay Reef and at Victor Islet
- Round Top Island
- Flat Top Island
- Taroba Rocks
- Dudgeon Point (Figure 3–13).

Such locations are not unique or notable at a whole of GBR scale. However, they do make an important contribution to the diversity of inshore coastal waters and are representative of coral reef habitats that are in decline across the GBR coast.

What does this mean?

The study area does not contain any unique or notable coral reefs at a whole of GBR scale, the dominance of inshore coral reefs means the study area is important in maintaining the biological diversity of the GBR.

While recent coral cover declines in the southern region of the GBR have been attributed to naturally occurring events (cyclones and floods, COTS outbreaks and mass bleaching events), the frequency of these events can reduce the corals and reef systems resilience to these disturbance events. Increased nutrient, sediment and pesticide loads from land-based sources reduce the natural resilience of reefs to these disturbances. This is why improvements in catchment land-use practices are a priority for management of the GBR.

Regional summary

Coral reefs are the foundation of the GBR ecosystem. The fringing reefs of the GBR vary considerably, from species-poor muddy reefs, often close to river mouths, to fragile hard and soft coral communities in inlets and bays. Around Shoalwater Bay area (south of the study area), conditions are not favourable for extensive reef formation due to turbid conditions and deep water. Conditions improve from the southern Mackay Islands, with shallow clear water, and improve further again around the Mackay-Whitsunday islands with shallow warm water and high island density providing excellent conditions for reef formation.

Cross-shelf (west to east) conditions for coral growth are influenced by distance from the coast, with inshore and fringing reefs exposed to lower wave energy and higher levels of turbidity sedimentation than the outer margin of the reef. Some inshore reefs however, experience strong tidal energy, which can influence coral community composition.

Overview of values

Coral reefs of the study area are an important value as they provide a structural and biological basis for high levels of species diversity, while also contributing to the world's largest coral reef ecosystem and the mosaic of reefs, islands and cays of the GBR. The study area is dominated by inshore coral reefs which are in general decline along the GBR coast. Remaining inshore coral reefs therefore have importance in maintaining the biological diversity of the GBR system.

The largest assemblage of coral reefs in the world, the GBR is internationally recognised as a biodiversity hot spot with vast numbers of species inhabiting the reef. Reef health is important for maintaining this species diversity. The interconnectedness and variety of habitats is important for the GBR to be able to withstand, recover and adapt to changing environments, that is, for the reef's resilience.

The reef also plays a role in protecting the coastline of the study area from wave action and tropical storms.

The economic value of the GBR is substantial, both through commercial and recreational fishing and tourism. The value of these industries is discussed in Sections 3.6.2 and 3.6.5.

Description of places

There are a number of reefs in the vicinity of Hay Point, including Hay Reef and at Victor Islet, Round Top Island, Flat Top Island, Taroba Rocks, and Dudgeon Point (Figure 3–13). These reefs are dominated by sediment-tolerant hard coral species.

Hay Point Reef lies within the Port of Hay Point, between the HPCT and DBCT trestles and approximately 300 m offshore. Hard coral cover is patchy, ranging from 0% to 60%, with mean of 16% on the northeast side and 1.3% on the southwest side. There is patchy coral cover up to 23% on rocky reef areas west and south of the Hay Point trestles, seaward on Hay Point and Dudgeon Point. The coral community is dominated by sediment-tolerant species, although the high strong currents substantially mitigate sedimentation.

A mainland fringing reef occurs off Dudgeon Point. The reef is a rocky tongue with dominated by macroalgae, predominantly *Sargassum* spp. Mean macroalgal cover was 35% in 2012. Scattered hard corals occur on the outer edge where the reef meets sand, mostly Faviid corals with *Montipora*, *Turbinaria* and *Siderasterid* corals also common. Sponges and soft corals are not common.

Round Top Island is about 9 km north of Hay Point. The island is characterised by steep sloping cliffs on the east side with gentler rocky slope on the west. The rocky slope has moderate hard coral cover low macroalgal cover. Coral, algae and invertebrate diversity is low compared with other GBR fringing reefs. The rocky shoal reef of Taroba Rocks is located northeast of Round Top Island.

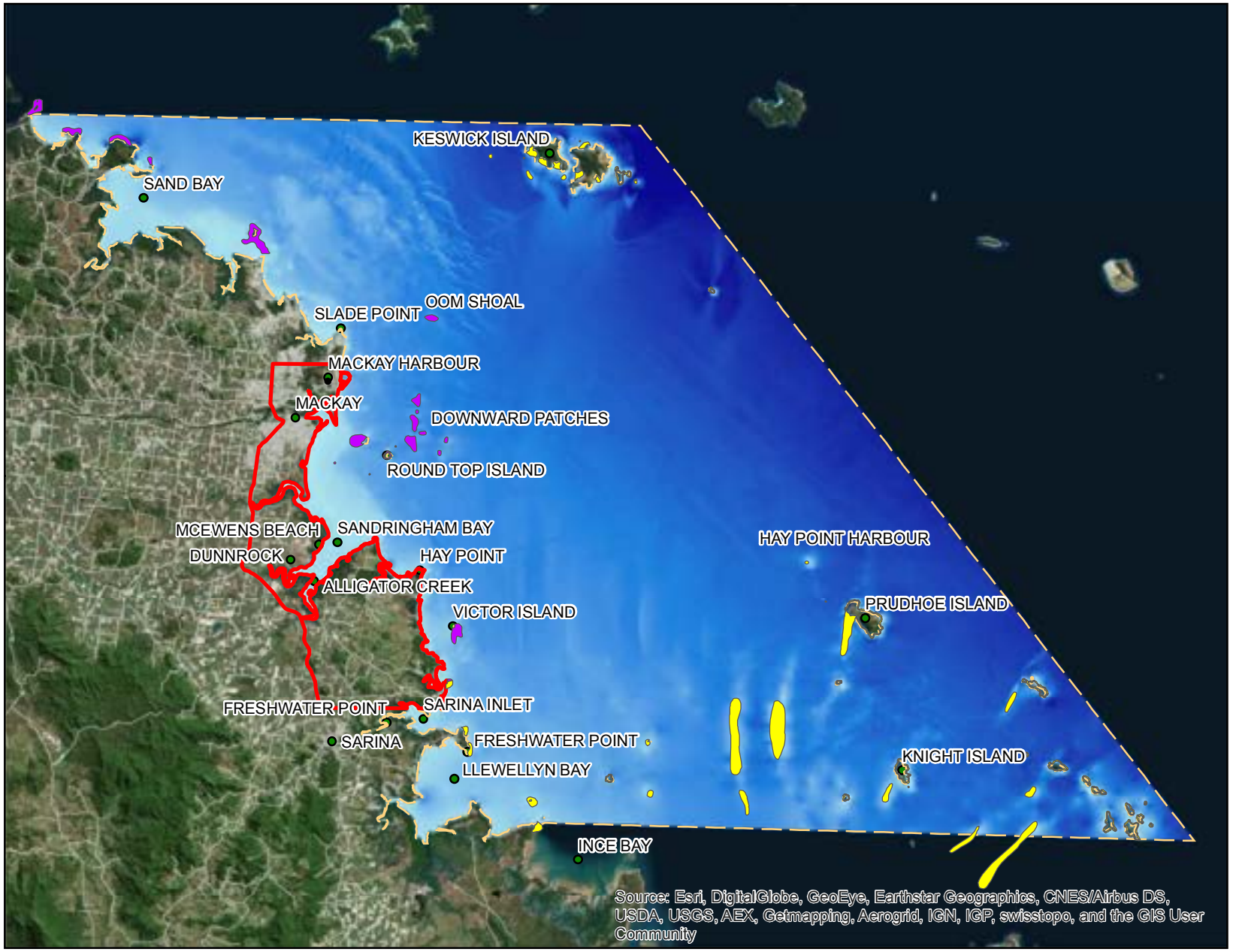
Flat Top Island is about 12 km northwest of Hay Point and about 1 km north of Round Top Island. The formation is very similar to Round Top Island, with deeper and steeper sloping cliffs on the east side. The west and northern side has gently sloping reef flat covering about 14 ha. The reef consists of low level of hard and soft corals, and occasional macroalgae. Hard coral diversity is low in comparison to other GBR fringing reefs; however, invertebrate diversity is relatively high.

Victor Islet, about 8 km south of the Port of Hay Point and 3 km from mainland, is very different in topography to Round and Flat Top Islands, with a reef flat extending 1 km at the southern end over an area of 45 ha. The reef is dominated by macroalgae, moderate hard and soft coral cover. Coral, algal and invertebrate diversity is low in comparison with other GBR fringing reefs.

Reefs in the vicinity of the Port of Mackay include fringing reefs at Slade Islet, Keswick Island and St Bees Island (see Figure 3–13). The reefs have some hard and soft corals, but the majority are dominated by microalgae.

Slade Islet is a small inshore island about 2 km northeast of Mackay Harbour. There is a large benthic community about 558 ha in size between Round Top Island and Slade Island which is dominated by soft corals, sea stars and sponges.

Figure 3-13 Coral reefs



LEGEND

- Landmass Project Extent
- Ocean Project Extent

Marine Bioregion

- RE4 Coastal Southern Reefs
- RE5 High Tidal Fringing Reefs

GDA94

A4 1:550,000

0 5 10

Kilometers

JACOBS

Keswick Island is about 30 km from Mackay and has reefs at Singapore Bay, Back Reef and Front Reef. Singapore Bay is on the southwestern side of the island. The reef has shallow and deep benthic communities dominated by macroalgae, with low cover of hard and soft corals. However, coral diversity is high. Back Reef is a fringing reef in the passage between Keswick and St Bees islands. The shallow reef is dominated by macroalgae; however, soft corals are also abundant. Hard coral cover is below average compared to other GBR fringing reefs. The deep reef is also dominated by macroalgae, with lower soft coral cover than the shallow reef and higher hard coral cover (about average for deep sites on GBR fringing reefs). Front Reef is a narrow fringing reef running into the southern end of the passage between St Bees Island. Hard coral cover is about average in comparison to other GBR fringing reefs and greater than other reefs on Keswick and St Bees. Soft coral cover is also above average. Deep sites are dominated by sand and rubble with only scattered coral colonies.

St Bees Island is immediately east of Keswick Island. Fringing reefs extend a variable distance from the north side of the island. The shallow benthic community is dominated by macroalgae and turf algae, with low hard and soft coral cover. However, hard coral diversity is high. The deep benthic community is similar to the shallow one, again with high hard coral diversity. A survey of 26 reefs on the GBR found this site to have the highest diversity of Siderasterid corals (with five recorded species) of any site.

Condition and variability

The condition and variability of coral reefs in the study area are embedded in trends for the GBR as a whole The 2009 GBR Reef Outlook Report indicated that the overall condition of the reef was relatively good, but likely to be declining slightly – particularly in inshore areas. Coral cover has more recently been shown to have declined in the 30 years from 1986, most severely on reefs south of Bowen since 2006. Coral cover reduced from 35% to 8% in the southern region of the GBR in that time. This is supported by the 2014 GBR Outlook Report, which reported particular coral cover declines in the southern region.

Hay Point is a harsh environment for corals and other reef organisms due to the high tidal range (6 m to 7 m) and strong currents which suspend fine sediment. Victor, Round Top and Flat Top islands are exposed to southeasterly winds, increasing wave action and further suspending sediment, often causing turbid conditions.

Coral groups that are usually common on fringing reefs were notably absent on reefs in the vicinity of Hay Point in a 2005 survey. This included all fungiid corals, most agariciids, pectiniids, and merulinids, and the genus *Echinopora*. Very few colonies were over 1 m in diameter, suggesting high historical disturbance. Coral species that were present were typical of turbid reefs. Coral diversity was low, although this is common on silty inshore reefs. The 2005 survey indicates that the reefs on these islands are adapted to the turbid conditions and the resultant low-light conditions.

The 2005 study compared the reefs at Victor Islet and Round Top and Flat Top islands to 12 other inshore reefs in other parts of the GBR. Hard coral cover at the three islands was generally lower than the other reefs, those between Mackay and Port Clinton with a high tide range. The low coral cover on the Hay Point reefs is thus comparable to other reefs in areas of strong tidal currents, which probably constrain coral development.

Fishes found on the reefs were also characteristic of very silty inshore reefs. The absence of common coral trout, and rarity of parrotfishes, surgeonfishes and emperors indicated the conditions are often turbid.

A 2012 survey identified a few partially bleached corals at sites at Round Top Island and Slade Islet. A small number (less than 0.5% of all colonies) of diseased and partially dead corals were recorded at Round Top, Victor Islet and Slade Islet. The coral groups most often affected were *Acropora*, *Montipora*, and *Turbinaria*, but massive faviid, siderastrid and poritid corals were also sometimes damaged by disease.

Potential effects of dredging on coral reefs around Hay Point have been monitored by NQBP and others. Coral monitoring conducted before, during and after capital dredging in 2006 and maintenance dredging in 2008 and 2010 at the Port of Hay Point found sediment deposition on reefs at Victor Islet and Round Top Island. Overall, the effect on reef condition was low. Coral sites on the leeward side of Victor Islet suffered the highest sedimentation impacts due to their position relative to the dredging. The residual impacts of the dredging at

Victor Islet remained visible for several years after dredging finished. However, assessments of live hard coral at Round Top Island and Victor Islet reported only minor changes, with low (<1%) coral colony mortality.

Levels of deposited sediment declined at Round Top Island in the five years after capital dredging was completed. Round Top appeared to be unaffected by dredging-related sediment in both the 2008 and 2010 maintenance dredging surveys.

The 2010 maintenance dredging operations did not perceptibly add sediment to the Victor Islet environment. In the November 2010 post-dredging survey both levels of sediment on corals and the density of sediment-damaged corals was at low levels (<0.5% damaged colonies) not recorded since the capital dredging baseline survey in early 2006. However, in recent surveys sediment appears to have been redeposited at Victor Islet over the past 15 months, probably due to cyclone and flood events, and over 3.5% of corals were sediment damaged in the latest survey. Recent in-water surveys of coral reefs across the GBR have identified that the average coral loss within the study area is 0%.

Vulnerability

Coral reefs within the study area are vulnerable to similar pressures as the rest of the GBR. Corals and other organisms tolerate high turbidity and sediment deposition, which happen naturally especially during storms, cyclones and floods, for short periods. Sustained high turbidity and sediment deposition, however, can damage or kill corals. Recent coral cover declines in the southern region of the GBR have been attributed to cyclones and floods, COTS outbreaks and mass bleaching events. All of these occur naturally, and corals and reef systems are resilient to these disturbances when in an undisturbed, healthy state. However, the increased frequency of cyclones and floods, and therefore possibly COTS outbreaks, due to climate change reduces the recovery time between events. Furthermore, increased nutrient, sediment and pesticide loads from land-based sources reduce the natural resilience of reefs to these disturbances. This is why improvements in catchment land-use practices are a priority for management of the GBR. Another serious threat to the GBR's resilience is ocean acidification, a result of human carbon dioxide emissions that is separate from climate change per se. Ocean acidification makes it more difficult for corals and other reef organisms to produce their calcium carbonate skeletons and shells, and therefore reduces resilience.

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3.5.5 Seagrass

AREA PROFILE: SEAGRASS

Shallow coastal seagrass meadows have been recorded in approximately 13%, or 6,000 km^2, of the GBRWHA, while deepwater seagrass meadows, defined as those living at depths greater than 5 m relative to mean sea level (MSL), in another 40,000 km^2. Seagrass beds are naturally highly variable in distribution and species composition due to seasonal and inter-annual factors, and though they have been mapped over these large areas the distribution is much more restricted at any given point in time. Deepwater seagrasses are particularly variable and ephemeral. Though they have been observed in large parts of the study area shallower than about 18 m at one time or another, they typically occur in sparse, scattered patches at any given time, and only between about July to November.

Environmental Values

Seagrasses are extremely important to ecosystem function. Larger species play an important role in stabilising coastal sediments, reducing resuspension and erosion, particularly during storms. Seagrass meadows trap nutrients, detritus and sediments, influencing nutrient cycling, nitrogen fixation and nutrient flows to adjacent waters. The meadows provide habitat for a number of resident and transient species. They are particularly important as breeding and nursery habitat for a range of prawns and fishes, including commercially important species. Seagrass is the preferred food of dugongs (*Dugong dugon*) and green turtles, and up to 154 invertebrate and fish species graze directly on seagrasses. Probably more important, however, are food webs based upon decaying seagrass leaves and other components.

Seagrass meadows area also thought to play a role in mitigating climate change. This is an emerging area of study, but seagrass habitats are thought to be efficient in carbon sequestration.

Contribution to OUV

Seagrass meadows are an attribute of OUV that provide important feeding habitat for listed threatened and listed migratory species. They also act as nursery areas for numerous vertebrate and invertebrate species. The vast biodiversity and sensitivity to changes in water quality inherent in seagrass communities makes seagrasses important indicators in overall health of coastal ecosystems. Within the study area, seagrass habitats provide a small contribution to OUV, by providing habitat for a range of species including dugong and turtles.

Vulnerability

The major threats affecting seagrass communities on the GBR generally include poor water quality, habitat loss and modification from coastal development, increased storm intensity and frequency, rising sea surface temperatures and sea level rise. Temperatures above the tolerance threshold of seagrass cause ‘burning’ and degradation of seagrass meadows.

Species of Halophila, which are common offshore at Hay Point, have reproductive characteristics that enable recovery from periodic disturbances. *H. decipiens* produces seeds that can lay dormant in the sediment for at least two years and rapidly recruit when conditions are right. However, the more dense coastal seagrass

AREA PROFILE: SEAGRASS

meadows are unlikely to show such resilience.

Seagrass surveys conducted at Hay Point between 2004 and 2008 showed that dredging had a negative impact during the program; however, the low-density deepwater seagrass meadows recovered within 12 months of the cessation of the dredging program.

Seagrass meadows in the Newry Region/Sand Bay may be vulnerable to minor physical and chemical disturbances from recreational boating in the area, to more widespread impacts such as increased sediment loads from nearby catchments due to land clearing and agriculture.

Gaps

Although there has been extensive monitoring in the study area, the spatial coverage is not at the extent of the EVA study area. The drivers of variability in seagrass abundance are not well understood. Monitoring has typically been conducted on a quarterly, semi-annual or annual basis, which does not capture the more important short-term dynamics during the winter growing season.

Summary of Importance

Seagrasses are extremely important to ecosystem function and provide a habitat for listed threatened and listed migratory species. They also act as nursery areas for numerous vertebrate and invertebrate species and are important indicators of ecosystem health.

Seagrass habitats within the study area are not particularly notable or important, when compared with other regions along the GBR coast. However, at a local scale, they provide a small contribution to the maintenance of habitat values for some threatened species, such as turtles, dugong and shorebirds.

What does this mean?

While seagrass habitats contribute to ecosystem function and provide habitat, seagrass meadows are often highly variable, both seasonally and inter-annually. Deepwater meadows are particularly variable

Species of *Halophila*, which are common offshore at Hay Point, have reproductive characteristics that enable recovery from periodic disturbances. These characteristics include producing seeds that can lay dormant in the sediment for a number of years and rapidly recruit when conditions are right. However, the more dense coastal seagrass meadows are unlikely to show such resilience.

Seagrass surveys conducted at Hay Point have shown that dredging had a negative impact during the program; however, the low-density deepwater seagrass meadows recovered within 12 months of the cessation of the dredging program.

Regional summary

Shallow coastal seagrass meadows have been recorded in approximately 13%, or 6,000 km^2, of the GBRWHA, while deepwater seagrass meadows, defined as those living at depths greater than 5 m relative to mean MSL, in another 40,000 km^2. Seagrass beds are naturally highly variable in distribution and species composition due to seasonal and inter-annual factors, and though they have been mapped over these large areas the distribution is much more restricted at any given point in time. Deepwater seagrasses are particularly variable and ephemeral. Though they have been observed in large parts of the study area shallower than about 18 m at one time or another, they typically occur in sparse, scattered patches at any given time, and only between about July to November.

The Mackay-Whitsunday Region has a number of seagrass habitats and species; 14 seagrass species have been recorded. The Newry Region, Sand Bay (north of the study area) and Llewelyn Bay and Ince Bay (south of the study area) were declared as Dugong Protection Areas (DPAs) in 1998, as their seagrass meadows support significant dugong numbers. The Newry and Sand Bay DPA is estimated to protect 2% of the dugong population in the southern GBR. Surveys in 1987 mapped 7.4 km^2 of seagrass meadows, with low (<10%) to medium (10%-50%) cover, and up to seven seagrass species from three families. Surveys in 1999 found

seagrass was common in the Newry Region, however none was observed in Sand Bay. The lack of seagrass at Sand Bay was probably due to wave exposure and resultant mobile sediment, limiting the ability for seagrass to take hold. In the Newry Region, nine species of seagrass from three families were identified at depths of 0.0 m to -5.5 m MSL during the 1999 survey.

Surveys of Llewellyn and Ince Bays in 1999 found seagrass in Llewellyn Bay confined to 11 small isolated patches within a 1.5 km strip of the coast, while Ince Bay had extensive seagrass meadows on intertidal sand banks extending 10 km along the coast and up to 3.5 km offshore. More recent surveys show that Llewelyn Bay is highly variable from no to sparse seagrass cover, while Ince Bay often has greater coverage and species diversity.

Overview of values

Seagrasses are extremely important to ecosystem function. Larger species play an important role in stabilising coastal sediments, reducing resuspension and erosion, particularly during storms. Seagrass meadows trap nutrients, detritus and sediments, influencing nutrient cycling, nitrogen fixation and nutrient flows to adjacent waters. The meadows provide habitat for a number of resident and transient species. They are particularly important as breeding and nursery habitat for a range of prawns and fishes, including commercially important species. Seagrass is the preferred food of dugongs and green turtles, and up to 154 invertebrate and fish species graze directly on seagrasses. Probably more important however, are food webs based upon decaying seagrass leaves and other components.

Surveys of deepwater seagrass meadows in the Hay Point area found that commercial prawn and fish species were less abundant than in more dense coastal meadows elsewhere in Queensland. Deepwater seagrass meadows in the Hay Point area are typically sparse; however, they may occasionally provide a food resource for dugongs moving between the Newry DPA to the north and the Ince Bay DPA to the south. These DPAs were established because of their resident dugong populations, a reflection of their high seagrass abundance. Dugongs usually move long distances to new feeding areas in response to food shortage in their normal habitat, and even low-value feeding areas can be important during the migration.

Seagrass meadows are also thought to play a role in mitigating climate change. This is an emerging area of study, but seagrass habitats are thought to be efficient in carbon sequestration.

Description of places

Surveys around the Port of Mackay in 2001 found that seagrass occurred in three meadows, two deepwater meadows of *Halophila decipiens* 7 km and 12 km east of Mackay Harbour and a coastal meadow of *Halodule uninervis* and *Halophila ovalis* off the northwestern shore of Round Top Island. The two deepwater meadows covered 273 ha and 294 ha. The coastal meadow covered an area of 2.2 ha. A 2015 survey conducted by TropWATER observed a new, relatively large, offshore *Halophila spinulosa* meadow off Mackay.

Common seagrass species in the Hay Point area include *H. uninervis*, *H. decipiens* and *H. spinulosa*. *H. uninervis* dominates in shallow coastal meadows. In some years there are significant areas (up to 35% of total bottom area) of deepwater seagrass, mostly light cover of *H. decipiens* with small patches of moderate cover in some surveys. *H. spinulosa* is occasionally abundant and has recently been observed as the dominant species around Keswick and St Bees Islands. The maximum depth for deepwater seagrass around Hay Point is about 18 m.

Condition and variability

The condition of seagrass meadows is assessed by their distribution, abundance, species diversity and other factors. The most recent Healthy Rivers to Reef Report Card for the inshore Mackay area rated seagrass condition as poor overall. This was due to poor scores for abundance, nutrient status and reproductive effort. However, the 2015 results of annual monitoring rated offshore seagrass condition to be satisfactory and noted that overall seagrass biomass is the highest it has been since 2012. The recent survey found that deepwater seagrass had improved; however, there were declines in smaller shallow meadows due to increased exposure.

However, understanding the natural variability of seagrass in the region is necessary to assess their true status. Seagrass meadows are often highly variable both seasonally and inter-annually. For example, a 1987 survey found a seagrass meadow northwest of Flat Top Island that was not observed in the 2001 survey.

Deepwater meadows are particularly variable. In the area around Hay Point, they are typically absent from about December to May and reappear, in some years, between about June and November. In some recent years deepwater seagrass meadows have failed to appear at all as a result of major cyclone-associated floods. Coastal seagrass also declined in response flooding and cyclones. When deepwater seagrass does appear, it is highly patchy, occurring in scattered meadows that are ephemeral from year to year. Thus, while composite maps of deepwater seagrass distribution across multiple surveys show a very wide deepwater distribution, only relatively small patches are present at any given time.

Vulnerability

The major threats affecting seagrass communities on the GBR generally include poor water quality, habitat loss and modification from coastal development, increased storm intensity and frequency, rising sea surface temperatures and sea level rise. Temperatures above the tolerance threshold of seagrass cause 'burning' and degradation of seagrass meadows.

Species of *Halophila*, which are common offshore at Hay Point, have reproductive characteristics that enable recovery from periodic disturbances. *H. decipiens* produces seeds that can lay dormant in the sediment for at least two years and rapidly recruit when conditions are right. However, the more dense coastal seagrass meadows are unlikely to show such resilience.

Seagrass surveys conducted at Hay Point between 2004 and 2008 showed that dredging had a negative impact during the program; however, the low-density deepwater seagrass meadows recovered within 12 months of the cessation of the dredging program.

Seagrass meadows in the Newry Region/Sand Bay may be vulnerable to minor physical and chemical disturbances from recreational boating in the area, to more widespread impacts such as increased sediment loads from nearby catchments due to land clearing and agriculture.

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3.5.6 Non-reefal benthic fauna

AREA PROFILE: BENTHIC INFAUNA

Benthic fauna include animals and protozoans that live within seabed sediments (infauna) and animals that live on the seabed (epifauna). Infauna communities are typically dominated, in the study area and elsewhere, by polychaete worms, molluscs (mainly bivalves and snails) and small crustaceans, but infauna communities include a diverse array of other groups. Benthic epifauna include macroinvertebrates such echinoids, sponges, ascidians, bivalves, byrozoans and crustaceans.

Infauna communities on the GBR have distinct regional patterns. Infauna community structure is strongly affected by sediment characteristics, especially sediment grain size, and depth, as well as the disturbance regime. Turbidity, sedimentation rate, nutrient availability and other water quality factors are also important. Increased sediment and nutrient inputs; thus strong wet seasons or dredging activities can significantly affect the infauna in the study area.

Environmental Values

Infauna are profoundly important in cycling nutrients and carbon, in controlling oxygen levels in the sediment, and re-working fine material down into the sediment column. Infauna are critically important as the base of the food web for a variety of other species, including commercially important ones such as prawns and bottom-living fishes.

Infauna typically have short generation times, so their communities tend to respond relatively rapidly to changes in the environment. Because they are relatively sedentary, infauna can also be a better indicator of the specific local environment than organisms that move from place to place. Thus, infauna communities are an indicator of environmental health at a given location and can be used to assess anthropogenic impacts.

Contribution to OUV

Some 93% of the GBRWMA is soft-sediment habitat; infauna are the dominant bilogical component of this

AREA PROFILE: BENTHIC INFAUNA

habitat. Though no aspect of soft-bottom infauna communities is directly attributable to the statement of OUV, benthic fauna are critical in maintaining ecosystem function.

Vulnerability

Infauna communities can be impacted by major natural disturbances such as floods and cyclones, and by sediment deposition associated with dredging-related sediment plumes and spoil deposition. Pollution can have major effects on infauna communities – in fact infauna are commonly used as indicators of pollution.

Gaps

Very little is known about the spatial or temporal variability of soft-bottom benthic fauna in the study area.

Summary of Importance

Benthic infauna communities have key roles in cycling nutrients and organic matter. They play an important role in mixing sediment, oxygenating and immobilising fine material down into the sediment column, as well as being critically important as the base of the food web for a variety of other species.

What does this mean?

Benthic fauna can be impacted by natural disturbance and by man-made disturbances, such as sedimentation associated with dredging-related sediment plumes and spoil deposition. Due to their short generation times, benthic fauna communities tend to respond relatively rapidly to changes in the environment.

Infauna communities at Hay Point have been monitored since 2009. Monitoring indicated a profound impact of the disturbance from Cyclone Ului in early 2010, with infauna abundance plummeting dramatically compared to the 2009 baseline survey. Infauna communities recovered dramatically within a year of the cyclone and within a few years appear to have returned to more or less natural variability. The monitoring did not detect any significant impact from dredged material disposal in 2010 or 2011.

Infauna communities were assessed for the Port of Mackay northern/eastern sites and the Mackay spoil ground, but the sites sampled within each area were not significantly different. The absence of 'grazing' species was attributed to the study area being largely devoid of marine plants. There was no evidence of changes to infauna trophic structures or species assemblages as a result of dredge spoil disposal.

Regional summary

Corals and seagrass are the most prominent benthic (living on the bottom) bilogical communities on the GBR, but a variety of other benthic organisms are essential to ecosystem function. Benthic fauna include animals and protozoans that live within seabed sediments (infauna) and animals that live on the seabed (epifauna). Infauna communities are typically dominated, in the study area and elsewhere, by polychaete worms, molluscs (mainly bivalves and snails) and small crustaceans, but infauna communities include a diverse array of other groups. Benthic epifauna include macroinvertebrates such echinoids, sponges, ascidians, bivalves, hydroids, byrozoans and crustaceans.

Infauna communities on the GBR have distinct regional patterns. Infauna community structure is strongly affected by sediment characteristics, especially sediment grain size, and depth, as well as the disturbance regime. Turbidity, sedimentation rate, nutrient availability and other water quality factors are also important. Increased sediment and nutrient inputs, thus strong wet seasons or dredging activities, can significantly affect the infauna in the study area.

Overview of values

Infauna may be one of the least charismatic ecological communities on the GBR, but they are profoundly important. While coral reefs dominate perceptions of GBR ecology, the seabed in most of the marine study area is actually soft sand or mud with infauna communities dominant. These communities have key roles in cycling nutrients and organic matter. Their burrowing mixes sediment, oxygenating and immobilising fine material down into the sediment column. Infauna are critically important as the base of the food web for a variety of other species, including commercially important ones such as prawns and bottom-living fishes.

Infauna typically have short generation times, so their communities tend to respond relatively rapidly to changes in the environment. Because they are relatively sedentary, infauna can also be a better indicator of the specific local environment than organism that move from place to place. Thus, infauna communities are an indicator of environmental health at a given location and can be used to assess anthropogenic impacts.

Description of places

Infauna communities at Hay Point have been monitored since 2009. Monitoring indicated a profound impact of the disturbance from Cyclone Ului in early 2010, with infauna abundance plummeting dramatically compared to the 2009 baseline survey. Infauna communities recovered dramatically within a year of the cyclone and within a few years appear to have returned to more or less natural variability. The monitoring did not detect any significant impact from dredged material disposal in 2010 or 2011.

Infauna communities were assessed for the Port of Mackay northern/eastern sites and the Mackay spoil ground, but the sites sampled within each area were not significantly different. The absence of ‘grazing’ species was attributed to the study area being largely devoid of marine plants. There was no evidence of changes to infauna trophic structures or species assemblages as a result of dredge spoil disposal.

Hay Point is sparsely inhabited by benthic macroinvertebrate (epifauna) and macroalgae communities, with submerged rocky outcrops in the shallow waters of Dalrymple Bay. Previous studies have identified two regions where a moderate density of benthic macroinvertebrates occurred, located within and due west of the designated spoil disposal site. The substrate in these regions contained patches of rubble and supported a diverse variety of erect and encrusting bryozoans and polychaete worms. Other areas that were less densely populated with epifauna supported individuals or small communities of varying combinations of bryozoans, polychaetes, echinoids, gastropods, barnacles and bivalves. Generally, previous surveys have not found any high densities of epifauna in the Hay Point region, with the majority of areas studies containing less than 5% cover.

Substrates in the Port of Mackay area support a low diversity and density of epifauna, with habitats primarily consisting of open substrates with occasional solitary individual benthic fauna. Areas that supported higher densities of epifauna were primarily located ~3 km offshore around islands and rocky reefs (e.g. Round Top Island, Slade Island), which were dominated by soft corals, sea stars and sponges.

Condition and variability

One of the key drivers of the structure and function of infauna assemblages is sediment particle size, so natural or anthropogenic changes in sediment characteristics are often reflected in changes to infauna communities.

The Port of Mackay channel, swing basin and berth pocket areas are subject to disturbance from maintenance dredging, which historically has occurred approximately every three years. The recovery process between dredging events is anticipated to be faster for more common, opportunistic infauna species.

A 1992 survey at Dudgeon Ledge, north of Hay Point, found a relatively low abundance of infauna at inshore locations. This was thought to be related to the high wave energy environment and not related to dredge disposal or sediment deposition.

In 2001 and 2003, infauna surveys at the Hay Point spoil ground found that while the benthic community had not returned to baseline (pre-dredging) conditions, the changes were consistent with control locations. This indicated that changes reflected natural variability and were unrelated to spoil disposal.

Monitoring in the Hay Point area from 2010 and 2015 showed, as noted above, a strong effect of Cyclone Ului followed by rapid recovery. The gravel content of sediments was found to significantly influence infauna abundance, richness and community structure.

A 2012 survey of benthic macroinvertebrates in anchorages in the Hay Point area found that in habitats with open substrate and low densities of epifauna, contact of anchors and anchor chains with the seafloor were unlikely to cause significant impacts to those habitat areas.

Vulnerability

Benthic fauna communities can be impacted major natural disturbances such as floods and cyclones, and by sediment deposition associated with dredging-related sediment plumes and spoil deposition. Pollution can have major effects on infauna communities – in fact infauna are commonly used as indicators of pollution. However, there is no evidence of pollution effects on benthic fauna communities in the study area. Physical disturbance, for example by trawling, can also affect benthic fauna but there has been no research on this in the study area.

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3.5.7 Megafauna

AREA PROFILE: MEGAFAUNA

Marine megafauna are used for the design and justification of marine protected areas around the world. The waters offshore from Hay Point and Mackay are in the Mackay/Capricorn Management section of the GBRMP. Marine megafauna form a significant component of the GBR's ecological, cultural and economic values and these animals are protected under the EPBC Act, the *Great Barrier Reef Marine Park Act 1975* (Cth) (GBRMP Act) and the *Nature Conservation Act 1992* (Qld).

Environmental Values

Marine mammals are valuable for their ecological, cultural economic and tourism significance. The ecological significance is evident through the listing for protection of many species under State and/or Commonwealth legislation, as well as internationally. Many of these species occur in the study area. Dugong are also recognised as one of the World Heritage values of the GBR. Dugong feeding patterns benefit the composition of seagrass meadows by encouraging the growth of pioneer species and increasing whole-plant nitrogen concentrations. Other species known to be ecologically significant includes dolphins. Dolphins are an important mobile predatory animal that can have significant influences on marine food-web interactions and ecosystem function and structure. Large changes to their distribution and abundance could have a large impact on the structure and functioning of coastal and open ocean ecosystems in the GBR.

Megafauna species such as marine turtles and dugong are an integral part of traditional culture for many coastal Indigenous people in northern Australia. Traditional Owners have the right to use marine resources under the *Native Title Act 1993* (Cth). The economic and tourism significance of species such as whales and dolphins is well known. The opportunity to see these species in the wild supports eco-tourism.

Contribution to OUV

Some 88 species of marine megafauna listed for protection at the Commonwealth level are either known to occur or may potentially occur (i.e. habitat exists which may support a resident population, breeding or feeding) in the study area.

All six species of marine turtle that occur in Queensland have been recorded in offshore, intertidal, estuarine and shoreline habitats in the Hay Point region. Hawksbill (*Eretomochelys imbricata*) and loggerhead (*Caretta*

AREA PROFILE: MEGAFAUNA

caretta) turtles also occur in the Mackay area, including observations of the species foraging within the Port of Mackay.

Mammals

Humpback whales (*Megaptera novaeangliae*) migrate through the study area June to October, peaking in August. Humpback whales use the waters off Hay Point during the migration.

The sei (*Balaenoptera musculus*) and fin (*Balaenoptera physalus*) whales are occasional visitors to the Hay Point area. While the blue (*Balaenoptera musculus*) and the southern right (*Eubalaena australis*) whales are listed as "may occur" in the study area, the study area is at the northern extent of their distribution and these species are unlikely to occur in inshore areas near the coast.

The pantropical spotted dolphin (*Stenella attenuate*), Indian Ocean bottlenose (*Tursiops aduncus*), Indo-Pacific humpback (*Sousa chinensis*) and potentially the Irrawaddy dolphin (*Orcaella brevirostris*) occurs in waters around Hay Point.

Dugongs are cited as one of the World Heritage values of the GBR. Dugongs are not known to forage in the study area due to the low abundance of seagrass, as noted above; however, seagrass in the study area could be important for transient dugongs moving along the coast during period of food shortage. Small herds of dugong have been recorded south of Hay Point at Ince Bay and Llewellyn Bay.

Reptiles

Mainland beaches in the study area are nesting sites for the flatback (*Natator depressus*) and possibly the green turtle (*Chelonia mydas*) may also nest at these locations. Haliday Bay, in the north of the study area, is one of the most important flatback nesting beaches in the Mackay region. A 2011 study of five potential nesting beaches around Hay Point and Dudgeon Point identified Louisa Creek Beach as the only site suitable for turtle nesting. However, turtle nesting has also been observed at McEwens Beach, Louisa Beach, Ballykeel Beach and Far Beach. Reptiles other than sea turtles known to occur or that may occur in the study area include sea snakes and the salt water crocodile (*Crocodylus porosus*).

Vulnerability

Many marine megafauna are mobile species that may travel large distances, which may expose them to numerous impacts. The vulnerability of megafauna varies depending upon the species, with potential impacts including:

- Boat strike/disturbance
- Marine pollution, including injury or fatality from ingestion of/entanglement in marine debris, hydrocarbon spills and other anthropogenic pollution
- Disease, for example the green turtle herpes virus, fibropapillomatosis, which has occurred in several other locations in Queensland, but has not yet been recorded in the study area
- Habitat loss and degradation (e.g. of seagrass, algal, coral reef and beaches) due to coastal development and human activity
- Physical displacement
- Underwater noise
- Declining water quality
- Fishing (e.g. trawling bycatch)
- Traditional hunting and possibly illegal poaching
- Incidental capture in shark control programs
- Climate change (e.g. through ocean acidification, increased water temperature, impacts on food resources)
- Storms, floods, cyclones causing either direct mortality and physical injury or due to impacts on food sources

AREA PROFILE: MEGAFAUNA

- Light pollution, particularly through the displacement and disorientation of nesting and hatchling turtles

Injury or death from maintenance dredging associated potentially impact marine turtles through physical interactions with the dredge. Dredging practices, including the use of includes turtle exclusion devices on the dredge head, can minimise the risks.

Gaps

No notable gaps in the available information have been identified from the perspective of the EVA. There is a gap in the relative contribution of the study area values to the broader GBR.

Summary of Importance

The study area provides general habitat for megafauna, but is not recognised as a significant area (for breeding, feeding, critical habitat etc.) for any megafauna.

What does this mean?

Many marine megafauna are mobile species that may travel large distances, which may expose them to numerous impacts occurring within and outside of the study area. The vulnerability of megafauna also varies depending upon the species.

A number of potential impacts to megafauna can however, be associated with port related activities. These include impacts associated with boat strike/disturbance, marine pollution, habitat loss and degradation, underwater noise, light pollution and dredging.

Regional summary

Marine megafauna are used for the design and justification of marine protected areas around the world. The waters offshore from Hay Point and Mackay are in the Mackay/Capricorn Management section of the GBRMP. Marine megafauna form a significant component of the GBR's ecological, cultural and economic values and these animals are protected under the EPBC Act, GBRMP Act and the Nature Conservation Act 1992 (Qld).

Overview of values

Marine mammals are valuable for their ecological, cultural economic and tourism significance. The ecological significance is evident through the listing of many species under State and/or Commonwealth legislation, as well as internationally. Many of these species occur in the study area. Dugong are also recognised as one of the World Heritage values of the GBR. Dugong feeding patterns benefit the composition of seagrass meadows by encouraging the growth of pioneer species and increasing whole-plant nitrogen concentrations. Other species known to be ecologically significant includes dolphins. Dolphins are an important mobile predatory animal that can have significant influences on marine food-web interactions and ecosystem function and structure. Large changes to their distribution and abundance could have a large impact on the structure and functioning of coastal and open ocean ecosystems in the GBR.

Megafauna species such as marine turtles and dugong are an integral part of traditional culture for many coastal Indigenous people northern Australia. Traditional Owners have the right to use marine resources under the *Native Title Act 1993* (Cth). The economic and tourism significance of species such as whales and dolphins is well known. The opportunity to see these species in the wild supports eco-tourism.

Description of places

An EPBC Act protected matters search of the Mackay and Hay Point area identified some 88 species of marine megafauna, listed for protection at the Commonwealth level, that are either known to occur or may potentially occur (i.e. habitat exists which may support a resident population, breeding or feeding) in the study area.

Megafauna identified in the protected matters search included marine mammals, reptiles (including marine turtles and sea snakes), sharks and rays, and fish (seahorse/pipefish).

Marine turtles

All six species of marine turtle that occur in Queensland have been recorded in offshore, intertidal, estuarine and shoreline habitats in the Hay Point region. Hawksbill (*Eretomochelys imbricata*) and loggerhead (*Caretta caretta*) turtles also occur in the Mackay area, including observations of the species foraging within the Port of Mackay.

Mainland beaches in the study area are nesting sites for the flatback (*Natator depressus*) and possibly the green turtle (C*helonia mydas*) may also nest at these locations. Haliday Bay, in the north of the study area, is one of the most important flatback nesting beaches in the Mackay region. A 2011 study of five potential nesting beach around Hay Point and Dudgeon Point identified Louisa Creek Beach as the only site suitable for turtle nesting. However, turtle nesting has also been observed at McEwens Beach, Louisa Beach, Ballykeel Beach and Far Beach.

Green turtles are the most frequently observed marine turtle in the study area. The main green turtle breeding season occurs from September to March, with hatchlings emerging from December to May. Green turtles have occasionally been recorded nesting on beaches between Dudgeon Point and Mt Hector Conservation Park. from November to April. Low density green turtle nesting has been recorded within the Hay Point port limits.

The flatback turtle is the predominant species known to nest in the Dudgeon Point area, and is the most commonly observed species nesting on beaches in the Mackay region. The Mackay region can have between 30 and 100 nesting flatback turtles nest annually across the 30 beaches, with each laying around three times per season. Hay Point Beach and Salonika Beach are known to be the most heavily used beaches, with limited nesting also known to occur on McEwens Beach, Louisa Beach, Ballykeel Beach and Far Beach. A low density nesting of flatback turtles have been recorded within the Hay Point port limits, with the peak nesting period occurring in November to December.

There is only a single record of leatherback turtle (*Dermochelys coriacea*) nesting in Mackay, with no recorded nesting since 1993. Loggerhead turtles have occasionally been sighted nesting in the Mackay region, with the first recorded sighting of a loggerhead nesting in the 2004/2005 season.

Inshore areas of the Port of Hay Point support a small resident population of green turtles. It has been suggested that they forage on algal covered rocky reefs and/or deepwater seagrass offshore of the coal terminals.

Marine mammals

Humpback whales migrate through the study area June to October, peaking in August. Humpback whales use the waters off Hay Point during the migration. Females with calves are relatively common within port limits during monitoring from 2009 to 2011. A core calving area has been identified offshore of Mackay. The exact location of this area is still unknown and further research is requried to conclusively identify the breeding habitats; however, this identified calving area is outside of the study area.

The sei and fin whales are occasional visitors to the Hay Point area. While the blue and the southern right whales are listed as “may occur” in the study area, the study area is at the northern extent of their distribution and these species are unlikely to occur in inshore areas near the coast.

The pantropical spotted dolphin (*Stenella attenuate*), Indian Ocean bottlenose (*Tursiops aduncus*), Indo-Pacific humpback (*Sousa chinensis*) and potentially the Irrawaddy dolphin (*Orcaella brevirostris*) occur in waters around Hay Point. These species are also likely to occur in the Mackay area. The Australian snubfin dolphin (*Orcaella heinsohni*) may also occur in the region due to the presence of its typical habitat (i.e. shallow coastal waters less than 20 m deep, often associated with tidal riverine and estuarine systems, enclosed bays and coastal lagoons).

As previously stated, dugongs are cited as one of the World Heritage values of the GBR. DPAs have been gazetted south of Hay Point at Llewellyn Bay (DPA Type B) and Ince Bay (DPA Type A), approximately 20 km and 35 km south of Hay Point, respectively. These areas have high ecological value associated with abundant seagrass, the primary food for dugongs. There are also DPAs north of the Mackay, at Sand Bay, Newry Region and Repulse Bay (outside of the study area), about 20 km, 40 km and 75 km north of Mackay, respectively. Small herds of dugong have been reported near Port Newry and Ince Bay.

Dugongs are not known to forage in the study area due to the low abundance of seagrass (as noted above); however, seagrass in the study area could be important for transient dugongs moving along the coast during period of food shortage. Small herds of dugong have been recorded south of Hay Point at Ince Bay and Llewellyn Bay.

Reptiles and fishes

Reptiles other than sea turtles known to occur or that may occur in the study area include sea snakes and the salt water crocodile. There have been sightings of saltwater crocodiles at the Tug Harbour.

The Bassett Basin Fish Habitat Area (FHA) is located near the mouth of the Pioneer River, about 1.5 km south of the Port of Mackay and 17 km north of the Hay Point. FHAs are established to protect inshore and estuarine fish habitats from disturbance by coastal development, while still allowing fishing.

Fish surveys in the Hay Point area from 2006 to 2008 found fish abundance to be very low compared to denser inshore seagrass habitats sampled elsewhere in Queensland. More recent surveys indicated that fish abundance and are also low on open sandy bottoms between the loading berths and the shoreline. Fish abundance and diversity are considerably higher in reef habitats, such as fringing reefs at Victor Islet, Round Top Island and Flat Top Island, which is typical on the inshore GBR. At these locations, the fish community is dominated by typical inshore species such as wrasses, damselfishes, angelfishes, butterflyfishes and snappers. Some fish species aggregate around the wharf pylons and structures at the Hay Point coal terminals.

Condition and variability

Many of the megafauna on the GBR are of conservation significance and listed for protection under State and/or Commonwealth legislation. Marine turtle foraging habitats have been identified as high priority areas for conservation in the GBRWHA, including the Mackay/Capricorn Management Area.

Vulnerability

Many marine megafauna are mobile species that may travel large distances, which may expose them to numerous impacts. The vulnerability of megafauna varies depending upon the species, with potential impacts including:

- Boat strike/disturbance
- Marine pollution, including injury or fatality from ingestion of/entanglement in marine debris, hydrocarbon spills and other anthropogenic pollution
- Disease, for example the green turtle herpes virus, fibropapillomatosis, which has occurred in several other locations in Queensland, but has not yet been recorded in the study area
- Habitat loss and degradation (e.g. of seagrass, algal, coral reef and beaches) due to coastal development and human activity
- Physical displacement
- Underwater noise
- Declining water quality
- Fishing (e.g. trawling bycatch)
- Traditional hunting and possibly illegal poaching

- Incidental capture in shark control programs
- Climate change (e.g. through ocean acidification, increased water temperature, impacts on food resources)
- Storms, floods, cyclones causing either direct mortality and physical injury or due to impacts on food sources
- Light pollution, particularly through the displacement and disorientation of nesting and hatchling turtles

Injury or death from maintenance dredging associated potentially impact marine turtles through physical interactions with the dredge. Dredging practices, including the use of includes turtle exclusion devices on the dredge head, can minimise the risks.

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3.5.8 Underwater noise

Regional summary

Underwater noise in the study area may be generated by port activities such as vessel movement and construction.

Overview of values

The ocean conducts sound very well. Some species, including whales and dolphins, rely on sound to communicate, hunt, navigate and sense their environment. Underwater noise can interfere with these functions on an individual and even population level. It can exclude these species from habitats or feeding areas if the animals avoid excessively noisy areas.

Description of places

Underwater noise from anthropogenic sources is generated from port-related activities at both the Port of Mackay and the Port of Hay Point. Activities at Mackay Harbour, adjacent to the Port of Mackay, also generate underwater noise. General shipping, and recreational and commercial fishing vessels, also generate noise throughout the study area. Shipping noise is likely to be greatest in and around shipping channels. While residential and other coastal development occurs in the study area, there is limited development of marine infrastructure; with the main development being boat ramps.

Condition and variability

As noted above anthropogenic noise is generated throughout the study area. Anthropogenic noise levels are almost certainly higher near centres of marine activities, but neither noise levels nor the effects of noise on animals have not been systematically monitoring in the study area.

Vulnerability

Construction activities including pile driving, underwater blasting and dredging can produce high levels of underwater sound, in excess of routine maritime activities. Blasting and piling generate particularly intense underwater noise that has the potential to significantly disturb or even injure marine mammals, sea turtles and fish in the vicinity of the activity. These can be managed by establishing exclusion zones around the activity, such that the zones are monitored and the noise-generating activities cease if fauna are observed within the zone, as well as through management measures such as limits on explosive charge sizes and “soft starts” at the commencement of pile driving.

Population increase and economic growth can be expected to lead to increased underwater noise. This is a growing concern in Australia and internationally, as it has become clear that human-generated noise can dominate the underwater soundscape. Internationally, measures such as improved ship design are proposed to reduce underwater noise generation.

Information sources

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3.6 Social values

3.6.1 Public amenity

AREA PROFILE: TOURISM, RECREATION AND PUBLIC AMENITY

Tourism and associated public amenities in the Mackay-Whitsunday Region is significant. In terms of the economic benefit to the Mackay Region, the overnight visitor economy is worth approximately $811 million across sectors including transport, accommodation, food services and retail. Tourism is also a major employment sector, with about 7,510 tourism jobs (either directly or indirectly) in the Mackay region.

Environmental Values

The diverse land uses, EVs and economic drivers in the Mackay-Whitsunday region all play a role in defining its character. This influences the liveability of the region, which is highly valued by both local residents and visitors. Beaches, riverine esplanades, regional and local parks, and open space provide recreational opportunities in close proximity to the urban population. The rural areas provide value through agricultural function and landscape character.

Contribution to OUV

Tourism and associated public amenities do not directly provide for OUV but maintaining the OUV is critical to the tourism industry.

Vulnerability

The strong focus of natural tourism destinations, such as the GBR and offshore islands, means that deterioration in the EVs of these natural assets has the potential to impact the tourist industry in the region. Further, development and growth in the study area has the potential to change the public amenity of the area.

Gaps

No notable gaps in the available information have been identified from the perspective of the EVA.

Summary of Importance

All offshore islands and large sections of the coastal fringe have been identified as having landscape character and/or forming part of the image corridor. The coastal fringe north and south of Hay Point is also mapped as part of the landscape character.

Mackay is also the jumping-off point for the outer reef. Specific areas for tourism and associated public amenities include:

- The GBR and offshore islands
- Brampton and Keswick Islands
- Armstrong, Sarina, Salonika and Grasstree beaches (south of the Port of Hay Point)
- Shoal and Slade points
- The Port of Hay Point lookout

What does this mean?

Tourism contributes approximately 3% of the economic output from the region, generating an estimated output of $457,403 million. The iconic nature of the GBR and offshore island gives tourists a reason to visit the region. As discussed above, the strong focus of natural tourism destinations means that deterioration in the EVs of these natural assets has the potential to negatively impact the tourist industry in the region. Balancing future growth and changes in the community is crucial to sustaining the liveability of the region.

Regional summary

The diverse land uses, EVs and economic drivers in the Mackay-Whitsunday region all play a role in defining its character. This influences the liveability of the region, which is highly valued by both local residents and visitors. Beaches, riverine esplanades, regional and local parks, and open space provide recreational opportunities in close proximity to the urban population. The rural areas provide value through agricultural function and landscape character.

Various planning and development frameworks are established to maintain and enhance the amenity of the study area. The main planning instruments are the Mackay Regional Council's planning scheme and the Mackay, Isaac and Whitsunday Regional Plan.

The Mackay, Sarina, Marian, Mirani and Walkerston are the main urban areas within the Mackay Regional Council local government (LGA). Mackay is the largest population centre of these urban areas and accommodated the majority of the population growth in the region (almost 70%). The Port of Mackay is approximately 6 km from Mackay, while Hay Point is approximately 17 km north east of Sarina. These urban areas ensure access to areas of high amenity value for recreation opportunities in urban areas.

The region's urban areas are serviced by five hospitals (four in Mackay and one in Sarina), two university campuses, a TAFE college, 57 schools, as well as a number of child care facilities, places of worship, community halls and sports/social clubs. Community facilities are provided by various government, private and community organisations. Regular public transport services are provided to and within Mackay, Sarina and Walkerston urban areas (approximately 950 services each week on 11 routes)

Regionally important park and recreation facilities/precincts include the Mack city centre riverfront (including Bluewater Lagoon, Bluewater Quay and Bluewater Trail), Regional Botanic Gardens, John Breen Park/Gooseponds precinct, Mulherin Park and Queens Park. Sporting and event facilities/precincts include South Mackay regional sporting precinct, Mackay and Sarina showgrounds, Ooralea Racecourse, Beaconsfield–North Mackay precinct and Golf Course, Brewers Park sub-regional sporting precinct in Sarina and the Sarina golf course.

Regionally important natural recreation areas include Mackay beaches, the Slade Point Nature Reserve and the Marian riverfront. Seaside foreshores and the East Point area in Mackay provide recreational and low intensity tourism opportunities that respect environmental constraints and benefits from the unique location on the riverine and seaside foreshore. In 2012, it was estimated that approximately 1,634 km^2 of the LGA was held as protected areas (e.g. national park, reserve). National parks make up about 845 km^2 (52%) of the protected area within the LGA.

The Mackay region has an established industry base and is projected to be the ninth largest growing LGA in Queensland from 2011 to 2036. Manufacturing and construction are major economic outputs from the region (making up approximately 37% of the regional output). In comparison, tourism contributes approximately 3% of the economic output from the region, generating an estimated output of $457,403 million.

The major industry for employment in the region (based on 2011 Census data) is the coal mining, with 8% of employed persons in the coal mining industry. This is significantly higher than the State and National percentages (1.2% and 0.4% respectively). The major industry employer around Hay Point is also coal mining; however, the major industry employer around the Port of Mackay is architectural, engineering and technical services.

Table 3.6 summarises the key demographic and community indicators for the localities around the Port of Mackay and Hay Point, the LGA and Queensland, based on 2011 Census data.

Table 3.6: Community profile and demographic indicators

Indicator	Mackay Harbour (gazetted locality)	Hay Point (gazetted locality)	Mackay Regional Council LGA	Queensland
Total area (km^2)	16.5	24.2	7,601.2	1,729,958.1
Population	733	1,470	112,798	4,332,739
Population density (persons/km^2)	44.4	60.7	14.8	2.5
Indigenous population (% of population)	0.5	4.1	4.4	3.6
Predominant country of birth (Top 3)	Aust. (74%) N.Z. (5%) England (3%)	Aust. (85%) N.Z. (2%) England (1%)	Aust. (82%) N.Z. (3%) England (2%)	Aust. (74%) N.Z. (4%) England (4%)
Gender ratio (female:male)	0.8:1	0.9:1	0.9:1	1:1
Median age	44	36	36	36
Predominant age group	50-54	50-54	45-49	40-44
Unemployment (%)	4	4.4	3.6	6.1
Industries of employment (Top 3)	Architectural, engineering & technical services (6%) Coal mining (5%) Real estate services (4%)	Coal mining (13%) Heavy & civil engineering construction (5%) Water transport support services (4%)	Coal mining (8%) School education (5%) Food services (3%)	School education (5%) Food services (4%) Hospitals (4%)
Median household income ($/weekly)	$1,799	$1,923	$1,578	$1,235
Average household size	2.2	2.9	2.7	2.6
Family characteristics				
• Total families	183	392	30,169	1,148,179
• Couples without children	114	157	11,783	453,102
• Couples with children	56	175	13,986	491,200
• One parent families	13	57	3,990	184,547
• Other families	0	3	410	19,330

Overview of values

The regional landscape is made up of multiple components, each with its own specific value and significance to the environment and residents of the region. Landscape areas provide multiple landscape values and ecosystem services. Inter-urban areas provide a valuable buffer between urban and agricultural areas, and rural areas have scenic amenity. The regional green space network provides a system of community areas that contributes to community health and wellbeing through physical activity, social interaction, liveability and direct interaction with the environment.

Visual amenity in the Hay Point area (e.g. particular outlooks when viewed from public places, public roads, thoroughfares, or residences) is valued by local communities. The aesthetics of the environment, including the appearance of structures as well as agriculture are also important values.

Description of places

Mackay Regional Council has identified areas with particular landscape character. These places have been identified to maintain and enhance the visual amenity of the region. All offshore islands and large sections of the coastal fringe have been identified as having landscape character and/or forming part of the image corridor. The coastal fringe north and south of Hay Point is also mapped as part of the landscape character.

Town/Far Beach, Sarina Beach and Armstrong Beach are popular tourist beaches. The closest of these to the Port of Mackay is Town/Far Beach, located approximately 8 km southwest of the port. The closest tourist beach to Hay Point is Sarina Beach, located approximately 12 km south of the port.

Popular tourist destinations also include the offshore islands. Keswick and St Bees are popular for walking and snorkelling and diving. These islands are located approximately 27 km from the Port of Mackay. Lindeman and Whitsunday Islands to the north of the Port of Mackay (approximately 75 km and 97 km) offer resort-style accommodation and activities.

Condition and variability

Landscape values should remain resilient to pressures from population growth, including requirements for major infrastructure. Identification of areas as part of the landscape character and image corridor under the Mackay Regional Planning Scheme affords these areas a certain level of protection from aspects of future development. Development within these areas is required to meet specific performance outcomes that will maintain or enhance the area's values.

Vulnerability

Development and growth in the study area has the potential to change the public amenity of the area. Balancing future growth and changes in the community is crucial to sustaining the liveability of the region.

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3.6.2 Tourism and recreation

Regional summary

Tourism in the Mackay-Whitsunday Region is a regionally significant sector. In terms of the economic benefit to the Mackay Region, the overnight visitor economy is worth approximately $811 million in direct and indirect expenditure across sectors including transport, accommodation, food services and retail. Tourism is also a major employment sector, with about 7,510 tourism jobs (either directly or indirectly) in the Mackay region.

Both residents and visitors undertake recreational and tourism activities based on the region's landscape character and areas of ecological significance. Attractions include national parks, gorges, and the GBR, as well as beaches and offshore islands.

Overview of values

The region's natural assets, particularly the GBRWHA, are a key to the tourist experience. The iconic nature of the GBR gives tourists a reason to visit the region. Other natural assets that are valuable draw cards include the proximity to offshore islands. Accessibility to high-quality and diverse fishing areas, including the reef and freshwater systems and dams, is also a valuable natural asset which attracts visitors to the region.

Description of places

The GBR and offshore islands are key tourist destinations within the region. Brampton and Keswick Islands are particularly important tourist destinations. Keswick Island and Brampton Islands are about 20 km and 33 km northeast of Hay Point, respectively.

Armstrong, Sarina, Salonika and Grasstree beaches are popular tourist beaches south of the Port of Hay Point. Other popular tourist beaches include Town and Far Beaches, which lie about 15 km northwest of the Port of Hay Point and about 6 km southwest of the Port of Mackay. Shoal and Slade points, north of the Port of Mackay are also popular coastal tourist destinations. The Port of Hay Point lookout is also a tourist site where tourists can view the port operations.

Condition and variability

Tourism in the region is highly reliant on the condition of natural assets to underpin the tourist experience. Both domestic and international tourism are also influenced by external factors. The global economic crisis, for example, saw a sharp reduction in international tourists, while a strong Australian dollar can result in an increase in domestic travel.

Vulnerability

The strong focus of natural tourism destinations, such as the GBR and offshore islands, means that deterioration in the EVs of these natural assets has the potential to impact the tourist industry in the region.

Information sources

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3.6.3 Traffic

Regional summary

Mackay and Sarina are the main service centres within the study area, with the Bruce Highway the main connector between the two centres. The hierarchy of roads throughout the study area maintains effective traffic movement.

Overview of values

The capacity of the existing road network and minimal traffic congestion provide many community and economic values. Traffic congestion is a significant issue in urban areas, but increased travel times due to increases in road use outside of urban areas can also be a significant community concern.

Description of places

Hay Point Road services the Port of Hay Point and the townships of Louisa Creek, Half Tide and Salonika. Hay Point Road is a two lane, bitumen-sealed road and is State controlled. Bally Keel Road intersects Hay Point Road east of the Bruce Highway and is a council controlled road that provides access to the southern boundary of the Dudgeon Point area. Harbour Road and Slade Point Road are bitumen-sealed, State controlled roads servicing the Port of Mackay, as well as Mackay Harbour and Slade Point.

A Queensland Rail network railway line operates in the Hay Point and Port of Mackay areas. The Hay Point network services coal trains from the Bowen Basin coalfields to the coal terminals. The Port of Mackay network services trains from the sugar mills and grain silos.

Condition and variability

The condition of Hay Point Road was reportedly affected by heavy loads during the Hay Point Coal Terminal Expansion project and remedial works were expected to be needed before future expansion projects.

Vulnerability

As the existing road network reaches its existing capacity, impacts on traffic will increase. Future port expansion would generate increased traffic during both construction and operation. Increased traffic including heavy commercial vehicles would be expected to use the road network. Increased traffic may impact local communities (e.g. noise, air/stormwater pollution, traffic delays) and transportation infrastructure.

Information sources

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3.6.4 Waste generation

Regional summary

Waste generated in the region includes both domestic and commercial waste. Within the Mackay Regional Council LGA, there are ten waste transfer stations and one resource recovery (recycling) facility (recycling facility). The main waste disposal facility is Paget Waste Management Centre. The remaining transfer facilities are supervised rural transfer stations. No commercial loads are accepted at any of the rural transfer stations; these must be taken to the Paget Waste Management Centre.

Overview of values

Waste management encourages sustainable practices. Provision of dedicated and appropriately managed collection, recycling, transfer and storage of waste protects human health and the environment.

Description of places

The Hay Point Rural Transfer Station is located approximately 2.5 km west of the Port of Hay Point. This transfer station does not accept commercial waste. The Paget Waste Management Centre is located about 16 km northwest of the Port of Hay Point and about 11 km southwest of the Port of Mackay.

Condition and variability

Illegal waste dumping is common on public land throughout the Mackay area and presents a significant, ongoing management issue.

Vulnerability

Illegal waste dumping/littering can result in management issues including weed infestation from dumping of garden waste and waterway pollution (including of beaches and offshore waters). Introduction of non-biodegradable plastics and other pollutants (e.g. vehicle oils/fluids) can also negatively impact natural systems and their flora and fauna. Public amenity can be reduced due to the unsightly impacts associated with illegal dumping, and increase the risks to public health.

Information sources

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3.6.5 Fisheries

AREA PROFILE: FISHERIES

Queensland's largest and most diverse fishery comprises commercial, recreational, charter and Indigenous sectors. The commercial sector is Queensland's fourth most valuable fishery (includes the Mackay region). The most recent data from the Australian Bureau of Statistics show that Queensland commercial fisheries produced over 33 million kg per year.

Recreational fishing surveys in 2010 identified that the most popular recreational method was line fishing, with 547,000 fish caught, 308,000 of which were released.

Environmental Values

Fisheries support:

- The local economy
- Tourism – as the principal extractive use of the GBR
- Approximately 34 000 people, or 24.8% of the Mackay-Whitsunday population, were recreational fishers

Contribution to OUV

Fisheries do not directly provide for OUV but do provide a financial incentive to maintain and support OUV, they also are a potential threat to OUV.

Vulnerability

Commercial, and to a lesser extent recreational fishing, increases the vulnerability of other EVs including marine fauna, seagrass and migratory shorebirds. Careful management is necessary to maintain sustainable levels of

AREA PROFILE: FISHERIES

species. Fisheries in the Mackay-Whitsunday region and the GBR generally are managed by the Queensland government, and fisheries management is considered to be generally effective.

Fisheries are threatened by:

- Overfishing
- Habitat loss
- Water quality degradation
- Increased storm intensity and frequency
- Loss of a few key species – can have flow-on effects to commercial and recreational fisheries

Gaps

No notable gaps in the available information have been identified

Summary of Importance

Commercial and recreational fishing is important to the Mackay-Whitsunday Region. Important areas for fisheries include:

- Newry Island and Newry Bay
- Llewellyn Bay
- Dudgeon Point and the Hay Point coastline
- Newry Region

What does this mean?

Commercial catches of some species have been declining in the GBR. Zoning within the GBRMP is established to protect areas that are important to specific species or spawning areas, and to provide refuges intended to enhance fish populations generally.

3.6.5.1 Commercial

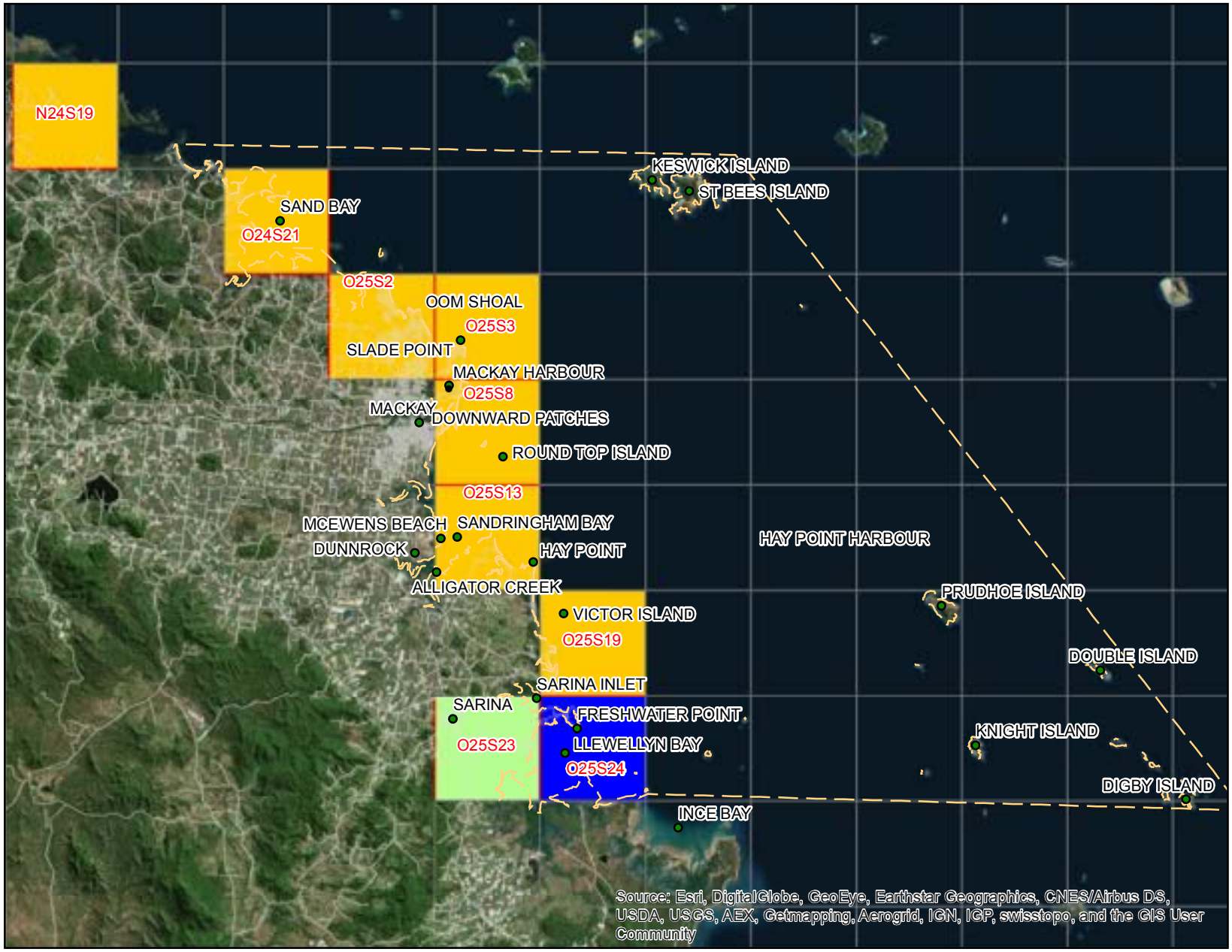
Queensland's diverse fisheries include the commercial, recreational, charter and Indigenous sectors. The commercial sector is Queensland's fourth most valuable fishery (which includes the Mackay region). The most recent data from the Australian Bureau of Statistics show that Queensland commercial fisheries produced over 33 million kg per year and a gross value of $4 million for the year 2009 to 2010.

The trawl fishery is Queensland's largest commercial fishery, with about 600 vessels producing up to 10,000 t of product worth about $110 million each year. Approximately 95% of the reported commercial catch of Coral Reef Fin Fishery (CRFF) over the 2010 to 2011 period was taken from areas within the GBRMP.

Prawns are the most valuable catch in the study area ($155,860), making up almost half of the total commercial fishery value for the year. However, other species targeted in the Mackay-Whitsunday Region include coral trout, red throat emperor (*Lutjanus sebae*), spangled emperor (*Lethrinus nebulosus*), saddletail snapper (*Lutjanus malabaricus*), stripey snapper (*Lutjanus carponotatus*) and rockcod (*Epinephalus ergastularius* and *E. octofaciatus*).

A spatial description of commercial fishing activity within the Mackay region (as catch weight) between 2004 and 2014 is defined in Figure 3–14 to Figure 3–17, and includes net, trawl, pot fishing and combined total catches, respectively. The data are based on fisher logbooks and reflect total catches within each defined grid (10 x 10 km grid cells defined by Dept. of Agriculture, Fisheries and Forestry).

Figure 3-14 Fish grids - net



LEGEND

- Landmass Project Extent
- Ocean Project Extent

Net Catch (2003 - 2014)

- No Catch
- < 10000 Kg
- 100000 - 200000 Kg
- 200000 - 300000 Kg
- > 300000 Kg

GDA94

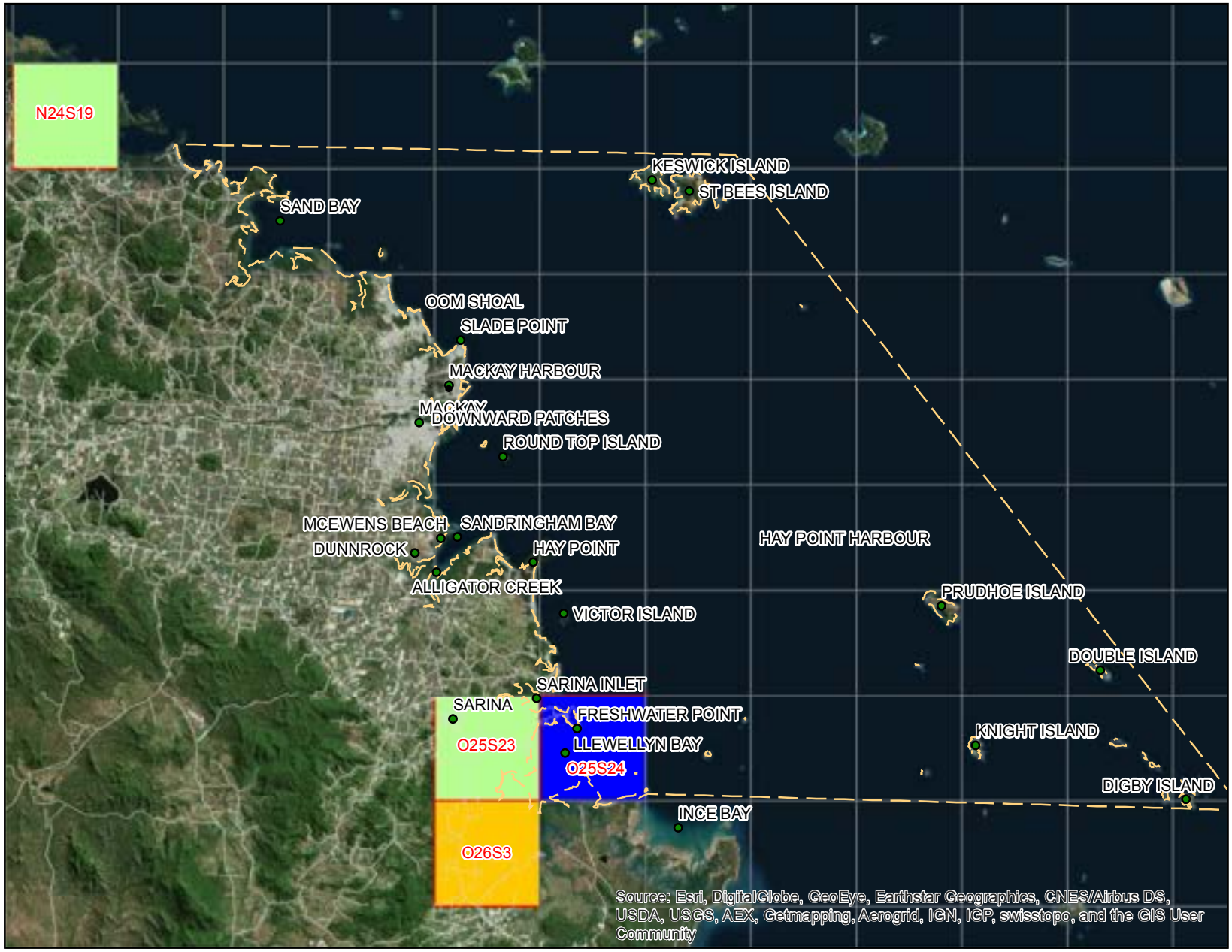
A4 1:600,000

0 5 10

Kilometers

JACOBS

Figure 3-15 Fish grids - pot



LEGEND

- Landmass Project Extent
- Ocean Project Extent

Pot Catch (2003 - 2014)

- No Catch
- < 20000 Kg
- 20000 - 40000 Kg
- 40000 - 60000 Kg
- > 60000 Kg

GDA94

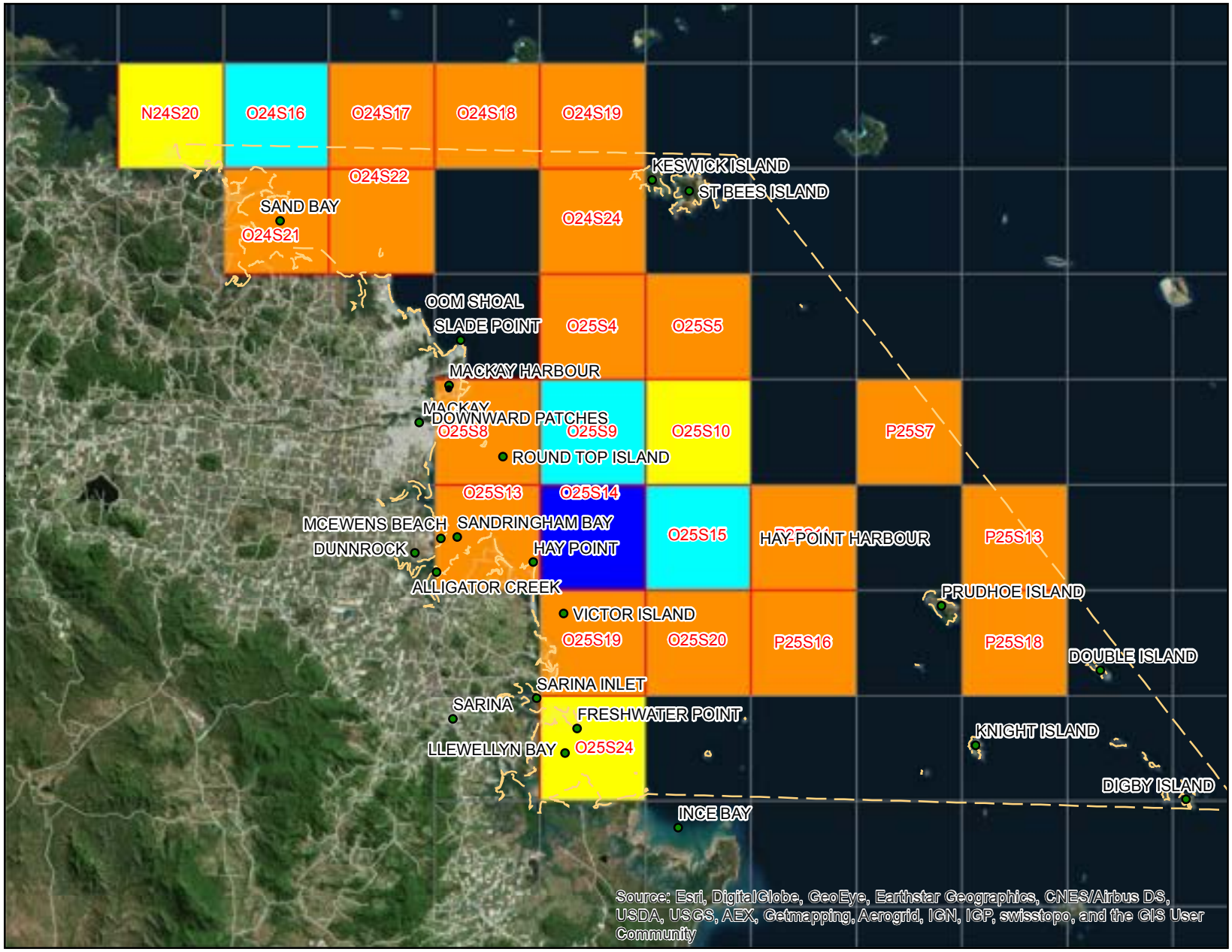
A4 1:600,000

0 5 10

Kilometers

JACOBS

Figure 3-16 Fish grids - trawl



LEGEND

- Landmass Project Extent
- Ocean Project Extent

Trawl Catch (2003 - 2014)

- No Catch
- < 50000 Kg
- 50000 - 100000 Kg
- 100000 - 150000 Kg
- 150000 - 200000 Kg
- 200000 - 250000 Kg
- > 250000 Kg

GDA94

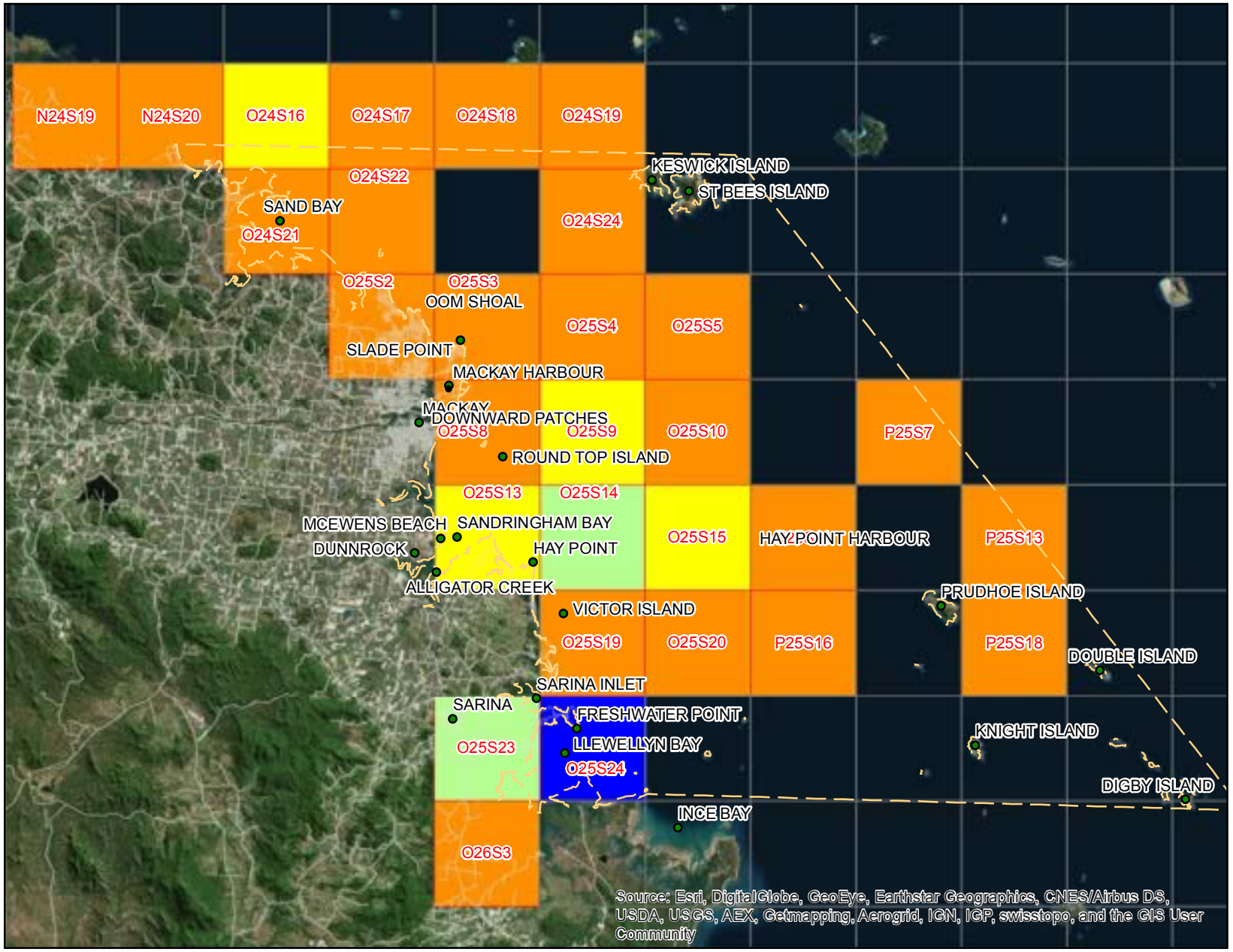
A4 1:600,000

0 5 10

Kilometers

JACOBS

Figure 3-17 Fish grids - total



LEGEND

- Landmass Project Extent
- Ocean Project Extent

Total Catch (2003 - 2014)

- No Catch
- < 100000 Kg
- 100000 - 200000 Kg
- 200000 - 300000 Kg
- 300000 - 400000 Kg
- 400000 - 500000 Kg
- > 500000 Kg

GDA94

A4 1:600,000

0 5 10

Kilometers

JACOBS

Based on this ten year dataset, the largest combined catches have been observed in waters containing Freshwater Point and Llewellyn Bay (>500,000 kg) and to the west of Hay Point (>20,000 kg). In the grids containing Hay point and Sandringham Bay (grid ref, O25S13), Sarina Inlet (O23S23), and grids O25S9 and O24S16, catches were in excess of 100,000 kg. Outside of these areas, total catches were all below 10,000 kg.

The trawl fishery is Queensland's largest commercial fishery, with about 600 vessels producing up to 10,000 t of product worth about $110 million each year. Most species are caught in the East Coast Otter Trawl Fishery (located between Cape York and Cape Conway). Within the Mackay region, waters to the east and north of Hay Point show the greatest values of catch weight (>150,000 kg, grid refs O25S14, O25S9 and O25S15), followed by waters around Freshwater Point and Llewellyn Bay.

Data from commercial net fishing relates only to coastal fringes. The highest catch weights were recorded in waters surrounding Freshwater Point and Llewellyn Bay (>300,000 kg). Elsewhere along the coast, catch weights across the years were below 1,000 kg.

Pot fishing is relatively small and largely confined to waters around Freshwater Point and Llewellyn Bay (~60,000 kg) and to the very east of the Mackay region (N24S19).

Species-specific information about fin fish, based on 2010-11 data, showed:

- Catches of coral trout (CT) are high throughout the extent of the GBR east and north of Shoalwater Bay
- The catch of red throat emperor (RTE) was highest in the central section between Townsville and Mackay. High catch of other coral reef species recorded in the southern regions were driven by catches of deep water bar rockcod (*E. ergastularius* and *E. octofaciatus*)
- In the north, high catches comprised of spangled emperor (*Lethrinus nebulosus*) but also red emperor (*Lutjanus sebae*), saddletail snapper (*Lutjanus malabaricus*) and stripey snapper (*Lutjanus carponotatus*)

3.6.5.2 Recreational

Recreational fishing is very important in the Mackay-Whitsunday Region. Approximately 28% of Mackay area resident's fish recreationally, compared to the state average of 17%. Recreational fishing surveys in 2010 identified that the most popular recreational method was line fishing, with 547,000 fish caught, 308,000 of which were released.

The most commonly caught fish (by species group) are tropical snappers and sea perch, with 91,000 caught in 2010, 12% of the total catch for the year. It is estimated that close to half of the catch was released. Yabbies were also a popular catch, also with an estimated total of 91,000 (12%) in 2010; however, 90% of yabbies caught were kept; yabbies' are primarily used as bait. Emperors were also popular, with 74,000 fish caught (10% of the total), with about half of them released.

In 2014, a more detailed species-level study indicated that the most commonly targeted species by Mackay-Whitsunday residents were sand whiting, mud crab, barred javelin, barramundi, coral trout and yellowfin bream. Barred javelin had high release rates. Mud crabs were the most commonly caught non-fish species, but many more were released than kept as a result of size and bag limits and the prohibition of retaining males.

Condition and variability

Commercial catches of some species have been declining in the GBR. A zoning plan is in place in the GBRMP to protect areas that are important to specific species or spawning areas, and to provide refuges intended to enhance fish populations generally.

Most predator fish populations on the GBR are relatively healthy, but a few species are under serious pressure. Removal of top predators, such as sharks, has potential flow-on effects on habitats and other species in the ecosystem.

Vulnerability

Fishing is the principal extractive use of the GBR. Commercial, and to a lesser extent recreational fishing, increases the vulnerability of other EVs including marine fauna, seagrass and migratory shorebirds. Careful management is necessary to maintain sustainable levels of species. Fisheries in the Mackay-Whitsunday region and the GBR generally are managed by the Queensland government, and fisheries management is considered to be generally effective.

Fisheries are vulnerable to overfishing, habitat loss, water quality degradation, and increased storm intensity and frequency. Catches of non-target species (by-catch), including protected species and other species of conservation concern, can alter the ecological balance and has the potential to increase the vulnerability of fisheries. The loss of a few key species in the ecosystem can have flow-on effects to commercial and recreational fisheries species.

Information sources

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Queensland Government (2014). Status Report 2011 – 2014: Queensland East Coast Inshore Fin Fish Fishery. Queensland Government.

3.6.6 Non-indigenous heritage

AREA PROFILE: NON-INDIGENOUS HERITAGE

Cultural heritage is considered to be items or places with aesthetic, historic, scientific or social significance for current and future generations.
Environmental Values
Non-indigenous cultural heritage include:

AREA PROFILE: NON-INDIGENOUS HERITAGE

- the GBRWHA
- Mount Hector Conservation Park
- Flat Top Island lighthouse

Contribution to OUV

The GBR was declared a World Heritage Area in 1981, internationally recognised by the World Heritage Committee for its outstanding universal value.

As such it contributes to the listed OUV outlined below:

- Globally outstanding example of an ecosystem evolved over millennia through glacial cycles
- Significant diversity of reef and island morphologies reflecting geomorphic, oceanographic and environmental processes
- Complex string of reef structures along the coast
- World's largest coral reef ecosystem, including examples of all stages of reef development

Vulnerability

Programs to improve the resilience of the GBR are being implemented at the State and Commonwealth levels. These programs are targeted at improving water quality, both within the marine environment and in the catchments feeding into the GBR. Programs to reduce the loss of coastal habitats and increase understanding of the effects of fishing and encourage sustainable practices are also being implemented.

Gaps

No notable gaps in the available information have been identified.

Summary of Importance

Aside from the GBRWHA, non-indigenous heritage places listed for protection in the study area are generally restricted to sites in Mackay. Both the Mount Hector Conservation Park and Flat Top Island lighthouse were listed on the Register of the National Estate, which was closed in 2007 and no longer has any statutory authority.

Important cultural heritage areas include:

- the GBRWHA
- Mount Hector Conservation Park
- Flat Top Island lighthouse

What does this mean?

Aside from the GBRWHA, non-indigenous heritage places listed for protection in the study area are generally within the developed, urban area of Mackay. Howerver, this does not mean that additional sites of local and State heritage significance will not be identified in the future.restricted to sites in Mackay. Both the Mount Hector Conservation Park and Flat Top Island lighthouse were listed on the Register of the National Estate, which was closed in 2007 and no longer has any statutory authority.

Regional summary

Aside from the GBRWHA, non-indigenous heritage places listed for protection in the study area are generally restricted to sites in Mackay, although some sites of State significance are outside the city. Other items or sites of cultural heritage that may be of significance to particular stakeholders or local residents may be scattered throughout the study area.

Overview of values

Cultural heritage is considered to be items or places with aesthetic, historic, scientific or social significance for current and future generations. Cultural heritage can classified as being of National, State and/or local significance. World Heritage places are also sites which are considered to be of significance to the global community.

Description of places

Mackay Regional Council has identified local heritage places, which are sites considered significant at the local level. All local heritage places are within the city of Mackay. At the State level, 32 sites listed on the Queensland Heritage Register that are in the Mackay Regional Council LGA, which includes areas outside the study area. Most of these sites are in Mackay. At Hay Point, the closest State heritage site is about 17 km away in Sarina, which is outside the study area.

Cultural heritage at the Commonwealth level is listed on the World Heritage List (sites that represent best examples of the world's cultural and natural heritage), National Heritage List (natural historical and indigenous places of outstanding significance to the nation) or Commonwealth Heritage List (natural, indigenous and historic places owned or controlled by the Australian government). Within the study area, the GBR is the only listed site.

The GBR was declared a World Heritage Property in 1981 and is also listed on both the National Heritage List and Commonwealth Heritage List. The GBRWHA extends from the mean low water mark and covers an area of about 348,000 km^2.

Mount Hector Conservation Park and Flat Top Island lighthouse were both registered places on the Register of the National Estate. This register was closed in 2007, and while the register no longer has any statutory authority, the list of properties is still available as a public and educational resource.

The sugar wharf at Louisa Creek has been identified as a site of local cultural heritage significance in studies for the Port of Hay Point. This site is not currently listed; however, it has been identified as having cultural heritage significance for the local sugar industry.

The Australian National Shipwreck Database identifies a number of shipwrecks within the study area. The majority of the shipwrecks are located in or around the mouth of the Pioneer River. None of these are listed as National maritime cultural heritage.

Condition and variability

The condition of the GBRWHA has been widely reported on, with emerging issues including port expansion, increased shipping, coastal development, intensification of and changes in land use in the catchments, resultant declines in water quality, population growth, marine debris, illegal activities, increases in extreme weather events including floods and cyclones, and other effects of climate change.

Vulnerability

Culturally significant areas and/or sites are protected under local, State or Commonwealth legislation. Additional items can be protected or added to heritage protection lists, should sufficient evidence of their significance be provided. Adding sites to heritage protection lists generally occurs when stakeholders seek protection of a

significant item, site or place. This can be triggered by encroachment of development or some other activity which places the item at risk of being lost.

Programs to improve the resilience of the GBR are being implemented at the State and Commonwealth levels. These programs are targeted at improving water quality, both within the marine environment and in the catchments feeding into the GBR. Programs to reduce the loss of coastal habitats and increase understanding of the effects of fishing and encourage sustainable practices are also being implemented.

Information sources

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WBM Oceanics (2004). Spoil ground site selection Port of Hay Point. June. Prepared for Ports Corporation Queensland, Queensland.

3.6.7 Indigenous heritage

AREA PROFILE: INDIGENOUS HERITAGE

Indigenous connection and cultural association with the GBR and adjacent coastal area is well recognised. More than 70 Aboriginal and Torres Strait Islander Traditional Owner clan groups are situated along the coast from the eastern Torres Strait Islands to just north of Bundaberg.

Environmental Values

NQBP-commissioned cultural heritage surveys of the Port of Hay Point have identified some areas of high cultural significance. The Mount Hector Conservation Park and adjacent coastal areas have indigenous cultural heritage significance. A fish trap of archaeological significance has been located in the small bay between DBCT and HPCT.

Contribution to OUV

The Great Barrier Reef Marine Park Authority (GBRMPA) works with Aboriginal and Torres Strait Islander Traditional Owners and acknowledges their continuing social, cultural, economic and spiritual connections to the Great Barrier Reef region. Therefore, indigenous heritage plays an integral part in the GBR and an indirect part in many aspects of the OUV.

Vulnerability

Development and ground disturbance are the main factors increasing the vulnerability of cultural heritage. Expansion of port-related activities could disturb or damage significant cultural areas or objects.

AREA PROFILE: INDIGENOUS HERITAGE

Gaps
No notable gaps in the available information have been identified.
Summary of Importance
Indigenous heritage plays an integral part in the GBR and, therefore, an indirect part in many aspects of the OUV. Other important areas include: • The Mount Hector Conservation Park • A fish trap of archaeological significance has been located in the small bay between DBCT and HPCT.
What does this mean?
Aboriginal cultural heritage can be both tangible items or objects and intangible elements, such as places of significance due to the connection and sense of belonging that the people have with the landscape and each other or the significance they have in creation stories and lore. The primary source of the value of cultural heritage is from the Aboriginal people to which the heritage relates. Cultural knowledge and other information relating specifically to their heritage is often integral to determining the value of a cultural heritage item or place.

Regional summary

Indigenous connection and cultural association with the GBR and adjacent coastal area is well recognised. More than 70 Aboriginal and Torres Strait Islander Traditional Owner clan groups are situated along the coast from the eastern Torres Strait Islands to just north of Bundaberg. The Mackay-Whitsunday Region supports a large and culturally diverse Indigenous population.

Cultural heritage relates to the places and items that are of significance to Aboriginal people. The cultural heritage reflects the Aboriginal connection to the area. Aboriginal cultural heritage can be both tangible items or objects and intangible elements, such as places of significance due to the connection and sense of belonging that the people have with the landscape and each other or the significance they have in creation stories and lore.

Overview of values

The primary source of the value of cultural heritage is from the Aboriginal people to which the heritage relates. Cultural knowledge and other information relating specifically to their heritage is often integral to determining the value of a cultural heritage item or place.

Description of places

Lands under the control of the Port of Mackay were used by Traditional Owners for hunting and collecting resources. Aboriginal cultural heritage surveys have been conducted at the Port of Mackay. No Aboriginal cultural heritage material has been identified; however, Port lands are known to have a range of traditional resources, such as bush medicines.

NQBP-commissioned cultural heritage surveys of the Port of Hay Point have identified some areas of high cultural significance. The Mount Hector Conservation Park and adjacent coastal areas have indigenous cultural heritage significance. A fish trap of archaeological significance has been located in the small bay between DBCT and HPCT.

Condition and variability

All items of Aboriginal cultural heritage in Queensland, whether registered or not or in good condition or not, are protected under the Aboriginal Cultural Heritage Act 2003 (Qld).

Vulnerability

Development and ground disturbance are the main factors increasing the vulnerability of cultural heritage. Expansion of port-related activities could disturb or damage significant cultural areas or objects.

Information sources

Connel Hatch (2009). Appendix E, Marine Ecology Assessment Hay Point Coal Terminal Expansion, BM Alliance Coal Operations Pty Ltd. 11 February 2009 Reference H330156. Revision 6. Connell Hatch. Spring Hill, Queensland.

North Queensland Bulk Ports (2011). Dudgeon Point Coal Terminals Project Initial Advice Statement. September 2011, North Queensland Bulk Ports.

WBM Oceanics (2004). Spoil Disposal Options Assessment. Appendix C for the Draft Environmental Impact Statement. Spoil Ground Site Selection Port of Hay Point, Assessment for land disposal options for dredge spoil at the Port of Hay Point. Available at: http://eisdocs.dsdip.qld.gov.au/Port%20of%20Hay%20Point%20Apron%20Areas%20and%20Departure%20Path%20Capital%20Dredging/EIS/appendix-c-spoil-ground-selection-(wbm-2004)-1.pdf. Ports Corporation of Queensland.

4. Gap Analysis

Many of the EVs in the study area have been extensively studied and documented, particularly the marine environments. However, some gaps in information include the following:

- ***Focus of studies.*** Many of the available studies are focused on specific issues (such as reporting on the GBR health) or assessing potential impacts associated with new development. The objectives for these studies are generally narrow and project-specific. Less work has been done on interactions among EVs, or on the status and vulnerability of EVs at the scale of the study area.
- ***Ongoing monitoring.*** Similarly, monitoring has often targeted project-specific environmental approvals or licensing conditions. Therefore, the parameters and sites monitored have often been project-specific and short-term. To remedy this gap, NQBP has established a long-term program to monitor water quality and seagrass and macroinvertebrate communities on the spatial scale of the present study area.
- ***Ability to compare data and results.*** A number of studies have been undertaken to provide 'snapshots' of the environmental conditions or aspects in the study area. These studies do not necessarily provide any connection to previous studies or allow comparison of the results.
- ***Shorebird population decline.*** Shorebird numbers in the region have declined and the reason for this is not clear. The physical nature of the roost sites has not changed yet the numbers have declined. Shorebirds are known to be sensitive to disturbances including noise, dust and light; however, evidence that disturbance is the main factor for the decline is not available.

5. Future Risks and Opportunities

5.1 Vulnerability of values to port activities

5.1.1 Land-based port activities

Desire to live and recreate within the coastal fringe has seen extensive development along the east coast of Australia. Much of the remaining undeveloped areas now provide important habitat for flora and fauna. This is no different within the study area. Undeveloped land surrounding the Port of Mackay is largely mapped as of-concern or endangered remnant vegetation. While there are cleared areas west of the Port of Hay Point, patches of endangered and of-concern regional ecosystems exist north and south of the Port. TECs and important wetlands also lie in close proximity to both ports. These areas provide important habitat for shorebirds and other threatened species. Important mangrove communities occur north and south of the Port of Mackay and north of the Port of Hay Point.

Direct disturbance of these areas would place further pressure on the remaining EVs in the study area. Clearance and development of these areas can also further fragment and isolate the ecosystems and reduce their functionality. Indirect disturbance can also influence the EVs of these areas. For example increases in dust, sediment loads, noise or light can place these communities under pressure.

Human communities surrounding the Port of Hay Point are also affected by port activities. While these communities have been living near and often working with the Port for many years, issues such as coal dust and noise have required ongoing work to resolve. Future port activities, including expansion of activities toward these communities, have the potential to change the character of the communities and reduce their liveability.

Remnant vegetation provides the Port of Hay Point some buffer between the surrounding residential areas. However, there is increasing pressure on this resource from coastal development. Changes in port activities or expansion of the Port of Mackay could also change the public amenity and character of the surrounding area.

5.1.2 Marine-based port activities

Aside from the movement of ships, the main marine activity of the ports is the disposal of maintenance dredge material. As with the environmental values within the terrestrial environment, direct disturbance by the placement dredge material can impact EVs such as corals and seagrass. This can indirectly disturb species that may inhabit or rely on these areas for their food resources.

The environmental value of the GBR is well known and studied. The continued pressure that land based activities is having on the reef is recognised. Decreased water quality and increased sediment loads entering the reef from land based activities can directly impact the EVs of the reef.

5.2 Resilience

The resilience of the EVs in the study area varies for each value. However, the main factor that influences resilience for all EVs is the pressure that the value faces now and in the future. If the value is under a number of different pressures, resilience to a new or increasing pressure is reduced. For example, coral reefs in relatively pristine environments are naturally resilient and have been shown to recover from disturbances such as damage from cyclones or COTS outbreaks within a few decades at most. Declining water quality, however, reduces this resilience to disturbance events and makes them more susceptible to disease.

Some EVs have been shown to be quite resilient. Seagrass beds in the study area are highly variable, changing in area and species composition through time. Certain species of seagrass have been shown to be quite resilient to periodic disturbances, while other species or communities (such as dense coastal seagrass meadows) do not demonstrate the same resilience.

Other EVs are less resilient. For example, terrestrial vegetation, once disturbed, can take a long time to recover, if it ever does, without active rehabilitation. The specific characteristics and requirements of some vegetation communities or flora species can mean that clearing or degradation cannot be offset somewhere else.

Appendix A. Summary and Special Values of REs in the Study Area

Regional Ecosystem	Name	Total area within study area (ha)	% of QLD total	VMA Class[1]	BD status[2]	Special values	TEC?
8.1.1	Mangrove closed forest of marine clay plains and estuaries	306.8	0.76%	LC	NCAP	Many of the plant species defining this vegetation type are unique to it, or only to this and other land zone 1 regional ecosystems. Breeding site for many marine fish species and habitat for a large number of specialised fauna and flora species which are restricted to this ecosystem. Recent records of the Little Kingfisher, which is largely restricted to this ecosystem, extend its previous known range (southern limit) (Malcolm et al., 1996). This regional ecosystem is also habitat for the significant species False Water Rat (listed as "Vulnerable" in the Queensland Nature Conservation Act 1992), Rusty Monitor, Crocodile, Mongolian Plover, Sooty Oystercatcher, Great Knot, Eastern Curlew, Terek Sandpipers, Bar-tailed Godwits, Whimbrel, Pacific Golden Plover, Pied Oystercatcher, Ruddy Turnstone (Watkins 1993), and Great -billed Heron (Crouter in Low 1993).	No
8.1.2	Samphire open forbland on saltpans and plains adjacent to mangroves	185.7	1.8	LC	OC	Habitat for *Tecticornia indica*, *Tecticornia halocnemoides* subsp. *tenuis*, *Sarcocornia quinqueflora*, *Tecticornia pergranulata* subsp. *queenslandica* which are largely restricted to this ecosystem. Many of the plant species defining this vegetation type are unique to it. Habitat for the significant species Beach Thick-knee, Mongolian Plover, Sooty Oystercatcher, Great Knot, Eastern Curlew, Terek Sandpiper, Bar-tailed Godwit, Whimbrel, Pacific Golden Plover, Pied Oystercatcher, and Ruddy Turnstone. (Watkins 1993).	No
8.1.3	*Sporobolus virginicus* tussock grassland on marine sediments	360.3	8.6	OC	OC	Many of the plant species defining this vegetation type are unique to it, or only to this and other land zone 1 regional ecosystems. Habitat for the threatened fauna species False Water Rat (*Xeromys myoides*) which is listed as "Vulnerable" in the *Queensland Nature Conservation Act 1992*.	No
8.1.4	*Schoenoplectus subulatus* and/or *Eleocharis dulcis* sedgeland or *Paspalum vaginatum* tussock grassland	249.0	17.4	OC	E	This RE is the main stronghold for *Schoenoplectus subulatus*, *Phragmites* spp. and *Eleocharis* dulcis. Habitat for the threatened fauna species False *Water Rat* (*Xeromys myoides*) (listed as "Vulnerable" in the *Queensland Nature Conservation Act 1992*) and the locally rare species Swamp Rat (*Rattus lutreolus*), and Pale Field Rat (*Rattus tunneyi*). Important as habitat for *Schoenoplectus subulatus*, *Paspalum vaginatum*, *P. distichum*, *Phragmites australis* and *Eleocharis spiralis* which are largely restricted to this	No

Regional Ecosystem	Name	Total area within study area (ha)	% of QLD total	VMA Class[1]	BD status[2]	Special values	TEC?
						regional ecosystem.	
8.1.5	*Melaleuca* spp. and/or *Eucalyptus* tereticornis and/or *Corymbia tessellaris* woodland with a ground stratum of salt tolerant grasses and sedges, usually in a narrow zone adjoining tidal ecosystems	120.8	9.9	OC	E	Habitat for the threatened fauna species False Water Rat (*Xeromys myoides*), (listed as "Vulnerable" in the Q*ueensland Nature Conservation Act 1992*) and the locally rare species Swamp Rat (*Rattus lutreolus*), and Pale Field Rat (*Rattus tunneyi*). Stronghold for the locally uncommon *Ceratopteris thalictroides*. Habitat for *Eleocharis* spp. which have a very restricted habitat range (e.g. *Eleocharis spiralis*). Habitat for some species which are poorly known or collected from CQC including *Bacopa monnieri* and *Nymphoides exiliflora*.	No
8.2.1	*Casuarina equisetifolia* woodland and/or sparse herbland to open scrub on foredunes and beaches	73.6	8.0	OC	OC	Provides nesting sites for significant species including the Flat Back Turtle (*Natator* depressus) (Pollock, 1995), and Beach Thick Knee, both are listed as "Vulnerable" in the *Queensland Nature Conservation Act 1992*. Habitat for the significant species Mongolian Plover, Sooty Oystercatcher, Great Knot, Eastern Curlew, Terek Sandpiper, Bar-tailed Godwit and Ruddy Turnstones (Watkins 1993). At the southern end of the bioregion (near Yeppoon) this ecosystem is possible habitat for *Paspalum batianoffii* listed as "Extinct" in the Queensland Nature Conservation Act 1992.	No
8.2.2	Semi-evergreen microphyll vine thicket to vine forest, on coastal dunes	44.1	2.0	OC	E	Habitat for flora species including *Xylosma ovata* (where sand overlies rocky substrate), *Brachychiton compactus*, *Senna acclinis*, *Rourea brachyandra*, *Bonamia dietrichiana* and *Macropteranthes fitzalanii*, *Cassia* sp. (Paluma Range G.Sankowsky+ 450), which are all listed as "Near Threatened" in the *Queensland Nature Conservation Act 1992*. Habitat for some plant species which are poorly known or collected from the Central Queensland Coast bioregion such as Brachychiton *acerifolius*, *Brachychiton bidwillii*, *Caesalpinia crista*, and a few range-restricted species such as Gossia *pubiflora*. Habitat for endemic snails and migratory birds - particularly significant for fruit pigeons.	Yes
8.2.6	*Corymbia tessellaris* +/- *Acacia leptocarpa* +/- *Allocasuarina littoralis* +/- *Banksia integrifolia* +/- rainforest species open forest on parallel dunes	364.1	7.7	OC	OC	Potential habitat for the species *Livistona drudei* which is listed as "Vulnerable" in the *Queensland Nature Conservation Act 1992*, (the only currently known records for this species in the Central Queensland Coast lie in the adjacent RE 8.12.13a on a sandy creekline). Habitat for the locally rare species *Acacia dietrichiana* (Pollock, 1995). Habitat for the Grey Goshawk and Beach Thick-knee.8.2.6x1a: Habitat for *Zoysia macrantha* subsp. macrantha which is at the northern limit of its range here.	No
8.2.7	*Melaleuca* spp. and/or *Lophostemon suaveolens* and/or	112.1	3.6	OC	E	A naturally rare and restricted vegetation community. Dense tall stands of *Melaleuca*	No

Regional Ecosystem	Name	Total area within study area (ha)	% of QLD total	VMA Class[1]	BD status[2]	Special values	TEC?
	Eucalyptus robusta open forest in wetlands associated with parabolic dunes					*leucadendra* in large swamps is unusual, and in the Slade Point area are considered to be part of an outstanding area of conservation significance (Pollock, 1995). Potential habitat for the threatened species Phaius australis ("Endangered" under the *Queensland Nature Conservation Act 1992*). Habitat for the fern *Blechnum indicum* which is locally rare. In the Slade Point area this vegetation type is also rich in bird and frog species (Pollock, 1995). 8.2.7e: Potential habitat for the threatened species *Phaius tancarvilleae* ("Endangered" under the *Queensland Nature Conservation Act 1992*). The buried swales with *Melaleuca leucadendra* as found in the Shoalwater Bay area (vegetation type c18a) are somewhat unusual. Within subregions 1 to 3 *Melaleuca quinquenervia* is very rare, and here occurs only in this vegetation type.	
8.2.9	Tussock grassland on coastal dunes	25.0	12.7	OC	E	The majority of this vegetation type occurs on large high aeolian deposits, and is overall very rare. The largest representation of this vegetation community occurs at Slade Point. This ecosystem is important habitat for small mammals. These dunes are a key factor affecting the hydrology of associated wetlands.	No
8.2.11	*Melaleuca* spp. closed forest in parallel dune swales	6.0	1.7	OC	OC	Potential habitat for the threatened species *Phaius australis* ("Endangered" under the *Queensland Nature Conservation Act 1992*) and Sowerbaea subtilis ("Vulnerable" under the *Queensland Nature Conservation Act 1992*).	No
8.2.13	*Melaleuca* spp. and/or *Corymbia* spp. and/or *Lophostemon suaveolens* and/or *Acacia* spp. open forest on dune sands mixed with alluvial material +/- marine sediments	113.8	19.6	E	E	Habitat for the only known occurrence of *Livistona drudei*, ("Vulnerable" under the Queensland Nature Conservation Act 1992), in the Central Queensland Coast bioregion.	No
8.2.14	*Banksia integrifolia* and/or *Corymbia tessellaris* and/or *Acacia disparrima* +/- rainforest spp. tall shrubland, on Holocene parabolic dunes	4.5	0.2	OC	OC	N/A	No
8.3.1	Semi-deciduous to evergreen notophyll to mesophyll vine forest, +/- sclerophyll emergents, fringing or in the vicinity of watercourses	14.2	0.2	OC	E	Habitat for flora species which are listed under the *Queensland Nature Conservation Act 1992* as "Near Threatened" (Actephila sessilifolia, *Macropteranthes fitzalanii*, *Rhodamnia glabrescens*, *Rhodamnia pauciovulata*, *Rourea brachyandra*, *Sarcotoechia* heterophylla, *Solanum sporadotrichum*) and "Vulnerable" (*Medicosma obovata*, *Neisosperma kilneri* and *Trigonostemon* inopinatus). *Medicosma obovata* and	No

Regional Ecosystem	Name	Total area within study area (ha)	% of QLD total	VMA Class[1]	BD status[2]	Special values	TEC?
						Neisosperma kilneri are also listed under the *Environment Protection and Biodiversity Conservation Act 1999* as "Vulnerable". Also habitat for a few plant species of restricted range such as *Arytera* sp. (Dryander Creek P.R.Sharpe 4184), and species poorly known or collected in the Central Queensland Coast bioregion such as Geophila repens and Ventilago pubiflora. Critical habitat for fruit pigeons and the Rufous Owl. In cleared farmlands, remnant rainforests on creek lines helps to slow their degradation and maintain water quality, which assists a variety of wildlife including fish, birds and invertebrates.	
8.3.2	*Melaleuca viridiflora* woodland on seasonally inundated alluvial plains with impeded drainage	116.1	1.5	E	E	This vegetation type often has a diverse ground stratum, and some of these species remain poorly collected and known. It is known habitat for the threatened species *Habenaria xanthantha* and *Eulophia bicallosa* which are both listed as "Near Threatened" in the *Queensland Nature Conservation Act 1992*. Habitat for a number of poorly known and collected species, or species at the edge of their range, including *Pheidochloa gracilis*, *Cartonema brachyantherum*, *Platostoma longicorne*, *Cyperus sanguinolentus*, *Hibbertia* sp. (Barakula V.Hando 122), *Eleocharis setifolia*, *Fimbristylis aestivalis*, *Fimbristylis depauperata*, *Fimbristylis tristachya*, *Haloragis heterophylla*, *Murdannia gigantea*, *Phyllanthus simplex*, *Scleria caricina*, *Salomonia ciliata*, *Mitrasacme paludosa*, *Byblis liniflora*, *Fimbristylis furva* and *Drosera burmanni*. Likely habitat for *Rhamphicarpa australiensis* which is listed as "Near Threatened" in the *Queensland Nature Conservation Act 1992*.	Yes
8.3.3	*Melaleuca leucadendra* and/or *M. fluviatilis* and/or *Casuarina cunninghamiana +/- Syncarpia glomulifera* open forest, on creek banks	8.7	0.1	LC	OC	Habitat for *Rourea brachyandra*, *Rhamphicarpa australiensis*, *Eulophia bicallosa* and *Lobelia membranacea* which are listed under the *Queensland Nature Conservation Act* as "Near Threatened". Also habitat for *Eucalyptus raveretiana* which are listed under the *Queensland Nature Conservation Act* as "Vulnerable". The combination of the fairly high diversity of canopy or subcanopy species, species not found in the surrounding landscape, and humid micro-environment makes this vegetation community an important food resource and refuge for a variety of fauna which are then often able to utilise the surrounding ecosystems. Habitat for the Rufous Owl and Grey Goshawk. 8.3.3b: Habitat for *Grevillea venusta* which is listed under the *Queensland Nature Conservation Act* and the *Environment Protection and Biodiversity Conservation Act 1999* as "Vulnerable". Habitat for species that are poorly known or poorly collected in the	No

Regional Ecosystem	Name	Total area within study area (ha)	% of QLD total	VMA Class[1]	BD status[2]	Special values	TEC?
						Central Queensland Coast bioregion including *Dodonaea triquetra*, *Daviesia umbellulata*, *Melaleuca hemisticta*, *Zieria minutiflora* subsp. *trichocarpa*, *Hibbertia velutina*, *Hovea longipes* and species at the northern limit of their range such as *Hibbertia vestita*, *Pomaderris ferruginea*, *Sannantha bidwillii*, *Philotheca difformis* subsp. *smithiana*, *Macrozamia miquelii*, *Lepidosperma elatius* and *Hovea clavata*. Also habitat for *Bowenia serrulata* which is restricted to the Shoalwater area. The combination of the fairly high diversity of canopy or subcanopy species, species not found in the surrounding landscape, and humid micro-environment makes this vegetation community an important food resource and refuge for a variety of fauna which are then often able to utilise the surrounding ecosystems.	
8.3.4	Freshwater wetlands with permanent water and aquatic vegetation	9.4	1.7	E	E	Intact (non-weedy) examples of this vegetation type are now very rare and those remaining are under severe threat. Habitat for a number of species with a narrow habitat range and poorly known/collected, including *Eleocharis philippinensis*, *Eleocharis* dietrich*i*ana, Nymphaea spp., *Nymphoides* spp., *Marsilea* spp., and *Utricularia* aurea. Important habitat for a large variety of water birds and other fauna. Important habitat for Barramundi.	No
8.3.5	*Eucalyptus platyphylla* and/or *Lophostemon suaveolens* and/or *Corymbia clarksoniana* woodland on alluvial plains	218.6	1.0	OC	E	A vegetation community with a very diverse ground layer, which has been poorly surveyed for flora and fauna. Likely to be habitat for the Red-cheeked Dunnart (*Sminthopsis virginiae*) which has been recorded south of Mount Blackwood, and otherwise rarely recorded in the bioregion. Habitat for many plant species which are poorly known and/or collected in the Central Queensland Coast bioregion (and/or at the limits of their known range), including *Jacksonia scoparia*, *Murdannia gigantea*, *Aristida acuta*, *Cyperus zollingeri*, *Hibbertia vestita*, *Goodenia pilosa*, *Panicum seminudum* var. *cairnsianum*, *Polygala wightiana*, *Schizachyrium* pseudeulalia and *Vigna* sp. (Station Creek R.J.Lawn CQ3284). Likely habitat for the poorly known species Rhamphicarpa australiensis which is listed as "Near Threatened" in the *Queensland Nature Conservation Act 1992*.	No
8.3.6	*Eucalyptus tereticornis* and/or *Corymbia intermedia* (or *C. clarksoniana*) and/or *C. tessellaris* +/- *Lophostemon suaveolens* open forest on alluvial levees and lower terrace	19.69	0.1	OC	E	Any remnants which are in good condition with minimal weed invasion (if they exist) are considered to be extremely high value as most remnants are heavily invaded by weeds. Known habitat for Red Goshawk (listed as "Endangered" *under the Queensland Nature Conservation Act 1992*) and arboreal mammals.	No

Regional Ecosystem	Name	Total area within study area (ha)	% of QLD total	VMA Class[1]	BD status[2]	Special values	TEC?
8.3.10	Semi-evergreen to evergreen notophyll vine forest, on gently to moderately-sloping alluvial fans adjacent to ranges	2.3	0.1	OC	OC	Habitat for plant species listed under the Queensland *Nature Conservation Act 1992* as "Near Threatened" (*Actephila sessilifolia*, *Brachychiton compactus*, *Cassia* sp. (Paluma Range G.Sankowsky+ 450), *Macropteranthes fitzalanii*, *Rhodamnia glabrescens*, *Rhodamnia pauciovulata*, *Rourea brachyandra*) and as "Vulnerable" (*Grevillea venusta*, *Medicosma obovata*, *Neisosperma kilneri*, *Omphalea celata*, *Ristantia waterhousei*). *Grevillea venusta*, *Medicosma obovata*, *Neisosperma* kilneri and *Omphalea celata* are also listed under the *Environment Protection and Biodiversity Conservation Act 1999* as "Vulnerable". Habitat in some areas for restricted species such as *Argyrodendron* sp. (Whitsundays W.J.McDonald+ 5831), *Gossia pubiflora* and Dissiliaria *indistincta*, and for species poorly known or collected in the Central Queensland Coast bioregion such as Brachychiton *acerifolius* and *Corymborkis veratrifolia*.	No
8.3.11	*Melaleuca viridiflora* var. *attenuata* open forest in broad drainage areas	1.1	0.5	E	E	This vegetation type is dominated by *Melaleuca viridiflora* var. *attenuata* which is uncommon in the Central Queensland Coast area, and which resembles *M. viridiflora* var. *viridiflora* but is taller, with softer white bark, and paler yellowish flowers which open later in the year than *M. viridiflora* var. *viridiflora*. The vegetation type is naturally restricted to small patches in low drainage depressions, a large proportion of which have now been drained and cleared. The remaining areas are often the only vegetation left standing in an otherwise cleared landscape, and provide valuable habitat for fauna and help to protect riparian systems from erosion. Habitat for species which are poorly known and/or rarely collected in the Central Qld Coast, such as *Utricularia aurea*, *Lemna aequinoctialis*, *Ottelia ovalifolia*, *Dentella repens*, *Fimbristylis littoralis*, *Eleocharis philippinensis*, *Lobelia stenophylla* and *Panicum paludosum*.	No
8.3.12	*Imperata cylindrica* and/or *Sorghum nitidum* forma *aristatum* and/or *Ischaemum australe* tussock grassland on alluvial and old marine plains	104.3	9.6	E	E	This vegetation unit was once very extensive, and a large percentage has now been ploughed and drained (and planted with sugar cane), sown with pasture grasses, and/or invaded by weeds. Given the size of the area that has disappeared (including apparently all of the examples on cracking black soils) it is likely that it was once made up of a variety of very different vegetation types, many of which are now extinct. Even the remnant areas are very poorly understood ecologically, and a common misconception is that these areas were timbered pre-clearing (this misconception is exacerbated by some areas now supporting regrowth *Melaleuca* spp. or *Eucalyptus* spp. perhaps due to drainage or climate change). How these areas remained treeless over long periods of	No

Regional Ecosystem	Name	Total area within study area (ha)	% of QLD total	VMA Class[1]	BD status[2]	Special values	TEC?
						time is not well understood but is likely to be a combination of soil and drainage properties, and frequency of burning. Habitat for the Red-cheeked Dunnart.	
8.3.13	*Eucalyptus tereticornis* and/or *Corymbia tessellaris* and/or *Melaleuca* spp. woodland on alluvial and marine plains, often adjacent to estuarine areas	213.6	3.0	OC	E	Habitat for a large number of plants that are wetland specialists and which are becoming rare as introduced plants become more dominant in wetlands. Habitat to several poorly known species such as *Nymphoides exiliflora* which has rarely been recorded in the Central Queensland Coast Bioregion. 8.3.13c: Habitat for some species which are poorly known/recorded in the Central Qld Coast, including *Panicum larcomianum*, *Alysicarpus schomburgkii*, *Lespedeza juncea* subsp. *sericea* and *Lobelia stenophylla*.	No
8.12.3	*Corymbia tessellaris* and/or *Eucalyptus tereticornis* +/- *C. intermedia* +/- *C. clarksoniana* open forest with a secondary tree layer of *Livistona decora*, on low hills on Mesozoic to Proterozoic igneous rocks	15.9	0.03	LC	NCAP	Habitat for flora species which are listed under the *Queensland Nature Conservation Act 1992* as "Near Threatened" (*Actephila sessilifolia*, *Bonamia dietrichiana*, *Brachychiton compactus*, *Cassia* sp. (Paluma Range G.Sankowsky+ 450), *Hernandia bivalvis*, *Rourea brachyandra*, *Macropteranthes fitzalanii*, *Rhodamnia glabrescens*, *Rhodamnia pauciovulata*, *Xylosma ovata*, *Graptophyllum excelsum*) and "Vulnerable" (*Actephila championiae*, *Actephila bella*, *Graptophyllum ilicifolium*, *Medicosma obovata*, *Neisosperma kilneri*, *Ristantia waterhousei*, *Trigonostemon inopinatus*) and "Endangered" (*Callicarpa thozetii*). Three of these species are also listed under the *Environment Protection and Biodiversity Conservation Act 1999* as "Vulnerable" (*Graptophyllum ilicifolium*, *Neisosperma kilneri* and *Trigonostemon inopinatus*). Habitat for *Gossia pubiflora* which is endemic to the Conway Range and Proserpine area, and *Larsenaikia jardinei* which is also of very limited distribution. Also habitat for poorly known or collected species including *Ehretia* sp. (Whitfield Range R.Jago 17) and *Heterostemma acuminatum*. Habitat for threatened fauna include Rufous Owl, endemic leaf-tail Geckos and Proserpine Rock Wallaby which is listed as "Endangered" in the *Queensland Nature Conservation Act 1992*. *Callicarpa thozetii* listed as "Endangered" in the *Queensland Nature Conservation Act 1992*.	No
8.12.11	Evergreen to semi-evergreen, notophyll to microphyll, vine forest to vine thicket, of foothills and uplands on Mesozoic to Proterozoic igneous rocks	105.3	0.7	LC	NCAP	Habitat for species listed under the Queensland Nature Conservation Act 1992 as "Near Threatened" (*Macropteranthes fitzalanii*, *Brachychiton compactus*, *Actephila sessilifolia* and *Bonamia dietrichiana*, *Cassia* sp. (Paluma Range G.Sankowsky+ 450), and "Vulnerable" (*Capparis batianoffii*, *Medicosma obovata*, *Omphalea celata* and *Neisosperma kilneri*). Also possible habitat for *Berrya rotundifolia* (listed as "Vulnerable"	No

Regional Ecosystem	Name	Total area within study area (ha)	% of QLD total	VMA Class[1]	BD status[2]	Special values	TEC?
						in the Queensland Nature Conservation Act 1992) which has been recorded on Calder Island. Habitat for species with a restricted range including *Homalium* sp. (South Molle Island J.A.Gresty AQ208995), *Gossia pubiflora*, *Larsenaikia jardinei* and *Dissiliaria indistincta*, and species poorly known or collected from the Central Queensland Coast bioregion such as *Tetrastigma thorsborneorum*, *Acalypha eremorum*, *Cassia brewsteri* and *Cupaniopsis simulata*. Important habitat for the fauna species *Petrogale persephone* (Proserpine rock-wallaby) which is listed as "Endangered" in the *Queensland Nature Conservation Act 1992.*	
8.12.12	*Eucalyptus tereticornis* and/or *Corymbia* spp. and/or *E. platyphylla* and/or *Lophostemon suaveolens* woodland to open forest on hill slopes on Mesozoic to Proterozoic igneous rocks	163.0	0.2	LC	NCAP	Habitat for *Paspalidium scabrifolium* (listed as "Near Threatened" in the *Queensland Nature Conservation Act 1992*). Habitat for the Northern Quoll (Pollock, 1995) which is listed as "Endangered" under the *Environment Protection and Biodiversity Conservation Act 1999*. Also Koala habitat.. 8.12.12d: Stunted, sparse coastal headland examples of this vegetation community are habitat for threatened flora species which are listed under the *Queensland Nature Conservation Act 1992* as "Near Threatened" (*Grewia graniticola*, *Solanum sporadotrichum, Peripleura scabra*) and "Endangered" (*Solanum graniticum*).	No
8.12.13	Tussock grassland, or *Xanthorrhoea latifolia* shrubland, including areas recently colonised by *Timonius timon* var. *timon* shrubland, on slopes of islands and headlands, on Mesozoic to Proterozoic igneous rocks and Tertiary acid to intermediate volcanics	1175.3	24.3	OC	OC	Habitat for threatened flora species including *Comesperma oblongatum*, listed as "Vulnerable" in the *Queensland Nature Conservation Act 1992*. Some areas of grasslands on islands are being colonised by either *Timonius timon* var. *timon* shrubland, or vine thicket. Many areas however appear to be stable. The maintenance of grasslands on islands and headlands appears to be related to topographic position and soil type which affect the amount of windshear/salt spray exposure. They generally occur on islands without exposed rock/boulders (and hence no sheltered microhabitats and no protection from fire). It is possible that burning by aborigines in the Whitsundays may have maintained some of the grasslands. There is no evidence that any of the grasslands mapped had a tree cover in pre-clearing times. There are problems with compaction by vehicles in southern subregions. Important habitat for ground orchids. 8.12.13a: This ecosystem most likely owes its existence to a combination of extreme windshear/salt-spray effects and a low surface rock content ensuring that it is not fire protected (Brennan 1986). It is therefore naturally restricted to exposed parts of islands and headlands. It is possible that burning by people in the Whitsundays may have	No

Regional Ecosystem	Name	Total area within study area (ha)	% of QLD total	VMA Class[1]	BD status[2]	Special values	TEC?
						maintained some of the grasslands for thousands of years. Some areas of grasslands on islands are being colonised by either *Timonius timon* var. *timon* shrubland, or vine thicket, however most grassland boundaries appear to be stable. There is no evidence that any of the grasslands mapped had a tree cover in pre-clearing times. Habitat for *Comesperma oblongatum* listed under the *Queensland Nature Conservation Act 1992* as "Vulnerable". C*omesperma oblongatum* and *Dichanthium setosum* are listed as "Vulnerable" under the *Environment Protection and Biodiversity Conservation Act 1999*. Also habitat for several species which are poorly known/collected from the Central Qld Coast area including, *Caladenia catenata*, *Chorizema parviflorum*, *Digitaria diffusa*, *Ophioglossum reticulatum* and *Zornia areolata*. Also habitat for a number of species at the northern limit of their range including *Hovea clavata*, *Phyllota phylicoides*, *Pseudanthus orientalis* and *Zornia areolata.* 8.12.13b: Habitat for *Dichanthium setosum* which is listed as "Vulnerable" under the *Environment Protection and Biodiversity Conservation Act 1999*.	
8.12.14	*Eucalyptus drepanophylla* and/or *E. crebra* and/or *E. exserta* and/or *Acacia spirorbis* subsp. *solandri* and/or *Lophostemon confertus* low woodland on islands and headlands, on Mesozoic to Proterozoic igneous rocks, and Tertiary acid to intermediate volcanics	243.5	1.5	LC	NCAP	Habitat for *Paspalidium scabrifolium* listed as "Near Threatened" in the *Queensland Nature Conservation Act 1992*. Stunted, sparse island and coastal headland examples of this vegetation community are habitat for *Grewia graniticola* (listed as "Near Threatened" in *the Queensland Nature Conservation Act 1992*) and *Solanum graniticum* (listed as "Endangered" in the *Queensland Nature Conservation Act* 1992). Also habitat for *Pseudanthus ligulatus* subsp. *ligulatus* which is uncommon in the bioregion and here occurs at the southern limit of its distribution. 8.12.14b: Possible habitat for the threatened species *Berrya rotundifolia* (listed as "Vulnerable" in the *Queensland Nature Conservation Act 1992*) which has been recorded on Calder Island.	No
8.12.18	Semi-evergreen notophyll/microphyll to complex notophyll *Argyrodendron* spp. vine forest +/- *Araucaria cunninghamii*, of foothills and uplands on near-coastal ranges and islands, on Mesozoic to Proterozoic igneous rocks	9.4	0.04	LC	NCAP	Habitat for *Graptophyllum excelsum*, *Macropteranthes fitzalanii*, *Hernandia bivalvis*, *Rhodamnia pauciovulata*, *Rourea brachyandra*, *Rhodamnia glabrescens*, *Brachychiton compactus*, *Actephila sessilifolia*, *Liparis simmondsii* and *Cassia* sp. (Paluma Range G.Sankowsky+ 450), which are listed as "Near Threatened" in the *Queensland Nature Conservation Act 1992*. Also habitat for *Actephila bella*, *Medicosma obovata* and *Neisosperma kilneri*, which are listed as "Vulnerable" in both the *Queensland Nature Conservation Act 1992* and the *Environment Protection and Biodiversity Conservation*	No

Regional Ecosystem	Name	Total area within study area (ha)	% of QLD total	VMA Class[1]	BD status[2]	Special values	TEC?
						Act 1999. Key habitat for *Dissiliaria* indistincta which is restricted to the Conway Ranges and ranges to the north of Proserpine, and for *Argyrodendron* sp. (Whitsundays W.J.McDonald+ 5831) which is endemic to the Conway Ranges and northern Whitsunday islands. Also habitat for many other plant species at range limits or which are poorly known and/or collected in the bioregion. Habitat for Proserpine Rock Wallaby which is listed as "Endangered" in the *Queensland Nature Conservation Act 1992*.	
8.12.22	*Eucalyptus drepanophylla* and/or *Corymbia clarksoniana* +/- *C. erythrophloia* +/- *E. platyphylla* +/- *E. exserta* +/- *C. trachyphloia* woodland on hills and ranges at low to moderate altitudes, in drier areas	2.4	0.01	LC	NCAP	Habitat for the threatened species *Cycas ophiolitica* listed as "Endangered" under the Queensland *Nature Conservation Act 1992.* Northern limit of *Cycas ophiolitica*.	No
8.12.25	*Eucalyptus tereticornis* +/- *E. tereticornis* x *E. platyphylla* woodland on hill slopes of islands on Mesozoic to Proterozoic igneous rocks	180.9	36.7	OC	OC	A rare (< 1000ha) regional ecosystem. Habitat for the poorly known orchid *Nervilia plicata*. Habitat for Koalas on St Bees island where they have been introduced, but where they are considered to be a valuable population of an animal which is threatened elsewhere in Queensland.	No
8.12.26	*Corymbia tessellaris* and/or *Eucalyptus tereticornis* open forest on hill slopes of islands and near coastal areas, on Mesozoic to Proterozoic igneous rocks, and Tertiary acid to intermediate volcanics	16.1	0.5	OC	E	Habitat for the significant species *Atalaya rigida*, *Xylosma ovata* listed as "Near Threatened" in the *Queensland Nature Conservation Act 1992* and Proserpine Rock Wallaby listed as "Endangered" in the *Queensland Nature Conservation Act 1992.*	No
8.12.27	*Corymbia tessellaris* and/or *Eucalyptus tereticornis* +/- *C. intermedia* +/- *C. clarksoniana* open forest with a secondary tree layer of *Livistona decora*, on low hills on Mesozoic to Proterozoic igneous rocks	772.1	26.7	E	E	A naturally restricted ecosystem. 8.12.27b: A naturally restricted ecosystem.	No

Regional Ecosystem	Name	Total area within study area (ha)	% of QLD total	VMA Class[1]	BD status[2]	Special values	TEC?
8.12.29	*Allocasuarina littoralis* and/or *Lophostemon confertus* and/or Acacia spp. and/or *Grevillea banksii* open shrubland on islands and headlands, on Mesozoic to Proterozoic igneous and Tertiary acid to intermediate rocks	452.8	7.8	OC	OC	Habitat for *Acacia polyadenia* listed as "Near Threatened" in the Queensland Nature Conservation Act 1992. Also habitat for *Leucopogon cuspidatus* listed as "Vulnerable" in the *Environment Protection and Biodiversity Conservation Act 1999.* Habitat for *Leptospermum anfractum* which is uncommon in the Central Queensland Coast bioregion and here occurs near the southern limit of its range. Likely habitat for *Paspalidium scabrifolium* listed as "Near Threatened" in the *Queensland Nature Conservation Act 1992.* 8.12.29b: Habitat for *Leucopogon cuspidatus* listed as "Vulnerable" in the *Environment Protection and Biodiversity Conservation Act 1999*. Also habitat for several species which are listed under the *Queensland Nature Conservation Act 1992* as "Endangered" (*Solanum graniticum*), "Near Threatened" (*Acacia polyadenia*, *Grewia graniticola*, *Peripleura scabra*) and "Vulnerable" (*Ozothamnus eriocephalus*, *Croton magneticus*). Also habitat for several species that are locally uncommon including *Ricinocarpos pinifolius*, *Leptosema oxylobioides*, *Pseudanthus ligulatus* subsp. ligulatus and *Tephrosia purpurea* var. *sericea*. Habitat for *Leptospermum anfractum* which is uncommon in the Central Queensland Coast bioregion and here occurs near the southern limit of its range.	No

[1] *Vegetation Management Act 1999* Class: E = Endangered; OC = Of Concern; LC = Least Concern

[2:] *Vegetation Management Act 1999* Biodiversity Status: E = Endangered; OC = Of Concern; NCAP = No Concern at Present

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